AGREEMENT

Between

BROWARD COUNTY

and

SHANGHAI ZHENHU HEAVY INDUSTRIES CO., LTD. INC., a/k/a ZPMC,
a Peoples Republic of China corporation
authorized to transact business in the state of Florida

for

CONSTRUCTION, TRANSPORTATION, ERECTION, TESTING, AND COMMISSIONING OF LOW PROFILE SUPER POST PANAMAX CONTAINER HANDLING GANTRY CRANES

RFP CONTRACT NO. X2111385P1

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RFP CONTRACT NO. X2111385P1

This Agreement for the construction, transportation, erection, testing and commissioning of low profile container handling gantry cranes hereinafter referred to as ("Agreement") between BROWARD COUNTY, a political subdivision of the state of Florida, hereinafter referred to as ("County"), by and through its Board of County Commissioners,

AND

SHANGHAI ZHENHUA HEAVY INDUSTRIES CO., LTD. INC. a/k/a ZPMC, organized under the laws of Peoples Republic of China, authorized to transact business in the state of Florida, hereinafter referred to as ("Contractor").

In consideration of the mutual terms, conditions, promises, covenants, and payments hereinafter set forth, and other good and valuable consideration, the receipt and sufficiency of which is hereby acknowledged, County and Contractor agree as follows:

ARTICLE 1 - DEFINITIONS

For the purposes of this Agreement, and the various covenants, conditions, terms, and provisions which follow, the definitions and identifications set forth below are assumed to be true and correct, and are agreed upon by the Parties. Whenever the following terms or pronouns in place of them appear in this Agreement the intent and meaning shall be interpreted as follows:

1.1 Assembly Facility(ies) – Shall mean the location where Contractor will assemble the crane(s).

1.2 Berth(s) – Shall mean Port Everglades Berths 30, 31, and 32 located at Southport, Port Everglades.

1.3 Board – Shall mean the Board of County Commissioners of Broward County, Florida, which is the governing body of the Broward County government created by the Broward County Charter.

1.4 Change Order – A written document ordering a change in the Contract price, or Contract time, or a material change in Work.

1.5 Commencement Date – Shall mean the date specified in each second Notice to Proceed, as the date on which Contractor's time period to reach the Substantial Completion Date and Final Completion Date with respect to each crane ordered will commence to run.

1.6 Conceptual Drawings – Shall mean the drawings developed by County for purposes of describing or representing certain design attributes of or design considerations for each crane, which drawings are attached hereto as Exhibit C.

1.7 Consultant – Shall mean the engineer selected by County to perform engineering services on behalf of County relating to the Project.

1.8 Contract or Agreement – Shall mean this Agreement and all addendums and amendments hereto between County and Contractor for the Project.

1.9 Contract Documents – Shall mean:

a) This Agreement; and

b) The Plans, Specifications, shop drawings, County Request for Proposal information and instruction to proposers, bonds, scope of work, general conditions, invitation to bid, addendum, supplemental instructions to proposers, and all other exhibits and forms attached to this Agreement or otherwise incorporated by reference herein; and

c) The initial and second Notices to Proceed for each crane and Payment and Performance Bonds, and all Change Orders, purchase orders, Field Orders and any additional document(s), the submission of which is required by this Agreement.

1.10 Contractor's Representative – Shall mean the person designated by Contractor as its authorized representative to communicate directly with County staff on all matters relating to the Project.

1.11 Contractor's Design Engineer – Shall mean the person or entity hired by Contractor for purposes of providing the professional design and engineering services necessary to develop the various calculations, shop drawings, plans, and schedules to be used in the prosecution of Work by Contractor in performance of its obligations and responsibilities under this Contract. The person or entity shall be a licensed Florida Professional Engineer.

1.12 Contractor's Superintendent – Shall mean the person or entity designated by Contractor as its representative for purposes of Contractor's provision of supervision and administration of the Work for the Project.

1.13 County – Shall mean Broward County, a body corporate and politic and political subdivision of the state of Florida.

1.14 County's Contract Administrator – Shall mean the ranking managerial employee of the agency of County government, which requested the Project, or some other employee expressly designated as Contract Administrator in writing by said ranking managerial employee to communicate directly with Contractor.

1.15 County's Inspection Representative – Shall mean the person, entity or firm authorized by the County to conduct inspections or audit of the Work and prepare inspection or audit reports for the benefit of County.

1.16 Fabrication Facility(ies) – Shall mean the location(s) where Contractor and its subcontractors will fabricate the component parts of the crane(s).

1.17 Field Order – Shall mean a written order issued by the County's Contract Administrator, which orders minor changes in the Work consistent with the intent of the Contract Documents, but does not involve a change in Contractor's compensation and/or time for performance of Work or a material change in Work.

1.18 Final Completion Date – Shall mean the date certified by County's Contract Administrator and Consultant that all of the conditions of all the required permits and regulatory agencies have been met, all Work, including corrective Work, has been performed by Contractor, and all administrative requirements of the Contract Documents have been completed, and County has received from Contractor a final release of liens or consent of Surety, release of claims by Contractor, corrected shop drawings and final plans, a final bill of materials, final invoice, copies of pertinent test results, correspondence and other necessary documentation relating to each crane ordered by County.

1.19 Notice to Proceed – Shall mean a written document issued by the County's Contract Administrator instructing Contractor to begin Work. Initial ("first") and second Notice to Proceed shall be issued for all three (3) base cranes and each option crane ordered by County.

1.20 Parties – Shall mean County and Contractor.

1.21 Plans – Shall mean the documents developed and prepared by Contractor for use in the construction, erection, testing, transportation, and commissioning of the crane(s).

1.22 Project – Shall mean all services required for the design, construction, transportation, erection, testing, and commissioning of each low profile container handling gantry cranes for the Port Everglades Southport facility including, but not limited to, warranty services.

1.23 Project Site or Site – Shall mean the area(s) designated by County's Contract Administrator, at the Port Everglades Southport Facility, Broward County, Florida, as the location where each crane(s) is to be delivered, erected, tested and fully commissioned by Contractor, and all warranty Work on each crane performed.

1.24 Specifications – Shall mean the Project design specifications developed by Contractor and Contractor's Design Engineer and reviewed by County and Consultant for the use in the construction, transportation, erection, testing, commissioning, and all warranty Work performed for each crane(s).

1.25 Subcontractor(s) – Shall mean a person, firm or corporation having a direct contract with Contractor including one who furnishes material worked to a special design according to the Contract Documents for this Project.

1.26 Substantial Completion Date – Shall mean the date certified by the County's Contract Administrator and Consultant that all of the terms and conditions of all the permits and regulatory agencies have been met, and each crane(s) has been delivered to Port Everglades, tested and commissioned in accordance with the terms and conditions of this Agreement allowing County to utilize each crane(s) for its intended purposes.

1.27 Surety – The surety company or individual, which is bound by the performance bond and payment bond with and for Contractor, who is primarily liable, and which surety company or individual is responsible for Contractor's satisfactory performance of the Work under this Agreement, and for the payment of all debts pertaining thereto.

1.28 Work – Shall mean all supervision, labor, materials, tools, equipment and services, including warranty services required for the Project, including, but not limited to, training of crane operators and County staff, as required by this Agreement to be provided by Contractor to fulfill all of Contractor's obligations and responsibilities hereunder. Work may constitute the whole or a part of the Project.

ARTICLE 2 - PREAMBLE

In order to establish the background, context, and frame of reference for this Agreement, and to generally express the objectives and intentions of the respective Parties herein, the following statements, representations, and explanations shall be accepted as predicates for the undertakings and commitments included within the provisions, which follow and may be relied upon by the Parties as essential elements of the mutual considerations upon which this Agreement is based.

2.1 It is the intent of the Contract Documents to describe a functionally complete Project. When words, which have a well-known technical or trade meaning are used to describe Work, materials, or equipment, such words shall be interpreted in accordance with that meaning. Reference to standard specifications, manuals, or codes of any technical society, organization or association, or to laws or regulations of any governmental authority, whether such reference be specific or by implication, shall mean the standard specification, manual, code, laws, or regulations in effect at the time of each second Notice to Proceed. Applicable laws or codes that may be changed after each second Notice to Proceed is issued, may result in additional compensation should additional Work be required on behalf of Contractor to insure compliance with same.

2.2 Contractor shall maintain six (6) copies of the Contract Documents; two (2) of which shall be preserved and always kept accessible (at the Assembly Facility, Fabrication Facility, and Site) to the County's Contract Administrator or his/her authorized representatives.

ARTICLE 3 - SCOPE OF WORK

The Work to be performed under this Agreement, shall include, but not be limited to, the furnishing of all supervision, labor, materials, tools, equipment, transportation, design, testing and engineering services, and all other services required to construct, transport, erect, test, permit, certify, commission and warrant up to six (6) sixty-five (65) long ton lift capacity under container spreader, low profile, electric, rail mounted Super Post Panamax, dockside ship to shore container handling rail mounted gantry cranes as more specifically set forth in Exhibit A, Scope of Work, attached hereto and made a part hereof. Contractor shall not be charged cargo wharfage at Port Everglades in connection with the performance of its Work hereunder.

ARTICLE 4 – TERM; TIME FOR COMPLETION AND PROJECT SCHEDULE

4.1 The term of this Agreement shall begin upon the date it is approved by the Board ("Effective Date"), and run until the expiration of the warranty period for each crane ordered by County hereunder ("Term"), unless sooner terminated as provided herein. The continuation of this Agreement beyond the end of any fiscal year shall be subject to both the appropriation and availability of funds in accordance with Chapter 129, Florida Statutes.

4.2 County's Contractor Administrator shall instruct Contractor to commence with the Work by written instructions, in the form of an initial Notice to Proceed for all base cranes and each option crane ordered.

4.3 Contractor shall furnish an Overall Project Schedule ("OPS") (for each crane ordered), all required bonds, insurance certificates, and documents as set forth herein to County's Contract Administrator within twenty-one (21) calendar days of Contractor's receipt of each initial Notice to Proceed. The OPS shall be written in the English language. The OPS shall include all activities at the Site, as well as, details involving design, submittals, materials and parts, fabrication, assembly, transportation, testing and commissioning of each crane. The OPS shall provide in detail, the orderly sequence of all activities, their descriptions, durations, start and finish dates, labor requirements, dependencies, including dependencies on Work of other contractors on or off the Site, and on or off the Assembly Facility and Fabrication Facility as necessary to the condition of the Work. The critical path for the entire Work shall be indicated in the OPS, which shall be updated by Contractor monthly and submitted with its payment requests. A second Notice to Proceed (for each crane ordered) directing Contractor to commence with fabrication and all other requested services of Contractor hereunder will not be issued until County's Contract Administrator and Consultant have completed review and acceptance of Contractor's submission of the OPS, Specifications and final crane design, and all required bonds, insurance certificates, and all other required documents as set forth herein. The Parties hereto agree, that the first Notice to Proceed for the first three cranes ordered (base crane order) will be issued no later than December 31, 2017. All second Notices(s) to Proceed (for each crane ordered) shall be sent no later than six (6) months from the date of issuance of the first Notice(s) to Proceed for each crane ordered.

4.4 Time is of the essence throughout this Agreement. Each crane ordered by County, shall be Substantially Completed within seven hundred thirty (730) calendar days from the Commencement Date specified in each first Notice to Proceed. Each crane ordered by County shall reach Final Completion and be ready for final payment within ninety (90) calendar days from the date certified by the County's Contract Administrator and Consultant as the Substantial Completion Date for each crane.

4.5 Upon failure of Contractor to substantially complete each crane, within the specified period of time, plus approved time extensions, if any, Contractor shall pay to County the sum of Five Thousand Dollars ($5,000.00) for each calendar day after the time specified in Section 4.4 above, plus approved time extensions, if any, for substantial completion. Liquidated damages assessed against each crane ordered by County shall be capped at One Million Eight Hundred Twenty-five Thousand Dollars ($1,825,000.00). These amounts are not penalties but liquidated damages to County for its inability to obtain full beneficial use of the Project. Liquidated damages are hereby fixed and agreed upon between the Parties, recognizing the impossibility of precisely ascertaining the exact amount of damages that will be sustained by County as a consequence of such delay, and both Parties desiring to obviate any question of dispute concerning the amount of said damages and the cost and effect of the failure of Contractor to complete the Project on time. In the event Contractor becomes aware that the Substantial Completion Date for each crane ordered by County will be delayed more than ninety (90) calendar days (except for delays caused by County or "Uncontrollable Forces" as set forth herein), Contractor shall notify County's Contract Administrator in writing of the delay. Within ten (10) calendar days of County's Contract Administrator's receipt of such notice, the Parties hereto shall meet and negotiate the scope and impact of the delay and an appropriate resolution to be implemented. The results of these negotiations shall be memorialized in an amendment to this Agreement, approved and executed by County's Contract Administrator and Contractor. If the Parties are unable to agree on a resolution of the outstanding delay issues, the outstanding delay issues will be presented for mediation as provided in Article 9 herein. Notwithstanding the foregoing, in the event the Substantial Completion Date for each crane ordered by County is delayed (except for delays caused by County or "Uncontrollable Forces" as set forth herein) for a period of one (1) year, Contractor agrees to waive all notices of default hereunder and any and all legal and equitable defenses against County; Contractor agrees that in such event, it is in material breach of this Agreement.

4.6 County is authorized to deduct liquidated damage amounts from the monies due Contractor for Work under this Agreement.

4.7 No extension(s) of time shall be granted to Contractor for delays in Work resulting from normal weather conditions prevailing at the Assembly Facility, Fabrication Facility and/or the Site as defined by the average of the last five (5) years of weather data recorded for each location(s).

ARTICLE 5 - COMPENSATION AND METHOD OF PAYMENT

5.1 This is a lump sum contract. County agrees to pay Contractor for the performance of all Work including all reimbursable expenses (authorized under County's

Procurement Code, as may be amended), the total lump sum price of Thirteen Million Eight Hundred Thousand Dollars ($13,800,000.00) per crane for the first three (3) cranes ordered by County (base crane order) which order shall be placed by County (by the issuance of a first Notice to Proceed). The total lump sum price for each option crane ordered no later than twenty-four (24) months from the date the first Notice to Proceed for the base crane order was sent by County to Contractor, shall be Thirteen Million Eight Hundred Thousand Dollars ($13,800,000.00) per option crane. The total lump sum price for each option crane ordered no later than thirty-six (36) months from the date the first Notice to Proceed for the base crane order was sent by County to Contractor, shall be Fifteen Million One Hundred Eighty Thousand Dollars ($15,180,000.00) per option crane. The total lump sum price for each option crane ordered no later than forty-eight (48) months from the date the first Notice to Proceed for the base crane order was sent by County to Contractor, shall be Sixteen Million Six Hundred Ninety-eight Thousand Dollars ($16,698,000.00) per option crane. The total lump sum price for each option crane ordered no later than sixty (60) months from the date the first Notice to Proceed for the base crane order was sent by County to Contractor, shall be Eighteen Million Three Hundred Sixty-seven Thousand Eight Hundred Dollars ($18,367,800.00) per option crane. The total number of option cranes ordered by County shall not exceed three (3). The total lump sum compensation paid by County to Contractor for each crane, is for all costs, including overhead and profit, associated with completion of all Work in full conformity with the requirements of this Agreement. County hereby waives all Port Tariff charges and fees against Contractor's ships calling Port Everglades to effectuate the terms and conditions of this Agreement. The Parties hereto acknowledge and agree, that at the time of contracting, there were no United States (U.S.) Tariff(s) or import duties to be imposed on each crane ordered by County. In the event of a subsequent change in the status of U.S. imposed Tariff(s) or import duties on each crane ordered by County, County will reimburse Contractor (on a direct cost basis) for any such U.S. Tariff charges or import duties imposed on each crane. Contractor shall provide County (with its reimbursement request) specific backup documentation evidencing Contractor's payment of such U.S. Tariffs or import duties on each crane.

Payment shall be made to Contractor at:
Via electronic wire transfer instructions to be provided to County by Contractor for the financial institution named below
Wells Fargo Bank N.A.
463 Broadway
New York, NY 10013

5.2 Contractor may make Application for Payment for Work completed during the Project at intervals of not more than once a month. Contractor's application shall show a complete breakdown of the Project components, the percentages completed and the amount due in proportion to the percentage of the Work completed or, as to General Conditions, at cost or, at County's Contract Administrator's option, as a Negotiated Lump Sum payable in proportion to the percentage of the Work completed. Each application shall be accompanied by such supporting evidence as may be reasonably required by Consultant and County's Contract Administrator. Contractor shall submit with each Application for Payment, an updated progress schedule acceptable to Consultant and County's Contract Administrator, a Certification of Payments to Subcontractors (Form 9 as attached hereto), and either release of liens from Contractor relative to the Work, which is the subject of the Application or consent of the surety as to such payment. All Applications for Payment shall be accompanied by a completed Statement of Compliance in the form attached hereto as Form 2, a completed Certification of Payments to Subcontractors in the form attached hereto as Form 9. Form 9 shall be accompanied by a copy of the notification sent to each subcontractor listed in item 2 of the Form, explaining the good cause why payment has not been made. Each Application for Payment shall be submitted in triplicate to Consultant for certification and distribution to County's Contract Administrator. Contractor's monthly payment application shall show a complete breakdown of the Project components, the quantities completed, and the amount due, together with all supporting documentation required by County's Contract Administrator. An application(s) for payment (hereinafter referred to as "Invoice") shall be stamped as received on the date on which it is received by County's Contract Administrator. Payment of an Invoice shall be subject to approval, and if approved, shall be paid within thirty (30) calendar days after the date on which the Invoice is stamped received. If the Invoice does not meet the requirements hereunder, the County's Contract Administrator shall reject the Invoice within twenty (20) business days after the date stamped received, and said rejection shall specify the deficiency and the action necessary to make the Invoice proper. If Contractor submits a request that corrects the deficiency, the corrected Invoice must be paid or rejected within ten business days after the corrected Invoice is stamped as received. If the dispute between County and Contractor cannot be resolved as set forth above, and the dispute directly relates to the promptness of payment, the dispute shall be resolved in accordance with the Prompt Payment Ordinance (Broward County Ordinance No. 89-49, as amended). For all other disputes related to payment, the dispute shall be resolved pursuant to the dispute resolution procedure set forth herein.

5.3 Ten percent (10%) of all monies earned by Contractor for each crane, shall be retained by County until Final Completion and acceptance of each crane by County in accordance with this Agreement, except that after fifty percent (50%) of the Work has been completed, the Contract Administrator shall reduce the retainage to five percent (5%) of all monies previously earned and all monies earned thereafter, and after ninety percent (90%) of the Work has been completed, the Contract Administrator may reduce the retainage to two and one-half percent (2½%) of all monies previously earned, and all monies earned thereafter. Any reduction in retainage below five percent (5%) shall be at the sole discretion of County's Contract Administrator, shall be recommended by Consultant. Contractor shall have no entitlement to a reduction. Any interest earned on retainage shall accrue to the benefit of County.

5.4 County may withhold, in whole or in part, Project payments to such extent as may be necessary to protect itself from loss on account of:

a) Defective Work not remedied.

b) Claims filed or reasonable evidence indicating probable filing of claims by other parties against Contractor or County because of Contractor's performance.

c) Failure of Contractor to make payments properly to Subcontractors or for material or labor.

d) Damage to another contractor not remedied.

e) Liquidated damages and costs incurred by County.

f) Failure of Contractor to provide any and all documents required by the Contract Documents.

When the above grounds are removed or resolved satisfactory to the County's Contract Administrator, payment(s) shall be made in whole or in part.

ARTICLE 6 – FINAL ACCEPTANCE AND FINAL PAYMENT

6.1 Upon receipt of written notice from Contractor that the Work for each crane ordered by County is ready for final inspection and final acceptance, Consultant shall, within ten (10) calendar days, make an inspection thereof. If Consultant finds the Work acceptable, the requisite documents have been submitted, the requirements of the Contract Documents fully satisfied, and all conditions of the permits and regulatory agencies have been met, a Final Certificate of Payment (Form 00926) attached hereto as Form 3 shall be issued by Consultant over its signature. The final certificate of payment shall provide the Final Completion Date of the crane(s).

6.2 Before issuance of the final certificate of payment, Contractor shall deliver to County's Contractor Administrator a full and final release of all liens and an affidavit certifying that all suppliers and subcontractors have been paid in full and that all other indebtedness connected with the Work has been paid or a consent of surety to final payment. The final Plans and the final bill for materials shall accompany Contractor's final payment application.

6.3 If, after the Work on each crane ordered by County is substantially complete and final completion thereof is materially delayed through no fault of Contractor, and Consultant so certifies, County shall, upon certificate of Consultant, and without terminating this Contract, make payment of the balance due for that portion of the Work completed and accepted. Such payment shall not constitute a waiver of claims by County.

ARTICLE 7 - ADDITIONAL SERVICES AND CHANGES IN SCOPE OF WORK

Without invalidating this Agreement, and without notice to surety, County reserves and shall have the right, to make such changes from time to time in the character or quantity of the Project as may be considered necessary or desirable to complete fully the Project in a satisfactory manner. Any extra or additional Work within the scope of the Project and related compensation may be accomplished by means of a fully executed and approved Change Order in conformance with County's Procurement Code, as may be amended from time to time.

ARTICLE 8 – COUNTY'S RESPONSIBILITIES

8.1 County shall assist Contractor by placing at its disposal, any available information pertinent to the Project including previous reports, laboratory tests and inspections of samples, materials and equipment; property, boundary, easement, rights-of-way, topographic and utility surveys; property descriptions; known zoning; deed and other land use restrictions.

8.2 County shall arrange for access to and make all provisions for Contractor to enter upon public and leased property as required for Contractor to perform its services hereunder at the Site.

ARTICLE 9 - RESOLUTION OF DISPUTES

9.1 To prevent all disputes and litigation, it is agreed by the Parties hereto, that Consultant shall decide all questions, claims, difficulties and disputes of whatever nature, which may arise relative to the technical interpretation of the Contract Documents and fulfillment of this Agreement as to the character, quality, amount and value of any Work done and materials furnished, or proposed to be done or furnished under or, by reason of, the Contract Documents and Consultant's estimates and decisions upon all claims, questions, difficulties and disputes shall be final and binding to the extent provided in Section 9.2. Any claim, question, difficulty or dispute, which cannot be resolved by mutual agreement of County and Contractor shall be submitted to Consultant in writing within twenty-one (21) calendar days of the date the Parties fail to reach agreement. Consultant shall notify the Parties in writing of its decision within twenty-one (21) calendar days from the date of the submission of the claim, question, difficulty, or dispute, unless Consultant requires additional time to gather information, or allow the Parties to provide additional information. Except for disputes relating to the promptness of payments by County hereunder, all nontechnical administrative disputes shall be determined by the County's Contract Administrator pursuant to the time periods provided herein. During the pendency of any dispute, and after a determination thereof, Contractor and County shall act in good faith to mitigate any potential damages including utilization of Project schedule changes.

9.2 In the event the determination of a dispute under this article is unacceptable to either party hereto, the party objecting to the determination must notify the other party in writing within twenty-one (21) calendar days of receipt of the written determination. The notice must state the basis of the objection and must be accompanied by a statement that any Contract time or Contract price adjustment claimed is the entire adjustment to which the objecting party has reason to believe it is entitled to. Within sixty (60) calendar days after the Final Completion Date of the crane, which is subject to unresolved disputed claims, the Parties shall participate in mediation to attempt to prevent litigation. The mediator shall be mutually agreed upon and costs shared equally by the Parties. The mediator's orders, decisions, and decrees shall be nonbinding. Should any disputed claim not be resolved in mediation or either Party disagrees with the results of the mediation, the Parties retain all their legal rights and remedies provided under Florida law. **COUNTY AND CONTRACTOR SPECIFICALLY WAIVE ALL OF THEIR RIGHTS, INCLUDING, BUT NOT LIMITED TO, CLAIMS FOR CONTRACT TIME AND CONTRACT PRICE ADJUSTMENTS AND THEIR RIGHTS AND REMEDIES UNDER FLORIDA LAW, IF EITHER FAILS TO COMPLY IN STRICT ACCORDANCE WITH THE REQUIREMENTS OF THIS ARTICLE.**

9.3 Pending final resolution of a disputed claim, Contractor shall continue to proceed diligently with performance of the Work, and County shall continue to make payments in accordance with this Agreement.

9.4 The mediator used shall be certified in accordance with Florida law. Mediation shall be conducted in Broward County, Florida.

ARTICLE 10 - PRECONSTRUCTION CONFERENCE

10.1 Before beginning Work on the base crane order of three (3) cranes and upon issuance of the second Notice to Proceed and prior to commencement of fabrication of the first crane, Contractor shall schedule, administer, and attend a kick-off preconstruction conference at a location designated by the Contractor, and bring Contractor's Design Engineer for the Project. A kick-off preconstruction conference shall also be held by the Contractor following the issuance of the second Notice to Proceed for each option crane order.

10.2 At the kick-off preconstruction conference(s), the Parties will discuss the Project, and review Contractor's Work schedule in keeping with requirements of the Conceptual Drawings, Plans, and Specifications. Contractor shall henceforth make every effort to expeditiously coordinate all phases of the Work to obtain the end result within the full purpose and intent of this Agreement.

ARTICLE 11 - PROJECT MEETINGS

11.1 Consultant shall schedule periodic Project progress meetings at Port Everglades between Contractor and County's representatives. Consultant shall:

a) Prepare agenda for the Project meetings; and

b) Distribute written notice of each meeting four (4) calendar days in advance of meeting date; except that in case of a special or emergency meeting, Consultant shall be required to give 24 hours advance notice of such meeting; and

c) Make physical arrangements for the Project meetings; and

d) Preside at the Project meetings; and

e) Record the minutes to include significant decisions made; and

f) Reproduce and distribute copies of the minutes within three (3) calendar days after each meeting:

i. To the participants in the Project meeting.

ii. To parties affected by decisions made at the Project meeting.

11.2 Representatives of Contractor and County attending the Project meetings, shall be qualified and authorized to act on behalf of the entity they each represent.

ARTICLE 12 - INSPECTION OF PROJECT

12.1 Inspection. Quality control review of the Work and workers performance and qualifications will be performed by County's Inspection Representative. Contractor shall make available for inspection and testing any specific crane part, fabrication, assembly or system, which may be requested by County's Inspection

Representative during construction, transportation, erection, testing, commissioning, and warranty servicing of each crane.

12.1.1 Full time quality control inspection of the Work shall be the sole responsibility of Contractor. Contractor's inspection reports shall be furnished to County's Inspection Representative upon request. During construction, at least one (1) of Contractor's quality control employees shall be assigned full time to each location where Work on critical path components are being performed.

12.1.2 A meeting to review Contractor's and its Subcontractor's quality control procedures shall be held prior to beginning construction of each crane, at the facility where the major structural components of each crane will be fabricated, and constructed, and may be attended by County's Inspection Representative. County shall pay all costs and expenses related to its Inspection Representative's travel, lodging, meals, and labor costs incurred in connection with County's Inspection Representative's attendance at the meeting.

12.1.3 Contractor shall notify County's Inspection Representative when any component or subassembly is ready for inspection. If any subassembly is assembled without such notification, and without affording County's Inspection Representative reasonable opportunity to inspect all of its components, County shall have the right to require Contractor, at Contractor's sole cost, to remove or disassemble in whole or in part the subassembly so proper inspection of its components can be made.

12.1.4 Any Work, materials, or equipment not conforming to the Contract Documents shall be considered defective, and shall be rejected by County's Inspection Representative. Defective Work shall be corrected in accordance with recognized methods and industry standards approved by County's Contract Administrator. In the event retesting, or reinspection is required due to defective Work, Contractor shall be responsible for all such costs.

12.1.5 Inspection and testing by County's Inspection Representative of any component of a crane, or any other aspect of the Work, shall in no way relieve Contractor of its responsibility to complete the Work in compliance with the terms and conditions of this Agreement.

12.2 Site Access. Contractor shall allow County's Inspection Representative access to all of Contractor's and its Subcontractor's Assembly and Fabrication Facilities for County's expressed purpose of performing inspection and testing of the crane(s) to substantiate progress and quality of the Work. Contractor shall provide County, free of charge, facilities necessary to satisfy this inspection and testing requirement.

12.3 Inspection Visits. Contractor at its sole cost, shall coordinate, arrange and pay for no more than a total of six (6) inspection visits by County personnel (maximum two (2) persons per inspection visit) per crane. Each visit shall not exceed two (2) weeks in duration. Costs include, but are not limited to, all round trip expenses for transportation, air travel at business class, lodging, food and subsistence and incidental ground transportation necessary for County's Inspection personnel to visit the Fabrication and Assembly Facilities to conduct inspection of the Work.

12.4 Testing. Contractor, at its sole cost, shall perform any and all specialty testing or retesting, including, but not limited to, ultrasonic testing, nondestructive testing, magnetic particle testing, dye penetration testing, and strength of materials testing, as necessary to validate or certify that the relevant portion of the Work complies with the requirements of the Contract Documents, as well as, the manufacturer's standards for any such Work or installation. Contractor shall provide for testing (by qualified and certified technicians) of any specific crane part, fabrication, assembly or system, as specified in the Specifications for the purpose of issuing certification that the Work complies with the requirements of the Contract Documents as well as the manufacturer's standards.

12.5 Reexamination and/or retesting of any Work may be ordered by the County's Contract Administrator and to be performed by independent agency. If such Work is found to be in conformance with the requirements of the Contract Documents, County shall pay the cost of reexamination, retesting and/or replacement. If such Work is found not to be in conformance with the requirements of the Contract Documents, Contractor shall pay all such cost(s).

ARTICLE 13 – SUPERVISION OF WORK

13.1 Instructions from the County to Contractor are to be given through the County's Contract Administrator and County's Inspection Representative, whose instructions are to be strictly and promptly followed in every case. Contractor shall assign and keep on the Project during its progress, a competent supervisor and necessary assistants all satisfactory to County's Contract Administrator. Contractor's Superintendent shall be responsible for continuous field supervision and coordination of the Work. Contractor's Superintendent shall not be changed without prior written notice to the County's Contract Administrator. Contractor's Superintendent shall give competent supervision to the Work.

13.2 Contractor's Superintendent shall prepare, on a daily basis, and keep available for inspection by County's Inspection Representative, a bound log setting forth at a minimum, for each day: a) the weather conditions and how any weather conditions affected progress of the Work; b) Work performed, equipment utilized for the Work; c) any idle equipment and reasons for idleness; d) visitors to the Assembly, Fabrication Facility, and Site; e) labor utilized for the Work; and, f) any materials delivered to the Fabrication Facilities. The daily bound log shall be available for inspection by County's authorized representative at all times during the Project.

13.3 If Contractor, in the course of prosecuting the Work, finds any discrepancy between the Contract Documents and the physical conditions of the locality, or any errors, omissions, or discrepancies in the Contract Documents, including Plans and Specifications, it shall be Contractor's duty to immediately inform the County's Contract Administrator in writing; and the County's Contract Administrator will promptly review same. Any Work done after such discovery, will be done at Contractor's sole risk.

13.4 Contractor shall coordinate, supervise and direct the Project competently and efficiently, devoting such attention thereto and applying such skills and expertise as necessary to perform the Project in accordance with the terms and conditions of this Agreement. Contractor shall be solely responsible for the design, means, methods, techniques, safety, sequences, and prosecution of all the Work.

ARTICLE 14 - COUNTY'S RIGHT TO TERMINATE AGREEMENT

14.1 If Contractor fails to begin the Work within twenty-one (21) calendar days following each initial Notice to Proceed, or fails to perform the Work with sufficient workers and/or equipment, or with sufficient materials to ensure timely completion of the Work, or shall perform the Work unsuitably, or cause it to be rejected as defective, or shall discontinue the prosecution of the Work pursuant to the accepted OPS, or if Contractor fails to comply with the terms and conditions set forth in this Agreement, or if Contractor becomes insolvent or commits any act of bankruptcy or insolvency, or shall make an assignment for the benefit of creditors, or from any other cause whatsoever fails to carry on the Work as required by the Contract Documents, or if Contractor is placed on the Scrutinized Companies with Activities in Sudan List or the Scrutinized Companies with Activities in the Iran Petroleum Energy Sector List created pursuant to Section 215.473, Florida Statutes, as amended, or if Contractor provides a false certification submitted pursuant to Section 287.135, Florida Statutes, as amended, then County's Contractor Administrator shall give notice in writing to Contractor of such delay, neglect or default. If Contractor, within a period of ten (10) calendar days after its receipt of the notice, does not proceed to cure in accordance therewith, then the Board may terminate this Agreement and exclude Contractor from the Project Site and take the prosecution of the Work out of the hands of Contractor and appropriate or use any or all materials and equipment located at the Assembly Facilities, Fabrication Facilities, and Project Site. In addition, County may enter into an agreement for the completion of the Project according to the terms and provisions of this Agreement, or use such other methods as in County's sole opinion shall be required for the completion of the Project according to the terms and provisions of this Agreement. All damages, costs, and charges incurred by County, together with the costs of completing the Project, shall be deducted from any monies due or which may become due to Contractor. In case the damages and expenses so incurred by County shall exceed the unpaid balance, then Contractor shall be liable and shall pay to County the amount of the exceedance.

14.2 If, after notice of default to Contractor is sent, it is determined for any reason that Contractor was not in default hereunder, the rights and obligations of County and Contractor shall be the same as if the notice of default had been issued as a termination for convenience as set forth in Section 14.3 below.

14.3 This Agreement may be terminated by Board for its convenience upon ten (10) days written notice to Contractor (delivered by U.S. certified mail, return receipt requested). In such case, Contractor shall be paid for all Work executed and actual expenses incurred prior to the termination date, in addition to termination settlement costs reasonably incurred by Contractor relating to commitments, which had become firm prior to the termination date. Payment shall include reasonable profit for Work performed. All actual expenses incurred shall have sufficient back-up documentation to verify that such expenses were actually incurred by Contractor. No payment shall be made for profit for Work, which has not been performed. Contractor acknowledges and agrees that it has received good, valuable and sufficient consideration from County, the receipt and adequacy of which is hereby acknowledged by Contractor, for County's right to terminate this Agreement for convenience.

14.4 In the event this Agreement is terminated by County, Contractor shall promptly discontinue all affected Work unless County directs otherwise and deliver or otherwise make available to County all data, Plans, Specifications, reports, estimates, summaries and all such other Project records required by the Contract Documents whether completed or in draft form.

ARTICLE 15 – SUSPENSION OF WORK

Contractor shall carry on the Work and adhere to the OPS notwithstanding, pending disputes or disagreements with the County. No Work shall be delayed or postponed pending resolution of any disputes or disagreements. Suspension of Work by Contractor during any pending dispute or disagreement with County shall constitute an event of default hereunder.

ARTICLE 16 - PLANS AND SPECIFICATIONS

16.1 County's Contract Administrator, shall have the right to require Contractor to modify the details of the Plans and Specifications, to supplement the Plans with additional information as the Work proceeds, which is within the specific intent and stated scope of the Project and, which the Parties agree does not cause an increase in Contract price or Contract time, all of which shall be considered as part of the Contract Documents at no additional cost to the County. The Plans are deemed a part of this Agreement, and the Plans and Specifications are to be considered together and are intended to be mutually complementary, so that any Work shown on the Plans, though not specified in the Specifications, and any Work specified in the Specifications though not shown on the Plans, is to be executed by Contractor as part of this Agreement. Figured dimensions are to prevail over scale. All things, which in the opinion of the County's Contract Administrator may be reasonably inferred from this Agreement, and the Plans and Specifications as developed by Contractor and reviewed by County and Consultant are to be executed by Contractor under the terms and conditions of this Agreement.

16.2 Updating of Plans. Contractor shall keep itself supplied with the latest issues of the Plans and Specifications and shall keep at least one (1) copy thereof, at all locations where any portion of the Work is ongoing. Contractor shall also promptly deliver any and all necessary updates of the Specifications and Plans to County, so as to keep County supplied, at all times, with one complete set of the Plans and Specifications. The Specifications and Plans shall at all times, be available for review and reference by County's Contract Administrator and any authorized representative of County.

16.3 Contractor shall verify all dimensions, quantities, and details shown on the Plans and Specifications received from Contractor's Design Engineer, and shall notify Contractor's Design Engineer of all errors, omissions and discrepancies found therein within three (3) calendar days of discovery. Contractor will not be allowed to take advantage of any error, omission, or discrepancy.

16.4 Ownership of Plans and Specifications. The Plans and Specifications, and all copies thereof, are and shall remain the property of County.

16.5 Delivery of Plans and Specifications. Contractor shall deliver to County one complete set of the Plans and Specifications in the form of final record reproducible transparencies showing all design additions and modifications; two bound sets of as-built calculations for all design modifications and one complete set of final record prints at the time of commissioning of each crane.

16.6 Design Considerations. Contractor shall design the cranes in accordance with the terms and conditions of this Agreement, and the design shall meet the requirements of the U.S. Department of Labor (USDL) as being equivalent to U.S. Standards. Contractor, at its own expense, shall furnish all technical data required to obtain any required USDL certification. Contractor hereby acknowledges that it has been made aware of the requirements of 29 CFR Parts 1910, 1917 and 1919, and agrees to conform the design and construction of the cranes to the requirements of said regulations as currently promulgated, or as may be hereafter amended.

ARTICLE 17 - WARRANTY

17.1 Contractor warrants to County that each crane(s) ordered by County will be new and perform and operate without defect or deficiency in material and performance and operate in accordance with the Contract Documents, and the terms and conditions of this Agreement. This warranty includes, but is not limited to, defects and deficiencies of design, materials, and workers performance and shall extend for the warranty period of three (3) years following the Final Completion Date for each crane ordered by County. All Work not conforming to these requirements, including substitutes not properly approved and authorized, may be considered defective. Contractor shall furnish satisfactory evidence as to the kind and quality of materials and equipment. This warranty is not limited by the provisions of Article 18 herein. Any defect(s) or deficiency(ies) shall be promptly repaired or corrected by Contractor at no expense to County.

17.2 Contractor shall at all times during the warranty period for each crane, maintain an agent located in South Florida, for purposes of providing warranty service to County. Contractor, through its South Florida warranty service agent, shall promptly repair and/or replace any defect or deficiency in the Work. Contractor shall act promptly in making warranty repairs at no expense to County. It shall be the responsibility of Contractor to promptly repair and/or replace the defective or deficient part(s) so as to ensure that County does not experience any extraordinary downtime in the usage of each crane. If the equipment fails to operate as warranted, Contractor, or its designated agent for handling repairs and trouble calls, shall respond in person at the Site, within twelve (12) hours of receiving notice from County's Contract Administrator of a problem. Contractor's designated agent shall be available three hundred sixty-five (365) days per year.

ARTICLE 18 - DEFECTIVE WORK

18.1 County's Contract Administrator shall have the authority to reject or disapprove Work for the Project, which County's Contract Administrator finds to be defective or nonconforming to the Contract Documents, in violation of code(s), installed in violation of the Contractor's written instructions or otherwise installed in an improper manner. Contractor shall promptly either correct all defective Work, or remove such defective Work and replace it with nondefective Work. Contractor shall bear all direct, indirect and consequential costs of such removal or corrections, including costs of testing laboratories and personnel.

18.2 If, within three (3) years of the Final Completion Date for each crane ordered by County any Work is found to be defective or not in accordance with the terms and conditions of this Agreement, Contractor, after receipt of written notice by County's Contract Administrator, shall promptly correct such defective or nonconforming Work within the time specified by County's Contract Administrator without cost to County, unless County has given Contractor a written acceptance of such defective or nonconforming conditions. Nothing contained herein shall be construed to establish a period of limitation with respect to any other obligation, which Contractor might have under the applicable state law.

18.3 Should Contractor fail or refuse to remove or correct any defective Work or to make any necessary repairs in accordance with the requirements of the Contract Documents within the time indicated in writing by County's Contract Administrator, County shall have the authority to cause the defective Work to be removed or corrected, or make repairs as may be necessary at Contractor's expense. Any expense incurred by County in making the removals, corrections or repairs shall be paid for out of any monies due or which may become due to Contractor, or may be charged against the Performance Bond. In the event of failure of Contractor to make all necessary repairs promptly and fully, County may declare Contractor in default.

18.4 Nothing contained herein shall be construed to establish a period of limitation with respect to any other obligation, which Contractor might have under the Contract Documents, including, but not limited to, Article 17 hereof and any claim made by County regarding latent defects in the Work.

18.5 County's failure to reject any defective or nonconforming Work shall not in any way prevent later rejection when such defect is discovered or obligate County to final acceptance of a crane.

ARTICLE 19 - TAXES

Contractor shall pay all applicable sales, consumer, use and other taxes required by law in performing the Work. Contractor is responsible for reviewing the pertinent Florida statutes involving state and local taxes and complying with all such requirements.

ARTICLE 20 – SUBCONTRACTS

20.1 Each Subcontractor must possess certificates of competency and licenses required by law. Contractor shall have a continuing obligation to notify County and Consultant of any change in Subcontractors.

20.2 Contractor shall not employ any Subcontractor against whom County or Consultant may have a reasonable objection. Contractor shall not be required to employ any Subcontractor against whom Contractor has a reasonable objection.

20.3 Contractor shall be fully responsible for all acts and omissions of its Subcontractors and of persons directly or indirectly employed by its Subcontractors and of persons for whose acts any of them may be liable to the same extent that Contractor is responsible for the acts and omissions of persons directly employed by it. Nothing in the Contract Documents shall create any contractual relationship between any Subcontractor and County or any obligation on the part of County to pay or to see the payment of any monies due any Subcontractor. County or Consultant may furnish to any Subcontractor evidence of amounts paid to Contractor on account of specific Work performed.

20.4 Contractor agrees to bind specifically every Subcontractor to the applicable terms and conditions of the Contract Documents for the benefit of County.

ARTICLE 21 – CHANGE IN QUANTITY OR CHARACTER OF THE WORK

21.1 Changes in the quantity or character of the Work within the scope of the Project, including all changes resulting in changes in the Contract price or the Contract time, shall be authorized only by a Change Order approved in advance and executed in accordance with the provisions of the Broward County Procurement Code, as amended from time to time.

21.2 Contractor shall not start Work on any changes requiring an increase in the Contract price or the Contract time until a Change Order setting forth the adjustments is approved by the County. Upon receipt of an executed Change Order, Contractor shall promptly proceed with the Work set forth therein.

21.3 In the event satisfactory adjustment cannot be reached for any item requiring a change in the Contract price or Contract time, and a Change Order has not been approved, County reserves the right at its sole option, to terminate this Agreement as it applies to the items in question and make such arrangements as may be deemed necessary to complete the disputed Work.

21.4 Upon the date of approval of a Change Order increasing the Contract price, Contractor shall ensure that both the Performance Bond and Payment Bond values are increased to reflect the increase in the total Contract price.

ARTICLE 22 - SEPARATE CONTRACTS

22.1 County reserves the right to let other contracts in connection with the Project. Contractor shall afford other persons reasonable opportunity for the introduction and storage of their materials and the execution of their work and shall properly connect and coordinate such work with Contractor's Work.

22.2 If any part of Contractor's Work depends for proper execution or results upon the work of any other persons, Contractor shall inspect and promptly report to Consultant any defects in such work that render it unsuitable for such proper execution and results. Contractor's failure to so inspect and report shall constitute an acceptance of the other person's work as fit and proper, except as to defects, which may develop later.

22.3 Contractor shall conduct its operations and take all reasonable steps to coordinate the prosecution of the Work so as to create no interference or impact on any other contractor or Port Everglades user on the Site. Should such interference or impact occur, Contractor shall be liable to the affected contractor or Port Everglades user for damages resulting from such interference or impact.

22.4 To insure the proper execution of subsequent Work, Contractor shall inspect the Work already in place and shall at once report to Consultant any discrepancy between the executed Work and the requirements of the Contract Documents.

ARTICLE 23 – LANDS FOR WORK AT SITE

County shall provide, as may be indicated in the Contract Documents, the lands upon which the Work at the Site is to be performed, rights-of-way and easements for access thereto, and such other lands as are designated by County for the use of Contractor.

ARTICLE 24 - DAMAGE TO EXISTING FACILITIES, EQUIPMENT, OR UTILITIES

24.1 Contractor shall exercise care and take all precautions during fabrication, erection, transportation, delivery and commissioning of each crane to prevent damage to any existing facilities, equipment or utilities. Any damage caused by Contractor shall be reported immediately to the County's Contract Administrator and such Work shall be repaired and/or replaced by Contractor in a manner approved by County. All costs to repair and/or replace any damage to existing facilities, equipment or utilities, shall be the sole responsibility of Contractor and performed expeditiously without cost to County.

24.2 Contractor shall provide required protection for finished Work at all times and protect adjacent Work during cleaning operations and make good any damage resulting from neglect of this precaution.

24.3 Protection of Work shall include, protecting Work that is factory finished, during transportation, storage and during and after installation. Where applicable and as required, Contractor shall close off spaces of areas where certain Work has been completed to protect it from any damages caused by others during their operations.

24.4 Contractor shall store materials and shall be responsible for and shall maintain partly or wholly finished Work during the continuance of this Contract until the Final Completion Date for each crane. If any materials or part of the Work should be lost, damaged or destroyed by any cause or means whatsoever, Contractor shall satisfactorily promptly repair and replace any damage done at Contractor's own cost. Contractor shall maintain suitable and sufficient guards, and barriers at night, as well as, suitable and sufficient lighting for the prevention of accidents at the locations where Work is being performed.

24.5 Contractor shall preserve all existing utilities within the Site. If utility conflicts are encountered by Contractor during delivery or commissioning, sufficient notice shall be given to their owners so that they may make the necessary adjustments. Damage to any utilities, which is caused by negligence on the part of Contractor, shall be repaired promptly by Contractor at Contractor's sole expense.

ARTICLE 25 - FIELD ORDERS AND SUPPLEMENTAL INSTRUCTIONS

25.1 County's Contract Administrator shall have the right to approve and issue Field Orders ordering minor changes in Work execution, providing the Field Order involves no change in Contract price or Contract time.

25.2 County's Contract Administrator shall have the right to approve and issue Supplemental Instructions setting forth written orders, instructions or interpretations concerning the intent of the Contract Documents, provided such Supplemental Instructions involve no change in the Contract price or Contract time.

ARTICLE 26 - CHANGE OF CONTRACT TIME OR CONTRACT PRICE

26.1 Any claim for a change in the Contract time or Contract price shall be made by written notice by Contractor to the County's Contract Administrator and to Consultant within five (5) calendar days of the commencement of the event giving rise to the claim or knowledge by Contractor of the claim and the notice shall state the general nature and cause of the claim. Thereafter, within twenty (20) calendar days of the termination of the event giving rise to the claim or knowledge of the claim, written notice of the extent of the claim with supporting information and documentation shall be submitted to the County's Contract Administrator and Consultant (hereinafter "Claim Notice"). The Claim Notice shall include Contractor's written notarized certification that the adjustment claimed is the entire adjustment to which Contractor has reason to believe it is entitled as a result of the occurrence of said event. **IT IS EXPRESSLY AND SPECIFICALLY AGREED THAT ANY AND ALL CLAIMS FOR CHANGES TO THE CONTRACT TIME OR CONTRACT PRICE SHALL BE WAIVED IF NOT SUBMITTED IN STRICT ACCORDANCE WITH THE REQUIREMENTS OF THIS SECTION.**

26.2 The Contract time will be extended in an amount equal to time lost on critical Work items due to delays beyond the control of and through no fault or negligence of Contractor or its Subcontractor(s) if a claim is made therefor as provided in Section 26.1. Such delays shall include, but not be limited to, acts or neglect by any separate contractor employed by County, fire, flood, lightning, epidemic, war, riot, civil disturbance, sabotage, abnormal weather conditions and governmental actions.

ARTICLE 27 – NO DAMAGES FOR DELAY

No claim for damages or any other claim, except for an extension of Contract time, shall be made or asserted against County by reason of any delays except as provided herein. Contractor shall not be entitled to an increase in the Contract price or payment or compensation of any kind from County for direct, indirect, consequential, impact or other costs, expenses or damages, including, but not limited to, costs of acceleration or inefficiency, arising because of delay, disruption, interference or hindrance from any cause whatsoever, whether such delay, disruption, interference or hindrance be reasonable or unreasonable, foreseeable or unforeseeable, or avoidable or unavoidable; provided, however, that this provision shall not preclude recovery of damages by Contractor for actual delays due solely to fraud, bad faith or active interference on the part of County or its Consultant. Otherwise, Contractor shall be entitled only to extensions of the Contract time as the sole and exclusive remedy for such resulting delay, in accordance with and to the extent specifically provided above.

ARTICLE 28 – EXCUSABLE DELAY; COMPENSABLE; NONCOMPENSABLE

28.1 Excusable Delay. Delay, which extends the completion of the Work and which is caused by circumstances beyond the control of Contractor or its Subcontractor(s), suppliers or vendors is Excusable Delay.

28.2 Contractor is entitled to an extension of the Contract time when the Work is delayed due to Excusable Delay. Contractor shall document its claim for any Contract time extension as provided herein.

28.3 Failure of Contractor to comply with requirements of this Agreement hereof as to any particular event of delay, shall be deemed conclusively to constitute a waiver, abandonment or relinquishment of any and all claims resulting from that particular event of delay.

28.4 Excusable Delay may be compensable or noncompensable:

28.4.1 Compensable Excusable Delay. Excusable Delay is compensable when

a) the delay extends the Contract time; and

b) is caused by circumstances beyond the control of Contractor or its Subcontractor(s), suppliers or vendors; or

c) is caused solely by fraud, bad faith or active interference on the part of County or its agents.

In no event shall Contractor be compensated for interim delays, which do not extend the Contract time.

28.4.2 Contractor shall be entitled to direct and indirect costs for Compensable Excusable Delay. Direct costs recoverable by Contractor shall be limited to the following:

a) Payroll costs for employees in the direct employ of Contractor in the performance of the Work under schedules of job classifications agreed upon by County and Contractor. Payroll costs for employees not employed full time on the Work shall be apportioned on the basis of their time spent on the Work. Payroll costs shall include, but not be limited to, salaries and wages plus the cost of fringe benefits which shall include social security contributions, unemployment, excise and payroll taxes, workers' compensation, health and retirement benefits, bonuses, sick leave, vacation and holiday pay application thereto. Such employees shall include superintendents and foremen at the Site. The expenses of performing the Work after regular working hours, on Sunday or legal holidays, shall be included in the above to the extent authorized by County.

b) Cost of all materials and equipment furnished and incorporated in the Work, including costs of transportation and storage thereof. All cash discounts shall accrue to Contractor unless County deposits funds with Contractor with which to make payments, in which case the cash discounts shall accrue to County. All trade discounts, rebates and refunds, and all returns from sale of surplus materials and equipment shall accrue to County and Contractor shall make provisions so that they may be obtained. Rentals of all construction equipment and machinery and the parts thereof whether rented from Contractor or others in accordance with rental agreements approved by County with the advice of Consultant and the costs of transportation, loading, unloading, installation, dismantling and removal thereof, all in accordance with the terms of said agreements. The rental of any such equipment, machinery or parts shall cease when the use thereof is no longer necessary for the Work.

c) Payments made by Contractor to Subcontractor(s) for Work performed by Subcontractor(s). If required by County, Contractor shall obtain competitive bids from Subcontractor(s) acceptable to Contractor and shall deliver such bids to County who will then determine, with the advice of Consultant, which bids will be accepted. If the subcontract provides that the Subcontractor is to be paid on the basis of cost of the Work plus a fee, the Subcontractor's cost of the Work shall be determined in the same manner as Contractor's cost of the Work. Subcontractor(s) shall be subject to the other provisions of the Contract Documents insofar as applicable.

d) Cost of specialty consultants, including, but not limited to, engineers, architects, testing laboratories and surveyors employed for services specifically related to the performance of the Work.

28.4.3 Supplemental costs including the following:

a) The proportion of necessary transportation, travel and subsistence expenses of Contractor's employees incurred in discharge of duties connected with the Work except for local travel (tri-county area) to and from the Site of the Work.

b) Cost, including transportation and maintenance, of all materials, supplies, equipment, machinery, appliances, office and temporary facilities at the Site and hand tools not owned by the workers, which are consumed in the performance of the Work, and cost less market value of such items used but not consumed, which remains the property of Contractor.

c) Sales, use, or similar taxes related to the Work, and for which Contractor is liable, imposed by any governmental authority.

d) Deposits lost for causes other than Contractor's negligence; royalty payments and fees for permits and licenses.

e) The cost of utilities, fuel and sanitary facilities at the Site.

f) Receipted minor expenses such as telegrams, long distance telephone calls, telephone service at the Site, expressage and similar petty cash items in connection with the Work.

g) Cost of premiums for additional bonds and insurance required because of changes in the Work.

28.4.4 County and Contractor recognize and agree that the amount of Contractor's precise actual indirect costs for delay in the performance and completion of the Work is impossible to determine as of the date of execution of this Agreement, and that proof of the precise amount will be difficult. Therefore, indirect costs recoverable by Contractor shall be liquidated on a daily basis for each day the Contract time is delayed due to a Compensable Excusable Delay. These liquidated indirect costs shall be paid to compensate Contractor for all indirect costs caused by a Compensable Excusable Delay and shall include, but not be limited to, lost profits, all profit on indirect costs, home office overhead, acceleration, loss of earnings, loss of productivity, loss of bonding capacity, loss of opportunity and all other indirect costs incurred by Contractor. The amount of liquidated indirect costs recoverable shall be Five Hundred Dollars ($500.00) per day for each calendar day this Agreement is delayed due to a Compensable Excusable Delay.

28.4.5 Noncompensable Excusable Delay. When Excusable Delay is

a) caused by circumstances beyond the control of Contractor, its Subcontractor(s), suppliers and vendors, and is also caused by circumstances beyond the control of the County or Consultant; or

b) is caused jointly or concurrently by Contractor or its Subcontractor(s), suppliers or vendors and by the County or Consultant, then Contractor shall be entitled only to a Contract time extension and no further compensation for the delay.

ARTICLE 29 - SUBSTANTIAL COMPLETION

29.1 When Contractor considers that each crane ordered by County is Substantially Complete, Contractor shall so notify the County's Contract Administrator in writing, and shall prepare for submission to the County's Contract Administrator a detailed list of remaining items to be completed or corrected, together with a schedule for completion or correction of all such items. The failure to include any item(s) on such list does not alter the responsibility of Contractor to complete and correct all

Work in accordance with the Contract Documents. The County's Contract Administrator and Consultant shall conduct an inspection to determine whether a crane is Substantially Complete. If County's Contract Administrator and Consultant determine that a crane is Substantially Complete, Consultant will then prepare and deliver to Contractor a Certificate of Substantial Completion, attached hereto as Form 1, which shall establish the Substantial Completion Date. Issuance of the certificate of substantial completion by Consultant shall be based upon Contractor's compliance with the Contract Documents and applicable codes, laws, rules and regulations applicable to the Project. The County's Contract Administrator, with the concurrence of Contractor, shall fix the Contract time within which Contractor shall complete or correct the remaining items of Work in order to reach the Final Completion Date for each crane ordered by County.

29.2 Each crane shall be considered "Substantially Complete" when all the following conditions are met:

a) The crane is certified to be ready for service by all necessary federal, state and local regulatory and governmental authorities, including the United States Department of Labor, per applicable regulations, including without limitation, 29 CFR Parts 1917 and 1919, all as currently provided or as amended; and

b) Satisfactory completion of all performance tests as delineated in the Contract Documents ("Manufacturing, Erection, Testing, Certification and Training"); and

c) Receipt of all permits from the governing governmental agencies; and

d) Receipt of certification from the U.S. Department of Labor, OSHA, that stairs, ladders, platforms and walkways meet OSHA General Industry Standards; and

e) Acceptance by the County's Contract Administrator and Consultant that the crane complies with the Contract Documents.

29.3 Partially Completed Work. Upon request of Contractor and if, in the opinion of Consultant, any part of the Work with respect to a given crane has progressed to the point that same can be safely and legally used by County, without interfering with the remaining Work activities, Consultant, upon inspection, shall provide a written report to County and Contractor, detailing the degree of completion of the Work with respect to that crane. Such report shall not be taken to constitute final acceptance nor substantial completion with respect to that crane. Consultant's report shall form the basis for determining the operational capacity of the crane.

ARTICLE 30 - SHOP DRAWINGS AND SUBMITTALS

30.1 Contractor shall provide County's Contract Administrator and Consultant with documents for all equipment, apparatus, machinery, fixtures, piping, wiring, fabricated structures and manufactured articles. The purpose of a documents is to show the suitability, efficiency, technique of manufacture, installation requirements, details of the item and evidence of its compliance or noncompliance with the Contract Documents.

30.2 Contractor shall thoroughly review and check documents and each and every copy shall evidence Contractor's approval thereon.

30.3 If the documents show or indicate departures from the Contract Documents, Contractor shall make specific mention thereof in its letter of transmittal. Failure to point out such departures shall not relieve Contractor from its responsibility to comply with the Contract Documents.

30.4 No Work called for documents shall be done until the documents have been furnished to and reviewed by the County's Contract Administrator and Consultant. County's and Consultant's review shall not relieve Contractor from responsibility for fit, form or function, or for errors or omissions of any sort on the shop drawings.

30.5 No partial submittal of documents is allowable for items, which interconnect and/or are interdependent. It is Contractor's responsibility to assemble the documents for all such interconnecting and/or independent items, check them and then make one submittal to the County's Contract Administrator and Consultant along with Contractor's comments as to compliance, noncompliance or features requiring special attention.

30.6 If catalog sheets or prints of manufacturers' standard drawings are submitted as documents, any additional information or changes on such drawings shall be typewritten or lettered in ink.

30.7 Contractor shall at all times, keep one set of documents marked with the Consultant's acceptance at the various locations where Work is performed.

30.8 Contractor's Design Engineer shall review and approve all submittals to ensure that they are complete and in conformity with the Contract Documents. Submittals shall be sufficient to allow Consultant to adequately review same and properly make a determination as to the conformity of the design and characteristics of the crane(s) to the Plans and Specifications, for purposes of informing County as to the progress of the Work. Submittals will include the following:

a) Submittal list and submittal schedule
b) Calculations
c) Plans and Specifications, including arrangement and detail drawings
d) Catalogue information
e) Quality assurance program
f) Priced spare parts list
g) Factory testing
h) Sea bracing, loadout and tie-down and unloading design
i) Schedule of submittals
j) Operating and maintenance manuals
k) Field test and checkout procedures
l) "As Built" drawings, calculations and manuals
m) Updated Overall Project Schedule with each progress payment request
n) Names of all Subcontractors, sub-subcontractors and materialmen providing services or materials in excess of $50,000.00.

30.9 Contractor shall provide to Consultant, at Contractor's expense, all submittals listed in this Agreement and in Exhibit A, Scope of Work, attached hereto, including, but not limited to, calculations, shop drawings, Plans, mill test reports, ultrasonic testing and nondestructive testing inspection and test reports, material lists and catalog cuts required for the proper execution of the Work and shall be responsible for the correctness of same. Contractor shall submit a sufficient number of submittals to enable Consultant to retain four (4) complete copies thereof. Review of submittals by Consultant will not relieve Contractor from the responsibility of designing, constructing, and fabricating a crane(s) to perform as required by the Contract Documents and as contemplated under the terms and conditions of this Agreement, nor of the responsibility of executing the Work in accordance with the Contract Documents. The submittal list and submittal schedule shall be delivered by Contractor to County's Contract Administrator and Consultant within twenty-one (21) calendar days following the issuance date of each initial Notice to Proceed.

30.10 Drawings, calculations and vendor's catalog information must be submitted in logical order, and in accordance with the approved OPS, so that they may be reviewed as they are received against previous information submitted.

a) Submission in logical order means:

i. Design drawings with calculations showing the logical development of loads and forces for each load combination for a given component(s) or assembly.

ii. Design drawings of the component(s) or assembly with calculations of the stresses, material used, the allowable stress for the load combination considered, when applicable, with vendor's published catalog descriptions, dimensions and rating information.

iii. Shop Assembly, Detail and Erection Drawings.

30.11 Calculations must be accompanied by the development of the loads or forces used in the calculations.

30.12 At the time Contractor makes its first submittal, it shall provide a drawing tree and numbering system, which shall be updated with subsequent submittals.

30.13 Submittals shall be made as a complete package consisting of all of the relevant information with respect to the assembly or subassembly or covered as determined by Consultant.

30.14 Submittals shall be numbered in a rational manner, preferably in chronological order, for ease of processing. Resubmittals shall be marked as such. All submittals shall be in the English language. All dimensions shall be shown in feet and inches. All weights shall be shown in pounds and/or kips.

30.15 Contractor shall be responsible for receiving, processing and forwarding submittals to Consultant and County's Contract Administrator and be responsible for providing clarification and similar technical assistance to Consultant and County's Contract Administrator with respect to submittals.

30.16 Contractor shall furnish all materials and submittals to County's Contract Administrator and Consultant in a timely manner consistent with the progress of the Work, and with sufficient time to allow Consultant the opportunity to perform its review and advisement functions hereunder in such a way as to maintain the County fully informed, at all times, as to the progress of the Work. Contractor shall deliver all submittals to County's Contract Administrator and Consultant by overnight mail or, if practicable, by e-mail, with original copies by overnight mail, it being understood that the intent of the Parties is to expedite all communications between Contractor and County in recognition of the importance of Contractor's performance of its obligations hereunder.

30.17 All calculations for structural, mechanical and electrical features shall be submitted to Consultant at the expense of Contractor.

30.18 Calculations for the following items shall be submitted to County's Contract Administrator and Consultant by Contractor's Design Engineer within ninety (90) calendar days following the issuance date of each first Notice to Proceed:

a) Stability and wheel load calculations.

b) Structural design calculations (including computer data, if any) for the frame and boom structures, and telescopic lifting beam, headblock assembly and cargo beam.

c) Design calculations for component parts of the main hoist, boom, trolley and gantry drive system including wire rope, gears, pins and axles.

d) Duty cycle calculations, including determinations for motor, switch and gear sizing.

e) Voltage drop calculations from cable reel-cable dock termination point to machinery house secondary main breakers under theoretical maximum momentary peak loading.

f) Lighting levels at wharf.

g) Short circuit calculations.

h) Load analysis, summarizing connected and demand loads.

i) Complete calculations (signed by a professional structural engineer registered in the state of Florida) for wharf loadings as a result of the crane(s) being off-loaded from a barge or ship, and indicate the means and methods for the off-loading of the crane(s).

30.19 Other calculations for structural, mechanical and electrical features shall be submitted to the County's Contractor Administrator and Consultant upon request.

30.20 All calculations shall be indexed and clearly cross-referenced to codes, specifications and other sections of the submittal. Furthermore, sufficient calculations shall be submitted with or prior to shop drawing and material submittals to allow the Consultant to reasonably review said shop drawing and materials submittals.

30.21 A general arrangement drawing of each crane shall be submitted with the first calculation submittal with dimensioned key working points on the structure. Dimensioned subassembly (i.e., main hoist, trolley drive, boom traverse drive, etc.) drawings shall be submitted clearly showing the dimensional relationship of that subassembly to working points on the general arrangement drawing.

30.22 All schedules, drawings, calculations and procedures for transporting the crane(s), including ocean shipment, shall be reviewed, approved and certified by

Contractor's Design Engineer. The calculations shall include procedures for loading and off-loading the crane(s). These schedules, drawings, calculations and procedures shall also be provided to County's Contract Administrator and Consultant for review and not for approval of means, methods, techniques, sequences or procedures.

30.23 Documents shall include, but shall not be limited to, shop detail drawings, electrical and hydraulic drawings, fabrication drawings, field layout drawings and similar classes of drawings. Shop drawings shall contain all required details and information in reasonable scale, and enough views to clearly show the Work to be done or the item to be furnished.

30.24 Drawings and calculations, including computer discs and vendor's catalog information, shall be in the English language. Dimensions shall be feet and inches, and weights shall be pounds or kips. A dual system with both metric and English dimensions is acceptable. The information shall be clearly presented so the Consultant may check all details for conformance with the Specifications. Consultant will be the sole judge of the adequacy of the information presented.

30.25 Calculations and drawings submitted by Contractor for all crane components shall be prepared and signed by Contractor's Design Engineer. These calculations shall demonstrate conformance to the Specifications. Review of the calculations by Consultant shall not relieve Contractor or Contractor's Design Engineer from liability resulting from errors or omissions.

30.26 IT IS EXPRESSLY UNDERSTOOD AND AGREED THAT THE RESPONSIBILITY FOR DESIGNING THE CRANES AND FOR ALL OTHER ASPECTS OF THE WORK, INCLUDING, WITHOUT LIMITATION, THE CONSTRUCTION, ASSEMBLY, TRANSPORTATION, ERECTION, TESTING AND COMMISSIONING OF EACH CRANE, RESTS SOLELY WITH CONTRACTOR AND ALL OTHERS ENGAGED BY CONTRACTOR FOR PURPOSES OF RENDERING SERVICES, LABOR, EQUIPMENT AND MATERIALS RELATED TO THE WORK. UNDER NO CIRCUMSTANCES SHALL THE REVIEW BY COUNTY OR THE INSPECTION AND APPROVAL BY COUNTY OR BY COUNTY'S REPRESENTATIVES OF ANY PLANS, CALCULATIONS, SPECIFICATIONS, MATERIALS, COMPONENTS, EQUIPMENT, FACILITY OR ANY OTHER ELEMENT OF THE WORK, RELIEVE CONTRACTOR OF SUCH RESPONSIBILITY, IT BEING UNDERSTOOD AND AGREED THAT THE FUNCTION OF THE REVIEW, INSPECTION AND APPROVAL PROVISIONS IN THIS CONTRACT IS SIMPLY A MEANS OF MAINTAINING THE COUNTY INFORMED AS TO THE PROGRESS OF THE WORK AND AS A MEANS OF MONITORING CONTRACTOR'S COMPLIANCE WITH THE CONTRACT DOCUMENTS.

ARTICLE 31 - MAINTENANCE AND CLEAN UP

31.1 The Site shall be kept reasonably clean during the progress of the Work. Contractor shall provide sufficient sanitary facilities and trash containers to eliminate any possible nuisance. No material, rubbish or trash shall be allowed to go adrift or to be placed, spilled, dropped, thrown or otherwise dumped into the waterways at the Site. Any debris afloat or dumped in the waterways as a result of Contractor's operations shall immediately be retrieved by Contractor. Any oil, detergent or other deleterious substance, which is spilled into the Intracoastal Waterway or elsewhere in such a manner that it may be washed into the waterways shall immediately be cleaned up by Contractor. Contractor shall take whatever measures as are necessary to avoid causing paint over spray or dust on surrounding leased premises and shall be responsible for any damage caused by paint over spray or dust from its operations.

31.2 Unless otherwise provided herein, Contractor shall remove from the Site and Port Everglades Jurisdictional Area any and all excess materials, debris and trash resulting from the Work. No burning or disposal of materials will be allowed within the Port Everglades Jurisdictional Area.

31.3 In the completion of this Project, Contractor shall comply and shall cause all of Contractor's subcontractor laborers to comply with all regulations, ordinances and statutes, which apply to any phase of the Project.

ARTICLE 32 - PREVAILING WAGE RATES

32.1 The rate of wages and fringe benefit payments for all laborers, mechanics and apprentices, for construction Work performed in the United States, shall not be less than those payments for similar skills in classifications of work as determined by the Secretary of Labor and as published in the Federal Register (latest revision), for all Work performed within the United States of America. See Exhibit B, Prevailing Wage Determination, attached hereto.

32.2 All mechanics, laborers and apprentices, employed or working directly upon the Site in construction activities, shall be paid unconditionally, and without subsequent deduction or rebate on any account (except such payroll deductions as are permitted by the Copeland Regulations 29 CFR Part 3, as amended), the full amounts due at time of payment, computed at wage rates not less than the aggregate of the basic hourly rates and the rates of payments, contributions or costs for any fringe benefits contained in the latest wage determination decision of the Secretary of Labor, regardless of any contractual relationship , which may be alleged to exist between Contractor or Subcontractor and such laborers, mechanics and apprentices. A copy of such wage determination decision shall be kept posted by Contractor at the Site in a prominent place where it can be easily seen by the workers.

32.3 In the event that any class of laborers or mechanics or apprentices, for Work performed in the United States, which is not listed in the wage determination decision, is to be employed under this Agreement, Contractor shall classify or reclassify same conformably to the wage determination decision and shall report the action to the County's Contract Administrator for his/her review and approval. If the Parties cannot agree on the proper classification of a particular class of laborers or mechanics or apprentices to be used, the County's Contract Administrator shall submit the question, together with his/her recommendation, to the County's Chief Administrator for final determination.

32.4 In the event it is found by the County's Contract Administrator that any laborer or mechanic or apprentice employed, for construction Work performed in the United States, by Contractor, or any Subcontractor directly on the Site covered by this Agreement, has been or is being paid at a rate of wages less than the rate of wages required by Section 26.5, Broward County Code of Ordinances, County's Contract Administrator may (1) by written notice to the prime Contractor terminate Contractor's right to proceed with the Project or such part of Project on which there has been a failure to pay said required wages; and/or (2) at County's option, prosecute the Project to completion by other lawful means. Whereupon, Contractor and its sureties hereunder shall be liable to County for any excess costs occasioned to County thereby.

32.5 Sections 32.1 through 32.4 above shall apply to this Agreement to the extent that it is (1) a prime contract subject to the ordinance; or (2) a subcontract also subject to the ordinance under such prime contract.

32.6 Contractor shall maintain payrolls and basic records relating thereto during the course of the Project and shall preserve them and make available for inspection by County's Contract Administrator for a period of three (3) years following the Final Completion Date of each crane ordered by County for all laborers, mechanics and apprentices working at the Site. Such records shall contain the name and address of each such employee; his/her current classification; rate of pay (including rates of contributions for, or costs assumed to provide, fringe benefits); daily and weekly number of hours worked; deductions made; and actual wages paid.

32.7 Contractor shall submit, with each monthly requisition for payment, a signed and sworn "Statement of Compliance" attesting to compliance with Broward County Ordinance No. 83-72. The Statement shall be in the form attached hereto as Form 2, Statement of Compliance (Prevailing Wage Rate) and made a part hereof.

32.8 County's Contract Administrator may withhold or cause to be withheld from Contractor so much of the payments requisitioned as may be considered necessary to pay laborers and mechanics, including apprentices, trainees, watch persons and guards employed by Contractor or any Subcontractor on the Site, the full amount of wages required by this Agreement.

32.9 If Contractor fails to pay any laborer, mechanic or apprentice employed or working on the Site all or any part of the wages required by this Agreement, the County's Contract Administrator may, after written notice to Contractor, take such action as may be necessary to cause suspension of any further payments or advances until such violations have ceased.

ARTICLE 33 – PAYMENT AND PERFORMANCE BONDS

33.1 Payment Bond and Performance Bond (Surety):

a) Contractor shall furnish the required Payment Bond and Performance Bond as set forth and described in each initial Notice to Proceed.

b) Each Bond (separate Payment Bond and Performance Bond) shall be in the form and containing all the provisions of the Performance Bond and Payment Bond attached hereto as Form 5 and Form 6 respectively and made a part hereof.

c) Each Bond shall be maintained in the amount of one hundred percent (100%) of the total aggregate Contract price for all cranes ordered by County by the issuance of a Notice to Proceed and shall guarantee to County the full completion and performance of all the Work covered by this Agreement, as well as full payment of all suppliers, materialmen, laborers and subcontractors. Each bond shall be with a surety company, which is qualified pursuant to Section 33.3 hereinbelow.

d) Bonding coverages for each crane ordered by County shall continue in effect until the expiration date of each crane's warranty period. Following the expiration date of each crane's warranty period, the total coverage amount of each bond shall be adjusted accordingly to reflect the then current total aggregate Contract price representing the number of crane(s) ordered that have not yet reached their respective warranty period expiration date.

33.2 Performance and Payment Guaranty. In lieu of a Performance Bond and Payment Bond, Contractor may furnish an alternate form of security, which may be in the form of cash, money order, certified check, cashier's check or irrevocable letter of credit. Such alternate forms of security shall be in a form approved by County's

Contract Administrator as set forth in Form 8, Performance and Payment Guaranty form Unconditional Letter of Credit, attached hereto, and shall be for the same purpose and shall be subject to the same conditions as those provided hereinabove for the Payment and Performance Bonds.

33.3 Qualifications of Surety:

a) A separate Payment Bond and Performance Bond must be executed by a surety company of recognized standing, authorized to do business in the state of Florida as surety, having a resident agent in the state of Florida and having been in business with a record of successful continuous operation for at least five (5) years.

b) In addition to the above-minimum qualifications, the surety company must meet at least one of the following additional qualifications:

i. The surety company shall hold a current certificate of authority as acceptable surety on federal bonds in accordance with United States Department of Treasury Circular 570, Current Revisions. If the amount of the bond exceeds the underwriting limitation set forth in the circular, in order to qualify, the net retention of the surety company shall not exceed the underwriting limitation in the circular, and the excess risks must be protected by coinsurance, reinsurance or other methods in accordance with Treasury Circular 297, revised September 1, 1978 (31 CFR Section 223.10 Section 223.111). Further, the surety company shall provide County with evidence satisfactory to County, that such excess risk has been protected in an acceptable manner.

ii. The surety company shall have at least the following minimum ratings in the latest revision of Best's Insurance Report:

Amount of Bond	Policy-Holder's Ratings	Best's Financial Size Category
500,001 to 1,000,000	A-	Class I
1,000,001 to 2,000,000	A-	Class II
2,000,001 to 5,000,000	A	Class III
5,000,001 to 10,000,000	A	Class IV
10,000,001 to 25,000,000	A	Class V
25,000,001 to 50,000,000	A	Class VI
50,000,001 or more	A	Class VII

ARTICLE 34 - INDEMNIFICATION

34.1 Contractor shall indemnify and hold harmless County, its officers and employees, from liabilities, damages, losses and costs, including, but not limited to, reasonable attorneys' fees, to the extent caused by the negligence, recklessness or intentionally wrongful conduct of Contractor and persons employed or utilized by Contractor in the performance of this Contract. These indemnifications shall survive the term of this Contract. To the extent considered necessary by County's Contract Administrator and County Attorney, any sums due Contractor under this Contract may be retained by County until all of County's claims for indemnification pursuant to this Contract have been settled or otherwise resolved, and any amount withheld shall not be subject to payment of interest by County.

34.2 The indemnification provided above shall obligate Contractor to defend at its own expense to and through appellate, supplemental or bankruptcy proceeding, or to provide for such defense, at County's option, any and all claims of liability and all suits and actions of every name and description covered by Section 34.1 above that may be brought against County whether performed by Contractor, or persons employed or utilized by Contractor.

ARTICLE 35 - INSURANCE

35.1 Contractor shall provide, pay for, and maintain in force at all times during the Project, such insurance, as will assure to County the protection contained in this Agreement. The insurance requirements for this Agreement are set forth in Exhibit D, Insurance Requirements Certificate, attached hereto. The Comprehensive General Liability policy shall clearly provide for the indemnification provision contained herein.

35.2 Such policy or policies shall be issued by United States Treasury approved companies and authorized to do business in the state of Florida, and having agents upon whom service of process may be made in the state of Florida.

35.3 Notice of Cancellation, Expiration and/or Restriction: The policy(ies) must be endorsed to provide County with thirty (30) calendar days' notice of cancellation, expiration and/or restriction, to the attention of the Broward County Risk Manager at Risk Management Division, Governmental Center, Room 210, 115 South Andrews Avenue, Fort Lauderdale, Florida 33301.

35.4 Contractor shall furnish to County's Contract Administrator Certificate(s) of Insurance evidencing the insurance coverages required herein on or before the date of issuance of each Notice to Proceed by County's Contract Administrator. Such certificate(s) shall reference this Agreement.

35.5 The official title of the owner is "Broward County." This official title shall be used in all insurance or other legal documentation. Broward County is to be included as "Additional Insured" with respect to liability arising out of Work performed for County by or on behalf of Contractor or acts or omissions of Contractor in connection with the Work.

35.6 Contractor shall provide to County Certificate(s) of Insurance or a certified copy of all insurance policies required under this article within fifteen (15) calendar days of a written request by County. Broward County Risk Management reserves the right to require certified copies if requested.

35.7 County's Risk Management Division reserves the right, but not the obligation, to review and revise any insurance requirements at the time of any Change Orders or Amendments, not limited to deductibles, limits, coverages, and endorsements.

ARTICLE 36 – MISCELLANEOUS

36.1 Royalties and Patents. All fees, royalties and claims for any invention or patent of any article, material, arrangement, appliance or method that may be used upon or in any manner be connected with the Project, are hereby included in the Contract price stipulated in this Agreement.

36.2 Rights of Various Interests. Whenever work being done by County's forces or by other contractors is contiguous to Work covered by this Agreement, the respective rights of the various interests involved shall be established by the County's Contract Administrator to secure the completion of the various portions of the Work in general harmony.

36.3 Contractor shall not unlawfully discriminate against any person in its operations and activities or in its use or expenditure of funds in fulfilling its obligations under this Agreement. Contractor shall affirmatively comply with all applicable provisions of the Americans with Disabilities Act (ADA) in the course of providing any services funded by County, including Titles I and II of the ADA (regarding nondiscrimination on the basis of disability), and all applicable regulations, guidelines and standards. In addition, Contractor shall take affirmative steps to ensure nondiscrimination in employment against disabled persons.

36.4 Ownership of Documents. Any and all reports, design documents, photographs, surveys and other data and documents provided or created in connection with this Agreement are and shall remain the property of County. In the event of termination of this Agreement, any reports, photographs, surveys and other data and documents prepared by Contractor, whether finished or unfinished, shall become the property of County and shall be delivered by Contractor to the County's Contract Administrator.

36.5 Contractor shall preserve all records, pertinent to this Agreement for the required retention period of the Florida Public Records Act, Chapter 119, Florida Statutes, if applicable, or, if the Florida Public Records Act is not applicable, for a minimum period of three (3) years after expiration of the warranty period of each crane. If any audit has been initiated and audit findings have not been resolved at the end of the retention period or three (3) years, whichever is longer, the records shall be retained until resolution of the audit findings.

36.6 All of Contractor's books, records and accounts, specifically including, but not limited to, lump sum contracts (i.e. fixed-price or stipulated sum contracts) unit price, or cost-plus or time and materials contracts, with or with guaranteed maximum (or not-to-exceed amounts) shall, upon reasonable notice, be open to inspection and subject to audit, scanning, and/or reproduction during normal business working hours. Such audits may be performed by any County representative or any outside representative engaged by County for the purpose of examining and auditing such records. County, or its designee, may conduct such audits or inspections throughout the Term of this Agreement and for a period of three years after expiration of the warranty period of each crane, or longer if required by law. County's representatives may (without limitation) conduct employee level verifications, witnessing the distribution of payroll, verifying information and amounts through interviews and written confirmations with Contractor employees, field and agency labor, subcontractors, and vendors.

Contractor's "records" as referred to herein shall include any and all information, materials and data of every kind and character, including without limitation, records, books, papers, documents, subscriptions, recordings, agreements, purchase orders, leases, contracts, commitments, arrangements, notes, daily diaries, superintendent reports, drawings, receipts, vouchers and memoranda, and any and all other agreements, sources of information and matters that may in County's judgment have any bearing on or pertain to any matters, rights, duties or obligations under or covered by any Contract Document. Such records shall include (hard copy, as well as computer readable data if it can be made available), written policies and procedures; time sheets; payroll registers; payroll records; cancelled payroll checks; subcontract files (including proposals of successful and unsuccessful bidders, bid recaps, negotiation notes, etc.); original bid estimates; estimating work sheets; correspondence; Change Order files (including documentation covering negotiated settlements); backcharge logs and supporting documentation; invoices and related payment documentation; general ledger, information detailing cash and trade discounts earned, insurance rebates and dividends; and any other contractor records which may have a bearing on matters of interest to the County in connection with the Contractor's dealings with the County (all foregoing hereinafter referred to as "records") to the extent necessary to adequately permit evaluation and verification of any or all of the following:

a) Compliance with Contract Documents.
b) Compliance with County's code of ethics.
c) Compliance with Agreement provisions regarding the pricing of change orders.
d) Accuracy of Contractor representations regarding the pricing of invoices.
e) Accuracy of Contractor representations related to claims submitted by the Contractor including subcontractors, or any of its other payees.

County's authorized representative(s) shall have reasonable access to the Contractor's facilities, shall be allowed to interview all current or former employees to discuss matters pertinent to the performance of this Agreement.

County, or its designees, shall have the right to audit, review, examine, inspect, analyze, and make copies of all written, electronic or other form of data, as described herein, in its original or written form, at a location within Broward County, during the Term of this Agreement, or for the document(s) required retention period. Contractor agrees to allow the County, or its designees, access to all of its records, facilities and current or former employees deemed necessary by County. County reserves the right to conduct such audit or review at Contractor's place of business, if necessary, with 72 hours advance notice. Contractor agrees to provide adequate and appropriate work space.

In addition to the normal paperwork documentation the Contractor typically furnishes to the County, in order to facilitate efficient use of County resources when reviewing and/or auditing the Contractor's billings and related reimbursable cost records, the Contractor agrees to furnish (upon request) the following types of information in the specified computer readable file format(s):

Type of Record	File format
Monthly Job Cost Detail	.pdf and Excel
Detailed job Cost History To Date	.pdf and Excel
Monthly Labor Distribution detail (if not already separately detailed in the Job Cost Detail)	.pdf and Excel
Total Job to date Labor Distribution detail (if not already included in the detailed Job Cost History to date)	.pdf and Excel
Employee Timesheets documenting time worked by all individuals who charge reimbursable time to the project	.pdf
Daily Foreman Reports listing names and hours and tasks of personnel who worked on the project	.pdf
Daily Superintendent Reports	.pdf

Detailed Subcontract Status Reports (showing original subcontract value, approved subcontract change orders, subcontractor invoices, payment to subcontractors, etc.	.pdf and Excel
Copies of Executed Subcontracts with all Subcontractors	.pdf
Copies of all executed change orders issued to	.pdf
Copies of all documentation supporting all reimbursable job costs (subcontractor payment applications, vendor invoices, internal cost charges, etc.)	.pdf

36.7 Contractor shall require all payees (examples of payees include subcontractors, material suppliers, insurance carriers, etc.) to comply with the provisions of this article by including the requirements hereof in a written agreement between Contractor and payee. Contractor will ensure that all payees (including those entering into lump sum contracts) have the same right to audit provisions contained in this Agreement.

36.8 Any incomplete or incorrect entry in such books, records, and accounts shall be a basis for County's disallowance and recovery of any payment reliant upon such entry.

36.9 If an audit inspection or examination in accordance with this article, discloses overpricing or overcharges to County (of any nature) by the Contractor and/or the Contractor's subcontractors in excess of five percent (5%) of the total contract billings reviewed, in addition to making adjustments for the overcharges, the reasonable actual cost of the County's audit shall be reimbursed to the County by the Contractor. Any adjustments and/or payments which must be made as a result of any such audit or inspection of the Contractor's invoices and/or records shall be made within a reasonable amount of time (not to exceed 30 days) from presentation of County's findings to Contractor.

36.10 Contractor represents that its execution of this Agreement will not violate Section 287.133, Florida Statutes, the Public Entity Crimes Act, which essentially provides that a person or affiliate who is a contractor, consultant or other provider and who has been placed on the convicted vendor list following a conviction for a Public Entity Crime may not submit a bid on a contract to provide any goods or services to County, may not submit a bid on a contract with County for the construction or repair of a public building or public work, may not submit bids on leases of real property to County, may not be awarded or perform work as a contractor, supplier, subcontractor, or consultant under a contract with County, and may not transact any business with County in excess of the threshold amount provided in Section 287.017, Florida Statutes, for category two purchases for a period of 36 months from the date of being placed on the convicted vendor list.

Violation of this section shall result in termination of this Agreement and recovery of all monies paid hereto, and may result in debarment from County's competitive procurement activities.

In addition to the foregoing, Contractor further represents that there has been no determination, based on an audit, that it committed an act defined by Section 287.133, Florida Statutes, as a "public entity crime" and that it has not been formally charged with committing an act defined as a "public entity crime" regardless of the amount of money involved or whether Contractor has been placed on the convicted vendor list.

36.11 Contractor is an independent contractor under this Agreement. Services provided by Contractor shall be subject to the supervision of Contractor. In providing the services, Contractor or its agents shall not be acting and shall not be deemed as acting as officers, employees or agents of County.

36.12 Neither Contractor nor County intend to directly or substantially benefit a third party by this Agreement. Therefore, the Parties agree that there are no third party beneficiaries to this Agreement and that no third party shall be entitled to assert a claim against either of them based upon this Agreement.

36.13 Whenever either party desires to give notice to the other, such notice must be in writing, sent by certified United States Mail, postage prepaid, return receipt requested, or by hand-delivery with a request for a written receipt of acknowledgment of delivery, addressed to the party for whom it is intended at the place last specified. The place for giving notice shall remain the same as set forth herein until changed in writing in the manner provided in this section. For the present, the Parties designate the following:

FOR BROWARD COUNTY:

Port Everglades Department
Attn: Chief Executive/Port Director
1850 Eller Drive
Fort Lauderdale, Florida 33316

FOR CONTRACTOR:

Alle – Zou Xianhui
3261 Dongfang Road
Shanghai, P.R. China 200125
Phone: +86 13916557464

AND

John M. Milledge, Esquire
200 S.W. First Avenue, Suite 800
Fort Lauderdale, Florida 33301
Phone: (954) 761-8640

36.14 Neither this Agreement nor any interest herein shall be assigned, transferred or encumbered by Contractor without the prior written consent of County.

36.15 Neither Contractor nor its employees shall have or hold any continuing or frequently recurring employment or contractual relationship that is substantially antagonistic or incompatible with Contractor's loyal and conscientious exercise of judgment related to its performance under this Agreement.

Contractor agrees that none of its officers or employees shall, during the term of this Agreement, serve as an expert witness against County in any legal or administrative proceeding in which he or she is not a party, unless compelled by court process, nor shall such persons give sworn testimony or issue a report or writing, as an expression of his or her expert opinion, which is adverse or prejudicial to the interests of County or in connection with any such pending or threatened legal or administrative proceeding. The limitations of this section shall not preclude such persons from representing themselves in any action or in any administrative or legal proceeding.

In the event Contractor is permitted to utilize subcontractors to perform any services required by this Agreement, Contractor agrees to prohibit such subcontractors, by written contract, from having any conflicts as within the meaning of this section.

36.16 Contingency Fee. Contractor warrants that it has not employed or retained any company or person, other than a bona fide employee working solely for Contractor, to solicit or secure this Agreement and that it has not paid or agreed to pay any person, company, corporation, individual or firm, other than a bona fide employee working solely for Contractor, any fee, commission, percentage, gift or other consideration contingent upon or resulting from the award or making of this Agreement. For a breach or violation of this provision, County shall have the right to terminate this Agreement without liability at its discretion, or to deduct from the Contract price or otherwise recover the full amount of such fee, commission, percentage, gift or consideration.

36.17 Failure by County to enforce any provision of this Agreement shall not be deemed a waiver of such provision or modification of this Agreement. No waiver shall be effective unless it is in writing and signed by the party against whom it is asserted. A waiver of any provision of this Agreement or failure to perform any of the terms, covenants, and conditions of this Agreement shall not be deemed a waiver of any prior or subsequent failure to perform any term, covenant or condition of this Agreement and shall not be construed to be a modification of the terms of this Agreement. County and Contractor agree that each requirement, duty and obligation set forth herein is substantial and important to the formation of this Agreement and, therefore, is a material term hereof.

36.18 Contractor shall comply with all federal, state and local laws, codes, ordinances, rules and regulations in the United States, and any other entity having jurisdiction over the Project, in performing its duties, responsibilities and obligations related to this Agreement.

36.19 In the event this Agreement or a portion of this Agreement is found by a court of competent jurisdiction to be invalid, the remaining provisions shall continue to be effective unless County or Contractor elects to terminate this Agreement. The election to terminate this Agreement based upon this provision shall be made within seven (7) days after the finding by the court becomes final.

36.20 County and Contractor acknowledge that they have sought and received whatever competent advice and counsel as was necessary for them to form a full and complete understanding of all rights and obligations under this Agreement, and the preparation of this Agreement has been a joint effort of County and Contractor and the resulting document shall not, solely as a matter of judicial construction, be construed more severely against one of the Parties than any other.

36.21 If there is a conflict or inconsistency between any term, statement, requirement, or provision of any exhibit attached hereto, any document or events referred to herein, or any document incorporated into this Agreement by reference and a term, statement, requirement, or provision of this Agreement, the term, statement, requirement, or provision contained in Articles 1 through 36 of this Agreement shall prevail and be given effect. Where there is a conflict between any provision set forth within this Agreement and a more stringent state or federal provision, which is applicable to any services performed under this Agreement, the more stringent state or federal provision shall prevail.

36.22 This Agreement shall be interpreted and construed in accordance with and governed by the laws of the state of Florida. All Parties agree and accept that jurisdiction of any controversies or legal problems arising out of this Agreement, and any action involving the enforcement or interpretation of any rights hereunder, shall be exclusively in the state courts of the Seventeenth Judicial Circuit in Broward County, Florida, and venue for litigation arising out of this Agreement shall be exclusively in such state courts, forsaking any other jurisdiction which either party may claim by virtue of its residency or other jurisdictional device. **BY ENTERING INTO THIS AGREEMENT, CONTRACTOR AND COUNTY HEREBY EXPRESSLY WAIVE ANY RIGHTS EITHER PARTY MAY HAVE TO A TRIAL**

BY JURY OF ANY CIVIL LITIGATION RELATED TO THIS AGREEMENT. IF A PARTY FAILS TO WITHDRAW A REQUEST FOR A JURY TRIAL IN A LAWSUIT ARISING OUT OF THIS AGREEMENT AFTER WRITTEN NOTICE BY THE OTHER PARTY OF VIOLATION OF THIS SECTION, THE PARTY MAKING THE REQUEST FOR JURY TRIAL SHALL BE LIABLE FOR THE REASONABLE ATTORNEYS' FEES AND COSTS OF THE OTHER PARTY IN CONTESTING THE REQUEST FOR JURY TRIAL, AND SUCH AMOUNTS SHALL BE AWARDED BY THE COURT IN ADJUDICATING THE MOTION.

36.23 No modification, amendment or alteration in the terms and conditions of this Agreement shall be effective unless contained in a written document prepared with the same or similar formality as this Agreement and executed by County and Contractor in accordance with the provisions of County's Procurement Code as may be amended from time to time. Contractor agrees that no representations or warranties shall be binding upon County unless expressed in writing herein.

36.24 This document incorporates and includes all prior negotiations, correspondence, conversations, agreements and understandings applicable to the matters contained herein and the Parties agree that there are no commitments, agreements or understandings concerning the subject matter of this Agreement that are not contained in this document. Accordingly, the Parties agree that no deviation from the terms hereof shall be predicated upon any prior representations or agreements, whether oral or written.

36.25 The truth and accuracy of each "Whereas" clause set forth herein is acknowledged by the Parties. The attached Exhibits and Forms are incorporated into and made a part of this Agreement.

36.26 This Agreement may be executed in five or more counterparts, each of which shall be deemed to be an original.

36.27 All terms and words used in this Agreement, despite the number and gender in which used, shall be deemed to include any other gender or number as the context or the use thereof may require. Terms such as "herein," "hereof," "hereunder," and "hereinafter" refer to this Agreement as a whole and not to any particular sentence, paragraph or section where they appear, unless the context otherwise requires. Whenever reference is made to a section of this Agreement, such reference is to the section as a whole, including all of the subsections and subparagraphs of such section unless the reference is made to a particular subsection or subparagraph of such section.

36.28 Captions and headings contained in this Agreement are for convenience and reference only and in no way define, describe, extend or limit the scope or intent of this Agreement, nor the intent of any provisions hereof.

36.29 This Agreement and the rights and obligations contained herein shall inure to the benefit of and be binding upon the Parties hereto and their respective successors and assigns, where otherwise permitted by this Agreement.

36.30 Any rights either party may have in the event it terminates this Agreement pursuant to the terms hereof shall survive such termination.

36.31 Contractor and County agree to execute, acknowledge, deliver and cause to be done, executed, acknowledged and delivered all such further documents and perform such acts as shall reasonably be requested of it to carry out this Agreement and give effect hereto. Accordingly, without in any manner limiting the specific rights and obligations set forth in this Agreement, the Parties declare their intention to cooperate with each other in effecting the terms and conditions of this Agreement.

36.32 For the purposes herein, the Parties agree that representations and warranties solely made herein are all material and of the essence of this Agreement.

36.33 Contractor hereby waives any claim against County, and its agents, servants and employees for loss of anticipated profits caused by any suit or proceedings directly or indirectly attacking the validity of this Agreement or any part thereof, or by any judgment of award in any suit or proceeding declaring this Agreement null, void or voidable, delaying the same or any part thereof, from being carried out.

36.34 All rights and remedies of County hereunder or at law or in equity are cumulative and shall be in addition to any other rights and remedies available. The exercise of any right or remedy shall not be taken to exclude or waive the right to the exercise of any other. Failure by County to promptly exercise any of its rights shall not operate to forfeit or be treated as a waiver of any such rights.

36.35 It is a requirement of County that it enter into contracts only with firms that certify the establishment of a drug free work place in accordance with Chapter 21.31(a) of the Broward County Procurement Code. Execution of this Agreement by Contractor shall also serve as Contractor's required certification that it either has or that it will establish a drug free work place in accordance with Chapter 21.31(a) of the Broward County Procurement Code.

36.36 It is expressly understood and agreed that if Contractor is not a resident of the state of Florida, or is an association or partnership without a member or general partner resident of said State, or is a foreign corporation, then in any such event Contractor does designate the Secretary of State, state of Florida, its agent for the purpose of service of process in any court action between it and County arising out of or based upon this Agreement, and the service shall be made as provided by the laws of the state of Florida for service upon a nonresident, who has designated the Secretary of State as his agent for service. It is further expressly agreed, covenanted and stipulated that, if for any reason, service of such process is not possible, and as an alternative method of service of process, Contractor may be personally served with such process out of this State by certified mailing to Contractor at the address set forth herein. Any such service out of this State shall constitute valid service upon Contractor as of the date of mailing. It is further expressly agreed that Contractor is amenable to and hereby agrees to the process so served, submits to the jurisdiction, and waives any and all objections and protest thereto. County agrees, that in addition to service on the Secretary of State or as otherwise provided above, it shall, within two (2) business days after filing any complaint or petition for judicial relief, provide a copy of such complaint or such petition for judicial relief to Contractor, by overnight delivery to the address set forth herein, in order to complete service of process.

36.37 Contractor agrees that in addition to all other remedies, its obligations contained herein shall be subject to the remedy of specific performance by appropriate action commenced in a court of proper jurisdiction.

36.38 Neither County nor Contractor shall be considered to be in default of this Agreement if delays in or failure of performance shall be due to Uncontrollable Forces, the effect of which, by the exercise of reasonable diligence, the nonperforming party could not avoid. The term "Uncontrollable Forces" shall mean any event, which results in the prevention or delay of performance by a party of its obligations under this Agreement and which is beyond the reasonable control of the nonperforming party. It includes, but is not limited to, fire, earthquakes, hurricanes, tornadoes, storms, lightning, epidemic, war, riot, civil disturbance, sabotage and governmental actions. Any delay caused by an Uncontrollable Force shall not be recognized unless Contractor shall notify County in writing within ten (10) calendar days after the Uncontrollable Force event. Neither economic impracticability nor inability of Contractor to perform in whole or in part for economic reasons shall constitute an Uncontrollable Forces event.

36.39 The individuals executing this Agreement on behalf of Contractor personally warrant that they have full Authority to execute this Agreement on behalf of entity for whom they are acting herein.

36.40 The Parties acknowledge and agree that County is purchasing, and Contractor is bound to construct, transport, erect, test, commission and warranty fully operational and Contractor certified gantry cranes. All the Work, shall be performed in accordance with the terms and conditions of this Agreement, and comply with all applicable laws and technical codes in effect at the time of the issuance by County of each second Notice to Proceed. Contractor shall be responsible for obtaining all required regulatory body inspections and certifications necessary for the commercial use of each crane in Port Everglades, Florida. Contractor shall keep itself fully informed of, and shall take into account and comply at its sole expense with, all applicable federal, state and local laws, rules, regulations and codes applicable to the Project, or the materials used or employed in the Project, or in any way affecting the conduct of the Project, and of all such orders and decrees of bodies or tribunals having any jurisdiction or authority over the same and of all provisions required by law to be made a part of this Agreement, all of which provisions are hereby incorporated by reference herein and made a part hereof. If any specification or contract for this Project is in violation of any such law, ordinance, regulation, order or decree, Contractor shall forthwith report the same to the County's Contract Administrator in writing. Contractor shall cause all its agents, employees, Subcontractors and consultants to observe and comply with all applicable laws, ordinances, regulations, orders and decrees.

36.41 Contractor shall be responsible for obtaining all permits and governmental approvals including, but not limited to, permits related to Contractor's performance of the Work on the navigable waters in and around Port Everglades and Federal Aviation Administration permits, required for the use of tall stick cranes during the erection of the cranes and for the actual use of the cranes once they are commissioned. Contractor shall provide, upon request of County's Contract Administrator, written evidence that all permits and governmental approvals have been obtained. Contractor has been made aware of the close proximity of the Site to the Fort Lauderdale/Hollywood International Airport runway approaches. Contractor shall be responsible, at its sole cost and expense, for providing all required notices to the Federal Aviation Administration ("FAA"), including, but not limited to, Form 7460-2 and shall, at all times, comply with all applicable FAA regulations as may be amended.

36.42 Contractor shall at all times enforce strict discipline and good order among its employees, consultants and Subcontractors at the Site and shall not employ on the Project any unfit person or anyone not skilled in the Work assigned to him or her. Work shall be performed in a thorough manner and shall follow the best modern practice in accordance with generally accepted industry standards. Work shall be performed by workers suitably skilled in their particular trades.

36.43 Contractor shall furnish labor that can work in harmony with all other elements of labor employed or to be employed in connection with the services to be rendered hereunder. Without limiting the generality of the foregoing, "harmony" shall include the provision of labor that will not cause, cause to be threatened, engage in, or give rise to, either directly or indirectly, any Work disruption, slowdown, or stoppage, or any violence or harm to any person or property while performing any Work, or activities incidental thereto, including, but not limited to:

(a) traveling to and from the Site; and

(b) loading, transporting and off-loading of equipment and materials on County-furnished facilities; and

(c) delivery, receipt and unloading of materials or equipment at any designated storage area or Site; and

(d) the performing of Work at the Site; and

(e) any nonworking time associated with the above while employees are on the Site or other County-owned facility (e.g., lunch hours, breaks, etc.).

Contractor agrees that it shall require every subcontractor and subconsultant to provide labor that can provide services in harmony with all other elements of labor employed or to be employed in the Work, and will include the provision contained hereinabove in every subcontract let for Work under this Agreement.

The requirement to provide labor that can work in harmony with all other elements of labor employed, or to be employed in the Work is a material element of this Agreement. Failure by Contractor or any of its Subcontractors or subconsultants to comply with this requirement shall be deemed a material breach of this Agreement, which will subject Contractor to all rights and remedies the County may have, including, without limitation, the right to terminate this Agreement.

36.44 Where required by Florida Executive Order, Contractor agrees to utilize the U.S. Department of Homeland Security's E-Verify system, https://e-verify.uscis.gov/emp, to verify the employment eligibility of: (a) all persons employed by Contractor to perform employment duties within United States (Florida); and (b) all persons (including subcontractors) assigned by Contractor to perform Work within United States (Florida) pursuant to this Agreement with Form 10, Employment Eligibility Verification Program Contractor Certification, attached hereto.

36.45 The payment of any compensation, regardless of its character or form, or the giving of any gratuity or gift or the granting of any favor by Contractor to any County employee, Consultant and/or County's authorized representative is forbidden, and any such act on the part of Contractor, shall constitute a noncurable breach of this Agreement and cause for termination by County.

36.46 Contractor shall be required to comply with all applicable written County's Port Everglades Department policy statements and directives ("Port Everglades Security Program") and all applicable federal, state and local legal requirements, including, without limitation, the following:

a) Contractor shall be responsible for compliance with federal, state and local laws, rules and regulations, and such laws and regulations as may be imposed from time to time by the U.S. Coast Guard, U.S. Customs and Border Protection, Broward Sheriff's Office or other federal or state or local agencies, and by County, with respect to seaport security, immigration, drug interdiction and other import and export controls. Furthermore, Contractor, at its sole cost, shall be responsible for complying with all applicable federal, state and local security-related measures required for the Project. Contractor shall cause its employees, representatives, business invitees, subcontractors, subconsultants and guests, to comply with the requirements of this section, including, but not limited to, all requirements for the Federal Transportation Worker Identification Credential ("TWIC").

b) If as a result of the acts or omissions of Contractor, its subcontractors, subconsultants, agents, employees, business invitees or guests, County incurs any fines and/or penalties imposed or any expense in enforcing the Port Everglades Security Program and/or any fines or penalties imposed or any expense in enforcing the rules and regulations of other applicable security agencies, then Contractor agrees to pay and/or reimburse to County all such fines, penalties, costs and expenses, including all costs of administrative proceedings, court costs and attorneys' fees and all costs incurred by County in enforcing this provision. Said costs and expenses, fines and penalties, shall not constitute Cost of the Work. Contractor further agrees to rectify any security deficiency caused by Contractor, its subconsultants, subcontractors, agents, employees, business invitees or guests, or other deficiency as may be determined as such by the County's Contract Administrator. In the event Contractor fails to remedy any such deficiency, County may do so at the cost and expense of Contractor. County reserves the right to take whatever action is necessary to rectify any such security deficiency or other deficiency. The provisions hereof shall survive the expiration or any other termination of this Agreement. Contractor shall include this provision in its contracts with its subconsultants and subcontractors.

c) Consent to Search/Inspection: Contractor agrees that all persons and vehicles, cargo, goods and other personal property used in connection with the Project are subject to being inspected and searched when attempting to enter or leave Port Everglades ("Port"). Contractor acknowledges and understands that the foregoing requirements are for the protection of users of the seaport and are intended to reduce incidents of cargo tampering, thefts and other unlawful activities at the Port. For this reason, Contractor agrees that persons not consenting-to-search/inspection shall not be employed by Contractor or Contractor's subcontractor(s) or subconsultants for the Project in any position requiring access to the Port.

36.47 Any requirements for a Project sign shall be as set forth within the Specifications section.

36.48 During such periods of time as are designated by the United States National Weather Service as being a tropical storm or hurricane watch or warning, Contractor, at no cost to the County, shall take all precautions necessary to secure the Site in response to all threatened storm events, regardless of whether the County or Consultant has given notice of same.

36.49 Contractor's compliance with any specific tropical storm or hurricane watch or warning precautions will not constitute additional services.

36.50 Suspension of the Work caused by a threatened or actual storm event, regardless of whether the County has directed such suspension, will entitle Contractor to additional time as noncompensable, excusable delay, and shall not give rise to a claim for compensable delay.

36.51 Contractor certifies and represents that it will comply with County's Domestic Partnership Act (Section 16½-157 of the Broward County Code of Ordinances, as amended) for work performed in the United States over the term of this Agreement. The failure of Contractor to comply shall be a material breach of this Agreement, entitling County to pursue any and all remedies provided under applicable law including, but not limited to: (1) retaining all monies due or to become due Contractor until Contractor complies; (2) termination of this Agreement; and (3) suspension or debarment of Contractor from doing business with County.

36.52 County may select and contract for the services of a language translator if, in its sole discretion, County determines that said services are necessary to properly communicate with Contractor. Contractor shall be responsible for all costs incurred by the County for translation services. Statements for these costs will be forwarded to Contractor who will promptly pay same.

36.53 Contractor shall furnish telescopic spreaders for the crane(s) which shall be Model Model STS45 with SCS and Height Indication System by Bromma, no equivalent.

36.54 Contractor shall be responsible for interfacing the telescopic spreaders with the crane(s), and for performing all tests with the spreaders affixed to the crane(s). The spreader manufacturer shall be responsible for warranty of the spreaders, but Contractor shall remain wholly responsible for interfacing the spreaders structurally, mechanically and electrically with the crane(s).

36.55 All equipment provided for each crane shall be designed and manufactured so that all like components are interchangeable between all cranes purchased by County.

36.56 Spreaders will be delivered to the Site at Port Everglades by Contractor for final assembly and final testing of the crane(s).

36.57 Contractor will supply a cargo beam for each crane in the base crane order, which shall be equipped with a control, full capacity, swivel cargo hook and two half capacity cargo hooks. The cargo hook shall stand upright to permit the headblock to attach without the requirement of additional support to the cargo beam and shall have a capacity of 100 long tons minimum for full range of trolley travel (see technical specifications 2.6.2).

36.58 Four sets of operating, maintenance and spare parts manuals (the "Manuals") shall be provided with the delivery of each crane. The Manuals shall provide a complete description of the operation of the various crane components and recommended procedures for preventive maintenance. The Manuals shall also be supplied to County's Contract Administrator in a digital PDF copy.

36.59 A preliminary copy of the Manuals shall be submitted to Consultant for review at least three (3) months before the Final Completion Date of each crane. Consultant's opinion shall govern with respect to adequacy and completeness of the Manuals. Contractor shall resubmit a preliminary manual until accepted by the Consultant. The Manuals shall be indexed and shall be bound in book form.

36.60 At Fabrication and Assembly Facilities. As evidence of the fabrication Work completed, Contractor shall provide County's Contract Administrator and Consultant with color photographs of all crane components, which are completed. The photographs shall be 3" x 5" and clearly marked to identify the subject matter. These photographs may be taken into account by County's Contract Administrator in evaluating the monthly progress payments submitted by the Contractor. Contractor shall also, upon request, furnish photographs of the Work in progress at the Fabrication Facility(ies) and at the Assembly Facility(ies).

36.61 At the Site. As evidence of the erection Work completed, Contractor shall provide County's Contract Administrator and Consultant with color photographs of the Work at the Site. Photographs shall be 8" x 10" and shall be taken from each side of the cranes. Insofar as possible, the progress photographs shall be taken from the same location each time. Six (6) photographs shall be taken each month. Three (3) on the first and three (3) on the fifteenth of each month. County's Contract Administrator and Consultant shall be furnished with a JPEG digital copy. The following information shall be typed in the lower right hand corner of each photograph and shall show on the print: (1) crane number; (2) location; (3) brief description of picture; and (4) date picture taken. If cranes are erected at a location away from Site all such photographs shall be sent to County's Contract Administrator and Consultant by quickest air route.

36.62 Completed cranes. Six (6) photographs from points designated by County's Contract Administrator shall be taken at the completion of the Work on each crane. Photographs shall also be provided in digital JPEG copy. Two (2) 8" x 10" prints of each shall be delivered to County's Contract Administrator and Consultant. Photographs shall also be provided in digital JPEG copy.

36.63 County is a public agency subject to Chapter 119, Florida Statutes. As required by Chapter 119, Florida Statutes, Contractor and all its subconsultants and subcontractors shall comply with Florida's Public Records Law. To the extent Contractor is a contractor acting on behalf of the County pursuant to Section 119.0701, Florida Statutes, Contractor and its subconsultants and subcontractors shall:

(a) Keep and maintain public records that ordinarily and necessarily would be required by County in order to perform the service;

(b) Provide the public with access to such public records on the same terms and conditions that County would provide the records and at a cost that does not exceed that provided in Chapter 119, Florida Statutes, or as otherwise provided by law;

(c) Ensure that public records that are exempt or that are confidential and exempt from public record requirements are not disclosed except as authorized by law; and

(d) Meet all requirements for retaining public records and transfer to County, at no cost, all public records in its possession upon termination of the applicable contract and destroy any duplicate public records that are exempt or confidential and exempt. All records stored electronically must be provided to County in a format that is compatible with the information technology systems of County.

(e) The failure of Contractor to comply with the provisions set forth in this section shall constitute a default and breach of this Agreement, and County shall enforce the default in accordance with the provisions set forth above.

36.64 Any monies not paid by County when claimed to be due to Contractor under this Contract, including, but not limited to, any and all claims for contract damages of any type, shall not be subject to interest including, but not limited to prejudgment interest. However, the provisions of County's prompt payment ordinance, as such relates to timeliness of payment, and the provisions of Section 218.74(4), Florida

Statutes, as such relates to the payment of interest shall apply to valid and proper invoices.

36.65 EEO Compliance:

(a) No Party to this Agreement may discriminate on the basis of race, color, sex, religion, national origin, disability, age, marital status, political affiliation, sexual orientation, pregnancy, or gender identity and expression in the performance of this Agreement. Contractor shall include the foregoing or similar language in its contracts with any Subcontractors, except that any project assisted by the U.S. Department of Transportation funds shall comply with the nondiscrimination requirements in 49 CFR Parts 23 and 26. Failure by Contractor to carry out any of the requirements of this section shall constitute a material breach of this Agreement, which shall permit the County to terminate this Agreement or to exercise any other remedy provided under this Agreement, or under applicable law, with all of such remedies being cumulative.

(b) Contractor shall affirmatively comply with all applicable provisions of the Americans with Disabilities Act (ADA) in the course of providing any services funded by County, including Titles I and II of the ADA (regarding nondiscrimination on the basis of disability) and all applicable regulations, guidelines, and standards. In addition, Contractor shall take affirmative steps to ensure nondiscrimination in employment against disabled persons.

(c) By execution of this Agreement, Contractor represents that it has not been placed on the discriminatory vendor list as provided in Section 287.134, Florida Statutes. County hereby materially relies on such representation in entering into this Agreement. An untrue representation of the foregoing shall entitle County to terminate this Agreement and recover from Contractor all monies paid by County pursuant to this Agreement, and may result in debarment from County's competitive procurement activities.

36.66 Small Business Participation Compliance:

(a) This Project must comply with 49 CFR Part 26 and all applicable United States Department of Transportation rules and regulations.

(b) In accordance with Title 49 CFR Part 26.39 and the Broward County Disadvantaged Business Enterprise Program Plan, this Project has an element of fostering Small Business Participation.

Small businesses must meet the definitions specified in Section 3 of the Small Business Act and the Small Business Administration regulations

(Title 13 CFR Part 121). A small business is a business that is independently owned and operated, is organized for profit, and is not dominant in its field, as determined by the County's Office of Economic and Small Business Development ("OESBD"). Depending on the industry, size standard eligibility is based on the average number of employees for the preceding twelve months or on sales volume averaged over a three-year (3) period.

The small business program under 49 CFR 26.39 has no geographic restrictions. Certified Disadvantaged Business Enterprises (DBEs) are considered small businesses under the program.

(c) Contract Assurances. The following clauses pertaining to compliance with 49 CFR Part 26 shall become a part of this Contract upon award and shall be incorporated into the terms of Contractor's solicitations, subcontracts, material supply contracts and purchase orders. In the event the following clauses conflict with any other terms or provisions of these Contract Documents, the clauses set forth in this section shall control.

(d) Contractor has agreed to commit to fostering Small Business Participation at the U.S. Department of Transportation overall 9.91% race-neutral Disadvantaged Business Enterprise (DBE) Program goal ("Commitment"). Contractor agrees to use its best efforts to meet the Commitment, including specifying elements of the Work in the Scope of Services, as may be amended, which are of a size and nature that small businesses, including DBEs, can reasonably perform throughout the multiple phases of the Project. Contractor agrees to use its best efforts to provide for such subcontracting opportunities and shall not purposefully self-perform all of the Work involved in the Project. Contractor's efforts under this subsection shall include the encouragement of subcontracts with consortia or joint ventures that include or consist of small businesses, including DBE's.

(e) Contractor shall be responsible for ensuring proper documentation with regard to its utilization and payment of small businesses.

(f) Contractor agrees to submit Monthly (DBE) Utilization, attached hereto as Form 7, reports to OESBD and the Contract Administrator on small business participation, which shall contain a record of payments made to small businesses. The monthly reports shall be submitted in a format acceptable to OESBD.

(g) Nondiscrimination – Contractor, sub recipient, or Subcontractor(s) shall not discriminate on the basis of race, color, national origin, or sex in the performance of this Contract. Contractor shall carry out applicable requirements of 49 CFR Part 26 in the award and administration of USDOT-assisted contracts. Failure by Contractor to carry out these requirements is a material breach of this Contract, which may result in the termination of this Contract or such other remedy as the County deems appropriate.

(h) Prompt Payment – Contractor hereby agrees to pay all Subcontractor(s) and suppliers within ten (10) calendar days following receipt of payment from the County for work satisfactorily completed by the Subcontractors that is not disputed by the Contractor. Contractor further agrees, if Contractor has withheld retainage from its Subcontractor(s), to release such retainage upon satisfactory completion of all work to be performed by Subcontractor(s). All retainage held for such completed work shall be paid by the Contractor to such Subcontractor(s) within thirty (30) calendar days of the date work was satisfactorily completed, and pay same within ten (10) calendar days following receipt of payment of retained amounts from the County. A finding of nonpayment to Subcontractor(s) and suppliers is a material breach of this Contract.

36.67 Federally Funded Contract:

Contractor certifies and represents by its execution of this Agreement, that it will (in its capacity as County's Managing General Contractor) comply with all Federal loan, grant, and contract document logging, reporting, and record keeping requirements (as applicable) related to this Project, and all applicable federal and state laws.

[REMAINDER OF PAGE INTENTIONALLY LEFT BLANK]

IN WITNESS WHEREOF, the Parties have made and executed this Agreement on the respective dates under each signature: BROWARD COUNTY through its BOARD OF COUNTY COMMISSIONERS, signing by and through its Mayor or Vice-Mayor authorized to execute same by Board action on the ___ day of _______________, 20__, and SHANGHAI ZHENHU HEAVY INDUSTRIES CO., LTD. INC. a/k/a ZMPC, signing by and through its ___________________, duly authorized to execute same.

ATTEST:

____
Broward County Administrator, as
Ex-officio Clerk of the Broward County
Board of County Commissioners

BROWARD COUNTY, by and through
its Board of County Commissioners

By ______________________________
Mayor

_____ day of ______________, 20__

Insurance requirements
approved by Broward County
Risk Management Division

By_______________________ 5.22.17
Signature (Date)

CARLOS DE LA GUERRA
RISK MANAGEMENT & CONT
BUSINESS ADMINISTRATION DIVISION
PORT EVERGLADES

____
Print Name and Title above

Approved as to form by
Joni Armstrong Coffey
Broward County Attorney
Port Everglades Department
1850 Eller Drive, Suite 502
Fort Lauderdale, Florida 33316
Telephone: (954) 523-3404
Telecopier: (954) 468-3690

By _______________________ 5/22/17
Russell J. Morrison (Date)
Senior Assistant County Attorney

RJM/dh/cr
05/01/17
Shanghai_FINAL
17-3005.01

AGREEMENT BETWEEN BROWARD COUNTY AND SHANGHAI ZHENHUA HEAVY INDUSTRIES CO., LTD. INC. a/k/a ZPMC,

CONTRACTOR:

ATTEST:

Corporate Secretary

Wang Jue.

Print Name

By

President or Vice President

LIU, QIZHONG

Print Name

12 day of May, 2017

(CORPORATE SEAL)

ZHENHUA HEAVY INDUSTRIES CO., LTD. 上海振华重工（集团）股份有限公司 SHANGHAI

PORT EVERGLADES
BROWARD COUNTY, FL

TECHNICAL SPECIFICATIONS

LOW PROFILE 22-WIDE SHIP-TO-SHORE

RAIL MOUNTED
CONTAINER HANDLING GANTRY CRANES

May 19, 2016

REVISION [2] MARCH 29, 2017—REVISION [1] AUGUST 12, 2016

PAGE I	OPTION CRANES REWRITE
PAGE IV	DELETE ITEM
PAGE V	CHANGE DEMAG TO KONE
SECT 1.1	REPLACE TEXT
SECT 1.2	REPLACE TEXT
SECT 5.11	REPLACE TEXT
SECT 8.5	REPLACE TEXT

PROJECT SUMMARY

TECHNICAL SPECIFICATIONS
LOW PROFILE 22-WIDE SHIP-TO-SHORE RAIL MOUNTED
CONTAINER HANDLING GANTRY CRANES
for
BROWARD COUNTY
Port Everglades, Broward County, Florida

OWNER

Broward County.

PROJECT SUMMARY

The Project Summary is provided for project overview. The Technical Provisions take precedence over the Project Summary.

The Cranes will interface with existing Samsung cranes. The crane rails for the Samsung cranes are offset from the rails for new cranes.

ENGINEER

Liftech Consultants Inc., Oakland, CA, USA

PROJECT

Location	Berths 30–32 at Port of Everglades, Broward County, FL
Base Order	
Cranes	Three (3) low profile cranes for Berths 31–32
Spreaders	Five (5) 20/40/45’, separating twin-twenty, telescoping, with actuated corner flippers (one spreader for each crane and two spare spreaders)
Over-height adapters	Three (3)
Cargo Beams	Three (3)
Option Cranes	*Two or three additional cranes with headblocks and spreaders for Berth 30 with spare parts as for base order* [0]
	~~*One additional crane with headblock and spreader for Berth 30*~~
Boom	Lattice shuttle boom: rope-towed
Trolley	Rope-towed, main hoist fleet-through trolley
Maintenance	Crane maintenance during warranty period

CAPACITY

Under spreader — See "Lifted Load" (LL) and "Rated Load" (RL) in the Specifications

65 LT twin-20'

50 LT single 20', 40', or 45' container

Under cargo beam — See "Cargo Beam Rated Load" (CBRL) in the Specifications

100 LT under cargo beam at restricted backreach and outreach, only to not govern stability or exceed allowable wheel loads

75 LT, minimum, for full range of trolley travel

GEOMETRY

Item	ft	(m)
Rail gauge	120.0	(36.58)
Setback of WS rail from face of wharf	19.0	(5.79)
Outreach from waterside rail	205.0	(62.5)
Backreach from landside rail	35.0	(10.67)
Lift above rails	133.0	(40.5)
Total lift	193.0	(58.8)
Maximum boom width	30.0	(9.15)
Clear height under portal tie beam	50.0	(15.24)
Clear horizontal distance between legs	60.0	(18.29)
Out-to-out gantry bumpers, maximum (compressed)	86.5	(26.4)
Approximate height to top of sill beam	20.0	(6.1)
Waterside rail set back from face of fender	24.0	(7.3)
Maximum crane height above rail*	175.0	(53.35)
Boom projection beyond waterside rail, boom retracted	13.0	(4.0)
Landside rail elevation higher than waterside rail by	0.0	(0.0)

** Aircraft clearance line is 175 ft maximum elevation above crane rail from the wharf face to 120 ft landside, and then reduces at a 1:40 slope.*

Refer also to the Drawings for crane-ship clearance diagrams

SPEEDS

Main Hoist:	ft/min	(m/min)
Hoisting or lowering with rated load	295	(90)
Hoisting or lowering with spreader only	591	(180)
Hoisting or lowering with cargo beam load	148	(45)
Trolley, against 50% WLO, with rated load	804	(245)
Gantry, against 50% WLO, with rated load	150	(46)
Against 100% WLO, with rated load	118	(36)
Boom shuttle time – full outreach to fully retracted	3 minutes	

ACCELERATION AND DECELERATION TIMES

		Accel seconds	Decel seconds
Main Hoist			
	Hoisting with rated load	2.0	1.5
	Lowering with rated load	1.5	1.5
	Hoisting or lowering with empty spreader	3.0	3.0
	Hoisting or lowering with cargo beam	6.0	6.0
Trolley	With rated load, against 50% WLO	5.0	5.0
Gantry	With rated Load, against 50% WLO	5.0	5.0
	With rated Load, against 100% WLO	10.0	10.0

ELECTRICS

Main power supply	13.2 kV, three phase AC, 60 Hz power supply
Drives	TMEIC all AC electrical system Integration of drive systems and start-up by TMEIC
Cable reel feed	670 m (2,200 ft) cable on reel; fiber optics in cable
Components	All components with UL listings
CMS	CMS with power line monitor with recording device and software
RCMS	Two RCMS stations in maintenance building through fiber optic; RCMS shall be compatible with existing RCMS with line monitoring and software upgrades
Power factor correction	Using IGBT technology
Harmonic filter	On all drive outputs

Back-up diesel electric power system on portal beam sized for emergency drives plus auxiliary power

MAIN HOIST REEVING

Four-fall system with electronic anti-sway

Mechanical trim ±3°, List ±3°, Skew ±3° with auto zero

Snag protection in main machinery house

Slack rope detection

OTHER FEATURES

Fixed main machinery house mounted on frame, above the boom—with machinery for main hoist and boom drive

Trolley drive machinery house mounted in boom

Gantry equalizer system: non-articulating, eight wheels per corner

Crane securing to wharf with tie-downs and stowage pins

Electronic Anti-Sway

Semi-automated operation: lane selection, row and tier selection (±1), ship profiling with cycle optimizations

TMEIC Maxview Smart Landing System

Dedicated emergency drives for hoist, boom and trolley driven through clutch connections

Hardware and software to integrate Cranes with existing TMEIC-Gotting transponder based crane position and crane-to-crane anti-collision system, including boom protection for corner area between berths 30–31, slight angle between Berths 32–33, and protection against existing cranes on different crane rails

Crane-to-ship and independent crane-to-crane anti-collision systems

Anti-rack system to maintain crane landside and waterside frame alignment

Gantry control to limit structural deflections in the gantry travel direction; see Section 3.14.6.2

Emergency drum brakes for boom shuttle drum

Ground level maintenance cab with CMS under landside sill beam

Ground level operating panel under landside sill beam

Boom operating station at waterside at boom level

Rope rereeving device for each rope reeving system in its respective machinery house

Machinery house (main and boom hoist) to dock waste lube oil handling system

Air compressors in main machinery house and trolley machinery house

Work bench in main machinery house

Gantry wheel brakes for all idler wheels with accumulators for high speed release for maximum gantry braking safety

~~Spreader and head block storage rack on top of waterside sill beam~~ [1]

Installing gantry bumpers and support brackets on existing cranes 4 and 5

Crane model, 1:72 scale

ACCEPTABLE SUPPLIERS

The acceptable suppliers shall be as follows:

Control system and electrical ....TMEIC
Electric motors ....Wolfer
Gear boxes and gearing ....Falk
Air compressor ....Ingersoll-Rand
Air conditioners...Trane
Anemometer ....Gill WindObserver IS
Bearings and seals ....SKF, FAG, Timken
Secondary bearings and seals, where approved......SKF, FAG, Timken, Koyo, Sealmaster, Rexnord
Brakes, high-speed, including discs ....Pintsch-Bubenzer
Brakes, gantry motor ....Pintsch-Bubenzer, adjustable torque
Brakes, non-driven gantry wheel(B) ....Pintsch-Bubenzer
Bumpers ....Oleo, with marine plating
Cable reel, gantry ....Cavotec pull and store
Cable reel, spreader ....Cavotec
CCTV Cameras ....Orlaco
Couplings, with brake disc ....by brake supplier
Couplings, drum ....Malmedie
Diesel auxiliary generator set ....Cummins / ONAN, EPA Tier 4F
Electric cable, gantry with 12 fibers......................Prysmian
Electric cable, spreader..Prysmian
Elevator ....Alimak
Encoders ....Huebner Gissen
Energy chain: trolley and boom systems ....IGUS
Hydraulic components...Rexroth, Parker, available in the U.S.

Hydraulic cylinders ....Rexroth, Parker, Hydropa available in the U.S.
Hydraulic power units, for brakes ....by brake supplier
Intercom ....Comtrol International
Fuses..Ferraz Shawmut, Bussmann, GE
Laser (anti-collision system) ....SICK
Lighting, floodlights..Phoenix
Lighting, aviation lights...Phoenix
Limit switches, magnetic..Schmersal
Limit switches, proximity.......................................Schmersal
Limit switches, mechanical ....GE, Omron
Limit switches, rotary cam ....GE
Load cells ....Brosa
Lubricants...Mobil
Master Switches ....Brieda Dynamic
Operator's cabin and consoles................................Brieda Dynamic
Paint...Hempel, International
Service cranes, powered ....~~Demag~~ KoneCranes [2]
Spreader cable plugs and sockets ....Pyle-National
Spreader..Bromma STS45 with SCS and Height Indication System
Spreader over-height adaptor.................................Bromma
Spreader cable shock-absorbing device ....Cavotec S06-S1227-500 bollard type damper with 2 springs
Trolley rail pads and clips.......................................Gantrex North America, WeldLok series
Welding machine ....Miller XMT 450 CC/CV 230/460V W/O AUX POWER Stock # 907481
Wire ropes ....Kiswire, HYFIL_K8, galvanized and pre-lubricated

Spare parts availability in the USA

DESIGN RULES

Mechanical Components

The design classifications and allowable stresses of the mechanical components shall be in accordance with FEM 3rd Edition, 1987, and 3rd Edition Revised 1998 as follows:

MECHANISM	MINIMUM LIFE	UTILIZATION CLASS	LOADING SPECTRUM	CLASS
Main Hoist	50,000 h	T8	L2	M8
Trolley Travel	50,000 h	T8	L2	M8
Gantry Travel	6,300 h	T5	L2	M5
Boom Travel	6,300 h	T5	L3	M6

Structural Components

Fatigue – According to British Standards, BS 7608-2014, except as modified in the Technical Provisions. For cumulative damage analysis use 37.5 t effective container weight and 760 mm eccentricity for 4.0×10^6 design cycle spectrum. See the Technical Provisions for the design load spectra.

Allowable stress analysis in accordance with load combinations and allowable stresses defined in these Specifications.

Design stowed hurricane wind: The load determined in accordance with ASCE 7-10, ASCE Standard Minimum Design Loads for Buildings and Other Structures, and in accordance with the Florida Building Code, using the following parameters as a minimum:

Basic wind speed:	180 mph
Risk Category:	III
Topographic factor:	1.0
Exposure category:	D
Gust effect factor:	0.85
Directionality factor:	0.85

The resulting gust velocity pressure, Gq_z (psf), evaluated at height z feet, above the top of rail is:

$Gq_z = 2270 \; z^{0.174}$ N/mm^2, z in meters

($Gq_z = 38.6 \; z^{0.174}$ psf, z in feet)

($Gq_z = 10.4 \times 10^{-6} \; z^{0.174}$ tsc, z in centimeters)

STRUCTURE

Crane frame structure: box type, no truss work

Boom structure: truss construction, fully inspectable

Calculated vertical deflection at maximum outreach due to the weight of the trolley, lift system, and rated load at maximum outreach shall be 12 in (300 mm) maximum

Calculated horizontal deflection at maximum outreach due to the weight of the trolley, lift system, and rated load at maximum outreach and gantry deceleration of 0.5 m/sec^2 shall be 16 in (400 mm) maximum

Adequate gantry frame stiffness to avoid adverse dynamic vibrations in trolley travel and gantry travel directions; natural period with trolley travel drive 1.5 s, maximum

Structural joints all welded; Owner approval required for bolted joints

See Appendix D for standard structural details

STRUCTURAL WORKMANSHIP

AISC, American Institute of Steel Construction

AWS D1.1/D1.1M Structural Welding Code—Steel, by American Welding Society

FLORIDA PROFESSIONAL ENGINEER

Design drawings	Design drawings and calculations shall be stamped and signed by professional engineer(s) registered in the state of Florida; see Section 1.10

ERECTION AND SHIPPING

Erected and tested at manufacturing site

Fully erect shipment

See Drawings for work area on the wharf at Berths 31–32

ENVIRONMENTAL

Ambient temperature:	0 °F to 110 °F (-18 °C to 44 °C)
Ambient relative humidity:	10% to 100%, condensing
Operating wind speed:	55 mph (25 m/s), full height, including gust

See above, and Technical Provisions, Sections 1.6.32 and 2.5.5 for stowed hurricane stowage pins and tie-downs engaged wind criteria and Sections 1.6.33 and 2.5.6 for stowed storm stowage pins engaged but tie-downs not engaged criteria

SITE DATA

Elevations based on NAVD88 reference datum.

MLW	-2.09 ft
MHW	0.39 ft
Waterside Rail	6.88 ft

Gantry Rail type	A150
Allowable Wheel Loads	Technical Provisions, Tables 2.10 and 2.11
Crane buffers	Fixed crane stop buffers, centered 4'–11" above top of rail
	Special interface to existing cranes with buffers at the portal tie beam level, since existing cranes and new Cranes do not share gantry rails
Cable trench	Maximum 75 mm diameter cable, centered 2'–6" waterside of waterside rail

See Drawings for additional information

HANDOVER

Handover	Twenty-four (24) months from contract signing

WARRANTY

Complete crane	Three (3) years minimum for structure and all components, Local warranty contract
Components repaired during warranty period	One (1) year minimum following repair
Paint	ISO 4628/3 Ri 3 within first 5 years No more than 3% degree of rust between 5 years and 10 years; see Section 9.6.2.12
Galvanizing	5 years; see Section 9.6.3
Wire rope	5 years; see Section 4.8.1.4

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TABLE OF CONTENTS — TECHNICAL PROVISIONS

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SECTION 1 GENERAL

1.1 SCOPE OF SUPPLY [3] [4]

1.1.1 These Specifications describe the technical requirements to design, manufacture, test, deliver, and commission low profile ship-to-shore, rail mounted, container handling gantry Cranes with headblocks and spreaders.

1.1.2 Base Bid Cranes — The base scope of supply shall include:

.1 Three (3) Cranes—Nos. SP-8, SP-9, and SP-10
.2 Five (5) telescoping 20', 40', 45', separating twin-20' spreaders, (one spreader for each Crane, and two spare spreaders)—Nos. BS-21, BS-22, BS-23, BS-24, and BS-25.
.3 Three (3) heavy lift cargo beams, Nos. LB-7, LB-8.and LB-9.
.4 Three (3) spreader over-height adapters, Nos. OH-3, OH-4 and OH-5.
.5 Spare parts; See Section 8.5
.6 One complete set of test weights with cart; See Section 7.25
.7 One detailed crane model at 1:72 scale; See Section 7.31
.8 One portable maintenance platform; See Section 7.23.

1.1.3 Option Cranes

~~1.1.3.1 Option 1: Scope of supply shall include two (2) additional cranes with headblocks and spreaders for Berths 30 – Crane Nos. SP-11and SP-12.~~ Option cranes, either for the two (SP-11 and SP-12) or three (SP-11, SP12, and SP-13) crane order, are each to be furnished with a headblock and spreader identical to those supplied with the Base Crane Order. **[3]**

~~1.1.3.2 Option 2: Scope of supply shall include one (1) additional crane with headblock and spreader – Crane No. SP-13.~~ Option cranes, either for the two (SP-11 and Sp-12) or three (SP-11, SP-12, and SP-13) crane order, are to be furnished with a complete spare parts package as is supplied with the Base Crane Order specified in Section 8.5.5.

1.1.4 The ~~basic scope of supply~~ Base Bid Cranes (1.1.2) and Option Cranes (1.1.3) shall include the following notable features and those additional features defined in these Specifications:

.1 Local and remote crane management system (CMS and RCMS); see Sections 6.8 and 6.9. The RCMS shall provide the same functionality, and be fully integrated with, the existing RCMS system. Two RCMS stations shall be provided in the maintenance building and be connected to the cranes by fiber optic cable. Fiber optic cabling will be coiled up in the second floor of the new switchgear building and the Contractor shall connect to and extend fiber optic cabling as needed to the RCMS. Raceways and boxes between the new and the existing switchgear building will be provided by the infrastructure contractor. Contractor shall provide all cabling, equipment, and make terminations for a fully complete and operational RCMS.
.2 Cable reel with cable and termination in the wharf; see Sections 2.4 and 5.7.3.
.3 Hardware and software for full integration with existing TMEIC/Gotting crane anti-collision system, including positioning equipment and wharf transponders landside and waterside.
.4 Closed circuit television cameras (CCTV); see Section 7.3.
.5 See Section 2.13 for list of other acceptable suppliers.
.6 Crane maintenance during Warranty Period.
.7 ~~Installing bumpers and support brackets on existing cranes 4 and 5.~~ Installing bumpers and support brackets on two existing cranes for Base Bid Cranes. **[4]**

1.2 DEFINITIONS [5]

1.2.1 *Approved Equivalent* – Where the term "or approved equivalent" is used, the Contractor may propose an alternative device, item, or manufacturer provided it provides at least equivalent performance, quality, and supportability to that of the specified item. Proposed alternatives must be provided within 30 calendar days of the Contract Award to be considered. The Owner has no obligation to accept the proposed alternative and the Contractor shall abide by the Owner's decision.

1.2.2 ~~*Award or Contract Award* – the date when the Notice to Proceed is issued to the Contractor by the Owner.~~ **[5]**
Award or Contract Award – the date when the Contract is approved by the Broward County Board of County Commissioners.

1.2.3 *Contractor* – the Contractor supplying the Cranes and the Contractor's representatives, subcontractors, and independent engineers retained by the Contractor, also, the party submitting a bid, otherwise known as the Bidder.

1.2.4 *Contractor's Engineer of Record (Contractor's EOR)* – the Contractor's engineers, for the design of the structure, ancillary structures, mechanical systems, and electrical systems, who shall be responsible for ensuring that the technical requirements of these Specifications are met. See Section 1.10 for other requirements.

1.2.5 *Crane*, *Cranes*, *Low Profile Cranes*, or *STS Cranes* – the low-profile, ship-to-shore, rail mounted, container handling gantry cranes as described in these Specifications, including the structure, trolley, headblock, spreader, all attached and ancillary components, all control systems and components, all monitoring and maintenance systems and components, special tools, spare parts, and all other items defined in these Specifications.

1.2.6 *Drawings* – The set of site and crane drawings accompanying these Specifications and listed in Appendix A. These drawings define the main parameters of the project and required design features of the cranes. The designs shown on the drawings are meant to convey the required features of the crane structures and mechanical systems. The Contractor may propose alternative designs that achieve the same functionality. See Section 3.3.

1.2.7 *Engineer* – the individuals and representatives or agents designated by the Owner as having the authority to interpret, clarify, and enforce the specification requirements; see Section 1.11.3.3 for the Engineer's address.

1.2.8 *Global Axis* – Crane orientation and analysis axis system referenced in the specifications: X axis parallel to trolley travel, Y axis vertical, Z axis parallel to gantry travel.

1.2.9 *Owner* – Broward County, at Port Everglades and the Owner's representatives and independent engineers retained by the Owner; see Section 1.11.3.3 for the Owner's address.

1.2.10 *Owner's Approval* – Where a component, concept, design, or other item is stated as being subject to the Owner's approval, the Contractor shall submit a written request with supporting data for the Owner's consideration of the proposed item and the Owner shall respond in writing. Acceptance of the item by the Owner shall not relieve the Contractor from responsibility for the design or compliance with these Specifications. Items requiring the Owner's approval may be rejected at any time unless the Contractor has submitted a written request for consideration and the Owner has accepted in writing.

1.2.11 *Owner's Facility* – Port Everglades, Fort Lauderdale, Florida, USA. See Drawings for site plan. See Section 1.11.3.3 for the Owner's address. Cranes will operate at Berths 31–33 and Berth 30. See Section 10.5 for restrictions at the Owner's Facility after delivery.

1.2.12 *Point of Common Coupling (PCC)* – The location where the Crane electrical system is connected to the wharf electrical system, defined as the end of the reeling cable where it terminates on the wharf.

1.2.13 *Specifications* – these Technical Specifications, including Project Summary, Technical Provisions, appendices, the Drawings, and any clarifications, deviations, or addenda agreed upon between the Owner and the Contractor and incorporated into the Contract. The intent of these Specifications is to provide structural, mechanical, electrical, and functional criteria, dimensions, operating speeds and accelerations, and pertinent details for the design, construction, and installation of reliable and efficiently functioning Cranes with accessories. Unless specifically stated otherwise, the Specification requirements apply to all Cranes and all components, even if the requirement is stated in the singular. One gender means both genders.

1.2.14 *Technical Provisions* – Sections 1 through 11 of the Specifications.

1.2.15 *Transport* or *Transporter* – Automatic and/or manually operated vehicles used to provide horizontal transport of container between the Crane and the container yard, gate, or other location; includes over-the-road (OTR) vehicles and chassis as well as those used within the terminal.

1.2.16 *Will* and *Shall* – These Specifications are written to the Contractor. When a provision of this Specification requires action by the Contractor, the verb “shall” is used. If the Contractor is allowed to exercise an option when limited alternatives are available, the phrasing “either … or …” is used. However, where the words “or approved equivalent” are used, the Owner reserves the option of rejecting the proposed equivalent. Statements provided in the Specification as information to the Contractor use the verbs “may” or “will.” Informational statements typically identify activities or options that “will be taken” or “may be taken” by the Owner.

1.3 PRECEDENCE OF CONTRACT DOCUMENTS

1.3.1 If a conflict exists, the order of precedence shall be:

.1 The law
.2 The Contract including these Technical Provisions, appendices, and any list of negotiated deviations and clarifications, excluding the Project Summary, Drawing Notes, and the Drawings
.3 The Drawing Notes
.4 The Drawings, excluding the Drawing Notes
.5 The Project Summary
.6 The most recent edition of the standards in Section 1.7 at the time of the bid
.7 The Bid Data Sheets submitted by the Contractor; see Appendix E
.8 The manufacturer’s recommendations

1.3.2 If other conflicts exist, the most restrictive requirement shall take precedence.

1.4 MINIMUM CRITERIA

1.4.1 The criteria specified in these Technical Provisions shall be considered the minimum acceptable. If, in the Contractor’s opinion, any of the criteria specified or in the referenced standards is in any way inadequate or insufficient for the intended use, it shall be the Contractor’s responsibility to use the more stringent criteria.

1.4.2 Except where otherwise specified, the Contractor shall furnish all materials, equipment, tools, labor, and incidentals necessary to fully and completely finish the project according to the true intent and meaning of these Specifications and drawings, even though every item or activity is not particularly mentioned or shown in these Specifications or Drawings.

1.4.3 The Contractor shall remain responsible for adequacy and safety of the design, fabrication, supply, installation, transportation, commissioning, and testing of the equipment specified while adhering to the minimum criteria set forth in these Specifications.

1.5 SAFETY DESIGN CRITERIA

1.5.1 A single electric (power or control) or hydraulic component failure or malfunction shall not damage the Crane or injure personnel.

1.5.2 Where possible, component failure or malfunction shall safely stop the Crane operation. Where this is not possible, a redundant system shall be supplied. The redundant system shall safely stop the Crane and prevent operation until maintenance personnel make corrections.

1.5.3 A means shall be provided so maintenance personnel may routinely check each redundant or backup system. The checking procedure shall be included in the maintenance manual.

1.5.4 No crane component shall change state as a result of a power failure. Powering or repowering the Crane or any system within the Crane shall not result in any unanticipated or potentially unsafe motion or condition.

1.6 LOAD NAMES AND DEFINITIONS

	Abbr.	Name	Description
1.6.1	CBLS	Cargo Beam Lifting System	The weight of the cargo beam, headblock, portions of the lifting ropes, sheaves and all other equipment which hangs from the main hoist ropes when the cargo beam is connected

	Abbr.	Name	Description
1.6.2	CBRL	Cargo Beam Rated Load	The greatest concentric load that can be lifted by the cargo beam without requiring any physical changes in the Crane components. See Section 2.6.2 for the minimum Cargo Beam Rated Load, which is shown as the "Capacity, Under Cargo Beam."
1.6.3	COLL	Collision Load	The loads determined by dynamic analysis for each of the following (not concurrently): The Crane, while traveling at full speed with the power off, hits the crane stops or hits another stopped Crane or existing crane The trolley traveling at full speed with the power off, hits its stops. The boom traveling at full speed with the power off, hits its stops. Bumpers shall be provided so these loads govern only local components. See Section 4.4.6 for bumper requirements.
1.6.4	DL	Dead Load	The weight of the Crane's structure including all permanently attached machinery and equipment.
1.6.5	EQ	Earthquake Condition	Earthquake loading is not considered, since it will not govern over wind load stowed hurricane loading.
1.6.6	F	Fatigue Condition	See Section 3.10.
1.6.7	HF	Hanger Failure	The loads, including dynamic effects, due to one of the waterside boom support hangers failing. All possible boom positions shall be considered. The trolley shall be at the most adverse position.
1.6.8	IMP	Impact	The loads due to vertical acceleration of the lifted load as sensed by the main hoist ropes. Impact loads shall be determined as described in Section 3.5.2.
1.6.9	LATF	Lateral Load Trolley, Fatigue	The trolley lateral inertia force applied parallel to the travel direction shall be at least 0.10×(TL+LS+LLF) for fatigue combinations. The simultaneous inertia force applied perpendicular to the travel direction shall be one-fourth of the force applied parallel to the travel direction. Stresses due to LATF shall be combined with the stresses due to vertical loads. There shall be two starts and two stops for each fatigue cycle.
1.6.10	LATG	Lateral Load Gantry	The loads imposed on the Crane due to acceleration of the gantry. The lateral force applied parallel to the travel direction shall be 1.5 times the maximum inertia force that can be developed due to acceleration of the gantry drive system, except the gantry inertia force shall be at least 0.05 times all weights present on the operating Crane. The simultaneous inertia force applied perpendicular to the travel direction shall be one-fourth of the force applied parallel to the travel direction.

	Abbr.	Name	Description
1.6.11	LATT	Lateral Load Trolley	The loads imposed on the Crane due acceleration or deceleration of the trolley. The lateral inertia force applied parallel to the travel direction shall be at least 0.10×*(TL+LS+LL)* for operating combinations The simultaneous inertia force applied perpendicular to the travel direction shall be one-fourth of the force applied parallel to the travel direction.
1.6.12	LEGL	Leg Lift	The load imposed on the Crane due to a 10-mm vertical displacement of one leg relative to the other three legs. This is a parameter load for information only and is not required to be used for stress calculations.
1.6.13	LIST	List	The effect of ±3° list of the spreader and rated load.
1.6.14	LL	Lifted Load	The total load under the spreader, including weight of the container and contents, with each container loaded at the geometric center of the container. See Section 2.6.1 for the lifted load and Section 1.6.21 for rated load containers.
1.6.15	LLE	Eccentric Lifted Load	The total load under the spreader, including eccentricity. The load arrangements described under Section 1.6.14, LL, shall be considered, with each container loaded eccentric to the geometric center of the container. When more than one container is lifted at once, container eccentricities shall be taken in the same directions. See Section 2.6.3 for eccentricities.
1.6.16	LLF	Fatigue Lifted Load	Fatigue design shall be based on an effective container which, for simplicity, is assumed to be equivalent to the actual spectrum of various weight containers including impact effects. The weight of the container plus its contents shall be taken as 37.5 t (82,650 lb) and shall be applied eccentric to the geometric center of the container 760 mm (30 in) longitudinally. The eccentricity should be considered at one side of the center of the container for half of the design cycles and the other side of the center for the remaining half of the design cycles. The vertical load does not need to be increased because of vertical acceleration. Forces due to horizontal accelerations shall be based on a container weighing 37.5 t.
1.6.17	LS	Lifting System	The weight of the spreader, headblock, portions of the lifting ropes, sheaves and all other equipment that hangs from the main hoist ropes and is supported by the container when the spreader is placed upon it. The minimum LS used in the calculations shall be 20 t (44,000 lb).
1.6.18	MF	Mechanical Fatigue Condition	Refer to Section 4.
1.6.19	OLn,j	Stress Overload	The stress overload conditions 1 through *n* with the boom in position *j*. Refer to Table 2.8.
1.6.20	OPn,j	Stress Operating	The stress operating conditions 1 through *n* with the boom in position *j*. Refer to Table 2.8.

	Abbr.	Name	Description
1.6.21	RL	Rated Load Container	Rated load containers shall be either one (1) ISO container of any size, or two (2) twenty foot ISO containers, weighing, with contents, the amount defined in Section 2.6.1, "Capacity, Under Spreader." Eccentricity shall be included (see LLE).
1.6.22	Sn,j	Stress Conditions	The stress conditions 1 through *n* with the boom in position *j*. Refer to Table 2.8.
1.6.23	SKT SKG	Skew Load, Trolley Skew Load, Gantry	The loads developed due to wheels rolling along a rail. The force shall be taken as acting horizontally and normal to the rail and tending to skew the structure. The horizontal force, perpendicular to the gantry rail, at each corner shall be the one fourth of the total vertical load due to $S \times (DL + TL + LS + LL)$. The term "$S$" shall be determined from the following graph.

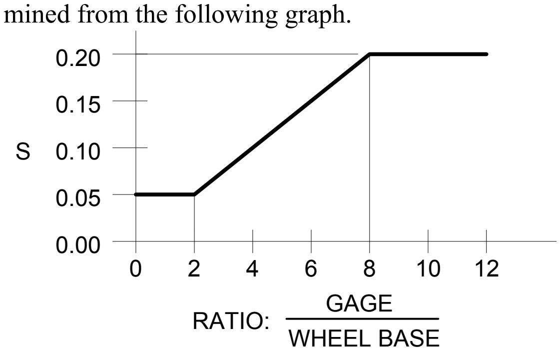


Figure 1.1: Skew load

			"Gage" is the center distance between the rails and "wheel base" is the center distance between the wheels, or, in the case of bogies or equalizer beams, the center-to-center distance between the main equalizer pins. If the Contractor demonstrates that a trolley and/or gantry skew load is less than the value shown because of either electrical or mechanical drive controls, then the reduced load may be used accordingly.
1.6.24	SN	Snag Load	The load imposed on the Crane due to the headblock and empty spreader traveling at maximum hoist speed becoming jammed in the ship's cell guides or being accidentally two-blocked against the underside of the trolley, resulting in the kinetic energy of the rotating equipment being dissipated by elastic deflection of the machinery and the structure and special energy absorbing devices. See Section 4.9.5.
1.6.25	SPRD	Leg Spread	The load imposed on the Crane due to a 25-mm horizontal displacement perpendicular to the rail of the waterside legs relative to the landside legs. This is a parameter load for information only and is not to be used for stress calculations.
1.6.26	ST*n,j*	Stability Conditions	The stability conditions 1 through *n* with the boom in position *j*. Refer to Table 2.9.
1.6.27	STL	Stall Torque Load	The load developed by stalling any motor in the Crane. For the main hoist, stall torque load shall be the load induced by stalling the hoist motors either with one end of a container or hatch cover dogged down, or with all four corners dogged down concentrically.
1.6.28	TL	Trolley Load	The weight of the trolley including all machinery and equipment permanently attached, but excluding LS.

	Abbr.	Name	Description
1.6.29	TRIM	Trim	The effect of ± 3° trim of the spreader carrying the rated load.
1.6.30	TWRP	Trolley Warping	The effect of a variation of the trolley rail elevation causing the trolley frame to warp. The out-of-plane warping stresses shall be calculated based on a vertical displacement of one corner relative to the other three. See Section 3.10.5.2.
1.6.31	WLO	Wind Load, Operating	The load due to an operating wind speed, assumed uniform over the full height of the Crane applied in any direction. The lifted container shall be the rated load container. See Section 2.5.4 for the operating wind speed.
1.6.32	WLSH	Wind Load, Stowed Hurricane, Tie-downs engaged	Design storm wind load: The load shall be determined in accordance with the Florida Building Code and ASCE Standard ASCE/SEI 7-10, *Minimum Design Loads for Buildings and Other Structures* using the following parameters, as a minimum: Basic wind speed, V: 180 mph (80 m/s), Section 2.5.5* Risk Category: III Topographic factor, K_{ZT}: 1.0 Exposure category: D Gust effect factor, G: 0.85 Directionality factor, K_d: 0.85 The resulting gust velocity pressure, Gq_z (psf), evaluated at height z, above the top of rail is: $Gq_z = 2270\ z^{0.174}$ N/mm^2, z in meters ($Gq_z = 38.6\ z^{0.174}$ psf , z in feet) ($Gq_z = 10.4 \times 10^{-6}\ z^{0.174}$ tsc, z in centimeters) Pressure for elevations less than or equal to 10 m (33 ft) shall be calculated with z = 10 m (33 ft, 1,000 cm). The calculated wind load shall be applied in any direction. The trolley shall be in the parked position. The Crane will be stowed with the boom latched in the stowed position (Boom Pos A), with all crane tie-downs and stowage pins engaged. See Table 2.1 for a summary of boom positions. Although the frequency of the Crane is less than 1 Hz, any applied gust effect factor can be taken as being no greater than that for a stiffer structure. * The "basic wind speed" is the 1700-yr mean recurrence interval, 3-s gust wind speed for Risk Category III, measured at 10 m (33 ft) elevation, for Exposure category C for strength design. This wind speed corresponds to an approximate 3% probability of exceedance in 50 yr (annual exceedance probability = 0.000588, MRI = 1700 yr). This wind speed includes the Load and Resistance Factor Design (LRFD) load factor, and is not an expected wind speed.

	Abbr.	Name	Description
1.6.33	WLSN	Wind Load, Stowed Storm, Stowage Pins Engaged, Tie-downs Not Engaged	Design storm wind load for parking the crane without tie-downs: The load shall be determined using the following parameters from ASCE/SEI 7-10, as a minimum: Basic wind speed, V: 92 mph (41 m/s), Section 2.5.6 Topographic factor, K_{ZT}: 1.0 Exposure category: D Gust effect factor, G: 1.00 Directionality factor, K_d: 0.85 The resulting gust velocity pressure, Gq_z (psf), evaluated at height z, above the top of rail is: $Gq_z = 700\ z^{0.174}$ N/mm², z in meters ($Gq_z = 11.9\ z^{0.174}$ psf , z in feet) ($Gq_z = 3.21 \times 10^{-6}\ z^{0.174}$ tsc, z in centimeters) Pressure for elevations less than or equal to 10 m (33 ft) shall be calculated with z = 10 m (33 ft, 1,000 cm). The calculated wind load shall be applied in any direction. The trolley shall be in the parked position. The Crane will be stowed with the boom latched in either the stowed position (Boom Pos A) or retracted position (Boom Pos R), with one inboard crane stowage pin engaged at each rail, but tie-downs not engaged. The Owner will determine the forecasted wind speeds for stowing the cranes without tie-downs. The trolley will be in the parked position. See Table 2.1 for a summary of boom positions. This wind speed includes the LRFD load factor, and is not an expected wind speed. Note: WLSN = WLSH / 3.24
1.6.34 1	WFOL*n*,*j*	Wheel Load, Factored Overload	The factored wheel load for overload conditions 1 through *n* with the boom in position *j*. Refer to Table 2.11
1.6.35	WFOP*n*,*j*	Wheel Load, Factored Operating	The factored wheel load for operating conditions 1 through *n* with the boom in position *j*. Refer to Table 2.11
1.6.36	WFS*n*,*j*	Wheel Load, Factored Stowed	The factored wheel load for stowed conditions 1 through *n* with the boom in position *j*. Refer to Table 2.11
1.6.37	WSOL*n*,*j*	Wheel Load, Service Overload	The service wheel load for overload conditions 1 through *n* with the boom in position *j*. Refer to Table 2.10
1.6.38	WSOP*n*,*j*	Wheel Load, Service Operating	The service wheel load for operating conditions 1 through *n* with the boom in position *j*. Refer to Table 2.10
1.6.39	WSS*n*,*j*	Wheel Load, Service Stowed	The service wheel load for stowed conditions 1 through *n* with the boom in position *j*. Refer to Table 2.10

1.7 STANDARDS

1.7.1 Unless otherwise noted, the applicable recommendations of the following organizations shall be used. Unless otherwise noted, in this Section 'National' means "USA."

Abbreviation	Standard
AASHTO	American Association of State Highway and Transportation Officials
ABMA	American Bearing Manufacturers Association
AGMA	American Gear Manufacturers Association
AISC	American Institute of Steel Construction – ASD
AISI	American Iron and Steel Institute
AIST	Association of Iron and Steel Technology (formerly AISE)
ANSI	American National Standards Institute
API	American Petroleum Institute
ASA	Acoustical Society of America
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
ASM	American Society for Metals
ASME	American Society of Mechanical Engineers
ASNT	American Society for Nondestructive Testing
ASTM	American Society for Testing and Materials
AWS	American Welding Society - Bridges and Dynamically Loaded Structures
BSI	British Standards Institute
CMAA	Crane Manufacturer's Association of America
DIN	Deutsche Industrie Normen
EN	European Standards
FBC	Florida Building Code
FEM	Federation Europeene de la Manutention
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronic Engineers
ISA	Instrument Society of America
ISO	International Standards Organization
JIC	Joint Industrial Council
NAAMM	National Association of Architectural Metal Manufacturers
NEC	National Electric Code
NEMA	National Electrical Manufacturer's Association
NFPA	National Fluid Power Association
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Administration of the United States Department of Labor and equivalent local agency
SAE	Society of Automotive Engineers
SSPC	Steel Structures Painting Council
SSRC	Structural Stability Research Council
UL	Underwriters Laboratory

1.7.2 See Section 3.1 for detailed standards used in the Structural Requirements.

1.7.3 These Specifications refer to various USA and international standards, materials, and procedures. If the Contractor believes that complying with these references is impracticable, alternative standards may be proposed. The alternatives will be accepted provided they are, in the Owner's opinion, at least equal to the referenced standards. The Contractor shall submit the alternatives with the bid including documentation demonstrating equivalence with the references. The Owner will review the proposed alternatives and decide if they are acceptable.

1.7.4 Where reference is made to a standard specification, e.g., AWS D1.1, the latest edition published before the date on the title page of these Specifications shall apply. If, however, the edition is stated, e.g., ISO 4628/3-1982(E), the stated edition shall apply.

1.7.5 The electrical installation shall conform to all federal, state, and local requirements at the Owner's Facility, including NFPA 70 National Electric Code (NEC). All electrical equipment, components, and materials shall be listed or recognized by a Nationally Recognized Testing Laboratory (NRTL) acceptable to the Owner such as Underwriters Laboratories (UL). The Contractor shall perform all work required to obtain the electrical permits necessary for lawful energizing of the Cranes at the Owner's Facility, including, but not limited to, plan check, inspection and approval by the entity having jurisdiction at the Owner's Facility, and/or inspection and approval by a NRTL approved by the entity having jurisdiction at the Owner's Facility.

1.7.6 Some commonly used units in the Specifications and symbols follow:

Quantity	Unit Name	Unit Symbol
Length	Meter	m
	Millimeter	mm
	Foot	ft
	Inch	in
Force	Newton	N
	Metric ton force	t or tonne
	Long ton	LT
Mass	Kilogram	kg
	Metric ton	t or tonne
	Pound	lb
Temperature	Fahrenheit	°F
	Celsius	°C
Time	Hour	h
	Minute	min
	Second	s
Voltage	Volt	V
Current	Ampere	A
Pressure	Pascal	Pa

1.7.7 Where dual dimensions are provided, the units listed in parenthesis are for reference only.

1.8 OVERALL PROJECT SCHEDULE

1.8.1 The Overall Project Schedule (OPS) shall be computerized in both network and Gantt formats using MS Project® software.

1.8.2 The schedule shall break down the engineering design, procurement, fabrication, assembly, shop testing, shipping, and field testing phases of the project. The network shall contain the logical relationships between activities and milestones, so the schedule shows the effect of a slip or improvement in any task on the completion date of the Crane, the contract, or both. The schedule shall contain the interrelationship between the Cranes being supplied. The first schedule submittal shall show the duration, restraints, early start, and early finish for each activity and milestone. The critical path shall be designated.

1.9 DESIGN APPROVAL

1.9.1 Concept Design Approval

1.9.1.1 To prevent misunderstanding of the Specification requirements and to provide an understanding of the Contractor's design, the Contractor's responsible mechanical, structural, and electrical engineers shall present the design concepts to the Owner. This meeting shall take place within 60 calendar days of the Award. The concepts presented shall be supported by calculations, layouts, sketches, typical previous designs, and details. The Contractor shall include all that he believes will help describe the concepts.

1.9.1.2 Safety concepts shall include at least the following:

.1 Safety procedures, functions, and systems
.2 Safety interlocks and sensors

1.9.1.3 Structural concepts shall include at least the following:

.1 Overall dimensional drawings
.2 Frame, boom, and trolley geometry
.3 Structural connections
.4 Boom vertical support and hold down systems at waterside and landside
.5 Boom lateral restraining system
.6 Boom latch
.7 Boom truss manufacturing considerations, including camber
.8 Crane stability
.9 Stowage pin and tie-down arrangements
.10 Crane tie-down system
.11 Wheel loads and crane weight
.12 FEA (finite element analysis) for load condition, stress, displacements, stability, plate buckling analysis approach, p-delta considerations, and fatigue.
.13 Estimated first mode frequencies in the trolley and gantry travel directions
.14 Structural deflections
.15 Structural inspection plan
.16 Access for structural inspection
.17 Machinery house and control room construction and supports
.18 Voyage conditions and bracing
.19 Crane transport and offload

1.9.1.4 Mechanical concepts shall include at least the following:

.1 Cross section through boom showing how lift height under spreader is met. Layouts shall address spreader/head block clearance with trolley, boom, and boom support. Special attention shall be paid to overtravel provided and protection for personnel riding the head block
.2 Machinery arrangements for main hoist, boom travel, trolley, and gantry motions including brakes, couplings, reducers, and sensors
.3 Gantry cable reel
.4 Interface between the cable from the gantry cable reel and the elevator at the portal level
.5 Gantry motor torque and brake adjustments with boom in all positions to provide proper traction and to prevent wheel skid
.6 Anti-collision and buffer system for new crane to existing crane interface
.7 Boom travel system
.8 Boom support rollers
.9 Boom hold down rollers
.10 Boom support rail
.11 Boom hold down rail
.12 Boom lateral side rollers
.13 Boom latch
.14 Trolley arrangement
.15 Catenary trolleys
.16 Main machinery house arrangement

.17 Trolley machinery house arrangement
.18 Reeving, sheave arrangements, and tensioners
.19 Hoist micro-motions
.20 Headblock and spreader, including headblock platform and access to trolley
.21 Trolley mounted cable reel
.22 Cable chain systems (electrical feed system for boom and trolley)
.23 Gantry wheel design considering frog traverse —see Drawings
.24 Lighting fixture support
.25 Test load
.26 Heavy lift cargo beam

1.9.1.5 Electrical concepts shall include at least the following:

.1 Power system modeling and analysis
.2 Protection coordination between substation and Crane
.3 Sizing and detailed specifications of switchgear and transformers
.4 Sizing and selection of inverters and main motors
.5 Drive system vendor's detailed specifications and detailed bill of materials shall be submitted to the Owner for approval prior to the concept design meeting.
.6 Power optimization calculations and torque, current, and speed characteristics (curves) of all major drive motors
.7 Theoretical duty cycle and energy consumption
.8 Single line diagram
.9 Electrical room arrangement
.10 Diesel-electric house equipment and arrangement
.11 Panelboard arrangement in electrical control room
.12 Lightning protection system and transient voltage suppression system (TVSS)
.13 Flexible cables and color coding
.14 Cabin drawings including internal arrangement
.15 Operating control stations
.16 Operator control devices
.17 Transponders and other hardware and software for integration with existing TMEIC-Gotting position and crane-to-crane anti-collision system; detailed description of system functionality
.18 Crane-to-crane anti-collision system
.19 Crane-to-ship laser anti-collision system
.20 Anti-rack system to keep gantry frame square—see Section 7.30
.21 Limit switch, sensors, and protective devices
.22 Flood light and lighting study
.23 Wire label materials and device identification labeling
.24 Wharf power connection
.25 Load weighing system
.26 Anemometer
.27 Air conditioners
.28 Gantry warning devices
.29 Terminal blocks
.30 Intercom system

1.9.1.6 Control concepts shall include at least the following:

.1 Operating modes
.2 Control functions
.3 Gantry control to limit deflections; see Sections 2.8.9 and 3.14.6
.4 Preliminary functional description; see Section 6.2.1.1
.5 Description of all CMS and RCMS functions, hardware, and operating systems. Description of integration of RCMS with existing. Description of crane positioning system and equipment.
.6 System architecture, network topology diagrams, and communication methods for all components
.7 Process and Instrumentation Diagram (P&ID)
.8 Local operating station(s)

.9 Description of all safety interlocks
.10 Software architecture
.11 Software security
.12 Software source code control system and revision system
.13 Closed Circuit Television (CCTV) systems and displays

1.9.1.7 Maintenance and reliability concepts shall include at least the following and shall include discussion and input from the Control System Supplier:

.1 Design for reliability
.2 Redundancy of key systems
.3 Maintenance mode
.4 Limping modes
.5 Design for maintainability
.6 Fault monitoring and diagnostics including root cause identification
.7 Reduction in the numbers of spare parts required to maintain the Cranes
.8 Maintenance hoists and permanent jib structures for maintenance
.9 Preventative maintenance tasks and frequencies
.10 Access for maintenance and repair including clearance for accessing and handling all mechanical and electrical components
.11 Methods for leveling and aligning headblock after rereeving

1.9.1.8 Other areas to be presented shall include at least the following:

.1 Walkways and access including access to and from the trolley by means of the headblock
.2 Signs, nameplates, and logos
.3 Crane color scheme
.4 Detailed paint procedure

1.9.1.9 No later than the concept design approval meeting, the Contractor shall present the project management plan including at least the following:

.1 Engineering schedule
.2 Project organization/work breakdown structure
.3 Submittal schedule
.4 Management of workmanship and quality control
.5 Subcontractor for fabrication and transportation
.6 Plan for instructions and manuals
.7 Plan for commissioning and testing

1.9.2 Maintenance and Operating Manual Review

1.9.2.1 Four weeks after the preliminary operating and maintenance manuals have been shipped to the Owner, the Contractor's design team shall present and justify the Operating and Maintenance procedures.

1.9.2.2 The Contractor shall present the step by step operating instructions. Instructions shall include explanation of all Operator devices and Operator warnings. Instructions shall include safety procedures.

1.9.2.3 The Contractor shall present the preventive maintenance tasks and procedures and shall provide estimated maintenance hours for each task, summed by each time interval called for. Contractor shall be prepared to justify each requirement and frequency. Maintenance procedures shall be approved by the Owner.

1.9.2.4 The Contractor shall define and demonstrate the safe working access for each operating and maintenance task, with special emphasis on wire rope rereeving, inspection, and lubrication.

1.9.3 Functional Description and Presentation

1.9.3.1 As part of a requirements analysis the Contractor shall provide and submit a detailed Functional Description as defined in Section 6.2.1.1 no later than 90 days after Contract Award.

1.9.3.2 No later than 120 days after Contract Award, the Contractor's responsible electrical engineer and the drive supplier's responsible control engineer shall present the Functional Description at the Owner's office.

1.9.3.3 Once approved by the Owner, the Functional Description shall govern the development of the Crane control software. Refer to Section 6.1.4 for additional software requirements.

1.10 FLORIDA PROFESSIONAL ENGINEER

1.10.1 The Contractor's EOR shall be a professional engineer registered in the state of Florida.

1.10.2 Final design drawings and calculations shall be signed by the Contractor's EOR. The intent is to include the structural, mechanical, and electrical systems. However, this requirement is not intended to include shop drawings, third-party vendor drawings, or ancillary drawings that have no significant impact on the project or that require no engineering. See Appendix F for a list of components for which drawings and calculations will need signature—the Contractor shall submit a detailed list of drawings and calculations that will and will not be signed for Owner review and approval.

1.11 SUBMITTALS

1.11.1 General Submittal Requirements

1.11.1.1 The following and other requirements of these Specifications shall govern submittals. After Award, however, the Owner will consider any suggestions from the Contractor that will reduce the paper work and expedite the submittal process without degrading the quality of the product or the completeness of the documentation.

1.11.1.2 Submittals will be for information only. The submittals may or may not be reviewed. All submittals must show compliance with the Specification. Requests for deviation from the Specification and substitutions shall be submitted in writing. Owner will respond in writing. Any deviations or substitutions, which are not approved in writing, may be rejected at any time, even if they are shown on the submittals. Submittal does not relieve the Contractor from compliance with these Specifications.

1.11.1.3 The Contractor shall submit the design drawings, calculations, catalog information, specifications, procedures, and shop drawings used by the Contractor for the design, fabrication, erection, shop testing, shipping, roll-off, and field testing of the Crane. For submittals: specifications are defined as the definition of major buy-out components; procedures are defined as process definition in operations such as, welding, painting, and alignment.

1.11.1.4 Sequence of submittals

1.11.1.4.1 Preferably, drawings, calculations, catalog information, and other submittals should be submitted in a logical order so that they may be processed as they are received. If, because of scheduling or other practical reasons, the submittal data is not developed in a logical order, the data shall be submitted as it is developed. For example, the calculations determining the size of the gantry drive motors should be submitted when they are developed, even though they are based on estimated wind loads and dead loads; if more accurate verification calculations are made after the loads are known, these more accurate calculations shall be submitted—eventually, all the specified data shall be submitted.

1.11.1.4.2 Preferably, the submittals shall be in the following order:

.1 General arrangement drawing of the Crane submitted with the first calculation submittal showing dimensioned key working points on the structure. Dimensioned sub-assembly drawings, i.e., main hoist, trolley drive, boom travel, shall be submitted, clearly showing the dimensional relationship of that sub-assembly to working points on the general arrangement drawing.

.2 Design drawings with calculations showing the logical development of the loads and forces for each load combination for a given component or assembly.

.3 Design drawings of the component or assembly showing stress calculations, materials and manufacturing processes used, allowable stress for the load combination, and, where applicable, published catalog descriptions, dimensions and rating information.

1.11.1.4.3 The applicable data shall be provided before each component is ordered or fabrication is begun. The determination of the percent complete for the purpose of payment will take into account the completion of the submittal data. If all the necessary data is not properly submitted, the item of work will not be complete.

1.11.1.5 Direct communication between the Contractor's design engineers and the review Engineer is strongly encouraged.

1.11.1.6 Submittals shall be numbered consecutively and submittal contents shall be described in a transmittal letter. The submittal number shall be marked on each drawing and the cover sheet of each document submitted. The urgency of the submittal relative to other pending submittals shall be included in the transmittal letter, preferably by relating it to the critical path schedule.

1.11.1.7 Original and revised drawings and calculations shall be checked and signed by the Contractor's responsible design engineer prior to submittal. All revisions shall have a revision number and the revisions shall be highlighted. The responsible engineer shall be licensed to practice his specialty in his state or country of residence. If his place of residence does not issue professional engineer's licenses, he shall submit credentials demonstrating equivalency to the requirements for registration at the location of the Owner's Facility.

1.11.1.8 Drawings, calculations, and catalog information shall be in the language described in Section 2.14. The units shall be international system of units (SI). Assembly and arrangement drawings shall be dual dimensioned in both SI and US Customary units. <u>Lettering and view scaling must be of sufficient size to make readable ANSI B (ISO A3) size reproductions</u>. If the previously prepared standard drawings do not conform, but meet the intent of these standards, the standard drawings will be accepted, provided all words are translated into the language described in Section 2.14, and all dimensions on arrangement drawings are converted to SI units. Terminology, calculations, symbols, dimensions, method of dimensioning, machine tolerances, screw threads, and gauges shall be provided, such that replacement or repair parts are readily identifiable and available without difficulty at the location of the Owner's Facility. Exceptions shall be noted in the bid documents.

1.11.1.9 Where practical, submittals shall be in electronic media as well as paper. The Contractor shall propose what documents can be submitted using electronic media and how they can be submitted.

1.11.1.10 Drawings shall be made to scale. Preferably the margin of the drawings shall contain row and column labels so a particular zone or "cell" may be referenced by row and column, e.g., B7.

1.11.1.11 The information shall be clearly presented so the Owner may review the details for conformance with these Specifications. The Owner will be the judge of the adequacy of the information presented.

1.11.1.12 After the Contractor's list of drawings is submitted, the Owner may allow fewer copies of certain documents to be submitted—this is to minimize paperwork.

1.11.2 Design Submittals Required with the Bid

1.11.2.1 The bid data sheets, arrangement drawings of the proposed Crane including general arrangement, crane structure and major machinery arrangements, and photographs of existing cranes (as applicable), shall be provided with the Bid. See Appendix E, Bid Data Sheets.

1.11.3 Schedule of Other Required Submittals

1.11.3.1 The Submittal Schedule shown in Section 1.11.3.2 shall take precedence over other Sections of these Specifications for document size, distribution, and due dates of presentations and submittals. Where distribution and document type are not specified, see specific referenced sections. Where document type is not specified elsewhere, Contractor may provide any type, in compliance with these Specifications.

1.11.3.2 Submittal Schedule: The Contractor shall submit the documents listed below and elsewhere in the Specifications to parties below.

Due Date	Description	Reference
With the Bid	Arrangement drawings and completed bid data sheets	Appendix E
When requested	Manufacturing inspection reports	9.1.4
15 days after Award	List of drawings, calculations, catalog information, and scheduled submittal numbers.	
	Overall project schedule (OPS)	1.8
Monthly	Updated and statused overall project schedule (OPS)	1.8
45 days after Award	All information to be presented at the concept design approval meeting	1.9.1
60 days after Award	Concept design approval meeting	1.9.1
90 days after Award	Wharf interface drawings and calculations. The data shall include at least the magnitude, direction, and location of all loads imposed by the Crane on the wharf, including wheel loads, bumper forces, and gantry securing device forces, and the specified allowable values. Information shall include the electrical power demand, electrical connection, and data connection.	2.12
	Quality control plan	9.1.3, 9.2.3.2
	Functional Description	1.9.3, 6.2.1.1
120 days after Award	Presentation of functional description	1.9.3, 6.2.1.1
As developed	Design and construction documents	1.11.1.3, 3.4.9
As developed	Scaled drawing of Crane with Owner logo	7.17.1
With design submittals	Theoretical duty cycle analysis	2.10.1
	Drawings of gears with data to demonstrate conformance with Specifications	4.6
Upon ordering steel	Copies of purchase order for all structural fabrication material	9.2.2.14
Prior to start of fabrication	Written procedures of all welded joints	9.2.1.6
	Certification of the qualifications of each individual welder, tacker, and welding operator	9.2.1.7
	Quality control plan	9.1.3
Before sub-component assembly	As-built drawings and documents	11.6
Before structural sub-component assembly	Structural maintenance program	3.17
270 days prior to shipment of first Crane	Priced bid for contract modification for any additional initial spares.	8.5
150 days prior to shipment of first Crane	Erection, shop testing, shipping, roll-off, and field testing plans.	3.18, 9.8–9.9, 10.3, 10.4
60 days prior to shipment of first Crane	Operating and lubrications instructions and inspection manuals; A4 in 3-ring binders no thicker than 75 mm	11.1, 11.2

Due Date	Description	Reference
	Spare part submittal; hard copy & Excel spreadsheet * plus 1 for each maintenance manual	8.5
	School and course outline of drive system technical training in the supplier's factory for experienced crane maintenance personnel.	11.4
	As-built calculations and procedures suitably bound and documents reduced to ISO A3	11.5, 11.6
	Maintenance training course outline and list of trainers with their qualifications, soft bound	
	Course outline, names and qualifications of proposed training specialists, and the proposed training schedule; soft bound	11.4
	Lubrication check list	10.3.8
Prior to testing of first Crane at site	All drawings, A or B size and DVD-ROM * prints; ** DVD-ROM	
Upon testing and acceptance of first Crane	Operating instructions validation	11.1.4
At acceptance	Operating instructions for the operator's cab; preliminary or "marked up" versions of the validated operating instructions * plus 1 electronic in Microsoft Word format	11.1.6
	Testing documentation	10
Within 30 days following the acceptance of first Crane	Final operating instructions and manuals, 100 copies* to Owner, 1 copy to the Engineer. * plus one (1) electronic copy in Microsoft Word™ format.	11.1.5, 11.1.7, 11.1.8
Within 60 days after acceptance of printed material	Calculations, drawings, instructions, operating instructions, maintenance manuals, and spare parts list, on DVD-ROM	11.6.7
Within 60 days after acceptance of last Crane	Drawing index and all manufacturing and assembly procedures	
	All as-built drawings in the following formats: Electronic submittal as one (1) to four (4) structured Adobe Acrobat PDF files. Four (4) bound sets printed on ANSI B or ISO A3 size bond One set of ANSI D or ISO AI size Mylar, to Owner.	11.6

1.11.3.3 Unless noted otherwise above, submittal shall be electronic to contacts listed below. Electronic submittals shall be in suitable Adobe Acrobat PDF files. Submittals shall be organized into logical volumes minimizing the number of individual files provided and shall include a hierarchical, navigable listing of the documents included in the submittal. AutoCAD and other native format files shall be provided when requested where the PDF files are not sufficient for review. Hardcopy submittals, where requested, shall be sent to the addresses below.

OWNER

Broward County
1850 Eller Drive
Fort Lauderdale, FL
33316-4201
USA

Attn: Arnold De La Cruz
Container Crane Maintenance Manager
adelacruz@broward.org

ENGINEER

Liftech Consultants Inc.
344 20th Street, Suite 360
Oakland, CA 94612
USA

Attn: Michael Jordan, SE
Principal Structural Engineer
mjordan@liftech.net

ENGINEER'S SUBCONSULTANT
TransHoist Engineering, Inc.
560 First St, Suite C107
Benicia, CA 94510
USA

Attn: Larry Wright, PE
Principal Mechanical Engineer
lwright@transhoist.com

SECTION 2 PROJECT REQUIREMENTS

2.1 CRANE DESCRIPTION

2.1.1 The Crane shall:

.1 Be a rail mounted, portal gantry, container handling crane
.2 Be of the low-profile type with a rope-towed, shuttle boom
.3 Have a rope-towed trolley with fleet-through main hoist

2.2 BOOM POSITIONS AND OPERATING MODES

2.2.1 General

2.2.1.1 The maximum lift height of the spreader shall be restricted in an area from five feet waterside of the waterside boom support rollers to the full landside backreach position, with one exception as discussed in the following paragraph. In this area the maximum possible lift height shall allow the spreader and the spreader flippers in the raised position to clear the boom support trucks, the trolley access walkway, and other obstructions. The maximum lift height in this area shall be 125 feet. The lift height waterside of this area shall be the full specified lift height. The head block and spreader transition between these two areas is shown on the Drawings and called the “Z” motion. The restriction in lift height in this area is a safety function and it shall not be possible for the crane operator to override it. Reduced hoist and trolley speed shall be permitted in this area.

2.2.1.2 With the trolley in the parked position and the boom in any position it shall be possible to raise the hoist to the maximum hoist position for access between the trolley and the headblock. No boom motion shall be possible with hoist above the 125 feet level. With the trolley to the landside of the area starting five feet waterside of the waterside boom support, no trolley motion shall be possible with hoist above the 125 feet level.

2.2.1.3 At the full hoist lift height waterside of the waterside boom support there is a danger that the swinging spreader with or without the load may hit the operator’s cab. One such possibility is an emergency stop of the trolley causing uncontrolled load swing. If analysis shows this swing contact is possible the rated trolley speed may be reduced at the upper hoist levels based on rational swing analysis. Dynamic testing of the completed cranes shall set the final reduced trolley speeds verses hoist height.

2.2.1.4 In normal operation it shall not be possible to move the boom unless the trolley is in the parked position. When the boom is moved, the trolley drive will operate simultaneously to keep the trolley in the parked position, relative to the frame. In an emergency, if the trolley drive is out of service, it may be required to move the boom back with the trolley not in the parked position. Interlocks shall protect against contact of the trolley with the landside O-frame.

2.2.1.5 The boom latch will only be dis-engaged for the purpose of changing the boom position. In each boom position, the boom latch shall be engaged after the boom stops moving.

2.2.2 Boom Positions

2.2.2.1 See Table 2.1 and the Drawings for boom positions.

Boom Position	**Operations**			**Stowage**
	Maximum Outreach	**Trolley Operation**	**Main Hoist Operation**	
Boom Pos. C	205’	Unrestricted	Unrestricted	
Boom Pos. B	166’	Unrestricted	Unrestricted	
Boom Pos. A	130’	Unrestricted for operation	Unrestricted for operation	Trolley at parked position Storm wind (WLSN): one inboard stowage pin per rail engaged, tie-downs not engaged Hurricane wind (WLSH): all stowage pins and tie-downs engaged
Boom Pos. R	0’ — fully retracted)	Between boom supports	Without load under spreader	Trolley at parked position Storm wind (WLSN): one inboard stowage pin per rail engaged, tie-downs may or may not be engaged

Table 2.1: Summary of Boom Positions, Operations, and Stowage

2.2.3 Manual Operating Mode

2.2.3.1 The primary operating mode of the Crane shall be under the manual control of the operator located in the trolley cabin.

2.2.3.2 The three Operating Positions are shown on the Drawings: Boom Pos. A, B, and C. Boom Pos. A shall also be the hurricane stowed position.

2.2.3.3 The crane shall be fully operational at each Operating Position, including for semi-automated operation.

2.2.4 Semi-Automated Operating Mode

2.2.4.1 In the semi-automated operating mode, the main hoist and trolley will move containers between designated truck lanes and a designated position over the vessel automatically using the optimum clear path. Landing of the lifting system and operation in the ship’s cell guides shall be manual.

2.2.4.2 Once the lifting system arrives at the designated position over the vessel, the crane operator will assume control of the trolley and main hoist, including spreader functions and the hoist micro-motions.

2.2.4.3 Once clear of the vessel, the operator may signal the Crane to take automatic control in which case the trolley and main hoist will automatically perform all motions to an adjustable distance above the designated truck lane.

2.2.4.4 When the operator maintains manual control, he shall be able to place the trolley and hoist at any operating location except as noted above and in the following. Interlocks shall prevent the hoist or trolley moving such that the lifting system or its load will collide with the crane structure or any fixed attachment.

2.2.4.5 The crane operator will use manual control to handle hatch covers, cargo beam loads, and oversize or over-height container loads.

2.2.5 Passing Mode

2.2.5.1 The Crane shall have a Passing Mode that

.1 Allows the Crane to gantry past obstructions on the vessel such as the ship superstructure or ship's gear
.2 Allows the Crane to be parked with the boom out of the shipping channel

2.2.5.2 In the Passing Mode, the boom will be in the retracted position, Boom Pos. R.

2.2.5.3 When gantrying in Passing Mode, the trolley shall be in the parked position and the main hoist lifting system shall be above the portal tie beam level.

2.2.5.4 When the crane is not gantrying in the Passing Mode:

.1 The main hoist lifting system shall be free to move with an empty spreader
.2 The trolley can move to any position between the boom supports

2.2.6 Stowed Mode

2.2.6.1 The Crane shall have a Stowed Mode to be used in high wind conditions.

2.2.6.2 In the Stowed Mode, the boom will travel to Boom Pos. R or Boom Pos. A.

2.2.6.3 In the Stowed Mode:

.1 The trolley will be in the parked position
.2 The main hoist lifting system will be locked to the waterside sill beam
.3 Gantry stowage pins will be engaged into stowage pin pockets on the wharf
.4 In Boom Pos. R the tie-downs may or may not be engaged
.5 In Boom Pos. A. tie-downs will always be engaged for hurricane crane stowage

2.2.7 Cargo Beam Mode

2.2.7.1 The Crane shall have a cargo beam mode in which the cargo beam is connected under the head block and used with the main hoist.

2.2.7.2 Speeds and accelerations in the cargo beam mode will be limited to an adjustable setting; see Section 2.7.2.2.

2.2.8 Limping Modes

2.2.8.1 The Crane shall be designed to continue container handling operations in a reduced manner if one or more systems do not work as intended. These reduced functioning modes are referred to as limping modes and shall allow a Crane to continue operations or move to a clear position under its own power in as safe and efficient a manner as possible until the problem is repaired.

2.2.8.2 The Crane shall enter the appropriate limping mode automatically and both the operator and maintenance personnel shall be notified that the Crane has entered a limping mode and the applicable restrictions.

2.2.8.3 The Crane shall log and communicate this reduced functionality to the CMS and RCMS.

2.2.9 Maintenance Mode

2.2.9.1 The Crane shall have a maintenance mode of operation. This mode shall contain features that warn and protect maintenance personnel who may be working in diverse areas of the Crane.

2.2.9.2 A keyed switch in the operator's cabin, at the ground level operating panel, and in the electric room shall turn this maintenance mode on or off.

2.2.9.3 The request for any crane motion (hoist, trolley, boom, or gantry) shall be followed by an adjustable time delay before any motion takes place. The delay shall initially be set at 15 seconds.

2.2.9.4 During the time delay period, audio and visual alarms shall warn of pending motion. As a minimum, the public address system shall produce a unique warning tone, and red strobe lights shall be energized in the electric room, the machinery house, and under the operator's cab.

2.2.9.5 For an adjustable period, initially set to 15 seconds, after the cessation of motion in maintenance mode, the visual alarms shall continue and brief audio alarm (chirp) shall sound no less than once every 3 s. During this period, motion can resume again without delay or further warning. After this period expires, the audio and visual alarms will cease and any subsequent motion in maintenance mode will be subject to the time delay and alarms described in Sections 2.2.9.3 and 2.2.9.4.

2.2.9.6 Motion commands from any maintenance station, including the gantry control station, shall at all times be subject to these warnings and delays, regardless of the position of the maintenance mode switch.

2.2.9.7 While in maintenance mode, the maximum speed of each motion shall be limited to an adjustable value between 10% and 100% of the motion's rated top speed. The initial setting for this value shall be 50% for all motions.

2.2.9.8 While in the maintenance mode, trolley motion shall automatically slow and stop wherever an obstruction exists that may injure personnel. To continue motion in that direction, the operator must release the trolley motion control and then once again select motion in that direction subject to the delays and warnings described above.

2.3 DESIGN VESSELS AND CLEARANCE REQUIREMENTS

2.3.1 The principal design vessel dimensions are as shown on the Drawings.

2.3.2 The design shall consider super-post-Panamax ships of approximately 15,000 TEU capacity with a maximum width of 22 containers, a maximum stack height of seven high-cube containers or four high-cube and four standard-cube containers above deck, a maximum stowage height of 10 containers below deck, and an average draft of 41 ft.

2.3.3 The design shall also consider New-Panamax ships of approximately 12,000 TEU capacity with a maximum width of 19 containers, a maximum stack height of seven high-cube containers or four high-cube and four standard-cube containers above deck, a maximum stowage height of 10 containers below deck, and an average draft of 41 ft.

2.3.4 The Contractor shall notify the Owner if, in the Contractor's opinion, the crane dimensions defined are insufficient to serve the specified ships.

2.4 ELECTRICAL POWER SUPPLY AND VOLTAGES

2.4.1 The power supplied to the Crane will be 13.2 kV, three phase AC, at 60 Hz.

2.4.2 Power will be via cable trench on the waterside of the Crane. There will be a maximum of four cables per trench and the total cable length on the cable reel shall be 670 m (2,200 ft).

2.4.3 The supply cable shall have a minimum of 12 fiber optic cables and include ground and ground check circuits.

2.4.4 Voltage – The voltage levels used on the Crane shall be as follows:

2.4.4.1 Low voltage from main transformer to inverters: 460 V, three phase AC, at 60 Hz or otherwise if required by the drive system vendor and approved by the Owner

2.4.4.2 Low voltage from main transformer to utility: 460 V, three phase AC; or 115 V, three phase

2.4.4.3 Control voltage: 110 V single phase AC and/or 24 V DC

2.5 ENVIRONMENTAL DESIGN CONDITIONS

2.5.1 All components shall be suitable for the marine environment.

2.5.2 Ambient temperature range is 0 °F to 110 °F (-18 °C to 44 °C)

2.5.3 Ambient relative humidity range is 10% to 100%, condensing.

2.5.4 The maximum operating wind speed shall be 25 m/s (55 mph), full height, including gust.

2.5.5 The maximum hurricane stowed *basic wind speed* shall be 180 mph (80 m/s), in accordance with the Florida Building code and ASCE/SEI 7-10, *Minimum Design Loads for Buildings and Other Structures*. See Section 1.6.32 (WLSH) for ASCE 7-10 design parameters. This wind speed includes the LRFD load factor, and is not an expected wind speed.

2.5.6 The maximum design storm *basic wind speed* for the stowage case with tie-downs not engaged and stowage pins engaged shall be 92 mph (41 m/s). See Section 1.6.33 (WLSN) for ASCE 7-10 design parameters. This wind speed includes the LRFD load factor, and is not an expected wind speed.

2.5.7 Components mounted on the Crane shall be specifically designed for the shock and vibration present on the Crane. Vibration isolation and shock absorbers shall be used where necessary to prevent damage to components. The Contractor shall submit to the Owner, upon request, calculations and product data demonstrating compliance with this requirement. Components which can be shown to have failed due to shock or vibration shall be replaced with suitable components at the Contractor's sole expense.

2.5.8 The Cranes will be located in close proximity of an international airport. The Cranes shall to be designed to operate without impact to operations, maintenance, and reliability from signals originating from airport operations. Additionally, the Cranes shall be designed to not produce signals that affect airport operations.

2.6 CAPACITY

2.6.1 Rated Load—the Crane shall be capable of handling the following under the spreader. This is also referred to as the lifted load (LL). Section 1.6 for LL and rated load container (RL) definitions.

2.6.1.1 Two 20 ft ISO containers under the spreader simultaneously, weighing with their contents 65 LT (66.0 t).

2.6.1.2 Any single RL container, hatch cover, or over-height ISO container, weighing with contents 50 LT (50.8 t).

2.6.2 Cargo Beam Rated Load— the Crane shall also be capable of handling general cargo under the cargo beam lift system, as follows. See Section 1.6 for cargo beam lift system (CBLS) and cargo beam rated load (CBRL) definitions.

100 LT at restricted backreach and outreach only to not govern stability or exceed allowable wheel loads

75 LT, minimum, for full range of trolley travel

2.6.3 Eccentricity

2.6.3.1 The Crane shall be able to accommodate eccentricity in all loads under the spreader where the center of gravity is eccentric to the geometric center of the load by a distance at least that shown in Table 2.2 below. The combination that produces the highest main hoist rope load shall be the lifted load eccentric (LLE) case described in Section 1.6. Where more than one container is lifted at once, the eccentricity for each container shall be taken in the same direction.

Under Spreader	**Longitudinal Eccentricity** (gantry travel direction)	**Transverse Eccentricity** (trolley travel direction)
Each 20 foot container	610 mm	250 mm
All other loads	1220 mm	250 mm

Table 2.2: Eccentricity

2.6.3.2 The Crane shall also be able to handle two 20 ft ISO containers, one empty and one loaded to the maximum eccentricity defined in Table 2.2, and the lifting system shall remain stable.

2.6.4 Proof Loads

2.6.4.1 The Crane shall be capable of handling 125% of the above rated capacities as a proof-load at creep speed at all applicable operating boom, hoist, and trolley positions.

2.7 PRINCIPAL DIMENSIONS

2.7.1 The main hoist travel shall meet the following minimum dimensions:

Lift above waterside rail	133.0 ft	(40.5 m)
Lift below waterside rail	60.0 ft	(18.3 m)
Total lift	193.0 ft	(58.8 m)

2.7.2 The trolley travel shall meet the following minimum dimensions for the extent of travel, measured to the centerline between the trolley hoist sheaves. The outreach shall be suitable for servicing the design vessels—See Section 2.3.

2.7.2.1 Boom Pos. C: Operating 205' Position

Outreach from centerline waterside rail	205.0 ft	(62.5 m)
Backreach from centerline landside rail	35.0 ft	(10.7 m)

2.7.2.2 Boom Pos. B: Operating 166' Position

Outreach from centerline waterside rail	166.0 ft	(50.6 m)
Backreach from centerline landside rail	35.0 ft	(10.7 m)

2.7.2.3 Boom Pos. A: Operating 130' Position

Outreach from centerline waterside rail	130.0 ft	(39.6 m)
Backreach from centerline landside rail	35.0 ft	(10.7 m)

Note: Boom Pos. A is also the hurricane stowed position, but with the trolley parked.

2.7.3 The Crane shall meet the following dimensions

Gantry rail gage	120.0 ft	(36.6 m)
Out-to-out gantry bumpers, maximum (bumpers uncompressed)	86.5 ft	(26.4 m)
Clear height under portal tie beam, minimum	50.0 ft	(15.2 m)
Clear horizontal distance between legs, minimum	60.0 ft	(18.3 m)
Overall width of boom and trolley (symmetric), maximum	30.0 ft	(9.1 m)
Waterside rail set back from face of fender	24.0 ft	(7.3 m)
Height of waterside rail above landside rail	Rails are at the same elevation	
Overall Crane Height limit	175.0 ft	(53.3 m)
Boom projection beyond waterside rail with boom stowed	13.0 ft	(4.0 m)

2.8 SPEEDS AND ACCELERATIONS

2.8.1 Speeds and accelerations defined here are minimum requirements. The Contractor shall provide higher speeds and/or acceleration rates if needed to meet the requirements of these Specifications.

2.8.2 The main hoist shall meet the following minimum top speeds and maximum acceleration and deceleration times:

2.8.2.1 Hoisting with rated load:

Top speed	295 ft/min	(90.0 m/min)
Acceleration time	2.0 s	
Deceleration time	1.5 s	

2.8.2.2 Lowering with rated load:

Top speed	295 ft/min	(90.0 m/min)
Acceleration time	1.5 s	
Deceleration time	1.5 s	

2.8.2.3 Hoisting and lowering with empty spreader:

Top speed	591 ft/min	(180.0 m/min)
Acceleration time	3.0 s	
Deceleration time	3.0 s	

2.8.2.4 Hoisting and lowering with the cargo beam, any load:

Top speed, adjustable ± 30%	148 ft/min	(45.0 m/min)
Acceleration time, adjustable ± 50%	6.0 s	
Deceleration time, adjustable ± 50%	6.0 s	

2.8.3 The trolley shall meet the following minimum top speeds and maximum acceleration and deceleration times in either direction while carrying any load and against up to an 18 m/s (40 mph) wind (50% of the operating wind load, WLO):

Top speed	804 ft/min	(245.0 m/min)
Acceleration time	5.0 s	
Deceleration time	5.0 s	

2.8.4 Main hoist and trolley speeds shall be at a reduced rate when operating at the upper hoist limit and shall include semi-automated operations.

2.8.5 The gantry drive shall meet the following minimum top speeds and maximum acceleration and deceleration times in either direction while carrying any load and with the boom in any position:

2.8.5.1 Against up to a 40 mph (18 m/s) wind (50% of the operating wind load, WLO):

Top speed	150 ft/min	(46.0 m/min)
Acceleration time	5.0 s	
Deceleration time	5.0 s	
Minimum adjustable range on acceleration and deceleration times:	+2.5 s / -0.0 s	

2.8.5.2 Against the operating wind load (WLO):

Top speed	118 ft/min	(36.0 m/min)
Acceleration time	10.0 s	
Deceleration time	10.0 s	
Minimum adjustable range on acceleration and deceleration times:	+5.0 s / -0.0 s	

2.8.6 The boom travel shall not exceed the following maximum times including any acceleration, deceleration, slow-downs, communication delays, ramp rounding, and any other factors:

From Boom Pos. C to retracted Boom Pos. R and vice versa .... 180 s

2.8.7 Acceleration and deceleration times defined above shall be from the masterswitch request for change to the achievement of the desired speed. Listed times include communications delays, ramp rounding, load sway, sway damping, automation functions, and any other factors.

2.8.8 Main hoist speeds for intermediate loads shall be at least those based on constant horsepower. Once the final motor design/selection is established, the hoist speeds at various loads shall be optimized and increased to the extent possible by utilizing the full capability of the motors. In this case, a regulator characteristic other than constant horsepower above base speed will be acceptable.

2.8.9 Gantry acceleration and deceleration times shall be adjustable and may require a drive control system that limits lateral displacements in the gantry travel direction; see Section 3.14.6.2. The Crane shall be designed to achieve at least the specified minimum range of acceleration and deceleration times. Actual acceleration and deceleration times shall be adjustable to any value within this range. This requirement does not apply to an emergency stop condition.

2.8.9.1 Gantry acceleration shall not exceed COLL load acceleration used for structural calculations—see Section 1.6.3.

2.8.9.2 Gantry acceleration affects the crane deflections—see Section 7.30.

2.9 DESIGN LIFE

2.9.1 A design life of 40 years at 2,000 hours of operation per year shall be used. This does not necessarily mean that the Crane will no longer be fit for its purpose at the end of that period or that it will continue to be serviceable for that length of time without adequate and regular inspection and maintenance.

2.9.2 Components in the systems for the major crane motions shall be designed for at least the following minimum design lives, and utilization, loading, and mechanism classifications according to FEM 1.001, 3rd Edition, Revised 1998, as shown in Table 2.3. Design lives shown are in operating hours of motion for the components in question.

Mechanism	Minimum Design Life	Utilization Class	Loading Spectrum	Classification
Main Hoist	50,000 h	T8	L2	M8
Trolley	50,000 h	T8	L2	M8
Gantry Travel	6,300 h	T5	L2	M5
Boom Travel	6,300 h	T5	L3	M6

Table 2.3: Minimum Mechanism Design Life and Classifications

2.9.3 The design life requirements are not intended to preclude the use of certain wearing components, such as seals, twistlocks, or wire rope, which as part of normal maintenance may require replacement prior to the expiration of the crane design life. Wearing components, along with their associated design life and maintenance intervals, shall be suggested by the Contractor and are subject to the Owner's approval. Wearing components are not intended to cover items such as gears, bearings, sheaves, drums, shafts, and other mechanical components which shall be designed to last the design life of the Crane.

2.9.4 No component, including electrical or computer components, or software, shall be used on the Crane which will not be supported by the component or software manufacturer for a period of at least fifteen (15) years after delivery of the Crane unless otherwise specifically approved in writing by the Owner or noted herein. The Contractor shall present to the Owner upon request certification from the component or software manufacturer, that the component or software will be supported by the manufacturer for a period of at least fifteen (15) years from the estimated crane delivery date. The Contractor shall, at no cost to the Owner, provide any and all engineering necessary to accommodate the use of alternate parts, software, or designs where the original equipment or software supplied is no longer supported by the original component or software manufacturer within this fifteen (15) year period. Drive components shall be supported for at least ten (10) years from delivery of cranes.

2.10 DUTY CYCLES AND LOAD SPECTRA

2.10.1 Main Hoist and Trolley Design Duty Cycle

2.10.1.1 The main hoist and trolley design duty cycle shall be used for the purpose of calculating times and equipment designs for the main hoist and trolley drives and shall be based on the following:

.1 Handling the rated load (RL) container
.2 Each motion accelerates, runs, and decelerates at the maximum rates and speeds for which it is designed
.3 Main hoist and trolley travel motions occur simultaneously without regard to crane or ship clearances
.4 Ambient temperature is the maximum value defined in Section 2.5
.5 The cycle is repeated indefinitely
.6 The wind load is 50% of WLO in the trolley travel direction
.7 The sequence of operations for the main hoist and trolley design duty cycle shall consist of the following steps repeated indefinitely:
.8 Engage container for 2 s
.9 Hoist 15 m and travel 45 m waterside
.10 Lower 2 m to cell guides
.11 Enter cell guides for 2 s
.12 Lower 12 m

.13 Disengage container for 2 s
.14 Hoist 14 m
.15 Travel 3 m waterside
.16 Lower 2 m to cell guides
.17 Enter cell guides for 2 s
.18 Lower 12 m
.19 Engage container for 2 s
.20 Hoist 14 m
.21 Travel 43 m landside and lower 13 m
.22 Lower 2 m to transporter
.23 Disengage container for 2 s
.24 Hoist 1 m
.25 Travel 5 m landside (alternate between landside and waterside)
.26 Lower 1 m to container

2.10.1.2 Where times are shown for operations, these are theoretical dwell times and shall be the only dwell times considered in calculating the design duty cycle.

2.10.2 Gantry Drive Design Duty Cycle

2.10.2.1 The gantry design duty cycle shall be used for the purpose of calculating times and equipment designs for the gantry drive and shall consist of accelerating, traveling a total of 900 ft (275 m) along the wharf, and decelerating, all against the operating wind load (WLO) without intermediate stops. The cycle shall be performed once.

2.10.3 Boom Travel Design Duty Cycle

2.10.3.1 The boom travel theoretical duty cycle shall be used for the purpose of calculating times and equipment designs for the boom travel drive and shall be based on the following steps which shall be repeated twice in immediate succession with no dwell time against and with the operating wind load (WLO):

.1 Travel the boom from Boom Pos. C to Boom Pos. R.
.2 Travel the boom from Boom Pos. R to Boom Pos. C

2.10.4 Rope Inspection Duty Cycles

2.10.4.1 To allow for rope inspection at slow speeds, all systems with wire rope reeving shall be subject to an additional duty cycle where the full range of motion will be traveled in the least favorable empty spreader condition at a speed not exceeding 15% of the maximum rated speed uninterrupted for a period of at least 15 minutes. Breaks between each 15 minute period of motion shall not exceed 5 minutes in duration.

2.10.5 Main Hoist Load Spectrum

2.10.5.1 Components in the main hoist system, including reducers, bearings, shafts, reeving, etc., shall be designed using a load spectrum at least as severe as defined in Table 2.4.

2.10.5.2 Speeds shall be based on the appropriate main hoist speed for the defined load.

Load Case	Load	Hours	Cycle Ratio
1	CBRL + CBLS	500	0.01
2	LLE + LS	7,500	0.15
3	0.67 LLE + LS	7,500	0.15
4	0.33 LLE + LS	10,000	0.20
5	LS	24,500	0.49
Total		50,000	1.00

Table 2.4: Main Hoist Load Spectrum

2.10.6 Trolley Load Spectrum

2.10.6.1 Components in the trolley system, including reducers, bearings, shafts, reeving, etc., shall be designed using a load spectrum at least as severe as defined in Table 2.5.

2.10.6.2 Maximum motor torque in Table 2.5 means the maximum torque the motors develop when accelerating the trolley with the maximum rated load against WLO.

2.10.6.3 Rated motor torque in Table 2.5 means the highest torque the motors develop when the trolley travels steadily at rated speed with the maximum rated load against 50% WLO.

2.10.6.4 Speeds shall be based on the trolley rated top speed.

Load Case	Load	Hours	Cycle Ratio
1	Maximum Motor Torque	7,500	0.15
2	Rated Motor Torque	7,500	0.15
3	0.67 Rated Motor Torque	10,000	0.20
4	0.33 Rated Motor Torque	25,000	0.50
Total		50,000	1.00

Table 2.5: Trolley Load Spectrum

2.10.7 Gantry Drive Load Spectrum

2.10.7.1 Components in the gantry drive system, including reducers, bearings, shafts, etc., shall be designed using a load spectrum at least as severe as defined in Table 2.6.

2.10.7.2 Maximum motor torque in Table 2.6 means the maximum torque the motors develop when accelerating the gantry with rated load (RL) against WLO.

2.10.7.3 Rated motor torque in Table 2.6 means the highest torque the motors develop when the gantry travels steadily at rated speed with the maximum rated load against 50% WLO.

2.10.7.4 Speeds shall be based on the gantry rated top speed.

Load Case	Load	Hours	Cycle Ratio
1	Maximum Motor Torque	945	0.15
2	Rated Motor Torque	945	0.15
3	0.67 Rated Motor Torque	1,260	0.20
4	0.33 Rated Motor Torque	3,150	0.50
Total		6,300	1.00

Table 2.6: Gantry Drive Load Spectrum

2.10.8 Boom Travel Load Spectrum

2.10.8.1 Components in the boom travel system, including reducers, bearings, shafts, reeving, etc., shall be designed using a load spectrum at least as severe as defined in Table 2.7.

2.10.8.2 Maximum motor torque in Table 2.7 means the maximum torque the motors develop when accelerating the boom against WLO. Include the effect of boom deflection slope on the support rollers as well as the rolling loses of the boom support rollers and hold down rollers

2.10.8.3 Rated motor torque in Table 2.7 means the torque the motors develop when traveling the boom steadily at rated speed against 50% WLO. Include the effect of boom deflection slope on the support rollers as well as the rolling losses of the boom support rollers and hold down rollers.

2.10.8.4 Speeds shall be based on the boom travel maximum speed.

Load Case	Load	Hours	Cycle Ratio
1	Maximum Motor Torque (Tmax)	945	0.15
2	Rated Motor torque	1,890	0.30
3	0.67 Rated Motor Torque	1,890	0.30
4	0.33 Rated Motor Torque	1,575	0.25
Total		6,300	1.00

Table 2.7: Boom Travel Load Spectrum

2.10.9 Other Duty Cycles and Load Spectra

2.10.9.1 Where components or systems support a primary system with a duty cycle and/or load spectrum listed above, those components or systems shall have a duty cycle and/or load spectrum at least as severe as the same duty cycle and/or load spectrum as their primary system where applicable.

2.10.9.2 The duty cycle for the trolley cable reel shall be at least as severe as for the main hoist.

2.10.9.3 The duty cycle for the gantry cable reel shall be at least as severe as the gantry drive.

2.10.9.4 The duty cycle for the hoist micro-motions shall be at least such that the system is moved through half of the full range of each motion and back to the home position twice during each cycle of the hoist and trolley; once with the load and once with an empty spreader. The loads and cycle ratios shall be the same as defined in the main hoist load spectrum, Table 2.4.

2.10.10 Duty Cycle Analysis Requirements

2.10.10.1 The Contractor shall submit a duty cycle analysis for each duty cycle defined above. Where motors or drives for a given motion are to be supplied by the electrical drive vendor, the analysis for those duty cycles shall be prepared by the electrical drive vendor and shall verify the adequacy of the selected equipment for the specified cycles.

2.10.10.2 The Contractor shall provide an analysis showing the peak crane power demand and RMS power demand in both kVA and kW, including lighting, ventilation, air-conditioning, and all other house loads, for the main hoist and trolley design duty cycle described in Section 2.10.1.

2.10.10.3 Each analysis shall be performed on a computer. Each submittal shall include, but not be limited to, the computer input and output, the program logic and complete documentation, and catalog information which substantiates the equipment design.

2.10.11 Load Spectra and Design Life Analysis Requirements

2.10.11.1 Where component design lives are analyzed using a defined load spectrum, Miner's rule shall be used to combine the lives of the load cases and develop the overall design life

2.11 LOAD COMBINATIONS FOR STRESS, STABILITY, AND WHEEL LOADS

2.11.1 The Crane shall be designed for the stress load combinations shown in Table 2.8.

2.11.2 The Crane shall be designed to meet the stability combinations shown in Table 2.9.

2.11.3 Additionally, the Contractor shall meet the allowable wheel loads and shall submit the calculated maximum waterside and landside factored wheel loads for the wheel load combinations shown in Table 2.10 and Table 2.11 for the service (unfactored) and factored (LRFD) load combinations, respectively.

2.11.4 The average wheel spacing used to calculate the allowable wheel spacing shall be determined according to Figure 2.1.

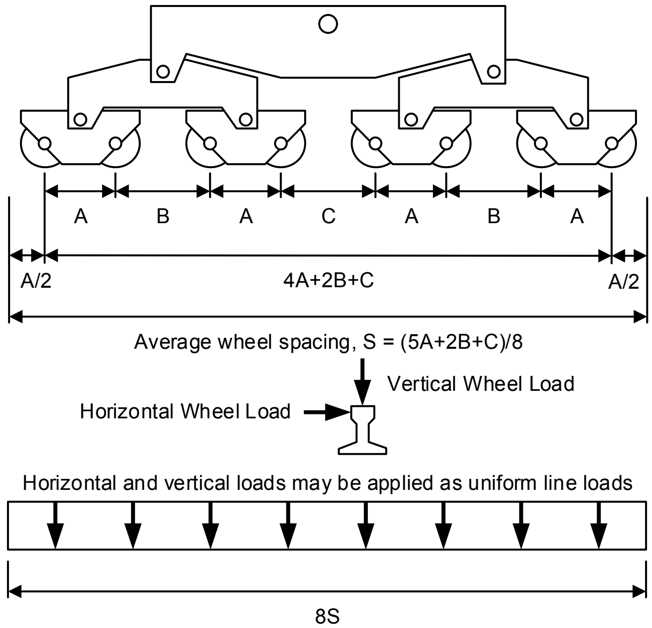


Figure 2.1: Average wheel spacing

Stress Calculation Load Combinations (ASD)												
BOOM POSITION [1]		**Operating**				**Overload**					**Stowed**	
Boom Pos. C		**OP1C**	**OP2C**	**OP3C**		**OL1C**	**OL2C**	**OL3C**	**OL4C**			
Boom Pos. B		**OP1B**	**OP2B**	**OP3B**		**OL1B**	**OL2B**	**OL3B**	**OL4B**			
Boom Pos. A		**OP1A**	**OP2A**	**OP3A**		**OL1A**	**OL2A**	**OL3A**	**OL4A**		**S1A**	**S2A**
Boom Pos. R		**OP1R**	**OP2R**			**OP1R**			**OL4R**		**S1R**	
Boom Pos. Variable					**OP4V**[3]					**OL5V**[3]		
Dead Load	DL	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Trolley Load	TL	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Lifting System	LS	1.0	1.0		1.0	1.0			1.0	1.0	1.0	1.0
Cargo Beam Lift System[2]	CBLS			1.0								
Cargo Beam Rated Load[2]	CBRL			1.0								
Lifted Load[2]	LL					1.0			1.0			
Eccentric Lifted Load[2]	LLE	1.0	1.0									
Impact[2]	IMP		1.0	1.0								
Trolley Lateral Load[2]	LATT		1.0									
Trolley Skew Load[2]	SKT		1.0									
List[2]	LIST	1.0	1.0			1.0	1.0	1.0				
Trim[2]	TRIM	1.0	1.0			1.0	1.0	1.0				
Gantry Lateral Load	LATG	1.0										
Gantry Skew Load	SKG	1.0										
Operating Wind Load	WLO		1.0	1.0	1.0	1.0	1.0			1.0		
Collision Load	COLL					1.0						
Stall Torque Load	STL						1.0					
Snag Load	SN							1.0				
Hanger Failure Load	HF								1.0			
Stowed Wind Load, Storm	WLSN										0.6	
Stowed Wind Load, Hurricane	WLSH											0.6
Number of stow pins engaged per rail	Landside	Not Applicable (N/A)				0 or 1	Not Applicable				1	2
	Waterside										1	1
Number of tie-downs engaged, per corner	Landside	Not Applicable									0	2
	Waterside	Not Applicable									0	1

EXAMPLE: OP-1-C is *1.0 DL + 1.0 TL + 1.0 LS + 1.0 LLE + 1.0 LIST + 1.5 TRIM + 1.0 LATG + 1.0 SKG* is operating load combination number 1 with the boom in Boom Pos. C. See Table 2.1 for boom positions.

Notes:

[1] For Boom Pos. R and Boom Pos. A operating and overload load combinations, the crane shall be operating or stowed, whichever is more severe. For the WLSN load combinations S1R and S1A, the crane shall be stowed with the stowage pins engaged, but tie-downs not engaged. For the WLSH load combination S2A, the crane shall be stowed with the stowage pins engaged and tie-downs engaged

[2] Do not include these loads in the Passing Mode and Stowed Mode load combinations (shaded region).

[3] The boom design shall consider stresses due to moving the boom between latched positions. For OP4V, the trolley shall be in the parked position. For OL5V, the trolley shall be at any position as an overload condition.

Table 2.8: Stress Load Combinations (ASD)

Stability Load Combinations										
BOOM POSITION [1]		**Operating**						**Stowed**		
Boom Pos. C		**ST1C**	**ST2C**	**ST3C**	**ST4C**	**ST5C**	**ST6C**			
Boom Pos. B		**ST1B**	**ST2B**	**ST3B**	**ST4B**	**ST5B**	**ST6B**			
Boom Pos. A		**ST1A**	**ST2A**	**ST3A**	**ST4A**	**ST5A**	**ST6A**	**ST7A**	**ST8A**	**ST9A**
Boom Pos. R		**ST1R**	**ST2R**	**ST3R**				**ST7R**		
Dead Load	DL	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.9	0.6
Trolley Load	TL	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.9	0.6
Cargo Beam Lift System	CBLS					1.0				
Cargo Beam Rated Load	CBRL					1.15				
Lifting System	LS	1.0	1.0	1.0			1.0	1.0	0.9	0.6
Lifted Load [2]	LL	1.0	1.0	1.0			1.5			
Trolley Load Lateral [2]	LATT	1.0					1.0			
Gantry Load Lateral	LATG	1.5								
Operating Wind Load	WLO		1. 5	1.0	1.0	1.0	1. 0			
Snag Load[3]	SN									
Collision Load	COLL			1.15						
Stall Torque Load	STL				1.15					
Stowed Wind Load, No Tie-Down	WLSN							1.0		
Stowed Wind Load, Hurricane	WLSH								1.0	0.6
Number of corners allowed to lift [4]		0	0	1	1	0	0	0, Note [7]	0, Note [5]	
Allowable tie-down load per corner [6]	Landside	Not Applicable							990 k (450 t)	620 k (280 t)
	Waterside								1485 k (674 t)	930 k (420 t)
If unstable, design requires		Ballast							Tie-downs	

EXAMPLE: ST1C is *1.0 DL + 1.0 TL + 1.0 LS + 1.0 LL + 1.0 LATT + 1.5 LATG* is the stability load combination number 1, with the boom in Boom Pos. C, and no legs allowed to lift off. See Table 2.1 for boom positions.

Notes:

1. For the operating and overload boom Passing Mode and Stowed Mode load combinations, the crane shall be operating or stowed, whichever is more severe. For the stowed load combinations, the crane shall be stowed with:
   - ST7R & ST7A — Stowage pins engaged, tie-downs not engaged
   - ST8A & ST9A — Stowage pins and tie-downs engaged
2. Do not include these loads in the Passing Mode and Stowed Mode load combinations (shaded region).
3. The snag load, SN, is not included in the stability combinations since the kinetic energy of the rotating equipment that is not dissipated cannot topple the crane.
4. One corner allowed to lift means one corner may lift, while the other three corners remain in contact with the gantry rail. Zero corners allowed to lift means no corners may lift—all wheels shall remain in contact with the gantry rail.
5. Tie-downs shall be provided for the stowed mode combinations ST8A and ST9A. The Crane tie-down system shall be designed for load combination ST8A, (see Section 3.12 for the design criteria), with the boom in the Stowed position (Boom Pos. A). Combination ST9A may be used for service level loading for the wharf tie-down hardware design. The 0.9 load factors for the DL, TL, and LS for load combination ST8A and ST9A may be replaced with 1.0 factors if the as-weighed crane, trolley, and lift system loads are used. The Contractor shall submit calculated maximum tie-down loads.
6. Refer to the Drawings for wharf hardware tie-down, stowage pin, and crane stop and geometry and numbers of tie-downs and stowage pins per corner for the landside and waterside.
7. No corners are allowed to lift; if unstable, ballast shall be used. The Contractor shall submit to the Owner the amount of ballast required to meet this requirement. The Owner may consider permitting uplift; if so, the stowage pin design shall include the effect of the resulting corner uplift with the wind load applied at the most adverse directions.

Table 2.9: Stability Combinations

Wheel Load Combinations—Service (Unfactored)								
BOOM POSITION [1]		**Operating**			**Overload [6]**		**Stowed**	
Boom Pos. C		**WSOP1C**	**WSOP2C**	**WSOP3C**	**WSOL1C**	**WSOL2C**		
Boom Pos. B		**WSOP1B**	**WSOP2B**	**WSOP3B**	**WSOL1B**	**WSOL2B**		
Boom Pos. A		**WSOP1A**	**WSOP2A**	**WSOP3A**	**WSOL1A**	**WSOL2A**	**WSS1A**	**WSS2A**
Boom Pos. R		**WSOP1R**	**WSOP2R**		**WSOL1R**		**WSS1R**	
Dead Load	DL	1.0	1.0	1.0	0.75	0.75	1.0	1.0
Trolley Load	TL	1.0	1.0	1.0	0.75	0.75	1.0	1.0
Lifting System	LS	1.0	1.0	1.0	0.75		1.0	1.0
Lifted Load[2]	LL	1.0	1.0	1.0	0.75			
Impact[2]	IMP			0.5				
Gantry Lateral Load	LATG	0.3						
Operating Wind Load	WLO		0.5		0.75			
Collision Load	COLL				0.75			
Stall Torque Load	STL					0.75		
Stowed Wind Load, No Tie-Down	WLSN						0.6	
Stowed Wind Load, Hurricane	WLSH							0.6
Calculated Service Wheel Loads (tons/wheel)[3]	LS							
	WS							
Allowable Service Wheel Loads [4], kips / wheel (tonne / wheel)	LS	68 klf x S_{ft} (101 t/m x S_m)					75 klf x S_{ft} (112 t/m x S_m)	68 klf x S_{ft} (101 t/m x S_m)
	WS	67.1 klf x S_{ft} (99.9 t/m x S_m)						88 klf x S_{ft} (132 t/m x S_m)
Allowable Stowage Pin Lateral Loads, parallel to gantry rail, kips / rail (tonne / rail)[5]	LS	Not Applicable					335 k (152 t)	520 k (236 t)
	WS	Not Applicable					195 k (88 t)	635 k (288 t)

EXAMPLE: W-S -OP -1-C = *1.0 DL + 1.0 TL + 1.0 LS + 1.0 LL+ 0.3 LATG*, is the wheel load, service level, operating combination "1," with the boom in Boom Pos. C. See Table 2.1 for boom positions.

Notes:

1 For the operating and overload Passing Mode and Stowed Mode load combinations, the crane shall be operating or stowed, whichever is more severe. For the stowed mode load combinations, the crane shall be stowed with:

WSS1R & WSS1A — Stowage pins engaged, tie-downs not engaged
WSS2A — Stowage pins and tie-downs engaged

2 Do not include LL in the Passing Mode and Stowed Mode load combinations (shaded region).

3 The Contractor shall submit calculated waterside and landside service wheel loads for the above combinations. See the Bid Data Sheets, Appendix E.

4 S_{ft} (and S_m) are the average wheel spacings at one corner in feet (and in meters), as described in Figure 2.1.
Example: If S_f = 5 ft, the allowable landside operating wheel load on the landside would be
68.1 klf x 5 ft/wheel = 340.5 kips per wheel

5 The allowable loads assume one stowage pin per rail for load combinations WSS1R and WSS1A, and two stowage pins per rail for load combination WSS2A.

6 Overload allowable loads are typically increased by a factor of 1.33 for short duration loading in accordance with ASCE 7-10, page 8, and as described in the Commentary, C2.4.1. Load factors represent loading such that no increase in allowable service wheel loads is permitted.

Table 2.10: Wheel Load Combinations, Service (Unfactored)

Wheel Load Combinations—Factored (LRFD)[1]										
BOOM POSITION [2]		**Operating and Overload**							**Stowed**	
Boom Pos. C		**WFOP0C**	**WFOP1C**	**WFOP2C**	**WFOP3C**	**WFOP4C**	**WFOL1C**	**WFOL2C**		
Boom Pos. B		**WFOP0B**	**WFOP1B**	**WFOP2B**	**WFOP3B**	**WFOP4B**	**WFOL1B**	**WFOL2B**		
Boom Pos. A		**WFOP0A**	**WFOP1A**	**WFOP2A**	**WFOP3A**	**WFOP4A**	**WFOL1A**	**WFOL2A**	**WFS1A**	**WFS2A**
Boom Pos. R		**WFOP0R**	**WFOP1R**	**WFOP2R**			**WFOL1R**		**WFS1R**	
Dead Load	DL	1.4	1.2	1.2	1.2	1.2	1.0	1.0	1.2	1.2
Trolley Load	TL	1.4	1.2	1.2	1.2	1.2	1.0	1.0	1.2	1.2
Cargo Beam Lift System[3]	CBLS					1.2				
Cargo Beam Rated Load[3]	CBRL					1.6				
Lifting System	LS	1.4	1.2	1.2	1.2		1.0		1.2	1.2
Lifted Load[3]	LL		1.6	1.6	1.6		1.0			
Impact	IMP				0.8	0.8				
Gantry Lateral Load	LATG		0.36							
Operating Wind Load	WLO			0.65			1.0			
Collision Load	COLL						1.0			
Stall Torque Load	STL							1.0		
Stowed Wind Load, No Tie-Down	WLSN								1.0	
Stowed Wind Load, Hurricane	WLSH									1.0
Calculated Factored Wheel Loads (tons/wheel)[4]	LS									
	WS									
Maximum Allowable Factored Vertical Wheel Loads, kips / wheel (tonne / wheel) [5]	LS	85 klf x S_{ft} (127 t/m x S_m)							112 x S_{ft} (166 x S_m)	100 x S_{ft} (148 x S_m)
	WS	83 klf x S_{ft} (124 t/m x S_m)								131 x S_{ft} (195 x S_m)
Allowable Stowage Pin Lateral Loads, parallel to gantry rail, kips / rail (tonne / rail)[6]	LS	Not Applicable							535 k (243 t)	830 k (377 t)
	WS	Not Applicable							310 k (141 t)	1010 k (458 t)

EXAMPLE: *W-F-OP-1-C= 1.2 DL + 1.2 TL + 1.2 LS + 1.6 LL+ 0.36 LATG,* is the wheel load, factored (LRFD) level, operating condition, combination "1," with the boom in Boom Pos. C. See Table 2.1 for boom positions.

Notes:

1 Based on ASCE/SEI 7-10 and ACI 318-11. LRFD is the Load and Resistance Factor Design approach

2 For the operating and overload Passing Mode and Stowed Mode load combinations, the crane shall be operating or stowed, whichever is more severe. For the stowed mode load combinations, the crane shall be stowed with:

WFS1R & WFS1A   Stowage pins engaged, tie-downs not engaged
WFS2A   Stowage pins and tie-downs engaged

3 Do not include LL in the Passing Mode and Stowed Mode combinations (shaded regions).

4 The Contractor shall submit calculated maximum waterside and landside factored wheel loads for the above combinations. See the Bid Data Sheets, Appendix E.

5 S_{ft} (and S_m) are the average wheel spacings at one corner in feet (and in meters), as described in Figure 2.1.

6 The allowable loads assume one stowage pin per rail for load combinations WFS1R and WFS1A and two stowage pins per rail for load combination WFS2A.

Table 2.11: Wheel Load Combinations—Factored

2.12 WHARF INTERFACE DEFINITION

2.12.1 The Contractor shall submit and include in the assembly drawings and in the maintenance manuals, drawings defining the Crane's complete interface with the wharf. As a minimum the drawings shall include:

2.12.1.1 The calculated maximum waterside and landside service and factored wheel loads, according to Table 2.10 and Table 2.11, respectively. Loads shall be revised as necessary after weighing the Crane. See Section 10.4. Loads shall include those vertical and horizontal in the direction perpendicular to gantry travel.

2.12.1.2 Corner loads applicable for crane roll-on and roll-off of the wharf. Loads shall be revised as necessary following the weighing of the Crane. See Section 10.4.

2.12.1.3 Locations and magnitudes of stowage pin forces for each wind speed condition including WLSN and WLSH.

2.12.1.4 Locations and magnitudes of crane tie-down forces in accordance with Table 2.9 load combinations ST8A and ST9A. See Section 3.12.

2.12.1.5 Locations and magnitudes of gantry bumper forces against adjacent Cranes and against wharf mounted crane stops. Loads against adjacent Cranes shall be based on the COLL loading described in Section 1.6.3. Loads against the wharf mounted crane stops shall be based on tipping the Crane about either the two left side or right side main equalizer pins (left and right facing the water).

2.12.1.5.1 Information shall be provided for existing adjacent cranes with a different rail gage, as well as with other new Cranes.

2.12.1.6 Electrical supply requirement for crane operation including at least the following: voltage, frequency, and phase.

2.12.1.7 Power demand at the PCC including at least the following in both kVA and kW: 15 minute RMS demand, instantaneous peak demand, and house loads.

2.12.1.8 Allowable voltage drop at the point of common coupling at peak demand.

2.12.1.9 Power quality associated with each Crane including at least the following: worst case power factor, worst case total harmonic distortion, power factor at idle (crane systems energized but stationary), total harmonic distortion at idle.

2.12.1.10 Environmental design conditions to include at least those listed in Section 2.5.

2.12.1.11 Wheel, gantry arrangement, stow pin, buffer, and tie-down design details.

2.12.1.12 Transponder locations and antennae details

2.13 ACCEPTABLE SUPPLIERS

2.13.1 Features and Acceptable Suppliers listed in this Section, 2.13, represent the Owner's preferences and shall be considered the "Base Bid," described in Section 1.1.2.

2.13.2 Control System. The Control System Supplier shall have parts for this crane system available within the United States or within immediate shipment to the United States and shall have software and hardware field engineer support within four (4) hour travel time of the Owner's Facility.

2.13.3 The acceptable suppliers shall be as follows:

Control system and electrical ....TMEIC
Electric motors ....Wolfer
Gear boxes and gearing ....Falk
Air compressor ....Ingersoll-Rand
Air conditioners..Trane
Anemometer ....Gill WindObserver IS

Bearings and seals	SKF, FAG, Timken
Secondary bearings and seals, where approved	SKF, FAG, Timken, Koyo, Sealmaster, Rexnord
Brakes, high-speed, including discs(B)	Pintsch-Bubenzer
Brakes, gantry motor(B)	Pintsch-Bubenzer, adjustable torque
Brakes, non-driven gantry wheel(B)	Pintsch-Bubenzer
Bumpers	Oleo, with marine plating
Cable reel, gantry(A)	Cavotec pull and store
Cable reel, spreader(A)	Cavotec
CCTV Cameras	Orlaco
Couplings, with brake disc	by brake supplier
Couplings, drum	Malmedie
Diesel auxiliary generator set	Cummins / ONAN, EPA Tier 4F
Electric cable, gantry with 12 fibers	Prysmian
Electric cable, spreader	Prysmian
Elevator	Alimak
Encoders	Huebner Gissen
Energy chain: trolley and boom systems	IGUS
Hydraulic components	Rexroth, Parker, available in the U.S.
Hydraulic cylinders	Rexroth, Parker, Hydropa available in the U.S.
Hydraulic oil	Mobil
Hydraulic power units, for brakes	by brake supplier
Intercom	Comtrol International
Fuses	Ferraz Shawmut, Bussmann, GE
Laser (for ship anti-collision)	SICK
Lighting, floodlights	Phoenix
Lighting, aviation lights	Phoenix
Limit switches, magnetic	Schmersal
Limit switches, proximity	Schmersal
Limit switches, mechanical	GE, Omron
Limit switches, rotary cam	GE
Load cells	Brosa
Lubricants	Mobil
Master Switches	Brieda Dynamic
Operator’s cabin and consoles	Brieda Dynamic
Paint	Hempel, International
Service cranes, powered	~~Demag~~ KoneCranes
Spreader cable plugs and sockets	Pyle-National
Spreader	Bromma STS45 with SCS and Height Indication System
Spreader over-height adaptor	Bromma
Spreader cable shock-absorbing device	Cavotec S06-S1227-500 bollard type damper with 2 springs
Trolley rail pads and clips	Gantrex North America, WeldLok series
Welding machine	Miller XMT 450 CC/CV 230/460V W/O AUX POWER Stock # 907481
Wire ropes	Kiswire, HYFIL_K8, galvanized and pre-lubricated

Notes:
(A) Drive shall be by the control system supplier.
(B) Bubenzer brakes, couplings, and discs shall be made in Germany.

2.13.4 Where multiple acceptable suppliers are listed for an item category, the Contractor shall procure all components of that type from only one of the suppliers listed unless otherwise approved in writing by the Owner. The intent is to minimize the number of different suppliers and parts used on the Crane.

2.13.5 Items shall be provided directly by the listed supplier, not by a licensee, unless otherwise approved in writing by the Owner.

2.13.6 Where the supplier of buyout items are not listed or otherwise specified, the buyout items shall be from recognized manufacturers of these items with a history of supplying the same or similar items to the United States. The manufacturers shall have an established support network at the Owner's Facility for troubleshooting, repairs, and replacement parts unless the items can be directly replaced in-kind by a similar item readily available in the United States. The manufacturers of all buyout items shall be subject to the Owner's approval.

2.14 LANGUAGE AT THE OWNER'S FACILITY

2.14.1 All nameplates, labels, signs, safety instructions, operator's displays, CMS screens, and other written information present on the Cranes shall be in English.

2.14.2 All manuals, operating instructions, and software documentation, both written and in the CMS, shall be in English.

SECTION 3 STRUCTURAL REQUIREMENTS

3.1 STRUCTURAL STANDARDS

3.1.1 The term “AISC Specification” refers to ANSI/AISC 360-10, Specification for Structural Steel Buildings, June 22, 2010, with Commentary. Except for eyebar and pin connected members, the structural design shall conform to the “design for strength using Allowable Strength Design (ASD)” in the AISC Specification, except ASD load combinations and allowable stresses shall be as specified in Sections 2.11.1 and 3, respectively.

3.1.1.1 The provisions for allowable stress design (ASD) section B3.4 shall be used for strength design. The provisions for load and resistance factor design (LRFD) in the AISC Specification shall not be used unless approved by the Owner.

3.1.1.2 The ASD load combinations and allowable stresses shall be as specified in Section 2 and Section 3.6 of these Specifications, respectively.

3.1.1.3 See Section 3.11.6 for eyebar specification requirements.

3.1.2 The terms “AWS Specification,” “AWS D1.1,” and “AWS D1.1/D1.1M-2015” refer to the AWS D1.1/D1.1M-2015, Structural Welding Code - Steel, an American National Standard. Provisions for bridges and dynamically loaded structures shall take precedence.

3.1.3 The terms “AWS D1.5,” and “AWS D1.5M/D1.5:2015” refer to the AWS D1.5M/D1.5:2015, Bridge Welding Code, an American National Standard.

3.1.4 The terms “BS 7608,” and “BS 7608:2014” refer to the BS 7608:2014, *Guide to fatigue design and assessment of steel products*, The British Standards Institution, 2014. Provisions for “damage tolerant design,” as described generally in this Section, Section 3, and in detail in Section 3.10 shall be used. Damage tolerant design relies on structural maintenance—see Section 3.17.

3.1.5 Unless otherwise noted, the applicable recommendations of the following standards shall also be used. See Section 1.7.3 regarding latest editions.

Abbreviation	**Standard**
ASCE 7	ASCE/SEI Standard 7-10, *Minimum Design Loads for Buildings and Other Structures*
ASCE 49	ASCE/SEI 49–12, *Wind Tunnel Testing for Buildings and Other Structures*
ASME B46.1	ASME B46.1, *Surface Texture, Surface Roughness, Waviness, and Lay*
ASTM A6	ASTM A36/A36M, *Standard Specification for Carbon Structural Steel*
ASTM A36	ASTM A36/A36M, *Standard Specification for Carbon Structural Steel*
ASTM A53	ASTM A53/A53M, *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless*
ASTM A123	ASTM A123/A123M, *Standard Specification for Zinc Coating (Hot-Dip Galvanized) Coatings on Iron and Steel Products*
ASTM A153	ASTM A153/A153M, *Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware*
ASTM A325	ASTM A325, *Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength*
ASTM A325M	ASTM A325M, *Standard Specification for Structural Bolts, Steel, Heat Treated 830 MPA Minimum Tensile Strength [Metric]*
ASTM A490	ASTM A490, *Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength*
ASTM A490M	ASTM A490M, *Standard Specification for High-Strength Structural Bolts, Classes 10.9 and 10.9.3, for Structural Steel Joints [Metric]*
ASTM A673	ASTM A673/A673M, *Standard Specification for Sampling Procedure for Impact Testing of Structural Steel*

Abbreviation	**Standard**
ASTM A709	ASTM A709/A709M, *Standard Specification for Structural Steel for Bridges*
ASTM E23	ASTM E23, *Standard Test Methods for Notched Bar Impact Testing of Metallic Materials*
AWS A4.3	ANSI/AWS A4.3, *Standard Methods for Determination of the Diffusible Hydrogen Content of Martensitic, Bainitic, and Ferritic Steel Weld Metal Produced by Arc Welding*
AWS A5.1	AWS A5.1/A5.1M, *Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding*
AWS C4.1	AWS C4.1, *Criteria for Describing Oxygen-Cut Surfaces and Oxygen Cutting Surface Roughness Gauge*
AWS D1.1	AWS D1.1/D1.1M, *Structural Welding Code -Steel, Includes Errata*
AWS D1.5	AASHTO / AWS D1.5M/D1.5, *Bridge Welding Code*
ISO 7778	ISO 7778, *Steel plate with specified through-thickness characteristics*
RCSC	Research Council on Structural Connections, *Specification for Structural Joints Using ASTM A325 or A490 Bolts.* Chicago, IL: Research Council on Structural Connections, 2004

3.2 GENERAL REQUIREMENTS

3.2.1 The structure shall consist of sections, box, or tubular members forming the gantry frame and boom. Cover plates and back-to-back angles or channels shall not be used. Wire rope or strand shall not be used for structural members. Flattening or crimping of tubing will not be allowed unless approved in writing by the Owner.

3.2.2 Welded joints shall be used where practical. Bolted joints shall be made using ASTM A325 or A490 bolts or approved equivalent. Joints which are not welded shall be bolted using slip critical friction type connections for operating loads. Bearing type connections may be used to resist overload and stowed wind load. Welds and bolts shall not share the load in any joints without Owner approval.

3.2.3 The sill beams, legs, portal beams, and boom support beams shall form a continuous rigid frame. The connections between these members shall be bolted or welded and be capable of resisting all six components of force.

3.2.4 The boom shall be a truss structure, supported by the gantry frame by support and hold down rollers. See Section 3.3 for Drawing Notes and structural concepts, 4.13 for boom support and hold down system, and Section 4.12.3 for boom latching requirements.

3.2.5 Fracture Critical Members—Fracture critical members or member components, FCMs, are tension members or tension components of members whose failure would be expected to result in collapse of the Crane, collapse or dropping of the trolley or operator’s cab, or dropping the load. Tension members or tension components include those portions of a flexural member that are subject to tension stress. Examples of FCMs are the upper chords of the boom, the boom hangers, and the tension flanges of the boom support beams. Stiffeners used to increase plate buckling strength, and which are not used in the calculations as part of the structural section, may be classified non-fracture critical. Other structural members that are not classified as fracture critical are non-fracture critical members, NFCMs.

3.2.5.1 The Contractor’s responsible structural engineer for the structure shall determine which members or member components are in the FCM category.

3.2.5.2 As a minimum, the Contractor’s responsible structural engineer shall consider the load case (DL + TL + LS + LL + IMP ± LATT) when determining if a member or member component is in tension for FCM classification. The trolley and boom shall be considered in any position. The effect of one trolley corner lifting vertically out of the plane formed by the other three corners should also be included in the above combination when analyzing under-hung trolleys.

3.2.5.3 All FCMs shall be identified as such on the drawings.

3.2.5.4 See Section 3.2.6 regarding access for inspection.

3.2.5.5 For FCMs, in-plane longitudinal stresses shall be carried through a welded joint by complete joint penetration (CJP) weld. The butt weld should be completed by fillet weld reinforcement on both faces of leg length at least equal to one fourth the thickness of the connected plate but not less than the minimum fillet weld size specified in AWS D1.1. See Section 9 for additional FCM material and inspection requirements.

3.2.6 Access for Inspection

3.2.6.1 Where practical, all structural members shall be large enough to crawl through, such that the interiors are accessible for periodic structural inspection.

3.2.6.2 All welds on FCMs shall be accessible for periodic structural inspections. If this is impossible, the Contractor shall identify where, in the opinion of the Contractor, it is impossible and demonstrate that redundancy is impractical. If the Owner accepts that access is impossible and redundancy is impractical, the allowable fatigue stresses shall be based on three standard deviations below the mean instead of two.

3.2.6.3 Members that cannot be internally inspected because of size or other practical reasons shall be sealed by welding. Sealed members shall be pressure tested at 10 kPa (1.5 psi) gage pressure using soap film to demonstrate air tightness. Sections shall be designed to resist the test pressure without yielding. Stresses developed by a 20 °C (36 °F) temperature change of the entrapped air shall not exceed 0.10 times the basic allowable stresses.

3.2.7 Connections shall be detailed to provide a ductile structure capable of withstanding yielding without brittle failure. The Owner may require redesign of connections which, in his opinion, cause unnecessarily high stress intensity.

3.2.8 Fillet welds deposited on opposite sides of a common plane of contact between two parts, "wraparound welds," shall be interrupted at a corner common to both welds. See AWS D1.1- section 2.9.3.5. The ends of the interrupted welds shall be stopped at least 10 mm from the edge of the connected parts. The connections shall be detailed so wraparound welds do not occur. If the interrupted joints are exterior, they shall be sealed with 100% silicone caulking.

3.2.9 Equalizer pins shall meet the requirements of Section 4.4.2. The allowable stresses are defined below in Section 3.6.1.3.

3.2.10 All pinned joints composed of links undergoing constant relative motion shall include aluminum bronze bushings or other equivalent manufactured bearings at all rotating bearing surfaces. All joints shall be designed assuming at least one bearing surface rotates. All bearing surfaces shall be lubricated. Pins shall not be used to resist forces that reverse during normal operating conditions.

3.2.11 The structural analysis of the Crane shall be performed or reviewed by the Contractor's EOR.

3.2.12 The structural design life shall be 4 million moves. This is the number of Total Moves, "TM," in Figure 3.3. The structural design life sets a criterion for fatigue reliability. The structural design life does not necessarily mean that the structure will no longer be fit for its purpose at the end of that period or that it will continue to be serviceable for that period without adequate and regular inspection and maintenance. See Section 3.10 for the fatigue criteria and Section 3.17 for the structural maintenance program.

3.2.13 The Contractor's EOR shall be familiar with the following reference documents. Except for documents .1 and .5, the Contractor may propose alternative documents for the Owner's acceptance, provided they are in the language described in Section 2.14, address the same topics as the listed documents, and are authored by a recognized authority.

.1 BS 7608: 2014, *Guide to fatigue design and assessment of steel products*, The British Standards Institution, 2014
.2 Collins, Jack A., *Failure of Materials in Mechanical Design—Analysis, Prediction, Prevention,* 2nd ed. Cambridge, England: John Wiley & Sons, 1993
.3 Maddox, S. J., *Fatigue of Welded Structures*, Edison Welding Institute, Columbus Ohio and Abington Publishing, 2nd ed., 1991
.4 Rolfe, Stanley T. and Barsom, John M., *Fracture and Fatigue Control in Structures*, Prentice-Hall, 2nd ed., 1987

.5 Structural Stability Research Council (SSRC), *Guide to Stability Design Criteria for Metal Structures*, Edited by Ronald D. Ziemian, John Wiley & Sons, 6th ed., 1988

3.2.14 A large placard shall be placed on the Crane's leg near the access ladder stating:

The structural integrity of this crane requires that no attachments or fixtures of any kind be welded to any part of the crane without prior written approval of the responsible Maintenance Manager.

3.2.15 Shop and field erection lugs that will not interfere with the operation or life of the Crane may be left on when approved by the Owner.

3.3 DRAWINGS AND DRAWING NOTES

3.3.1 A set of Drawings accompany these Technical Provisions. The Drawings include layouts showing the required structural functions of major components. The Drawing Notes explain the functions and state some detailed requirements. Some of the Drawing concepts are copied from the Samsung Heavy Industries (SHI) 40 LT Everglades LP C/C drawing set owned by the Owner. Since the loads applied to the new Cranes are larger than those for the Samsung cranes, the new sections will be larger.

3.3.2 The Contractor may use arrangements other than those shown on the Drawings, provided the functions and requirements noted in the Specifications and on the Drawings are met.

3.3.3 Drawing Notes— Drawing Notes are included below and repeated on the Drawings. The SHI drawing sheet numbers are noted for the Contractor's assistance. Sections 3.3.3.1, 3.3.3.2, 3.3.3.3, and 3.3.3.4 supplement requirements in Section 4.13.

3.3.3.1 Drawing Sheet S1.1, Waterside Boom Support Hanger and Latch

Note **1/S1.1**. Boom support hangers shall carry the downward vertical loads from the boom to the support beam. Fully equalized wheels shall support the boom. Eccentric bushings shall allow for adjustments in rotation about the Y axis, in translation along the Y axis, and in the support wheel gage. Rolling friction loads from the boom support wheels and due to the inclination of the boom support trucks shall also be taken by the hanger. Inclination of the boom support truck about the Z axis, shall not exceed one percent. See SHI drawing 26276. The hangers shall not carry the boom wind or inertia loads. These loads shall be carried by the side rollers in the Z direction. In the X direction wind and inertia loads shall be carried by the tow ropes when the boom is not latched and by the latch when it is latched. The gage of the boom support wheels shall not change when the frame deflects. If a different boom support system is proposed, it shall be stable, and shall not require lateral support at the boom support wheels.

Note **2/S1.1**. Side rollers shall be mechanically equalized and transmit boom lateral Z loads from the boom upper chords, or flange, to the boom support beam. An elastomeric pad shall be placed between the roller base plate and the bracket plate to cushion lateral impact forces. Since the rollers should remain in contact or near contact with the upper chord or flange, shim plates may be used to provide adjustment. At all latched positions, the clearance between the side rollers and the chord or flange shall not exceed 1/8 in. When the boom is between latched positions, the clearance shall not exceed 1/2 in. See SHI 26301 for typical details.

Note **3/S1.1**. Boom hold down rollers shall resist upward vertical loads from the boom. Hold down rollers shall be flangeless, so the lateral loads in the Z direction will be transferred by the side rollers only. At Positions A, B, and C, the landside hold down wheels shall be in contact with the rail and preloaded so the boom does not lift off of the boom support wheels. This hold down concept shall be different from that on the existing cranes. The space between the wheels and the rail shall be adjustable. The preload shall be applied after the boom is latched, and released before the boom is unlatched. One acceptable concept is shown. Two wheels are supported on an equalizing linkage. A horizontal strut, connecting two levers, passes through the header beam in a tube.

Note **4/S1.1**. Hanger shear blocks shall fit neatly so that gap is small, comparable to that of the existing crane. The stresses due to flexing of plates, including P-delta effects when the hanger shifts to close the gap, shall be included. See SHI drawing 26283 for clearances and other details.

Note **5/S1.1**. Hanger pin in the header beam and the eccentric bushings shall provide the ability for the hanger pin to rotate about the Y axis, to be raised or lowered, and to adjust the support wheel gage. Once the adjustments are complete, the bushings shall be locked. See SHI drawings 76272ff.

Note **6/S1.1**. Eccentric bushings at the truck pins shall be used to provide for small vertical adjustments of the boom support wheel elevations. See SHI drawing 26273.

Note **7/S1.1**. Boom support wheels shall be mechanically equalized and shall have enough width so the flanges do not engage during normal operations. Lateral loads from the boom shall not be transferred at the boom support wheels—see Note **2/S1.1**.

Note **8/S1.1**. Boom hanger side support rollers keep the hangers vertical if the boom lifts off the wheels. The side support shall be spring loaded and easily adjustable. The support wheel flanges shall not engage during normal operations. See SHI drawing 26273.

Note **9/S1.1**. Boom side guides shall prevent the hanger from swinging outward, away from the boom, when the boom support wheels are unloaded. See SHI drawing 26273.

Note **10/S1.1**. The boom latch shall hold the boom accurately in the intended position. While the boom is traveling, the loads in the X direction shall be taken by the tow ropes. Once the boom is near a latched position, the latch lowers into the latch socket. As the latch is pushed into the socket, the rollers on the ends of the links push the boom longitudinally to the intended position. Once there, the boom latch is fully lowered against the stop block. Since the boom latch is an over center device, once it is fully lowered, longitudinal forces do not tend to disengage it. See SHI drawing 26305. The device shall be bolted to the header beam so it can be adjusted. See SHI drawing 26295. Another device that is self-locking and fail safe may be used, provided it performs as well as the SHI device.

3.3.3.2 Drawing Sheet S2.1, Landside O-Frame and Boom Support and Platform Layout

Note **1/S2.1**. Boom support trucks shall carry the downward vertical loads from the boom. The design shall comply with the applicable provisions for the waterside boom support. Some ability to adjust the wheel alignment shall be provided; however, adjustable bushings and side guides are not required.

Note **2/S2.1**. Side rollers: See Note **2/S1.1**.

Note **3/S2.1**. Boom hold down rollers: See Note **3/S1.1**. The rail shall contact the landside hold down rollers when the boom is in an operation position.

Note **4/S2.1**. Boom support wheels shall be mechanically equalized and shall have enough width so the flanges do not engage during normal operations. Lateral loads from the boom shall not be transferred at the boom support wheels. See Note **7/S1.1**.

3.3.3.3 Drawing Sheet S3.1, Boom Layout

Note **1/S3.1**. Hanger Failure Criteria: The specifications require that the boom will not collapse if one waterside hanger fails. This induces torsion moments about the Z axis across the boom. If the boom structure is a truss, torsion framing between the side trusses is required so that the unsupported side truss is restrained from rotating excessively relative to the other truss. The torsion framing may be a space truss consisting of the upper chord bracing, the vertical side trusses, panel bracing, and bracing in the plane of the lower horizontal panel brace. Torsion framing has been used successfully on several low profile booms. Other structural solutions may be used. The structure may have any compliant framing and may be located anywhere along the boom. The crane does not need to be operational after the hanger failure event. However, the intact hanger and the diagonally opposite hold down shall be able to support loads caused by the hanger failure and the boom travel drive shall be able to be bring the boom to position R.

3.3.3.4 Drawing Sheet S3.2, Boom Details

Note **1/S3.2**. Hold down rails shall be placed on the upper chord. Preferably, it will be integral with the chord. The height of the rail may vary to suit conditions at each latched position. The bearing surface of the rail shall be smooth, and a transition in height shall not cause impact loads. The boom upper chord rail shall extend along the boom chord far enough so the rollers will engage the rails for a load due to 0.90 times all loads that reduce the uplift force plus 1.10 times all loads that increase the upward force with the boom at any outreach, not necessarily at a latched position, and the unloaded trolley and lift system in any location.

Note **2/S3.2**. As described in Note **2/S1.1** lateral loads parallel to the gantry travel direction shall be taken from the upper chord to the side rollers. The side rollers may bear directly on the flange plate edge. See Note **2/S1.1**.

Note **3/S3.2**. All welds on primary boom members shall be able to be inspected and repaired from the outside. Butt welds on primary boom members shall be complete joint penetration welds wherever a member is spliced or where there is through thickness stress. The welds between the boom rails and the flange plates may be fillet welds, provided the contact bearing surfaces have at least 75% firm bearing.

Note **4/S3.2**. See Note **3/S3.2**. The weld between the trolley rail bed and the vertical web plate shall be a CJP weld. The weld shall be improved by grinding. Toe grinding shall comply with BS 7608-2014. The portion of the weld between the toe grindings shall be ground to a smooth radius with the direction of grinding perpendicular to the rail axis.

3.4 CALCULATIONS

3.4.1 Assemblies shall be analyzed with the aid of an appropriate computer program.

3.4.2 The mathematical model shall accurately simulate the real structure. When ancillary members are attached to the structure, these members must either be accurately modeled or the connecting details shall be designed to allow for compatible deformations. The size of joints shall be taken into account. If a joint is modeled as pinned, it shall either be actually pinned or connected with a flexible element capable of flexing as required without overstress. The effect of axial load shall be included in the analysis of such flexible components.

3.4.3 P-delta effects shall be included.

3.4.4 The boundary conditions at the gantry rails shall be selected to suit the various load cases.

3.4.4.1 For vertical loads:

.1 The wheels shall be modeled as free to spread perpendicular to the rails and free to move parallel to the rails.

3.4.4.2 For horizontal loads perpendicular to the gantry rails:

.1 The wheels may be considered to be restrained in the direction perpendicular to the rails, at both the landside and waterside rails, and free to move parallel to the rails.

3.4.4.3 For horizontal loads parallel to the gantry rails:

.1 For operating cases, including those with the boom at Boom Pos. R, the loads due to driving or braking shall be taken according to driving and braking forces developed at each corner. The wheels shall be free to spread parallel and perpendicular to the rails.

.2 For stowed conditions, the horizontal loads parallel to the gantry rails shall be taken to the stowage pins. Loads perpendicular to the gantry rails shall be taken to the rails. Corner uplift forces shall be calculated for the most adverse condition, with either all wheels considered to be restrained or one side modeled as free to spread in the direction perpendicular to the rails. Rational analysis may be used to limit the calculated uplift force for the conditioned modeled as free to spread, based on the total gap between the wheel flange and the rail. Stowage pin prying action, if any, shall be included in the analysis.

3.4.5 The effect of the horizontal forces parallel and perpendicular to the rails shall be included in the calculation of truck and equalizer forces.

3.4.6 Load paths shall be developed for all details. The calculations shall contain free bodies showing these load paths.

3.4.7 For load combinations where one leg lifts off, proper boundary conditions shall be used and the gantry frame shall be checked for stresses using the allowable stress for the corresponding stress combination.

3.4.8 Calculations based on the analysis of the preliminary structural design do not need to be revised to suit the final design unless there is a significant discrepancy between the preliminary and final designs. After the design is complete and all changes have been made, a final computer analysis shall be run to verify that the design revisions do not significantly increase the calculated stresses. The allowable stresses for the verification analysis shall be the stated allowable stresses plus 3%.

3.4.9 The initial wheel load and stability calculations shall be based on the calculated component weights. The final calculations shall be based on the weighed data. See Section 10.4.

3.4.10 The calculations shall be submitted for information only and may or may not be reviewed by the Owner. As least the following items shall be included in the calculation package:

- .1 Table of Contents
- .2 General description of computer programs used with definitions of any special terminology
- .3 Listing of the governing specifications
- .4 Listing of all loads
- .5 Listing of load combinations and corresponding allowable stresses
- .6 Calculations for determining the magnitude of each basic design load and each governing combined load—the internal forces and stresses for each load shall be reported independently if requested by the Owner; if a dynamic analysis is used to determine impact loads, this analysis may be submitted separately
- .7 Sketches showing computer input data including geometry, node numbers, member or element numbers, global axis, local axis, member properties and boundary restraints
- .8 Stress calculations for members
- .9 Stress calculations for joints and other details
- .10 Cumulative damage analysis
- .11 Gantry frame buckling analysis
- .12 Buckling analysis of plate elements, including stiffener sizing
- .13 Stability calculations
- .14 Wheel load calculations
- .15 Computer output for the gantry frame and boom including the following information:
- .16 Echo of input data, including descriptive sketches
- .17 Member forces for each of the specified individual loads—for moving loads, results need not be given for all members for each moving load position; however, maximum and minimum forces and the corresponding moving load positions shall be provided for all members
- .18 Displacements at appropriate joints for each of the specified individual loads
- .19 Sum of forces at each node; computer results will not be accepted if this summary shows significant round-off error
- .20 Period and mode shape for the lowest gantry frame mode of vibration excited when the trolley stops and starts
- .21 Period and mode shape for the lowest gantry frame mode of vibration excited when the gantry stops and starts with the trolley located midway between the gantry rails
- .22 Support reactions for each of the specified individual loads
- .23 Cumulative damage ratios at critical zones of each connection or change of section

3.4.11 Mathematical Computer Models

3.4.11.1 Mathematical computer models and methods shall comply with the recommendations in BS 7608. The terms and definitions used in this specification have the meanings defined in BS7608 section 3. If a finite element analysis (FEA) model is used, the analysis and allowable stresses shall be in accordance with the recommendations in BS7608:2014, including Tables 1 through 10.

3.4.11.2 Gross structural discontinuities shall be modeled. The mesh shall be fine enough to generate accurate results. If required by the Engineer, the mesh shall be refined until the mesh is fine enough to produce the desired accuracy.

3.4.11.3 If required by the Engineer, selected details conforming to those with a known mathematical solution shall be analyzed to demonstrate the accuracy and appropriateness of the application and the model.

3.4.11.4 Methods used to calculate allowable buckling load shall be verified by demonstrating they are equivalent to methods described in the AISC Specifications and result in allowable loads less than or equal to the calculated allowable loads using AISC methods. Compliance with this requirement shall be demonstrated by analyzing some calibration structures. The calibration structures shall include a simply supported column with the following. See AISC commentary, chapter E3.

$$\frac{KL}{r} = C\sqrt{\frac{E}{F_y}} \quad ,$$

where C equals 2.0, 4.0, 6.0, and 9.0.

3.4.11.5 Levels of analysis—either a first order or second order analysis shall be made, as appropriate, according to the following.

3.4.11.5.1 First order analysis: P-delta and T-delta (collectively "P-delta") effects are neglected. This is suitable when the additional stress due to P-delta effects are less than ten percent of the calculated stress.

3.4.11.5.2 Second order analysis: P delta effects are calculated.

3.4.11.5.2.1 P-delta effects can be calculated using an appropriate program. Since allowable stress design (ASD) allowable stresses are specified, the applied ASD loads shall be multiplied by appropriate load factors for the P-delta analysis. The calculated stresses from the analysis shall then be divided by the appropriate load factor and compared to the ASD allowable stress.

3.4.11.5.2.2 The model geometry shall include construction tolerances for members and plates. The geometry shall be based on an initial distorted shape using the maximum allowable distortion. This maximum distortion may be reduced to 80% of the maximum allowable distortion, provided the contractor guarantees to fabricate the critical structural components within 80% of the specified tolerance. All distortions due to fabrication tolerances shall be combined, i.e., global and local distortions shall be combined. In most cases, including allowable tolerance distortions will increase the calculated stress. The distortion patterns shall be selected to produce maximum calculated stresses.

3.4.11.5.2.3 For simplicity, when the buckling mode shapes are known, reasonably accurate P-delta results can be calculated using linear elastic programs and by using the following method:

.1 Apply a "notional load" with no other applied loads so that distorted structural plate and member shapes match the primary buckling mode shapes. Adjust the notional load magnitude so the maximum distortion equals the allowable tolerance.

.2 With the notional load applied, perform a linearly elastic analysis by combining the notional load with the specified combined loads times the appropriate load and resistance factor design (LRFD) load factors.

.3 Subtract the stresses due to the notional load, acting alone, from the calculated elastic stresses calculated in according to the previous step. The resulting stresses are the factored stresses including P-delta and initial distortion effects.

.4 Divide the factored stresses by the appropriate load factor to get the ASD stress. The calculated stress shall be less than the specified allowable stress. See Section 3.6.1.

3.4.11.5.2.4 The elastic modulus used in the calculations shall be 0.8*E to account for residual stresses

3.4.11.6 Beam Element Models—for calculation of nominal stresses

3.4.11.6.1 The preferred methods for determining fatigue performance are beam models, including stress concentrations where appropriate, or FEA models that account for geometric stress concentrations other than those at the weld toe. The calculated structural stress damage shall then be used to demonstrate the component is acceptable.

3.4.11.6.2 Beam element models are suitable for calculating nominal stresses. Local stress concentrations are not included. This is the usual and suitable method of determining acceptability of statically loaded beams and struts.

3.4.11.6.3 The structural stresses shall be the calculated beam element stresses increased by stress concentrations due to gross structural discontinuities.

3.4.11.6.4 Beam element model analysis is the preferred method for analyzing typical members and details. It is also suitable for calculating stress ranges in cyclically loaded members when the fatigue classifications in BS 7608 Tables 1 to 10 apply. Stress concentrations due to overall geometry shall be included, but concentrations due to the weld profile need not be included, since the fatigue classifications in Tables 1 to 10 take the stress concentrations at the weld toe into account. See BS 7608 section 3.21.

3.4.11.7 Membrane and Shell Element Models

3.4.11.7.1 FEA mathematical models may include beam elements, membrane elements, and shell elements. Typically, the beam element analysis results provide the six components of force on each end of each beam member—this is useful for checking equilibrium. For membrane and shell elements, the six components of force at free body cuts are usually not reported. For the Engineer to verify if the results are correct, enough data, such as forces and moments, shall be provided at appropriate free body cuts to help check equilibrium.

3.4.11.7.2 Membrane Element Models

3.4.11.7.2.1 Membrane elements are suitable for plate structures, without bending about the plane of the plate, for calculating nominal stresses and structural stresses.

3.4.11.7.2.2 The analysis shall include the effects of gross structural discontinuities. See Section 3.4.11.6.3.

3.4.11.7.2.3 Membrane element analysis is not suitable when there is bending about the plate weak axis.

3.4.11.7.3 Shell Element FEA Models—for calculation of structural stresses

3.4.11.7.3.1 FEA is suitable for calculating local axial shear stresses, including stress concentrations due to discontinuities. However the stress concentrations in the weld cannot be reliably calculated, since the weld profile is unknown.

3.4.11.7.3.2 Stresses shall be reported at all surfaces and at the middle of plates.

3.4.11.7.3.3 Orthogonal, principal, shear, and Von Mises stresses shall be reported.

3.4.11.7.3.4 FEA is not suitable for calculating stress intensities.

3.4.11.7.3.5 FEA models may be used to calculate "hot spot" stress concentrations at the weld toe. The effort to calculate hot spot stresses is usually not justified for details on a container handling crane. BS 7608 provides guidance for calculating hot spot stresses.

3.4.11.7.3.6 Some detailed recommendations for using FEA to evaluate fatigue performance are provided in BS 7608, and in "Fatigue Analysis of Welded Components; Designer's guide to the structural hot-spot stress approach (IIW-1430-00)," by Niemi, Fricke, and Maddox, published by the International Institute of Welding (IIW).

3.4.11.7.3.7 In addition to reporting results for combined loads, some loads shall be applied separately, so the structural behavior can be easily understood. In most cases, the dead load, wind load, live and inertia loads, or parameter loads applied at a few critical locations, will be sufficient.

3.4.11.7.3.8 The element size must be small enough to indicate stress concentrations. The Contractor's designer may determine the element size. The Engineer may, however, require refined element sizes if stress concentrations are not determined with sufficient accuracy.

3.4.11.7.3.9 Where strength is the controlling factor, plastic stress distribution may be used, provided the strains are within typical strain limits for seismic design according to AISC Specifications. However, once a portion of the structure has deformed plastically during the initial loading, it shall not be allowed to deform plastically during subsequent loading conditions.

3.4.11.8 Stress analysis for fatigue reliability

3.4.11.8.1 It is not currently possible to predict the fatigue life of typical welded details subjected to given stress spectra using FEA alone. Consequently, it is not possible to predict behavior at the weld toe. There are too many variables, e.g., the shape at the weld toe is unknown and residual stresses are not known. Allowable fatigue stresses have been determined by statistically evaluating numerous fatigue tests of typical detail and assigning a probability of failure when the detail is subjected to fatigue damage. See Section 3.2.13 for some references that address fatigue considerations.

3.4.11.8.2 The preferred methods for determining fatigue performance are beam models, including stress concentrations where appropriate, or FEA models that account for geometric stress concentrations other than those at the weld toe. The calculated structural stress damage shall then be used to demonstrate the component is acceptable.

3.4.11.8.3 If an FEA model is used, the analysis and allowable stresses shall be based on the recommendations in BS 7608, including BS 7608 Tables 1 through 10.

3.5 LOADS

3.5.1 See Section 1.6 for loads names and definitions, Section 2.3.1 for load capacities, and Section 2.10.1 for load combinations. Loads due to temperature effects, erection stresses, and others based on the Contractor's experience shall be included in the analysis if they cause significant stresses. If rational analysis indicates loads larger than specified, the larger loads shall be used.

3.5.2 Minimum impact loads shall be the following, even if dynamic analysis indicates lower impact loads:

0.10 × (TL) plus 0.25 × (LS + LL) applied to load combinations using LL
0.10 × (TL) plus 0.25 × (LS + LLE) applied to load combinations using LLE
0.10 × (CBLS + CBRL) applied to load combinations using CBRL

3.5.3 Wind Loads

3.5.3.1 Wind loads shall be calculated using force coefficients from recognized engineering references or from wind tunnel tests on similar cranes. Wind force coefficients shall include angled wind effects for wind from any horizontal angle.

3.5.3.2 Wind tunnel test results, if used, shall include angled wind effects for wind from any horizontal direction. The tests shall comply with the requirements of ASCE 7-10, Chapter 31, Wind Tunnel Procedure, and to ASCE/SEI 49. Total base reactions—shears and moments— for the design shall be equal to or greater than the measured total base reactions obtained from wind tunnel tests, appropriately scaled.

3.6 ALLOWABLE STRESSES

3.6.1 Load Conditions and Corresponding Allowable Stresses:

3.6.1.1 Load combinations are specified in Table 2.8. The allowable stresses are:

Condition	**Allowable Stress**
Operating	Base stress
Overload	1.5 × Base stress
Stowed	1.11 × Base stress
(Table 2.8 combination S1P)	*Note: ASCE Standard ASCE/SEI 7-10, Paragraph 2.4.1 does not permit an increase in AISC allowable stresses for combinations with wind loads.*

3.6.1.2 Base stress shall be 90% of allowable stress derived from the allowable strength of the ASD provisions given in AISC Specification, except the basic allowable compressive stress for local buckling shall be as specified in Section 3.9. Basic allowable equivalent stress, defined below in Section 3.6.2, at points subjected to combined shear and axial stresses shall be 1.25 times the basic allowable stress for pure tension.

3.6.1.3 The basic allowable bearing stresses for pins shall be as shown in Table 3.1. Bushings shall be used as shown and as required by Section 3.2.10.

Pin	**Bushing**	**Allowable Bearing Stress**			
		Operating		**Storm and Overload**	
		Rotating Surfaces	**Non-rotating Surfaces**	**Rotating Surfaces**	**Non-rotating Surfaces**
Boom hangers and other components composed of links requiring bushings (if applicable)	Required	85 MPa (12 ksi)	0.4 x Fy	0.4 x Fy	0.8 x Fy
Gantry equalizer pins	Not Permitted	85 MPa (12 ksi)	N/A	Section 3.6.1.1	N/A
Other FCM	Not Required	0.4 x Fy	N/A	Section 3.6.1.1	N/A
Other NFCM	Not Required	Section 3.6.1.1	N/A	Section 3.6.1.1	N/A

Table 3.1: Pin Bushings and Allowable Bearing Stress

3.6.1.3.1 For design of gantry equalizer pins subject to the 85 MPa (12 ksi) allowable bearing stress, it is permissible to neglect the SKG loading and use the calculated lateral force due to the rated acceleration or deceleration of the gantry drive system, instead of the LATG load described in Section 1.6.10.

3.6.1.4 For trusses, except for load combinations which include fatigue conditions, when the calculated stresses include secondary effects caused by elastic deformation of the structure or joint rigidity, the sum of the terms in the interaction equation combining the bending and axial stresses may be 1.2 , instead of 1.0, provided the structure conforms to the allowable stress requirements when secondary effects are neglected. The secondary effects shall include the continuity of compression members through support points.

3.6.1.4.1 For a detailed method of applying this provision, refer to BS 2573:Part 1:1983, Rules for the Design of Cranes, Paragraph 5.3, Secondary Stresses. The allowable stresses for bending and axial forces, however, shall be as stated in this Specification.

3.6.1.5 For fatigue analysis, secondary effects must be included and there shall be no increase in the allowable cumulative damage.

3.6.2 Combined Stresses:

3.6.2.1 The equivalent stress, fe, for members subjected to combined shear and axial stress and/or bending stress at a point shall be taken as

$$f_e = \sqrt{\left(f_x^{\,2} + f_y^2 - f_x f_y + 3 f_{xy}^2 \right)},$$

where:

f_x and f_y are orthogonal axial stresses (tension is positive, compression is negative) and f_{xy} is shear stress.

3.7 CRANE STABILITY

3.7.1 Loads and load factors for calculating stability are specified in Table 2.9. Angled wind effects shall be included in WLO, WLSN, and WLSH.

3.7.2 For increased stability, stools shall be provided between the sill beams and main equalizer beams, directly above the outboard intermediate equalizer pins. The stability stools shall be such that a gap is provided to allow the equalizer beams to rotate as the crane travels on the gantry rails. The Contractor shall provide a procedure for the Owner to shim each corner depending on as-built tolerances and existing rails. The stability stools are intended to provide stability for unforeseen loading, such as a runaway crane, and are not intended to be relied upon to provide stability for the load cases shown in Table 2.9.

3.7.3 See Section 3.12 for gantry securing devices, including gantry stowage pins and tie-downs.

3.8 CRANE WHEEL LOADS

3.8.1 Loads and load factors for which wheel loads shall be calculated and allowable wheel loads are specified in Table 2.10 and Table 2.11, for the service (unfactored) and factored (LRFD) load combinations, respectively.

3.8.2 The maximum wheel load for each combination shall be calculated with the trolley in the most severe position and the wind acting in the most severe horizontal direction. The calculated wheel loads shall not exceed the allowable wheel loads provided by the Owner.

3.9 MEMBERS SUBJECT TO BUCKLING

3.9.1 The design of columns, beam columns, frames, and beams subject to lateral buckling shall be in accordance with the AISC Specification. The design of flat plates, curved plates, and plate stiffeners shall be in accordance with a recognized method that considers the combined effect of shear, compression, and flexure. The effects of biaxial stresses and initial tolerances shall be included. Examples of acceptable criteria include those given in DIN, FEM, JIS, and SSRC; other criteria meeting the requirements of this Section are also acceptable. Since the different specifications use different loads, load combinations and allowable stresses, the applied loads and allowable stresses used to check local buckling shall conform to the requirements of the selected specification. If the SSRC is selected, the loads and combinations shall be as specified in these Specifications, and the load factors for local plate buckling shall be in accordance with the FEM specification.

3.9.2 Elastic buckling shall include effects of residual stresses and tolerances.

3.9.3 For all structural plates, the ratio of the minimum clear dimension, b, to the thickness, t, shall not exceed 60, i.e. $b/t \le 60$.

3.9.4 The local buckling criteria given in the AISC and AISE standards are unacceptable because biaxial and combined stress effects are ignored. The choice of a practical method of calculation is left to the Contractor who shall state the origin of the method chosen.

3.9.5 Tension field action may be included for evaluating pure shear resistance during overload and stowed conditions, provided the tension field shear panels are designed for a factor of safety against collapse of at least 1.25. Tension field panels shall be assumed to have zero capacity to resist bending, bearing or axial stress

3.10 FATIGUE DESIGN CRITERIA

3.10.1 Fatigue design shall conform to BS 7608:2014, except as modified in this Section. Modifications to BS 7608 pertain primarily to clarifications for use with "damage tolerant design," the insertion of design load spectra applicable to container cranes, clarification of details for use with container cranes, and different provisions for tubular joints. The criteria stated in this Section, Section 3.10, shall take precedence over the design criteria in AWS D1.1. The Owner will judge if the design is compliant with the Specifications.

3.10.2 Recommendations in BS 7608 shall be followed, except where specifically excluded in these Specifications. BS 7608 includes discussions and recommendations for many conditions not included other standards, i.e., tack welds, weld forms, tapers at class E butt welds, butt welds in rolled sections, unclassified details, treatment of low stress and high stress cycles, toe grinding, heat treating, fatigue design philosophy, fracture mechanics, and FEA, including hot-spot stresses. In the event of a conflict, the order of precedence shall be: (1) these Specifications, (2) BS 7608. Some of the exceptions to BS 7608 are:

3.10.2.1 Clarifications for use with damage tolerant design—BS 7608:1993 was written with "damage tolerant design" as the basis. BS 7608:2014 assumes "safe life design" as the basis. For container cranes, damage tolerant design is required.

.1 BS 7608, section 7, fatigue loading: The load spectra in these Specifications represent the "expected" loading, not the "upper bound" estimate described.

.2 BS 7608 annex A.3, fatigue design philosophy: The design shall be damage tolerant design.

Commentary Note: BS 7608:1993 described the "expected" loading as the basis, with "damage tolerant design." BS 7608:2014 uses the "upper bound estimate" instead, but has the same allowable fatigue damage as the 1993 version and assumes "safe life design." The only stated difference in design basis between the two versions is the loading estimate.

3.10.2.2 BS 7608 "4.3.2 Effect of material thickness": The correction on stress range specified below, in Section 3.10.14, shall govern.

3.10.2.3 BS 7608 "B.5.2.1 Misalignment": The AWS D1.1 requirements shall apply.

3.10.2.4 BS 7608 "Section 12, classification of details," including table 1 through table 10.

.1 Table 3, type no. 3.2—Shall be Class D. Notes state that accidental stop/starts are not uncommon even in automatic processes…and as a result, the use of this type is not recommended.

.2 Table 4, type no. 4.2, 4.3, and 4.4

a. Equivalent BS 7608 weld classes for "long" stiffeners shall be calculated as shown in Table 3.2. Square cut ends shall be avoided where possible and shall be prohibited for FCMs:

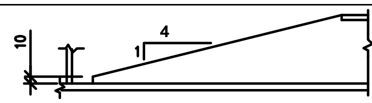
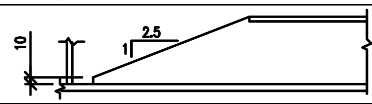
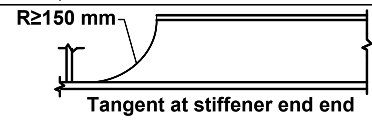
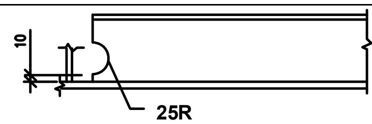
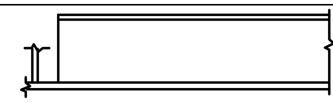
Description	**BS 7608 Weld Class**	**Stiffener End Detail**	**Comment**
Bevel 1:4	E		Improved, bevel
Bevel 1:2.5	F		Typical
Circular	F		Weld toe improvement required; See Section 3.10.2.6.
Square, R=25 mm	F2		Short stiffeners
Square, No Improvement	G		Detail is prohibited for FCMs

Table 3.2: Stiffener End Fatigue Details

b. Stiffener fillet welds shall not extend around the ends of longitudinal stiffeners—a 5 mm clearance between the end of stiffener fillet welds and the stiffener end is recommended for structural drawings such that the weld will not extend to the stiffener end, although this is not a strict requirement.

i. A CJP weld at the stiffener end is also permitted, if the weld toes are ground tangent to the plate and improved according to Section 3.10.2.6. Also refer to Paragraph "a," above.

c. Toes of stiffener fillet welds shall be held back a minimum of 10 mm from the toe of the diaphragm weld or the thickness of the stiffened plate, whichever is greater; consideration shall be made for clearance between the stiffener end and diaphragm for adequate plate flexure.

d. Except as described below, attachments shall be held back from plate edges to provide a minimum of 10 mm clearance between the weld toe and the plate edge.

  i. Primary longitudinal welds between web and flange plates may have less than 10 mm clearance, but care shall be taken to avoid undercutting the plate edge.

  ii. Attachment plates may be welded directly to the edge of a plate; the equivalent BS 7608 weld classes for such edge attachment plates shall be calculated as shown in Table 3.3. Weld toes for details F, F2, and G shown shall be ground tangent to the plate and improved according to Section 3.10.2.6.

BS 7608 Weld Class	**Stiffener End Detail**	**Comment**
F	$\frac{r}{L} > \frac{1}{3}$ $or\ r \geq 150\ mm$	Weld toe improvement required; See Section 3.10.2.6
F2	$\frac{1}{6} \leq \frac{r}{L} \leq \frac{1}{3}$	
G	$\frac{r}{L} < \frac{1}{6}$ $,but\ not\ square\ cut$	Weld toe improvement required; See Section 3.10.2.6 Detail is prohibited for FCMs
G2	$square\ cut$	Detail is prohibited for FCMs

Table 3.3: Plate Edge Fatigue Details

[Commentary Note: Recommendations above are based on EN 1993-1-9, which has a similar methodology as used in BS 7608, but has additional testing based on plate end improvements.]

.3 Table 4, type no. 4.7—Shall also include attachments welded within 10 mm of a plate edge, except as noted regarding primary longitudinal welds in paragraph .2.d. See Section 3.2.8 regarding wraparound welds.

.4 Table 5, type no. 5.5—Shall be class G.

a. AWS D1.1, Section 5.9.1.4(1): "Steel backing of welds that are transverse to the direction of computed stress shall be removed, and the joints shall be ground or finished smooth. (2) Steel backing of welds that are parallel to the direction of stress or are not subject to computed stress need not be removed, unless specified" by the Owner.

b. If used, the edges of the baking bar shall not be welded to the plate; instead, the plate and baking bar shall be tack welded at the bevel joint such that the CJ P weld shall incorporate the tack weld. Lap or joggle welds shall be prohibited.

.5 Table 6, type no. 6.8—See comments for type no. 5.5.

.6 Table 6, type no. 6.9 and table 9, type no. 9.3—Stiffeners shall support the component of stress due to the bend in the main plate. The stiffener centerline shall intersect the point where the main plate centerlines intersect.

.7 Table 7, type no. 7.2—Shall be class G.

.8 Table 7, type no. 7.6—If used, the base plate shall be restrained by plates below. The plate below shall be designed for the eccentricity of the plate center lines. Unrestrained eccentric lap joints shall not be used to transmit axial stress.

.9 Table 7, type no. 7.2—Shall be prohibited; moments about the weld axis and tension in the weld root shall not be allowed.

3.10.2.5 BS 7608 Class D and E Details: Generally, BS 7608 class D details are impractical for cranes, and class E details are practical only if care is taken not to degrade the joint. Class E details are practical locally, but are generally impractical for an entire member. Class E and D details should be used with caution.

3.10.2.6 Weld Toe Improvement: The weld toe is a primary source of fatigue cracking because of the severity of the stress concentration it produces. The stress concentration is worsened by the presence of minute crack-like flaws that are inherent features of fusion welds and are not necessarily regarded as defects. For such welded joints involving potential fatigue cracking from the weld toe, if a remedial treatment by controlled local machining or grinding of the weld toe is provided, the allowable fatigue stress may be increased by 30%.—this is equivalent to a factor of 2.2 on life. See Figure 3.1 for grinding requirements. If the reduction in plate thickness exceeds 5%, this should be taken into account in the stress calculation. Particular care should be taken to not excessively reduce the plate thickness, and that the required weld throat thickness is maintained.

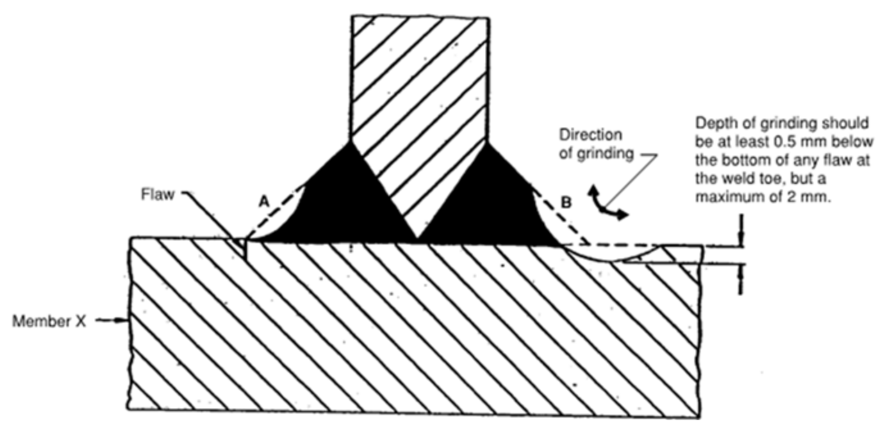


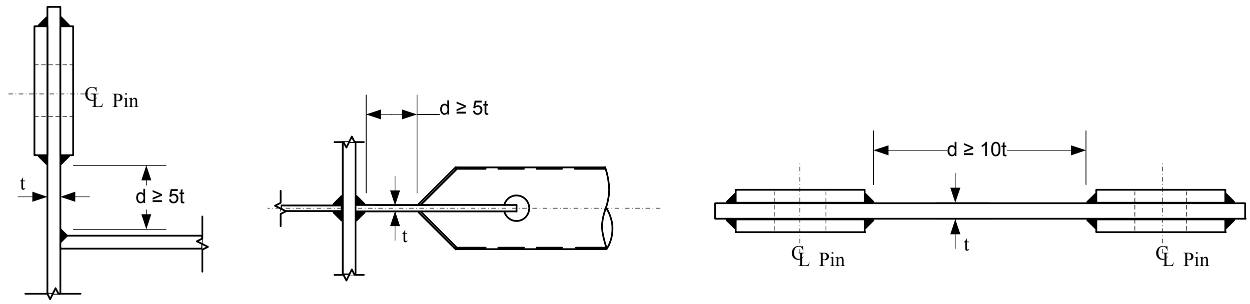
Figure 3.1: Toe grinding to improve fatigue strength (figure from BS 7608)

3.10.3 Tubular Joints—Fatigue classification of tubular joints shall be according to one of the following:

3.10.3.1 AWS D1.1: The values shown in Table 3.4 for AWS D1.1 tubular details are close, but not identical, to those given in AWS D1.1. The tabulated values given here shall be used for AWS fatigue design. When using AWS D1.1 for tubular joints, joint classification and calculations shall be in accordance with AWS D1.1.

3.10.3.2 EN 1993-1-9: Fatigue of tube-to-tube connections may be evaluated using EN 1993-1-9, table 8.6 for details 3 through 9, and table 8.7 instead of using the AWS D1.1 values tabulated above in Table 3.4. Note that the EN "detail category" is equivalent to BS 7608 classification C1 (NFCM) for two million cycles. The γ_{ym} factor of 1.15 for damage tolerant "high consequence" of failure shall be applied to the calculated stress for FCM details. Conversion for the total moves described in Section 3.2.12 shall be made.

3.10.4 Frame and boom diagonal pipes, and similar members connected at the ends with gusset plates, shall be designed to include the effects of fluctuating stresses due to weak axis bending. The length of the gusset plate that can flex is the clear distance between the boss plate or pipe end weld toe to the connecting plate weld toe. The clear flexure distance, d, shall be a minimum 5.0(t), where "t" is the thickness of the flexing gusset plate. For structural links, the clear distance between the boss plate toe welds shall be a minimum of 10.0(t), where "t" is the thickness of the link plate. See Figure 3.2. If FEA indicates P-delta effects require greater distances than what is shown in Figure 3.2, the greater distances shall be used.



Typical Structural Pin Connections | Typical Gusset Plates | Structural Links

Figure 3.2: **Required clear flexure distance, d**

3.10.5 Cumulative damage shall be evaluated for the normal operating conditions detailed in this Section. The specified loads and cycles represent the effects of the actual anticipated operating conditions, for determining the *expected stresses* during the life of the crane, for damage tolerant design. (This differs from the description in BS 7608:2014, which requires an *upper bound estimate* of the stresses, for safe life design.) If, in the Contractor's opinion, the specified loads and cycles are inadequate for fatigue design, the Contractor shall use the more stringent criteria.

3.10.5.1 For the Crane structure, only fluctuating stresses due to variations in the lifted load, the trolley motion, and boom motion need be considered. The effects of dead load, wind load, and gantry travel may be neglected. The trolley load (TL), lifting system (LS), fatigue lifted load (LLF), the fatigue lateral load (LATF), and boom movement shall be used for the fatigue calculations of the Crane structure.

3.10.5.2 For the trolley structure, in addition to the loading described in Section 3.10.5.1, the effect of trolley warping due to the vertical displacement of one trolley corner relative to the plane created by the other three corners (TWRP) shall be included in the trolley fatigue analyses. The warping stresses shall be added to the stresses due to the lifted loads and trolley motion. The damage shall be calculated based on the resulting spectrum. The applied vertical corner displacements, TWRP, as described in Sections 1.6.30, shall be a minimum of 0.001 of the trolley rail span, which is the greatest trolley rail unevenness permissible by FEM 1.001, 3rd Edition, Rules for the Design of Hoisting Appliances, Booklet 8, Section 8.2.2.6. The stress spectrum shall, at a minimum, simulate the stress range encountered for one wheel rising over a bump and subsequently dipping through a valley in the trolley rail. The TWRP load shall, therefore, be applied two times positive and two times negative, as shown in Figure 3.5, for each cycle, as described below, to simulate the trolley passing over the uneven surface in each direction of travel. If the Contractor cannot fabricate the trolley rail to these requirements, the expected higher displacement shall be used. The stress range shall be calculated so that the effect of the TWRP load is the most unfavorable to the trolley structures.

[Commentary Note: In recent projects, the rail has not met the FEM 1.001 requirement for evenness. The Contractor is, therefore, encouraged to use a larger TWRP displacement for fatigue warping based on conservative rail unevenness for the trolley design, considering the Contractor's experience.

<u>Example</u>: If the calculated TWRP for fatigue based on FEM is 6 mm, but the Contractor's initial installation is typically 10 mm, and the Contractor has experience whereby the unevenness may become 15 mm with normal use, the Contractor should use TWRP = 15 mm based on expected conditions.]

3.10.6 Definitions of container moves and cycles

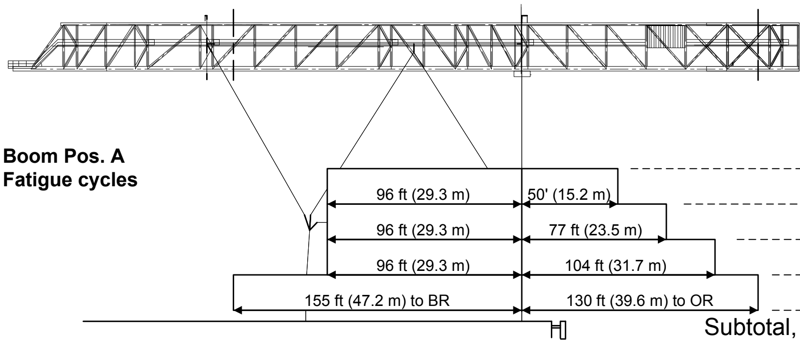
Move: Lift the LLF container from the ship, travel the trolley, and set the container on the transporter; or the reverse operation.

Single Cycle: Lift the LLF container from the ship, travel the trolley and set the container on the chassis with the lifting system supported by the container, pick the lifting system, return to the vessel, set the lifting system on the next container, and prepare to lift the container from the vessel; or the reverse of the above. There is one move per single cycle. See Figure 3.4.

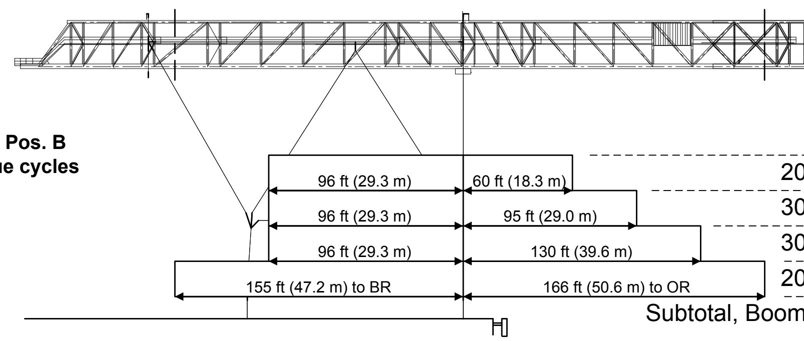
Double Cycle (*For reference only—the primary structure shall be designed for all single cycles*): Lift the LLF container from the vessel , travel the trolley and set the container on the chassis with the lifting system supported by the container, pick the LLF container from the container transfer platform, return to the vessel, set the container on the vessel with the lifting system supported by the container, and prepare to lift the container from the vessel; or the reverse of the above. The same container may be set and picked; the trolley does not need to be relocated between setting and picking. There are two moves per double cycle.

3.10.7 The load spectra for development of the stress cycle spectra shall be as described in these Specifications. Since the distribution of cycles to each of the boom operating positions, Boom Pos. A, B, and C are unknown, three fatigue cases, Case 1, Case 2, and Case 3, shall be investigated nonconcurrently. The design spectra, including fatigue cases, respective boom positions, and cycle definitions shall be as defined in Figure 3.3. The Crane structure shall be designed for all three Cases. The spectra by boom position shall be further divided as shown. The dimensions BR and OR shown in the figure shall mean the backreach and outreach for each boom position—see Table 2.1 for boom positions:

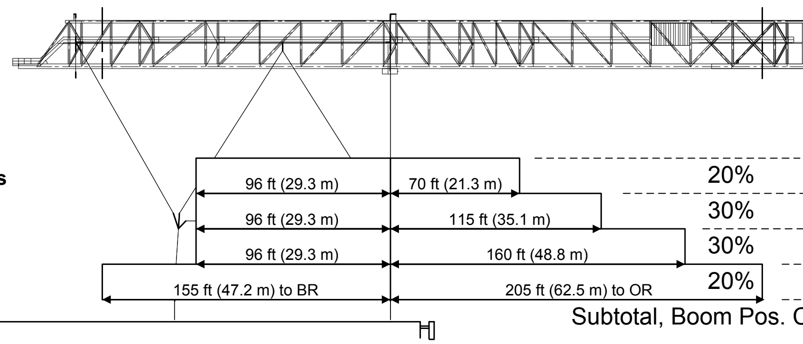
Boom Pos. A
Fatigue cycles



Boom Pos. B
Fatigue cycles



Boom Pos. C
Fatigue cycles

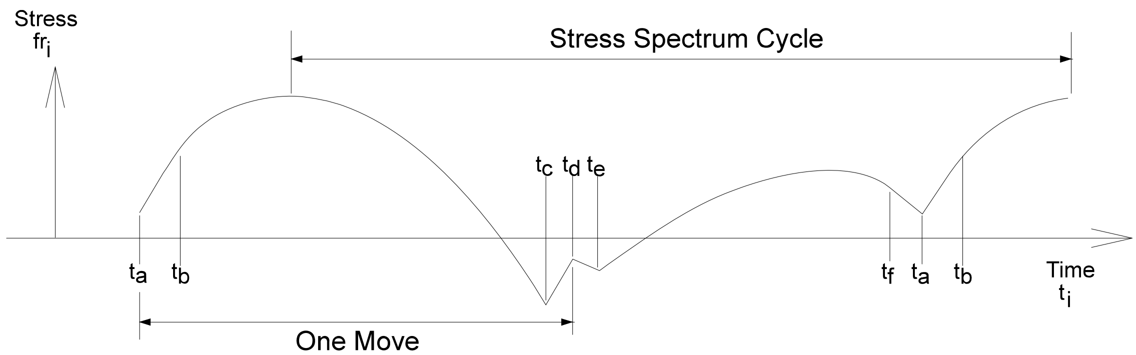


	Number of Single Cycle Moves (x10^6)		
	Case 1	**Case 2**	**Case 3**
	Boom Pos. A		
20%	0.26	0.13	0.13
30%	0.40	0.20	0.20
30%	0.40	0.20	0.20
20%	0.27	0.14	0.14
Subtotal, Boom Pos. A	1.33	0.67	0.67
	Boom Pos. B		
20%	0.27	0.40	0.26
30%	0.40	0.60	0.40
30%	0.40	0.60	0.40
20%	0.27	0.40	0.27
Subtotal, Boom Pos. B	1.34	2.00	1.33
	Boom Pos. C		
20%	0.26	0.26	0.40
30%	0.40	0.40	0.60
30%	0.40	0.40	0.60
20%	0.27	0.27	0.40
Subtotal, Boom Pos. C	1.33	1.33	2.00
TM, Boom Pos. A, B, and C	**4.00**	**4.00**	**4.00**

TM = Total Moves; See Section 3.2.12, also referred to as the structural design life.

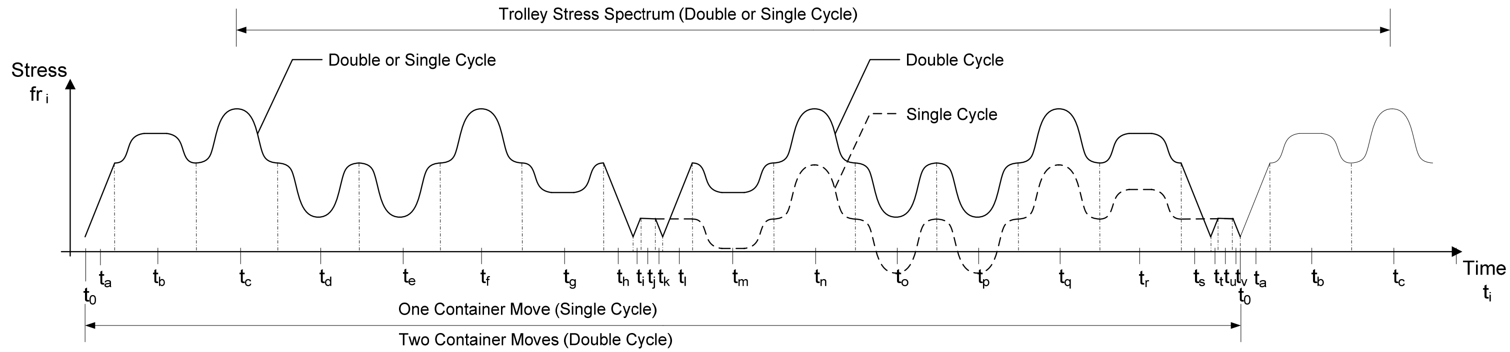
Figure 3.3: **Design cycle spectra**

3.10.7.1 In addition to the trolley moves shown above, the fatigue design shall consider a minimum of 200,000 boom cycles between Boom Pos. R and C.



Time	
t_a	lifting system is set on container; stress is due to trolley only
t_a to t_b	lifting system and container are lifted; stress is due to trolley plus lifting system and container plus impact
t_b to t_c	trolley travels
t_c to t_d	lifting system and container are lowered and set; stress is due to trolley only
t_d to t_e	lifting system is lifted
t_e to t_f	trolley returns
t_f to t_a	lifting system is set on container

Figure 3.4: Typical single-cycle stress spectrum



Time	Single Cycle Trolley Motion	Double Cycle Trolley Motion (*For Reference Only*)
t_0	at rest landside with lift system resting on the container	same as single cycle
t_a	hoist lift system and fatigue lifted load (LS + LLF)	“ “ “ “
t_b	accelerate (LATF) waterside to a constant speed	“ “ “ “
t_c	one waterside wheel travels up and over a bump (TWRP)	“ “ “ “
t_d	one landside wheel travels up and over a bump (-TWRP)	“ “ “ “
t_e	one waterside wheel travels down into and out of a valley (-TWRP)	“ “ “ “
t_f	one landside wheel travels down into and out of a valley (TWRP)	“ “ “ “
t_g	decelerate to a stop, (-LATF)	“ “ “ “
t_h	lower the load	“ “ “ “
t_i	hoist lift system	“ “ “ “
t_j	not applicable	travel slowly to another container on the ship
t_k	not applicable	lower LS to rest on container on the ship
t_l	not applicable	hoist LS + LLF
t_m	accelerate landside (-LATF) to a constant speed	same as single cycle
t_n	one landside wheel travels down into and out of a valley (TWRP)	“ “ “ “
t_o	one waterside wheel travels down into and out of a valley (-TWRP)	“ “ “ “
t_p	one landside wheel travels up and over a bump (-TWRP)	“ “ “ “
t_q	one waterside wheel travels up and over the bump (TWRP)	“ “ “ “
t_r	decelerate to a stop (LATF)	“ “ “ “
t_s	not applicable	lower load
t_t	not applicable	hoist lift system
t_u	not applicable	travel slowly to another container on the wharf
t_v	lower lift system to rest on container on the ground	same as single cycle
t_0	cycle repeats	

Figure 3.5: Typical trolley stress spectrum

3.10.8 Fluctuating stresses and the number of cycles of each fluctuation shall be determined from the stress spectra. Stress cycle value and counting shall be done by the "reservoir method." See BS 7608 "Annex H, Cycle counting by the reservoir method." Typical single and double cycle stress spectra are shown in this Section.

3.10.9 The applied cumulative damage at each critical point shall be calculated using Miner's rule:

$$L = \sum_{i=1}^{N} \left(f_{ri} \right)^{m} \times n_i \text{ , where}$$

L =	applied cumulative damage
f_{ri} =	ith stress range determined from the stress spectra using the reservoir method
m =	exponent from the tables in this Section
n_i =	number of occurrences of f_{ri} during the specified number of cycles for each load spectrum

3.10.10 The allowable cumulative damage for each joint classification, C_1 or C_2, and the corresponding reference allowable stress range,$\Delta\sigma_1$ or $\Delta\sigma_2$, at four million cycles are given in Table 3.4. C_2 values shall be used for fracture critical members, based on two standard deviations below the mean. C_1 values shall be used for non-fracture critical members, based on one standard deviation below the mean. (*Note: Previous versions of Liftech specifications used "K," according to BS 5400 (now obsolete); these Specifications use "C," according to BS 7608*.)

3.10.11 BS 7608, section 16.1 shall apply for tensile stress limitations: "The procedures given in [BS 7608] for deriving fatigue stresses should only be deemed to be valid if the calculated maximum fiber stress on the net area of a member, remote from geometric stress concentrations and excluding self-regulating stresses (such as residual or thermal stresses), does not exceed [the allowable operating stress shown in Section 3.6] under normal operating conditions and [the allowable overload stress shown in Section 3.6] under extreme loading conditions. In this context, the expected number of cycles exceeding normal operating conditions in the anticipated life of the structure [shall be no] greater than 100."

3.10.12 The values tabulated here for AWS D1.1 tubular details are close, but not identical, to those given in AWS D1.1. The tabulated values given here shall be used.

3.10.13 When a detail does not match a standard detail, two alternative methods may be used to determine the fatigue class:

Alternative 1: Prepare a stress analysis of the detail. See Section 3.4.11.8.

Alternative 2: Conduct tests in accordance with BS 7608 "Annex E, Fatigue testing and the use to test data to define design stresses."

3.10.14 Effect of Material Thickness—For a plate thickness or nominal bolt diameter, *t*, greater than 25 mm and, for plates, where the coefficient m is less than or equal to four, a reduced allowable cumulative damage, C_1' and C_2' shall be determined as follows.

$$C_1' = C_1 \times \left(\frac{25}{t}\right)^{(b \times m)} \qquad C_2' = C_2 \times \left(\frac{25}{t}\right)^{(b \times m)},$$

where "b" (usually 0.25 or 0.2) is as indicated in BS 7608 table 4 to table 10 for as-welded joints or BS 7608 section 16.3.5 for improved weld toes, or 0.25 for bolts.

For example: For a 50 mm plate at a BS 7608 table 3, type 3.5 weld with b = 0.25, the allowable cumulative damage would be factored as follows:

$$C_1' = C_1 \times \left(\frac{25}{50}\right)^{(0.25 \times 3)} = 0.59 \times C_1$$

And the allowable stress range would be factored by:

$$(0.59)^{\left(\frac{1}{3}\right)} = 0.84$$

Joint Details									
Detail Class BS 7608	**m**	**C_1 (NFCM)**	**C_2 (FCM)**	**$\Delta\sigma_1$ (NFCM)**	**$\Delta\sigma_2$ (FCM)**	**C_1 (NFCM)**	**C_2 (FCM)**	**$\Delta\sigma_1$ (NFCM)**	**$\Delta\sigma_2$ (FCM)**
		$(t/cm^2)^m$		**t/cm^2**		**$(N/mm^2)^m$**		**N/mm^2**	
B	4.0	1.67×10^{7}	1.09×10^{7}	1.43	1.29	1.54×10^{15}	1.01×10^{15}	140.1	126.1
C	3.5	7.24×10^{6}	4.53×10^{6}	1.18	1.04	6.76×10^{13}	4.23×10^{13}	116.2	101.6
D	3.0	2.61×10^{6}	1.61×10^{6}	0.87	0.74	2.46×10^{12}	1.52×10^{12}	85.1	72.4
E	3.0	1.96×10^{6}	1.10×10^{6}	0.79	0.65	1.85×10^{12}	1.04×10^{12}	77.3	63.8
F	3.0	1.11×10^{6}	6.71×10^{5}	0.65	0.55	1.04×10^{12}	6.33×10^{11}	63.9	54.1
F2	3.0	7.72×10^{5}	4.58×10^{5}	0.58	0.49	7.28×10^{11}	4.32×10^{11}	56.7	47.6
G	3.0	3.97×10^{5}	2.65×10^{5}	0.46	0.40	3.74×10^{11}	2.50×10^{11}	45.4	39.7
G2	3.0	2.64×10^{5}	1.57×10^{5}	0.40	0.34	2.49×10^{11}	1.48×10^{11}	39.7	33.3
W1	3.0	1.62×10^{5}	9.89×10^{4}	0.34	0.29	1.53×10^{11}	9.33×10^{10}	33.7	28.6
X	3.0	6.03×10^{5}	3.72×10^{5}	0.53	0.45	5.69×10^{11}	3.51×10^{11}	52.2	44.4
S_1	5.0	3.79×10^{6}	2.21×10^{6}	0.99	0.89	3.44×10^{16}	2.00×10^{16}	97.0	87.1
S_2	5.0	1.77×10^{6}	7.22×10^{5}	0.85	0.71	1.61×10^{16}	6.55×10^{15}	83.4	69.6
Detail Class AWS D1.1									
T-A	5.8	4.56×10^{7}	1.52×10^{7}	1.52	1.26	1.62×10^{19}	5.4×10^{18}	149.2	123.4
T-B	4.4	3.41×10^{6}	1.14×10^{6}	0.96	0.75	1.97×10^{15}	6.6×10^{14}	94.6	73.7
T-C1	4.1	2.01×10^{6}	6.69×10^{5}	0.85	0.65	2.94×10^{14}	9.79×10^{13}	82.9	63.4
T-C2	3.6	6.55×10^{5}	2.12×10^{5}	0.60	0.44	9.68×10^{12}	3.13×10^{12}	59.3	43.4
T-D	3.3	3.68×10^{5}	1.23×10^{5}	0.49	0.35	1.37×10^{12}	4.59×10^{11}	47.6	34.1
T-E	3.2	2.02×10^{5}	6.72×10^{4}	0.39	0.28	4.77×10^{11}	1.59×10^{11}	38.6	27.3
T-F	4.6	2.36×10^{5}	7.85×10^{4}	0.54	0.43	3.42×10^{14}	1.14×10^{14}	53.0	41.7
T-DT	4.4	3.71×10^{4}	1.23×10^{4}	0.35	0.27	2.15×10^{13}	7.12×10^{12}	33.8	26.3
T-ET	3.4	1.04×10^{4}	3.45×10^{3}	0.17	0.13	6.14×10^{10}	2.04×10^{10}	17.0	12.3
T-FT	4.2	1.57×10^{4}	5.22×10^{3}	0.27	0.21	3.63×10^{12}	1.21×10^{12}	26.2	20.2
T-K1	4.5	4.13×10^{2}	1.38×10^{2}	0.13	0.10	3.78×10^{11}	1.26×10^{11}	12.8	10.0
T-K2	4.3	2.59×10^{2}	8.13×10^{1}	0.11	0.08	9.48×10^{10}	2.98×10^{10}	10.4	7.9

NFCM is Non-Fracture Critical Members
FCM is Fracture Critical Members
The "T" preface is used to distinguish AWS D1.1 tubular class from BS 7608 class. Also see Section 3.10.3 for permissible alternative use of EN 1993-1-9.
Note: To convert $(t/cm^2)^m$ to $(N/mm^2)^m$ multiply C_1 or C_2 by $(98.066)^m$

Table 3.4: Allowable Cumulative Damage (Cd) and Reference Allowable Stress Range ($\Delta\sigma_d$) at 4×10^6 Cycles

3.10.15 Fatigue detail Classes G and G2 shall not be used on FCMs. All FCM details shall be F2 or better. Smooth transitions shall be provided at changes in section on FCMs.

3.10.16 Some typical acceptable and unacceptable details are shown in Appendix D.

3.10.17 Series Reliability—Special calculations shall be made for members in series. FCMs in series shall be verified to have the design reliability of at least 0.977. A single FCM subject to the design (allowable) cumulative damage, C_2, has a reliability of 0.977. If two or more members are in series as links of a chain, the combined reliability of the series of FCMs, the series of links, is the product of the reliability of each link. For example, if there are three links with reliabilities of 0.990, 0.999, and 0.991, the combined reliability would be $0.990 \times 0.999 \times 0.991 = 0.980$. Notice, if the ratio for each link is 0.40 or less, the series effect is negligible.

3.10.17.1 The reliability of elements in series shall be determined using fundamental principles of reliability analysis. The boom tension chords and tension zones of the frame are in series. The reliability of the series shall be at least 0.977. When a detail occurs on two sides, both sides shall be included in the series. The effects of bending shall be included.

3.10.17.2 Some judgment is required to identify a link. The link shall be the element closest to the test sample used to determine the BS 7608 values. The lowest class detail shall be used to determine the reliability of each link.

3.10.17.3 For the series calculations, the values in the Table 3.5 shall be used to determine the reliability of each link. This reliability will be a factor in the calculations for the series. Linear interpolations shall be used between ratios.

Detail	**RATIO L/C_2**			
	1.0	**0.8**	**0.6**	**0.4**
B, C, D, E, F, F2, G, G2, W1, and Tubular	0.977	0.993	0.999	1.000

Table 3.5: Fatigue Detail Reliability

3.10.17.4 A typical example of components in series is shown on Sheet S11 of Appendix D.

3.10.18 The calculations shall summarize the values of L, C_1, C_2 and the cumulative damage ratios $D = L/C_1$ or L/C_2. These ratios are a measure of the anticipated applied fatigue damage.

3.11 CONNECTION DESIGN

3.11.1 FCM connections shall be designed to resist artificial local loads imposed by a stress equal to the average of the allowable and the calculated stress, but they shall be designed for not less than 75% of the allowable strength of the member. Notice that whenever the calculated stresses are less than 50% of the allowable stress, the 75% requirement applies.

3.11.2 Stresses at weld throats shall be calculated as the vector sum of the individual stresses applied to the weld throat. For fatigue design when calculating the stress range, the vector difference of the greatest and least vector sum stress may be used instead of the algebraic difference.

3.11.3 Welded joint design shall conform to BS 7608, and for static loads only AWS D1.1.

3.11.4 For end-loaded fillet welds with lengths up to 60 times the leg dimension, it is allowed to take the effective length equal to the actual length. For lengths greater than 60 times the leg dimension, the effective length shall be limited to 60 times the leg dimension.

3.11.5 Bolted joint design shall conform to BS 7608, and to the AISC Specification using 0.9 times AISC allowable values. Prying action due to distortion of the connection details shall be considered. Bolts subject to fluctuating tensile stress shall be checked according to BS 7608. Bolts governed by fatigue strength shall comply with ASTM A325.

3.11.6 Eyebars and pin connected members shall be designed in accordance with the 1989 edition of AISC using 0.9 times AISC allowable values, and shall be checked for fatigue using either the allowable net section stress range for Class F details or the stress concentration factors and the stress range for Class B details at the face of the hole. The 1989 edition of AISC refers to the *Specification for Structural Steel for Buildings, Allowable Stress Design and Plastic Design, June 1, 1989, with Commentary.* If the net section is governed by fatigue, then all other proportions shall be increased on a basis consistent with the AISC requirements.

3.12 BOOM SUPPORT SYSTEM

3.12.1 See Section 3.3.3 and the Drawings. See Sections 4.12.3 for boom latch requirements and Section 4.13 for boom support and hold down requirements.

3.13 GANTRY SECURING DEVICES

3.13.1 Gantry Stowage Pins

3.13.1.1 The Crane shall be equipped with stowage pins which meet the following requirements:

3.13.1.2 Stowage pins will be engaged when the Crane is stowed.

3.13.1.3 Stowage pins shall mate with sockets installed on the gantry runway, as shown on the Drawings. The design of the stowage pin assemblies shall accommodate the maximum amount of motion allowed by the gantry wheels perpendicular to the rail. The location and adequacy of the stowage pin sockets shall be verified by the Contractor. The Contractor shall be responsible for ensuring the stowage pins fit in all wharf pockets.

3.13.1.4 Stowage pins shall be designed to hold the crane against the hurricane wind load stowed hurricane (WLSH) and wind load stowed storm (WLSN) loading, according to Table 2.8. For WLSN loading the design shall consider only one inboard stowage pin engaged at each rail.

3.13.1.5 The engagement mechanism shall be designed for ease of manual operation by one workman and shall not require a force of more than 200 N (45 lb) to disengage.

3.13.1.6 A mechanical lock shall be provided to maintain each pin in the disengaged position and limit switches shall be provided that will disable the gantry drive unless all pins are in the disengaged position. An additional mechanical lock and limit switch shall be provided as a positive indication that each stowage pin is fully lowered. The lock does not need to be designed for possible vertical loads at the stowage pin. An override shall be provided at the ground level operating panel to allow positioning the Crane for stowage pin engagement. A visual means shall be provided to indicate the engagement level of the stowage pin.

3.13.1.7 Stowage pins shall be mounted on brackets at the centerline of the sill beam. Stowage socket locations and dimensions are shown on the Drawings. The Contractor shall confirm pin locations and coordinate stowage pin locations and design with the Owner.

3.13.2 Tie-Downs

3.13.2.1 Tie-downs shall be used to resist overturning uplift forces caused by the design hurricane storm wind, WLSH—see Section 1.6.32. The tie-down system consists of the structural components forming the load path that transfers the tie-down force from the crane structure to the wharf structure, including but not limited to connection plates, pins, turnbuckles, link plates, wharf hardware, and wharf anchorage.

3.13.2.2 The location and details of the tie-downs are shown on the Drawings. The Contractor shall coordinate tie-down locations and design with the Owner. The Contractor shall be responsible for ensuring the tie-downs match and mate with the wharf hardware.

3.13.2.3 The design of the tie-downs shall be such that two persons without tools or additional equipment can attach all tie-downs on a crane to the mating wharf embedded attachments within 30 minutes. Similarly, the design shall be such that one person without tools or additional equipment can detach all tie-downs on a crane and make the crane ready for gantry travel within 30 minutes. The Contractor shall provide a time study with the design submittal demonstrating this requirement can be met.

3.13.2.4 A mechanical, electric, or hydraulic lift system shall be provided to lift and lower turnbuckle assemblies for ease of attaching turnbuckles in dock receptacles.

3.13.2.5 The tie-down system shall be designed for the load combinations given in Table 2.9, load cases ST8A and ST9A. The allowable stresses in structural components shall be 1.5 times the base stress given in Section 3.6. The allowable force in turnbuckles and other threaded or off-the-shelf components shall be the breaking strength of the component divided by: 2.0 for fabricated components and 2.5 for off-the-shelf components.

3.13.2.6 Twenty-five (25%) percent of turnbuckles shall be proof-tested to 125% of the factored design load. After the proof test, the turnbuckle shall have no permanent deformation and the threaded components shall be able to be turned easily for the full length of thread.

3.13.2.7 The effect of the crane structure deformation and the alignment of the tie-down components shall be considered in the tie-down system design. If there is more than one tie-down per crane corner, for instance, the deformation or misalignment of the crane structure may significantly affect the load distribution between the tie-downs. Additionally, the deformation and misalignment may result in unequal force distribution in the structural connections, including the tie-down turnbuckle and link pin plates, wharf hardware pin plates, embedded wharf hardware, etc. The effect of the following shall be considered in the tie-down system design:

3.13.2.7.1 Deformation displacements and rotations of the crane structure relative to the wharf, including but not limited to:

3.13.2.7.1.1 Deformation of the crane structure as determined by structural including member translations and rotations.

3.13.2.7.1.2 Displacements caused by clearances between the Crane and wharf, such as between crane wheels and rails and between crane stowage pins and wharf stowage pin sockets; such displacements shall be based on expected conditions, but shall be at least:

.1 Sill beam displacement in the trolley travel direction due to the total possible gap between the gantry rail and the wheel flange with one wheel flange against the rail

.2 Sill beam displacement in the gantry travel direction due to the total possible gap between the stowage pin and the stowage pin wharf hardware, with the stowage pin against one surface of the wharf stowage hardware

3.13.2.7.2 Extreme misalignment of the tie-down system components, for example, unequal gaps between connection plates at pin connections may result in an unequal load distribution between outer connection plates.

3.13.2.8 Owner-approved equalization methods such as mechanical equalizer beams or ductile yielding structural element systems, e.g., “ductile link” systems, may be used to equalize the loads between tie-downs when more than one tie-down is used per corner. Other methods may be proposed by the Contractor.

3.14 GANTRY FRAME DEFLECTIONS AND STIFFNESS

3.14.1 Deflection shall be defined as the calculated distance the point in question moves from the unloaded state to the loaded state relative to the global coordinate system. Model shall include effects of joint deformation.

3.14.2 The deflection requirements shall apply to Boom Pos. A, B, and C.

3.14.3 The specified vertical and lateral loads in this Section, Section 3.14, are parameters, and allowable deflections are based on performance of other recent cranes. Other loads, such as DL, shall not be included unless specifically shown.

3.14.4 The calculated vertical deflection at the maximum outreach due to a parameter load equal to (TL + LS + LL) applied to the boom with the trolley at the maximum outreach shall not exceed 12 in (300 mm).

3.14.5 Frame stiffness shall also be evaluated by applying a parameter lateral load equal to 0.30*(TL + LS + LL) in the trolley travel direction at the boom elevation and calculating horizontal displacements at the boom support connections. The calculated deflections shall not exceed 2 in (50 mm) parallel to the boom.

3.14.6 The structural stiffness of the gantry frame shall be adequate for proper operation of the Crane for all design load cases.

3.14.6.1 Ratios of the crane structure natural period of vibration in the trolley travel direction to the natural period of the hanging load and to the rated trolley acceleration time shall be designed to prevent the frame from experiencing magnified dynamic displacements due to trolley motion. Recent jumbo cranes with a natural period of the first mode of vibration in the direction parallel to the trolley travel motion less than 1.5 s have performed well.

3.14.6.2 Recent jumbo cranes have experienced magnified dynamic displacements due to gantry acceleration.

3.14.6.2.1 The calculated horizontal deflection in the gantry travel direction at the outreach, due to a parameter load equal to 0.05*(DL + TL + LS + LL) applied to the boom in the gantry travel direction, with the trolley located at the maximum outreach, shall not exceed 16 in (400 mm). The difference in elevation of the trolley rails shall not exceed 2 in (50 mm). The Engineer's calculations indicate that adding torsion frames between the boom trusses will help reduce the twist in the boom for meeting this requirement.

3.14.6.2.2 The Section 3.14.6.2.1 requirement is <u>not</u> expected to be adequate for operator comfort and operations. The operator's cab will move horizontally and rotate about the boom axis. Motions affect operator comfort, health, and productivity. Typically, cranes with the same load requirements of Section 3.14.6.2.1, but limited to 10 in (250 mm) calculated lateral deflections at the maximum outreach have performed well for operations. The Engineer's preliminary calculations indicate that it will be difficult to meet operational requirements by only increasing boom and frame stiffness, without resulting in excessive dead load.

3.14.6.2.2.1 The gantry drive system shall be designed to limit structural deflections during gantry travel with the boom in any position to normal industry standards. Accelerometers at the boom outreach and backreach and at the landside and waterside boom support beams may be required to provide structural response feedback for the gantry control system. The Contractor may increase the acceleration time on the gantry travel if needed for operator's comfort, and with the Owner's approval. However, this shall not affect the gantry drive sizing requirements described in Section 2.8.5.

3.14.6.2.2.2 Adjusting gantry acceleration and deceleration times to an integer multiple of the natural period of the first mode of vibration in the direction parallel to the gantry travel motion also helps to minimize these effects. This does not apply for E-stops. See Section 2.8.9. Any final adjustments shall be made at the Owner wharf during commissioning.

3.14.6.2.2.3 See Section 7.30 for anti-rack requirements.

3.15 CAMBER

3.15.1 Since there are three operating boom positions, Boom Pos. A, B, and C, the trolley runway cannot be cambered so the trolley path is approximately level when the trolley travels from the maximum backreach to the maximum outreach for all three positions.

3.15.2 The lift height for all cases shall be at least the height specified when the trolley is at any position over the vessel including the maximum outreach. The load combination shall be:

DL + TL + LS + LL

3.15.3 The camber of the boom shall not reduce the specified lift height of the crane with a loaded spreader or infringe on the FAA aircraft clearance requirement, when the boom is at any position.

3.15.4 Some boom camber shall be provided. The magnitudes and methods shall be developed during the design of the structure by the Contractor's responsible structural engineer. The Engineer's preliminary analysis indicates that some camber will be required to satisfy the Crane requirements and that optimum camber consists of a level boom between the landside and waterside boom supports and boom deflected up beyond the waterside boom supports with the boom in Pos. C. The Contractor shall submit the camber design early for approval by the Owner.

3.16 CRANE ALIGNMENT

3.16.1 The trolley travel path from the face of the ship fender to the maximum trolley outreach on the boom shall not vary from a line normal to the centerline of the waterside gantry rail by a static variation of more than 2" (50 mm), with the waterside gantry wheels centered on the rail. This shall be measured and recorded after erection at the Contractor's site and verified at the Owner's site by the Contractor using a theodolite or similar device.

3.16.1.1 See Section 10.3.6 for manufacturing and erection alignment criteria at the Contractor's site.

3.16.1.2 See Section 10.5.15 for demonstration requirements and criteria at the Owner's site.

3.16.2 The boom vertical and horizontal landside supports shall be capable of being adjusted to a minimum of 1.5 in (38 mm) each way, vertically and in the gantry travel direction, during erection.

3.17 STRUCTURAL MAINTENANCE PROGRAM

3.17.1 The fatigue criteria in this specification are based on producing a damage tolerant design. Because of the variation of fatigue performance and that usage may exceed the design conditions, there is a risk that a structure or component may fail in service. When fatigue cracks develop, the remaining structure should sustain the maximum working load without failure until the cracks are discovered. Satisfactory performance of the damage tolerant design, therefore, depends on adequate methods of fatigue crack detection and the ability to repair or replace the damaged component. The intent of this Section is to define a method of routinely inspecting for fatigue cracks to significantly improve the structural reliability.

3.17.2 Periodic structural inspections are required to detect cracks that have developed during the life of the Crane. The inspection intervals defined below are based on fracture mechanics calculations, reliability analysis, and the fact that fatigue cracks can be classified as infant and aging failures. The Delivery Inspection and Warranty Inspection should detect infant failures and subsequent periodic Maintenance inspections should detect aging failures. Infant failures are primarily due to deficient fabrication; underestimation of fatigue damage, which may be due to deficient design or excessive loading; or a combination of these. Aging failures are primarily due to cumulative damage from normal operations and properly designed and manufactured components.

3.17.3 Since the integrity of the structure depends on inspections, interpretation of the results, and the choice of repair, it is important for the Contractor and the Owner to review all reports. Copies of all inspection reports, reports of structural difficulties of any nature, and reports describing any modifications will be sent to the Contractor and to Liftech Consultants Inc. (See Section 1.11.3.2 or www.liftech.net for Liftech's mailing address.)

3.17.4 The Contractor shall submit a Structural Maintenance Program for review.

3.17.4.1 The program shall be based on the principles of fracture mechanics and shall include the following information for both infant and aging failures:

.1 Inspection intervals, based on aging failures
.2 Locations to be inspected
.3 NDT procedures to be used
.4 Reporting procedures
.5 Repair procedures
.6 Documentation showing the parameters used to determine the inspection intervals in accordance with the criteria specified below

3.17.4.2 Inspection methods shall be selected to detect fatigue cracks. Only critical locations need to be inspected by NDT methods such as MT, DPT, RT, and UT. Critical locations on all members are those locations where fatigue cracks, if any, would be expected to initiate. The inspected region shall extend a reasonable distance beyond critical points. MT shall be used at critical locations of fillet welds and UT shall be used at critical locations of butt welds. VT shall be used at all locations of potential fatigue cracks.

3.17.4.3 Inspection intervals shall be determined according to Table 3.6. Locations where the cumulative damage ratios are less than those for 24 years need not be included in the Structural Maintenance Program.

INSPECTION INTERVAL VS. CUMULATIVE DAMAGE RATIO
$D=L/C_1$ OR $D=L/C_2$

BS 7608 WELD CLASS	24 YEARS		12 YEARS		6 YEARS	
	NFCM	FCM	NFCM	FCM	NFCM	FCM
B, C, D, E, F, and F2	0.15–0.29	0.13–0.26	0.30–0.50	0.27–0.45	0.51–1.00	0.46–1.00
G and G2	0.21–0.41	Not allowed	0.42–0.70	Not allowed	0.71–1.00	Not allowed
W1 and Tubular	0.20–0.35	0.15–0.30	0.36–0.64	0.31–0.50	0.65–1.00	0.51–1.00

Table 3.6: Inspection Interval Criteria

3.17.4.4 The Structural Maintenance Program shall be reviewed by the Contractor's responsible structural engineer, and he shall certify in writing that he has reviewed the program and is satisfied with it. The program shall be included in the maintenance and inspection manual.

3.17.5 If a sea state rougher than the design sea state of Section 3.18 is encountered during the delivery voyage, the Contractor shall inform the Owner and a Delivery Inspection will be performed. The extent of the Delivery Inspection will be determined by the Owner. The Delivery Inspection will occur prior to commissioning. Within 30 days after the inspection, the Contractor shall submit a plan to repair any defects found. Upon the Owner's approval of the Contractor's plan, the Contractor shall repair the defects at his expense. The Owner's independent agency will inspect the repaired defects. If any of the repairs are not acceptable the Contractor shall make additional repairs as necessary. The costs of the inspection and additional repairs shall be borne by the Contractor.

3.17.6 The Contractor's responsible structural engineer or other qualified engineer shall perform a walkthrough visual inspection of the Crane after delivery and after removal of all sea-fastening and other temporary attachments and certify in writing that he reviewed the Crane and is satisfied with it. Alternatively, the Contractor may perform this inspection prior to shipment, but after all structural attachments are made, if he also submits a report describing the required sea-fastening removal inspection for the Owner to perform. The costs of the inspection and any repairs shall be borne by the Contractor.

3.17.7 Overload Inspections will be made in the event of an overload event that could reasonably be expected to have caused damage to the crane structure, including, but not limited to severe gantry collisions, ship-to-boom collisions, boom-to-boom collisions, boom travel rope failure, boom hanger failure, high-speed snag, and hurricane stowed wind loading (WLSH). The Owner will visually inspect the structure, using a competent person, at all structural details that would reasonably be expected to be damaged in such an event.

3.17.8 Unless agreed otherwise, Structural Maintenance Program inspections will be performed by an independent agency retained by the Owner and in accordance with the Structural Maintenance Program.

3.17.8.1 Annual Visual Inspections shall be included in the inspection manual (these inspections shall be more frequent if required by local or other governing safety agencies). The Owner will visually inspect the structure annually, using a competent person, at all FCMs and accessible NFCMs, according to the inspection manual.

3.17.8.2 The Warranty Inspection will be made prior to the end of the warranty period, but no earlier than 150,000 moves and no later than 200,000 moves (see Section 3.10.6 for the definition of a "move"). All FCM details and all details that are scheduled to be inspected at an interval of 24 years or less shall be inspected as described in Section 3.17.4.2. The inspection procedures, other than VT, used for the Warranty Inspection shall be the same as those used for subsequent Periodic Maintenance Inspections.

3.17.8.3 Subsequent Periodic Maintenance Inspections will be made according to the recommended inspection intervals from the Structural Maintenance Program. The first Periodic Maintenance Inspection period will begin after completion of the Warranty Inspection, described in Section 3.17.7.

3.17.8.4 Within 30 days after the Warranty Inspection or any Periodic Maintenance Inspection occurring during the structural warranty period, the Contractor shall submit a plan to repair any defects found. Upon the Owner's approval of the Contractor's plan, the Contractor shall repair the defects at his expense. The Owner's independent agency will inspect the repaired defects. If any of the repairs are not acceptable, the Contractor shall make additional repairs as necessary. The costs of the additional inspection and repairs shall be borne by the Contractor.

3.17.9 The Contractor shall provide permanent access ladders and platforms at all inspection locations, with inspection intervals of 12 years or less.

3.17.9.1 Access shall meet applicable safety laws and regulations.

3.17.9.2 Platforms or ladders may be used to provide access to more than one inspection location, for instance if the trolley or boom is travelled.

3.18 VOYAGE CRITERIA

3.18.1 The transportation procedures for the assembled crane and crane components shall be reviewed by the Contractor's responsible structural engineer.

3.18.2 The design shall comply with the requirements of Section 3.3. Gravity loads shall be applied to the un-braced structure. Environmental loads shall be applied to the braced structure.

3.18.3 All workmanship and attachments shall comply with the requirements of these specifications.

3.18.4 As a minimum, the following issues shall be considered:

.1 Vessel characteristics, including deadweight capacity
.2 Stowage arrangement and loading condition
.3 Initial stability including the GM corrected for the free surface effects, and static stability
.4 External restrictions such as sailing draft, air draft and beam
.5 Route and estimated departure date
.6 Design environmental criteria. This shall be for at least a seasonal 10 year return sea state and a 1-minute sustained wind speed, or equivalent, to provide the 5% probability of exceedance of wave height and wind speeds based on the Global Wave Statistics
.7 Expected ship motions and accelerations
.8 Wind force on the cargo and the vessel, including overturning moment
.9 Crane bracing and sea fastening of all cargo
.10 Static and dynamic deck loads
.11 Stability during loading, transport and off loading
.12 Loading and off-loading procedures and calculations
.13 Ballast
.14 Auxiliary equipment used during the loading and off-loading operations
.15 Pulling and braking forces
.16 Jacking methods and equipment
.17 Quay geometry, water depth, and tidal data
.18 Safety procedures and contingency plans

3.18.5 If the natural roll period of the loaded vessel is less than the shortest design wave period, then additional ship motions shall be considered for a set of sea states with the mean wave period ranging from the natural roll period minus one second to the natural roll period plus one second, including significant wave heights. If roll resonance in these alternative sea states results in more severe design accelerations, then these more severe accelerations shall be used.

3.18.6 The design forces shall be those due to the following effects. The linear and rotational components shall be included.

.1 Gravity
.2 Wind
.3 List (including list due to the design wind)
.4 Roll
.5 Trim
.6 Pitch
.7 Heave

3.18.7 The allowable stresses for maximum voyage conditions shall be 1.33 times the basic AISC allowable stresses.

3.18.8 Fatigue shall comply with Section 3.10. The cumulative damage due to voyage stresses combined with the cumulative damage due to the operating fatigue stresses described in Section 3.10 shall not exceed 125% of the values in Table 3.4.

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SECTION 4 MECHANICAL REQUIREMENTS

4.1 GENERAL REQUIREMENTS

4.1.1 Mechanical parts shall be designed to withstand all possible combinations of loading with appropriate durability and safety factors.

4.1.2 Mechanical parts shall have thermal ratings as required by the theoretical duty cycles defined in Section 2.10.

4.1.3 Parts shall be constructed so that they are readily accessible for easy repair, maintenance, lubrication, and inspection. The maintainability of each design shall be carefully considered throughout the project. See Section 8.

4.1.4 Fabricated and welded mechanical components shall meet the requirements of Section 3.

4.1.5 The design classifications and allowable stresses of the mechanical components shall be in accordance with FEM 3rd Edition Revised, 1998 for the classifications shown in Table 2.3. The assumption of a design life, as represented in Table 2.3, provides a minimum reliability for mechanical design with adequate and regular maintenance and inspection, and does not necessarily mean that the mechanism will no longer be fit for its purpose at the end of the design life.

4.1.6 The FEM classification of other mechanisms shall be determined by the Contractor in accordance with the required operating conditions and the lifetime intent. The selected classifications shall be submitted to the Owner for approval.

4.1.7 The application of FEM to container crane design is left to the judgment of the designer. Table 4.1 gives the minimum interpretation of FEM and the minimum load cases to be considered in the design of mechanical equipment. It is the Contractor's responsibility to consider all other applicable load cases. Refer to Section 1.6 for load definitions. The overload case of Table 4.1 is in addition to FEM cases of loading I, II and III. Allowable combined stress for the overload case is 81% of yield.

4.2 CALCULATIONS

4.2.1 Mechanical calculations and published catalog data shall be submitted demonstrating compliance of the mechanical systems and components with the requirements of these Specifications. Published catalog information shall define the rating criteria of standard catalog items and the safety or service factors applied. Mechanical calculations shall include at least the following:

.1 Table of contents
.2 Development of all loads
.3 Stress and fatigue calculations of all load bearing parts not having published catalog ratings
.4 Calculations verifying the rating adequacy of standard catalog items
.5 Calculations verifying that the required speeds, accelerations and decelerations will be attained
.6 Calculations verifying the traction requirements of the gantry drive at each boom position.
.7 Emergency stop analysis of all drives in accordance with these Specifications
.8 Snag load dynamic analysis
.9 Deflection and vibration calculations of machinery decks and platforms

Mechanism	Examples in Load Path	FEM Cases I & II	FEM Case III	Overload	Fatigue	FEM Class
Hoist Equipment	Drum, Pillow Blocks, Sheave Pins, List, Trim, Skew, and Snag Devices	LS+LLE CBLS+CBRL	STL	STL SN	LS+LL+LATT	M8
Trim/List/Skew		LS + Trim + 1.25 LLE	STL	STL SN	LS+LL	M8
Trolley Drive Machinery		TL+LS+LL+LATT + WLO	STL		TL+LS+LL+LATT + 50% WLO	M8
Trolley	Wheel Axles, Bumpers	TL+LS+LLE+ LATT+WLO+SKT TL+CBLS+CBRL+ LATT+WLO+SKT	TL+STL+WLO	TL+STL+WLO TL+LS+LLE+ WLO+COLL TL+SN	TL+LS+LL+LATT	M8
Gantry Drive	Wheel Axles, Bumpers, Shafting	DL+TL+LS+LLE+ LATT+50% WLO+ SKG+LATG DL+TL+LS+LLE+ LATT+WLO	DL+TL+STL+WLO	DL+TL+LS+WLS DL+TL+STL+WLO DL+TL+LS+LLE+ WLO+COLL	DL+TL+LS+LL+ LATT DL+TL+LS+ LATG+50% WLO	M5
Boom Travel	Drum, Pillow Blocks, Sheave Pins	Boom System DL+ WLO + Support wheel incline		Failure of one set of tow ropes Combined failure of slowdown and end-stop limit	Boom System DL + 50% WLO	M6
Spreader Cable Reel						M8
Headblock	Sheave Pins, Spreader Connections, and Twistlocks	LS+LLE+LATT+ WLO CBLS+CBRL+ LATT+WLO	STL SN	STL	LS+LL+LATT+ 50% WLO	M8

Table 4.1: Mechanical Load Combinations

4.3 MACHINERY MOUNTING & INSTALLATION

4.3.1 Groups of equipment, including but not limited to foot-mounted items such as motors, brakes, reducers, and pillow blocks, shall be mounted on independent rigid base frames with machined support pads at least 25 mm wider than the foot pads of the equipment on all sides. Equipment shall be mounted with at least 6 mm thick shims to allow for future realignment. Individual shims thicker than 3 mm shall not be used. All shims shall be stainless steel and no more than five shims shall be used on any one pad.

4.3.2 Base frames and their support shall be rigidly designed to minimize misalignment of gearing and other machinery elements due to dynamic deflections of the crane structure.

4.3.3 Major machinery and electrical components shall be furnished with lifting lugs suitable for attaching slings or other fittings for lifting.

4.3.4 The Contractor shall provide for the safety of personnel by providing ample space and safety devices adjacent to rotating equipment.

4.3.5 Floor openings around equipment shall have minimum clearance and shall have toe plates in accordance with applicable safety regulations.

4.3.6 Machinery elements such as motors, reducers, brakes, and pillow blocks shall have a means for maintaining alignment after final machinery alignment, such as taper dowel pins or a similar device subject to the Owner's approval.

4.3.7 Machinery bases, including pillow block mounts and brake mounts, shall have sufficient clearance to allow removal of brake discs, drums, and similar mounted equipment without extensive disassembly or any cutting.

4.4 MECHANICAL COMPONENTS

4.4.1 Bearings and Seals

4.4.1.1 The B-10 life of bearings shall be based on the FEM Design Classifications of this Section.

4.4.1.2 Bearing lives shall be calculated based on the load spectrums shown in Table 2.4 through Table 2.7. Maximum bearing load under any condition shall not exceed 125% of the basic static capacity of the bearing.

4.4.1.3 Pillow blocks shall be split on the bearing centerline. Pillow blocks or bearing cartridges made of cast iron shall not be used.

4.4.1.4 Bearings and housings shall be sealed by caps or spring loaded lip-garter type seals, and except for reducer bearings, provided with pressure grease lubrication. Bearing housings shall have removable end caps to allow periodic inspection of the shafts by non-destructive methods. Labyrinth seals are not acceptable except where used to grease protect the outside of oil seals (taconite seal).

4.4.1.5 Running surfaces of shafts under seals shall have a surface finish no rougher than 32 micro-inches (0.8 micro-meters).

4.4.1.6 All secondary systems, such as deflector rollers, cable chain wheels, etc., shall use sealed-for-life bearings to keep the number of lube fittings requiring maintenance to a practical minimum. Main motion motors shall not have sealed bearings.

4.4.1.7 For anti-friction bearing assemblies where the bearings may need to be removed, and where such bearings are to be reused, the shaft or bearing mounting design shall allow removal of the bearings with no load transferred through the rolling elements of the bearing.

4.4.1.8 Fits between bearings and their corresponding shafts and housings shall be per ANSI/ABMA 7, *Shaft and Housing Fits for Metric Radial Ball and Roller Bearings*, or the bearing manufacturer's recommendations. Alternate fits may be proposed by the Contractor for the Owner's consideration on a case by case basis.

4.4.1.9 Seals shall be of a size, fit and design as to be replaceable by SKF or National Seals. Contractor shall provide interchangeability definition with SKF or National Seals if other product is used.

4.4.1.9.1 Seal design and material shall be selected to achieve long seal life with good wear resistance properties. Seal material shall be fluoroelastomer (FKM/FPM) such as Viton or SKF Duralife unless the Contractor can demonstrate an alternate material provides equivalent or superior performance and the alternate material is approved by the Owner.

4.4.1.10 Thin-wall composite bushings shall not be used. Where composite bushings are proposed and approved by the Owner, they shall be centrifugally cast, arranged to prevent edge crushing, and have a minimum wall thickness of at least the following:

Bore (mm)		**Minimum Wall**
Over	**To**	**Thickness (mm)**
	50	3
50	80	6
80	120	9
120	180	12
180	250	15
250	315	19
315	400	22
>400		25

Table 4.2 - Minimum Wall Thickness for Composite Bushings

4.4.2 Equalizer Pins

4.4.2.1 The term “equalizer pin” shall refer to any pin, which is subject to slight relative motion due to frame action.

4.4.2.2 If steel-to-steel equalizer pin bearings are used, the pin hardness shall be at least 50 points HB harder than the housing hardness.

4.4.2.3 Pin diameters shall be reduced in internal nonbearing areas to facilitate removal.

4.4.2.4 The bearing areas on the pins shall be fine shot blasted and lubricated with MoS_2 grease prior to assembly.

4.4.2.5 Pins shall have annular grooves at the midpoint of each of the four bearing areas and each groove shall be independently lubricated by means of a high pressure grease fitting.

4.4.2.6 Pin keepers shall not restrain pin rotation unless the contractor can show a pin retention design acceptable to the Owner.

4.4.3 Keys and Keyways

4.4.3.1 Keys and keyways shall conform to ANSI B17.1, ANSI B17.2, ANSI B18.25.1M, or ANSI B18.25.2M.

4.4.4 Pins and Shafts

4.4.4.1 Shaft fillet radii sized for fatigue considerations shall be limited by tolerances and surface finish which shall be shown on the drawings.

4.4.4.2 For shafting which transmits a calculated reversing torque through couplings, gears, or other hub type connections, the fit between the shaft and the hub shall be an interference fit capable of transmitting the entire calculated torque at the least material condition without relying on a key.

4.4.4.3 Where possible, shaft fits shall comply with the preferred limits and fits given in ANSI B4.1 and ANSI B4.2 and shall be called out as such on the drawings.

4.4.4.4 Surface finish on shafts shall be suitable for the fits defined on the drawings and the service expected of the shaft (such as sliding in journals or rubbing against seals). Refer to Section 4.4.1.5.

4.4.4.5 Unless otherwise approved by the Owner, non-bearing areas of shafts shall have their diameter reduced at least 5mm (0.2in) to facilitate installation and removal of shafts and mating components. The reduced diameter area shall be painted to prevent corrosion.

4.4.4.6 Machined surfaces of shafts which are not painted shall be protected from corrosion using a means suitable to the Owner.

4.4.5 Fasteners

4.4.5.1 Fastenings shall be secured with locking devices.

4.4.5.2 Critical areas, such as trolley wheel keeper plates, shall have fastener groups wired together. Locknuts, lockwashers, set screws and snap rings are unacceptable on rotating equipment.

4.4.5.3 See Section 9.6.1 for the material requirements for small fastenings.

4.4.5.4 Threaded fasteners shall not be subjected to fluctuating tensile stresses unless approved by the Owner. Calculations for pretensioning of such fasteners shall be furnished.

4.4.6 Bumpers

4.4.6.1 Self-returning pneumatic-hydraulic bumpers shall be provided at each end of the trolley and they shall have sufficient energy absorbing capacity to stop the trolley with rated load at maximum lift traveling at full speed without structural or mechanical damage to the Crane or trolley. The bumpers may be located on the trolley or the end of the boom and the O-frame.

4.4.6.1.1 The Contractor shall consider the operator safety and limit the maximum deceleration experienced by the operator in a trolley collision event.

4.4.6.1.2 The maximum trolley deceleration rates shall be determined and the operator shall be restrained, using seat belt and shoulder harness, against the accelerations without restricting required motion for crane operation.

4.4.6.1.3 The effect of a swinging load shall also be considered; see Section 2.2.1.3.

4.4.6.1.4 Additional sources of energy absorption such as rope stretch, friction, and load lift, may be used in the analysis to select the bumpers. Means shall be provided to automatically remove power to the trolley drive motors and slow the trolley to no more than 50% of the rated trolley speed prior to impacting the bumpers given any single failure on the Crane. The bumper stroke shall be such that the maximum deceleration rate when impacting the bumpers shall be no greater than 4.8 m/s^2 (16 ft/s^2). Requirements of OSHA 29 CFR 1910.179(e)(3)(i) shall also be met.

4.4.6.2 The four corners of the gantry shall be provided with pneumatic-hydraulic bumpers of sufficient energy absorbing capacity to prevent damage when one Crane meets another, considering both Cranes at full speed under power without load, and to prevent damage when one Crane meets the end stops at full speed not under power and without load. Gantry bumpers when fully compressed shall extend at least 75 mm beyond any part of the trucks.

4.4.6.2.1 Where existing adjacent cranes run on different gantry rails, the Contractor shall provide bumper interface for the new and existing crane structures to meet this requirement. In this case, bumpers shall be located at the portal beam level and be laid out to clear all walkways and equipment, including deformation of the crane structure. Special structures shall be provided as required. Existing crane bumpers may be relocated. See the Drawings.

4.4.6.2.2 If option cranes 11 and 12 are later delivered, the Contractor shall provide a similar interface for Cranes 12 and 5.

4.4.6.3 Self-returning hydraulic bumpers shall be provided to prevent damage to the boom or crane structure in the event of a full speed collision between the boom and the boom stops.

4.4.6.4 The effects of reeving geometry and WLO shall be considered in the design of bumpers and stops.

4.4.6.5 Hydraulic bumpers shall be provided with protective covers over the rods and stainless steel safety chains or wires. Protective cover shall not be twisted or damaged by bumper piston's rotation when compressed and released. Hydraulic bumpers shall have marine corrosion protection.

4.5 BRAKES

4.5.1 Unless otherwise specified, all brakes, brake couplings, discs, calipers, pads, and corresponding hydraulic equipment and power units, where applicable, shall be manufactured by the approved brake system supplier.

4.5.2 Each brake shall be capable of stopping its respective drive under all operating and emergency conditions from maximum speed to zero unaided by motor regeneration. Each application shall be appropriately derated for the operating mode of the brake.

4.5.3 Certified dynamometer test results shall be provided to the Owner for each brake design used for the main hoist, trolley drive, boom travel, and gantry drives. Tests shall have been performed using similar inertias, speeds, and overhauling loads to those the brakes will see in service on the Crane. Where tests have been performed previously, they need not be repeated where results are provided which meet these requirements. Interpretations shall be provided with the results as needed.

4.5.4 The Contractor shall give due consideration to the maximum torque the machinery may be subjected to in the worst case. Maximum brake torques shall be controlled to prevent damage to the machinery and injurious deceleration rates.

4.5.4.1 The Contractor may propose, for the Owner's consideration, setting delays or other methods for limiting the maximum braking torque applied to the machinery while maintaining the braking redundancy.

4.5.4.2 Any design delay in the setting of the brakes shall have fail-safe provisions for immediate setting in the event of an over-speed.

4.5.5 The Contractor shall minimize the inertia of the rotating machinery. Brakes shall use the minimum size brake discs and couplings compatible with the requirements of these specifications. Additional caliper sets, rather than larger discs, shall be used if additional torque is required, provided the brake manufacturer demonstrates the energy capacity remains adequate for the specified criteria.

4.5.6 Each brake shall have a maintained manual release. Each manual release shall either disengage as a result of brake activation or shall be equipped with a limit switch preventing motion while maintained released.

4.5.7 Enclosed brakes outside the machinery house shall have space heaters. Calipers and brake discs shall be protected from the weather, including driving rain, using enclosures which are easily removable for inspection and maintenance. Brake enclosures shall weigh no more than 10 kg and shall take a single maintenance person no longer than 1 minute to remove or install.

4.5.8 Brakes shall be run-in until the lining is seated and the coefficient of friction stabilizes and is verified. Instructions and calibration charts shall be provided in the maintenance and inspection manual for future testing and recalibration the brakes.

4.5.9 Refer to Section 6.2.6 for brake logic and interlocks. Refer to Section 7.25.6 for automatic brake testing requirements.

~~**4.5.10 For the gantry drive motor brakes the brakes shall have automatic torque adjustments to prevent wheel skidding when the boom is in any position. Where torque adjustments require electrical power this shall be provided with battery backup where power loss causes the brakes to set. The brakes shall have multiple calipers.**~~ **[1]**

4.6 GEARING

4.6.1 General

4.6.1.1 These gearing requirements shall apply to all main crane motions and to those devices directly supporting those motions. Application shall include, as a minimum, main hoist, trolley drive, boom traverse, gantry drives, spreader cable reel, gantry cable reel, and other reducers rated at 10 kW or larger. Emergency drives may be excluded from these requirements.

4.6.1.2 Gears and gear reducers shall be the product of a company regularly engaged in the production of gear reducers used in crane service and must be approved by the Owner.

4.6.1.3 All gears shall be single helical or spiral bevel. All gears shall be carburized and hardened. All gears shall be finished by grinding. Flame or induction hardened gears are not acceptable.

4.6.1.4 For reversing drives, the maximum allowable assembled backlash between a stationary input shaft and the output shaft shall be 0.3 degrees at the output shaft.

4.6.1.5 Base mounted reducers shall be horizontally mounted and shall be doweled to their base frame.

4.6.1.6 Shaft mounted reducers are allowed only for the gantry drive. Where shaft mounted reducers are used, their mounting shall be designed for ease of removal and installation.

4.6.2 Rating

4.6.2.1 Gears shall be rated for durability and strength in accordance with the latest edition of ANSI/AGMA 2101-D04 or ANSI/AGMA 2003-C10. The Contractor shall submit detailed calculations and supporting drawings which demonstrate compliance with these requirements.

4.6.2.2 The minimum design lives and load spectra defined in Sections 2.9 and 2.10 shall be used and the lives for each load case shall be combined using Miner's Rule to determine the gearing lives. The loads in the load spectra have not been multiplied by safety factors.

4.6.2.3 Gear lives shall be calculated based on a unity reliability factor Cr = 1.0, R = 99% reliability. Strength life shall be four times the specified durability life.

4.6.2.4 Gears shall be rated utilizing the values presented in the AGMA Standards for the grade of material selected except that carburized gears shall not use an allowable yield strength greater than 1100 MPa.

4.6.2.5 The Contractor shall verify that major metallurgical factors affecting allowable stress numbers are met. Certification records shall be fully identified and traceable to the gears through serial numbers.

4.6.2.6 Gears and bearings shall be capable of absorbing overloads due to either the snag load or the motor stall torque load without incurring plastic deformation of the gear teeth or the rolling elements or the raceways of the bearings.

4.6.2.7 Bearings shall be rated using standard ABMA formulas for the appropriate load spectra shown on Table 2.4 through Table 2.7. Miner's Rule shall be used to calculate bearing lives. The loads given in Table 3.3 through Table 3.6 have not been multiplied by safety factors. Bearing lives shall be calculated based on R = 90% reliability and using a material factor and lubrication factor equal to unity. The Contractor shall supply detailed calculations which demonstrate all design decisions.

4.6.3 Efficiency

4.6.3.1 The following are the most optimistic gearing efficiencies and losses allowed in the design calculations. The Contractor shall use less optimistic figures if required to meet the specified performance. Drum winding and coupling losses are included in the gearing efficiencies.

4.6.3.2 Enclosed Reducers; Helical, or Spur if allowed:

Cold	.96 per reduction	For sizing motor torque for maximum load and acceleration
Warm	.98 per reduction	For duty cycle motor sizing
	.99 per reduction	For evaluating stopping and holding torque of brakes; see also ANSI B30.2

4.6.3.3 Open Gearing, where allowed by these specifications:

.96 per reduction	Except as noted below
.98 per reduction	For evaluating the stopping and holding torque of brakes

4.6.4 Carburized Gearing

4.6.4.1 Carburized gears shall be made from alloy steels, such as AISI 4320 or AISI 4820, with sufficient hardenability to obtain both good case and core properties. Impact strength, notch sensitivity, and ductility shall be considered. The steel alloy shall be selected, and the carburizing process shall be controlled, to obtain a microstructure which has both good strength and good fracture toughness. Alloys such as AISI 8620 or AISI 4620 are not acceptable for pinions larger than 100 mm diameter, gears larger than 200 mm diameter, or normal modules coarser than m_n = 4 mm.

4.6.4.2 Gear accuracy shall conform to the requirements of ANSI/AGMA 2009-B01 or ANSI/AGMA/ISO 1328. Single helical gears shall meet ISO grade 6 or better. Bevel gears shall meet AGMA accuracy grade B6 or better. Gear accuracy inspection records shall be provided for each gear. All records shall be fully identified and traceable to the gears through serial numbers.

4.6.4.3 Helical gears shall have an axial face contact ratio of at least 1.0.

4.6.4.4 Gear tooth geometry shall be full depth.

4.6.4.5 Undercut teeth are not acceptable.

4.6.4.6 Ground teeth shall be cut with protuberance hobs. Grinding steps in tooth flanks and grinding in root fillets of the teeth is prohibited.

4.6.4.7 Ground tooth surfaces shall have a finish of 0.8 microns or finer.

4.6.4.8 Ground gear teeth shall have tip chamfers, edge rounds and end rounds.

4.6.4.9 Each gear set shall have profile and helix modification designed to compensate for deflections, assembly tolerances, and manufacturing variations.

4.6.4.10 All carburized and hardened gears shall meet the requirements of Table 9 of ANSI/AGMA 2001-D04 except core hardness shall be Rc 30-40 for gears with a module of 12 mm or lower.

4.6.4.11 100% Nital etch inspection shall be performed on all ground gear teeth after grinding. Grinding burns are not acceptable.

4.6.4.12 100% magnetic particle inspection shall be performed on all gearing. Cracks are not acceptable.

4.6.5 Gearbox Housings

4.6.5.1 All gears shall be oil-bath lubricated and totally enclosed in welded steel or cast steel housings designed and constructed to prevent harmful distortions resulting from the transmitted loads or dynamic deflections of the Crane structure.

4.6.5.2 Housings shall be horizontally mounted and shall be flanged and split on the horizontal shaft plane, and shall employ a flat metal-to-metal joint maintained oil-tight without gaskets. Gantry reducers may have a vertical split line where the Contractor can demonstrate that leakage can be prevented.

4.6.5.3 Housings shall be equipped with breathers, oil level dip sticks with sight gage, drain valves and magnetic plugs which allow removal without loss of oil. Material for air breathers and dipsticks shall be stainless steel. The drain valve shall have sufficient access for draining, or shall be piped to a clear position. Breathers shall be mounted on stand-offs sufficient to prevent splashing oil from exiting the breathers.

4.6.5.4 Shaft bearings shall be lubricated with a continuous supply of oil during operation. Troughs which direct splashed oil into each bearing are acceptable. Provision shall be made to maintain partial submersion of the lower rolling elements of each bearing during extended idle periods.

4.6.5.5 Removable, gasketed inspection covers shall be provided in the housings for direct visual inspection of the full face width of all gear meshes. The inspection openings shall be a minimum of three-quarters of the gear face width.

4.6.5.6 Jackscrews, lifting lugs, eyebolts, and joint alignment dowels shall be provided to facilitate disassembly and reassembly of the housings.

4.6.5.7 Reducer housings shall be fabricated and the reducers assembled at the manufacturer's plant prior to shipment to the Contractor.

4.6.5.8 Gearbox shafts shall be sealed using a grease filled double seal arrangement with spring loaded lip-garter type seals. The seal arrangement shall vent excess grease to the outside and prevent grease from contaminating the gearbox oil. The outer seal shall be protected from damage and debris with a metal shield.

4.6.5.9 Axial displacement of reducer shafts shall be less than 0.3 mm after assembly.

4.6.6 Cooling

4.6.6.1 The maximum surface temperature of gearboxes shall not exceed 60°C (140°F).

4.6.6.2 Oil coolers or gearbox ventilation shall not be used except where the Contractor can demonstrate the gearbox cannot otherwise be designed to meet the maximum temperature requirement and where approved by the Owner.

4.6.7 Lubrication

4.6.7.1 Gear lubrication shall conform to the requirements of ANSI/AGMA 9005-E02. Gears shall be inspected after commissioning to demonstrate foreign particles or chips are not inside the gear housing.

4.6.7.2 Shaft bearings shall be lubricated with a continuous supply of oil during operation. Troughs which direct splashed oil into each bearing are acceptable. Provision shall be made to maintain partial submersion of the lower rolling elements of each bearing during extended idle periods.

4.6.7.3 Gearboxes rated over 10 kW (13 hp), with the exception of the gantry drive gearboxes and the boom travel gear box(es), shall have forced filtration systems which continuously circulate the lubrication oil through a high efficiency filter when crane control power is energized. The filtration system shall have a pressure differential gauge that flags a warning in the CMS when the filter requires replacement. Valves shall be supplied to isolate the filter for quick replacement without spilling oil.

4.6.8 Quality

4.6.8.1 Each pair of mating gears shall be checked for tooth contact in accordance with the latest edition of ISO/TR 10064-4. Permanent records of the contact patterns shall be made.

4.6.8.2 After acceptable contact patterns have been obtained, and prior to the installation of the gearboxes on the Crane, each pair of mating gears shall have the load side of several pinion and gear teeth coated with hard lacquer such as "DYKEM" layout fluid. The tooth contact pattern shall be then be inspected after full-load testing by observing the areas where the lacquer has worn off and the contact pattern on each gear mesh shall meet the requirements of ISO/TR 10064-4.

4.6.8.3 Oil samples shall be taken from each reducer during field testing. Refer to Section 10.

4.6.8.4 Reducers shall be properly protected to prevent damage or corrosion during shipment and the Contractor's responsible QC personnel shall notify the Owner's representative to allow for a joint inspection upon receipt. Reducers shall be inspected for corrosion, damage, and foreign particles or chips prior to filling and before and after commissioning.

4.7 DRUMS

4.7.1 Drums shall be fabricated with rolled steel plate or centrifugally cast steel with a solid through shaft or stub shafts with double end diaphragms.

4.7.2 Drum design shall prevent brinelling or corrugation of the rope grooves.

4.7.3 Drums shall have a pitch diameter not less than 40 rope diameters for the main hoist and trolley drives and 30 rope diameters for the boom travel.

4.7.4 Drum shell material shall be 345 MPa (50 ksi) minimum yield strength.

4.7.5 Rope grooves shall be accurately machined, with continuous groove profiles conforming to DIN 15 061 and the following:

.1 Groove depth shall be between 37% and 39% of the nominal rope diameter.
.2 Groove pitch distance shall be at least 112% of the nominal rope diameter.
.3 Groove radius shall be between 53% and 55% of the nominal rope diameter.
.4 After machining the rope grooves shall be hardened to a minimum of 280 BHN.
.5 The rope grooves shall be ground to a 6.3 microns finish or better.

4.7.6 Rope shall be spooled in one layer, with three unclamped full dead wraps remaining on the drums when the rope is fully paid out for normal operation and with two empty grooves remaining on the drums when all the rope is fully wrapped.

4.7.7 Ends of rope shall be clamped on two successive grooves with independent clamps. Each clamp shall only clamp one rope.

4.7.8 Design of the drum shell thickness beneath the grooves shall allow for rolling or casting tolerances. The net thickness under the groove shall not be less than that of the rope diameter unless approved by the Owner.

4.7.9 All drums shall have flanges at each end. Flanges shall be at least 25 mm thick and shall have an outside diameter of at least 125 mm greater than the pitch diameter of the drum.

4.7.10 Drums shall be stress relieved before machining.

4.7.11 Drums shall be statically balanced.

4.7.12 The floor space under wire rope drums shall be provided with removable drip pans to catch excessive grease or oil from the wire rope. The drip pans shall be removable for cleaning. The drip pans may be made up of multiple individual segments if required for ease of handling. The pans shall not be bolted.

4.8 REEVING

4.8.1 Wire Rope

4.8.1.1 Wire rope is a consumable item in crane operation and as a result its replacement costs shall be minimized. The specified wire rope minimum design lives shall be achieved through crane and reeving design features using wire rope as specified. The wire rope shall be compacted, galvanized, and pressure lubricated. See Sections 4.9.4 ,4.11.3, and 4.12.2 for main hoist, boom travel, and trolley tow rope design requirements.

4.8.1.2 Wire rope shall be designed for operation around sheaves and drums and shall be the construction recommended by the wire rope manufacturer subject to the Owner's approval.

4.8.1.3 All ropes shall be sized to have a safety factor based on the manufacturer's published catalog breaking strength with reeving efficiency considered.

4.8.1.4 Warranty: the wire ropes shall be guaranteed to be free of rust other than on the exposed surface of the wires for a period of 5 years.

4.8.2 Sheaves

4.8.2.1 The sheave losses used in calculating reeving efficiency shall be based on the following minimum ratio of stress in rope unwinding from each sheave to the stress in the rope winding on to the sheave, K:

Sheave Pitch Diameter to Rope Diameter	≥ 30:1	≥ 24:1
K Factor for Anti-Friction Bearings	1.015	1.02

4.8.2.2 Sheave mountings shall be designed so that the complete assembly including bearings and shafts can be removed as a unit. Headblock mounted sheave assemblies may be excluded from this requirement. For mounting assemblies above ground level, the assembly shall be accessible by one of the installed service hoists.

4.8.2.3 Sheaves shall be positioned such that the wire rope travel distance between adjacent sheaves is greater than the maximum acceleration distance of the rope unless otherwise approved by the Owner in writing.

4.8.2.4 Reverse or out of plane bends are not allowed without the specific written approval of the Owner.

4.8.2.5 Wire rope sheaves shall be machined from forged (rolled) or cast steel with rope groove contour per the AIST Specification, except that the groove radius shall be between 0.53 and 0.55 times the nominal rope diameter for sheaves with a groove radius 12 mm (1/2 in) or greater and 0.53 times the nominal rope diameter with a maximum tolerance of +0.4 mm / -0.0 mm for sheaves with a groove radius smaller than 12 mm (1/2 in). The surface finish of the rope grooves shall be no rougher than 3.2 microns. Rope grooves shall have a minimum surface hardness of at least 50 Rc to a depth of 2 mm and a minimum hardness of at least 40 Rc at a depth of 5 mm from the surface. The sheave material and hardening process used shall be submitted to the Owner for approval. Fabricated sheaves are not acceptable.

4.8.2.6 Sheaves shall have at least two holes in their webs to facilitate handling.

4.8.2.7 Sheaves shall have substantial, close-fitting guards around the rope contact area, which shall prevent the rope from leaving the sheave groove under any condition of slack or bouncing rope. These guards shall also be used to retain grease or oil thrown off the wire rope during operation. The guards shall be removable for cleaning without unreeving the rope. The guards shall be designed to minimize pinch points and surfaces which may damage the rope.

4.8.2.8 Sheaves shall be preferably equipped with non-adjustable tapered roller bearings with seals. The amount of axial play shall be calculated by the Contractor and is subject to the Owner's approval.

4.8.3 Fittings

4.8.3.1 Solid thimbles with wire rope clips or open wedge sockets with wire rope clips shall be used unless otherwise specified.

4.8.3.2 Speltered sockets shall not be used.

4.8.4 Slap Blocks and Deflector Rollers

4.8.4.1 Replaceable ultra-high molecular weight (UHMW) polyethylene anti-friction material shall be provided to prevent bouncing wire rope from premature wearing or from damaging other components. All UHMW material shall comply with ASTM D4020 and is subject to the Owner's approval. In addition to the ASTM requirements, the UHMW material shall have a density in the 0.929 to 0.939 G/CC range and an Intrinsic Viscosity (IV) value greater than 24. The material shall be UV protected for its expected life.

4.8.4.1.1 See Section 4.11.8.2 for additional catenary trolley UHMW requirements.

4.8.4.2 Rollers or sheaves with anti-friction bearings and seals shall be provided as necessary to prevent running wire rope from contacting any obstruction. The roller surface in contact with the ropes shall be an easily replaceable Owner-accepted anti-friction material sleeve at least 12 mm (1/2 in) thick. All sleeves shall be of the same diameter and equal sleeve length. For intermittent contact with sagging running wire ropes, individual interchangeable UHMW polyethylene discs rotating directly on polished stainless steel shafts shall be used. Sheaves shall be machined from solid Owner-accepted anti-friction materials and provided with anti-friction bearings and seals. Sheave and roller inertia should be considered to insure that slippage does not occur while the rope accelerates the sheave or roller.

4.8.4.3 Where the contractor has experience with nylon sheaves or other plastic sheaves these may be presented along with the experience record for consideration by the Owner.

4.8.5 Fleet Angles

4.8.5.1 The maximum fleet angle to drums shall not exceed 2.5° to the axis of grooving at the point of tangency. No contact between the ropes and groove tips or between adjacent ropes shall be allowed.

4.8.5.2 The maximum fleet angle to sheaves with a constant fleet angle or where the fleet angle does not pass through zero degrees near the midpoint of normal travel shall not exceed 2.5°.

4.8.5.3 The maximum fleet angle to sheaves where the fleet angle varies approximately equal about either side of zero degrees during normal travel shall not exceed 3.0°.

4.8.5.4 The fleet angle between the trolley and headblock sheaves may exceed 3.0° when the headblock is within 3 m (10 ft) of its highest position but shall not exceed 3.5° or the rubbing angle of the sheave groove, whichever is less.

4.8.5.5 When the sheave axles are mounted more than 15° from the horizontal plane, running wire rope shall be supported by auxiliary sheaves with a pitch diameter of at least 10 times the rope diameter to prevent the wire rope from jumping off the sheaves. Ropes shall maintain contact with these auxiliary sheaves at all times.

4.9 MAIN HOIST SYSTEM

4.9.1 Main Hoist Machinery - The main hoist machinery concept described here is the same as used on the existing PED crane main hoist machinery.

4.9.1.1 The main hoist machinery shall consist of two electric motors with two disc brake assemblies, driving through two base mounted helical gear reduction units directly connected to each end of the machine grooved main hoist drum.

4.9.1.2 The main hoist machinery shall be mounted on two rigid bases and located in the frame machinery house.

4.9.1.3 The single rope drum driven by base mounted reducers shall be directly connected to and supported by the low speed shafts of the reducers using flexible couplings bolted to the end diaphragms of the drum. One of the drum couplings shall be modified to axially locate the hoist drum.

4.9.1.4 Main hoist couplings shall have a service factor of at least 2.0 based on the manufacturer's catalog rating and the transmitted load for load combination LS + LLE.

4.9.2 Main Hoist High Speed Brakes

4.9.2.1 Each disc brake assembly shall consist of a one or more spring-set thruster-released calipers acting on a single brake disc. The brake disc shall be mounted directly on the main hoist reducer high speed shaft extension, independent of the motor coupling. A special coupling having the brake disc mounted on a rigid hub will be acceptable subject to approval of the specific coupling proposed. Removal of a disc shall not require moving motors or reducers.

4.9.2.2 Each high-speed brake assembly shall have a dynamic rating equal to at least 100% of the torque required when hoisting the rated load (RL) or cargo beam rated load (CBRL), whichever is greater. Refer to Section 2.6.

4.9.2.3 Each brake shall have sufficient torque and energy absorption capacity to bring the hoist with rated load to a complete stop from maximum rated speed under emergency stop conditions. The combined torque and energy absorption capability of both brakes shall be sufficient to stop a runaway rated load traveling at the speed that trips the overspeed switch initiating an emergency stop. All the energy shall be absorbed by the brakes alone. No energy shall be assumed to be absorbed electrically or by any other means. The brakes shall remain operable following such an event. Brake response time from loss of power shall be considered.

4.9.3 Main Hoist Low Speed Brakes – Not required due to redundant hoist braking and reducer load paths

4.9.4 Main Hoist Reeving

4.9.4.1 Main hoist ropes shall have the following minimum safety factors

.1 Five (5.0) with a load of LS + LLE with eccentricity in the longitudinal (gantry travel) direction only
.2 Five (5.0) with a load of CBLS + CBRL

4.9.4.2 The main hoist rope reeving system shall be designed such that 90% of the ropes achieve a minimum life of 2,000 hoist hours.

4.9.4.3 Main hoist running sheaves shall have a minimum pitch diameter of 30 rope diameters for the main hoist. This pitch diameter is a minimum and may need to be increased to achieve the specified reeving system design life requirements.

4.9.4.4 The effect of operating wind load (WLO) in all horizontal directions shall be considered in designing clearances for the wire rope.

4.9.4.5 The trolley shall be the fleet-through type. Main hoist ropes shall be continuous from the drum through the system and back to the drum. Both ends of each hoist rope shall be secured to the drum to facilitate rereeving. The midpoint of each rope shall be secured on the gantry frame, in the machinery house. The rope attachments shall be capable of releasing to allow rereeving from the machinery house. Sheaves or rollers required for rereeving shall be permanently mounted.

4.9.4.6 The reeving geometry shall be such that with no list of the ship, no hoist ropes shall contact the clearance envelope shown on Crane/Ship Clearance drawing in the Drawings. When the ship is listed 1° in either direction, the live, running hoist ropes shall not contact the clearance envelope shown on the Crane/Ship Clearance Drawing.

4.9.4.7 The slack rope system defined in Section 6.2.5 shall prevent the generation of slack rope such that these conditions are met when landing on the target container at full masterswitch reference in the lowering direction.

4.9.4.8 The hoist reeving geometry shall be symmetrical about the centerline of the Crane in the trolley travel direction.

4.9.5 Snag Protection

4.9.5.1 Snag control shall be provided to limit mechanical and structural loads to their design limits. The snag control device shall have the following features:

.1 Be hydraulic.
.2 Absorb energy by fluid flow over relief valves or by a functionally similar hydraulic circuit.
.3 Allow for powered reset after a snag incident. Replacement of parts, manual adjustment or manual charging of an accumulator does not meet the intent of this requirement.
.4 Automatically compensate for internal leakage. External leakage is not acceptable.
.5 Meet all the requirements of the hydraulic section of this Specification.

4.9.5.2 Snag device shall be set not to trip for any rope load less than 110% of any operating rope load including design impact and eccentricity. In addition to the Operating Conditions shown in Section 2.11, the “high fifth wheel” condition shall be considered.

4.9.5.3 The Electrical Control Supplier shall certify motor and brake response times used in the snag analysis. Chart recording taken prior to shipping from the erection site shall verify this data.

4.9.5.4 A convenient means shall be provided for maintenance personnel to periodically field-verify pressure setting of relief valves. Verification procedures shall be included in the Maintenance Instruction Manual, and demonstrated prior to shipping from the erection site. Verification of relief valve settings shall be performed on the Crane using installed equipment and shall not require the use of additional equipment other than common hand tools.

4.9.5.5 Snag analysis shall consider the activating time of relief valves. Response time shall be certified by the valve manufacturer.

4.9.5.6 The snag analysis shall investigate all possible snag load combinations to ensure sufficient energy absorbing capabilities. The minimum snag and two blocking cases to be investigated are:

.1 Two blocking empty spreader and headblock at the full speed; spreader at maximum trim and list.
.2 Jamming one side (two ropes) in ship’s cell, 18 m above gantry rail elevation, at full speed with an empty spreader
.3 Jamming both sides (four ropes) in ship’s cell, 18 m above gantry rail elevation, at full speed with an empty spreader

4.9.5.7 The snag device shall be demonstrated prior to shipping from the erection site as well as at crane acceptance testing.

4.9.5.8 The snag device shall be located in the machinery house. See Section 4.9.5.9 for trim/list/skew requirements.

4.9.5.9 Trim, List, and Skew Micro-Motions

4.9.5.9.1 The Crane shall be provided with mechanisms to adjust the trim and list of the LS + LLE to ±3° from horizontal, and a mechanism to adjust the skew about a vertical axis to ±3°. These mechanisms shall be powered and independently controlled from the operator's cab. Each mechanism shall have a digital readout, visible to the operator, which indicates the mid-point and travel positions. The readout may be included in the operator cab CMS screen provided it is easily readable whenever the operator actuates the trim/list/skew mechanism. Each mechanism shall have a positive means to maintain the selected spreader position under all operating conditions, including the main hoist stall condition. Travel time from center to maximum list, trim, or skew shall be between 5 s and 10 s. A means shall be provided to allow the operator to independently zero each micro motion, or alternatively, at his option, to zero all motions at once.

4.9.5.9.2 The trim, list, and skew mechanisms shall be located in the machinery house and integrated with the snag protection system. Externally mounted, resettable, absolute encoders shall be mounted on each actuator.

4.9.5.9.3 Maintenance personnel shall be capable of establishing a new "spreader home" position within a rope position of ±6 in (±150 mm). Actuator stroke shall be sufficient to accommodate the extreme combination travel of trim, list, skew, and homing in addition to snag.

4.9.5.9.4 A local operating station complying with the requirements of Section 6.4.2.3 shall be provided near the micro-motion system to allow maintenance personnel to extend and retract individual actuators and set the home position. Refer to Section 7.2.4.

4.9.5.9.5 To maintain sufficient clearance between the headblock service platform and the trolley structure opening no headblock list is allowed above the 125' hoist elevation when the hoist and trolley are prevented from operation, unless approved by the Owner.

4.10 LIFTING SYSTEM

4.10.1 Sheave Headblock

4.10.1.1 The Contractor shall be responsible for the interface between the sheave headblock and the spreader. The Owner requires detailed input into the design to ensure the operation and maintenance requirements meet the Owner's needs. Headblock design and details shall be approved by the Owner prior to manufacture.

4.10.1.2 The headblock to spreader interface shall be standardized and the manufacturing tolerances held sufficiently tight for interchangeability with all, spreaders and cargo beams.

4.10.1.3 Each headblock shall consist of a sheave hoist blocks and guarded sheaves that are permanently reeved into the main hoist.

4.10.1.4 A prime consideration in the design of the headblock, with its associated sheaves and sheave guards, will be the prevention of surfaces, pinch points, or other objects which may damage the main hoist ropes when they are slack.

4.10.1.5 The headblock shall not exceed 2,150 mm (7 ft) in width. Outside surfaces shall be smooth and without discontinuities to prevent snagging on adjacent containers, cell guides or other structures.

4.10.1.6 Each headblock structure shall comply with Section 3. In addition, the design accelerations, both vertically and horizontally, imposed on the headblock from the spreader contacting containers or the ship's structure (cell guides) shall be a minimum of ten (10) times gravity or the spreader manufacturer's recommendation, whichever is greater. The headblock structure design shall also consider single sided snag while caught in cell guides. As a minimum the headblock structure shall be designed to withstand a full snag wire rope load at angles of four (4) times the maximum trim and/or list angles defined in this Specification without deformation.

4.10.1.7 The headblock weight shall be sufficient to allow stable controlled hoisting and lowering anywhere on the boom without a spreader or cargo beam attached.

4.10.1.8 The centerline spacing of the side rope falls shall be between 5,700 mm and 5,500 mm.

4.10.1.9 The headblock shall be designed for quick manual connection to the telescoping spreader using heavy duty twist locks.

4.10.1.10 The connection between the headblock and spreader shall be designed for the specified load combinations including list, trim, snag, eccentricity, and trolley acceleration and impact forces.

4.10.1.11 Locking devices shall be provided at each point of connection to the spreader.

4.10.1.12 See Section 5.8 for electrical requirements.

4.10.1.13 A heavy duty personnel platform with adequate head room and floor space for four standing men shall be provided.

.1 Adequate headroom to protect standing personnel shall be provided when the headblock is subjected to a full dynamic two blocked event.
.2 The platform shall be enclosed by handrails with gravity closed gates. All access gates shall be gravity closed split cylinder type with heavy duty stainless steel spring and an automatic positive latching system. Hinges and latches must withstand the high shock loads imposed on the spreader. Gate latches shall be positive.
.3 Screens shall be provided to prevent personnel contact with running ropes and turning sheaves.
.4 The platform shall be accessible from both waterside and landside, with the spreader at wharf level.
.5 Access ladders shall be provided on the spreader. The spreader ladders shall meet the requirements of Section 7.5, including the requirement for non-slip ladder rungs.
.6 The platform shall have a heavy duty cone basket with minimum volume of 0.25 m^3, with a hinged cover that can be used as a seat. The cover shall positively latch in place to prevent opening during container handling operations.
.7 The platform shall have fall arrest anchor points as described in Section 7.6.
.8 The headblock personnel platform is to be used as a secondary means to transport personnel between ground level and the trolley. With the hoist "two blocked" against the trolley access to and from the trolley frame is by a ladder from the trolley mating with the headblock platform. Access to the cab from the trolley is down a vertical caged ladder down to the rear platform at the cab access level.
.9 The size and layout of the headblock platform shall be coordinated with the layout of the headblock landing opening in the trolley deck and the short ladder trolley access. See the Drawings.
.10 An emergency stop pushbutton shall be provided within the personnel platform.

4.10.2 Telescoping Spreader

4.10.2.1 Spreaders shall be Bromma Separating Twin-Twenty Telescopic STS45.

4.10.2.2 The following features shall be provided:

.1 SCS control system
.2 Height Indication System
.3 Brosa Force sensor washers in twistlocks for load weighing
.4 TTDS with by-pass
.5 HS-14 rotary actuators

.6 Two (2) three-light LED panels
.7 Cell guide sensors
.8 Flipper up sensors
.9 Low profile design with high strength steel
.10 Twin 20’ protection – electronic sensor
.11 Auto positioning using inductive proximity limit switches.
.12 Inductive proximity limit switches
.13 Emergency gear
.14 Over-height speed loader adaptor attachment brackets
.15 Center twist lock housings with additional float
.16 Main junction box on top and protected
.17 All attachment shackles

4.10.2.3 All spreaders supplied shall mate with all the headblocks provided.

4.10.2.4 The spreader shall have ladders on the both sides that mate with those on the headblock. Ladders shall meet the requirements of Section 7.5 including anti-slip rungs.

4.10.2.5 The spreader structure shall comply with Section 3, except the number of fatigue cycles may be according to the spreader manufacturer’s standard.

4.10.2.6 All structural steel shall be easily weldable by field welding using welders with ordinary qualifications.

4.10.2.7 Spreader shall be provided with lifting padeyes and lifting gears for attachment of irregular or damaged loads.

.1 Four (4) padeyes shall be provided on the spreader end sections in the vicinity of the twistlock housings.
.2 Four (4) additional padeyes shall be provided on the spreader center section approximately 2,600 mm (8.5 ft) either side of center.
.3 Each padeye shall be designed for 25 t and be suitable for attaching a 25 t shackle with slings and hooks.
.4 Each padeye shall be clearly labeled with its capacity and loading requirements.

4.10.2.8 The spreader shall be primed and painted in accordance with Section 9.6.1.

.1 The flipper color shall be “Fluorescent Yellow”.
.2 Lettering showing the safe working load (SWL) in long tons (LT) shall be durably painted on each side of the center section of the spreader.
.3 Spreaders shall be consecutively numbered in the same sequence as their serial numbers, in large lettering, at least 100 mm (4 in) high. See Section 1.1 for spreader numbering.

4.10.2.9 See Section 5.8 for electrical requirements.

4.10.3 Heavy Lift Cargo Beam

4.10.3.1 Heavy lift cargo beams for lifting non-containerized cargo shall be supplied according to Section 1.1.

4.10.3.2 The cargo beam shall comply with Section 3.

4.10.3.3 The cargo beam shall be designed for the maximum CBRL defined in Section 1.6.2.

4.10.3.4 The minimum CBRL defined in Section 2.6.1.2 shall have unrestricted trolley travel.

4.10.3.5 The cargo beam shall have provisions for connection to the headblock identical to those of the telescoping spreader.

4.10.3.6 The length of the beam shall not exceed the length of a 20’ container.

4.10.3.7 A balanced, swivel safety single cargo hook with heavy duty, spring set latch shall be suspended from the center of the beam. Smaller, similar cargo hooks shall be provided on the underside of the cargo beam at each end. Each end hook shall be designed for one-half the cargo beam capacity at 45° sling angle. The cargo hooks shall comply with ANSI/ASME B30.10, *Hooks*.

4.10.3.8 The SWL of the cargo beam shall be displayed in long tons (LT) on each side of the cargo beam in large letters. The end hook capacity shall be displayed adjacent to each end hook on both sides of the beam.

4.10.3.9 The beam shall be designed to be free standing on the wharf with the hook clear of the ground.

4.10.3.10 The beam shall have forklift pockets suitable for handling by the equipment at the Owner's Facility.

4.10.4 Spreader Over-Height Adaptor

4.10.4.1 Over-height adaptors shall be provided which quickly attach and detach from the spreader and extend the twistlock down an additional 6'-0" (1,829 mm) of height for handling containers and flat-racks with irregular upper surfaces. Adapters shall extend with the spreader from 20 ft to 45 ft.

4.10.4.2 The over-height adapter shall be supplied by the spreader manufacturer, comply with the requirements of Section 3, and have sufficient capacity for the LLS and LLES load conditions. The SWL of the over-height adapter shall be displayed on each side of the adapter in large letters.

4.11 TROLLEY SYSTEM

4.11.1 Trolley Drive Machinery

4.11.1.1 Trolley drive gearing, couplings and shafting shall be designed for reversing loads. Fits shall transmit motor stall torque in the least material condition without relying on the key fit.

4.11.1.2 The tow ropes drive shall be mounted on a single rigid base located in the boom mounted trolley machinery house and shall consist of a motor and brake driving machined grooved drums through an enclosed base mounted helical gear reducer. Trolley drive machinery supports shall not reduce headroom over the central trolley access platform.

4.11.1.3 Rope drum(s) shall be driven by a base mounted reducer and shall be directly connected to and supported by the slow speed shaft of the reducer using a flexible drum coupling bolted to the diaphragm of the drum(s).

4.11.1.4 Trolley couplings shall have a service factor of at least 1.5 based on the manufacturer's catalog rating and the transmitted load for combinations OP1 and OP2.

4.11.1.5 A spring set thruster released caliper disc brake assembly shall be provided with a dynamic rating equal to at least 100% of the motor's peak accelerating torque. The trolley brake shall have the thermal capability to stop the trolley from rated speed with rated load at maximum elevation with a following WLO two times in succession under emergency stop conditions.

4.11.2 Trolley Configuration

4.11.2.1 The trolley shall be of the fleet-through type with the hoist sheaves supported on a welded steel structural frame carried on steel wheels with replaceable axles. The structural frame shall comply with Section 3.

4.11.2.2 The trolley shall be rope towed.

4.11.2.3 The deck shall be covered with galvanized industrial platform grating secured by welding. The welds shall be cleaned and coated in accordance with Section 9.6.1.

4.11.2.4 The overall trolley width shall not infringe on the clearance requirements shown in on the Crane/Ship Clearance Drawing.

4.11.2.5 Drop lugs shall be provided to support the trolley and limit the drop to 12 mm (1/2 in) if an axle fails.

4.11.2.6 Jacking lugs shall be provided which will allow axle replacement at any point of trolley travel.

4.11.2.7 A positive means shall be provided to prevent wheels from lifting off the rails.

4.11.2.8 The trolley shall be stable when subjected to hoist stall.

4.11.2.9 The trolley shall be stable in all load configurations. No wheel on the trolley is allowed to lift.

4.11.2.10 Trolley mounted machinery, including the trolley wheel and sheave assemblies, shall be accessible by the trolley drive machinery house service crane through adequately sized hatches in the machinery house floor for removal and lowering to the wharf.

4.11.2.11 The center area of the trolley structure over the suspended headblock shall be clear so that a "two blocked" headblock shall still have standing room clearance for personnel on the headblock service platform.

4.11.2.12 The opening at the center of the trolley shall be sufficient to allow the service platform on the headblock to enter with a minimum of 12 in (300 cm) of clearance all around. A space shall be provided to allow a man on the headblock platform, in the fully raised position, using the headblock and spreader ladder, to climb down to the top of an adjacent container at the spreader twistlock level.

4.11.2.13 The trolley sheaves may be located above the trolley deck at a height sufficient to meet the sheave rope angle requirements of Section 4.8.5.4 with the headblock fully raised. See the Drawings for acceptable concepts.

4.11.2.14 Access shall be provided for personnel on the headblock platform to traverse to the main trolley platform and from there to the cabin level by means of a caged ladder. The access shall be fully compliant with OSHA and other applicable regulations.

4.11.2.15 When being raised to its maximum position, the headblock shall enter a "gather" at the trolley level that guides it to its final position and restrains lateral movement.

4.11.2.16 See the Drawings for a conceptual trolley layout.

4.11.3 Trolley and Catenary Trolley Tow Rope Reeving

4.11.3.1 Trolley tow ropes and catenary support trolley tow ropes shall have the following minimum safety factors:

.1 Five (5.0) for the main trolley and catenary trolley tow ropes with a load of TL + LS + LL + 0.5 WLO + acceleration + effect of rope tensioner

4.11.3.2 The trolley tow rope and catenary trolley tow rope reeving systems shall be designed such that 90% of the ropes achieve a minimum life of 2,000 trolley hours.

4.11.3.3 Trolley tow rope running sheaves, including catenary trolley tow ropes sheaves, shall have a minimum pitch diameter of 30 rope diameters. This pitch diameter is a minimum and may need to be increased to achieve the specified reeving system design life requirement.

4.11.3.4 The trolley shall be propelled by two sets of tow ropes. Each tow rope shall be continuous from the trolley drive drum(s) around frame turning sheaves to equalizer sheaves on the trolley and returned to the drum. The ropes shall be clamped on the trolley except when rereeving.

4.11.3.5 The trolley reeving geometry shall be symmetrical about the centerline of the Crane in the trolley travel direction.

4.11.4 Tow Rope Tensioner

4.11.4.1 Hydraulically operated tow rope tensioning shall be provided and shall maintain proper rope tension during normal operation and compensate for unequal rope stretch of both the trolley tow ropes and the catenary trolley tow ropes.

4.11.4.2 The trolley rope tensioner shall be designed to prevent slack rope or over tensioned rope during maximum trolley acceleration and deceleration.

4.11.4.3 The tensioner shall be designed with at least 20% spare stroke and capacity.

4.11.4.4 The tensioning device shall be designed for continuous operation and shall be located in the backreach of the boom.

4.11.5 Trolley Wheels

4.11.5.1 Trolley wheels, including catenary trolleys, shall be carried on anti-friction bearings

4.11.5.2 The alignment of trolley wheels shall conform to the requirements of section 8.2.2 of FEM 1.001.

4.11.5.3 Trolley wheels shall be sized to comply with FEM 1.001.

4.11.5.4 Trolley wheels shall be double-flanged, rolled steel, rim toughened to 50 Rc minimum to a minimum depth of 6 mm (1/4 in).

4.11.5.5 Wheel treads shall be machined to a uniform diameter concentric with the bore within 0.125 mm (0.005 in) TIR. Tread contours shall comply with the AIST Specifications.

4.11.6 Trolley Rails

4.11.6.1 Only crane rails, those specifically designed for high wheel loads with thick webs, shall be used. Minimum rail sizing shall be 135 lb/yd crane rail or A75 (56.2kg/m).

4.11.6.2 Trolley rail shall be continuously supported on a structural member with a continuous web centered under the web of the rail. Where the rail will trap water on the boom chord, frequent drains shall be provided through the boom chord.

4.11.6.3 Rail support surfaces shall meet the rail levelness and alignment criteria of Section 8.2.2 of FEM 1.001 with the boom in any latched position. Shims shall not be used.

4.11.6.4 The rail shall be secured with bolted rail clips. If welded studs are used, the studs shall be fillet welded to the structure. The use of resistance "stud gun" welding is not allowed.

4.11.6.5 The rail base and mounting surface shall be painted before rail installation.

4.11.6.6 Rail sections shall be joined with complete penetration welds and ground smooth to accurately machined templates. The weld procedure and flatness criteria shall be called out on the drawing. Rail straightness and surface shall meet FEM 1.001 criteria.

4.11.6.7 Each rail run shall be secured against axial movement with welded shear bars mating with milled slots in the trolley rail.

4.11.6.8 The rails shall be supported by continuous reinforced rail pads. Rail clips and mounting details shall be acceptable to the rail pad manufacturer for use with its product. Rails, pads, clips, and mounting hardware shall all be approved by the Owner.

4.11.7 Guide Rollers

4.11.7.1 A side guide roller shall be provided at each corner of the trolley.

4.11.7.2 Guide rollers shall be a minimum of 400 mm (16 in) diameter and shall meet the material and hardness requirements for the trolley wheels.

4.11.7.3 Guide rollers shall be designed to bear on one of the trolley rail heads and shall be arranged to have a sufficient operating clearance to prevent binding. The side guide roller rail clearances shall be easily adjustable by rotating an eccentric shaft.

4.11.8 Rope Catenary Support System

4.11.8.1 The main hoist and trolley tow ropes shall be supported by two rope towed catenary support trolleys: one on the landside of the main trolley and one on the waterside. The drive of the catenary trolleys shall be such that they will continuously maintain their position midway between the main trolley and its end of travel. The trolley and catenary runway shall allow for the catenary trolleys to be out of position by 12" (300 mm) in either direction before the catenary tow ropes must be adjusted.

4.11.8.2 The rope supports on the catenary trolleys shall be UHMW sheaves or rollers. Where the rope does not fleet across the surface, sheaves shall be used. Means shall be provided to either restrain the rope on the roller or sheaves or to fully enclose each rope in a UHMW lined frame. Support rollers and sheaves shall be equipped with anti-friction bearings.

4.11.8.3 The catenary trolley tow ropes shall be terminated with fully adjustable connectors located within fully guarded access platforms. The tow ropes shall be automatically tensioned; see Section 4.11.4.

4.11.8.4 The catenary reeving geometry shall be symmetrical about the centerline of the Crane in the trolley travel direction.

4.11.8.5 The catenary trolleys shall have hold down brackets, which shall positively keep the catenary trolleys from jumping the rails.

4.11.9 Additional Safety Requirements

4.11.9.1 Equipment, structures, bumpers, walkways, and other features on the trolley shall be arranged to minimize the risk to personnel on the trolley and operator's cabin. Particular attention shall be paid to fall hazards, crushing hazards, pinch points when the trolley is in motion, and when the headblock approaches the two-blocked position under the trolley. Where it is not practical to eliminate such hazards, they shall be clearly marked with safety signs complying with Section 7.18.1.

4.11.9.2 In addition to the fall arrest anchors described in Section 7.6, the arrangement of walkways and handrails shall minimize the risk of falling from the top of the trolley or operator's cabin.

4.11.9.3 A local control pendant shall be provided as described in Section 7.2.7.

4.11.9.4 An OSHA approved means of access shall be provided for emergency escape from the upper trolley platform to the boom walkway with the boom and trolley in any position.

4.11.9.5 See 7.3.1 for CCTV requirements on the trolley.

4.12 BOOM TRAVEL SYSTEM

4.12.1 Boom Travel Machinery

4.12.1.1 The boom travel machinery shall be mounted in the frame machinery house. The boom travel machinery shall comply with the requirements for trolley drive machinery except for the following:

4.12.1.1.1 Boom travel couplings shall have a service factor of at least 2.0 based on the manufacturer's catalog rating and the maximum transmitted load during the hoisting cycle.

4.12.1.1.2 Boom Travel Rope Drum Brake: A spring set, electrically or hydraulically released caliper disc brake shall be mounted on the rope drum. The brake shall be capable of stopping the travel of the boom at any point in its travel without assistance from an overspeed condition. The controls shall cause the drum brake to set after an adjustable time interval after the motor brake sets on a normal stop. The brake shall set immediately upon loss of electrical power or activation of emergency stop. The brake shall be run-in during shop testing until the lining is seated and the coefficient of friction stabilizes and is verified. Instructions and calibration charts shall be provided in the Maintenance and Inspection Manual for future testing and recalibration of the brake. The springs of spring set brakes shall be calibrated and certified by a testing laboratory. Spring set brakes shall have a spring adjustment indicator which shall relate to the certified calibration curve. This capability shall be demonstrated during acceptance testing.

4.12.1.2 See Sections 2.2 and 6.2.5.10 for boom operation requirements.

4.12.2 Boom Travel Reeving

4.12.2.1 The boom shall be positioned relative to the frame by means of tow ropes.

4.12.2.2 Boom travel ropes shall have a minimum safety factor of five (5) when traveling against WLO. Design shall consider the effect of boom deflection slope on the support rollers as well as the rolling loses of the boom support rollers and the hold down rollers.

4.12.2.3 Boom travel running sheaves, if required, shall have a minimum pitch diameter of 24 rope diameters.

4.12.2.4 The boom traversing ropes shall terminate on the boom with adjustable turnbuckles capable of tensioning the ropes to a minimum of 10% of the rope breaking strength. There shall be two (2) tow ropes waterside and two (2) tow ropes landside.

4.12.3 Boom Latch and Stowage

4.12.3.1 A powered lock pin latch shall be provided to lock the boom in each of its latched positions (Boom Pos. R, A, B, and C).

4.12.3.1.1 The latch system shall be designed for the maximum hurricane stowed wind loads, WLSH. See SECTION 3 for other structural requirements.

4.12.3.1.2 Once latched the boom motion at the latch in the trolley travel direction shall not exceed 0.5 in (13 mm). The gage of the support wheels shall not change when the frame deflects. The boom support linkage system shall be stable, and shall not require lateral support at the boom support wheels.

4.12.3.1.3 The boom latch system used on the existing cranes at PED is an acceptable concept for these cranes. See the Drawings.

4.13 BOOM SUPPORT AND HOLD DOWN SYSTEM

4.13.1 The boom shall be supported by the gantry frame using hangers and support wheels. Hold down rollers shall support the boom in all boom positions requiring a hold down force.

4.13.2 In all latched boom positions, the boom shall meet the specified clearance requirements.

4.13.3 The boom supports shall comply with Section 3.

4.13.4 Means shall be provided for inspection, maintenance and replacement of boom support and hold down rollers when the boom is in the fully retracted position (Boom Pos. R). This shall include provisions for relieving the loads on the rollers and bearings, removal of the pins and bearings, and support of the boom sections. Permanent platforms shall be provided for access. A detailed explanation for these procedures shall be provided in the maintenance manual.

4.13.5 Boom Support Wheels, Hold Down Rollers, and Rails

4.13.5.1 Boom support wheels and hold down rollers as well as rail sections and rail mounting shall meet the requirements for the trolley wheels and rails in Section 4.11, as applicable.

4.13.5.2 The boom support rails and hold down rails shall be continuous and welded to the boom to be part of the cross sectional area of the boom chord. ASTM A514 flat bars, 100 ksi yield, may be used as support and hold down rails provided the thickness is sufficient to locally not overstress the chord rail supporting web. The boom support rail shall be a minimum of 150 mm wide. Where flat bars are used for rail, the wheel treads shall be crowned to prevent edge loading of the rail.

4.13.5.3 It is envisioned that two (2) equalized boom support wheels will be used to support the boom at each of the four (4) supports. If so, the wheels shall be a minimum of 60 inch (1,500 mm) tread diameter.

4.13.5.4 Where two or more wheels or rollers are used to support a corner load, the loads shall be equalized.

4.13.5.5 The structural support for the wheels and rollers shall be designed for proper alignment of the wheels or rollers with the boom support rails as the boom moves over the entire travel distance. Frame and boom deflections shall be considered in the design. In addition, means shall be provided to field adjust wheel and roller alignment.

4.14 GANTRY SYSTEM

4.14.1 Gantry Drive Machinery

4.14.1.1 Each drive shall be self-contained within its drive truck and shall consist of an AC electric motor with an electrically released fail-safe operational brake driving through totally enclosed, oil-lubricated, helical and/or spiral bevel gearing with one motor with brake driving one wheel. The motor shall be flange mounted to the reducer. Worm gearing shall not be used.

4.14.1.2 Drive components shall be protected by location or by substantial fenders against damage by vehicular traffic. Where possible, gantry drive components shall be mounted waterside of the waterside leg and landside of the landside leg.

4.14.1.3 Common parts shall be used for wheels, drive axles, idler axles, and bearing assemblies wherever possible unless otherwise approved in writing by the Owner.

4.14.1.4 Based on the manufacturer's catalog rating, gantry couplings shall have a service factor of at least 1.5 based on load combinations OP1 and OP2.

4.14.1.5 The Contractor shall submit calculations verifying the tractive capability of the Crane. In any case, at least 50% of the wheels at each corner shall be driven and operationally braked. Motor stall torque shall be automatically adjusted depending on boom position.

4.14.2 Gantry Brakes

4.14.2.1 The gantry drive and brake system shall provide sufficient thermal capacity, torque, and traction for all operating conditions.

4.14.2.2 The motor mounted operational brakes shall be capable of stopping the Crane from full speed with a following WLO without regenerative braking.

4.14.2.3 Gantry Motor Brakes: A spring set electromagnetically released disc brake shall be provided at each motor with a dynamic rating equal to at least the maximum motor torque. The gantry motor brakes shall have the thermal capability to stop the gantry, with the boom in any position, from rated speed with a following WLO once under power off emergency stop conditions, without the aid of any wheel or rail brakes. ~~**Each brake shall be in a rain-tight enclosure. Gantry motor brake torques shall be automatically adjusted to prevent wheel skid depending on boom position.**~~ **The brake enclosure shall be IP67 rated.** **[1]**

4.14.2.4 Gantry Wheel Brakes: Spring applied, thruster released wheel brakes designed for dynamic stopping, not just static holding, shall be installed on all idler gantry wheels. **The design shall be a fixed caliper type, with at least one piston on each side of the wheel.** The wheel brakes shall be capable of stopping the Crane from over-speed with 150% WLO from the worst case direction without the aid of the gantry motor brakes. The wheel brakes shall have brake released limit switches and gantry motion shall not be allowed unless all wheel brakes are released. The wheel brakes shall release within two seconds of the operator command for gantry travel. The wheel brakes shall reset after an adjustable time delay after gantry motion has stopped. An adjustable hydraulic time delay shall prevent the brakes from setting until the motor brakes have brought the gantry to a stop in the event of an emergency stop. Provisions shall be made to automatically bypass this delay in the case of overspeed. **[1]**

4.14.2.5 See Section 2.8.9 regarding gantry acceleration adjustability requirements.

4.14.2.6 **The Contractor shall propose an option for a variable torque motor braking system, which automatically compensates for the wheel loads during gantry motion with the boom at either of four possible positions, to prevent wheel skidding during braking.** **[1]**

4.14.3 Gantry Trucks

4.14.3.1 Each truck shall be fitted with a safety drop block which will limit its drop to 25mm (1 in) and support it in the event of axle failure.

4.14.3.2 Rail sweeps shall be provided on both ends of each gantry truck.

4.14.3.3 Other than the wheels, rail sweeps, and drop blocks, all parts of the truck assemblies shall be at least 50 mm (2 in) above the top of the rail.

4.14.3.4 A 25 mm (1 in) diameter flexible personnel safety cable loop of non-lubricated galvanized bridge strand (6x19 wire rope) shall be provided at the ends of the extreme trucks waterside and landside. The free end of the safety loop shall be approximately 1m (3ft) above the wharf and sufficiently flexible to avoid injury to personnel.

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4.14.3.5 Means for jacking up the gantry bogie shall be provided sufficient for replacement of gantry wheels.

4.14.4 Gantry Wheels

4.14.4.1 Gantry wheels shall be double flanged, rolled steel, and rim toughened to HB 321 minimum and conform to ASTM A504, Class C. All non-contact surfaces shall be painted per the requirements of Section 9.6.1.

4.14.4.2 Wheel treads shall be 25 mm (1 in) wider than the rail head. The crane structure shall be designed for this clearance. The gantry rail size and specification will be defined by the Owner. After the Crane is aligned to the rail at the job site, means shall be provided to remove lateral float from the waterside truck and equalizer beam connections.

4.14.4.3 Wheel size and tread contour shall comply with the AISE Specification for Table 2.8 load combination OP1 with the boom in the most adverse position, but shall be at least 40 in (1,016 mm) diameter. Wheel treads shall be turned to a true surface and shall be within 0.05 in (±0.125 mm) of the nominal diameter. Drive wheel diameters shall be matched within 0.002 in (0.050 mm).

4.14.4.4 Wheels shall be designed for travel across rail frogs on the wheel flanges. See the Drawings. Flanges of wheels shall be designed using the same criteria as for the wheel tread bearing surface. Wheel flange bearing area need not exceed 2 inches in effective bearing width.

4.14.4.5 Gantry wheel axles shall be finished all over and pressed or shrunk into wheels.

4.14.5 Equalization System

4.14.5.1 The gantry wheel arrangement shall comply with the allowable wharf loading shown in Table 2.10 and Table 2.11.

4.14.5.2 Wheels shall be mounted in equalized trucks connected by equalizer beams to ensure that the gantry corner loading is equally distributed to all wheels.

4.14.6 Securing Devices

4.14.6.1 See Sections 3.13.1 and 3.13.2.

4.15 HYDRAULICS

4.15.1 General

4.15.1.1 Hydraulic equipment shall be designed in accordance with the pertinent provisions of the codes and standards in Section 1.7. If the Contractor prefers to employ design and manufacturing methods or procedures or materials which **do not** conform to standards of industry or technical associations defined in **[1]** Section 1.7, such alternative standards shall be submitted to the Owner for review and analysis. Alternative standards may be used only after it has been demonstrated that they are equal or superior to the specified standards, and the proposed equipment is directly interchangeable with equipment meeting the specified standards, and after the Owner has accepted the alternative standards in writing. Standards shall be submitted in the language described in Section 2.14.

4.15.1.2 All hydraulic components shall be subject to approval by the Owner.

4.15.1.3 The hydraulic systems shall meet all applicable sections of these Specifications. This may require special fasteners, corrosion prevention, and painting.

4.15.1.4 All hydraulic power units shall be designed for maintenance operations of all motions at the hydraulic unit.

4.15.2 Design

4.15.2.1 The hydraulic system design shall be in accordance with applicable requirements of ANSI B31.3, *Chemical and Refinery Piping*, and JIC hydraulic standards for hydraulic equipment for a working pressure of 20.7 MPa (3,000 psi) gage, but system working pressures shall not exceed the following:

.1	Snag protection system during snag trip	20 MPa gage (2,900 psig)
.2	All other systems	15 MPa gage (2,200 psig)

4.15.2.2 After assembly, all systems shall be hydrostatically tested to 150% maximum system pressure.

4.15.2.3 Hydraulic systems shall be designed for use with both standard and bio-degradable hydraulic fluids.

4.15.2.4 All power units shall be constructed in such a manner that the pump suction does not exceed 16.7 kPa (2.4 psi) at any time. This includes cold start at minimum rated oil temperature. If flooded suction lines are used, they shall be provided with isolation ball or butterfly valves with limit switch indicators to indicate full open position of the valve. These indicators shall be interlocked with the pump motor starter such that the electric motors will not start unless the suction isolation valves are fully open.

4.15.2.5 Hydraulic pump drive electric motors shall operate at 1800 rpm maximum. Pump shafts shall be coupled to electric motor shafts using flexible couplings. Pumps may be mounted directly to the motor with a C-face mount or may be mounted to a machined sub-base. Hydraulic pumps shall be connected to piping using flexible hose. All pump connections shall be SAE 4-bolt flange or SAE tube ports. Pump drain connections shall be at the highest point possible on the pumps. Drain lines shall be no smaller than the drain port and shall have no restrictions or excess pressure drop. Pump drain lines shall be sized for a maximum of 1.5 m/sec speed based on the manufacturer's rated case flows at working pressure.

4.15.2.6 All open loop pumps shall be pressure compensating where open center valves are not used. Closed loop pumps shall have pressure compensating override on both sides of center.

4.15.2.7 Each electric motor in a hydraulic system shall drive no more than two pumping systems. A pump system is defined as one open loop pump or one closed loop pump with its replenish and servo systems. All auxiliary circuits and valves, such as cross port relief valves, etc., shall be mounted external to the pump. Pumping systems with all functions in one housing or casting shall be avoided where possible.

4.15.2.8 No pump or other hydraulic device shall be used that produces in excess of 85 dBA noise level measured according to ANSI S12.23, *Method for the Designation of Sound Power Emitted by Machinery and Equipment*. Reservoir and bases shall be designed to attenuate noise levels. Isolation mounts may be used to reduce transmitted mechanical shock and noise levels.

4.15.3 Valves

4.15.3.1 All control valves shall be sub plate mounted or cartridge type. Shut off valves, check valves and needle valves may be line mounted. Maximum flow rates and pressures through valves shall not exceed manufacturer's rated flow and pressure.

4.15.3.2 Relief valves shall reseat within 3% maximum of cracking pressure, and shall have a rated working pressure of not less than 150% of operating pressure. Relief valves subject to changeable backpressure shall be externally drained. Wherever possible, relief valves shall be used as safety reliefs and shall be set a minimum of 10% higher than maximum operating pressure.

4.15.3.3 Solenoid operated directional valves shall have oil immersed or wet pin solenoids. Each solenoid shall have means for external mechanical actuation for testing. If internally drained, tank ports will not be subjected to more than 6.9 MPa (70.31 kgf/cm^2) or maximum pressure allowed by manufacturer, whichever is less. External drain lines shall be designed to minimize pressure surges and reduce back pressure. Four-way valves shall spring center or spring offset to a failsafe position upon electrical failure. All solenoids shall be replaceable without disassembling the valve or removing it from the sub plate or manifold.

4.15.3.4 Flow control valves shall be pressure and temperature compensated over the full range of flow for which the valve is rated. Flow setting shall be adjustable and shall have facilities for locking when proper flow setting is reached. Flow control valves must be adjustable to zero flow.

4.15.3.5 Check valves may be either ball type or piston type. Swing checks shall not be used. Check valves shall be spring loaded closed and have zero reverse flow.

4.15.3.6 Servo valves shall be rated for maximum operating flow with a maximum pressure drop of 2.75 MPa (28.12 kgf/cm^2) across both ports combined. Servo valves shall have non-bypass type 3 micron absolute full flow filters on their supply lines. Each servo valve shall have externally adjustable null.

4.15.3.7 Hydraulic control valves shall be mounted on drilled or laminated manifolds wherever possible. Manifolds shall be designed for five (5) times maximum operating pressure at yield stress. Manifolds shall be steel or stainless steel. Aluminum manifolds shall not be used. All manifolds shall be securely fastened to structures such that their dead load is not supported by the connecting piping.

4.15.4 Piping and Hose

4.15.4.1 Piping connections shall be made by SAE 4 bolt welded flange or O-ring welded union fittings. Tubing connections shall be bite type fitting or 37 degree flared fitting. Tapered pipe thread connections shall be avoided wherever possible. Pipe threads shall not be used unless approved in writing by the Owner. Where used, tubing and tube fittings shall be stainless steel. Pipe shall be stainless steel.

4.15.4.2 Hose connections shall be SAE O-ring port, SAE O-ring split flange, O-ring union connection or 37 degree flared connection. Hydraulic piping, tubing and hoses shall be standard sizes. Permanently attached, swaged, fittings shall be used on hoses. Pressure hoses shall be rated for the maximum operating pressure and shall have a minimum burst pressure of four times operating pressure. Suction hoses shall be reinforced with spiral wire to prevent collapse. Suction hoses shall have a minimum working pressure of 345 kPa (3.51 kgf/cm^2) and drain hoses a minimum of 1725 kPa (17.58 kgf/ cm^2). Connections 3/4 in and larger shall be SAE O-ring split flange.

4.15.4.3 Hose and pipe connections shall be stainless steel.

4.15.4.4 Welded pipe fittings shall be forged steel 20.7 MPa (210.9 kgf/ cm^2) gage or 41.4 MPa (421.9 kgf/ cm^2) gage rated. All welded fittings 75 mm (3 in) or less shall be socket weld. Pipe bends shall be a minimum of three pipe diameters and shall be made with no flats or excess thinning of the back wall. Pipe spools shall be fabricated with sufficient flanges to remove and install all sections of the piping without teardown of machinery. There shall be no more than 1.8 m (6 ft) of unsupported piping and all hoses shall be supported as required to maintain manufacturer’s recommended minimum bend radius.

4.15.4.5 Hoses shall be installed so that there are no torsional stresses in the hose. All hose assemblies must have a minimum bend of 45 degrees.

4.15.5 Reservoirs

4.15.5.1 Fluid reservoirs shall be sized for a minimum volume of three times the maximum flow rate of oil per minute entering or leaving the reservoir. The reservoir shall be sized so that a minimum of 20% of total volume is air space when the reservoir is at maximum operating level. Smaller reservoirs may be proposed on a case by case basis for the Owner’s approval.

4.15.5.2 The reservoir shall be baffled to ensure return oil is separated and deaerated before mixing with suction oil.

4.15.5.3 The bottom of the reservoirs shall be v-shaped, leading to a low point or sump. There shall be a drain valve to drain all oil from the reservoir.

4.15.5.4 Reservoirs shall contain a magnetic plug which can be removed for cleaning without draining the reservoir.

4.15.5.5 A sight glass shall be located to show a minimum and maximum reservoir fluid level.

4.15.5.6 Wetted surfaces of the reservoir shall be stainless steel.

4.15.5.7 The reservoir shall be equipped with cleanouts and covers to allow access to all interior surfaces for inspection and cleaning.

4.15.5.8 An oil temperature gage shall be installed on the reservoir.

4.15.5.9 A breather with a 10 micron (0.4 mil) minimum rating filter shall be installed at a high point on the reservoir.

4.15.5.10 A low level float switch and high temperature switch shall be installed and connected to the control circuit such that low level will stop all pumps and high temperature will be indicated to the operator. Trolley and spreader mounted hydraulics require time delays or adequate baffles to avoid movement induced shutdowns.

4.15.5.11 Reservoirs shall be cleaned and hydrostatically tested to 34.5 kPa (5 psi). All carbon steel surfaces shall be blasted to white metal and coated with a hot oil and corrosion resistant epoxy or "Glyptal".

4.15.5.12 If suction strainers are used, they shall be external to the reservoir and shall be accessible for cleaning without draining the reservoir.

4.15.6 Catch Basins

4.15.6.1 All hydraulic power units will have catch basins to collect leakage from the power unit and its components. The basin shall be sized to a minimum of 10% of the reservoir's volume.

4.15.6.2 Catch basins shall be fitted with manual valve equipped drains. Space shall be provided for a container to accept the drained fluid. Where the catch basin is compartmentalized, the various compartments shall be piped together to form a single drain point.

4.15.6.3 Catch basins in locations exposed to weather shall be fully guarded from windblown rain water entering the catch basin, preferably by the power unit enclosure.

4.15.7 Filtration

4.15.7.1 All hydraulic systems shall be flushed until an ISO 4406 17/15/12 cleanliness level is reached. ISO 4406 17/15/12 cleanliness requires that each milliliter of fluid contain:

.1 Less than 1300 particles larger than 4 micro-meters
.2 Less than 320 particles larger than 6 micro-meters
.3 Less than 40 particles larger than 14 micro-meters

4.15.7.2 The oil cleanliness shall be certified as required in Section 10.3.12.

4.15.7.3 The filtration system shall be adequate to maintain an ISO 4406 17/15/12 cleanliness or better during normal operation. Oil meeting ISO 4406 17/15/12 shall be installed in the reservoirs for start-up and test at the installation site. Samples shall routinely be taken from the reservoir during acceptance testing to verify the ability of the filtration system to maintain ISO 4406 17/15/12 or better. See Section 9.3.1.6.

4.15.7.4 Filters shall be equipped with indicators to indicate dirty filter element conditions. Filters shall be sized for no more than a 5 psi drop across the filter element and housing at full rated flow with 450 SSU oil and clean elements. Filter shall not bypass, nor indicate dirty filter element, during normal cold oil start-ups with clean elements. All filters shall be available for purchase and stocked in the USA. All filters shall be readily available for removal and replacement without requiring any disassembly of the power unit or adjacent equipment or structures.

4.15.7.5 Inline polymeric filters, with indicators, shall be installed to absorb water from the hydraulic fluid.

4.15.8 Heat Exchangers

4.15.8.1 Heat exchangers shall be air/oil type and shall be sized to limit the maximum reservoir oil temperature to 63 °C (145 °F). The frame for the heat exchanger shall be stainless steel. All heat exchangers shall be provided with bypass valves to limit maximum operating pressure to 680 kPa (7.03 kgf/cm^2) or less.

4.15.8.2 Thermal calculations for a standard one hour duty cycle of the hydraulic system shall be submitted. The calculations shall include heat exchanger sizing calculations based on 45°C (113°F) air temperature and 60 °C (140 °F) maximum oil temperature. Calculated heat exchanged to surroundings by radiation and convection from piping and reservoirs shall be limited to 2.0 J/°C/cm^2 (0.0068 Btu/°F/in^2) of wetted surface.

4.15.8.3 Heat exchanger fans may be either electrically or hydraulically operated. Fans shall be controlled by a thermal switch in the reservoir. The heat exchangers shall be mounted so that air flow is unobstructed and not directed at maintenance access areas or crawl spaces.

4.15.9 Components

4.15.9.1 Hydraulic cylinder rods shall be chromed stainless steel suitable for maritime use. Retractable bellows shall be supplied over all cylinder rods.

4.15.9.2 Each hydraulic component shall be identified by a stamped, etched, or engraved stainless steel nameplate, permanently attached adjacent to the component by stainless steel fasteners. Each nameplate shall relate the component to the hydraulic schematic and identify its function.

4.15.9.3 Solenoids, motors and other electric components shall be related to both hydraulic and electric schematics.

4.15.9.4 The following information shall either be stamped on the main body of the valve or etched or engraved on an additional nameplate attached to the valve:

.1 Manufacturer's name
.2 Serial number
.3 Function identified, solenoid operated or spring return

4.15.10 Standard Hydraulic Packages

4.15.10.1 For standard hydraulic packages 3.75 kW (5 hp) and less and manufacturer's standards, specialty cylinders for bumpers and brake actuators that do not meet the specific hydraulic requirements of the remainder of Section 4.15 may be used if they meet all of the following requirements:

.1 Failure would not prevent continued container handling operations. Examples of those units that must meet the detailed hydraulic Specification are hydraulic units and cylinders used for trolley rope tensioning, sway damping, lift beam, snag protection, and trim/list/skew as applicable.
.2 Have a history of five or more installations of over five years in service in dockside container crane operation without component failure.
.3 The units meet the listed standards.
.4 The units meet the applicable Sections of these Specifications, which include electrical and wiring, fasteners, corrosion prevention, and painting.

4.15.10.2 For hydraulics on the spreaders or headblocks, it is important to minimize weight and size and to increase reliability against shock loading. Where hydraulic components have been previously used successfully on spreader applications but otherwise do not meet the requirements of these hydraulic specifications, the Contractor may request an exception on a case-by-case basis. Each request shall be fully documented and include the reasons that the noncompliant component meets or exceeds the intent of the Specification. The decision of the Owner shall be final.

4.16 LUBRICATION

4.16.1 Components shall be selected such that frequent lubrication is not required. No component of the Crane shall require lubrication more frequently than once-per-year unless the Contractor can demonstrate more frequent lubrication is essential, an alternate design or component would be impractical, and the Owner approves the exception in writing.

4.16.2 Oil lubrication shall be provided for enclosed gear trains and speed reducers.

4.16.3 Lubrication of other mechanical operating parts shall be by means of a high pressure grease gun. Buttonhead type grease fittings made of brass, monel, or stainless steel shall be used throughout.

4.16.4 Bearings for all electric motors, and gearbox shaft seal assemblies requiring grease, shall be greasable using distinct fittings not compatible with the buttonhead style fittings used elsewhere.

4.16.5 The lubricating fittings of journals or bearings shall be readily accessible. Grease fittings shall be gathered at the same place as much as possible by means of stainless steel tubing for convenient lubrication.

4.16.6 Only one size and type of lubricating fitting shall be used except the electric motors and gearbox shafts. All fittings shall be plainly visible and accessible.

4.16.7 The Contractor shall furnish and install lubricants and hydraulic fluid in sufficient quantities for initial lubrication of the Crane.

4.16.8 The Crane shall be lubricated with products from a single company.

4.16.9 Oil samples shall be taken from each reducer and hydraulic power unit during field testing as required in Section 10.3.12.

4.16.10 The Contractor shall provide a listing of all lubricants installed in the Crane prior to shipment.

SECTION 5 ELECTRICAL REQUIREMENTS

5.1 GENERAL

5.1.1 The Contractor shall be responsible for the safe and reliable operation of the equipment in accordance with the requirements of these Specifications including Section 1.5. He shall demonstrate with his drawings and specifications and with the required tests that the equipment is capable of performing the specified functions with a minimum of down time.

5.1.2 Special consideration shall be given to all safety related items to ensure safe operation at all times. As a minimum the Crane design shall comply with:

- .1 NFPA 70 “National Electric Code (NEC)”
- .2 NFPA 79 “Electrical Standard for Industrial Machinery”
- .3 IEC 61508 “Functional Safety of E/E/PE safety-related system”
- .4 IEC 61511 “Functional Safety: Safety Instrumented Systems for the Process Industry”
- .5 IEC 60204-11 “Safety of Machinery – Electrical equipment of machines – Part 11: Requirements for HV equipment for voltages above 1,000 V AC or 1500 V DC and not exceeding 36 kV”
- .6 IEC 60204-32 “Safety of Machinery – Electrical equipment of machines – Part 32: Requirements for hoisting machines”
- .7 IEC 62061 Safety of Machinery - Functional Safety of safety related electrical, electronic, and programmable electronic control systems
- .8 EN ISO 13849 – 1:2006 Safety of Machinery – Safety related parts of control systems Part 1

5.1.3 For the purposes of these Specifications, the terms medium-voltage (MV) and high-voltage (HV) are interchangeable and shall indicate any voltage above 600 V. On all drawings, schematics, manuals, nameplates, and other identifying marks or labeling, circuits carrying voltages above 600 V shall have their voltage level clearly defined, shall be referred to according to their IEC or IEEE designation (medium voltage, high voltage, etc.), and shall be clearly labeled with hazard signs stating “Danger High Voltage” complying with Section 7.18.1.

5.1.4 The electrical equipment shall provide reliable power for the rapid and precise handling of containers in continuous loading and unloading operations under the environmental conditions defined in Section 2.5.

5.1.5 Unless superseded by the requirements of national or local codes, the electrical equipment and installation shall conform to the standards listed in Section 1.7 specifically including the requirements of Section 1.7.5.

5.1.6 All the electrical and electronic equipment and parts shall be supplied and integrated by the companies designated by the Owner in Section 2.13. They shall be listed, labeled and identified by a compliant testing laboratory or equivalent body where required by applicable codes, local regulations, or law.

5.1.7 Equipment and material for the same, similar, or allied services shall be of the same manufacturer and type and, when of the same rating, shall be interchangeable. The Contractor shall size components and conductors to suit the demands of the equipment supplied.

5.1.8 The maintainability of each design shall be carefully considered throughout the project.

5.1.9 All electrical and electronic equipment and related hardware shall be suitable for use in the environment at the Owner’s facility as defined in Section 2.5.

5.1.10 All electrical components, including motors, drives, computers, and software, shall be supported by the component or software manufacturer as specified in Section 2.9.4.

5.1.11 All materials mounted on the exterior of the Crane shall be UV resistant.

5.1.12 Working (clearance) space around electrical equipment shall be provided per NEC Article 110, or local codes applicable at the Owner’s Facility, whichever is greatest. Sufficient space shall be provided for egress from electrical panels with their doors in the fully open position.

5.1.13 Detailed equipment specifications and requirements are subject to the Owner’s approval.

5.2 CALCULATIONS AND LOADS

5.2.1 The Contractor shall provide the preliminary power system modeling and network analysis to the Owner prior to the concept design meeting. Peak electrical power demand, RMS demand, harmonics content, and permissible voltage drop as defined by the drive system supplier shall be subject to the Owner's approval. The analysis shall demonstrate the Crane will operate without impact to operations, maintenance, and reliability with the Owner's Facility. The impact of the Cranes on electrical infrastructure and other electrical/electronic equipment including other cranes, will be the responsibility of the Owner. The Owner will provide the Contractor with the available information on the wharf power system upon request.

5.2.2 The Contractor shall provide a fuse/breaker coordination study for the entire electrical network from the terminal substation breaker throughout the Crane. Time and current curve of proposed protective devices shall be submitted to the Owner at the concept design meeting.

5.2.3 The Contractor shall provide a short circuit analysis and voltage drop analysis throughout the Crane from the PCC.

5.2.4 The Contractor shall provide an arc flash analysis for the Crane in accordance with regulations. The required labeling shall be provided and installed throughout the Crane.

5.3 POWER SUPPLY AND SURGE PROTECTION

5.3.1 Refer to Section 2.4 for the definition of the electrical power supplied to the Crane and the voltage levels to be used.

5.3.2 Coordination with Terminal Power

5.3.2.1 Protection coordination between the Crane and terminal shall be considered in the selection of protective devices. The Contractor shall coordinate with the Owner for protection coordination between protective devices.

5.3.3 Voltage Drop

5.3.3.1 The Crane shall be designed for a maximum voltage drop of 5% from the PCC.

5.3.4 Power Quality

5.3.4.1 Power factor shall be controlled between 0.90 lagging and 1.0 under any working condition. Power factor regulation shall be stepless and shall not introduce switching voltage transients, line notch transients, or line notch ringing into the power system.

5.3.4.2 Total harmonic current and voltage distortion at the PCC shall meet the guidelines as set forth in IEEE 519-1992 Tables 10.3 and 11.1 respectively. Harmonics injected into the system shall be appropriately mitigated on board each Crane to prevent undesired harmonic current injection into the power system in excess of that allowed by IEEE 519-1992 Tables 10.3 and 11.1.

5.3.4.3 Harmonics within the Crane shall be controlled to prevent interference with the proper functioning of systems on the Crane and to meet the requirements of IEEE 519-1992. Harmonic filters shall be provided as necessary.

5.3.5 Protection Systems

5.3.5.1 The Crane will be subjected to lighting strikes on the Crane structure and incoming power system.

5.3.5.2 All gantry equalizer pins and any wheel or structural bearings shall have a short length lightning energy bypass jumper at least 95 mm^2 or AWG 4/0 in diameter.

5.3.5.3 Gantry rail grounding drag shoes shall be installed in at least two locations on the gantry waterside rail and two locations on the gantry landside rail to bypass lightning energy past the gantry wheel bearings.

5.3.5.4 Boom rail grounding drag shoes shall be installed on each boom rail to pass lightning energy past the boom wheel bearings.

5.3.5.5 Trolley rail grounding drag shoes shall be installed on each trolley rail to pass lightning energy past the trolley wheel bearings.

5.3.5.6 The drag shoes shall be the width of the rail with angled or rounded edges so the shoes do not catch at rail joints.

5.3.5.7 Transient voltage surge suppression (TVSS) shall be provided to protect circuitry from power surge and spikes. The TVSS shall be monitored to determine adequate protection after transient voltage events. The type and installation locations of the TVSS shall be approved by the Owner and shall include at least the following:

.1 Medium voltage; lightning arrester on the 13.2kV power line as close to the source as possible
.2 AC power source; TVSS on the 480 volt line
.3 Control AC source; TVSS on the 120 volt line

5.3.6 Main Power Emergency Disconnect

5.3.6.1 Two break-glass style emergency power disconnect switches shall be mounted in conspicuous locations, one each on the landside of the waterside gantry and on the waterside of the landside gantry on opposite corners at wharf-level.

5.3.6.2 Activating either switch or the opening of an energized medium voltage enclosure, shall trip the Crane's circuit breaker in the wharf sub-station removing all power to the Crane via the ground-check circuit.

5.3.6.3 See Section 5.15 for sign requirements.

5.4 SWITCHGEAR AND TRANSFORMERS

5.4.1 The medium voltage switchgear and transformer shall be installed within the machinery house.

5.4.2 The switchgear shall comprise a vacuum circuit breaker (VCB), protective relays, indicating lights and auxiliary equipment. Individual switchgear shall be provided for each transformer. Arrangements shall be provided to bleed-off charged medium voltage cables.

5.4.2.1 The switchgear shall have a continuous rating and symmetrical interrupting capacity suitable for the design.

5.4.2.2 Fused load break switches (FLBS) shall not be used.

5.4.2.3 Captured key interlocks shall be required between terminal's substation switchgear and the Crane to prevent access to energized medium voltage equipment. An engraved stainless steel captured key diagram shall be provided on MV switchgear on the Crane. The Contractor shall be responsible for coordination with the ground substation supplier. Each crane shall have unique keying.

5.4.2.4 All bus bars in the panels shall be rated for at least 20 kA for 1 s and shall be silver or tin plated copper.

5.4.2.5 The MV switchgear panels located within fully enclosed and protected spaces shall be rated IP 21 minimum, and shall be complete with ground bus and shall include space heaters. The panels shall be electrostatic powder coated and all hardware shall be stainless steel. The low voltage section shall be segregated from high voltage section. The enclosures shall be lockable in the open position. A stainless steel engraved circuit diagram shall be provided on the front of the switchgear panels.

5.4.2.6 A wharf-level remote energizing switch shall be provided if switchgear does not automatically energize upon restoration of power after a power outage.

5.4.3 Power Monitor

5.4.3.1 The 13.2 kV power monitoring device shall communicate with the CMS computer, which shall save and annunciate events and record as a minimum:

.1 Under voltage
.2 Over voltage
.3 Power factor
.4 Total harmonic distortion
.5 Peak power

.6 Peak reactive power
.7 Power usage in kilowatt-hours

5.4.3.2 The monitoring device shall be suitable for power factor control. The monitor shall remain active upon loss of power for at least 5 s.

5.4.3.3 The power monitoring device shall be approved by the Owner.

5.4.4 Transformers

5.4.4.1 Air cooled, cast coil isolation transformer(s) shall be provided for main drives and auxiliary power. Forced ventilation shall not be used.

5.4.4.2 Transformers shall be braced and spacers used to minimize movement from short circuits, shock loads and vibrations found on cranes.

5.4.4.3 Bus taps shall be silver or tin plated copper.

5.4.4.4 Transformer coils shall be either copper or aluminum.

5.4.4.5 Transformers shall be housed in enclosures suitable for the environment with proper coating and no forced ventilation. All hardware shall be stainless steel. Top of enclosure shall be fully closed to prevent dust ingress.

5.4.4.6 The drive transformer shall have electrostatic shields and windings and shall be braced for IGBT drive systems.

5.4.4.7 Voltage drop through the transformer shall not exceed 4% at peak instantaneous current.

5.4.4.8 Transformers shall have a minimum K factor of:

.1 Four (4) for IGBT AC drives
.2 One (1) for auxiliary loads

5.4.4.9 A separate auxiliary transformer shall be provided for the motor control center and control power or, as an alternate, a single transformer with two independent secondary windings may be provided such that the main drives and auxiliary loads each have their own individually replaceable winding.

5.4.4.10 Transformers shall have 2.5% and 5% full capacity taps above and below the rated primary voltage.

5.4.4.11 Transformer insulation shall be at least class H.

5.4.4.12 Secondary windings shall be provided with a ground resistance detection system with operator alarm of fault and after a time delay trip the main secondary output breaker shunt trip. Each transformer secondary winding shall be protected by a circuit breaker.

5.4.4.13 Temperature sensors and monitors shall be provided with the values reported to the controls and displayed on the CMS.

5.4.4.14 Insulation test rating shall be at least 110 kV BIL for 15 kV systems.

5.4.4.15 Switchgear and transformers shall be subject to the Owner's approval.

5.5 LOW VOLTAGE SWITCHGEAR AND MOTOR CONTROL CENTER

5.5.1 Low Voltage (LV) switchgear shall be provided at the secondary of main transformer. It shall include a main circuit breaker, contactors, and auxiliary parts as necessary. The circuit breaker shall have a symmetrical short circuit rating suitable for the design.

5.5.2 A Motor Control Center (MCC)/intelligent starter panel shall be provided at the secondary of the auxiliary transformer and have an enclosure rating of at least IP21. It shall include a main circuit breaker with ground fault interrupting (GFI) protection, feeder circuit breakers, motor protection and control devices, and control contactors necessary to distribute the power from either the auxiliary transformer or diesel generator. Feeder circuit breakers shall be provided for at least the following:

.1 Drive control power
.2 Crane control power transformer
.3 Elevator
.4 Machinery house service crane
.5 Jib crane, if provided
.6 Welding machinery receptacles
.7 Cab/Spreader control panel feeder
.8 Cable reels
.9 One spare 100 A frame circuit breaker
.10 Flood light circuit breakers including GFI protection

5.5.3 The auxiliary generator shall be interlocked such that they cannot back-feed the crane auxiliary transformer or each other.

5.5.4 For feeder circuitry both internal and external to the MCC, Molded Case Circuit Breakers (MCCB) shall be used. Fused switches shall not be used. All equipment shall be rated for at least 600 V AC and a short circuit capability suitable for the available short circuit current. A main circuit breaker shall be provided at incoming side. All auxiliary loads shall be individually disconnected and isolated for service using individual circuit breakers and one (1) spare breaker of each type and size shall be installed. Wiring within the MCC shall meet the requirements of Section 5.9.1.4.

5.5.5 Contactor and combination motor starters with utilization category AC-3 shall be provided for all AC auxiliary motors and all brakes on the Crane. Spare starters shall be provided. Each integral starter shall include electronic overload protection, short circuit protection and auxiliary contacts for control and diagnostics. Relays shall be adequate to extinguish the arc upon opening under all conditions.

5.5.6 Bus bars shall be copper, shall be silver or tin plated, and shall be protected against accidental contact by clear insulating barriers.

5.5.7 Conductors of wire size 8 AWG or 10 mm^2 and smaller shall be terminated at spring clamp type terminal strips; larger conductors shall be terminated with lugs.

5.5.8 Ferroresonant constant voltage transformers, or other methods where approved by the Owner, shall be used for stable control power supply against harmonics and voltage fluctuation. Control power supply transformers shall be sized for a minimum of two (2) times maximum design load. The control power supply for PLCs, peripherals, and field sensors shall be separated.

5.5.9 Space heaters shall be supplied within the MCC as needed to prevent condensation.

5.5.10 The MCC shall be supplied and manufactured by the same vendor that supplies the drive systems to ensure system compatibility, design integration, and service responsibility as well as commonality and availability of replacement parts.

5.6 INVERTERS AND MAIN MOTORS

5.6.1 The drives for the main hoist, boom travel, trolley, and gantry motions shall be supplied by the Control System Supplier and shall be variable frequency AC, stepless, regulated, reversing, and regenerative over the entire range of speeds.

5.6.2 The ratings of the motors and conversion assemblies shall be checked by the electrical vendor on the basis of mechanical information provided by the Contractor to confirm that the ratings are adequate to meet the speeds, accelerations and theoretical duty cycles described in Section 2.

5.6.3 The main hoist and gantry functions may share Inverters on a first come first served basis. Trolley and boom traverse functions shall be separate inverters to allow simultaneous operation.

5.6.4 Inverters shall be of modular and slide-in type for easy handling and maintenance. Individual phase-power modules are preferred. Inverter enclosures shall be at least IP20 with air filters.

5.6.4.1 The regenerative converter units that feed the DC bus shall be constructed using four quadrant operation IGBTs. The IGBT breakdown voltage shall be at least 2.5 times the inverter supply voltage. The DC conversion unit shall be capable of regulating the power factor to the limits defined in Section 5.3.4.1.

5.6.4.2 Voltage and current meters shall be flush mounted on the front of the panels and shall be provided for at least the following:

.1 DC bus voltage
.2 Voltage and current of major motion motors (main hoist, boom travel, trolley, gantry)

5.6.4.3 Where inverter power requirements are within 25% of each other, they shall be the same size and interchangeable.

5.6.4.4 The current rating of each inverter shall exceed the continuous calculated RMS and overload ratings as defined by the performance requirements.

5.6.4.5 All electronic boards shall be protected from short-circuits and shall be properly varnished.

5.6.4.6 Bus bars shall be copper, shall be silver or tin plated, and shall be protected against accidental contact by clear insulating barriers.

5.6.4.7 Conductors of wire size 8 AWG or 10 mm^2 and smaller shall be terminated at spring clamp type terminal strips; larger conductors shall be terminated with lugs.

5.6.4.8 Filters shall be installed on the inverter load-side bus, as needed

5.6.4.9 Inverter parameters shall be accessible from the CMS computer defined in Section 6.8. Data interface between PLC and CMS shall be by fiber optic cable or Ethernet cables within the E-house.

5.6.4.10 Inverter noise levels shall not exceed those defined in Section 7.7.13.

5.6.5 Motors for the major motions and their support systems shall meet the following requirements:

5.6.5.1 Motors shall be sized based on a computer run of the design duty cycles with the proposed motors, plus the maximum power and peak torque requirements which may be imposed at any time, and in accordance with FEM 1.001 for continuous operation at the classifications defined in Table 2.3.

5.6.5.2 Motors shall be inverter-rated with insulation class F or H. Insulation shall be rated for at least 2,000 V.

5.6.5.3 Temperature sensors shall be provided for main hoist, trolley, boom travel, and gantry motors.

5.6.5.4 See Section 5.12 for space heater requirements.

5.6.5.5 Motors exposed to the weather and all gantry motors shall have a minimum protection rating of at least IP65.

5.6.5.6 Motors located inside the machinery house shall have a minimum protection rating of IP23. If forced ventilation is used, air entering the motors shall be filtered.

5.6.6 Main machinery motors shall have motor over-temperature detection with alarm/shutdown features and be monitored by the crane CMS and RCMS.

5.6.7 Motors outfitted with forced air cooling shall be monitored by the CMS and RCMS for failure of cooling air.

5.6.7.1 Encoders attached to motors shall be accessible without dismantling adjacent machinery.

5.6.7.2 Exposed motor shafts shall have protective caps.

5.6.7.3 Motors shall have insulated ball bearings with proper grounding of the shaft and be grease lubricated. Provisions shall be made to prevent shaft currents from damaging adjacent machinery.

5.6.7.4 Grease fittings, drain plugs, and any components attached to the motor, as supplied, shall be easily accessible from safe working areas without dismantling adjacent equipment or guards.

5.6.7.5 Connections for motors larger than 20 kW (30 HP) shall be through terminal boards.

5.6.7.6 Torque / current / speed characteristics (curves) of all major drive motors shall be provided to the Owner prior to the concept design meeting.

5.6.7.7 Where motor power requirements are within 25% of each other, they shall be identical and interchangeable including the terminal boxes and coupling halves.

5.7 CABLE REELS AND CABLE CHAINS

5.7.1 Cable Reels

5.7.1.1 Cable reels shall be rigidly coupled to the motors and brakes through an enclosed gearbox. The drive assembly shall be capable of stalling for a period of at least fifteen minutes without overheating and the cable reel drive motors shall be protected against over-temperature

5.7.1.2 Cable reel drives and controls shall be integrated by the Control System Supplier.

5.7.1.3 Cable reel drives shall provide adequate torque and speed to follow the appropriate crane motion over the entire range of speeds and acceleration.

5.7.1.4 All necessary provisions, including adequate control logic, brake adjustment, sensors, switches, and interlocks, shall be provided to prevent damage and abnormal wear to the reeling cable.

5.7.1.5 The reeling cable shall not go slack or be stressed beyond the cable manufacturer's maximum continuous safe reeling tension in any operating or overload condition including power loss.

5.7.1.6 Cable reels shall be mono spiral.

5.7.1.7 Cable reels shall have no less than three wraps remaining on the reel at the extents of travel.

5.7.1.8 Cable reels and fairleads shall accommodate cable ±10% of the design cable diameter and weight.

5.7.1.9 The reel frame and all hardware shall be made of stainless steel; galvanized is not acceptable.

5.7.1.10 The enclosure for the slip rings shall be stainless steel; galvanized is not acceptable. The slip ring enclosure shall have a space heater and a Lexan window for inspecting the ring assembly without the need to open the enclosure.

5.7.1.11 A local manual operating station shall be provided near each reel for maintenance.

5.7.2 Cable Chains

5.7.2.1 Cable chains shall be designed for the speeds and accelerations of the appropriate crane motion.

5.7.2.2 Cable chains shall run in guide channels provided by the cable chain supplier. Guide channels shall be made of stainless steel, protected from damage due to adjacent machinery or ropes, and be easily accessible along their entire length.

5.7.2.3 Tow arms and connecting joints shall be provided by the cable chain supplier.

5.7.2.4 Cables installed in cable chains shall be supplied by the cable chain supplier and shall be designed for use with the cable chains.

5.7.2.5 All material shall be UV-resistant.

5.7.2.6 Intercom cables and other low power level shielded or twisted pairs shall be run in separate cables and shall terminate at both ends in separate junction boxes from the power and control circuits.

5.7.2.7 Installation of the cable chain and flexible cables shall be inspected and approved in writing by the cable chain supplier.

5.7.3 Gantry Cable Reel

5.7.3.1 A cable reel assembly complying with Section 5.7.1, complete with reeling cable, shall be installed on the gantry structure at the portal tie elevation to handle the main power supply cable to the Crane. The gantry cable reel and guides shall be the heavy duty “Pull and Store” type specifically designed for container crane service as manufactured by SPECIMAS or as approved.

5.7.3.2 A clutch may be used without variable frequency AC motors for the pull-and-store gantry cable reel.

5.7.3.3 The gear box shall be provided with a system to prevent water contamination caused by condensation.

5.7.3.4 The mechanical components of the cable reel shall meet all the requirements of Sections 2.9 and 2.10 as applicable for gantry drive, including FEM classifications, design lives, duty cycles, and load spectra.

5.7.3.5 Refer to Section 2.4 for cable reel voltage and travel distance requirements as well as the requirements for the reeling cable features. The gantry cable reeling cable shall be 15 kV rated, unshielded, with concentric ground conductors, ground check conductors (to trip the wharf substation circuit breaker), and a minimum of twelve (12) fiber optic cables. The reeling cable shall be suitable for the tension expected by the cable reel during normal and power loss conditions.

5.7.3.6 The reel shall be equipped with redundant slip rings with brushes, brush holders, etc., such that the Crane can continue operation in the event of failure of one slip ring or brush. The reel shall include a separate brush and slip ring assembly, with an optical rotary coupler which will provide clear transmission of data for the full motion range of the cable reel. Space heaters shall be provided for the separate power and data transmission optical coupler housings.

5.7.3.7 The cable type and size shall be subject to Owner’s approval.

5.7.3.8 A multi-roller, radius cable guide mounted on the leg adjacent to the reel plus four cable guide rollers shall be provided to lead the cable from the reel down the leg. A bi-directional multi-roller, curved cable guide shall be provided at the wharf level. Cable guides and fairleads shall be approved in writing by the cable reel supplier and the reeling cable supplier for use with their products.

5.7.3.9 The slip ring enclosure shall be secured with a Kirk-Key electrical safety interlock device which requires removing power at the appropriate switchgear before the enclosure can be opened.

5.7.3.10 The opening of the enclosure while energized shall automatically trip the ground-check circuit controlled substation circuit breaker.

5.7.3.11 The Contractor shall anchor and terminate the reeling cable in the wharf connection point using Elastimold medium-voltage terminations.

5.7.3.12 Cable reel and cable shall be “hi-potential” tested when installed and after completion of all terminations.

5.7.4 Trolley Spreader Cable Reel

5.7.4.1 A cable reel assembly complying with Section 5.7.1, complete with reeling cable, shall be provided on the trolley to feed power and controls to the spreader.

5.7.4.2 The cable reel shall be controlled by a variable-frequency AC inverter. Fluid, magnetic, eddy-current, or friction couplings shall not be used.

5.7.4.3 The cable reel shall be located to minimize overhead clearance. See the Drawings.

5.7.4.4 There shall be minimum five (5) spare slip rings.

5.7.4.5 The cable reel position and speed shall be slaved to the main hoist drum position and speed by means of encoder feedback.

5.7.4.6 The mechanical components of the cable reel shall meet the requirements of Sections 2.9 and 2.10 as applicable for the main hoist, including FEM classifications, design lives, duty cycles, and load spectra.

5.7.4.7 The drive shall provide adequate torque and speed to follow the spreader at any specified spreader elevation, acceleration, and speed and shall prevent slack cable or over-tension of the cable under any operating condition including snag and power interruption.

5.7.4.8 A shock absorbing device shall be provided on the spreader. The device shall have sufficient range of motion to prevent stressing the reeling cable beyond the cable manufacturer's maximum continuous safe reeling tension rating due to loss of power while hoisting or lowering, and snag load. Under all other operating conditions, the flexible cable shall be adequate for acceleration/deceleration time and speed of main hoist and shall not be stressed beyond 85% of the cable manufacturer's maximum continuous safe reeling tension rating. The shock absorber shall be subject to approval by the Owner.

5.7.4.9 The flexible cable conductor shall have at least three (3) spare conductors and shall be terminated on both ends using a multiple contact plug and receptacle with sufficient pins for all conductors including spares. All spares shall also be terminated. A shorter, but otherwise identical length of cable shall be provided, with identical plugs and receptacles, and also with at least three (3) terminated spare conductors, for the connection between the headblock and spreader. The plugs and receptacles shall be rated for the voltage and current required by the spreader and shall be mounted and supported in such a manner as to be suitable for the shock and vibration on the spreader and shall be subject to the Owner’s approval.

5.7.4.10 Filters shall be provided as needed to prevent electrical noise or harmonic resonance in the spreader cable from damaging equipment or interfering with spreader communications or controls.

5.7.4.11 The cable shall connect to the spreader by means of a quick disconnect plug mating with a quick disconnect receptacle on the spreader. The cable connection to the plug and plug shall be isolated from the cable reel loads.

5.7.5 Trolley and Boom Cable Chains

5.7.5.1 Cable chain systems complying with Section 5.7.2 shall be provided to feed the trolley and boom.

5.7.5.2 Fiber optic cables, intercom cables, and other low power level shielded or twisted pairs shall be run in separate cables and shall terminate at both ends in separate junction boxes from the power and control circuits.

5.7.5.3 Installation of the cable chain and cables shall be inspected and approved in writing by the cable chain supplier.

5.7.5.4 The cable chain cables shall be protected against damage by sunlight.

5.8 HEADBLOCK AND SPREADER ELECTRICAL REQUIREMENTS

5.8.1 Headblocks

5.8.1.1 Headblocks shall be provided with a junction box which shall receive the electrical connection from the trolley and provide for an electrical connection to the spreader. The junction box shall be mounted vertically, have a pneumatic door closer, be protected against the shock and vibration present on the headblock, and meet the requirements of Section 5.10.2. Reinforcement of the junction box and internal components shall be provided as needed to ensure proper operation given the high shock loads present on the headblock.

5.8.1.2 Limit switches on the headblock shall be proximity switches. The proximity switches shall be identical to, and interchangeable with, those on the spreaders.

5.8.1.3 Plugs, sockets, and connecting cables shall meet the requirements of Section 5.7, and shall be adequately secured and protected.

5.8.1.4 The headblock shall be equipped with a bollard type damper to reduce shock loads in the spreader cable.

5.8.1.5 Headblock design, including the headblock junction box and cable routing, shall be approved by the Owner prior to manufacture.

5.8.1.6 An emergency stop switch shall be provided in the service platform area.

5.8.2 Spreaders

5.8.2.1 The interface between the spreader and the crane controls shall be by means of an industry standard bus control protocol, suitable for transmission over standard conductors in the trolley to spreader cables and shall not require twisted pair, shielded, or fiber optic connections for reliable data transmission. The spreader control method is subject to approval by the Owner.

5.8.2.2 All electrical equipment on the spreaders, including motors, shall be properly grounded through the spreader cable to minimize interference with the spreader control bus signals.

5.8.2.3 Spreaders shall be provided with a junction box to receive the electrical connection from the headblock. The junction box shall be positioned to allow safe access from the top surface of the spreader and shall be readily accessible with the spreader connected to the headblock. The junction box shall be reinforced as necessary to resist the shock and vibration present on the spreader, shall be mounted on shock absorbers, and shall meet the requirements of Section 5.10.2.

5.8.2.4 All the electrical components in the box shall be designed to accommodate the shock and vibration present on the spreader. The power supply shall be adequate for the climate at the Owner's Facility and shall be of heavy duty construction suitable for the shock and vibration present on the spreader. Delicate or precise electronic components or power supplies shall not be used. Miniature circuit breakers shall not be used.

5.8.2.5 The spreader shall be equipped with a load sensor in each twistlock to weigh each lifted container.

5.8.2.6 Twin 20 sensors shall not be subject to interference from glare due to standing water on container tops or by a specific paint color.

5.8.2.7 Limit switches shall be proximity switches with quick disconnects and shall be of identical make and model throughout the spreader.

5.8.2.8 I/O distribution units shall be protected from weather and rain and shall be hardened and appropriately mounted for the shock and vibration present on the spreader.

5.8.2.9 The spreader shall record twistlock lock/unlock cycles, display these locally on the spreader, and report them to the crane control system for display on the CMS.

5.9 WIRING, CONDUIT AND CABLE TRAYS

5.9.1 Wiring design and installation shall be in accordance with the latest edition of either IEC 60204-32 and IEC 60204-11, or NFPA 70 National Electric Code (NEC), as defined in Section 1.7 and shall also meet the following minimum requirements:

5.9.1.1 Cableways, cable types, and termination practices shall be as recommended by drive supplier.

5.9.1.2 All conductors shall be multi-stranded copper construction.

5.9.1.3 If designed to IEC requirements, Cranes shall use only standard metric wires sizes. If designed to NEC requirements, Cranes shall use only standard American Wire Gage (AWG) size wires.

5.9.1.4 Power wires external to panels shall not be smaller than 2.5 mm^2 / 12 AWG. Control wires external to panels shall not be smaller than 1.5 mm^2 / 14 AWG. Wires inside panels shall not be smaller than 1.5 mm^2 / 14 AWG for power, 1.0 mm^2 / 16 AWG for 110v control, and 0.5 mm^2 / 20 AWG for low voltage signals. Wire size shall be in accordance with IEC/NEC requirements or the drive supplier's recommendation, whichever is larger.

5.9.1.5 Multi-conductor cables shall be used external to panels.

5.9.1.6 Single core medium-voltage cables shall be constructed with ethylene propylene rubber (EPR) insulation, shielded, and have a 133% voltage rating.

5.9.1.7 Low voltage conductor insulation material shall be cross linked polyethylene (XLPE) or better, except that conductors properly secured against motion may use polyvinylchloride (PVC) insulation.

5.9.1.8 Digital data cables shall be laid in separate conduits, even when run in cable tray.

5.9.1.9 Cables for variable frequency AC (VFAC) motors shall be designed for VFAC use, rated for 600 V with a peak capacity of at least 2,000 VAC, constructed of symmetrical three phase conductors and symmetrical grounds (one per phase), and contain copper tape shielding underneath the outer cable covering. VFAC motor cables shall be approved for use by both the motor supplier and the drive control supplier for their intended use.

5.9.1.10 All the wires and cables exposed to weather shall be resistant to oil, chemical, ozone, and ultra-violet (UV) rays.

5.9.1.11 Control wire runs shall have minimum 20% spares connected to identified spare terminal blocks.

5.9.1.12 Conductors of wire size 10 mm^2 / 8 AWG and smaller shall be terminated at spring clamp type terminal strips in PLC control panels, inverters, MCC, distribution panels, junction boxes and local control boxes. Terminal boards or through-bolted and solderless lugs shall be used for larger conductor sizes. The Contractor shall provide at least 10% spare terminal blocks for control wiring 10 mm^2 / 8 AWG and smaller, in addition to those provided for spare conductors. Only one wire to a termination point shall be permitted.

5.9.1.13 Splices will not be permitted in raceways or fittings. Splices or joints in feeders or branches will be permitted only in junction boxes and pull boxes using terminal boards, where specifically approved by Owner.

5.9.1.14 Wires shall be grouped and segregated by medium-voltage power, main motor, power loads, control, and low voltage signals. Medium voltage cables above 600 V AC shall be run in separate conduits and boxes. Power and control conductors shall be segregated per the control equipment manufacturer's recommendations. Low voltage signals shall be run in separate conduits. Where cables are run in cable tray or cable ladder, suitable separators shall be provided between each wire group. Where common junction boxes are used, suitable metal barriers shall be provided between each wire group.

5.9.1.15 Cables within cable trays or cable ladders shall cross only when crossing trays are perpendicular to each other and shall minimize the overlapped distance.

5.9.2 Conduits and raceways shall meet the following minimum requirements:

5.9.2.1 All wire shall be run in conduit, cable tray, cable ladder and/or approved cable raceways. The crane structure shall not be used as a raceway.

5.9.2.2 Conduit, cable ladders, and cable trays shall be run inside the structural members for maximum protection.

5.9.2.3 Cables external to the electric and machinery house, and crane structural members shall be enclosed their entire length with rigid and/or seal-tight flexible conduits.

5.9.2.4 Where cables inside crane structural members are to exit the structure through rigid and/or seal-tight flex, junction box(es) shall be provided inside the structure, cables terminated in the junction box(es), and individual wires, such as THWN or equivalent, shall be routed to the final electrical consumers. Multi-conductor cables shall not be allowed inside rigid and/or seal tight flexible conduit.

5.9.2.5 No conduit, cable trays, cable ladders, raceways, or enclosures shall be mounted on the landside, waterside, or inboard faces of the crane legs, the top of either sill beam, the inside surfaces of the portal tie beams, or boom, or at any other location where it may be subject to damage from containers or whipping wire ropes.

5.9.2.6 Cables and wires in vertical or sloped conduit, including the boom, shall be supported if the vertical rise exceeds 30 m (100 ft) or the distance prescribed by the IEC/NEC, whichever is less. Medium-voltage cables shall be supported inside pull boxes every 15 m (50 ft) of vertical rise. Cables on vertical or sloping cable trays or ladders, including all cable trays on the boom, or on horizontal cable trays or ladders oriented such that the weight of the cables is supported by the strapping, shall be strapped with insulated 10 mm or larger stainless steel strapping every 900 mm or less. Cables on horizontal cable trays or ladders oriented such that the weight of the cables is supported by the cable tray or ladder shall be strapped with insulated 10 mm or larger cable strapping every 2 m or less. Cables may be additionally secured by Ty-wraps as needed; however, Ty-wraps cannot be substituted for insulated 10mm stainless steel strapping.

5.9.2.7 Rigid conduit shall be galvanized steel with a minimum trade size of 21 mm (0.75 in) and shall conform to the requirements of IEC 60981 / ANSI C80.1.

5.9.2.8 Conduit shall be supported using stainless steel "U" bolts with self-locking stainless steel nuts at intervals not exceeding 2 m (6 ft). Welds shall not be used to support conduit.

5.9.2.9 Low points in conduit or seal-tight flex runs shall be fitted with gravity drains.

5.9.2.10 Conduit fittings shall be threaded, galvanized, malleable iron, with "O"-ring gaskets or approved equivalent. Threadless type couplings, connectors, and fittings shall not be used.

5.9.2.11 Pipe compound shall be used on all conduit joints. Exposed threads shall be thoroughly cleaned and painted. All conduit and fittings shall be cleaned and coated with the paint system specified in Section 9.6.1.

5.9.2.12 Flexible conduit shall be synthetic jacketed, spirally wound, galvanized steel. Flexible conduit shall not be used in place of rigid conduit bends. Flexible conduit shall only be used to accommodate relative motion between machine components and the structure. Each use of flexible conduit shall not exceed 1 m (3 ft) in length and shall be supported in accordance with IEC/NEC requirements.

5.9.2.13 External cable trays or cable ladders are not allowed. Internal cable trays, cable ladders, and raceways shall be stainless steel or hot-dip galvanized after fabrication.

5.9.2.14 Cableways for main drive motors shall be designed to eliminate the interference to adjacent cables. Rigid conduit shall be used for medium voltage cable only.

5.9.3 The entire crane structure and all non-insulated metals shall be electrically continuous and grounded. Grounding shall be in accordance with IEC 60204-32 and 60204-11 or NEC where applicable.

5.9.3.1 Conduit shall be properly grounded using approved grounding bushings and 4 mm^2 / 12 AWG wire.

5.9.3.2 All cable trays shall be electrically bonded at every joint to ensure electrical continuity.

5.9.4 The installation of fiber optics shall meet the following minimum requirements:

5.9.4.1 Fiber optic cable shall be 62.5/125 micron multi-mode, except single-mode fiber shall be used between the Crane control system and the wharf.

5.9.4.2 Fiber optic connector shall be metal type ST, 3M "Fiberlok", or approved equivalent.

5.9.4.3 Fiber optic runs shall contain at least 100% spare fibers.

5.9.4.4 For redundancy all fiber circuits shall be looped such that a failure of one fiber can be identified, but shall not stop operations.

5.9.4.5 Fiber optic distribution centers outside the electrical control room shall be sealed "air tight".

5.9.4.6 All fiber optics, including spares, shall be terminated, identified, and rigidly mounted inside the distribution centers.

5.9.4.7 All fiber optic cables shall be supported within 50 mm of their terminations.

5.9.4.8 All junction boxes and pull boxes shall be sized to at least 120% of IEC/NEC requirements.

5.10 PANELBOARD AND ENCLOSURES

5.10.1 Panels in the electrical control room and operator's cabin shall meet the following minimum requirements:

5.10.1.1 Panels mounted indoors shall have a minimum rating of IP 21 and shall be electrostatic powder coated. They shall be designed and fabricated to withstand the shock and vibration forces encountered on the Crane. Height and depth of all the panels in the electrical control room shall be uniform.

5.10.1.2 The panels shall be floor mounted with wiring entrances from the bottom. Interconnections between panels may be made through wire ducts in the upper portion of the panel.

5.10.1.3 Panelboards shall be accessible and removable from the front. Covers of electrical enclosures shall be hinged and able to open to fully expose and allow removal of panelboards and other equipment inside the enclosures. There shall be a minimum of 1 m of clear space in front of all panelboards.

5.10.1.4 Each panel shall have an overhead light and door switch.

5.10.1.5 A dimensioned layout drawing of drive system panels and control panel shall be submitted to the Owner for approval as required by 7.9.10.

5.10.2 Outdoor enclosures shall meet the following minimum requirements:

5.10.2.1 Enclosures outside of the air conditioned electrical room or operator's cabin shall be rated at least IP 55 / NEMA 4X and made of 316 grade stainless steel and unpainted. Fasteners, hinges, hinge pins and fittings shall be stainless steel. Panels requiring access more than once per month, such as the ground level control station, shall be provided with single lever handles.

5.10.2.2 Weather protection shall be provided to allow maintenance of outdoor enclosures in rainy weather.

5.10.2.3 All enclosures containing electronic circuitry and exposed to direct sunlight shall be covered with stainless steel shades at top and side walls.

5.10.2.4 Gravity-activated drain plugs or 6 mm (0.25 in) drain holes shall be provided in the bottom of every outdoor enclosure.

5.10.2.5 Local control panels located outdoors shall have space heaters with adjustable temperature controller and a drain hole with breather.

5.10.2.6 Cooling fans shall not be used.

5.10.2.7 All the wires and cables shall enter from the bottom unless otherwise approved by the Owner. There shall be a minimum of 200 mm between the bottom of the enclosure and the terminal blocks.

5.10.3 Terminal strips within panels and enclosures shall be accessible from the front and shall be located between 50 mm (2 in) and 100 mm (4 in) clear of the wire ducts.

5.11 LIGHTING [6]

5.11.1 General

5.11.1.1 Solid State Lighting (SSL) LEDs shall be used on the Crane. Incandescent, fluorescent, HID, high-pressure sodium, or metal-halide light fixtures shall not be permitted on the Crane unless the Contractor can demonstrate a suitable LED fixture is not available and the deviation is approved in writing by the Owner on a case-by-case basis. At the Owner's sole discretion, non-compliant lighting shall be replaced by the Contractor at no cost to the Owner at any time prior to the end of the warranty period. ~~LED floodlights shall be Phoenix Modcom fixtures for the trolley, Phoenix Ecomod for all other locations.~~ LED floodlights shall be Phoenix Ecomod fixtures for all locations. **[6]**

5.11.1.2 All lighting on the Crane, including floodlights, walkway lights, working lights, and logo lights, shall be designed and installed to minimize light pollution. Shrouds, proper aiming of lights, minimizing reflective surfaces which may direct light away from the intended areas, and other established means of limiting fugitive light and scatter shall be employed to minimize the impact of light pollution. The Contractor shall provide a written report which details the steps taken to minimize light pollution from the Crane and shall include an analysis and study of the effectiveness of the proposed abatement methods. The light pollution abatement methods shall be subject to the Owner's approval.

5.11.1.3 Lighting within electrical panels, as supplied, may be manufacturer's standard.

5.11.2 Design

5.11.2.1 Illumination levels shall be at least those required by ANSI/IES-RP-7, *Lighting Industrial Facilities*, unless otherwise specified.

5.11.2.2 Illumination levels shall not exceed a ratio of 3:1 within a 3 m (10 ft) radius of any point in the specified lighted areas.

5.11.2.3 Illumination shall be designed to account for degradation of lighting levels as the lighting elements age. An initial derating factor of at least 0.7 shall be used to obtain the maintained illumination level unless an alternate derating factor can be demonstrated by the lighting supplier and is approved by the Owner.

5.11.2.4 The Contractor shall provide a computer generated lighting study demonstrating that the fixtures and locations proposed satisfy the lighting levels requirements defined in this section. The lighting study shall be subject to the Owner's approval.

5.11.2.5 Each area shall be illuminated by a minimum of two circuits for each type of lighting (walkway, floodlights, etc.) with fixtures staggered so that adjacent lights are not affected by the trip of a single breaker thereby preventing complete black outs in local areas of the Crane. A trip or failure of any one lighting circuit shall not reduce the illumination in any area of the Crane by more than 50% of the specified lighting levels.

5.11.2.6 A maximum of nine (9) LED lights per three phase circuit shall be allowed. Each branch of lights shall have its own ground fault interrupt circuit breaker in MCC. The MCC main feeder circuit breaker shall not be tripped when a ground fault occurs at one of branch circuits. Circuit breaker trips shall be annunciated on the CMS. Lights shall be staggered across multiple circuits so that a trip of one circuit does not cause adjacent lights to go out. Individual circuit breakers and contactors shall be provided for the protection and control of at least the following:

.1 Boom floodlights
.2 Portal beam floodlights
.3 Perimeter floodlights
.4 Trolley floodlights

5.11.2.7 Emergency lighting and other battery backed-up lighting shall only switch to battery power when normal power is interrupted and the back-up diesel generator fails to start. All batteries and chargers shall be located in the machinery house or electric room. Individual emergency light fixture backup arrangements may be considered by Owner on a case by case basis.

5.11.3 Lighting Controls

5.11.3.1 The PLC shall control all of the lighting circuits, except lights in the machinery house and electric room and the emergency egress lights. All breakers for lighting circuits shall be wired into the PLC to indicate when the breaker is tripped. Tripped breakers shall be identified on the CMS.

5.11.3.2 The PLC shall have an astronomical clock and be wired to external ambient light meters. Lighting shall be automatically turned off in daytime hours and on when lighting falls below a suitable level. A switch bypassing this function to allow independent control of the floodlights shall be located in the machinery house at the lighting control panel, at the wharf level maintenance panel, and at the ground level entry to the stairs. These interlocked switches shall have three positions: OFF/AUTO/ON.

5.11.4 Fixtures

5.11.4.1 Fixtures shall be specifically designed for rough service, shock, and vibration typical of a container handling crane. All materials shall be protected for marine service and all fasteners, cable glands, and hardware shall be stainless steel. Optical systems shall be environmentally sealed.

5.11.4.2 Fixtures shall be installed on vibration damping mountings using stainless hardware. All fixtures shall be equipped with a stainless steel safety chain or wire rope, secured to the Crane structure, which shall provide backup support should the support arms or base fail. Mounting locations shall permit easy and safe access from walkways or fixed maintenance platforms.

5.11.4.3 All lighting fixtures, including but not limited to flood lights, working lights, walkway lights, house lights, and emergency lighting, shall be solid state lighting LED specifically designed for rough service. All lighting power supplies, drivers, and ballast shall be high-efficiency, high-power factor, class H insulated, with at least 80% efficiency as certified by a recognized testing laboratory submitted to and accepted by the Owner. All fixture materials shall be suitable for marine service and all fasteners shall be stainless steel. See Section 2.13 for acceptable suppliers of lighting.

5.11.4.4 All lighting, including fixtures, lamps, power supplies, drivers, and ballast, shall have a minimum operating life of 50,000 operating hours. No maintenance of any kind, including lighting element replacement, shall be required to achieve this life. End of life shall be defined as when the fixture produces less than 70% of its initial light intensity. The Contractor shall demonstrate the minimum design life available from each proposed fixture using IES TM-21, *Projecting Long Term Lumen Maintenance of LED Light Sources*, or another method submitted to and accepted as an alternate by the Owner.

5.11.4.5 All lighting shall have a matched color rendering index (CRI) of 22 to 75 and a matched corrected color temperature (CCT) between 2,100 K and 5,500 K suitable for the tasks performed in the area illuminated. Lighting color shall be selected to provide sharp contrast and high definition of illuminated areas.

5.11.4.6 All lighting shall be compatible with NTSC and PAL video cameras and shall not result in distortion or impairment of a clean video signal.

5.11.4.7 Lighting components shall not generate electro-magnetic noise which interferes with radio, intercom, or other data, communication, or control signals.

5.11.4.8 All fixtures shall be subject to the Owner's approval.

5.11.5 Wharf and Ship Floodlights

5.11.5.1 A maintained minimum illumination of 300 lx shall be provided at any point on the wharf directly under and within 12 m (40 ft) either side of the Crane's centerline, and 100 lx on the adjacent wharf within 30 m (100 ft) either side of the Crane's centerline along the wharf.

5.11.5.2 A maintained minimum illumination of 300 lx shall be provided at any point on the ship's deck at 5 m (15 ft) above wharf level within 8 m (25 ft) either side of the boom's centerline at wharf elevation, and 100 lx within 12 m (40 ft) either side of the boom's centerline at wharf elevation.

5.11.5.3 The following additional floodlights shall also be provided:

.1 One fixture adjacent to each crane leg on the portal tie beams and directed toward the truck lanes at the center of the Crane; separately switchable from the wharf level, the machinery house, and the operator's cab
.2 Four fixtures on the trolley to light the area directly below the trolley and the operator's cab
.3 Two fixtures at the lower part of the boom tip and pointing back at the ship
.4 Two fixtures on the landside legs which point in the backreach area

5.11.5.4 Floodlights shall be separated into branches as defined in Section 5.11.2 and controlled as logical zones as approved by the Owner. Each zone shall be controlled from both the PLC and from push-button stations conveniently mounted inside the electric room, the ground level access point, and the remote operator's station. Failure of the PLC shall not prevent control by the push-button stations. See Section 5.11.3.

5.11.5.5 The type, arrangement, and circuits for the floodlights shall be subject to the Owner's approval.

5.11.6 Machinery House and Electric Room

5.11.6.1 Lighting shall be provided for a maintained average illumination of 300 lx in both the main machinery house and electrical control room and the trolley drive machinery house.

5.11.6.2 Lighting fixtures shall be positioned to eliminate equipment shadows on the floor.

5.11.6.3 For any additional lighting desired above this level of illumination, the machinery house convenience outlets will be used with portable work lights.

5.11.7 Other Machinery Areas

5.11.7.1 In areas where machinery is present, work lighting shall be provided for a maintained average illumination of 300 lx on the work area with sufficient distribution to eliminate shadows on work or floor areas.

5.11.7.2 The working lighting shall be provided by the same fixtures as used for machinery house and walkway lighting. The fixtures shall be mounted at a sufficient elevation above the work area to prevent irritation to the eyes.

5.11.7.3 Areas that require this lighting will depend on the Contractor's design, but as a minimum the following areas require this lighting: top of the trolley in the parked position, boom control station and trolley rope tensioner.

5.11.8 Ladders, Stairs, Walkways, and Platforms

5.11.8.1 Lighting shall be provided for a maintained average illumination of 30 lx on all ladders, stairs, walkways, and platforms.

5.11.8.2 Three-way switches shall be installed at wharf elevation adjacent to the elevator, inside the machinery house door closest to the elevator, and at the cab access platform.

5.11.9 Operator's Cab

5.11.9.1 Two switches shall be provided for the operator's cabin lights: one on the operator's auxiliary control panel and one on the wall near the cab entrance.

5.11.9.2 A dimmer control within reach of the seated operator shall allow the operator to select an average illumination on operating surfaces from 0 to 300 lx.

5.11.10 Emergency Egress Lighting

5.11.10.1 Battery powered emergency egress lighting shall be provided to allow personnel to exit the Crane from the operator's cab and machinery house.

5.11.10.2 The egress route is the frame access stairs.

5.11.10.3 An emergency light shall be provided in the elevator cage.

5.11.10.4 Emergency lights shall be operable for a period of at least one hour while on battery power.

5.11.10.5 Battery power shall only go on if both the main power and diesel are not operating.

5.11.10.6 For external emergency egress lighting, battery power shall only be engaged between dusk and dawn.

5.11.11 Aviation Lights

5.11.11.1 FAA approved aircraft warning lights (obstruction lights) shall be provided at, as a minimum, eight locations. The locations shall include two each at the fore and aft ends of the boom, top right and left, and two each atop the waterside and landside boom support girders.

5.11.11.2 Each obstruction light shall consist of two LED light elements.

5.11.11.3 Aircraft warning lights shall be ON at all times except in broad daylight.

5.11.11.4 A battery backup suitable for at least four hours of operation without external power shall be provided. The battery backup shall be interlocked with the auxiliary diesel generator and only engage if the diesel is not operating.

5.11.11.5 All obstruction lights shall be within easy and safe reach for maintenance platforms or walkways and shall be within the lightning rod protection envelope.

5.11.12 Boom Stop Spotlights

5.11.12.1 The Crane shall be equipped with spotlights that illuminate the boom latch.

5.11.12.2 The boom spotlights shall be separately controlled by a switch in the boom travel control station.

5.11.13 Logo Lights

5.11.13.1 The Owner's logos shall be illuminated with dedicated lighting controlled by the PLC's astronomic timers to an adjustable schedule initially set for between dusk and dawn at the location of the Owner's facility.

5.11.14 Emergency Exit Signs

5.11.14.1 Battery backed-up illuminated exit signs shall be provided over all exits from the machinery house and electric room. Signs shall have their own self-contained batteries, have a convenient means of periodic testing, and be designed for use in industrial facilities in the United States.

5.11.14.2 Battery power shall only go on if both the main power and diesel are not operating.

5.12 SPACE HEATERS

5.12.1 Space heaters, sized for marine applications, shall be provided for control panels and panels with electronics in them, enclosed brakes, medium-voltage disconnects, and motors larger than 3 kW (4 hp). Any enclosure that houses electronics shall have heaters; except that panel enclosures in continuously air conditioned spaces such as the electrical control room need not have heaters.

5.12.2 Space heaters shall be automatically energized when the Crane is not in service. Heaters shall automatically cut off during crane operation unless heaters are thermostatically controlled to maintain operating temperatures when the Crane is operating.

5.12.3 Heaters shall be powered by dedicated circuits. Hazard signs shall be provided at each heater location warning of this separate power source.

5.13 GANTRY WARNING DEVICES

5.13.1 One electrically operated automatic warning siren shall be mounted at each gantry leg and shall sound automatically whenever the gantry motors are energized. Volume levels shall be set within allowable levels and are subject to the Owner's approval.

5.13.2 One red dome weather proof flashing strobe light shall be mounted at each gantry leg and shall flash automatically whenever the gantry motors are energized.

5.14 AUXILIARY DIESEL GENERATOR

5.14.1 An auxiliary diesel generator shall be provided to supply limited power to the cranes in the event of a utility power outage.

5.14.2 Diesel generator shall be sized to provide all loads connected to the auxiliary transformer. Main motion converter/inverter power is not included. Emergency drives shall be powered with operation of one motion at a time.

5.14.3 The diesel generator and fuel tank shall be mounted to the same portal tie beam as the gantry cable reel.

5.14.4 Diesel generator fuel tank shall be double walled with leakage alarm, sized for 24 hr of 100% generator nameplate load. Fueling of the tank shall be from a dock level fuel tanker truck. No fuel pump is required to fill the tank. The tank shall have a hose cap, breather, fuel level gage, bolted access cover on the top of the tank, and drain valve to empty the tank for maintenance.

5.14.5 See Section 2.13.3 for acceptable suppliers and EPA tier certification.

5.14.6 An automatic transfer switch shall be provided to automatically start the diesel generator on loss of utility power and load automatically transferred to the diesel generator when up to speed.

5.14.7 The diesel generator shall be housed in a stainless steel enclosure with doors, and include auxiliary controls such as a battery charger, gauges, etc.

5.14.8 The diesel shall be controlled by a Hand/Off/Automatic switch at the diesel generator with remote starting controls from control station at the landside wharf level.

5.14.9 The diesel generator dock level controls shall include all necessary controls to start, stop, and monitor the diesel generator including a fuel tank level indicator.

5.14.10 Diesel generator engine and electrical load data shall be monitored by the crane CMS system.

5.15 NAMEPLATES

5.15.1 Electrical equipment shall be supplied with a nameplate immediately adjacent and symmetrical to the equipment.

5.15.2 These nameplates shall carry appropriate inscriptions, or identification markings, which will enable the operator and mechanics to form a quick and accurate appraisal of the overall relationship and relative functions of their respective components.

5.15.3 Nameplates fitted outdoors shall be engraved stainless steel with filled letters and attached with stainless screws. Nameplates may be engraved phenolic if located within the machinery house or electric room.

5.15.4 Nameplates for all operator’s control devices shall be engraved stainless steel with filled letters for identification. The letters shall be a minimum of 6 mm (0.25 in) high and easily readable. See Section 2.14 for languages at the Owner’s facility.

5.15.5 Nameplates for electrical equipment, components, and apparatuses, such as all junction boxes, panel boards, control devices, transformers, and lighting fixtures, shall include the electrical diagram sheet number.

5.15.6 Nameplates shall be provided for any special precaution, maintenance or operating instructions shall be included on nameplates or on a separate plate attached to the equipment. Hazards shall be identified in accordance with Section 7.18.1.1.

5.15.7 The designation on nameplates shall agree with the designation on the electrical diagrams.

5.15.8 The content, construction, and location of all nameplates shall be subject to the Owner’s approval.

5.16 CIRCUIT IDENTIFICATION

5.16.1 Cables and conductors internal and external to panels including shielded cables and fiber optics shall be identified.

5.16.2 For conductors, hot stamping on white PVC sleeves or heat shrinking sleeves of 3M, Raychem, Brady or approved equivalent shall be used. For cables, identification shall be of a type resistant to the environment and shall be securely attached to both ends of the cables. Sleeve type markers shall be restrained from slipping along the wire or cable. Ferrule type markers shall not be used. Hand-written markers shall not be used. The method of marking cables and conductors shall be subject to Owner’s approval.

5.16.3 Wires and conductors shall be labeled on both ends as denoted in the electrical schematics and in accordance with the control supplier’s circuit diagrams.

5.16.4 Conductors leaving the motor control panels, AC motor control center, and cab control panel shall be marked with the conduit number in addition to the wire number.

5.16.5 Power wire color identification shall be in accordance with IEC/NEC requirements, or the local code requirements at the Owner’s Facility if defined. Color coding of conductors shall be consistent. Where insulation colors are not compatible, colored synthetic tubing or sleeves with a minimum length of 50 mm (2 in) shall be used at conductor ends and identified with circuit letter and number. The color green shall not be used for any non-ground conductor, including cores within multi-conductor cables, or motor internal conductors. Color coding shall be subject the Owner’s approval.

5.17 CONVENIENCE OUTLETS

5.17.1 Convenience outlets shall be single-phase outdoor duplex outlets with ground fault interrupt protection at the circuit breaker and shall be provided, at a minimum, as follows:

.1 Two in the operator’s cab
.2 Fifteen spread along the boom.
.3 Four in the ground level maintenance cab
.4 One on each crane frame boom support beam
.5 Six in the machinery house
.6 Two in the trolley machinery house
.7 Two in the electrical cabinet of the trolley drive machinery house

.8 Six in the electric room
.9 Two additional outlets in electrical control room from UPS labeled "For programmer use only"
.10 Four at wharf elevation (two waterside and two landside)
.11 One at the boom cable chain service platform (center of chain length)
.12 One at the boom travel control station
.13 Two on top of the trolley
.14 One at backreach
.15 Elevator (cage roof)
.16 Elevator pit

5.17.2 Additional receptacles shall be provided where potential maintenance tests warrant, such as drive and control enclosures, trolley panels, etc.

5.17.3 Receptacles shall be grounded and suitable for operation of conventional hand power tools.

5.17.4 Receptacles in exposed locations shall be in NEMA 4 enclosures with screw caps and gaskets. Receptacle caps shall be rated for wet weather outdoor use and be attached to the receptacle with a suitable stainless steel wire or chain.

5.17.5 Convenience outlets shall be NEMA 5-15 polarized and grounded receptacles rated for 125V, 15A and shall be ground fault interrupting (GFI) protected.

5.18 RADIO FREQUENCY INTERFERENCE (RFI)

5.18.1 All crane electrical systems shall be shielded and grounded to protect from radio frequency interference including powerful radar emissions from adjacent vessels, aircraft, and signals from transmission towers and stationary radars.

5.18.2 The Crane shall meet FCC specifications regarding radio frequency emissions.

5.19 LIGHTNING PROTECTION

5.19.1 Two (2) lightning air terminals (lighting rods) shall be provided at both the boom tip and backreach, and two on the top of the top of each cross tie beam. (Total eight)

5.19.2 Lightning air terminals shall be a minimum of 1.25 m (4 ft) in length.

5.19.3 See Section 5.3 for surge suppression requirements.

SECTION 6 SOFTWARE AND CONTROLS

6.1 GENERAL

6.1.1 Refer to Section 5.1, the requirements of which shall also apply to the software and controls.

6.1.2 Refer to Sections 1.5 and 5.1 for additional safety requirements.

6.1.3 Refer to Sections 1.9.3 and 6.2.1.1 for the Functional Description and Presentation requirements which shall govern the design and development of the crane controls and software.

6.1.4 The Crane's drives, control systems, and control software shall be provided and integrated by the Control System Supplier. The Control System Supplier's personnel shall oversee the installation and configuration of the control system and shall perform the start-up and commissioning. Authorized representatives, subsidiaries, or other third parties shall not be used to provide the control software, perform integration, or provide start-up or commissioning services.

6.2 CRANE SOFTWARE AND CONTROL LOGIC

6.2.1 The crane control logic shall be prepared in at least the following three phases:

6.2.1.1 Functional Description

6.2.1.1.1 The Functional Description is the high level description of the desired Crane functions and behavior written in plain text. Typically this is prepared by the Contractor and the control supplier as a basis for developing the detailed software logic. The Functional Description shall be complete, consistent, and sufficiently detailed to be used as a manual for the design and testing.

6.2.1.1.2 The Functional Description shall include descriptions of the controls and systems on the Crane, including the TLS and interface with the Owner's TOS, which clearly and accurately describe all control functions and all interactions between the user and the Crane, the controls, the CMS, and any function and control logic required to meet this Specification.

6.2.1.1.3 All safety-critical functions shall be carefully specified in the Functional Description prior to application development.

6.2.1.1.4 The Functional Description shall define all mathematical and logic terms used.

6.2.1.1.5 The Function Description shall include all manual and automated functions described in these Specifications in addition to those necessary to provide a fully functioning Crane as intended by this Specification including at least the following:

.1 The Crane control functions
.2 The interlocks, permissives, sequencing, processes and timing of the Crane's protective functions and devices
.3 Detailed timelines for container handling cycles and for significant Crane sequences showing parallel activities
.4 All internal and external functions and user interfaces including all details required for the development of all external interfaces
.5 A list of all inputs and outputs including switches, encoders, tachometers and all programmable devices
.6 Hoist, trolley, boom, and gantry control logic and timing
.7 Micro-motion control logic and timing
.8 Spreader control logic and interlocks including timing
.9 All CMS/RCMS functions
.10 All TLS functions
.11 Items related to the operation including at least those described in Section 1 and Section 2

6.2.1.2 Preliminary Logic – The control logic software and documentation prepared by the control supplier based on the functional description and the final design configuration of the Crane. Typically this is at a much more detailed level than the functional description and includes references to individual devices, sensors, and interlocks.

6.2.1.3 Final Logic – The final control logic software and documentation prepared by the control supplier after field testing.

6.2.2 Software Documentation

6.2.2.1 The Contractor shall prepare and maintain the software documentation that clearly defines the inputs, internal logic, and output for each software element. The documentation shall include not only detailed descriptions on the interlocks, permissives, sequencing, and timing of the Crane's control and protective devices, but also a detailed timeline for a typical container handling cycle. Software documentation shall be subject to the Owner's approval.

6.2.2.2 As a minimum, the software documentation shall include the following:

.1 A list of all inputs and outputs including control devices indoors, switches and sensors in the field as well as data via data bus interface
.2 Main hoist control logic including permissives, slowdowns, interlocks and timing
.3 How power is optimized and main hoist speed varies per load weight
.4 Trolley control logic including permissives, slowdowns, interlocks and timing
.5 Boom travel control logic including permissives, slowdowns, interlocks and timing
.6 Gantry control logic including permissives, slowdowns, interlocks and timing
.7 Snag load detection timing and shut down logic and safe reset sequence logic
.8 Spreader landing, twistlock operating and hoisting from slack rope condition logic and interlocks including timing
.9 An instrumentation diagram complying with IEC 81346 and showing all control devices

6.2.3 PLC Program

6.2.3.1 One common and interchangeable PLC program shall be used on all Cranes supplied under this order. The Contractor shall demonstrate that the program running in one Crane is able to run on all of the others.

6.2.3.2 Differences between the Cranes shall be stored in the software database/or control software and shall not be hard coded into the PLC or control software.

6.2.3.3 The PLC application program shall meet the requirements of IEC 61131-3 and shall be in Ladder Diagram (LD). Functional Block Diagram (FBD), Sequential Flow Chart (SFC) or Instruction List (IL) shall not be used.

6.2.3.4 The Contractor shall demonstrate that the PLC and safety concept shall enable safe working conditions under all working modes.

6.2.3.5 See Sections 6.2.4 and 6.11 for software revision and security requirements.

6.2.4 Software Version Verification

6.2.4.1 An automated software verification system shall be provided to ensure the operating software on all Cranes matches a known good configuration. The system shall periodically verify, at least once per day, that the software on all Cranes matches the master copy of the known good software.

6.2.4.2 The verification system shall also scan for software overrides and forces.

6.2.4.3 Should the verification system detect a mismatch in the software or an override or force, it shall log a warning in the crane fault log.

6.2.4.4 The CMS and RCMS shall be capable of displaying the results from the latest verification sweep in a clear and concise format including at least the following: crane number, software version, equal or not equal to master version of known good software, and the presence of any overrides or forces.

6.2.4.5 The schedule for verification sweeps shall be adjustable to occur at any given time during the day or night up to ten times a day. Verification sweeps shall not affect the operation of the Cranes.

6.2.4.6 The master copy of the known good software shall reside on the RCMS and shall be read-only to prevent accidental changes.

6.2.4.7 Successful demonstration of the verification system and a known good copy of the software shall be required prior to the start of the endurance testing on each Crane.

6.2.5 Additional Control Requirements

6.2.5.1 Control of the hoist, trolley, and gantry motions shall be stepless regulated, regenerative over the entire operating speed range of the equipment.

6.2.5.2 All control functions except “emergency stop” and emergency drive motors shall be multiplexed through programmable controllers.

6.2.5.3 All motions shall begin within 100 ms of the motion command. Any and all delays including but not limited to sensing, torque proving, and brake release, shall be within this 100 ms.

6.2.5.4 Automatic slow-down shall be provided:

.1 For the trolley at boom ends and at the O-frame
.2 For the boom at limits of travel
.3 For the main hoist at the upper main hoist limits

6.2.5.5 See Section 2.2.1for other requirements for boom, trolley, and hoist operation.

6.2.5.6 Hoist slack rope shall be sensed by both the limit switches on headblock and load weighing system. It shall provide a spreader “anti-bounce” circuit to insure that no twistlock has rotated to the locked position outside of the container corner box and prevent hoist wire rope from excessive pay-off from the drum. Hoisting speed shall also be limited to 20% rated base speed until the hoist ropes are fully tensioned by the weight of the spreader. See Section 4.9.4 for additional requirements.

6.2.5.7 Hoist and trolley controls shall prevent swinging the lifting system or load into, or setting it upon, any portion of the Crane including the boom supports, O-frame, sill beams, gantry machinery, walkways, electric controls room, , operator’s cabin, or switchgear room.

6.2.5.8 Gantry motion shall be fine-tuned in order to minimize crane frame and boom sway due to gantry acceleration. See also Sections 7.30 and 3.14.

6.2.5.9 The trolley shall automatically move such that boom extension or retraction motions will cause the trolley to stay at the same position, such as at the trolley access platform.

6.2.5.10 Boom operation:

6.2.5.10.1 Boom shuttle operation shall be controlled by a keyed switch. Only authorized personnel may operate the boom.

6.2.5.10.2 The boom shall extend or retract automatically to its final position when the boom extend or retract pushbutton is pressed and the desired position selected.

6.2.5.10.3 Except for trolley repositioning motion during boom extend or retract motions, trolley operation shall not be allowed unless the boom latch is engaged.

6.2.5.10.4 Automatic or manual operation of the boom shall be available in the operators cab and the boom control station. At the ground level operating panel, only manual operation of the boom shall be allowed.

6.2.5.10.5 Boom latch lock pins shall automatically retract before the boom motor operates. After the boom moves to the desired position, the boom latch lock pins shall automatically extend into the pin sockets.

6.2.5.10.6 Limit switches at the pin pockets shall be used for positioning: rotary limit switches or encoders on the boom motor shall not be used for pin alignment due to boom rope stretch.

6.2.5.10.7 Automatic operation shall only be allowed while the operator is present, verified by a light banner or seat switch.

6.2.5.10.8 In manual operation, provisions shall be made to manually retract or extend lock pins.

6.2.6 Brake Control Requirements

6.2.6.1 The controls shall bring the load to a near stop on motor torque before setting the brakes.

6.2.6.2 Holding brakes shall set and the contactors open after independently adjustable time delays of up to 30 s after the master switches are returned to the off position.

6.2.6.3 Slippage on hoist service brakes shall be detected by encoder. Fault processing and reset sequence shall be same as an overspeed fault.

6.2.6.4 Under some operating conditions, brakes may be held released by timers or controls when its associated drive is active, but at zero speed.

6.2.6.5 Each brake manual release shall have limit switch indication for control inhibit of that motion unless the brakes automatically reapply following a manual release.

6.2.6.6 All brakes shall have interlocks to indicate positive release. Release sensors shall be activated by the manual release unless separate manual release sensors are used.

6.2.6.7 A convenient means shall be provided for maintenance personnel to periodically verify the dynamic torque of all brakes on the Crane using automated test functions in the Crane controls. Refer to Section 7.26. This method shall be used to demonstrate the dynamic torque capability of the brakes during acceptance testing; see Section 10.

6.3 PROGRAMMABLE LOGIC CONTROLLER AND REMOTE I/O

6.3.1 A Programmable Logic Controller (PLC) shall be mounted in an enclosure installed within the air-conditioned electric room.

6.3.2 The PLC and PLC software shall meet IEC 61131-3 standards for industrial control programming.

6.3.3 Application program shall be stored in EEPROM or nonvolatile RAM and shall not be lost or corrupted by power failure. The PLC shall automatically restart after a power failure without requiring a manual reset.

6.3.4 PLC memory shall have a minimum of 130% of the operating capacity needed for the control software to allow for future expansion. The PLC power supply shall provide at least 130% of the required peak capacity for future expansion.

6.3.5 An easily accessible display on the PLC shall show the PLC status and any faults.

6.3.6 Input/output (I/O) entry into the control system shall be accomplished using distributed interface devices.

6.3.7 PLC communications with remote I/O units shall use an industry standard bus protocol approved by the Owner.

6.3.8 Cycle time to scan all I/O modules and execute PLC program shall not exceed 100 milliseconds.

6.3.9 All I/O modules shall be protected against short-circuits, surges, and spikes; see Section 5.3.

6.3.10 Analog I/O shall be isolated between channels.

6.3.11 PLC and remote I/O station power supplies shall us standard crane voltage levels defined in Section 2.4 and shall be provided for each remote I/O station.

6.3.12 I/O modules shall not be affected by interference from radar, radio waves, or other EMI sources, and shall be properly secured against the shock and vibration of the operating crane; see Section 5.18.

6.3.13 Where distributed interface devices are used, a minimum of 10% spare input and 10% output points shall be provided for each type of I/O used at each location.

6.3.14 An uninterruptable power supply (UPS) or other means shall be provided to maintain PLC communication, CMS recording of alarms, and field bus power in case of short term power black-out.

6.4 OPERATOR'S AND MAINTENANCE CONTROL DEVICES

6.4.1 General

6.4.1.1 Operator's control devices shall be provided as needed for the safe and productive operation and maintenance of the Crane. See Sections 7.1 and 7.2 for operator's control devices required at the various operating stations.

6.4.1.2 Arrangement, location, and functions of all the operator's control devices shall be approved by the Owner. See Section 5.15 for nameplate requirements.

6.4.2 Master Switches

6.4.2.1 Master switch data shall be programmable to a linear or an exponential curve with "anti-jerk" characteristics. All acceleration times shall be less than or equal to those required by Section 2.7.2.2 including any "anti-jerk" and communication delays.

6.4.2.2 The "float" switch on all master switches shall permit the load to float (no movement) with the brakes released. The "float" switch shall not bypass any limit switches. The master switch shall be returned to the "off" position to reset "float" operation.

6.4.2.3 Mater switches shall automatically return to the "off" position when released.

6.4.2.4 Master switches shall have quick-disconnect connections to ease replacement.

6.4.3 Local Control Stations

6.4.3.1 Local control stations shall be in enclosures meeting the requirements of Section 5.10.2 regardless of location.

6.4.3.2 All control devices and indicators shall have a minimum rating of IP 55.

6.4.3.3 Control stations shall be adequately sized to accommodate I/O modules and wiring.

6.4.3.4 The interior of all control stations shall have lights activated by a door switch.

6.4.3.5 Control power illuminated pushbuttons and mushroom head "Emergency Stop" pushbuttons shall be installed on all local control stations; refer to Sections 6.4.4 and 6.4.4.3.

6.4.3.6 Local control stations shall be equipped with instructional placards and hazard signs as appropriate; refer to Section 7.18.1.

6.4.4 Emergency Stop

6.4.4.1 'Emergency stop' buttons shall be oversized red palm-operated manually-reset push-buttons accommodated in stainless steel enclosures meeting the requirements of Section 5.10.2 regardless of location.

6.4.4.2 Each location on the Crane that has operating machinery shall have "Emergency Stop" pushbutton switch(es) conspicuously located and easily accessible. The design of the Crane will determine the required location of these switches, but as an indication of the areas that should have switches; the following must be included as a minimum: backreach, machinery house, boom tip platform and any other location that the Contractor's design will make necessary an emergency stop.

6.4.4.3 Eight 'Emergency stop' pushbuttons shall be located at wharf elevation; two each on the landside and waterside of the waterside sill beam and two each on the waterside and landside of the landside sill beam. See Section 7.18.2 for sign requirements.

6.4.4.4 Activation of Emergency Stop pushbuttons shall be automatically logged in the CMS and RCMS and shall include a unique identifier for each pushbutton.

6.4.5 Control Power Indicators

6.4.5.1 Each control station shall have an illuminated push button to establish control power to that station. Steady red illumination of the push button will indicate when that station has control and control power is engaged. Steady illumination of an alternate color or blinking illumination shall be used at the control power push buttons at all other control stations to indicate control power is energized but control is at a different station. The method for indicating control power is established at a different station shall be subject to the Owner's approval.

6.4.5.2 LED light fixtures with red lenses shall be installed to indicate when control power is energized. The fixtures shall be wired electrically parallel with the relay controlling the AC control power for the drive controls. As a minimum, the fixtures shall be mounted in the following locations:

.1 Backreach visible from the entire wharf area even in bright sunlight
.2 Electrical control room visible throughout the room
.3 Main and trolley machinery house visible throughout the house

6.4.6 Bypass Switches

6.4.6.1 Where switches are provided to bypass one or more crane interlocks, they shall be key operated switches and shall be labeled with appropriate safety signs.

6.4.6.2 The purpose and effect of each bypass switch shall be clearly described in the operating manual along with appropriate safety instructions.

6.4.6.3 Activation and release of bypass switches shall be automatically logged in the CMS and shall include a unique identifier for each switch.

6.5 LIMIT SWITCHES, SENSORS, AND PROTECTIVE DEVICES

6.5.1 The Contractor and the drive system vendor shall make every effort to minimize the variety of devices used in order to reduce the maintenance burden and to minimize spare parts inventories. To the extent possible, all the limit switches and sensors shall be of identical and interchangeable design. Limit switches, sensors, and protective devices other than those listed in Section 2.13.3 shall be subject to Owner's approval.

6.5.2 Interchangeable inductive proximity limit switches with indicating LEDs and quick disconnects shall be used for all limit switches on the Crane. Where the Contractor can demonstrate that the use of these switches is unsuitable, and that redesign of the system to use these switches is not feasible, alternate switches can be used subject to the Owner's approval on a case-by-case basis.

6.5.3 Rotary cam switches shall have snap-acting contacts with minimum of three (3) spare contacts.

6.5.4 Laser, infrared or ultrasonic switches shall be suitable for their intended use and shall not be affected by heavy rain, dense fog, heavy snow, or wind-blown particulates.

6.5.5 Over-speed switches shall be either mechanical centrifugal type or electronic type. They shall be set at 115% of the top rated speed.

6.5.6 Encoders shall be of heavy duty construction and directly coupled to the motor or drum.

6.5.7 Vibration sensors shall be accelerometers.

6.5.8 Temperature sensors shall be embedded in transformers, inverters, cable reels, and the major motion motors.

6.5.9 All the limit switches, sensors and protective devices installed outdoors shall have protection degree of at least IP67.

6.5.10 All limit switches shall be installed at easily accessible locations.

6.5.11 Functions of all limit switches and sensors shall be described in the Functional Description; refer to Section 6.2.1.1.

6.5.12 The main hoist drive shall have at least the following limit switches and sensors:

- .1 Block-operated type limit switch on trolley for hoist over-travel detection
- .2 Rotary cam limit switch attached to the drum
- .3 Absolute encoder attached to the motor
- .4 Overspeed switch attached to the drum
- .5 Snag load sensing shall be by hydraulic pressure switch or Owner approved equivalent; see Section 4.9.5
- .6 Brake release proximity switches
- .7 Motor over temperature switches

6.5.13 The trolley drive shall have at least the following limit switches and sensors:

- .1 Heavy duty lever limit switches at both ends of trolley travel, with the boom in any position—the trolley may not hit the O-frame.
- .2 Magnetic proximity switches installed along trolley run way
- .3 Absolute encoder attached to the motor
- .4 Mushroom pushbutton with warning sign on trolley to keep the trolley from moving
- .5 Parked position indication.
- .6 Brake release proximity switches
- .7 Motor over temperature switches

6.5.14 The boom travel drive shall have at least the following limit switches and sensors:

- .1 Heavy duty lever limit switches at each boom position.
- .2 Rotary cam limit switch attached to the drum
- .3 Overspeed switch attached to the drum
- .4 Absolute encoder attached to each motor
- .5 Gate access switches with warning sign at each boom access and exit gate to prevent the boom from traveling while personnel are entering or exiting the boom
- .6 Pressure switch in the operator's chair seat with time delay to prevent boom motion from the operator's console unless the maintenance technician is in the seat; see Section 7.1.8
- .7 Light banner or push button sequence at boom travel control station to prevent boom motion unless the maintenance technician is standing in the station; see Section 7.2.1
- .8 Interlocks with trolley operation to verify trolley is in parked position
- .9 Interlocks to verify trolley is maintained in parked position while boom is operated
- .10 If trolley drive is out of service, interlocks permitting slow boom operation after trolley drive is released, but maintaining all appropriate safety distances, particularly of the trolley to the landside O-frame.
- .11 Boom rope tension overload swithces
- .12 Brake release proximity switches
- .13 Motor over temperature switches
- .14 Boom latch engaged and disengaged limit switches.
- .15 Boom latch pocket alignment limit switches.

6.5.15 The gantry drive shall have at least the following limit switches and sensors:

- .1 Encoder attached to at least one motor on both the landside and waterside gantry rail
- .2 Proximity switches for bumper compression at all corners
- .3 Proximity switches for stowage anchor pins
- .4 Sensors for anti-collision protection; see Section 7.29
- .5 Motor brake and wheel brake release proximity switches
- .6 Motor over temperature switches
- .7 Gotting Ethernet based gantry anti-collision system with transponder antennae; See Section 7.29.1.
- .8 Laser scanning system(s); See Sections7.29.3 and 7.29.4.
- .9 See also Section 7.30.

6.5.16 The gantry cable reel shall have at least the following limit switches and sensors:

- .1 Proximity switches on the cable guide roller attached to gantry bogie
- .2 Rotary cam limit switch or absolute encoder attached to the slip ring shaft
- .3 Encoder attached to the motor

6.5.17 The spreader cable reel shall have at least the following limit switches and sensors:

.1 Rotary cam limit switch or absolute encoder attached to the slip ring shaft
.2 Encoder attached to the motor

6.6 SWAY CONTROL

6.6.1 An electronic sway control system shall be provided. Sway control shall be a closed loop system which verifies the no-sway condition of the lifting system and provides sway correction where required. Sway correction with a stopped trolley shall not move the load beyond its present sway excursions. The trolley and load shall respond to the operator's trolley and hoist commands with minimum disruption to the operator's commands.

6.6.2 No sway is defined as sway less than ±2 in (±50 mm) as measured at the bottom corners of the 45' container or the twistlocks of an empty spreader at any hoist height above dock level. Sway includes any induced rotary (skewing) motion of the load.

6.6.3 Average acceleration or deceleration of the trolley with sway control shall be not less than 75 percent of the trolley acceleration rates defined in Section 2.7.2.2 for any hoist pendulum length above dock level.

6.6.4 While trolleying, the operator may hoist or lower at the same time without affecting load sway.

6.6.5 The electronic sway control system shall operate automatically and maintenance personnel shall be capable of easily adjusting the severity of the sway control in at least five increments from off to maximum using controls in the electric controls room. Controls for adjusting the sway control shall not be present in the operator's cabin.

6.6.6 The electronic sway control shall be transparent to the operator. The operator shall be able to command speed with the trolley master switch, and the load shall be brought to that speed with no sway. The operator may change the speed command before the load reaches the commanded speed, and the load will respond to the revised speed command with no load sway.

6.6.7 Sway angle reading sensors shall have an auto-diagnostic capability. Any sway sensor failure shall be displayed on CMS. Proper and immediate repair or recovery procedures shall be provided along with any hardware as necessary.

6.7 SHIP PROFILING

6.7.1 The laser-based ship profile and operator landing assist system shall be provided by the electrical control system supplier. See Section 2.2.4 for requirements.

6.8 CRANE MONITORING SYSTEM (CMS)

6.8.1 A crane monitoring system (CMS) shall be supplied on each Crane. The main station for this system shall be located in the CMS partition in the Electrical Control Room.

6.8.2 The CMS shall be the latest available model of the drive manufacturer's version with *all* of the diagnostic, production, operation and maintenance modules and options.

6.8.3 All CMS displays shall be displayed and switched to the language described in Section 2.14. Details of CMS and language translation shall be subject to the Owner's approval.

6.8.4 All computers supplied on the crane shall be latest model, "state-of-the-art" with solid state primary drives and standard type backup drives.

6.8.5 The CMS shall have the capability of monitoring the condition and status of at least the following:

6.8.5.1 Power switchgears, main drive inverters, motors, brakes, PLC, I/O modules, bus interface, communication status, operator's control devices, sensors and limit switches, auxiliary equipment, spreader, permissives and safety interlocks shall be monitored and updated on a real time basis.

6.8.5.2 Status of permissive and energy flow of main drive circuitry shall be displayed on conventional single line diagram.

6.8.5.3 The system shall have the capability of monitoring drive functions and storing two crane cycles worth of five parameters such as motor current, speed reference, speed command, and load cell versus time in sufficient detail to be capable of analyzing and troubleshooting the drives. The data shall be easily downloaded to memory stick, portable HDD, or similar devices.

6.8.5.4 Set values of warning and trip points shall be adjustable by maintenance personnel with password protection.

6.8.5.5 Fault and status data shall be displayed immediately. Nuisance and consequential fault messages shall be minimized. It shall be easy to narrow down the faults to determine the root-cause fault. By clicking over the fault, or when the fault is highlighted by pressing a single keyboard key, a diagnostic screen should appear showing the fault troubleshooting. Multiple troubleshooting screens could be open at the same time from different consecutive faults. Each fault troubleshoot should have a space to include the Owner maintenance personnel experiences and should be editable by a proper Owner's administrator with password.

6.8.5.6 Electrical drawings, PLC software, and drive software/parameters shall be accessible from a password-protected screen.

6.8.5.7 The following performance data shall be logged and maintained even for a total power loss. A graphical report of the data shall also be available.

.1 Control-on hours
.2 Motion hours of main hoist, trolley, boom travel, and gantry
.3 Number and frequency of faults
.4 Power consumption per drive

6.8.5.8 It shall be capable of prompting preventive maintenance of consumable parts such as wire rope, brake pads and disk, bearing and etc. Utilization hours shall be recorded and compared with the pre-set value of replacement interval.

6.8.5.9 The system shall be capable of storing at least twelve (12) months of fault history.

6.8.6 The CMS shall store the state of all PLC and drive signals for at least the last six-hundred (600) hours of operation or thirty (30) calendar days, whichever is less, with a sample rate equal to the scan rate of the PLC or 100 ms, whatever is shorter. Each entry shall have a timestamp showing the year, month, day and time with a resolution of 10 ms. The time stamp shall be automatically synchronized with the CMS. This information shall be suitable for recreation of the crane state and motions at any time during the recorded period, shall be read-only, and shall be protected from modification or deletion.

6.8.7 The CMS shall be capable of providing operation log and performance reports for at least fifteen (15) months of crane operation. Daily, weekly, monthly, and custom date/time range reports shall be available. Reports shall be able to be exported to a standard Microsoft Office format. The following performance data shall be included:

.1 Operation hours of major crane motions
.2 Container moves per size, weight, shift and operator
.3 Time, weight and container size of each cycle
.4 Average cycle, productivity per vessel, operator, and crane
.5 Hang time; the time for a spreader to wait stationary to load or unload
.6 Frequency of breakdowns
.7 Mean time between moves and mean moves between failure

6.8.8 Operator's and Ground Level CMS Terminals

6.8.8.1 CMS terminals shall be provided in the operator's cabin and in the ground level maintenance cab.

6.8.8.2 The CMS in the operator's cabin shall be a full function independent station, the same as that in the electrical control room.

6.8.8.3 The CMS station at the ground level maintenance cab shall be a display, keyboard, and mouse connected to the electrical control room CMS computer via a KDM system.

6.8.8.4 These two CMS terminals shall be non-corrosive IP65 or NEMA 4X rated, shock mounted, and shall have a minimum view size of 250 mm by 250 mm (10 in by 10 in). Control shall be by touch screen.

6.8.8.5 The CMS terminals shall communicate with the CMS computer in the electrical control room via fiber optic.

6.8.9 The control system shall record the lifted load and position and display it on the CMS as shown in Table 6.1. This information shall be read-only and protected against modification or deletion.

TROLLEY POSITION	**LIFTED LOAD RANGE, METRIC TONS (Load Under Spreader)**								
	0[1]<L≤15	15<L≤25	25<L≤35	35<L≤45	45<L≤50	50<L≤55	55<L≤60	60<L≤65	L>65
Passing 95% outreach	N_{11k}	N_{12k}	N_{13k}	N_{14k}	N_{15k}	N_{16k}	N_{17k}	N_{18k}	N_{19k}
Passing 90 % outreach	N_{21k}	N_{22k}	N_{23k}	N_{24k}	N_{25k}	N_{26k}	N_{27k}	N_{28k}	N_{29k}
Passing 75 % outreach	N_{31k}	N_{32k}	N_{33k}	N_{34k}	N_{35k}	N_{36k}	N_{37k}	N_{38k}	N_{39k}
Passing 50 % outreach	N_{41k}	N_{42k}	N_{43k}	N_{44k}	N_{45k}	N_{46k}	N_{47k}	N_{48k}	N_{49k}
Passing 25 % outreach	N_{51k}	N_{52k}	N_{53k}	N_{54k}	N_{55k}	N_{56k}	N_{57k}	N_{58k}	N_{59k}
Passing WS Rail	N_{61k}	N_{62k}	N_{63k}	N_{64k}	N_{65k}	N_{66k}	N_{67k}	N_{68k}	N_{69k}
Passing midway between rails	N_{71k}	N_{72k}	N_{73k}	N_{74k}	N_{75k}	N_{76k}	N_{77k}	N_{78k}	N_{79k}
Passing LS rail	N_{81k}	N_{82k}	N_{83k}	N_{84k}	N_{85k}	N_{86k}	N_{87k}	N_{88k}	N_{89k}
Passing 95% backreach	N_{91k}	N_{92k}	N_{93k}	N_{94k}	N_{95k}	N_{96k}	N_{97k}	N_{98k}	N_{99k}

Outreach and backreach are the distances from the WS rail to full out and from the LS rail to full back. Full out is different for the three boom latch positions.

N_{ijk} is the count of the number of times the trolley passes the position, going either way, with the load in the range shown. Subscript "i" shall be the trolley position, "j" shall be the lifted load range, and "k" shall be the operating boom latch position, A, B, or C.

The system shall append, to an ASCII file, the array data for the previous month's data, and the date, at 12:00 midnight of the last day of the month.

Note [1]: Zero (0) tons lifted load includes moves made with an empty spreader.

Table 6.1: Trolley Position vs. Load Data

6.8.10 The CMS shall have a convenient and automatic method of backing up productivity, routine drive trends, fault logs, running time, load vs. position, and other logged data. Backups shall be stored on the RCMS, if present, or on a separate removable storage device otherwise.

6.8.11 The CMS hardware shall be manufacturers LCMS standard industrial grade computer

6.8.12 An uninterruptable power supply (UPS) shall be provided to maintain CMS operation, including communication with the PLC and field bus in case of power loss. The UPS shall be sized for 150% of the connected load and shall have a minimum run time of 60 minutes at 100% of the connected load. In order to preserve the functioning life of the UPS and batteries, the UPS shall switch from external power to battery power only in the case of power loss or under-voltage and shall not continuously draw from the batteries during normal operations.

6.9 REMOTE CRANE MANAGEMENT SYSTEM (RCMS)

6.9.1 The Contractor shall provide a remote crane management system (RCMS) that will monitor each of the Cranes provided with this contract and integrate with the existing RCMS system used by the Owner for its existing cranes. Also see Section 1.1.4. Two complete RCMS stations shall be provided with the first Crane. Each station shall be networked and fully configured to function and to monitor all Cranes. All cabling and equipment needed for this system shall be provided and installed by the RCMS contractor.

6.9.2 The RCMS hardware shall be server grade and shall have the capability to operate with additional software.

6.9.3 The RCMS shall have the capability of polling the status of any of the Cranes on the wharf through a communications link. Should a Crane generate a fault while this system is monitoring a different Crane, the system shall alert the operator and with a short key stroke or command shall transfer to the faulted Crane.

6.9.4 The RCMS shall automatically receive, store and assemble productivity and maintenance data from each Crane.

6.9.5 The RCMS shall notbe configured to allow uploading data to the Cranes or to alter the Crane controls. The RCMS shall be capable of down loading files from the CMS on each Crane.

6.9.6 The RCMS shall be capable of accommodating at least twenty (20) cranes.

6.9.7 The RCMS shall also be loaded with the latest version of Microsoft Office™ Professional at the time of delivery. Full documentation and license keys shall be provided for all software provided.

6.9.8 The RCMS shall have the Operating and Maintenance Manuals and the drawings defined in Section 11 along with the necessary navigation software for each data type. In addition, a DVD-RW device and necessary software shall be provided for the routine backup, archiving, and restoration of data and software.

6.10 PORTABLE CRANE MONITORING TERMINALS (LAPTOPS)

6.10.1 The Contractor shall provide one (1) laptop computer for each Crane, of a make and model approved by the Owner, for remote monitoring of crane status and troubleshooting. The system shall be similar to the CMS described in Section 6.8 but shall also have the capability to connect to the CMS, the PLC, and the drives. It shall also have the capability of connecting directly to any Crane, spreader, or other software driven system on the Cranes. The system shall be capable of downloading files from each Crane's monitoring system but shall not have the capability of altering the Crane's operation except when connected directly to the Crane.

6.10.2 The laptop computers shall be furnished with the latest microprocessor at the time of delivery, and a minimum configuration of: 8 GB memory, DVD- RW drive, two USB 3 ports, 200 GB solid-state data storage, and the latest version of Microsoft Office™ available at the time of delivery. The operating system shall be the same as the CMS units on the Crane.

6.10.3 A protective carrying case and connecting cables shall be provided for each laptop.

6.10.4 Full documentation shall be provided for all software provided. Clear, detailed instructions for connecting the laptops to the CMS on each Crane, the spreaders, and all other software driven systems on the Cranes shall also be provided.

6.11 LICENSES, SECURITY, AND REMOTE ACCESS

6.11.1 Licenses

6.11.1.1 License keys, activation codes, hardware key devices, and all similar items necessary for the complete and proper functioning of all software and hardware present on the Cranes and supporting devices shall be provided to the Owner, along with written instructions on how to recover these items if lost, at least thirty (30) days prior to the start of commissioning.

6.11.2 Security

6.11.2.1 The entire crane control system shall be protected by a "defense-in-depth" system utilizing the latest in intrusion prevention technology and industry best practices for the securing of a computer network against unauthorized access and misuse, intentional or otherwise. The Contractor shall supply a detailed network topology and a detailed description of the security measures which will be implemented to achieve this requirement.

6.11.2.2 The Contractor shall provide detailed written instructions for maintenance, configuration and updating of the hardware and software included in this system. These instructions shall be provided in a separate binder, one copy for each copy of the maintenance manuals described in Section 11.2. A master electronic copy of the instructions shall also be provided on CD-ROM.

6.11.3 Connection to External Networks and Remote Access

6.11.3.1 The control system on each Crane shall be accessible to the Control System Supplier or other authorized persons via a temporary connection to the Internet.

6.11.4 Any access from an external network to the RCMS or Cranes shall require the direct involvement of an authorized person at the Crane or RCMS terminal who must actively provide access through a keyboard, mouse, or other Owner-approved action, and this shall be logged. Access shall be automatically limited to an adjustable time duration, not exceeding 180 minutes, after which access must be re-permitted by an authorized person.

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SECTION 7 SUPPORTING SYSTEMS

7.1 OPERATOR'S CABIN AND PRIMARY OPERATING STATION

7.1.1 General – The complete cab including the operator's chair and operating consoles and devices shall be provided by the supplier shown in Section 2.13.3. The following functions shall be provided with the cab unless approved otherwise by the Owner.

7.1.1.1 The prime consideration in the design and fabrication of the cab shall be the operator's safety, comfort, and efficiency. Operator fatigue due to vibration, shock, and inconveniently located controls will materially affect crane production. The cab layout, auxiliary control and indicating panels, console, operating and indicating devices, and locations shall be subject to the Owner's approval.

7.1.1.2 Operator's vision is critical to productive operation of the Crane. The operator's cab shall be mounted to the landside of the trolley. Location of the cab relative to the lifted load, ship structure, and trolley must all be considered when positioning the operator relative to the trolley. The Contractor shall submit vision diagrams for the operator that demonstrates that the operator is positioned in the optimum location. The vision diagrams shall include vision of the boom, to landside and waterside, during boom travel. Location should be as far landside as possible to provide a good angle when viewing the chassis, but not so far landside as to provide an unacceptable view into the ship. The location and elevation shall be submitted to the Owner.

7.1.1.3 The Contractor shall place the highest regard on ergonomics when designing the layout of the operator's cab, chair, and console. The design and location of these items shall allow safe and efficient operation of the Crane while allowing the operator to maintain, at a minimum, an acceptable working posture as defined in ISO 11226, *Ergonomics – Evaluation of Static Working Postures*.

7.1.1.4 The Contractor shall provide clear warnings, as appropriate, regarding the risks of repetitive stress injury and instructions on how to help minimize the risk, both in the published operating instructions, and on hazard signs and safety instructions at the operator's work area. The Contractor shall submit the proposed instructions, signs, and locations to the Owner for approval. Refer to section 7.18.1.

7.1.1.5 The sound level inside the cab shall not exceed 72 dBA at any point when measured according to ANSI S1.13, *Measurement of Sound Pressure Levels in Air*, when the Crane and all devices are operating normally, excluding the PA system and any audible alarms. The noise level will be verified by Owner prior to provisional acceptance.

7.1.2 Operator's Cab Construction

7.1.2.1 The interior floor of the cab shall be as recommended by the cab supplier and approved by the Owner.

7.1.2.2 The cab shall be thermally and acoustically insulated, of rigid construction, and corrosion resistant.

7.1.2.3 All fasteners and hardware used on or in the cab shall be stainless steel, unless otherwise approved by the Owner.

7.1.3 Air Conditioning

7.1.3.1 Automatic and thermostatically controlled air conditioning shall be provided that will maintain conditions of 20 °C dry bulb and 50 percent relative humidity. The air conditioning unit shall be split system type and shall include a heat pump. The air conditioner shall not draw outside air into the cab. Window mount air conditioning units shall not be used.

7.1.3.2 The air conditioning unit shall be designed for use at the Owner's Facility and shall comply with all applicable regulations.

7.1.3.3 The air conditioning controls shall automatically turn off the unit after an adjustable delay, originally set to 30 minutes, after control power is switched off. The air conditioning units may be restarted without control power enabled, but will automatically turn off after the same delay unless control power is established before then.

7.1.4 Protection from Smoke Intrusion

7.1.4.1 A proven filtering system capable of removing stack gases shall be provided on the cab. The filtering system proposed shall have been in successful use for a minimum of two (2) years. The filter media used shall as a minimum be designed and tested to remove diesel exhaust fumes and filter particulates from the air.

7.1.4.2 The air supply shall be sufficient for a minimum of six (6) changes of air per hour.

7.1.4.3 The construction of the cab shall be air tight. No unfiltered outside air shall be introduced into the cab when the doors and windows are closed and the air conditioning, heaters, and defoggers are operating. The filter system, when using a mixture of half external filtered air and half recycled internal air, will maintain the cab at an overpressure of 120 Pa (1/2" H_2O) over the outside ambient pressure. This shall be demonstrated to the Owner's satisfaction during commissioning and again as part of acceptance testing once the Crane arrives on site.

7.1.5 Cab Access

7.1.5.1 Fixed permanent access to the operator's cab shall be provided from the elevator and stairs to the trolley's parked position near the waterside legs. Access shall be provided from the elevator landing platform at cab level to the platform at the rear of the cab. Automatic closing and latching gates shall protect both the moving and fixed platforms, and opening of either gate shall disable trolley motion. Interlocks shall be provided to prevent trolley motion when the gates are not closed and latched.

7.1.5.2 A pushbutton at the side of the access gate fixed to the crane structure shall sound a chime in the operator's cabin to let the Operator know someone is waiting at the access gate.

7.1.5.3 A secondary means of access to the cabin shall be provided using the headblock platform. It shall be possible to raise the headblock to a position allowing personnel to safely enter onto the trolley main platform from the headblock platform. From the main trolley platform, access shall be provided down to the cabin level platform. When the headblock and spreader are landed on a container at the maximum hoist height over the ship, it shall be possible for personnel standing on the headblock platform to climb off the headblock and stand on a container adjacent to the container on which the spreader is landed. See the Drawings

7.1.5.4 Walkways shall be provided on the right and left sides and at the rear of the operator's cabin. The cab access door shall be located in the rear of the cab.

7.1.5.5 The cab access door shall be weather-proof, stainless steel with a safety glass window in the upper panel and marine/industrial type master keyed locks. A drip shield shall be provided over the door. Door hardware shall be marine or industrial quality stainless steel. Access shall be such that a disabled operator can be removed on a stretcher to the gantry frame without special rigging. The cab shall be safely accessible at all points of trolley travel including under the trolley machinery house.

7.1.5.6 The cab door shall swing open to the outside of the cab and away from the direction of egress. The door shall have effective weather seals, a closer capable of automatically closing the door at 10% WLO, and latches to hold the door open or closed. The door shall be approximately 6.5 ft (198 cm) tall and 2.5 ft (76 cm) wide to limit the loads on the door due to the cab overpressure and wind.

7.1.5.7 Cab shall also be accessible from the two-blocked headblock; see Section 4.10.1.13.

7.1.6 Windows and Mirrors

7.1.6.1 Cab design shall provide the operator with adequately sized fixed windows for full visibility of all crane operations. The cab shall be glazed from the inside. Access shall be provided to all glass for cleaning purposes. Drip rails shall be provided over the windows and doors. All vertical and sloping glass shall be safety glass. All glass shall be tinted with the exception of the window at the operator's feet. Windows in the top 50% of the cab shall be dark tinted and fitted with semi-transparent shades adjustable to any position and secured against crane motion. Tinted glass samples shall be submitted to the Owner for approval.

7.1.6.2 A fixed window shall be provided in the floor at the operator's feet. This is the main window used by the operator to view the container handling and is to be in one piece. The window shall be a minimum of 40 mm thick of clear, un-tinted, tempered glass with an anti-scratch coating and a defroster system. The glass shall be designed for a person weighing at least 250 kg (550 lb) standing directly on the glass. The glass shall be protected on the inside from accidental breakage by sliding adjustable metal foot rests which do not unduly limit the operator's visibility. The design of the metal foot rests shall be approved by the Owner.

7.1.6.3 There shall be two windows mounted in the floor behind the operator's seat to provide visibility of the wharf area. These windows shall be a minimum of 20 mm thick, clear, tempered safety glass and shall be designed for a person weighing at least 250 kg (550 lb) to safely stand directly on the glass. These two windows shall be hinged inward to allow cleaning.

7.1.6.4 Electrically operated, heavy duty, durable windshield wipers shall be provided on windows as necessary to afford the operator unimpaired vision. Windshield wipers shall have an automatic park position out of the operator's direct vision.

7.1.6.5 Electric defoggers shall be installed on the windows as necessary to afford the operator unimpaired vision.

7.1.6.6 Two adjustable convex rear view mirrors shall be positioned outside each front corner of the cab. Each mirror shall have at least a 500 mm (20 in) diameter viewing surface made of polished metal and shall be positioned to allow the operator an unobstructed view of the area behind the trolley including the cab access walkway and the backreach maintenance platform.

7.1.7 Operator's Cab Interior

7.1.7.1 The interior of the cab shall be finished to the Owner's satisfaction.

7.1.7.2 The interior of the cab shall have a clean appearance. Exposed conduit, pull boxes, conduit fittings, and enclosures shall not be allowed. Intercom speakers, lighting fixtures, and breaker panels shall not be surface mounted. Devices, fixtures, and enclosures shall be flush mounted within the cabin walls or ceiling with the exception of the operator's left and right console, the operator's auxiliary console, and the cab control panel.

7.1.7.3 The interior of the cab shall be painted white or as approved by the Owner and all surfaces shall have a matte finish and be non-reflecting. The top portion of the operator's consoles shall be matte finish, uncoated, brushed stainless steel and shall not glare or obstruct the operator's view. The remainder of the consoles shall be either brushed stainless steel or painted carbon steel with a dark matte finish.

7.1.7.4 The operator's cab shall have a coat hook and small shelf.

7.1.7.5 The cab shall be provided with a fold down "jump seat" for observers and trainers, equipped with lap belt and shoulder harness.

7.1.7.6 The cab shall have adjustable lighting.

7.1.8 Operator's Chair and Consoles

7.1.8.1 Within the console, an upholstered, ergonomic, adjustable chair shall be provided. The operator's seat shall be adjustable forward and aft to vary the relationship between the operator and his controls. The height of the seat shall be adjustable as well as the weight control of the seat suspension. The seat back shall have multiple tilt positions and adjustable lumbar support. Seat adjustments shall be motorized and shall be designed to accommodate the fast speeds, quick accelerations, shock, and vibration present on the trolley.

7.1.8.2 The seat shall be provided with a safety seat belt and shoulder harness. The seat belt and shoulder harness shall be designed, configured and supported to allow the operator to rest comfortably against them in the optimum operator's position as defined by the vision diagram; reference 7.1.1.2.

7.1.8.3 The Contractor shall provide warning signs and safety instructions regarding the use of the seat belt and safety harness in accordance with Section 7.18.1.

7.1.8.4 The seat shall have a slot in the front edge, between the operator's legs, for visibility.

7.1.8.5 The seat shall have a pressure sensitive switch that detects when the operator is in the seat. Motion and other critical crane controls initiated from the operator's consoles in the cab shall only be functional when the operator is in the seat. The switch shall have an adjustable time delay to prevent false trips when the operator leans forward or otherwise momentarily removes his weight from the seat.

7.1.8.6 The operator's console shall be easily adjustable to accommodate an operator between 1500 mm (4'-11") to 2000 mm (6'-7") in height and between 50 kg (110 lb) and 150 kg (330 lb) in weight. The operator shall be able to sit comfortably in the operator's chair with elbows on the armrests, hands on the trolley and hoist master switches, back against the seat, and feet on the metal foot rests. The operator shall be able to look straight down through the glass floor by only tipping his head forward.

7.1.8.7 The entire operator's platform, seat, consoles, base, and bearing shall be adjustable forward and aft by the operator to vary the relationship between the operator-seat-consoles and the lower front window.

7.1.8.8 No PLC modules or I/O modules shall be allowed within the operator's console.

7.1.8.9 The top portion of the operator's consoles, auxiliary indication panel, and the mullion shall be brushed 316 stainless steel with a matte finish and shall not glare or obstruct the operator's view.

7.1.8.10 The indicator bar at the lower window mullion shall be flush with the mullion and shall contain at least the following indicating lights: "Slack Cable", "Twistlocks Locked", "Twistlocks Unlocked", and "Spreader Landed".

7.1.8.11 The operator's console shall include all functionality and controls described under Boom Travel Control Station 7.2.1.4.

7.1.8.12 The chair and consoles shall be subject to the Owner's approval.

7.1.9 Shock and Vibration

7.1.9.1 Particular attention shall be given to isolating the operator from the shock and vibration inherent in container cranes. The connection of the cab to its immediate support and the mounting of the operator's chair shall provide effective shock and vibration isolation.

7.1.9.2 No device or component shall be installed in the operator's cab which is not suitable for the shock and vibration present.

7.1.9.3 Computers shall not be used in the cab. Computers for the operator's displays shall be rack mounted in the electric room and shall communicate via fiber optic converters.

7.1.10 Spreader Operating Lights for Maintenance

7.1.10.1 LED light panels duplicating the spreader light functions shall be mounted on the bottom of the cabin facing downward so that they are visible by a maintenance technician on the ground.

7.1.10.2 The lights shall be of similar quality, brightness, and appearance as the lights located on the spreader.

7.1.10.3 The lights shall hardwired to duplicate the functionality of the spreader operating lights.

7.1.10.4 The details of the lights, their layout, appearance and installation shall be approved by the Owner.

7.1.11 Sound System

7.1.11.1 The operator's cabin shall be equipped with a high quality stereo system with AM/FM radio, CD player and separately mounted stereo loud speakers.

7.1.11.2 The system shall be equipped with iPhone and AUX plugs

7.1.11.3 The sound system shall be approved by the Owner.

7.2 ADDITIONAL OPERATING STATIONS

7.2.1 Boom Travel Control Station

7.2.1.1 A local control station complying with the requirements of Section 6.4.2.3 shall be provided on the waterside of the waterside frame inside a small cabin, collectively referred to as the boom travel control station. The cabin door shall be identical in construction to the operator's cab door.

7.2.1.2 The station shall be lighted and equipped with an intercom station.

7.2.1.3 Station and window location shall provide visibility of the boom travel, wire rope entering the machinery house, and the boom latch and bumpers at the boom support beam.

7.2.1.4 The boom travel control station shall have at least the following controls:

.1 Station "CONTROL ON", keyed switch and red indication light
.2 Mushroom head illuminated pushbutton "EMERGENCY STOP" with manual reset
.3 Boom control "MANUAL/AUTO" selector key switch, key removable in AUTO
.4 Illuminated spring-loaded pushbuttons for manual Boom "FWD", "REV" motions
.5 Boom "FWD" and "REV" motions shall occur only when the spring loaded buttons are held down by the maintenance operator (manual control).
.6 Illuminated pushbuttons for "Floodlights on Frame" and "Floodlights on Boom".
.7 Indicating lights for "TROLLEY PARKED", "BOOM TRAVELLING", "BOOM LATCHED"
.8 Illuminated spring-loaded pushbuttons for automatic boom travel to each of the four boom positions.
.9 "BOOM 205 FT," orange indicating light
.10 "BOOM 166 FT," orange indicating light
.11 "BOOM STOWED 130 FT," orange indicating light
.12 "BOOM RETRACTED", orange indicating light
.13 Pushbuttons for "FAULT RESET", "BOOM OFF," "CONTROL OFF" and "LAMP TEST".
.14 Selector switches for Boom "FAST" and SLOW"
.15 Selector switch for Window Wiper "ON" or "OFF".
.16 Selector switch for Boom Stowage Latch "LATCH" and "UNLATCH."
.17 "BOOM LATCH ENGAGED" orange indicating light.
.18 "BOOM LATCH RELEASED" green indicating light.
.19 Final Panel configuration shall be approved by the Owner after boom control logic finalized.

7.2.1.5 The boom travel control station shall be supplied with a photo sensitive light banner that detects when the maintenance technician is in the station. Motion and other critical crane controls initiated from the boom travel control station shall only be functional when the operator is in the station. The light banner shall have an adjustable time delay to prevent false trips when the operator momentarily steps away from the station.

7.2.2 Ground Level Maintenance Cab

7.2.2.1 A gantry maintenance cab shall be located under the landside sill beam near the center of the crane and shall be capable of housing two (2) standing persons. A door, identical to those defined by paragraph 7.7.5, shall be provided on the waterside wall of the cabin. The door shall be equipped with a lock.

7.2.2.2 The cabin shall be lighted and equipped with an intercom station. Windows shall allow vision to landside and waterside.

7.2.2.3 The layout and design of the cab shall be approved by the Owner.

7.2.2.4 The cab shall be thermally and acoustically insulated, of rigid construction, and corrosion resistant.

7.2.2.5 All fasteners and hardware used on or in the cab shall be marine or industrial quality stainless steel, unless otherwise approved by the Owner.

7.2.2.6 Automatic and thermostatically controlled air conditioning shall be provided that will maintain conditions of 68 °F (20 °C) dry bulb and 50 percent relative humidity. The air conditioning unit shall be split system type and shall include a heat pump. The air conditioner shall not draw outside air into the cab. Window mount air conditioning units shall not be used.

7.2.2.7 The air conditioning unit shall be designed for use at the Owner's Facility and shall comply with all applicable regulations.

7.2.2.8 The air conditioning controls shall automatically turn off the unit after an adjustable delay, originally set to 30 minutes, after control power is switched off. The air conditioning units may be restarted without control power enabled, but will automatically turn off after the same delay unless control power is established before then.

7.2.2.9 The cab shall contain a remote terminal with full access to the CMS system described in section 6.8. The CMS keyboard, mouse, and pointing device shall be functionally identical to the CMS installed in the electric room. The remote terminal shall be NEMA 4X.

7.2.3 Ground Level Operating Panel

7.2.3.1 Appendix C shows the layout and functions of the existing ground level operating panel for STS cranes at the Owner's facility. A similar panel shall be provided with the functions shown in Appendix C and additional functions as specified. The panel layout, lights, and functions shall be approved by the Owner before fabrication.

7.2.3.2 The panel shall be separate NEMA 4X stainless steel panel mounted near the ground level maintenance cab at the waterside of the landside sill beam. All labels shall be paint filled stainless nameplates.

7.2.3.3 In addition to functions and lights described in Appendix C, functionality shall include, as a minimum:

- .1 Adjustable two-speed push-button for main hoist raise and lower, empty spreader only, with trolley in the parked position
- .2 Adjustable two-speed push-buttons for gantry right and gantry left
- .3 "Station Control On", keyed switch and red indication light
- .4 "Emergency Stop" maintained mushroom pushbutton, twist to release
- .5 "Twistlock Bypass" and "Normal" two-position, maintained keyed selector switch
- .6 "Twin-Twenty Bypass" and "Normal" two-position, maintained key selector switch
- .7 "Overload Bypass / Normal", two-position, maintained key selector switch
- .8 "High Wind Bypass / Normal", two-position, maintained key selector switch
- .9 Three position, spring return, switches for Trim, List, and Skew micro-motions
- .10 Spreader maintenance controls for all spreader functions
- .11 "Boom Out" and "Boom Back" illuminated spring loaded pushbuttons. Motions shall occur only when the spring loaded buttons are held down by the maintenance operator.
- .12 "BOOM LATCH DISENGAGE" indicating pushbutton
- .13 "BOOM LATCH ENGAGE" indicating pushbutton
- .14 "BOOM 205 FT, orange indicating light
- .15 "BOOM 166 FT, orange indicating light
- .16 "BOOM STOWED 130 FT, orange indicating light
- .17 "BOOM RETRACTED", orange indicating light
- .18 "Main Power Reset" pushbutton for restoration of power after a main power failure
- .19 Diesel operating functions to start, stop, and monitor the diesel generator including a fuel tank level indicator.
- .20 "MV POWER RESET" indicating pushbutton, as needed
- .21 There shall be at least two spare pushbuttons and two spare illuminated pushbuttons installed.

7.2.4 In addition to 7.2.3.1, the Contractor shall also submit details of station construction and control arrangement to the Owner for approval before fabrication.

7.2.5 Maintenance Control Stations

7.2.5.1 Local control stations complying with Section 6.4.2.3 shall be provided at any location where local manual control of machinery may be necessary for maintenance. The following locations shall be provided with local control stations as a minimum:

- .1 AC emergency drives

.2 Gantry cable reel on the portal tie
.3 Spreader cable reel on the trolley
.4 Snag/Trim/List/Skew system
.5 Rereeving devices
.6 Diesel-generator

7.2.5.2 Maintenance control stations shall have sufficient control devices to move the adjacent machinery through the complete range of motion at a selectable slow or fast speed and to control all auxiliary functions of the machinery.

7.2.6 Electric Room Control Station

7.2.6.1 A local control station complying with Section 6.4.2.3 shall be provided in the electrical control room and shall contain at least the following:

.1 Mushroom head illuminated pushbutton “Emergency Stop” with manual reset
.2 Illuminated pushbutton for “Control Power On”
.3 Three position selector switches for “Boom Floodlights OFF/AUTO/ON”
.4 Two position selector key switches for “Limit Switch Bypass”, “Spreader Interlock Bypass”, “TLS Encoder Bypass”, “Main Hoist Encoder Bypass”, “Trolley Encoder Bypass”, “Boom travel Encoder Bypass”, “Slack Rope Bypass”, “High Wind Bypass” and “Twin Twenty Bypass”
.5 Electromechanical, non-resettable, hour meters, with a minimum of 7 digits including tenths of an hour, to display the hours for control on and each of the major crane motions
.6 Selector switch for anti-sway level
.7 Load weight and eccentricity displays

7.2.7 Trolley Top Control Pendant

7.2.7.1 A local control pendant, long enough to reach all areas on top of the trolley, shall be provided within a lockable stainless steel enclosure on the trolley top.

7.2.7.2 The local control pendant shall be suitable for controlling both the hoist and trolley motions in both directions at slow speed.

7.2.7.3 The pendant controls shall be designed to prevent accidental activation.

7.2.7.4 Hoist and trolley motion from other operating stations shall be disabled when the local control pendant is active.

7.3 CLOSED CIRCUIT TELEVISION (CCTV)

7.3.1 A CCTV system shall be provided such that at least the following views are available on displays in the operator’s cabin, ground level operator panel, ground level maintenance cab, at the CMS on the Crane, at the RCMS, and at the boom travel control station:

.1 Top face of container at ground level from waterside and landside
.2 Truck lanes from both sides able to read truck license plate number and container number with pan/zoom/tilt
.3 Corner casting cones of transporter
.4 Gantry path at four (4) corners showing any obstacles along the gantry rails
.5 View from trolley down on to headblock
.6 View of the wharf in the backreach and between the legs using a fish eye lens
.7 From the front of the trolley, forward vision when a container is fully raised in front of the operator
.8 At the top of the trolley, looking at the opening where the headblock enters
.9 Boom buffers on the frame at landside and waterside
.10 From landside end of top frame, looking backwards at the boom on both sides.
.11 From waterside of top frame, looking waterside, on both sides of the boom.

7.3.2 Safe access shall be provided to all cameras.

7.3.3 The video format shall meet at least the following:

.1 NTSC

.2 720 x 480 image resolution or greater

7.3.4 The cameras shall be manufactured for rough duty service on industrial vehicles or mining equipment and shall have at least the following features:

.1 Operating temperature range of at least -40°C to +85°C (-40°F to +185°F)
.2 An over pressurized enclosure, rated at least IP 68, to prevent ingress of dust and moisture
.3 Shock and vibration resistance suitable for use on cranes and maritime equipment
.4 18x optical zoom
.5 Low light (night) mode
.6 Auto focus and iris control
.7 Protection against infrared reflection at sunrise and sunset

7.3.5 CCTV enclosures shall be stainless steel to accommodate power supply, FO connections, and all control gear. Cable glands shall be stainless steel or brass.

7.3.6 All video signals shall be digitally recorded and retained for at least one month on the CMS or a separate video storage system supplied with each Crane. All video shall be time stamped synchronized with the CMS time.

7.3.7 The image data generated at each Crane shall be made available to the Owner's IT department and RCMS in addition to Operator's Displays and CMS.

7.3.8 Detailed specifications of hardware, software, and interfacing to other systems shall be subject to the Owner's approval.

7.4 PERSONNEL ELEVATOR

7.4.1 A four person capacity personnel elevator, large enough to transport a laden Stokes basket with attendant, shall provide access to the portal tie beam, operator's cab, and machinery house. The elevator shall be located over the gantry equalizer beams, outboard of the leg. No part shall extend beyond the width of the sill beam into the truck lanes at elevations below the bottom of the portal tie.

7.4.2 The medium voltage cable from the gantry cable reel must pass in close proximity to the elevator at the portal level. At the concept design meeting, the Contractor shall propose a solution for acceptance by the Owner.

7.4.3 Landing platforms shall be sized for emergency egress with stretcher. The lower landing shall be as close to the ground as possible to minimize stair height access to the lower landing. An elevator call button shall be provided at each landing.

7.4.4 The elevator shall traverse from the lowermost to the uppermost landing in less than one minute.

7.4.5 Controls shall be fully automatic with automatically controlled slow down and stop at the selected station and call push-buttons at each station. Interlocks for doors shall be mechanical, not electrical.

7.4.6 Means for safe manual lowering of the elevator shall be provided within the elevator.

7.4.7 Electrical provisions shall be in compliance with Section 5 including enclosures and control stations; see Sections 5.10 and 6.4.2. All junction boxes and enclosures shall be stainless. Power and control leads to the elevator shall be contained within a covered energy chain supported in a stainless steel track.

7.4.8 The complete elevator system shall be stainless steel or hot dipped galvanized, including the mast runway. Spray galvanized will be acceptable only where the hot dip process would cause distortion in the item. Stainless steel, where used, does not need to be painted. All fasteners used shall meet the corrosion protection requirements specified in Section 9.6.1.

7.4.9 An elevator service representative supplied by the elevator manufacturer shall supervise the installation of the elevator.

7.4.10 The Contractor shall obtain the required elevator certifications. Local elevator agents shall be involved in obtaining local certifications.

7.4.11 For storm wind conditions, the elevator personnel cage will be stowed at the lowest landing. Each of the landing access doors and protective guards shall be designed to withstand the WLSH.

7.4.12 The elevator shall not be used prior to the provisional acceptance of the crane by the Owner except for elevator testing and certification, unless otherwise approved by the Owner. If this requirement is violated, the Contractor, at his own expense, shall replace the elevator parts at the Owner's sole discretion.

7.4.13 A lockable cover shall be placed over the elevator main power switch near the elevator entrance. This cover shall have a padlock installed.

7.4.14 Safe access means shall be provided for maintenance and lubrication.

7.5 STAIRS, LADDERS, PLATFORMS AND WALKWAYS

7.5.1 Stairs, ladders, platforms, and walkways shall be provided on the crane to make readily accessible all components, including all accessory components and assemblies to which access is required for the crane's operation, lubrication, service, maintenance and inspection.

7.5.2 Platforms, walkways or other surfaces used for walkways, which shall not be used during crane motion, shall be clearly identified with signs per Section 7.18.1.

7.5.3 Service platforms and access shall be provided at the following locations as a minimum:

.1 Boom sheaves at backreach
.2 Boom waterside sheaves
.3 Cab window washing platform in backreach of crane with at least two meters of walkway around all sides of the cab when parked at the window washing platform
.4 Both catenary trolleys, including wheel assemblies
.5 Boom—See Section 7.5.16 for boom access to trolley
.6 Around and through machinery houses
.7 Boom latch mechanism
.8 Boom tip
.9 Boom travel control station
.10 Trolley tensioner
.11 Trolley
.12 Trolley cable chain system
.13 Trolley wheel assemblies
.14 Trolley mounted platforms for trolley rail maintenance; these may be removable
.15 Permanently mounted catenary access platforms at the boom tip and the backreach
.16 Both portal tie beams; ladder access at left waterside leg for left portal tie beam
.17 Load cells
.18 Frame inspection openings
.19 Rope dead ends
.20 Machinery house service cranes
.21 Wire rope inspection
.22 Wire rope rereeving locations
.23 Access to the roof of the machinery house
.24 Outside of gantry cable reel spool at portal tie level
.25 Cable reels
.26 Electrical junction boxes and pull boxes
.27 All lighting fixtures
.28 All CCTV cameras
.29 The entire length of cable trays or raceways where used
.30 The entire length of the trolley cable chain runway
.31 The entire length of the trolley machinery house cable chain runway
.32 Structural inspection locations
.33 Boom support rollers and any machinery
.34 Boom hold down rollers and any machinery
.35 Boom cable chain system
.36 Elevator platform access from ground by stairs

7.5.4 The minimum passageway, walkway stair, platform, etc., shall be 711 mm (28 inches) clear width.

7.5.5 Walkways, stairways, handrails, ladders, platforms and other access ways shall comply with the following OSHA regulations:

.1 29 CFR 1910.23 Guarding floor and wall openings and holes (ANSI A12.1)
.2 29 CFR 1910.24 Fixed industrial stairs, including Table D-1 (ANSI A64.1)
.3 29 CFR 1910.27 Fixed ladders (ANSI A14.3)
.4 Other governing local OSHA regulations

7.5.6 Access at the top of ladders shall not be through the ladder uprights unless specifically approved by the Owner. Access changes in elevation shall be by stairway, except where ladders are specifically allowed by the specification or ladder access is approved in writing by the Owner.

7.5.7 Connections to the structure shall be approved by the Contractor's responsible structural engineer. The connections shall allow for the deflection and thermal expansion of the structure.

7.5.8 Stairway access to the crane shall be mounted on the right waterside leg, looking to waterside. Stairway access shall be provided from ground level to the portal tie beam mounted cable reel, the machinery house, the boom and the operator's cab. Walkway and stairway access shall be provided to the landside O-Frame trolley platform. At ground level, personnel guards shall be installed to brush aside inattentive personnel in the way of the stairway during gantry travel operations.

7.5.9 Handrails shall preferably be solid bar. Pipe or tube is not acceptable unless they are hot dip galvanized inside and out after fabrication. If hollow sections are proposed, the Contractor shall obtain Owner approval for the galvanizing process.

7.5.10 Ladder rungs shall be formed channel ladder rungs no less than 40 mm wide and 28 mm deep with buttonhole, serrated diamond, or similar non-slip surface patterns. Rebar, rung covers, or anti-slip coatings shall not be used.

7.5.11 All walkway grating and stair treads shall be welded metal bar grating complying with ANSI/NAAMM MBG 531-1993, *Metal Bar Grating Manual.* Tread noses on stairs shall be standard round nose anti-slip

7.5.12 Handrails, stanchions, kick plates, ladders, ladder cages, grating, and stair treads shall be hot dipped galvanized after fabrication according to Section 9.6.3. Prior to installing any galvanized components, the galvanized bearing surfaces which contact the painted steel support structure shall be finished painted with the specified paint to act as barrier to the galvanizing.

7.5.13 Grating shall be secured to the walkway structure using self-locking fasteners. Positive (non-friction) grating restraints are required on the trolley, and catenary trolleys. Once the grating is installed, the grating and grating support structure shall be protected from any construction and/or shipping damage by installing plywood sheets over the grating. The plywood may be removed after all construction is complete. Any damage to the grating or grating support structure is to be repaired at this time.

7.5.14 Fasteners used shall be stainless steel or treated as specified in Section 9.6.1.5.

7.5.15 Main horizontal girders used for access shall be equipped with handrails and kickplates on both sides. Where normal access for operation or maintenance uses the horizontal surface of a girder, the surface shall be covered with a non-skid surface.

7.5.16 An access walkway shall be furnished for the full length of the boom for direct access to the trolley at any position of trolley travel.

7.5.17 Each access gate from the frame to the boom shall be interlocked such that it cannot be opened when the boom is out of position and the boom may not move when the gates are open.

7.5.18 The access gate to the trolley shall be interlocked such that it cannot be opened when the trolley is not in the parked position and so the trolley may not move when the gate is open.

7.5.19 All access gates shall be gravity closed split cylinder type with a heavy duty stainless steel spring and a positive self-latching system.

7.5.20 All access platforms or walkways shall allow for a minimum of 914 mm (3 ft) of clearance around machinery and electrical equipment. Clearances around electrical equipment shall also comply with the requirements of the NEC 110-34 or the local code requirements, whichever is greater.

7.5.21 Hazards on or Near Access Platforms:

7.5.21.1 The following applies to any stairs, ladders, platforms, walkways, or other surfaces intended to provide access to machinery, equipment, or inspection points, referred to as access platforms.

7.5.21.2 Where hazards exist to personnel standing, working, or walking on access platforms, such platforms shall be clearly marked with signs identifying the nature of the hazard as required by Section 7.18.1.

7.5.21.3 The Contractor shall give special consideration to hazards which result from motion of the crane. Areas of access platforms where it is unsafe for personnel to be during crane motion shall be clearly marked as required by Section 7.18.1. These areas shall also be conspicuously noted in the operating instructions and maintenance manuals; see Section 11.

7.6 FALL ARREST ANCHOR POINTS

7.6.1 Where personnel may be required to work outside of access platforms that are protected on all sides with handrails, or where personnel may otherwise be subject to a fall hazard, fall arrest anchor points shall be provided.

7.6.2 Anchor points shall be suitable for use with typical fall arrest harness tethers and shall be designed for a minimum load of 5,000 lbf (23 kN) per person, or the load required by the codes applicable at the Owner's Facility, whichever is greater, applied in any direction.

7.6.3 Anchor points shall be painted a bright safety color and shall be clearly marked using safety instruction signs complying with Section 7.18.1 which state the maximum number of persons who may be tethered to the anchor point.

7.6.4 As a minimum, anchor points suitable for the attachment of two persons each shall be provided at:

.1 Each of the four corners on top of the trolley
.2 Each of the four corners on the platform on the headblock
.3 Each side of the landside edge of the boom tip
.4 Each side of the waterside edge of the boom backreach
.5 Each side of both catenary trolleys
.6 Each of the four corners of personnel cage on the spreader

7.6.5 Where additional mobility may be required while personnel are tethered, anchor points may consist of jack lines or similar arrangements provided the design is suitable for the loads described in Section 7.6.2, the lines are protected from corrosion and UV degradation, and the lines are arranged to limit the fall distance to the length of the fall arrest tether.

7.6.6 The Contractor shall provide drawings showing the location and details of all anchor points on the crane and shall include instructions for proper use of the anchor points in the Maintenance Manual.

7.7 MAIN MACHINERY HOUSE AND PLATFORM

7.7.1 Main hoist machinery, boom travel machinery, and electrical power distribution equipment shall be mounted on a machinery platform enclosed in a weatherproof machinery house. The design of the platform and machinery house shall comply with the Section 3 structural specifications and shall have a neat and simple appearance. Localized storm wind pressures at machinery house corners shall be considered.

7.7.2 The machinery platform shall be sufficiently rigid to prevent machinery misalignment and component vibration beyond allowable under any operating condition. The natural frequency of the machinery platform shall be measured prior to paint application in order to avoid resonance at motor operating speeds. The machinery platform shall provide safe access and working space around all machinery components and electrical equipment.

7.7.3 A hatch shall be provided in the platform deck. It shall be of sufficient size to permit the machinery house service crane to lower the largest piece of equipment in the house to the wharf without dismantling with the exception of the main hoist drum(s), the main transformer and the assembled main hoist reducer. Hatches shall be located so there is a clear unobstructed opening to the wharf. The hatch shall be provided with a roll-away cover with provisions for controlled opening and closing and securing in the open and closed position. A small hatch, of sufficient size to pass an oil drum sideways, with a hinged manually-opened cover shall be provided to allow raising small tools and supplies from the wharf. If necessary, additional hatches shall be provided for servicing trolley machinery by the machinery house service crane. Removable safety chain guards shall be provided around all hatch openings and shall be mounted in sockets flush with the floor. Location of the hatches shall consider ropes that will obstruct access to the trolley and ground. One or more bolted removable hatches in the roof shall provide access by a mobile truck crane for access to the main hoist drums, assembled main hoist reducer, and main and auxiliary transformers.

7.7.4 The machinery house shall be constructed of structural shapes and galvanized metal cladding. The machinery house shall fit within the aircraft clearance elevation of 175’ shown on the Drawings. The roof shall have sufficient slope from the center ridge to prevent standing water. Cladding shall be a minimum of 1.5 mm thick metal deck with a pattern conforming to SDI (Steel Deck Institute) intermediate rib or approved equivalent. Cladding seams and connection to the machinery house structure shall be continuous welds. Cladding shall join to the underside of the upper framing members to help reduce the possibility of leaks.

7.7.5 Marine quality weatherproof, galvanized, metal doors with safety glass windows in the upper panels with latches and locks keyed alike shall be provided in two opposite walls of the machinery house. Drip shields shall be provided over the doors. Door hardware shall be marine quality and shall be stainless steel. The doors shall have effective weather seals, closers capable of automatically closing the doors at 10% WLO, and latches to hold the doors open.

7.7.6 The machinery house shall be provided with thermostatically and PLC controlled fans with ducting arranged to prevent the entry of water or driving rain. The fans shall have sufficient capacity to prevent heat build-up, which may be damaging to any component. As a minimum, fans shall have the capacity to change the air in the machinery house in one minute or the requirements of all the motor ventilation fans and the electrical room ventilation fans, whichever is greater. The fan openings shall be on the walls of the machinery house, not the roof, and shall be baffled to prevent entry of driving rain. Aluminum shall not be used for any part of the ducting, fans, filters, or any other portion of the ventilation system. Filters shall be washable stainless steel. The filters shall be easily accessible from walkways for replacement.

7.7.7 The ventilating system in the machinery house shall not exceed 90 dBA noise level measured according to ANSI S12.23, *Method for the Designation of Sound Power Emitted by Machinery and Equipment*. Isolation mounts may be used to reduce transmitted mechanical shock and noise levels.

7.7.8 Drip pans shall be provided under each of the wire rope drums. They shall be removable for cleaning.

7.7.9 A minimum of 3 ft (915 mm) clearance shall be provided around the main hoist, boom travel as well as the main transformer and switchgear. Clearances around electrical equipment shall also comply with the requirements of the NEC or IEC, whichever is greater. The front of MV switchgear and transformer shall have rubber mat of the same type supplied in the electric room.

7.7.10 The machinery house shall have an area in one corner, 10 ft by 10 ft (3 m by 3 m), equipped with a work bench, two lockers, and duplex 120V outlet. Work bench and lockers shall be heavy duty and suitable for the weight of crane components to be supported. No other item, including hatch covers, shall be allowed within this floor space.

7.7.10.1 The work bench shall be a heavy duty 900 mm x 1800 mm (35 in x 71 in) metal frame wood-topped work bench complete with 100 mm (4 in) bench vise. The bench shall be designed to support 225 kg (500 lb) machine parts.

7.7.10.2 The lockers shall be heavy duty industrial metal lockers. One shall have standard shelving and the other shall have parts storage bins of various sizes. Each locker shall be lockable and approximately 1200 mm (47 in) wide by 2000 mm (79 in) high by 400 mm (16 in) deep. Lockers and shelving shall be capable of supporting heavy machine parts and tools.

7.7.11 Handrails within the machinery house shall be no longer than 2 m (6.5 ft) in length. The handrail sections shall be galvanized. The handrails shall fit into mounting holes that are flush with the floor when in use and are stored on a secure hanging device when not in use. When the handrails are mounted they shall not move more than 20 mm (3/4 in) from side to side or 5 mm (3/16 in) lengthwise.

7.7.12 All walkways around the outside of the machinery house and electrical control room shall be at the same level. Entrances shall be at the walkway level.

7.7.13 No device, component, or equipment shall be installed in the machinery house which produces a noise level greater than 90 dBA measured according to ANSI S12.23, *Method for the Designation of Sound Power Emitted by Machinery and Equipment*. The noise level at any point in the machinery house shall not exceed 92 dBA when measured according to ANSI S12.36, *Survey Methods for the Determination of Sound Power Levels of Noise Sources*, and when the crane is operating and all auxiliary devices are functioning, with the exception of the PA system and any audible alarms. The noise level will be verified by the Owner prior to provisional acceptance.

7.7.14 The machinery house shall include a platform practically located and substantial enough to perform all required maintenance and repair on the machinery house service hoist.

7.7.15 The layout of the machinery house shall be approved in writing by the Owner prior to construction.

7.8 TROLLEY DRIVE MACHINERY HOUSE

7.8.1 The trolley drive machinery shall be mounted on a machinery platform which is enclosed in a weatherproof machinery house. The design of the platform and machinery house shall comply with the Section 3 structural specifications and shall have a neat and simple appearance. Localized storm wind pressures at machinery house corners shall be considered.

7.8.2 The machinery platform shall be sufficiently rigid to prevent machinery misalignment under any operating condition and provide safe access and working space around all machinery components. A hatch shall be provided in the platform deck. It shall be of sufficient size to permit lowering to the dock by the machinery house service Crane the largest piece of equipment without dismantling. The hatch shall be provided with a roll away cover with provisions for controlled opening and closing and securing in the open and closed position. In addition, a small hatch approximately 2' square with a hinged manually opened cover shall be provided to allow raising small tools and supplies from the dock. Additional hatches shall be provided, as necessary, for servicing trolley machinery by the machinery house service Crane. Removable safety chain guards shall be provided around all hatch openings and shall be mounted in sockets flush with the floor.

7.8.3 The machinery house shall be constructed of structural shapes and galvanized metal deck cladding. It shall have sufficient vertical height for the machinery house service Crane to pick any piece of machinery or electrical equipment from within and move it to the floor access hatch without dismantling. The machinery house structure shall be designed to support the service crane. Cladding seams and connection to the machinery house structure shall be continuous welds.

7.8.4 Weatherproof stainless steel hollow metal marine doors with safety glass windows in the upper panels and architectural type master keyed locks shall be provided in two opposite walls of the machinery house. Drip shields shall be provided over the doors. Automatic closers and latches to hold the doors in the open position shall be provided. Door hardware shall be brass or stainless steel.

7.8.5 The machinery house shall be provided with a thermostatically controlled fan with automatic gravity louvers arranged to prevent the entry of water. The fan shall have sufficient capacity to prevent heat buildup which may be damaging to any component. As a minimum, it shall have the capacity to change all of the air in the machinery house in one minute. The fan motor shall be TEFC, 1.15 service factor.

7.8.6 The access slots in the machinery house for passage of running ropes shall be provided with flexible rubber lips, or other means, that seal the opening from water.

7.8.7 The trolley drive machinery house shall be provided with a service crane.

7.8.8 Trolley machinery may be handled by the machinery house crane, if it can be demonstrated through layouts and subsequent field demonstrations that all components can be accessed by the machinery house service crane.

7.8.9 Power supply and control to the trolley drive machinery house shall be by cable chain.

7.9 .ELECTRICAL CONTROL ROOM

7.9.1 An electrical control room shall be provided inside the main machinery house to house the electric drive control panels and associated equipment. The CMS, bookshelf, and desk shall be located in a separate partition of the electric room.

7.9.2 The electrical control room, including the CMS partition, shall be insulated and air-conditioned. Air conditioning systems shall be automatic and thermostatically controlled to maintain conditions within the electric room at 20 °C (68 °F) and less than 50% relative humidity.

7.9.2.1 The air conditioning system shall consist of at least two (2) identical systems and shall be fully redundant. The design for each air conditioning system shall provide for at least 150% of the calculated cooling capacity. Two (2) continuous temperature sensors shall be located in the electric room and the temperature shall be displayed on the CMS. The thermostat for each unit shall be controlled by the PLC and the units shall automatically switch between the primary unit set to 20 °C and the redundant unit set to 25 °C at least once a week so that both units are utilized approximately the same amount. If either air conditioning system fails or the redundant unit is required at any time (temperature exceeds 25 °C), a fault shall be recorded and maintenance personnel shall be alerted via the CMS and RCMS. The fault shall not shut down Crane operations.

7.9.2.2 The PLC/CMS partition shall be cooled by the same system that cools the rest of the electrical control room using a plenum with thermostatically controlled dampers, louvers, or similar to allow separate temperature control of the PLC/CMS partition. Subject to the Owner's approval, a complete separate system, meeting all of the above requirements, including complete redundancy, may be provided specifically for the PLC/CMS partition.

7.9.2.3 Means shall be provided to select between PLC or manual control of the air conditioning system. It shall be logged as a warning in the CMS and RCMS when the air conditioning system is not under PLC control.

7.9.2.4 Air conditioning units shall be commercial grade units suitable for outdoor use in a marine environment and shall be designed for the shock and vibration present on the Crane. Air conditioner units intended for stationary buildings shall be vibration isolated from the machinery house and crane structure. The air conditioning units shall be protected from the weather.

7.9.2.5 The air conditioners shall have soft-start fans and multi-stage compressors to prevent short cycling of the units in cooler conditions.

7.9.2.6 The air conditioning units shall not draw outside air into the electrical control room. Cool air shall be ducted to enter into the electrical room so as not to blow directly on the electrical panels to prevent condensation inside the panel enclosure. Any part of the electrical panels exposed to direct cool air shall be insulated.

7.9.2.7 Safe access to maintain the air conditioning units shall be provided.

7.9.3 The electric room, including the PLC/CMS partition, shall be reasonably sealed and maintained at a pressure at least 60 Pa (0.01 psi) above the ambient atmospheric and machinery house pressure. Make-up air shall be taken from the machinery house through additional filters with a minimum efficiency rating of MERV 10 per ASHRAE 52.2 or F5/M5 per EN 779.

7.9.4 The floor's walking surface shall be covered with 6 mm (1/4 in) thick green rubber matting with non-skid walking surface. Matting shall be suitable for use at switchboards, with voltage resistance of 5,000 volts. Matting shall be seamless and shall lay flat.

7.9.5 A minimum of 50% of the interior wall length adjacent to the machinery area shall be constructed of safety glass panels located to allow maximum visual contact with mechanical equipment from the electrical control room to facilitate maintenance operations.

7.9.6 Five (5) lockable stainless steel doors with wire mesh glass window and automatic closure shall be provided, one between the PLC/CMS partition and the inverter area, one on the far end of the inverter area from the PLC/CMS partition to outside, one from the inverter area to the machinery house large enough to move inverter panels into the machinery house and either flush with the floor or with a removable sill, one from the PLC/CMS partition to the machinery house, and one from the PLC/CMS partition to outside. Doors shall open toward the outside, or in the case of the door between the inverters and PLC/CMS partition, toward the PLC/CMS partition, with a panic bar mechanism on the inside and a hasp for a padlock the outside. The doors shall open from the inside for emergency egress without the need to unlock the doors. All door hardware shall be marine or industrial quality and shall be stainless steel. Door hinges shall be heavy duty type with grease fittings. "High Voltage" and "Authorized Personnel" warning signs complying with Section 7.18.1 shall be posted at all access doors.

7.9.7 One 900 mm x 1,500 mm (3 ft x 5 ft), elbow-height (approximately 1,000 mm (3 ft)) work table shall be provided in the PLC/CMS partition of the electric room along with a high quality, ergonomic, adjustable office chair on casters. Cabinets and drawers suitable for storing electrical manuals and tools shall be located under the table. A duplex utility outlet adjacent to the table shall be provided. There shall be a clearance for passage between the table and panels with panel door open.

7.9.8 The noise level at any point in the PLC/CMS partition of the electrical control room shall not exceed 80 dBA when measured according to ANSI S1.13, *Measurement of Sound Pressure Levels in Air*, and when the Crane is operating and all auxiliary devices are functioning, with the exception of the PA system and any audible alarms. The noise level will be verified by the Owner prior to acceptance.

7.9.9 The walls of the machinery house and the electrical control room shall be welded to create a seamless wall.

7.9.10 The panels in the electrical control room shall be arranged in a line against a single wall. An alternative layout will be considered. The layout of the ele

7.9.11

7.9.12 ctrical control room shall be approved in writing by the Owner prior to construction.

7.9.13 The main power inverters and control enclosures located in the electric room shall be suitably supported to the wall for crane service.

7.10 MACHINERY HOUSE SERVICE CRANES

7.10.1 Each machinery house shall be equipped with an electric powered service crane capable of lifting components other than the main and auxiliary transformers, the main hoist drum, and assembled main hoist reducer. The cranes shall be of the overhead type, spanning the machinery house and capable of centering over, lifting, and traveling with the assembled equipment without the need for spreader bars, intermediate lifting lugs, or additional lifting devices. The reach of the service cranes shall be such that the center of the hook can travel, in all directions, at least 150 mm beyond the center of gravity of all components in the machinery house which may need servicing and weigh more than 20 kg (44 lb), including but not limited to all motors, reducers, pillow blocks, brakes, and switchgear.

7.10.2 Reducers may be dismantled for removal from the machinery house; however, the vertical lift of the crane shall be sufficient for the gear case cover to clear the gears while in position.

7.10.3 The cranes shall also be cable of placing and removing reels of cable on the rereeving device without assistance.

7.10.4 The complete trolley mounted cable reel assembly shall be accessible for the machinery house service hoist to lift from the trolley and lower to the wharf and vice-versa.

7.10.5 Electrical components from the electric room may be carried into the machinery house area into a clear area by the electric room door(s) where they shall be reachable by the service crane.

7.10.6 Where a means of lifting any piece of equipment in and out of the machinery house is not clear, a layout shall be made and submitted to the Owner which demonstrates that capability.

7.10.7 Safe access shall be provided to service all areas of the service crane requiring maintenance.

7.10.8 The lifting speed shall be at least 6 m/min (20 ft/min) for heavy loads and 24 m/min (80 ft/min) for lighter loads. Overload protection shall be provided and shall be interlocked to prevent the higher speed motion for loads above the light load rating.

7.10.9 The service cranes shall have protection for over-travel, slack rope, and two-blocking.

7.10.10 The lifting height shall be sufficient to lay the lowered block on the wharf.

7.10.11 The machinery house service crane wire rope shall be a standard rotation-resistant wire rope readily available at the Owner's Facility and is subject to the Owner's approval.

7.11 SERVICE CRANES OUTSIDE THE MACHINERY HOUSES

7.11.1 Permanently installed jib structures shall be provided at all locations containing machinery weighing over 30 kg (66 lb) that must be periodically replaced, rebuilt, or that may require extensive servicing. The service crane shall be located such that they can be positioned over the center of gravity of all components and assemblies which may require removal and such that there is a clear path for lowering such components or assemblies to either the top of the trolley or to wharf level. The location and details are subject to Owner's approval.

7.11.2 Transfer from a service crane to the trolley and subsequent transfer to the machinery house or backreach service crane for lowering to wharf level is acceptable.

7.12 INTERCOM

7.12.1 A multi-station, single-party intercom shall be installed with loudspeakers, handsets, and amplification and balancing equipment to permit communication between the control stations, as described below. The intercom controls shall be located in the electric room.

7.12.2 The intercom shall announce crane alarm functions. The intercom shall be connected to the crane drive system for alarm signals. Alarms shall sound from all intercom speakers. Alarms will stop automatically when the fault is cleared. Unique alarms warning tones shall include:

.1 Overload
.2 Snag
.3 Wind Warning
.4 Wind Alarm
.5 Gantry Collision Alarm
.6 Corner Seated Override

7.12.3 The intercom shall be wireless and be provided with an interface to existing UHF stations and headsets at the Owner's facility.

7.12.4 The operator shall have the additional capability by means of a loudspeaker mounted on the cab's exterior to talk to personnel on the ship or the wharf. The intercom shall be a single phase AC central amplifier with low voltage communication circuits. Handsets shall have "push-to-page" bars. Stations shall have individual listen volume control. The external handsets shall be mounted in waterproof enclosures. Non-metallic enclosures will be allowed for these handsets. The wharf handsets shall be located adjacent to the wharf operating station and at the centerline of the crane on the opposite sill beam. The intercom shall include at least the following features:

7.12.4.1 Machinery House

.1 Loudspeaker, 400 mm (16 in) diameter
.2 Handset
.3 Headset with 15 m (50 ft) minimum retractable cord and access to HV electrical equipment within the machinery house, or jacks at several convenient locations for plug-in headset with 6 m (20 ft) retractable cord; headset shall have a manual button to talk and a manual button to PA; voice activation or an open mic is not allowed

7.12.4.2 Electric Room

.1 Line balancing assembly
.2 Loudspeaker, 100 mm (4 in) diameter

.3 Handset
.4 Headset with sufficient cord on a retractable reel to reach all points in the room; headset shall have a manual button to talk and a manual button to PA; voice activation or an open mic is not allowed

7.12.4.3 Operator's Cab

.1 Indoor type loudspeaker , 100 mm (4 in) diameter
.2 Handset
.3 Loudspeaker for ship and wharf paging, 400 mm (16 in) diameter, mounted outside of cab
.4 Gooseneck microphone extending from right wall with foot pedal to the PA

7.12.4.4 Boom Travel Control Station

.1 Loudspeaker, 100 mm (4 in) diameter
.2 Handset

7.12.4.5 Gantry Station at Wharf Elevation: two (2) required, waterside and landside at approximately the center of the gantry

.1 Loudspeaker, 100 mm (4 in) diameter
.2 Handset

7.12.4.6 Inside elevator

.1 Loudspeaker, 100 mm (4 in) diameter
.2 Handset or talk-back speaker with PA and talk buttons

7.12.4.7 Trolley Machinery house

.1 Loudspeaker, 100 mm (4 in) diameter
.2 Handset or talk-back speaker with PA and talk buttons

7.12.5 All loudspeakers shall have their volumes adjusted to be compatible with the work spaces they support and comply with governing regulations.

7.13 WELDING MACHINE AND WELDING OUTLETS

7.13.1 A heavy duty welding machine shall be provided with each crane.

7.13.2 Three phase welding outlets shall be located at each stowage pin area on the boom, at the boom back reach, waterside and landside at wharf level, boom tip, boom support beams, as well as in the frame and trolley machinery houses.

7.13.3 Sufficient length of welding leads shall be provided to reach all equipment in the area of the outlets, including all portions of the trolley.

7.13.4 The welding machine and outlets shall be subject to the Owner's approval.

7.14 AIR COMPRESSOR AND AIR DISTRIBUTION SYSTEM

7.14.1 An AC electric motor driven air compressor shall be furnished and installed in the frame machinery house and the boom mounted machinery house for blast cleaning machinery, lubrication, and operating small auxiliary units or hand tools. The air compressors shall be complete with automatic-manual reloader, intake filter, instruments, controls and 0.45 cubic meter (120 gal) air receiver meeting ASME standards, all rated 12.2 kgf/cm^2 (175 psi). The air compressors shall be the dual stage positive displacement type and shall be at least 10 horsepower, 990 liter/min (35 ACFM) @ 175 psi. The air compressor shall automatically start when the air receiver pressure drops to 7 kgf/cm^2 (100 psi) and shall stop when the pressure reaches 10.2 kgf/cm^2 (145 psi). The air receiver shall be provided with a pressure gage and automatic moisture ejector piped to the outside.

7.14.2 The air compressors, including the receivers, shall be designed and certified for use at the Owner's Facility. The Contractor shall provide the necessary regulatory certificates to the Owner. See Section 10.6.

7.14.3 A hose reel shall be furnished and installed. Piping from the air compressor unit to the hose reel shall be rigid except that less than 500 mm (20 in) of flexible hose may be installed immediately adjacent to the compressor. The reel shall have sufficient length of hose to reach any part of the machinery house and shall have a pistol grip blow gun.

7.14.4 The compressed air shall be piped to Amflo C2 (female) shut off valves and quick disconnects at the boom tip, the trolley machinery house on the boom, the landside of the boom, boom support roller platforms and at the landside gantry level. Piping shall be routed within the structure where possible. Male disconnects where used shall be Amflo CP1. The entire air pipe shall be stainless steel.

7.14.5 The air compressors, tank, relief valves, piping and components shall be certified by the proper regulatory authority prior to provisional acceptance.

7.14.6 s\Signs warning that the air compressor starts automatically shall be installed in accordance with Section 7.18.1.

7.14.7 Drain valve position and piping drawings shall be submitted to the Owner for approval.

7.15 ROPE TENSION AND LOAD WEIGHING

7.15.1 Separate load cell systems shall detect rope tension and container weight. Rope tension in each hoist rope shall be detected by load cells that are independent of the spreader. The container weight shall be determined by load cells in the spreader twistlocks.

7.15.2 The rope tension system shall protect the crane against lifting more than the rated load or greater than the design eccentricity. The system shall have sufficient speed and accuracy to provide redundancy to the slack rope detection sensors in preventing slack rope and to provide overload protection.

7.15.3 The rope tension system shall detect a broken wire rope and notify maintenance personnel via the CMS.

7.15.4 The load weighing system on the spreader shall weigh each lifted container when a spreader so equipped is attached to the Crane. The rope tension system shall weigh the lifted load when no spreader is attached or if the load weighing system on the spreader is not present or not functioning.

7.15.5 A digital readout of the aggregate lifted load in long tons shall be provided at both the local control station in the electrical control room and on the operator's auxiliary panel in the cab. In addition, the weight of each container and the load on each rope shall be independently displayed on the CMS.

7.15.6 The aggregate load displayed shall have an accuracy of at least ±500 kg with a precision of at least 100 kg. Load eccentricity shall be recorded and displayed to the operator.

7.15.7 Load cells shall have integrated signal converters and isolated 4-20 mA outputs.

7.16 WIRE ROPE REREEVING DEVICE

7.16.1 The Contractor shall provide electric powered rereeving devices on each crane for all wire rope reeved systems. The rereeving devices shall not utilize hydraulics or electronics. The rereeving devices shall be subject to the approval of the Owner. A detailed procedure for rereeving each rope system (main hoist, trolley drive, boom drive, and catenary trolleys) shall be provided. Particular attention shall be given to ease of rope equalization and termination of rope ends.

7.16.2 The rereeving devices shall consist of two independently driven devices, each with a motor, reducer, and brake, for pulling the used rope out of the reeve-up and reeling it on a standard commercial reel while pulling the new rope in from a standard shipping reel, all under controlled power and braking. The devices shall accommodate reels with outside diameters ranging from 600 mm to 1100 mm (24 in to 44 in), width from 600 mm to 1100 mm (24 in to 44 in), and bore diameters from 50 mm to 150 mm (2 in to 6 in). Since the dimension of the reels will be decided based on actual rope length, the reel dimensions will be reviewed by the Owner once wire rope length is decided by design. The Contractor shall submit the reel design for Owner approval. Motor sizing and brake design shall consider the catenary and friction forces for the size of wire rope used.

7.16.3 Rereeving will be performed within the machinery houses and the rereeving device shall be permanently installed on the machinery house floors. If the Contractor can demonstrate that rereeving of the catenary tow ropes cannot be achieved from within the trolley machinery house, the Contractor may propose a separate, trolley mounted rereeving device that will allow safe and controlled replacement of the catenary trolley tow ropes from the cabin top or trolley top. The trolley mounted device shall be subject to the Owner's approval.

7.16.4 All attachment points and rigging devices required for rereeving shall be provided by the Contractor.

7.16.5 The controls for the rereeving device shall allow bi-directional powered spooling at variable speed from both a control pendant with ample cable length and from a fixed operating station within each machinery house. Crane control power shall not be required to operate the rereeving devices.

7.17 SPREADER CARTS

7.17.1 Spreader carts are not required.

7.18 CRANE SIGNS AND NAMEPLATES

7.18.1 Safety Signs

7.18.1.1 Hazards which may result in injury to personnel shall be clearly marked with signs in the language described in Section 2.14. Signs shall describe the nature of the hazard, the consequence of not avoiding the hazard, and how to avoid the hazard. Signs shall be permanently secured in a conspicuous location and, unless otherwise defined by local codes or regulations, shall conform to ANSI Z535. Standard pictorial symbols indicating the nature of the hazard shall be used. Where lengthy instructions or procedures for avoidance of hazards are required, the signs shall refer to the appropriate section of the maintenance manuals. The format, language, graphics, and placement of all hazard signs shall conform to the recommendations of ANSI Z535 and shall be approved by the Owner.

7.18.1.2 Provide "Hard Hat Area" in the language described in Section 2.14 with 300 mm lettering on the landside and waterside of the landside sill beam and on the landside of waterside sill beam.

7.18.1.3 Refer to Section 3.2.14 for structural integrity warning placard requirement.

7.18.1.4 Refer to Section 5.15 for electrical warning and nameplate requirements. Electrical warning signs shall comply with 7.18.1.1.

7.18.1.5 Equipment which is automated or which may start automatically shall be marked as a hazard as required by 7.18.1.1. The machinery house air compressor and hydraulic power units are examples of this type of equipment.

7.18.1.6 All signs shall be designed and manufactured for durability and legibility through the expected life of the crane. Signs shall be rigidly mounted, corrosion resistant, and secured against damage from exposure to weather. The Contractor shall provide written procedures in the maintenance instructions for the maintenance and replacement of all hazard signs in accordance with the recommendations of ANSI Z535.4.

7.18.2 Emergency Stop and Power Disconnect

7.18.2.1 Eight (8) "Emergency Stop" signs shall be installed 1800 mm above the surface of the wharf at the location of the emergency stop push-buttons required by Section 6.4.4.3. Signs shall have baked porcelain enamel paint, red background with 100 mm high white letters and shall be in the language described in Section 2.14.

7.18.2.2 An "Emergency Power Disconnect" sign shall be installed at the location of the disconnect switch defined in Section 5.3.6.1. The sign shall have baked porcelain enamel paint, red background with 100 mm high white letters and shall be in the language described in Section 2.14.

7.18.3 Manufacturer's Nameplate

7.18.3.1 A nameplate shall be attached to the crane adjacent to the normal access route showing the manufacturer's name, address, crane serial number, and year the crane was placed into service. The numbers, nameplate, and hardware shall be corrosion resistant. The name plate shall be no larger than 300 mm x 300 mm (12 in x 12 in), stainless steel with black etching.

7.18.4 Safe Working Load

7.18.4.1 Safe working load (SWL) in long tons shall be displayed on the outside of each portal tie beam. SWL shall be shown for the single container under spreader, twin-twenty under spreader, and the cargo beam. The lettering shall be legible from the wharf.

7.18.5 Crane Numbers

7.18.5.1 Crane numbering shall be indicated as follows:

.1 On the landside of the machinery house – 2 m high
.2 Outside of legs at the boom elevation – 1 m high, two (2) places
.3 Outside of legs at bottom of legs – 1 m high, two (2) places
.4 Inside of sill beams at the center of each sill beam – 1 m high, two (2) places
.5 In electrical control room – number height approved by the Owner
.6 In machinery houses – number height approved by the Owner
.7 In cab – number height approved by Owner.

7.18.6 Logos

7.18.6.1 The Owner's logo shall be painted on each side of the machinery house. The logo shall be installed as large as possible while providing reasonable borders on the sides of the machinery house.

7.18.7 Drawings

7.18.7.1 Drawings for all signs, nameplates, and logos, with size of each nameplate, lettering, and location, shall be submitted to the Owner for approval prior to purchase or fabrication. Drawings shall be to scale and shall include definitions of colors, materials, and manufacturing procedures where applicable.

7.19 CRANE KEYING

7.19.1 The number of keys shall be minimized consistent with maintaining the necessary level of security on the Cranes and the keying system shall be subject to the Owner's approval. All locks shall be common keyed within each Crane and among cranes. All machinery house and cab door keys shall be common. All electrical key switches shall be common. All locker, desk, and work bench keys shall be common. All locks shall be high-quality industrial or marine grade and shall be subject to the Owner's approval.

7.19.2 Where keyed push-button switches are used, such as for bypass switches, maintenance mode, or similar, the Contractor shall coordinate with the Owner to provide a key system acceptable to the Owner.

7.20 FIRE EXTINGUISHERS

7.20.1 Certified, industrial quality, fire extinguishers shall be purchased by the Contractor locally near the Owner's Facility and shall be designed and certified for industrial use at the Owner's Facility. Imported or foreign sourced fire extinguishers shall not be used.

7.20.2 As a minimum, the following CO_2 fire extinguishers, rated BC, shall be provided in the following locations:

.1 Two (2) 10 lb units located immediately inside doors in the machinery house
.2 One (1) 10 lb unit located in the PLC/CMS partition of the electrical control room near the door
.3 One (1) 10 lb unit located in the inverter partition of the electrical control room near the door
.4 One (1) 10 lb unit located immediately inside doors of the trolley machinery house
.5 One (1) 5 lb unit located in the operator's cab
.6 One (1) 5 lb unit located in the maintenance cab

7.20.3 As a minimum, the following chemical fire extinguishers, rated ABC, shall be provided in the following locations:

.1 Two (2) 15 lb units located at the wharf elevation, one adjacent to the access ladder and one adjacent to the personnel elevator access stairway
.2 Two (2) 10 lb units located immediately inside doors in the machinery house
.3 Two (2) 10 lb units located immediately inside doors in the trolley machinery house
.4 One (1) 10 lb unit located adjacent to every hydraulic unit on the crane except spreader
.5 One (1) 5 lb unit located in the elevator

7.20.4 These fire extinguishers are a minimum requirement. The Contractor shall provide and install additional fire extinguishers, meeting the above requirements, as required by his design and applicable safety regulations.

7.21 STRETCHERS

7.21.1 The Contractor shall furnish and install two industrial, x-ray compatible, basket stretchers. One shall be mounted on the inside wall of the machinery house adjacent to the principal entry door. The other shall be mounted at the wharf elevation adjacent to the access stairway. The stretchers shall be provided with securing devices and slings for suspension from a hook.

7.22 EMERGENCY AC DRIVES

7.22.1 Emergency AC motor drive machinery shall be provided for the main hoist, trolley drive, and boom traverse machinery by means of a quick disconnect coupling. A permissive switch shall allow normal machinery operation only when the emergency drive is disconnected.

7.22.2 Emergency drive motors shall be controlled by full voltage motor starters.

7.22.3 The emergency motor(s) shall be provided with a fail-safe disc brake that will release when power is applied to the motor and set when power is removed from the motor. The brakes shall be able stop and hold the maximum load. The emergency motor(s) shall be equipped with overspeed switches for stopping of the emergency drive.

7.22.4 The emergency drive(s) shall be capable of raising or lowering the hoist with rated load at 2 m/min (6 ft/min), travel the trolley with rated load at 12 m/min (40 ft/min) and travel the boom from Boom Pos. C to Boom Pos. R or vice-versa in one hour.

7.22.5 All emergency drives shall be controlled and operated independent of the PLC from the local control switches in the machinery house and shall not require crane control power.

7.22.6 The control stations for the emergency AC drives shall be located where the emergency operator can view the emergency drive. Activation of any hardwired limit switch or emergency stop pushbutton shall stop the emergency AC drive.

7.22.7 Operation of multiple emergency drives shall be limited when powered by the auxiliary generator as described in Section 5.14.

7.23 PORTABLE MAINTENANCE PLATFORMS

7.23.1 The portable maintenance platform shall provide access to the lower chord of the boom and the inboard vertical surfaces of the legs.

7.23.2 The maintenance platform shall be designed to be picked up by the spreader in the 20 ft position. The platform floor where a man stands shall be 9,000 mm (30 ft) long longitudinally along the boom to reach the boom tip, wide and high enough to reach boom bottom at main hoist normal stop. Floor shall be adequate for a minimum of 200 kg/m² (40 psf). Grating shall be the same as provided for the walkways defined in Section 7.5.

7.23.3 The maintenance platform shall have forklift pockets suitable for handling by the equipment at the Owner's Facility.

7.23.4 The design shall be subject to Owner's approval.

7.24 OIL DRAIN SYSTEM

7.24.1 From the frame machinery house, waste oil systems shall be provided to collect and drain used lubricating, hydraulic and engine oil from their respective locations to the wharf level. The system shall be constructed from black iron pipe with socket weld connections, running down one waterside leg and attached to the crane with shop-welded pipe supports. It shall be possible to drain all oil containing components (reducers, hydraulic power units, diesel engines, etc.) via valves and fittings into the drain system for collection at wharf level. A shutoff valve and holes connection shall be provided at wharf level.

7.24.2 Premade hoses with fittings shall be provided and stored on the crane for making temporary connections between all moving components, such as the trolley reducer to the frame, the tensioner power unit to the frame, the trolley cable reel to the frame, and all others as determined by the Contractor's design.

7.25 TEST LOAD SYSTEM

7.25.1 The Contractor shall provide the test load system which shall become the property of the Owner after completion of the load tests on all cranes.

7.25.2 The test load system shall be a reinforced flat rack or similar with eight (8) ISO twistlock corner boxes suitable to test separating twin 20' spreader capacity and shall be able to handle 1.25 times the maximum cargo beam load (CBRL) and 1.25 times the maximum rated load under the spreader (RL). In addition to the concentric load, the weights shall be able to be positioned to produce the eccentric loads (LLE and LLES).

7.25.3 The basic weight of the platform shall not exceed 30 t and removable calibrated weights shall be used to achieve the desired gross weight and eccentricity.

7.25.4 The testing device shall have ISO compliant corner castings at 20 ft, 40 ft, and 45 ft, along with the center corner castings for twin 20 ft operation, for use with the spreader and shall have lifting eyes for testing the cargo beam. Fabrication, painting, and other requirements of this Specification shall be applied to the test load system. Internal maintenance access and internal corrosion protection are important design considerations. The test load drawings shall be submitted for Owner's approval before fabrication.

7.25.5 The test load system, including all calibrated weights and any other loose components, shall include nameplates with clearly specified dimensions and capacities, serial numbers, and appropriate labels such as the SWL and safety instructions.

7.25.6 The weights shall be steel or steel encased concrete with lifting lugs.

7.25.7 The test load system shall include a cart or carts for organizing and transporting the weights

7.25.8 The weights and the frame shall meet the requirements of these Specifications, including Section 9.6.

7.26 AUTOMATED BRAKE TESTS

7.26.1 A convenient means shall be provided for maintenance personnel to periodically verify the dynamic torque of all brakes on the crane independently.

7.26.2 All brakes, including drum mounted disc brakes, for the main hoist, boom traverse, trolley, and gantry shall be capable of being tested with this system. The brakes shall be capable of being open and closed independently as necessary to perform these tests. Gantry motor brakes may be tested as group.

7.26.3 These brake torque tests shall be automated to the extent possible, with input from the maintenance personnel only as needed for safety. The CMS system shall provide clear step-by-step instructions for setting up the tests and for any required actions by maintenance personnel and shall highlight important safety instructions.

7.26.4 Tests shall not require maintenance personnel to make any modifications to the crane control logic or manually actuate brake starters or manual releases.

7.26.5 The brake tests shall verify the dynamic torque of the brake being tested by driving through the brake at half speed with the brake closed long enough for the brake torque to stabilize. Motor current readings and the development of the equivalent brake torques shall be displayed in the CMS as well as the allowable torque range and a pass/no-pass indication for each test. Failure to drive through the brake being tested (stall condition) shall be considered a no-pass result.

7.26.6 This brake torque data for at least the last three complete sets of tests for each motion shall be stored in and displayed on the CMS. The CMS shall be capable of printing a record of the test for signature by the maintenance personnel performing the test and incorporation into the permanent maintenance record.

7.27 ANEMOMETER

7.27.1 An anemometer shall be provided on each Crane at the apex, free of wind shielding and protected from lightning strikes, to measure wind speed and direction. Wind speed and direction data shall be recorded on the CMS and shall be used to provide warnings to the operator and ground personnel. The anemometer shall be a maintenance free solid state type with no moving parts, shall be adequate for a marine environment, and shall be subject to the Owner's approval.

7.27.2 The first alarm set point shall indicate an Operating Wind Warning. This set point shall be adjustable and set initially at 35 mph. At that point, the operator shall receive an audible and visual warning of the high wind and a warning tone shall sound through the Crane's public address (PA) system audible at ground level.

7.27.3 The second alarm set point shall indicate the Wind Alarm. This set point shall be adjustable and set initially at 45 mph. At this point, the operator shall receive a distinct audible and visual high wind alarm and a different warning tone shall sound through the PA system.

7.27.4 Minimum requirements for the anemometer shall be as follows:

- .1 Adjustable wind speed settings for wind speeds between 30 mph (13 m/s) and 168 mph (75 m/s)
- .2 Wind speed measured as 3-s gust duration
- .3 Maximum and average 3-s gust wind speed recorded for each 5 min interval
- .4 Able to withstand winds to 225 mph (100 m/s), including the support structure
- .5 Maintenance free, suitable for a marine environment
- .6 Not sensitive to wind gusts of three seconds or less
- .7 Not sensitive to vibrations of the Crane
- .8 Manual reset peak velocity indicator
- .9 Automatic alarm reset as wind speed goes below set point
- .10 Interface with Crane PLC and CMS
- .11 Record at least 72 hours of wind speed data, including peak and average wind speed over each five minute period, with control power on or off

7.28 FIRE DETECTION SYSTEM

7.28.1 Fire detection, consisting of heat and smoke sensors with audible and visual alarms, shall be provided in the following areas:

- .1 Electrical control room
- .2 PLC/CMS partition
- .3 Machinery house – both main and trolley drive
- .4 Operator's cabin

7.28.2 The fire detection system shall be connected to the Crane's control system, the CMS, the RCMS, and the fire alarm system at the Owner's facility. Maintenance alerts such as sensor self-test failure and other faults and warnings shall be logged in the CMS for action by maintenance personnel.

7.28.3 Fire detected on a crane shall stop the crane, trigger a fire alarm warning on the CMS and in the fire alarm system at the Owner's facility, and activate audio and visual alarms noticeable at all areas on the Crane and nearby on the ground.

7.28.4 The system shall be subject to the Owner's approval.

7.29 CRANE ANTI-COLLISION SYSTEMS

7.29.1 General

7.29.1.1 Each Crane will operate on Berths 31–32 or Berth 30 at the Owner's Facility. Berths 30–31 form a corner.

7.29.1.2 The Contractor shall provide two independent and redundant Crane anti-collision systems.

7.29.1.3 All anti-collision systems shall bring the Crane to a controlled stop, with maximum deceleration less than 0.075g and prevent further gantry motion in that direction unless overridden with a keyed bypass switch. While bypassed, motion shall be limited to slow speed. Motion away from the collision shall not be inhibited and shall not require a bypass to move away.

7.29.1.4 Supplied sensors shall operate reliably in all weather conditions, including rain and fog, and shall not be blinded by direct sunlight.

7.29.1.5 The Contractor shall demonstrate the effectiveness of each anti-collision system during acceptance testing and shall provide instructions in the Maintenance Manual for proper maintenance, calibration, and periodic testing of each system.

7.29.2 TMEIC-Gotting Anti-Collocation System

7.29.2.1 The Owner currently operates a TMEIC-Gotting transponder based position and anti-collocation system controlling the operation of all existing ship-to-shore cranes. The Cranes under this contract shall be equipped with necessary hardware and software and shall be fully integrated into this existing system. The Contractor shall modify the existing system as needed for a complete integration meeting the requirements of this specification. The existing system uses transponders located along landside and waterside rails. Details of the existing system will be provided by the Owner upon request. The system monitors the crane position and communicates via Ethernet to a central computer controlling crane positioning to protect against crane to crane collisions at the gantry, portal, or boom level, including at the wharf corner between Berths 30–31 and the bend between Berths 32–33.

7.29.2.2 The Contractor shall provide and install transponders along the full length of the Berths 31–32 landside and waterside crane runway for the Cranes as shown on the Drawings. Positions for transponder installation will be prepared by the Owner. Transponders shall be Gotting HG70652ZA or equal and approved by the Owner. Transponder installation shall be according to the manufacturer's instructions for "In the Ground" installation achieving maximum signal strength. The Contractor shall verify that there is no metal within the manufacturer specified parameters at each installation point prior to drilling each transponder hole. Each transponder shall be installed, fixed in place and sealed using a procedure and products approved by the Owner. Final transponder installation, survey of each position, and fine tuning of the positioning system is the responsibility of the Contractor.

7.29.2.3 The maximum distance between transponders along the landside or waterside rail shall be 50 ft (15.2 m). The transponders along the landside rail shall be offset from the transponders along the waterside rail by 25 ft (7.6 m) so that the effective spacing between transponders at either landside or waterside is 25 ft (7.6 m). See Section 8.5.5 for spare transponders required.

7.29.2.4 For the TMEIC-Gotting system, position data for each crane shall be determined by two independent and redundant systems:

.1 Using transponders
.2 Using absolute encoders on the gantry wheels

7.29.2.5 For each crane, the position indicated by the encoder based positioning system shall be regularly updated using the transponders. In case the encoder based position differs from the transponder based position by more than 1.5 in across two consecutive transponder positions, the system shall report a malfunction. If the encoder based position differs from the transponder based position by more than six inches at one transponder the system shall report a malfunction and shut down the crane and the two adjacent cranes.

7.29.2.6 The system shall be fail-safe. In case the signal from a crane disappears, or any other error occurs inhibiting position indication or safe functioning, the system shall immediately shut down the crane associated with the error, the adjacent cranes on either side, and any other cranes which may contact an affected crane with their boom based on the last known position of the crane or cranes.

7.29.2.7 In case of an error in the system and related crane shut down, the system shall have a by-pass function allowing slow speed movement of each affected crane to a pinned position.

7.29.2.8 The logic and functioning of the system shall be submitted for approval by the Owner and the complete functioning of the system shall be demonstrated prior to the hand-over of any crane.

7.29.3 Boom Anti-Collision Scanning Laser

7.29.3.1 A scanning laser system shall be provided to slow and stop the gantry and/or boom motion prior to collision with a ship or boom-to-boom or boom-to-crane collision at the backreach.

7.29.4 Gantry Anti-Collision System

7.29.4.1 A scanning laser system shall be provided at the four corners of the gantry frame to prevent collision with people, objects near the gantry rails, or another Crane.

7.29.4.2 The sensors shall have a sensing distance of no less than 40 m (130 ft), but in any case sufficient to bring the Crane to a controlled stop prior to hitting the obstruction as described in Section 7.29.1.

7.30 CRANE ANTI-RACK REQUIREMENTS

7.30.1 Background: The Crane structure is flexible for gantry displacement at one rail with respect to the other. For the Crane structure to perform adequately, the landside and waterside sill beams must travel together with minimal relative displacement.

7.30.2 The Contractor shall provide a system that maintains the centerline of the landside and waterside gantry frames aligned to within ±1.5 in (±38 mm) of each other, parallel to the gantry rail.

7.30.3 The Contractor shall obtain Owner approval for the anti-rack system. See Section 1.9.1.4 for design approval requirements.

7.31 CRANE MODEL

7.31.1 One model of the container Crane at a 1:72 scale shall be provided.

7.31.2 The scale model shall have adjustable boom positions, latching at four positions similar to the actual Crane. The scale model shall be in sufficient detail to identify all systems including access stairs, ladders, and platforms. The model shall be painted with the color system of this project with all signs and logos. The model shall be displayed in a scratch resistant clear enclosure on the top and all four sides. The model shall be strong enough to withstand normal shipping forces.

7.31.3 The model shall be delivered to the Owner to an address advised by the Owner. The model shall be delivered before provisional acceptance of the first Crane.

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SECTION 8 RELIABILITY AND MAINTENANCE REQUIREMENTS

8.1 GENERAL

8.1.1 The crane shall be designed, manufactured, assembled, and commissioned to promote reliability while minimizing the maintenance burden necessary to achieve the specified reliability.

8.2 MINIMUM RELIABILITY

8.2.1 Crane reliability shall be defined here as the total time all systems of the crane necessary for specified container operation are operating to their specified performance levels divided by the time the crane is requested to operate. As an example, if the crane or a system within the crane is down for 0.08 hours (4.8 minutes) because of a failure or other issue within an 8 hour shift, the resulting reliability for that shift is (8 - 0.08) / 8 = 0.990 or 99.0%. Out of service time resulting from scheduled maintenance, inspections, or as a result of the crane not being scheduled to operate against a vessel shall not apply to the calculation of reliability.

8.2.2 Each crane supplied shall achieve the following minimum reliability requirements:

> 8.2.2.1 Overall crane reliability during the first six (6) months of operation, or 2,500 hours, whichever comes first, shall be greater than 95%.
>
> 8.2.2.2 Reliability during the second six (6) months of operation, or from 2,500 hours to 5,000 hours, shall be greater than 97.5%.
>
> 8.2.2.3 Overall crane reliability for the second year of operation, or from 5,000 hours to 10,000 hours, and subsequent years, until the specified Design Life is reached, shall be greater than 99.0%.

8.2.3 See Section 3 for Crane structural reliability design requirements.

8.3 MAINTAINABILITY

8.3.1 Scheduled and mandated maintenance tasks shall be reasonable in scope and duration and shall be justified in their frequencies.

> 8.3.1.1 Scheduled maintenance for the crane, with the exception of spreaders, shall not exceed 500 man hours per crane per year.
>
> 8.3.1.2 Scheduled spreader maintenance for the crane shall not exceed 500 man hours per spreader per year.
>
> 8.3.1.3 Scheduled inspections (pre/post-operation, monthly, quarterly, annual, and any others) shall not exceed 700 man hours per crane per year and shall include all regulatory mandated crane and wire rope inspections.

8.3.2 The Contractor shall prepare listings and descriptions of every maintenance and inspection task required for all systems on the crane, including those required by manufacturers of components selected by the Contractor for use on the crane. The listing of tasks shall include at least the following:

.1 Description of task,
.2 Frequency of task,
.3 Method of safe access to perform task,
.4 Tools required to perform task,
.5 Manpower and man-hours to perform task,
.6 Parts, and materials required to perform task,
.7 Reporting requirements, if any.

8.3.3 The Contractor shall also prepare a list of initial maintenance and inspection requirements that reflect those tasks that may be required during the initial operating period of crane operation, typically one to two years. As example, the cleanliness of each reducer and hydraulic reservoir should be verified at the end of a short initial operating duration. Additionally, thermal and vibration measurements should be taken to verify the soundness of the original installation. See also Section 11.2 for submittal requirements.

8.3.4 The Contractor shall present these descriptions as part of design reviews and with each respective submittal. The assembly of all maintenance tasks shall be presented as part of the maintenance review. The Contractor shall justify the requirements for each task.

8.3.5 Components and materials shall be selected for their reliability, durability and ease of maintenance. Wearing and degrading components such as switches, breakers, seals and gaskets shall be made of long life materials. Hoses, electrical wire insulation, and other materials exposed to the weather and sunlight shall be suitably UV and weather protected. Lubricants shall be extended life grade having the ability for periodic filtering and restoration of additives rather than exchange.

8.3.6 Components and parts performing the same or similar functions shall be interchangeable so as to minimize spare parts requirements and to ease maintenance training and familiarization. This requirement applies to components such as; drive controllers, motors, encoders, limit switches, relays, I/O blocks, operator's devices, light bulbs, ballasts, bearings, hydraulic cylinders, hydraulic components, and others.

8.3.7 The selection and installation of components shall be conducted to promote maintenance access to those components and assemblies with limited reliability. Where lower reliability assemblies or components are used, or where periodic replacement may be required, additional measures shall be taken to promote access.

8.3.8 Safe access and working clearance shall be provided around all components, devices and systems requiring maintenance or adjustment.

8.3.9 All low voltage (< 600 V) panels, enclosures, junction boxes and other wiring devices shall be safely accessible in their energized condition.

8.3.10 A safe means shall be provided to inspect and lubricate the entire length of every wire rope on the crane. The Contractor shall provide platforms and detailed procedures so as to provide access to the complete length of each wire rope.

8.3.11 Rereeving device(s) and rereeving procedures shall be designed and the procedures structured such that any hoist rope can be replaced in less than two (2) hours of set-up by two (2) maintenance persons, plus eight (8) hours of rope change by four (4) maintenance persons. Rope change time shall include rope adjustment and clean-up.

8.4 SPECIAL TOOLS

8.4.1 Special tools shall be those tools, jigs, devices, or other assemblies that are necessary for operation, maintenance, repair, or inspection of any system on the crane and which are otherwise not readily available as catalog items from typical tool suppliers servicing the Owner's Facility.

8.4.2 The Contractor shall furnish two (2) complete sets of special tools.

8.4.3 Each special tool shall be stamped for easy identification of size and use.

8.4.4 Special tools shall comply with these specifications, meet OSHA and other applicable US standards, and be supplied with test certification for capacity when applicable.

8.4.5 The Contractor shall supply the following additional special tools prior to acceptance of the first Crane:

> 8.4.5.1 Hydraulic jack(s) and puller(s) sufficient to remove all motor and drum couplings on the crane, as well as the boom hanger pins, boom support truck, and gantry equalizer pins.

8.5 SPARE PARTS [7] [8]

8.5.1 Continued reliable operation of these cranes will be dependent on access to replacement parts. To support achieving the minimum reliability requirements, two classes of spare parts are required: an initial inventory of spare parts to be furnished with the crane, and a listing of all long-term wearing and replacement parts for the crane.

8.5.2 ~~Spare parts quantities listed below shall be furnished with the first Crane of a multi-crane purchase. These spare parts quantities are suitable for up to four (4) Cranes, thus no additional spare parts are required for Cranes 2-4. An additional set of spare parts is required for Cranes 5-8 or fraction thereof.~~ Spare parts detailed in 8.5.5 in the quantities listed, shall be furnished with Base Crane Order of three cranes. [7]

8.5.3 Start-up spares for use during start-up, commissioning and final acceptance testing of the Cranes shall be provided by the Contractor separately from the Spare Parts to be supplied with the Cranes.

8.5.4 ~~For multi-crane purchases with separate delivery dates, spares for upgraded parts (if applicable) on later cranes shall be supplied with the first crane of the later delivery.~~ Spare parts, for either a two crane or three crane option order, shall be furnished identical to those supplied with the Base Crane Order as detailed in 8.5.5. **[8]**

8.5.5 Initial spare parts to be furnished with first crane

8.5.5.1 The following spares shall be furnished prior to acceptance of the first Crane. The intent is for the Contractor to provide each item only once. If an item is included in a more general category, only the quantity defined in the most specific category is required. The cost for each individual item listed below shall be included in the bid.

8.5.5.2 One hundred percent (100%) means one times the total quantity on one Crane. Four hundred percent (400%) means four times the total quantity on one Crane.

8.5.5.3 Mechanical Spares

.1 Two (2) of each individual type, size and configuration of cylinder and hydraulic actuator. Only one (1) spare snag cylinder is required.
.2 One (1) spare of each cylinder position/encoder assembly
.3 Two (2) of each hydraulic valve control circuit card
.4 Four (4) of each type and dimension of rod seal kits
.5 One (1) of each individual type and size of hydraulic valve on the Crane
.6 Fifty percent (50%) replacement hydraulic valve solenoids on the Crane
.7 Two hundred percent (200%) replacement hydraulic filter elements
.8 One hundred percent (100%) replacement twistlocks/pins for the headblock in addition to those included in the spare headblock
.9 One hundred percent (100%) replacement of each type and size of hydraulic pump, including spreader pump
.10 One hundred percent (100%) replacement of trolley wheels, wheel shafts, bearings, and seals
.11 Two replacement sheaves of each size and type complete with bearings and seals on the Crane, complete with bearings and seals
.12 Ten (10) of each type and size of "O" rings on one Crane
.13 One hundred percent (100%) brake replacement pads and one (1) disc for the hoist and trolley
.14 One (1) complete service brake thruster of each type
.15 Two hundred percent (200%) replacement all air filters
.16 One (1) complete elevator brake assembly with pads
.17 One (1) complete elevator safety device
.18 One hundred percent (100%) replacement UHMW sleeves and discs
.19 One (1) replaceable rope support guide roller and UHMW sheave assembly on Main Trolley and Catenary trolley for each type and size
.20 One (1) gantry drive wheel assembly complete with shaft, bearing and seal
.21 One half (1/2) complete set of gearing and shafting for each type of gearbox rated at 5 kilowatt or greater
.22 One (1) complete set of bearings and seals for the hoist and trolley reducer used on the Crane
.23 Four (4) sheave sets of bearings and seals of each type of sheave used on the Crane.
.24 Ten percent (10%) additional spare transponders of each type provided with the Crane (See Section 7.29.2.2.

8.5.5.4 Electrical Spares

.1 Two (2) of each type of power semi-conductor device used on the Crane including IGBT
.2 One (1) complete power conversion unit for each type and size
.3 One (1) each of slip ring assembly of spreader cable reel on trolley and gantry cable reel
.4 One (1) fiber optic rotary joint for the gantry cable reel
.5 Two hundred percent (200%) of each consumable protective device including semi-conductor fuses
.6 Two (2) of each starter type and size

.7 Two (2) of each breaker type and size
.8 Two hundred percent (200%) replacement of all control fuses
.9 One (1) replacement spreader cable connecting the headblock and the trolley, complete with plugs at both ends that are prewired and tested
.10 One hundred percent (100%) replacement of all ribbon cables for one Crane
.11 One hundred percent (100%) replacement of all cable chain cables for one Crane
.12 Cable chain spares as recommended by cable chain maker
.13 One (1) spare variable speed motor of each type and configuration for each hoist, trolley drive, gantry drive, boom drive, and cable reel
.14 One (1) spare variable speed AC motor of each type and configuration
.15 One (1) spare fixed speed AC motor for each type and size for auxiliary equipment
.16 Four (4) complete spare limit switches of each type, complete with head and arm, where used
.17 Five (5) complete floodlight assemblies of each type to include ballast
.18 Three (3) aircraft warning light lenses and bulbs

8.5.5.5 Control Spares

.1 One (1) of each PLC assembly complete with base, CPU, power supply, communication modules, and other devices as is configured on the Crane
.2 Two (2) of each type and size of input/output card/block
.3 One (1) of each model of PLC CPU
.4 Two (2) of each type PLC interface device
.5 One (1) of each type of fiber optic modem
.6 One (1) of each computer fully configured with daughter cards and other accessories
.7 One (1) of each operator and maintenance display
.8 One (1) of each router and switch
.9 One (1) of each power supply
.10 One (1) of each type camera with accessories
.11 One (1) of each camera controller
.12 Two (2) of each scanner/position sensor
.13 Two (2) tachometers/encoders complete of each type
.14 One (1) spare master switch for each type supplied including sending unit
.15 Six (6) push-buttons, indicating lights, and selector switches of each type
.16 One hundred percent (100%) of each type of indicating light globes
.17 One per contract anemometer assembly

8.5.5.6 Spreader Spares

.1 One hundred percent (100%) of each twistlock
.2 One hundred percent (100%) of each flipper
.3 One hundred percent (100%) of each corner plunger assembly
.4 One floating corner housing assembly, if used
.5 Two (2) of each individual type, size and configuration of cylinder and hydraulic actuator
.6 One (1) spare of each cylinder position assembly
.7 Two (2) of each hydraulic valve control circuit card
.8 Four (4) of each type and dimension of rod seal kits
.9 One (1) of each individual type and size of hydraulic valve
.10 One hundred percent (100%) replacement valve solenoids
.11 Two hundred percent (200%) replacement hydraulic filter elements
.12 One (1) complete spreader communication node (spreader end)
.13 One (1) complete spreader communication node (crane end)
.14 One hundred percent (100%) replacement of each type and size of hydraulic pump.

8.5.5.7 The Initial Parts List shall be submitted to the Owner for review. Each item of this list shall also be included in the List of Spare Parts. The list shall be made a part of the Maintenance Instructions, and shall be provided in electronic format as one DVD containing an IBM PC compatible spreadsheet in the fields and format required for the List of Spare Parts. The list shall be tabular and shall include:

.1 Identification by the original manufacturer's catalog identification number, if such number exists, on the Contractor's drawings, operating and lubrication instructions, and the maintenance and inspection manual
.2 Sequence number
.3 Contractor's part number
.4 Contractor's Piece Mark shown on the fabrication drawing
.5 Part description
.6 Locations on Crane
.7 Original manufacturer's name
.8 Original manufacturer’s full part number
.9 Quantity per Crane
.10 Recommended spare quantity

8.5.6 List of Replacement Parts

8.5.6.1 The Contractor shall prepare a replacement parts list containing all crane parts that are either wearing or may need to be replaced over the 40-year life (Design Life) of the Crane. See Section 8.5.5.7 for list requirements, which shall be similar to those for the List of Spare Parts.

8.5.6.2 The List of Replacement Parts shall be submitted to the Owner for review. The list shall be made a part of the Maintenance Instructions, and shall be provided in electronic format as one DVD containing an IBM PC compatible spreadsheet in the fields and format required for the List of Spare Parts.

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SECTION 9 MANUFACTURING AND QUALITY

9.1 QUALITY CONTROL SYSTEM

9.1.1 Quality Control (QC) shall be the responsibility of the Contractor. Any inspection performed by Owner shall be only as verification of the Contractor's own program and is not to replace any portion of the Contractor's program. The Contractor shall assign a senior QC person to be accountable for the duration of the project.

9.1.2 The Contractor and each major subcontract fabricator shall have in place a documented, functioning quality control system. Certification to ISO 9001 is strongly preferred. Certification to other standards will be considered. Without standardization, the Contractor's quality system shall address each of the elements of ISO 9001.

.1 Management responsibility
.2 Quality system principles
.3 Quality in marketing (contract review)
.4 Quality in specifications and design (design control)
.5 Quality documentation and records
.6 Quality in procurement (purchasing)
.7 Material control and traceability
.8 Quality in production (process control)
.9 Product verification (inspection and testing)
.10 Control of inspection and testing equipment
.11 Control of verification status (inspection and test)
.12 Nonconformity (control of nonconforming product)
.13 Corrective action
.14 Handling and post production functions (handling storage, packaging, and delivery)
.15 Quality records
.16 Auditing the Quality System (Internal)
.17 Personnel (training)
.18 After sales service
.19 Use of statistical methods

9.1.3 The Contractor shall submit the written quality control plan in the language described in Section 2.14 to the Owner for review prior to the start of fabrication. The Contractor shall follow this plan throughout the contract and shall submit any revisions to the Owner. See Section 1.9.3 for submittal requirements.

9.1.4 The Contractor's inspection reports shall be submitted to the Owner upon request.

9.1.5 Owner may retain independent inspection laboratories and engineers to audit the Contractor's QC and to perform inspection of the Crane during fabrication and erection. These inspectors shall have free access to the mills or shops of the Contractor and his subcontractors or vendors and their drawings and specifications. Welded joints may be inspected by the Owner's representative using procedures deemed appropriate.

9.1.6 Inspection by Owner's representative will be performed in such a manner as to not unnecessarily delay the work. The Owner's representative shall not be restricted from photographing or video recording work in progress.

9.1.7 The Contractor shall notify Owner's representative when any component or sub-assembly is ready for inspection. If any sub-assembly of the Crane should be assembled by the Contractor without such notification or without affording Owner's representative reasonable opportunity to inspect all of its components, Owner shall have the right to require the Contractor to remove or disassemble, in whole or in part, that assembly so proper inspection of its components can be made. The Contractor shall bear the cost of such removal, disassembly, and reassembly, and no extension of time shall be granted because of the increased work required.

9.1.8 Any work, material, or equipment, whether or not in place, not conforming to these specifications will be considered defective and will be rejected by Owner's representative. Work performed from drawings or revisions that have not been signed or initialed by the Contractor's EOR will not be inspected and will be considered rejected. However, Owner has no obligation to exercise such authority, and the Contractor shall remain fully responsible for the completion of his work as specified.

9.1.9 Owner will pay for the cost of the inspectors retained by Owner.

9.1.10 In the event that retest and re-inspection are required due to defective work, the cost of the retest and re-inspection will be at the Contractor's expense.

9.1.11 Inspection and acceptance by the Owner of any component of the Crane shall in no way relieve the Contractor of his responsibility for complete compliance with these specifications.

9.1.12 The Contractor shall obtain all the required regulatory body inspections whose certification is necessary for the commercial use of the Crane.

9.2 STRUCTURAL

9.2.1 Structural Workmanship

9.2.1.1 Work shall conform to the requirements of the AISC Specification, Allowable Stress Design, and the cyclically loaded structures requirements of AWS D1.1. Welding procedures and electrodes shall be shown on the drawings. See Section 3.1.1.

9.2.1.2 All welding, inspection, and weld repair on fracture critical members shall comply with AWS D1.5, Section 12, "AASHTO/AWS Fracture Control Plan (FCP) for Nonredundant Members." See Section 3.1.3.

9.2.1.3 Work shall be performed in a thorough, workmanlike manner and shall follow modern practice in the manufacture of high grade machinery. Work shall be performed by workmen suitably skilled in their particular trades.

9.2.1.4 Welders, welding operators, and tackers shall be certified for the materials, processes and type of weld being performed by an independent testing laboratory within 6 months prior to performing such work. The Owner shall have the option to approve the certifying laboratory.

9.2.1.5 Welding procedures may be AWS pre-qualified or they shall be qualified in accordance with AWS by the approved testing laboratory.

9.2.1.6 Written procedures for all welded joints shall be submitted to the Owner. Procedures shall identify required inspections that may be critical to the specific welds. Procedures shall be identified on the drawings and shall be made available to all appropriate shop personnel. Procedures shall be prepared in a manner such that shop personnel can understand and use them without referencing the applicable codes.

9.2.1.7 Certification of the qualifications of each individual welder, tacker, and welding operator shall be furnished to the Owner. Welds installed using unqualified procedures or welding performed by non-certified welders shall be subject to removal by the Contractor at his expense, at the discretion of the Owner.

9.2.1.8 These requirements shall apply to all welding, burning, cutting, and grinding on the crane structure. This includes welds for erection attachments, whether or not they are removed, and electrical clips and conduit supports. All welds shall be shown on the drawings and shall be approved by the Contractor's responsible structural engineer before the welds are made.

9.2.1.9 Bolts that are 22 mm in diameter or less may be tightened to the required tension by any standard method in the AISC manual.

9.2.1.10 A325 and A490 bolts greater than 22 mm (7/8 in) diameter shall be tightened to the required tension by the calibrated wrench method only. The following supplemental requirements shall apply in addition to the requirements of the "Specifications for Structural Joints Using High-Strength Bolts, December 31, 2009," by Research Council on Structural Connections.

.1 Hardened washers shall be placed under the both the head and the nut.
.2 The Contractor shall notify the Owner if the highest and lowest torques measured during wrench calibration vary by more than 10 percent of the average torque, so they may develop the appropriate solution. If the range exceeds this tolerance, field tightening may be erratic.
.3 The "snug tight" tension shall be within 15–45 percent of the specified tension and shall be achieved using a calibrated wrench or an impact wrench.
.4 The sequence of bolt tensioning shall be shown on the drawings.

.5 After the snug tight condition is achieved, an initial tension of 75 percent of the final tension shall be developed in all the bolts. Only then shall the final tension be developed.

.6 The final tension shall be at least 70% of the specified tensile strength of the bolt.

.7 The final tension shall be verified by testing 10 percent of the bolts after all the bolts are tensioned. If the verification indicates loss of tension in some bolts, the Contractor shall notify the Owner. The Owner and the Contractor will develop the appropriate action.

.8 The projected flange contact bearing surfaces shall have at least 75% of the bearing cross-sectional area in contact. The outer surface of the flanges shall fit within 0.25 mm (0.01 in) for 75% of the length of the edge and not more than 1.0 mm (0.04 in) for the remaining 25% of the length, as shown below in Figure 9.1.

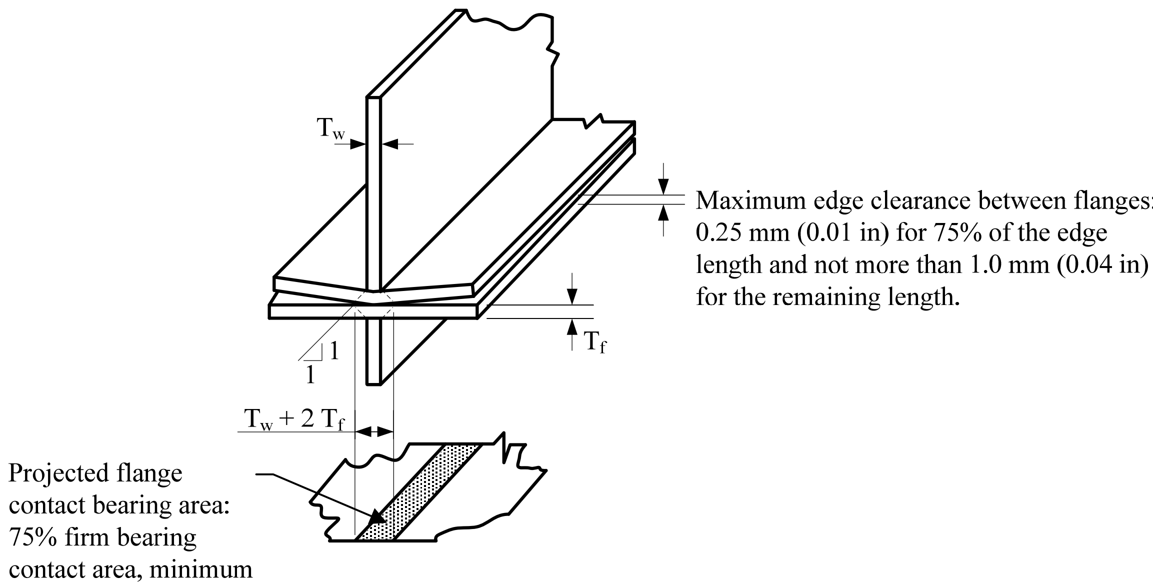

Figure 9.1: Flange bearing requirements

.9 The Owner shall have the option to verify the bolt tension. The locations will be selected by the Owner. Bolt tension verification shall be performed by the Contractor in such a manner that the reviewing engineer can read the torque wrench gage during verification

9.2.2 Structural Material

9.2.2.1 Material shall be new and unused. Material shall be suitable for exposure to the marine environment and the temperatures shown in Section 2.5.

9.2.2.2 Structural steel shall conform to the AISC Specification, Allowable Stress Design, chapter 5, section A3, Material, except as modified in this Section.

9.2.2.3 Structural steel subjected to a calculated tensile stress, except stairs, ladders, platforms and walkways shall conform to the current ASTM A 709/A709M, Standard Specification for Structural Steel for Bridges, including the following supplementary requirements:

.1 S60, Frequency of Tension Tests

.2 S93, Limitation on Weld Repair

.3 ASTM A6/6M, General Requirements for Rolled Steel Plates, Shapes, Sheet Piling, and Bars for Structural Use

9.2.2.4 Charpy V-Notch impact requirements shall meet the requirements of ASTM A 709/A 709M. Test temperature shall be in accordance with ASTM A 709/A 709M, Table 8, based on the Zone corresponding to the lowest ambient temperature listed in Section 2.5. Orientation of test bars shall be transverse to the direction of final rolling unless longitudinal orientation is approved by the Owner.

9.2.2.5 Structural steel made to another specification may be substituted for ASTM A 709/A 709M providing it conforms to the specified requirements of ASTM A 709/A 709M and the other requirements of these Specifications.

9.2.2.6 All FCM material, plates, and sections shall comply with AWS D1.5, Section 12. The term "Engineer" in the code shall mean the Contractor's responsible structural engineer. The reviewing engineer will review the decisions of the Contractor's responsible structural engineer for compliance with the AWS Specifications.

9.2.2.7 Weld electrodes shall meet the following requirements, as a minimum:

9.2.2.7.1 Electrodes shall be in accordance with AWS D1.5 Section 4 and AWS D1.1 Table 3.1, except E60xx rods shall not be used.

9.2.2.7.2 Weld filler metal strength and ductility shall meet the requirements of AWS D1.5 Table 4.1 or Table 4.2.

9.2.2.7.3 Steel that requires Charpy V-notch testing shall be welded with electrodes having a Charpy V-notch toughness in compliance with AWS D1.5 Table 4.1 or Table 4.2 for NFCMs and AWS D1.5 Table 12.1 for FCMs.

9.2.2.7.4 Electrodes used for welding plates shall have a minimum toughness as described in Table 9.1.

Plate Yield Strength from Mill Certificate		**Minimum CVN Test Energy**		**Test Temperature**	
MPa	**(ksi)**	**J**	**(ft-lb)**	**°C**	**(°F)**
248-435	(36-63)	34	(25)	-30	(-20)
435-579)	(63-84	41	(30)	-30	(-20)
579-828	(84-120)	48	(35)	-35	(-30)
> 828	(>120)	Notify Engineer			

Table 9.1: Electrode toughness requirements

9.2.2.7.5 Electrodes shall meet the guidelines presented in AWS D1.5 Annex G, "Guidelines on Alternative Methods for Determining Preheat," for hydrogen control. Electrodes shall also meet the maximum hydrogen content requirements as defined by AWS A5.1 Table 11, in accordance with AWS A4.3 determination methods, conforming to the following optional supplemental diffusible hydrogen designator:

Specified welded plate yield strength	Diffusible Hydrogen Designator NFCM	FCM
Fy ≤ 380 MPa (3.9 tsc, 55 ksi)	H16	H8
Fy > 380 MPa (3.9 tsc, 55 ksi)	H8	H4

where H16, H8, and H4 designators represent electrodes capable of depositing weld metal with a maximum diffusible hydrogen content of 16 mL/100 g, 8 mL/100 g, and 4 mL/100 g, respectively.

9.2.2.7.6 In addition to the above Section 9.2.2.7 requirements, electrodes used to weld FCM plates and shapes shall meet the requirements of AWS D1.5, Section 12, including Section 12.6, "Consumable Requirements."

9.2.2.7.7 If a conflict exists between the above Section 9.2.2.7 requirements, the most restrictive requirement shall be used.

9.2.2.8 Plate Through-Thickness Requirements— Plates and sections subjected to through-thickness stress shall be given special attention during design, base metal selection, and detailing. The Contractor's responsible structural engineer shall be familiar with the AISC Commentary on Highly Restrained Welded Connections, Engineering Journal, third quarter, 1973 and the AWS D1.1 commentary, section C2.6.3, which discuss lamellar tearing and give guidance to minimize the probability of occurrence. Table 9.2 lists required UT testing and Z-Steel requirements for tension through-thickness welded connections. "Tension," shall be determined by load combinations given in Table 2.8. "FCM" in Table 9.2 shall be determined as described in Section 3.2.5. See Figure 9.2 for through-thickness plate connection details and nomenclature.

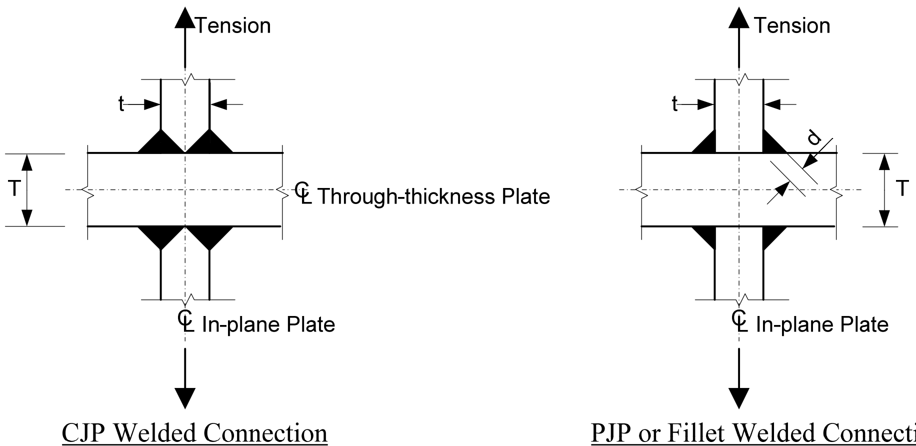

Figure 9.2: Through-thickness plate connection details

9.2.2.8.1 Z-Steel Requirements—As required in Table 9.2, plates subject to through-thickness tension stress shall be designated "Z-steel" material. Z-steel shall comply with the following in addition to the other requirements of this Specification:

9.2.2.8.1.1 ISO-7778. For plate thicknesses outside the thickness range of ISO 7778, an appropriate test method complying with the intent of ISO 7778 shall be proposed by the Contractor. The Owner will review the proposed method. If the method is not acceptable, the Owner and Contractor will jointly develop a method acceptable to both.

9.2.2.8.1.1.1 For in-plane FCMs, the requirements of "Z 25" shall be used, as a minimum.

9.2.2.8.1.1.2 For in-plane NFCMs, the requirements of "Z 15" shall be used, as a minimum.

9.2.2.8.1.2 The sulfur content shall be a maximum of 0.01%. See AWS D1.5, Section 12.4.4.1 for reference.

9.2.2.8.1.3 Each plate with Z-Steel requirements shall be clearly identified in the plan.

	In-plane Plate	Through-thickness Plate	Through-thickness Plate Thickness, T[1] (mm)	Z-steel Req'd?	Through-thickness Plate UT Req'd?	Comments
CJP	FCM	FCM & NFCM	> 16	Yes	Yes	Z 25, ISO-7778
		FCM & NFCM	≤ 16	No	Yes	
	NFCM	FCM	> 16	Yes[2]	Yes	Z 15, ISO-7778
		FCM	≤ 16	No	Yes	
		NFCM	> 25	No	Yes	
		NFCM	≤ 25	No	No	
PJP/ fillet	FCM	FCM & NFCM	All	N/A	N/A	Not allowed. See Section 3.2.5.5.
	NFCM	FCM	> 16	Yes[2]	Yes[3]	Z 15, ISO-7778
		FCM	≤ 16	No	Yes[3]	
		NFCM	All	No	No	

Notes

[1]See Figure 9.2 for nomenclature.
[2]Z-steel is recommended to reduce the frequency of repairing FCM plates subjected to through-thickness tension. The Contractor's responsible structural engineer shall decide.
[3]UT of through-thickness plate prior to welding according to Section 9.2.2.8.2, and after welding in the region under the welds, extending toward the in-plane plate as much as practical.

Table 9.2: Tension Through-thickness Plate UT and Z-steel Requirements

9.2.2.8.2 Plate UT Requirements—As required Table 9.2, the region of the plate with through-thickness tension stress shall be UT-inspected to check for lamination before welding and again at least 36 hours after welding to check for lamellar tearing. The region tested shall extend the full length of the in-plane plate for a minimum width of (2t+T). See Figure 9.2. In general, for FCM and CJP connections with through-thickness tension, the through-thickness plates should be UT-inspected according to this Section. For PJP or fillet welded tension connections with through-thickness plates thicker than 16 mm or with weld throats greater than 12 mm, the through-thickness plates should also be UT-inspected according to this Section. These through-thickness plate UT requirements are in addition to the weld NDT requirements specified in Section 9.2.6.

9.2.2.8.2.1 Through-thickness plate UT requirements shall be clearly identified in the plan.

9.2.2.8.2.2 UT Before Welding: Acceptance criteria shall be based on AWS D1.1, Table 6.3 "UT Acceptance-Rejection Criteria (Cyclically Loaded Nontubular Connections)," as a minimum.

9.2.2.8.2.3 UT at Least 36 Hours after Welding: Inspection criteria shall be in accordance with AWS D1.1, Table 6.3 "UT Acceptance-Rejection Criteria (Cyclically Loaded Nontubular Connections)." The thickness of the continuous plate and 70 degree transducer shall be used for determining the acceptance category. The amplitude shall be calibrated on a 1/16" (1.5 mm) diameter side-drilled-hole (SDH). Correction for distance (depth) is not necessary. The Contractor may submit an alternative method to the Owner for approval. Refer to Figure 9.3.

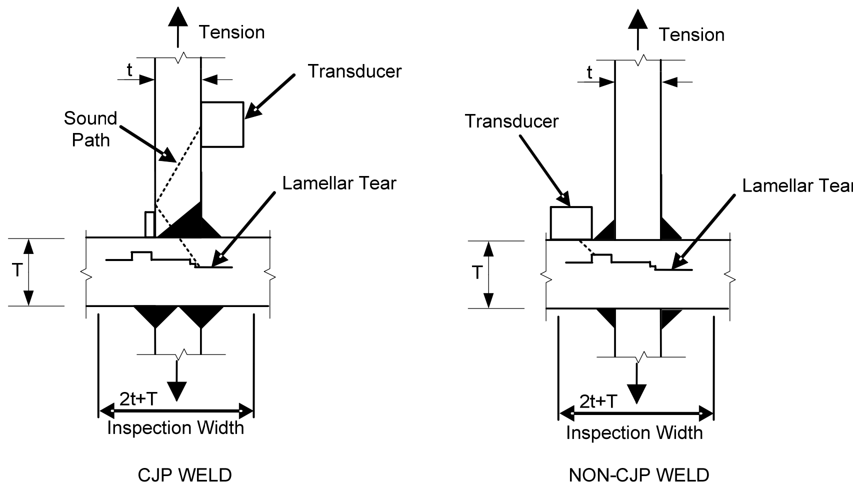

Figure 9.3 UT for lamellar tearing (example)

9.2.2.9 Plates, rolled sections, and tubes shall have a minimum thickness of 8 mm unless otherwise noted.

9.2.2.10 Bolted connections shall be made with high strength bolts. All connections made with high strength steel bolts shall conform to the "Specifications for Structural Joints Using High-Strength Bolts, December 31, 2009," by Research Council on Structural Connections—the coefficient of friction shall also be determined in accordance with that specification.

9.2.2.11 Structural bolt assemblies made with A325 or A490 bolts shall be kept separated by production lot. Mixing of bolts and nuts from different production lots, even of the same diameter, grade, and length, shall not be permitted. Only pre-tested combinations of bolt lot, nut lot, and washer lot, as established by the supplier are permitted to be installed.

9.2.2.12 The critical end properties of parts requiring heat treatment by other than the prime mill source and the method and basis for acceptance or rejection of parts requiring non-destructive testing shall be shown on the drawings.

9.2.2.13 The Contractor shall maintain material traceability for structural steel (except stairs, ladders, platforms and walkways), bolts, and all load bearing mechanical parts from the prime mill source through all manufacturing processes to and including each finished part. For these items, the original mill test reports and certificates for supplementary processes and tests shall be furnished to the Owner. The Contractor shall test random samples to verify the original mill test reports and shall furnish the results to the Owner. The number of random samples to be taken will depend on the Contractor's experience with the particular steel and bolt suppliers. Material obtained directly from a mill usually needs less verification than material obtained from secondary sources. The Contractor's quality control department shall determine the degree of verification needed to assure mill certificate reliability.

9.2.2.14 The Contractor shall furnish to the Owner copies of all purchase orders issued for this Contract. These copies do not need to include cost information, but must be in the language described in Section 2.14.

9.2.2.15 If required by the Owner, the Contractor shall bear the reasonable cost of furnishing evidence that the quality of material, equipment, and workmanship complies with the requirements of these Specifications

9.2.3 Quality Control for Structural Components

9.2.3.1 Quality Control (QC) for structural components shall be the responsibility of the Contractor. The Contractor must implement a written QC program that is appropriate for this Contract and shall submit it to the Owner. The Contractor's inspection reports shall be furnished to the Owner upon request.

9.2.3.2 The QC program shall include at least the following:

.1 Incoming material, consumables, and machinery
.2 Traceability of material
.3 Lofting, cutting, fit-up, welding, forming and dimensions of structural components
.4 Welding and inspection procedures
.5 Welding and inspection personnel qualification and certification
.6 Welding and inspection equipment maintenance and calibration
.7 Heat treating, stress relieving and other special treatments
.8 Machining, finish surfaces, painting and bolting

9.2.4 At least one of the Contractor's quality control employees shall be assigned full-time to each shop during fabrication, including subcontractor's shops. If fabrication is subcontracted, the subcontractor's own quality control personnel may be used to supplement the Contractor's quality control employee.

9.2.5 Welds shall meet the requirements cyclically loaded structures of AWS D1.1. The specific method of weld inspection shall be shown on the drawings. Weld inspection procedures shall be submitted to the Owner.

9.2.6 The extent of NDT performed by the Contractor shall be as shown below. The acceptance criteria shall be AWS D1.1. For inspections less than 100%, the majority of the inspection sampling shall be at areas most likely to develop cracks, such as weld ends and welds around corners.

<u>All welds</u>:		100% VT
<u>Fillet and PJP welds on</u>:		
	FCMs:	100% MT
	NFCMs:	10% MT
<u>CJP welds</u>:		
Tension complete penetration:		100% UT + 25% MT (Tension shall be determined by stress levels due to operating load combinations OP1–OP3.)
Compression complete penetration:		25% UT + 10% MT

9.2.6.1 The Contractor may use NDT inspection levels that differ from the above requirements, with Owner approval.

9.2.7 Rejection of any portion of a weld inspected on a less than 100% basis shall require inspection of 100% of that weld.

9.2.8 Ultrasonic testing of tension complete penetration welds shall be performed by or under the direct supervision of an ASNT certified Level III individual. UT inspection of compression complete penetration welds and MT inspection shall be performed by an NDT Level II inspector or by an NDT Level I under the supervision of an NDT Level II, as required by AWS D1.1, section 6.14.6.

9.2.9 Defective welds shall be corrected in accordance with AWS D1.5, Section 12.17, “Repair Welding.”

9.3 MECHANICAL

9.3.1 Mechanical Workmanship

9.3.1.1 Mechanical Fabrication

9.3.1.1.1 Welding shall comply with the requirements stated in Section 9.2. In addition, special procedures shall be developed and documented for the joining of dissimilar steels.

9.3.1.1.2 Mechanical fabrication drawings shall clearly state the acceptable tolerance criteria for each fabrication dimension. Default tolerance values may be used so long as they are clearly stated on each fabrication drawing.

9.3.1.1.3 One sheave from each lot will be randomly selected by the Owner for destructive testing by the Contractor to demonstrate the rope groove hardness and hardness depth meets the specification criteria. Failure shall result in rejection of the entire lot. One machined and etched section from each tested sheave shall be delivered to the Owner.

9.3.1.2 Machining

9.3.1.2.1 All machining drawings shall state the surface roughness requirements of machined finishes. Default roughness values, if clearly stated on each machining drawing, may be used.

9.3.1.2.2 All drawings shall state the acceptable tolerance criteria for each machined dimension. Default tolerance values, if clearly stated on each machining drawing, may be used.

9.3.1.2.3 All machining dimensions shall be inspected using testing devices that have a resolution greater than that called for on the drawing. The testing device shall have been calibrated to a known standard in the past six months. Any damage or abuse of an instrument shall require its immediate inspection, necessary repair, and recalibration. The Contractor shall define these procedures of the Quality Control plan.

9.3.1.2.4 The Contractor shall maintain a program for the corrosion protection of in-process machined parts. The program shall also protect mechanical parts from physical damage due to mishandling, adjacent manufacturing activities, and environmental contamination. The program shall be effective from the beginning of machining operations through final crane acceptance.

9.3.1.3 Mechanical Process Control

9.3.1.3.1 The Contractor shall maintain clear procedures for each process to be performed. Processes include stress relieving, interference fit installation by heating and/or freezing, bearing installation, plating, and galvanizing.

9.3.1.4 Mechanical Assembly

9.3.1.4.1 All mechanical assembly drawings shall define the acceptable tolerance criteria between adjacent components. As a minimum, tolerance dimensions shall be stated for the relationship between bearing locations, mechanical fits, machinery positioning of drums, couplings, reducers, brakes, motors, cylinders, gearing, shafting, axles, and pins.

9.3.1.4.2 The Contractor shall maintain a record of all actual as-assembled dimensions.

9.3.1.4.3 Each mechanical system and assembly shall be passed through its motion at factory assembly, prior to final assembly and prior to shipment to the Owner.

9.3.1.5 Lubrication

9.3.1.5.1 The Contractor shall establish inspection procedures and records verifying that all lubrication has been installed at factory assembly. Should it be impractical to install full lubricants during factory assembly, the Contractor shall suitably mark or tag the component and shall provide adequate corrosion prevention measures. A record of this lubrication shall be included in the acceptance check list.

9.3.1.6 Hydraulics

9.3.1.6.1 Hydraulic reservoirs shall be tested to demonstrate compliance with the requirements of Section 4.15.5.

9.3.1.6.2 All hydraulic hose and pipe assemblies shall be pressure tested to a minimum of 130% of design maximum operating pressure. All hoses and pipe assemblies shall be flushed at supercritical Reynolds number for a minimum of 2 hours to remove contaminants.

9.3.1.6.3 All hydraulic systems shall be flushed in the partially assembled condition. Supply and return (rod end and cylinder end) cylinder and motor connections shall be interconnected and the system flushed at supercritical Reynolds number for a minimum of 4 hours to ensure cleanliness. Oil samples shall be drawn from the center of the reservoir at the completion of flushing. Should the level of contamination fail to achieve the requirements of Section 4.15.7.1, the flushing operation shall be repeated until the unit achieves this cleanliness level.

9.3.1.6.4 Fabricated piping components, power units, hoses, piping, and component openings left open for transportation or awaiting assembly shall be capped with metallic caps or plugs which utilize the sealing method of the designed joint.

9.3.1.7 Gearing: See Section 4.6 for gearing quality and inspection requirements.

9.3.2 Mechanical Material

9.3.2.1 Mechanical components shall be designed to good notch toughness practices using fine grained steels. The Contractor's responsible mechanical engineer shall determine the required fracture toughness. However, the minimum Charpy value in the direction of principal stress shall meet the fracture toughness requirements of Section 9.2.2. In addition to the Section 9.2.2 requirements, the minimum CVN test value energy shall be at least 20 J (15 ft-lb) for non-fracture critical members. Fracture critical members shall have a Charpy test performed for each heat at a minimum. Samples for non-fracture critical members shall be selected and tested at random. See Section 3.2.5 for other fracture critical member requirements.

9.3.2.2 Cast iron shall not be used for any part unless specifically approved in writing by the Owner except that motors may be cast iron where not available in steel and where approved by the Owner in writing.

9.4 ELECTRICAL

9.4.1 Electrical workmanship shall comply with the requirements and recommendations of the latest version of NFPA 70 National Electric Code (NEC) and as set out in Section 5.

9.4.2 All electrical material and components shall be UL listed, or, where otherwise allowed by local codes and regulations, listed by an approved Nationally Recognized Testing Laboratory (NRTL) or other testing laboratory acceptable to the Owner as defined in Section 1.7.5.

9.5 SOFTWARE AND CONTROLS

9.5.1 The Contractor shall present his internal procedures, quality standards, organization, and quality controls for the development of complex control systems, IT system architecture and controls, and other application software in compliance with the standards defined in Section 1.7.

9.5.2 Common practice systems engineering processes and tools shall be applied by the Contractor and his subcontractors.

9.5.3 The Contractor and his subcontractors shall apply a common software quality management process into the development lifecycle of the project to ensure the successful development of a quality product. This process shall include but not be limited to standards, regulations, and procedures to produce, verify, evaluate, and confirm the quality of the works and products during the software development lifecycle. This shall include off-the-shelf software tools to support the internal quality control process as well as the interaction with the Owner.

9.5.4 Proper process and tools shall be established for version and configuration control and for change management. These processes and tools shall also be used for the interaction with the Owner and shall be presented to the Owner for approval before they are applied. See Section 6.2.4.

9.6 CORROSION PREVENTION

9.6.1 General

9.6.1.1 Potentially corroding materials shall be protected by either seal welding or coatings per this specification. The Contractor may alternatively seal with caulk, but only with the Owner's approval. All parts shall be accessible for inspection and maintenance or renewal of their corrosion prevention provisions except for sealed members.

9.6.1.2 The interior of unsealed members shall be well ventilated and drained. Gooseneck vent pipes shall be installed near each end of each horizontal member and near the top of each vertical or sloping member. Sufficient drains shall be provided to prevent collection of standing water inside unsealed members.

9.6.1.3 Exterior surfaces of all members shall be free to drain.

9.6.1.4 All fittings and fastenings 14 mm (1/2 in) diameter and less shall be 300 series stainless steel. If it can be shown that the use of stainless steel fasteners will compromise a proprietary manufactured product which otherwise meets the requirements of these Specifications, then alternate means of preventing seizing and/or corrosion may be used if approved by the Owner.

9.6.1.5 All fasteners greater than 14 mm (1/2 in) diameter including ASTM A325 and A490 bolts, shall be coated with Dacromet® coatings meeting the following requirements:

9.6.1.5.1 The coatings shall be applied by a company officially licensed to apply Dacromet® coatings.

9.6.1.5.2 The coatings shall provide corrosion resistance capable of withstanding standard 5% salt spray testing for a minimum of 1,000 hr in accordance with ASTM B117-03, with no red rust on significant surfaces. Significant surfaces on threaded fasteners are exposed surfaces, excluding sharp edges of threads, when the fastener is in its installed position.

9.6.1.5.3 The Dacrotizing® process shall at a minimum comply with all of the requirements of ASTM F1136-04. Coatings of parts finished under this specification shall be supplied by the Dip-Spin method, which incorporates a minimum of two basecoats Dacromet® having a minimum combined thickness of 20 g/m^2 (5 microns) and a single topcoat of an appropriate Dacromet®+Plus® sealer.

9.6.1.5.4 Corrosion protection requires isolation of the Dacrotized® bolts from galvanized surfaces.

9.6.1.5.5 If the Dacromet® coating is known to compromise a proprietary manufactured product that otherwise meets these specifications, the Contractor may use alternative coating methods if approved by the Owner.

9.6.2 Shop Cleaning and Painting

9.6.2.1 Metallic surfaces of the Crane shall be painted except nameplates, marine corrosion-resistant stainless steel, and wearing or internal surfaces of mechanical parts.

9.6.2.2 Exposure Definitions

9.6.2.2.1 "Exposed exterior surfaces" means surfaces exposed to the atmosphere. This includes surfaces exposed to weather and surfaces that are not exposed to weather, such as the inside of the machinery house. It does not include exposed interior surfaces.

9.6.2.2.2 "Exposed interior surfaces" means interior surfaces exposed to the atmosphere but not to the weather and not normally exposed to view, such as the inside of unsealed structural members.

9.6.2.2.3 "Sealed surfaces" means interior surfaces of members sealed with seal welds and pressure tested in accordance with Section 3.2.6.

9.6.2.3 Exposed surfaces shall be painted. Sealed surfaces do not need to be painted.

9.6.2.4 Painting of Standard Buyout Components

9.6.2.4.1 For buyout standard components, the manufacturer's standard paint system will be acceptable if the Contractor demonstrates that the paint system is suitable for the environment. The Owner may require a top coat to match the Crane's color scheme. The Crane's paint supplier shall confirm that the top coat is compatible with manufacturer's standard paint system. If the system is not compatible, a tie coat shall be used. The tie coat shall be applied only to an undamaged and uncorroded standard coat.

9.6.2.4.2 The thickness of the top coat shall comply with Table 9.5 or Table 9.6. The total thickness shall be the thickness of the manufacturer's standard coating system plus the tie coat, if any, plus the finish coating.

9.6.2.4.3 Examples of standard buyout components:

.1 Control panels
.2 Transformers
.3 Brakes
.4 Limit switches
.5 Hydraulic components
.6 Heater and air conditioners
.7 Elevator cab (but not elevator runway)
.8 Operator devices
.9 Operator's seat
.10 Reducers
.11 Motors

9.6.2.5 Surface Preparation

9.6.2.5.1 Dirt, oil, grease, and chemical contamination shall be removed by solvent washing or other suitable means before exposed surfaces are cleaned. All surfaces shall be cleaned as required by the Steel Structures Painting Council Surface Preparation Specification No. SSPC-SP 1, Surface Preparation Specification No. 1, Solvent Cleaning.

9.6.2.5.2 All exposed exterior and exposed interior surfaces which are to be painted shall be cleaned by abrasive blasting or centrifugal blasting unless otherwise directed by the Owner. The cleaning method shall be shown on the drawings. Exposed surfaces shall be cleaned as required by SSPC-SP 6-63 to No. 6, Commercial Blast Cleaning if the surface is shop primed and to NO. 10 Near White Blast Cleaning if the surfaces are not shop primed. Refer also to ISO 851 SIS.SS 055900. If the paint manufacturer requires more stringent cleaning, the paint manufacturer's recommendations shall be followed. All mill scale, rust, rust scale, paint, and foreign matter shall be removed.

9.6.2.5.3 Prior to abrasive blasting or centrifugal blasting, weld spatter, slivers, scabs and underlying mill scale and all welding flux, including that in crevices, shall be removed. Welds shall be flush with adjoining metal. Tits and sharp edges shall be ground to a minimum 1 mm radius to assure paint adhesion and prevent buildup of paint. Surfaces shall be cleaned in accordance with SSPC-SP 2, Surface Preparation Specification No. 2, Hand Tool Cleaning and SSPC-SP 3, Surface Preparation Specification No. 3, Power Tool Cleaning.

9.6.2.5.4 The compressed air supply used for abrasive blasting shall be free of detrimental amounts of water and oil. Separators and traps of a size and type recommended by the compressor manufacturer shall be provided.

9.6.2.5.5 Only dry abrasive blasting material will be allowed. Blasting grit shall be Graded Flint, Crystal Silica, Green Diamond, or a synthetic media equal to the preceding.

9.6.2.5.6 The cleaned surface shall be rendered rust free prior to the application of the prime coat.

9.6.2.5.7 No acid washes or other cleaning solutions or solvents shall be used on the surfaces after abrasive blasting or centrifugal blasting. This includes any inhibitive washes intended to prevent rusting.

9.6.2.5.8 Abrasive blasting or centrifugal blasting and painting operations shall be scheduled so they will not be in progress simultaneously, or so that blasting is not in progress while wet paint is within range of contamination. The blast cleaned surface shall be painted with one coat of primer prior to sunset of the day the surface is blasted, and before any visible rusting occurs. Unprimed blasted surfaces which are wet due to either rain or condensation shall be reblasted.

9.6.2.5.9 Outdoor abrasive blasting will be permitted only during daylight hours and only when the surfaces will be dry after blasting and before painting.

9.6.2.5.10 Abrasive blasting or centrifugal blasting will not be permitted when surfaces are less than 3°C above the dew point, with the exception that rough initial blasting will be allowed during the night, provided the surfaces are cleaned and brightened the next morning with fresh light abrasive blasting or centrifugal blasting to produce the required blast cleaning.

9.6.2.5.11 The paint supplier representatives shall inspect the surface preparation and paint application at various stages and an officer of the paint manufacturer shall certify, in writing, that the applied paint system complies with their recommendations.

9.6.2.5.12 Surfaces shall be cleaned to remove surface contaminants and moisture in accordance with the paint manufacturer’s instructions not more than 24 hours prior to the application of subsequent coats. The minimum and maximum recoat times shall not be violated per the paint manufacturer’s instructions.

9.6.2.5.13 Damage to previous coats shall be repaired before subsequent coats are applied.

9.6.2.5.14 The Contractor’s responsible QC inspector shall approve the surface preparation, cleaning, and repair of previous coats if applicable, prior to the application of each coat.

9.6.2.5.15 Surfaces shall be approved by the Contractor’s responsible QC inspector prior to application of the prime coat.

9.6.2.6 Paint Application

9.6.2.6.1 See Section 2.13 for acceptable suppliers of the paint. Alternative paint suppliers may be considered if the alternative paint systems are generically similar to the specified systems and the paint is manufactured in the USA or under license to a USA paint manufacturer. Lead based paint is not acceptable and shall not be used.

9.6.2.6.2 Painting procedures shall be in accordance with the paint manufacturer's recommendations and in accordance with applicable portions of Steel Structures Painting Council Specification SSPC-PA, "Shop, Field and Maintenance Painting." Refer also to ISO 851 SIS.SS 055900.

9.6.2.6.3 The detailed paint procedure, approved by the paint manufacturer, shall be submitted to the Owner for approval. An officer of the paint manufacturer shall certify in writing that the painting equipment and technique is satisfactory for the proper application of their paint. As a minimum, the procedure shall include the following:

.1 Mixing of paints
.2 Thinning of paint
.3 Surface preparation prior to fabrication
.4 Surface preparation procedure following fabrication
.5 Surface preparation equipment definition and limitations
.6 Inspection and monitoring of surface preparation equipment and procedures
.7 Surface preparation procedures for alternate surfaces such as galvanized parts
.8 Repair of galvanized surfaces
.9 Cleaning procedures between coats
.10 Temperature limitations for application of the various coats
.11 Humidity limitations for applications of the various coats
.12 Dry film thickness measurement and acceptable variations
.13 Repair of damaged first coat prior to application of top coat
.14 Spray application procedures
.15 Equipment requirements for spray application
.16 Inspection and monitoring of spray painting equipment
.17 Rejection criteria for paint surfaces
.18 Brush application procedures
.19 Brush application equipment
.20 Touch-up and repair surface preparation
.21 Touch-up and repair paint procedures
.22 Field touch-up

9.6.2.6.4 The Owner may make destructive tests of the paint on reasonably small areas to verify adherence. The Contractor shall repair these areas at his expense.

9.6.2.7 Exterior Exposed Surfaces Paint System

9.6.2.7.1 Exterior exposed surfaces shall be painted in accordance with Table 9.3 or Table 9.4. The coatings shall be applied at the crane manufacturer's shop.

Coat	**Product**	**Dry Film Thickness (Microns)**
First / Prime	Galvosil 15700	50 to 75
Second	Hempadur 45150	125 to 150
Finish / Top	Hempathane 55210	50 to 75
Total		**225 to 300**

Table 9.3: Exterior Exposed Surfaces Paint System (Hempel)

Coat	**Product**	**Dry Film Thickness (Microns)**
First / Prime	Interzinc 22	75 to 100
Second	Intergard 269	25 to 50
Third	Intergard 400	75 to 100
Finish / Top	Interthane 990	50 to 75
Total		**225 to 325**

Table 9.4: Exterior Exposed Surfaces Paint System (International)

9.6.2.7.2 The coatings shall be applied at the crane manufacturer's shop unless otherwise approved by the Owner in writing on a case-by-case basis.

9.6.2.7.3 In regions of low humidity, the curing process for inorganic zinc shall be approved by the paint manufacturer.

9.6.2.7.4 The prime coat shall be applied after all fabrication welding and attachment welding has been completed. Each primer coat shall have a distinct color, different from the finish coat. Surfaces shall be cleaned to remove surface contaminants and moisture and the surface blasted to the cleanliness and tooth profile as specified.

9.6.2.8 Interior Structure Exposed Surfaces Paint System

9.6.2.8.1 Interior exposed surfaces shall be painted in accordance with Table 9.5 or Table 9.6. The coating shall be shop applied.

Coat	**Product**	**Dry Film Thickness (Microns)**
First / Prime	Hempadur Zinc 15360	40 to 60
Last / Top	Hempadur 45150	85 to 115
Total		**125 to 175**

Table 9.5: Interior Exposed Surfaces Paint System (Hempel)

Coat	**Product**	**Dry Film Thickness (Microns)**
First / Prime	Interplate 11	15 to 30
Last / Top	Interseal 670HS	200 to 245
Total		**215 to 275**

Table 9.6: Interior Exposed Surfaces Paint System (International)

9.6.2.8.2 If an interior exposed surface was coated with the exterior exposed surfaces paint system during fabrication, surfaces that were masked for welding may be coated with the interior exposed surfaces system.

9.6.2.9 Sealed Surfaces

9.6.2.9.1 Sealed surfaces do not need to be painted.

9.6.2.10 The Crane color scheme shall be as shown in the Drawings. A drawing of the Crane's color scheme shall be submitted to the Owner for approval. The Contractor shall submit paint manufacturer paint numbers and color chips to the Owner for approval.

9.6.2.11 Damaged paint repair

9.6.2.11.1 Once the crane components are painted, every effort shall be made to prevent damage to the painting system. This shall be addressed during the design phase of the Crane. Attachments brackets for electrical wiring and devices shall be welded before painting. Walkway attachment brackets shall be welded before painting. Lifting lugs installed to prevent paint damage during handling. Sea bracing designed to minimize paint damage during removal. Any attachments that can be welded to the structure before painting shall be attached unless approved by the Owner.

9.6.2.11.2 If paint damage does occur, the paint shall be repaired to this specification as recommended by the paint supplier. If it is shown by the Contractor and approved by Owner that paint repair preparation by blasting is not practical for the paint repair, then a compatible zinc-rich (at least 80% zinc) organic primer shall be applied for the paint repair after preparing the surface in accordance with SSPC-SP 3.

9.6.2.12 Paint Warranty: Degree of rusting no more than ISO 4628-3, Ri3 within the first five years and no more than 3% between years five and ten.

9.6.2.12.1 The paint system specified has a lifetime expectancy of remaining in place and an expectancy of protecting the steel structure from corrosion for over 15 years. Failure to perform satisfactorily is indicated by blistering or peeling of the paint or rusting of the steel. Failure is directly attributed to improper surface preparation or improper application. This is under the Contractor’s control.

9.6.2.12.2 Owner will notify the contractor in writing two years after crane acceptance of any premature paint failures that have occurred other than mechanical damage to the paint due to container handling operations. The contractor shall take immediate steps to repair the failed paint in accordance with the paint specification for field application of paint in this specification. Preparation and painting will only be allowed when there are no container handling operations planned. Owner will give the contractor a minimum of 4 hr notice of when preparation and painting operations must be interrupted and the Crane returned for container handling operations. All preparation and painting must meet the requirements of this specification and applicable laws in effect at the time of repainting.

9.6.2.12.3 Owner will notify the Contractor in writing prior to the expiration of the paint warranty period of any paint failures that have occurred other than mechanical damage to the paint due to container handling operations. The Contractor shall take immediate steps to repair the failed paint in accordance with the paint specification for field application of paint in this specification. Preparation and painting will only be allowed when there are no container handling operations planned. Owner will give the contractor a minimum of 4 hour notice of when preparation and painting operations must be interrupted and the Crane returned for container handling operations. All preparation and painting must meet the requirements of this specification and applicable laws in effect at the time of repainting.

9.6.2.13 If shop primers are used, they shall be by the same manufacturer as the specified paint system and shall be approved in writing by the paint manufacturer to be compatible with the specified paint system. Shop primers shall be weldable.

9.6.2.14 Paint systems, including those used for touch up and repair at the Owner's Facility, shall comply with the regulatory requirements having jurisdiction at the time of application, including but not limited to VOC restrictions, restrictions on open-air blasting, restrictions on surface preparation, safe collection and disposal methods, and acceptable application methods. The Contractor shall submit to the Owner documentation showing compliance with applicable VOC requirements and written certification from the paint manufacture that the low VOC compounds proposed are compatible with the factory applied paint system.

9.6.3 Galvanizing

9.6.3.1 After complete fabrication, the specified component shall be hot dipped zinc coated to not less than 600 g/m^2 (2 oz/ft^2) each side. Galvanizing shall conform to ASTM A 123 for fabricated items and to ASTM A 153 for hardware. Damaged areas shall be recoated by melting into the prepared surface a continuous film of zinc-lead alloy bar solder or by coating with an approved zinc rich cold galvanizing compound in strict accordance with the manufacture's recommendations.

9.6.3.2 The Contractor shall warrant the galvanizing for a minimum of five years.

9.6.3.3 Galvanizing failures identified during the warranty period shall be repaired in the same manner as defined above for the paint

9.7 BOLTED CONNECTIONS AND FAYING SURFACES

9.7.1 Faying surfaces at bolted joints shall receive one coat of inorganic zinc with 50 to 75 microns (2,000 to 3,000 micro inches) dry film thickness. No finish coat shall be applied on the faying surface.

9.7.2 After assembly, damaged areas and the split line between the parts shall be cleaned and painted with 125 microns of the interior exposed surface top coat. If the paint cannot seal the split line, a bead of DAP Butyl Flex caulking or approved equivalent shall be used to seal the split line. The caulking shall be approved by the paint manufacturer.

9.7.3 Finish coat the exposed surfaces as repaired.

9.8 CRANE ERECTION

9.8.1 If a subcontractor erects the Crane, the erection subcontractor shall be subject to the approval of Owner.

9.8.2 As a minimum, the completed boom and machinery house structures shall be weighed to within 2% accuracy and the center of gravity of the component shall be established. This data will be used to find discrepancy between the calculated and weighed data for the completed Crane.

9.8.3 Only field bolting or pinning of the structure will be allowed. Field welding shall be approved by the Owner except for repairs and welds of secondary members such as stairs, ladders, platforms, and walkways.

9.8.4 Where field burning, grinding, or welding is unavoidable, any structure, mechanism and/or electrical equipment that is adjacent to or underneath the repair area shall be protected against damage or contamination from burn splatter, weld splatter and grinding particles. Damage to the factory applied paint system is to be minimized. Special attention shall be applied to areas covered by grating. Contamination or paint repair to areas with grating will require removal of the grating for an acceptable decontamination and paint repair.

9.8.5 All temporary attachments must be shown on the drawings and be approved by the Contractor's responsible structural engineer. Temporary welds shall not degrade the fatigue class. For example, if a member is classified as Class F for design, a temporary class F2 weld shall be prohibited, even if the weld is removed. All welds, including those for temporary attachments and secondary members, shall be made by AWS qualified welders and shall be in accordance with the requirements of these Specifications. All temporary attachments shall be removed after completion of work. The weld area shall be ground flush to a roughness of less than 500 micro-inches. Refer to AWS C4.1 or ANSI B46.1. After grinding, the area shall pass MT examination.

9.9 ERECTED CRANE SHIPMENT

9.9.1 The Cranes shall be fully erected in the Contractor's facility or an alternate site and tested prior to shipment. The Bidder shall describe the proposed erection and shipping plan to be offered.

9.9.2 The shipping subcontractor shall be subject to the approval of the Owner.

9.9.3 The Contractor shall suitably restrain the Crane and crane components during shipment so as to avoid damage to the Crane and crane components. The Contractor shall protect components to minimize damage and corrosion during loading, shipping, and unloading operations. See Section 3.18.

9.9.4 The Contractor shall prepare detailed plans for crane partial disassembly, on-loading onto the transportation, restraining the Crane and crane components, protecting the Crane and crane components, off-loading the Crane on to the wharf. These procedures shall be submitted to the Owner. See Section 1.9.3 for submittal timing requirements.

9.9.5 The shipper and the Contractor must off-load the Crane around the Owner's operational schedule. Port operations will take first priority. The Owner will not be liable for any damages or delays to the Contractor or the shipper. Close communication is required by all parties concerned.

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SECTION 10 INSPECTION, TESTING, AND CERTIFICATION

10.1 GENERAL

10.1.1 Tests and inspections shall be conducted by the Contractor to ensure that the Crane including its subsystems, components and all functions meet the requirements of these Specifications and all applicable codes, regulations, standards, and guidelines.

10.1.2 Tests shall be carried out at the Contractor's facility prior to shipment as well as at the Owner's facility after transportation.

10.1.3 In addition, the Contractor shall perform acceptance tests to be witnessed by the Owner. In particular it shall be demonstrated that:

> 10.1.3.1 All agreed methods, standards, formats, qualities, and procedures have been applied and are adhered to.
>
> 10.1.3.2 The methods and techniques used, components and subsystems are fit for the purpose, reliable, durable, and are easy to maintain.
>
> 10.1.3.3 All functions are safe, complete, and correct.

10.1.4 Where specific tests are described in these Specifications, they are listed as particular tests to be performed. This shall not be interpreted to mean that the Contractor is limited to only the tests described.

10.1.5 Tests shall include verification that the associated documentation such as operating or maintenance manuals is complete and correct. Incomplete or incorrect documentation shall be grounds for failure of the test.

10.1.6 The final test record documentation shall contain all measurements, check-offs, chart recordings, fault logs, print-outs, other documentation or results developed or recorded during shop and field testing, and all required certificates. Test documentation shall be organized into logical binders for each Crane and an electronic copy of all test documentation shall be provided.

10.2 FACILITY OBLIGATIONS FOR THE OWNER'S REPRESENTATIVES

10.2.1 At no additional cost to the Owner, the Contractor shall furnish to the Owner's representatives at each fabrication site, including subcontractors, for the duration of the Contract, a private, heated and air conditioned office, at least 50 m^2 (540 ft^2), equipped with two lockable desks, chairs, lockable file cabinet, telephone capable of placing international calls, broadband internet connection, and electrical power. If the facility has a cafeteria for the use of employees, then the Owner's representatives shall be allowed to use it.

10.2.2 The Contractor shall be responsible for providing facilities as needed for the Contractor's personnel, including subcontractors, at the Owner's facility. The Contractor need not provide facilities for the Owner's personnel at the Owner's facility.

10.3 SHOP ASSEMBLY AND PRE-SHIPMENT TESTING

10.3.1 The Contractor shall inspect the crane components throughout the assembly process to verify that the adjustments and installations comply with the requirements of the design and of the component manufacturer. The Contractor shall satisfy himself that each assembly fully complies with these Specifications, the requirements and intentions of the crane's designers, and the requirements and recommendations of the subsystem suppliers; including at least all mechanical fits, bearing and seal installations, keeper and lock wire installation, mechanical fastener installations, mechanical drive train component alignments, gear engagements, electrical wiring integrity checks, meggering, wire numbering, ampacity measurements, and voltage drops.

10.3.2 The Contractor shall prepare a detailed shop assembly program, including tests and dimensions, to verify the proper installation and alignment of the crane's components. The program shall include drawings, diagrams, and acceptance criteria for each dimension. As a minimum, the program shall include structural member dimensional checks, structural frame alignment dimensions, pin and bore fits, bolt torques, and machinery alignments.

10.3.3 The assembled Crane shall be inspected and tested at the Contractor's facility prior to shipment. All installations and functions shall be verified for compliance with the Specifications and the requirements of the crane's designers and subsystem suppliers.

10.3.4 Testing shall include the operation of all motions except gantry as per Section 10.1.1. At the Owner's sole discretion, certain tests carried out at Contractor's facility may be omitted during the tests at the Owner's facility after shipment.

10.3.5 Machinery alignment

10.3.5.1 The assembly tolerances of all motor couplings and drum couplings shall be verified prior to duty cycle testing. These results shall be included in the acceptance check list.

10.3.6 Boom & trolley rail alignment

10.3.6.1 Prior to shipping, the trolley path from the face of the wharf to the maximum outreach shall not vary from a line perpendicular to the centerline of the waterside sill beam by more than 1" (25 mm).

10.3.6.2 The detailed procedure for measuring boom alignment and reporting the results shall be submitted to the Owner at least 30 days prior to the making the measurement.

10.3.6.3 The alignment shall be measured prior to shipping and again when the Crane is operational on the wharf. See Section 10.5.1. Notice that this tolerance is increased for the testing at the Owner's site.

10.3.6.4 Contractor shall verify that the variation in the trolley rail elevation is such that the expected fatigue damage due to trolley travel over the as-built rail surface does not exceed the calculated damage resulting from the TWRP requirements described in Section 3.10.5.2.

10.3.7 Prior to applying MV power to the crane, the Contractor shall preform turns ratio testing of the transformer(s) and high potential testing of the transformer(s), high-voltage cable, and high-voltage slip ring assembly. High potential testing shall meet the requirements of IEEE 400; VLF AC high potential testing to IEEE 400.2 is preferred. High potential testing shall include all wire terminations, splices, and permanent lugs.

10.3.8 Prior to shop testing, the crane shall be thoroughly lubricated in accordance with the manufacturer's recommendations. A complete lubrication check list shall be submitted to the Owner before testing begins.

10.3.9 Tests

10.3.9.1 Tests shall be carried out at the Contractor's fabrication shop prior to shipment as well as the Owner's facility after transportation.

10.3.9.2 The Contractor shall prepare the Commissioning and Test procedure for the Owner's review and approval no later than 150 days after the Award. The test procedure shall include the check sheets and record of all the tests and measurements in this Section.

10.3.9.3 At least the following tests shall be performed prior to operational Crane testing:

.1 Measure principal dimensions as specified in Section 2.7.

.2 Check and demonstrate that each emergency stop pushbutton and overspeed device operates properly, and that the activation is logged in the CMS.

.3 Check and demonstrate that each limit switch and interlock is operational and properly set. Verify operation of all limit switches, over-travel devices, and sensors.

.4 Inspect and demonstrate that all electrical wiring and wiring components are installed and properly marked.

.5 Brake dynamic torque values shall be verified for each drive by driving through each brake and calculating the braking torque from the current draw using the automated brake test procedure defined in Section 7.26. Thermal capacity of the brakes shall be verified in the same manner with torque, time and brake revolutions recorded. All brakes shall have their linings properly burnished or seated to the manufacturer's recommendations prior to testing.

.6 Run each motion through its limit switches and into the over travel regions, through bumpers and against hard stops, to demonstrate the lack of interference. Motions having bumpers shall compress bumpers at creep speed.

.7 Verify that all machinery components are properly aligned and adjusted. This includes motors, couplings, bearings, pillow blocks, and brakes. For example, the alignment test results of each gear coupling shall be recorded. Verify that vibration measurements of main drives are consistent with the requirements.
.8 Demonstrate that structural inspection locations are accessible as required in Section 3.17.

10.3.9.4 Demonstrate that snag protection system is properly set and functioning as required in Sections 4.9.5.3 and 4.9.5.7.

10.3.9.5 Power optimization of main hoist motion shall be tested to verify compliance with the motor design.

10.3.9.6 Shaft movement delay shall be measured per Section 6.2.5.3.

10.3.9.7 Check PLC memory for 30% redundancy at least. See Section 6.3.4.

10.3.9.8 Check and verify that each auxiliary system is operating as specified and as intended by its manufacturer. Those are cable reels, emergency drive, trim/list/skew system, air compressor, intercom, service hoist in the machinery house, and flood light illumination level.

10.3.9.9 Verify illumination levels required by Section 5.11 are achieved.

10.3.10 Distances

10.3.10.1 The required operating distances and range of motion shall be demonstrated.

10.3.10.2 The required clearance dimensions shall be demonstrated. In particular, the vertical clearances for aircraft and for lift height shall be demonstrated with the boom in all positions.

10.3.11 Performance Testing

10.3.11.1 At a minimum, the tests described below shall be performed as part of the performance testing prior to crane shipment.

10.3.11.2 Check and demonstrate the acceleration, speed and full travel of each motion of the crane.

10.3.11.3 Check and demonstrate the operation of the boom positioning and automatic latch pin insertion and retraction for each boom position.

10.3.11.4 Run the boom from Pos. R to each operating position, A, B, and C, and back. Verify that all boom support wheels run smoothly, without slipping at any point. Verify clearances of side support and hold down rolers at each boom position and in between. Verify that there are no sudden boom or support movements and no sharp creaking or other load sounds coming from the boom or support structures when the boom is moving between positions. The clearance criteria are described in the Drawing Notes.

10.3.11.5 Verify that the full limit of each travel is available independent of speed.

10.3.11.6 With full load under spreader and the boom in each operating position, run all motions to the limits of their speed and travel distance. Check slow down and end limit switches by running each motion at full speed to its extreme of travel position, depending solely on limit switches to slow and stop each motion.

10.3.11.7 Supply chart recordings of all drives with speed reference, speed feedback, voltage, current, and torque of the following motions:

Main Hoist:

.1 Hoisting and Lowering with the rated load
.2 Hoisting and Lowering with empty spreader only

Trolley:

.1 Traveling inboard and outboard with the rated load
.2 Traveling inboard and outboard with empty spreader only

Boom travel:

.1 Travel from Boom Pos R to each operating position, Boom Pos. A, B, and C.
.2 Travel from each operating position, Boom Pos A, B, and C, to Boom Pos. R
.3 Travel between each operating position

Gantry:

.1 Traveling left and right with or without the rated load, with the boom in each position. Testing shall include travelling with full load at maximum height at full outreach, with the boom in Pos. C and full backreach, with the boom in Pos. A.

10.3.11.8 Subject each motion to emergency stop conditions in the worst possible condition of the Crane, perform at least the following tests:

.1 Full speed hoisting and lowering with rated load, two brakes
.2 Full speed hoisting and lowering with empty spreader, two brakes
.3 Full speed trolley travel in each direction with rated load at highest permitted height
.4 Boom at multiple positions
.5 Full speed gantry in each direction with rated load at full height at full outreach
.6 Full speed gantry in each direction with rated load at full height at full backreach
.7 Full speed gantry in each direction with boom at Boom Pos. R

10.3.11.9 Demonstrate the crane operations described in Sections 2.2.1.1 through 2.2.1.4.

10.3.11.10 Demonstrate the electronic anti-sway effectiveness

10.3.11.11 Operate the boom through two consecutive travel cycles with minimum intervals between cycles

10.3.11.12 With the certifying test overload run all motions to the limits of their travel.

10.3.11.13 Verify crane to crane collision protection systems.

10.3.12 After pre-shipment testing, before shipment, oil cleanliness shall be certified by an independent testing laboratory approved by the Owner. Samples shall be certified ISO 4406 17/15/12 cleanliness or better.

10.3.12.1 During demonstration of the crane and prior to the start of duty cycle testing, sample and test all reducers and other devices lubricated with oil, including hydraulic power units, for verification of proper lubricant, freedom from contamination, and absence of deterioration of the lubricated device. Test results demonstrating the proper lubricant, lack of contamination, and absence of deterioration shall be provided to the Owner at least one week before shipment.

10.3.12.2 All systems shall be certified clean before they are shipped. As a minimum, two 100 ml samples shall be taken from each hydraulic system reservoir and reducer housing at least 15 minutes apart during flushing (for hydraulics) or motion (for reducers). Samples shall be identified by:

.1 Crane
.2 Device
.3 Manufacturer, model, and serial number
.4 Lubricant installed in the device
.5 Approximate hours of operation
.6 Date samples were taken

10.3.12.2.1 Samples shall be analyzed by a qualified independent laboratory. As a minimum, tests shall include:

.1	Kinematic Viscosity @ 40º C	ASTM 445
.2	Particle Count	ISO 11500 and ISO 11171
.3	Water by Karl Fisher	ASTM D1533
.4	Metals by Spectroscopic	

10.4 CRANE WEIGHING

10.4.1 Prior to shipping, one completed Crane shall be weighed to within 3% accuracy and the center of gravity of the completed Crane shall be established with the boom at Boom Pos. R, A, and C. This data shall be used to verify that the Cranes can be supported by the wharf before shipping and to verify the stability calculations. The weighing procedure shall be according to these specifications.

10.4.2 The boom for the first Crane shall be weighed in the fully operational condition, with or without the trolley, but with all mechanical and electrical components attached. See also Section 9.8.2.

10.4.3 The trolley for the first Crane shall be weighed in the fully operational condition, with the operator's cab and all mechanical and electrical components attached.

10.5 ACCEPTANCE TESTING AFTER DELIVERY

10.5.1 The work at the Owner's facility includes the off-loading and setting up of the crane on the rails, removal of the shipping hardware, installation and electrical power connection, suitable modifications of existing crane buffer systems, completion of all other items including washing to remove salt spray, paint touch-up, verification of all shop test, tuning, certification by regulatory agencies, oil testing, and performance and endurance testing. The Contractor shall install the connections and/or splices of the medium voltage reeling cable at the point of common coupling in the wharf and shall perform high potential testing of the system after the connection is completed to IEEE 400 and preferably to IEEE 400.2. The Contractor shall provide all personnel and equipment required to complete the work, to perform the tests, and to obtain certifications. The Contractor shall supply all labor and materials required to install and connect the cable reel cable to wharf power supply in the vault.

10.5.2 A wharf area to be used by the Contractor to offload, test and commission the cranes will be made available by the Owner. See the Drawings. The Crane(s) may not be offloaded at the Owner's facility if the shop erection, shop start up and shop testing has not been completed in accordance with this specification. If any Crane has sustained shipping damage, the damage must be repaired before the crane may be unloaded at the Owner's facility unless approved by the Owner. Discharge of the crane from the ship may not take place during line haul container handling operations at the terminal. The ship transporting the Cranes may not tie up to the Owner's facility unless actually unloading the cranes. Unloading shall be coordinated with the Owner. The Contractor shall coordinate his operations with the Owner.

10.5.3 The Contractor shall obtain all services and permits required to roll-off and field test the crane. This includes, at least, crane rental, guard services, fire watch services, lubricants, spare parts for "start-up", seals, telephone, utilities, building permits, fire permits, and electrical permits. Office space and storage space shall be provided by the contractor.

10.5.4 The Contractor shall have a qualified field project engineer and the electrical vendor shall have a qualified electrical startup engineer at the job site at all times, when the work is in progress. The field engineer shall ensure that all field work is in accordance with the approved designs and that all tests are in compliance with the approved procedures and the original equipment manufacturer's recommendations. The field project engineer and the electrical vendor electrical startup engineer shall have demonstrated their qualifications by each successfully completing two similar crane projects within the past three years. Acceptable references shall be provided to the Owner.

10.5.5 The boom shall be in the operating positions (Boom Pos. A, B, and C) only at times approved by the Owner. At the Owner's request, the boom shall be moved to Boom Pos. R for ship and channel clearance.

10.5.6 The Owner's facility includes a wharf area, roadway, and fenced off tenant container storage yard. The roadway and tenant space will be beneath the boom at the backreach when the boom is retracted to Boom Pos. R. The Contractor shall notify the Owner of any overhead welding or other work over the roadway or tenant space. The Owner will need to flag off the area prior to work. The acceptance testing area is shown on the Drawings.

10.5.7 The Contractor shall repair any damage done to the Owner's Facility as a result of his activities, including damage to pavement and utilities.

10.5.8 The Contractor shall repeat the factory test at the Owner's Facility of all emergency stop circuits, overspeed devices, and end of travel limits, including anti-collision systems. All structural and mechanical alignment testing shall be re-verified after shipment. See also Sections10.3.4, 10.3.9.3, and 10.3.11.9.

10.5.9 Boom and frame deflections and vibration measurements shall be made according to a plan and criteria approved by the Owner. This testing shall consider the boom, trolley and load at multiple positions. The Contractor shall measure and verify the boom alignment using a method approved by the Owner; see Section 10.3.6.

10.5.9.1 The trolley path from the face of the wharf to the maximum outreach shall not vary from a line perpendicular to a line through the center of the outermost waterside gantry wheels by more than 2 in (50 mm). This measurement shall be retested after gantrying the crane in each direction along the wharf.

10.5.10 When crane testing has been completed, except for the endurance test, the crane anti-collision systems shall be tested. The Contractor shall submit a complete procedure and criteria for acceptance to the Owner for approval. The testing of these systems shall consider the position of the boom at various positions for multiple cranes and shall include as a minimum:

.1 Crane position detection along the wharf, by independent, redundant measurements
.2 Correction of the encoder based gantry position by the transponder based position
.3 Boom position by independent, redundant measurements
.4 Laser scanning protection against crane to crane and boom to boom collision
.5 Laser scanning protection against collision with ship
.6 Boom and crane movement stop. Measure crane and boom lateral deflection and deceleration rate during stop.
.7 Failure functions
.8 Recovery from Emergency Stop
.9 Crane collision, bumper to bumper, at 50% speed, new crane to new crane and new crane to existing crane.
.10 Recovery from collision

10.5.11 The crane anti-rack system shall be tested using a procedure approved by the Owner. See Section 7.30.

10.5.12 Power factor and harmonic distortions at the PCC of the test crane as per Section 5.1.9. Power factor and harmonic voltage and current distortions shall be recorded with the main hoist and trolley operating and accelerating with rated load at rated speed and with the main hoist and trolley operating and accelerating with empty spreader to top speed.

10.5.13 With the certifying test overload run all motions to the limits of their travel.

10.5.14 Endurance Cycle Tests

10.5.14.1 Following the substantial completion of the crane and the successful accomplishment of all other testing, the crane shall be given a separate endurance duty cycle test to demonstrate combined operation of all crane systems and reliability of the components.

10.5.14.2 All hardware and software jumpers, overrides, or bypassing of code sections shall be removed prior to the start of the endurance test.

10.5.14.3 A 30-hour continuous cycling operation test of the main hoist and trolley shall be conducted to simulate the hoist and trolley design duty cycles defined in Section 2.10 with regard to demand on the motors, travel distances, and relative times of no-load and full-load operation. Supporting systems shall be cycled through their duty cycles as defined in Section 2.10.

10.5.14.4 The endurance cycle test shall include travel in both the outreach and the backreach. Once every hour, the Crane shall travel with load to the full outreach and the full backreach. Every two hours, the Crane shall travel the boom to Boom Pos. R, gantry approximately 150 m and back, and extend the boom to the full outreach operating position, Boom Pos. C. The electrical vendor, using a computer program, shall verify that the proposed test procedure agrees with the RMS loadings of the design cycles defined in Section 2.10.

10.5.14.5 For the last 12 hours of the endurance test, the spare fiber optics shall be used.

10.5.14.6 The endurance duty cycle test shall be run using fully proficient, professional crane operators supplied by the Owner.

10.5.14.7 Hourly temperature measurements shall be made of all main hoist and trolley drive bearings and reducers within the machinery house and all hydraulic systems throughout the crane.

10.5.14.8 The endurance test shall be deemed a success when there are no alarms or trips during the final twelve continuous hours of the test.

10.5.15 Additional Tests

10.5.15.1 Demonstrate the time to install and remove the tie-downs.

10.5.15.2 The wire rope sheaves shall be inspected after the duty cycle tests, periodically throughout the warranty period, and again just prior to the expiration of the warranty period. Any sheaves with corrugation or imprinting of the wire rope on the sheave grooves shall be replaced with new sheaves by the Contractor at his expense.

10.5.15.3 The grooves of all wire rope drums shall be inspected after the duty cycle tests, periodically throughout the warranty period, and again just prior to the expiration of the warranty period. Any drums with corrugation or imprinting of the wire rope on the grooves shall be replaced by the Contractor at his expense.

10.6 CERTIFICATION

10.6.1 The Contractor shall obtain and deliver to the Owner all the certifications and certificates that are required by the governing regulatory agencies. The certifications shall include at least the following:

- .1 Elevator certifications; in addition to the required regulatory certification, the elevator manufacturer shall certify that the elevator complies with his requirements and can safely perform its intended operations and is fit for its intended service.
- .2 Regulatory agency elevator certificate
- .3 Certification of service cranes
- .4 Wire rope certifications
- .5 Air receiver and compressor certifications
- .6 Twistlock certification

10.6.2 The Crane and all supporting equipment including, but not limited to, service cranes, spreaders, headblocks, cargo beams, and over-height adapters, shall be certified in accordance with OSHA 29 CFR 1917.50, 29 CFR 1919, and any additional local codes or requirements as applicable. It shall be the responsibility of the Contractor to have this certification made by individuals or organizations with the necessary accreditation. The tests and inspection made by the accredited individuals or organizations shall be in addition to the other testing described in these Specifications.

10.7 TEST DOCUMENTATION

10.7.1 The documentation shall contain all measurements, check-offs, chart recordings, fault logs, and print-outs taken during shop and field testing, and all required certificates. Test results shall include oil samples, boom alignment, gear alignment, and coupling alignment. Oil sample results from each reservoir shall be given to the Owner prior to provisional acceptance.

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SECTION 11 INSTRUCTIONS, DOCUMENTATION, AND TRAINING

11.1 OPERATING INSTRUCTIONS

11.1.1 A complete set of Crane Operating Instructions shall be provided. Instructions shall be written from the crane operators' perspective, and shall include instructions for proper and safe use of the equipment and procedures for proper start-up and shut-down of the Crane. The operating instructions shall address and comply with all the applicable requirements of all regulatory agencies.

11.1.2 See Section 2.14 for languages at the Owner's facility.

11.1.3 The Crane Operation Instructions shall include the following:

- .1 A step-by-step procedure to initiate container unloading from a container ship, starting with the Crane stowed
- .2 A description of all motions and accessories
- .3 A description of each operator's control device, including purpose and when to use each
- .4 A description of each indicating light
- .5 The purpose and meaning of each alarm and warning light with instructions for how to proceed when the warning is encountered. Abnormalities which may occur that do not activate an alarm or light shall also be addressed.
- .6 An explanation of the wind alarm system, including the meaning of each alarm
- .7 An explanation of the control logic for wind warnings
- .8 A step-by-step procedure for taking the Crane out of service and stowing
- .9 A step-by-step procedure to stow the Crane for high winds

11.1.4 The Operating Instructions shall be validated during the testing and provisional acceptance of the first Crane.

11.1.5 The Contractor shall provides 10 soft bound copies of the Operating Instructions for each crane, approximately 125 mm by 200 mm in size, within 30 calendar days of provisional acceptance of the first Crane.

11.1.6 A copy of the Operating Instructions shall be permanently mounted in the operator's cab in a convenient, easily accessible storage device that will protect it from damage. Four copies of the preliminary or "marked up" version of the validated Operating Instructions shall be installed in the operator's cab at provisional acceptance.

11.1.7 Copies of the Operating Instructions shall be contained in the Maintenance Manuals.

11.1.8 A DVD-ROM with the Operating Instructions in MS Word and Adobe PDF formats, complete with embedded graphics, shall be provided to the Owner in addition to the printed copies.

11.2 MAINTENANCE INSTRUCTIONS AND MANUALS

11.2.1 General

11.2.1.1 Concurrent with the design engineering process, the Contractor shall prepare and submit listings and descriptions of every maintenance task required for all systems on the Crane, including those required by manufacturers of components selected by the Contractor for use on the Crane. The listing of tasks shall include at least the following: description of maintenance task required, frequency of task, method of safe access to perform task, tools required to perform task, manpower and man-hours to perform task, and tools, parts, and materials required to perform task. The Contractor shall present these descriptions as part of design reviews and with each submittal. The assembly of all maintenance tasks shall be presented as part of the maintenance review. The Contractor shall justify the requirements for each task. Refer to Section 8.3 for limits on total annual maintenance burden for each Crane.

11.2.1.2 Provide one hard copy for each Crane, plus four additional hard copies, of the maintenance instructions and manuals.

11.2.1.3 Each volume shall be neatly bound in a three-ring or post-binder no thicker than 75 mm. Each section shall have a tab stating the section number and title. Each manual shall contain a table of contents for each of the following sections: Maintenance Instructions, Mechanical, Electrical Drive, Electrical Non-Drive, and Structural.

11.2.1.4 The Maintenance Manuals shall include the Spare Parts List and the List of Recommended Initial Spare Parts to be furnished with the Crane.

11.2.1.5 The Maintenance Manuals shall be submitted for review and approval 60 days prior to the shipment of the first Crane.

11.2.1.6 See Section 2.14 for languages at the Owner's facility.

11.2.1.7 A separate list of all of the components and pieces shall be supplied after all of the components are purchased or known. The list shall include:

.1 Supplier's name
.2 Address
.3 Phone
.4 Fax
.5 Contact person
.6 Part number
.7 Part description
.8 Original Supplier
.9 Closest Supplier to the Owner's facility that stocks each component

11.2.2 Mechanical Maintenance Instructions

11.2.2.1 The mechanical maintenance instructions shall include a listing of all mechanical checks and inspections, including frequency, for all mechanical components, e.g., couplings, brakes, reducers, pumps, sheaves, wheels, rails. Inspections shall call for the type of inspection to be conducted - visual, measurement, disassembly, level measurement, fluid sampling - and shall provide criteria for adjustment, refurbishment or replacement. Frequencies shall be provided in either crane operating hours, drive operating hours, or calendar days.

11.2.2.2 Oil and lubrication instructions shall be included in the Mechanical Maintenance Instructions and shall be laminated in plastic and mounted in the machinery house. The manual shall contain a listing of the lubricants approved by the manufacturer for use in each of the crane components. A variety of lubricants and a range of operating temperatures shall be listed. Schematic diagrams of the major areas of the Crane shall be provided with call-outs for the lubrication points. Each point shall be numbered and keyed with the type of lubricant to be used. Along with the diagrams, a table shall be provided listing the lubrication point, the description of the item, the lubricant to be used, the method of application, and the lubrication frequency.

11.2.2.3 Lubrication monitoring shall be encouraged. As a minimum, the Maintenance Manual shall contain instructions for monitoring the gear box, hydraulic and similar lubricants. The manual shall specify the frequency at which samples shall be taken from each component, the tests to be performed on the lubricant, and the criteria for replacement or reconditioning.

11.2.2.4 Emergency operating instructions shall be provided which clearly and definitively guide the operations and maintenance personnel through step-by-step procedures to safely and efficiently recover from emergency situations including, at least, the following:

.1 Trolley wheel breaks while trolley is over the vessel
.2 Main power failure with spreader inside vessel cell
.3 Gantry drive axle failure while gantrying
.4 Boom travel failure during vessel operations
.5 Loss of hydraulic functions
.6 Boom support roller failure

11.2.2.5 A Maintenance Program shall be provided which itemizes all mechanical and electrical preventative maintenance tasks required during the life of the Crane. The tasks shall be specific and clearly worded. Each task shall be listed with its location cross-referenced to a master drawing for ease of identification. Where tasks require further description, reference shall be made to the appropriate section containing specific and clearly worded detailed instructions. Each listing shall also provide the task frequency and any special parts, materials or tools required. Where parts are to be replaced, the listing shall include drawing number or page number in the service manual, the part reference number, and the manufacturer's part number.

11.2.2.6 Vendor literature that will assist in the rebuilding, servicing, adjusting and ordering of replacement parts shall be logically organized in the maintenance instructions. All mechanical assemblies shall be included. If catalogue maintenance information is included which represents a range of part numbers, or if there are numerous part numbers on a page, the part number that applies to this project shall be identified by underlining, an arrow in the margin, or the remainder of the item numbers neatly crossed out.

11.2.2.7 A summary paint repair procedure shall be included which identifies product description and color numbers.

11.2.2.8 Detailed instructions for proper use of the test load system shall be include in the Mechanical Maintenance Instructions.

11.2.2.9 The Mechanical Maintenance Instructions shall include instructions for appropriate and safe access to perform each maintenance task. The Contractor shall include warnings for access platforms and areas where it is not safe for personnel to walk, stand, or work. Refer to Section 7.5.21 above. The Instructions shall include detailed explanations of all necessary precautions and proper methods for lock out and tag out of components prior to performing each maintenance task.

11.2.2.10 The Mechanical Maintenance Instructions shall include written procedures for the maintenance and replacement of all hazard signs in accordance with the recommendations of ANSI Z535.4.

11.2.3 Electrical Maintenance Instructions - Drive System Supplier

11.2.3.1 The complete maintenance instructions for all of the electrical components of the drive system, controls, operators, motors, etc. shall be included in the manuals. Maintenance Manuals for PLC, drive, and other significant devices may be bound separately, if they are published as bound volumes themselves.

11.2.3.2 All PLC application program shall be documented to the fullest extent possible. Any variable or constant shall have a tag name and clear description.

11.2.3.3 All required maintenance tests shall be included in the Maintenance Program. See Section 11.2.2.5.

11.2.3.4 The Maintenance Manuals shall contain a written description of the control logic of the Crane. The description shall be directed at knowledgeable maintenance or engineering personnel.

11.2.4 Electrical Maintenance Manuals - Non-Drive Components

11.2.4.1 Maintenance manuals shall be included for the numerous electrical items on the Crane that do not fall under the drive system category, including items such as auxiliary motors, floodlights, anemometer, intercom, load cells and limit switches. All components requiring servicing, maintenance, periodic inspection, or replacement shall be included. If catalogue maintenance information is included which represents a range of part numbers, or if there are numerous part numbers on a page, the part number that applies to this project shall be identified by underlining, an arrow in the margin, or the remainder of the item numbers neatly crossed out. Where maintenance is required, instructions shall be included in the Maintenance Program.

11.2.4.2 All required maintenance tasks and inspections shall be included in the Maintenance Program. See Section 11.2.2.5.

11.2.5 Structural Inspection Manual

11.2.5.1 The requirements for the structural inspection are contained in the structural design requirements of these specifications. See Section 3.17.

11.3 OPERATOR TRAINING

11.3.1 The Contractor shall provide four 4-hour operator training sessions. Training does not need to be repeated for additional crane options. The instructor shall be knowledgeable in the operation of the Cranes. The instructor shall explain the features of the Cranes, the contents of the operating instructions, and allow time for the operators to operate the Cranes during the sessions. The instructor shall be available to answer questions during the sessions. The training schedule will be determined by the Owner. The sessions shall take place immediately following provisional acceptance of the first Crane.

11.3.2 As part of the operator training, the Contractor shall highlight the ergonomic features of the cabin, seat, and consoles, and describe appropriate steps to help avoid repetitive motion injuries.

11.4 MAINTENANCE TRAINING

11.4.1 The Contractor shall provide qualified structural, mechanical, and electrical specialists to train maintenance personnel in the maintenance and operation of the Crane. The sessions shall take place prior to provisional acceptance of the first Crane. Training does not need to be repeated for additional crane options.

SPECIALTY	DURATION	SPECIALIST
Structural	8 Hours	Structural Specialist
Mechanical	30 Hours	Mechanical Systems Specialist
Electrical	2 × 40 Hours	Drive Vendor Start Up Engineer
Hydraulic	24 Hours	Hydraulic Specialist

11.4.2 Structural Training shall include a thorough review of all aspects of the structural maintenance program as well as a general training session in the features and potential problems that the maintenance personnel should be watchful of.

11.4.3 Mechanical System training shall consist of a review of each of the mechanical drive systems on the Crane. As part of in this training, the Contractor shall demonstrate the safe procedure for performing those maintenance tasks called for in the Mechanical Maintenance instructions. Tasks such as rereeving, rope inspection, rope lubrication, trolley rail clamp inspection, trolley wheel replacement, and others shall be demonstrated. An item by item review and instruction shall be provided on each of the required and recommended maintenance procedures called for in the Contractor' maintenance instructions. In addition, dedicated training shall be given by the subcontractor or manufacturer of significant subcomponents. As a minimum these shall include:

.1 Reducers
.2 Brakes
.3 Boom support system
.4 Hydraulics and Snag system
.5 Automatic lubrication system
.6 Elevator

11.4.4 Electrical Subsystem training shall include those electrical devices not part of the Drive system. In addition to the drive system training, the electrical subcontractor or manufacturer of significant subcomponents shall provide training for their systems. As a minimum these shall include:

.1 Power monitoring system
.2 Cable chain system
.3 Load Cells
.4 Cable reel(s)

11.4.5 The training sessions shall be performed at the Owner's Facility and in classroom facilities near the site furnished by the Owner. The training sessions are required to be given three times, once for the day shift, the night shift, and the hoot shift. Each session shall be for approximately 10 individuals. The training schedule will be determined by the Owner. The sessions shall start immediately following provisional acceptance of the first Crane.

11.4.6 The electrical training shall include operation and training on the drive simulator, if supplied.

11.4.7 The Control System Supplier shall provide drive system and controls technical training in the Supplier's factory for six experienced crane maintenance personnel. The training shall include the theory and application of the generic drive and control system supplied on the Cranes. The training shall include a total of 240 hours on site, 80 hours at the manufactures facility, and shall take place within 60 calendar days prior to the delivery of the first Crane. Factory training shall be consecutive so as to eliminate the requirement for multiple travels to the factory training facilities. Within 120 days prior to delivery of the first Crane, the supplier shall submit a school and course outline to the Owner for approval.

11.5 AS-BUILT CALCULATIONS

11.5.1 The Contractor shall provide two hard bound copies of all calculations. These calculations shall have consistent values throughout that reflect as-built conditions. They shall incorporate all of the Owner's "Make Changes Noted" comments. They shall reflect any changes made by the Contractor resulting from changes and repairs made during fabrication and changes in vendor supplied items. Calculations shall be stamped and signed by Florida Professional Engineer(s).

11.6 AS-BUILT DRAWINGS

11.6.1 One full set of drawings shall consist of:

11.6.1.1 One (1) DVD-ROM or similar media with a complete electronic copy of all drawings in Adobe PDF format, shown full size with line weights suitable for printing onto ISO A1 and ANSI D size physical media, with a hierarchical index for quick navigation

11.6.1.2 One (1) complete bound set on ISO A3 or ANSI B high quality bond paper, bound into logically organized volumes with a drawing index

11.6.1.3 One (1) complete unbound set on ISO A1 or ANSI D Mylar

11.6.1.4 All drawings identified in Appendix E shall be stamped and signed by Florida Professional Engineer(s)

11.6.2 At the beginning of shop assembly or subassembly, the Contractor shall submit one full set of the current drawings for use during the Owner's review. In addition to the drawings, two bound sets of all procedures shall be provided. Drawings shall include vendor drawings, electrical elementaries, wiring diagrams, wire schedules, electrical installation drawings, software descriptions, and software listings.

11.6.3 When the first Crane is shipped from the erection site, the Contractor shall submit one full set of all drawings and other documentation described in Section 11.6.2. These drawings shall reflect any changes made by the Contractor resulting from changes and repairs made during fabrication, assembly, start-up and changes in vendor supplied items.

11.6.4 Within 60 calendar days following the provisional acceptance of the first Crane, the Contractor shall submit four full sets of all drawings, except only one set of drawing Mylars shall be provided. Drawings shall be revised to reflect the "as-built" configuration of the delivered Cranes. The Contractor shall also submit high quality electronic and bond paper copies of the drawing index and all manufacturing and assembly procedures.

11.6.5 Four full sets of as-built electrical elementary diagrams shall be neatly bound in a three-ring binder and placed in the electrical control room of each Crane. Letter size prints are acceptable so long as they are clearly legible. Marked up prints are acceptable at Crane turn over, but updated drawings shall be installed in each binder within 60 calendar days following the provisional acceptance of the first Crane.

11.6.6 After provisional acceptance, The Contractor shall provide the Owner with all original documentation and license for software installed on the cranes.

11.6.7 Electronic Record Copies

11.6.7.1 Within 60 calendar days following the provisional acceptance of the printed material, the Contractor shall furnish five (5) complete sets of all as-built documentation including calculations, drawings, instructions, operating instructions, maintenance manuals, and spare parts list used in the crane construction and needed for maintenance and documentation of the Crane on DVD-ROM. All original vendor and contact information shall be included in the DVD.

11.6.7.2 A printable drawing index shall be provided listing all drawings and documentation needed to define the Crane. All drawings shall be included in AutoCAD or compatible format together with a navigation program which shall enable the user to search through a drawing breakdown structure or logically presented drawing list and which will directly open the respective drawing. In addition, all drawings shall be printed full size at high resolution to a single Acrobat PDF file. Separate files may be acceptable for major disciplines such as mechanical, structural, electrical. All vendor installation and part drawings may be provided as full scale high resolution PDF files if AutoCAD format files are not available. The DVD shall also contain all calculations, all manufacturing assembly and test procedures, and all test documentation. Data shall be presented on DVD-ROM in a format acceptable to the Owner.

11.6.7.3 The DVD shall contain a navigation program using menus and submenus that allow rapid access through the data. Clean, scanned images will be acceptable.

11.7 ACCEPTABILITY OF DOCUMENTATION

11.7.1 Owner reserves the right to refuse any submittal not in compliance with the specification requirements or is of unacceptable reproduction quality. The cost of correcting and reproducing the original documents shall be borne by the Contractor.

APPENDIX A – CONTRACT DRAWINGS

G1.1 – Site and Crane Location Plan
G2.1 – General Arrangement and Clearances, Positions A, B, and C
G2.2 – General Arrangement, Stowed Mode, Position A
G2.3 – General Arrangement, Passing Mode, Position R
G3.1 – Crane to Wharf Interfaces
G4.1 – Crane Paint Scheme and Logos
S1.0 – Boom Design Notes
S1.1 – Waterside Boom Support Hanger and Boom Latch
S2.1 – Landside O-Frame Boom Support and Platform
S3.1 – Boom Layout
S3.2 – Boom Details
S4.1 – New and Existing Crane Bumper Interface
M1.1–Boom, Trolley, Headblock, and Spreader Interface Layout
M2.1–Z Motion at Waterside Boom Support

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APPENDIX B – REFERENCE DRAWINGS

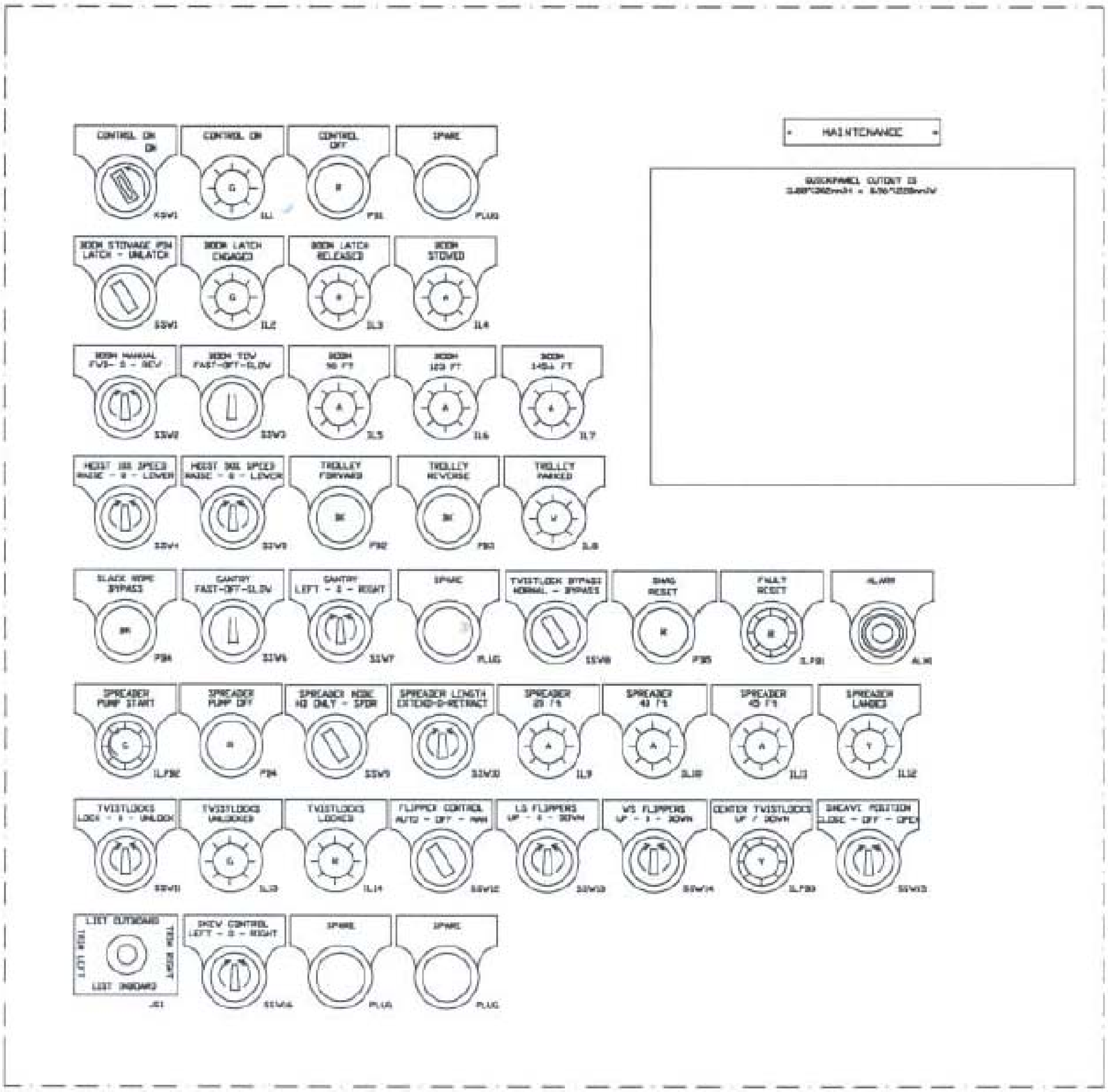
Broward County, Florida, PUBLIC WORKS DEPARTMENT SEAPORT ENGINEERING AND CONSTRUCTION DIVISION Package “A” Landside Infrastructure Upgrade Construction Plans for Berths 31-33, 30 Extension, and Switchgear Building. Approximately 160 drawings, latest Revision

Broward County, Florida, PUBLIC WORKS DEPARTMENT SEAPORT ENGINEERING AND CONSTRUCTION DIVISION Package “B” Landside Infrastructure Upgrade Construction Plans for Berth 30. Approximately 61 drawings, latest Revision

Samsung Heavy Industries – Port Everglades 40 LT LP Container Cranes

The Reference Drawings are available from the Owner

APPENDIX C – GROUND LEVEL OPERATING PANEL LAYOUT



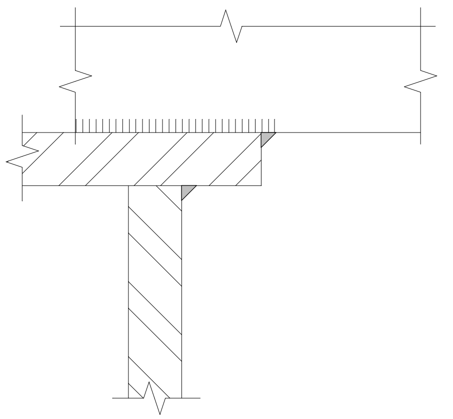
APPENDIX D – LIFTECH STANDARD STRUCTURAL DETAILS

Liftech Standard Structural Details

This document has been prepared in accordance with recognized engineering principles and is intended for use only by competent persons who, by education, experience, and expert knowledge, are qualified to understand the limitations of the data.

The publication of the information is not intended as a representation or warranty by Liftech Consultants Inc. Anyone making use of the information assumes all liability arising from such use.

Structural Details



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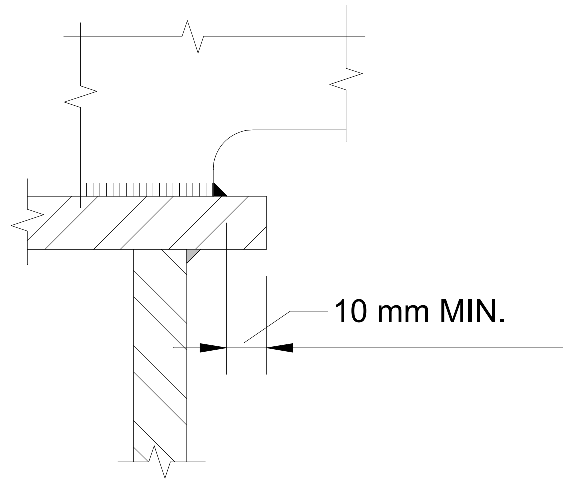

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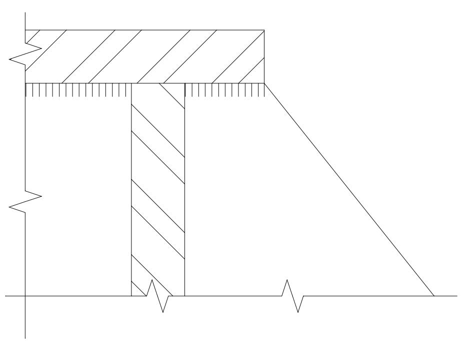

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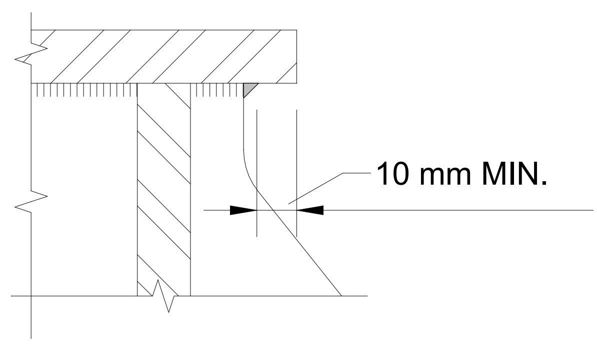

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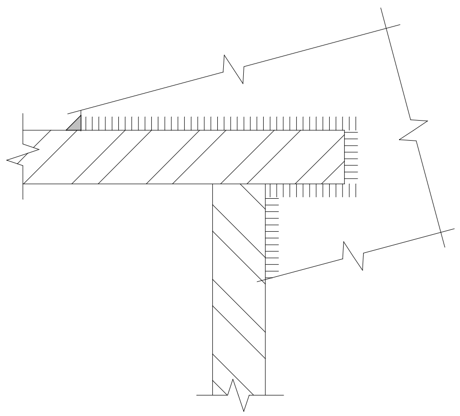
Structural Details



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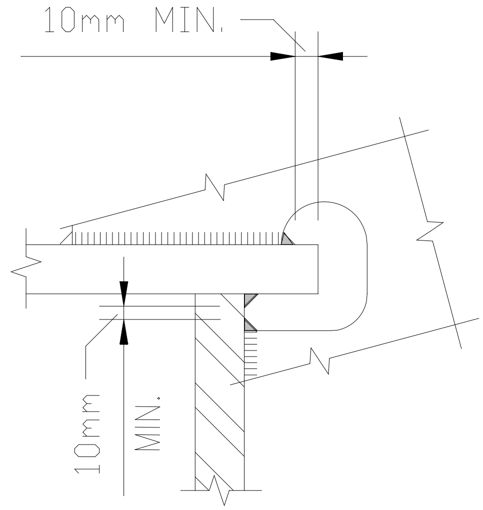

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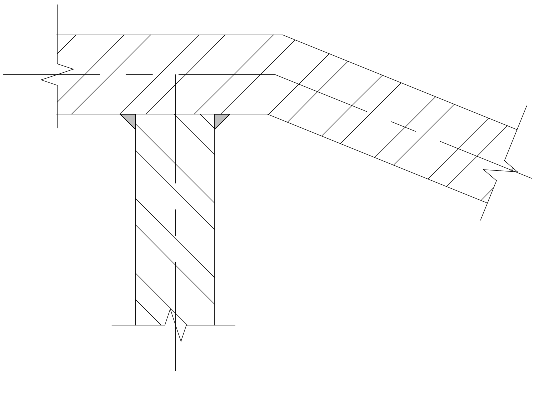

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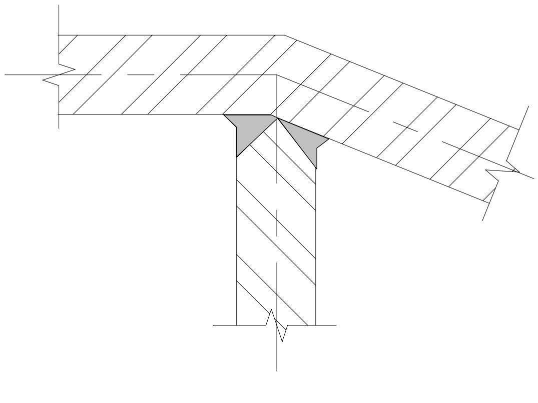

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Structural Details

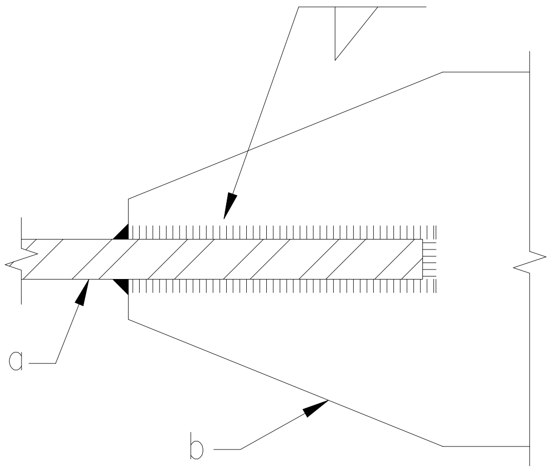
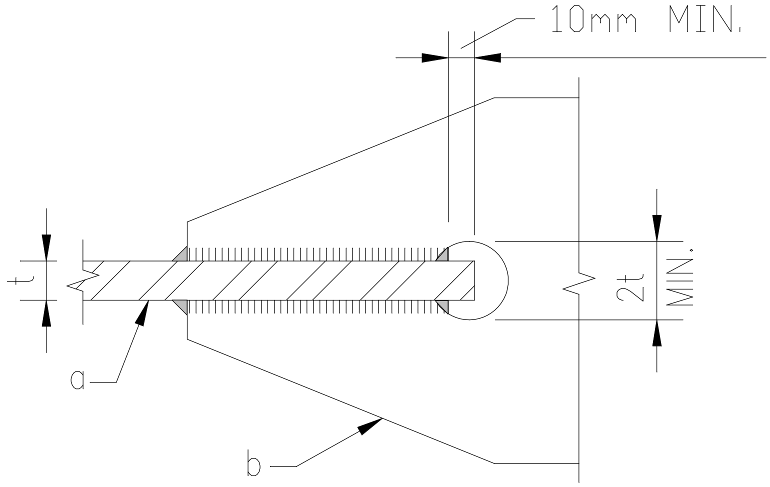


PLATE b SLOTTED



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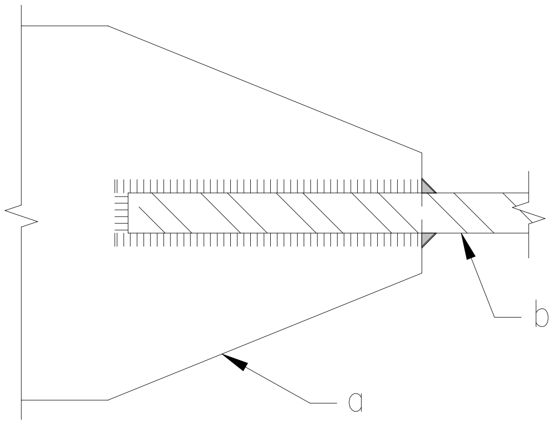

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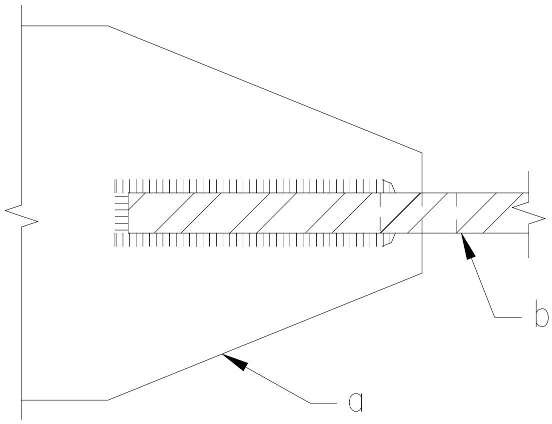

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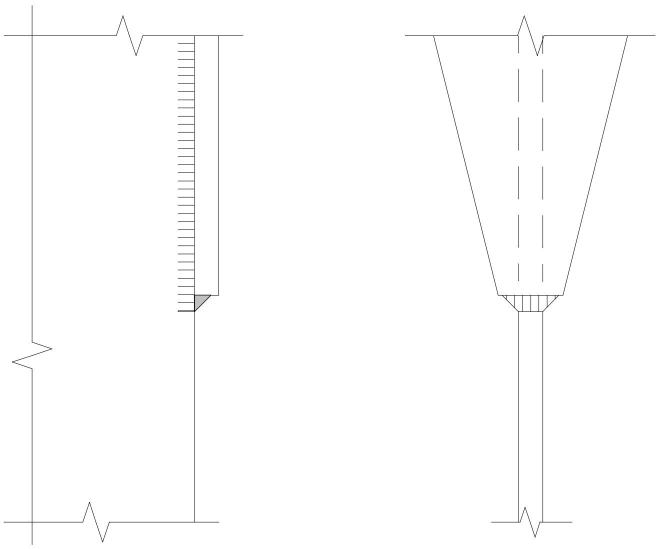

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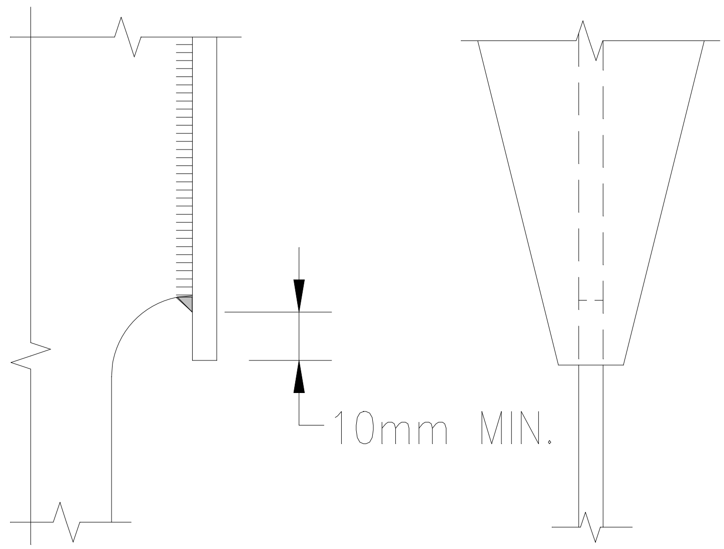

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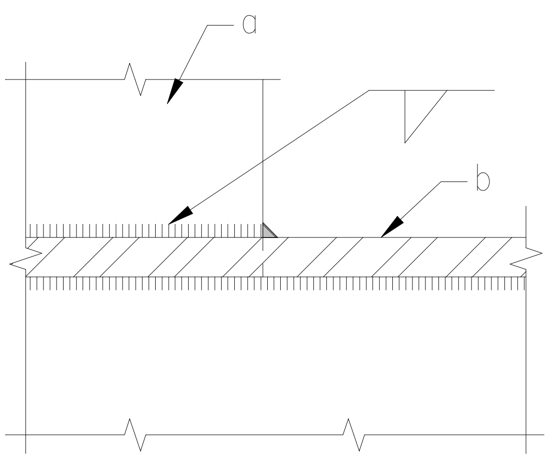

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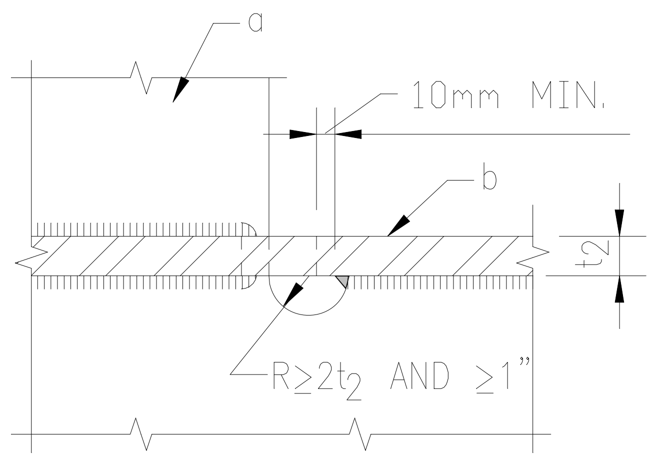
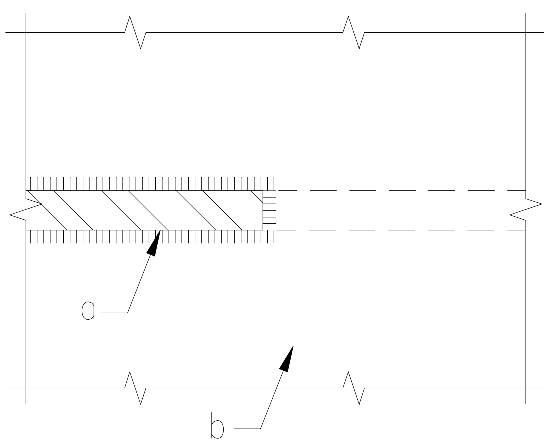


PLATE b SLOTTED



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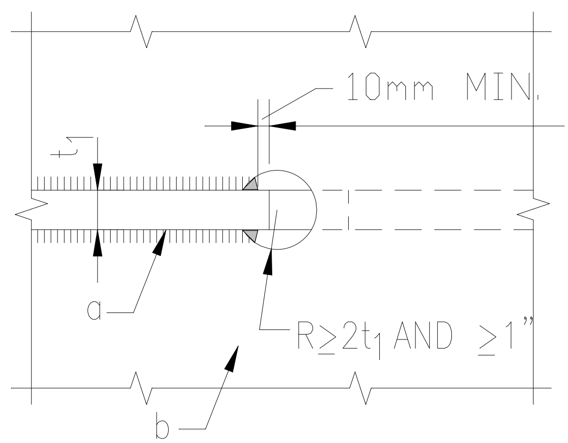

Acceptable

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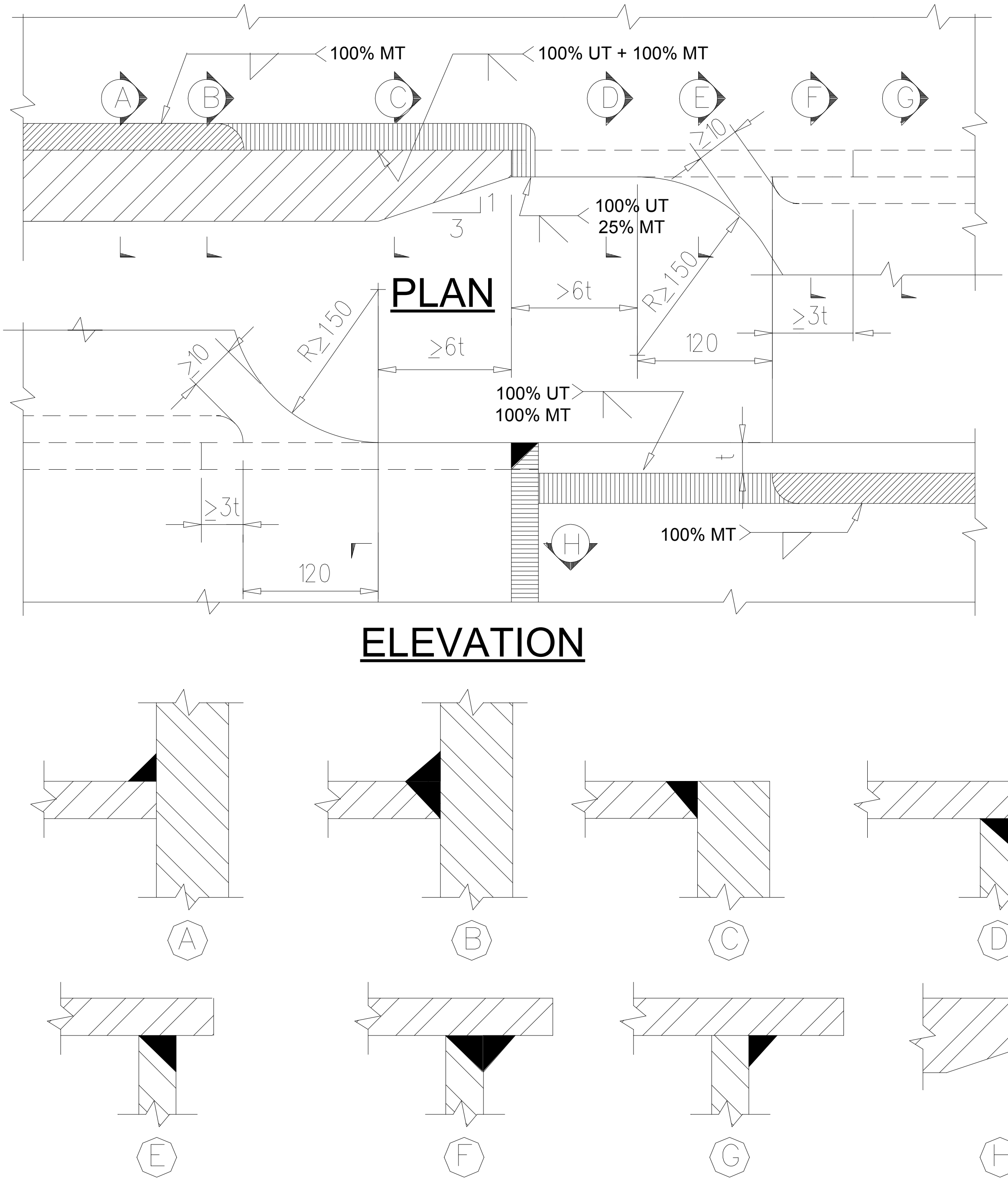
Structural Details

Avoidance of Wraparound Weld
Acceptable

See Sht. 7 for isometric view.



Note: Welds shall conform to the most recent edition of AWS D1.1, including the requirements for cyclically loaded structures.

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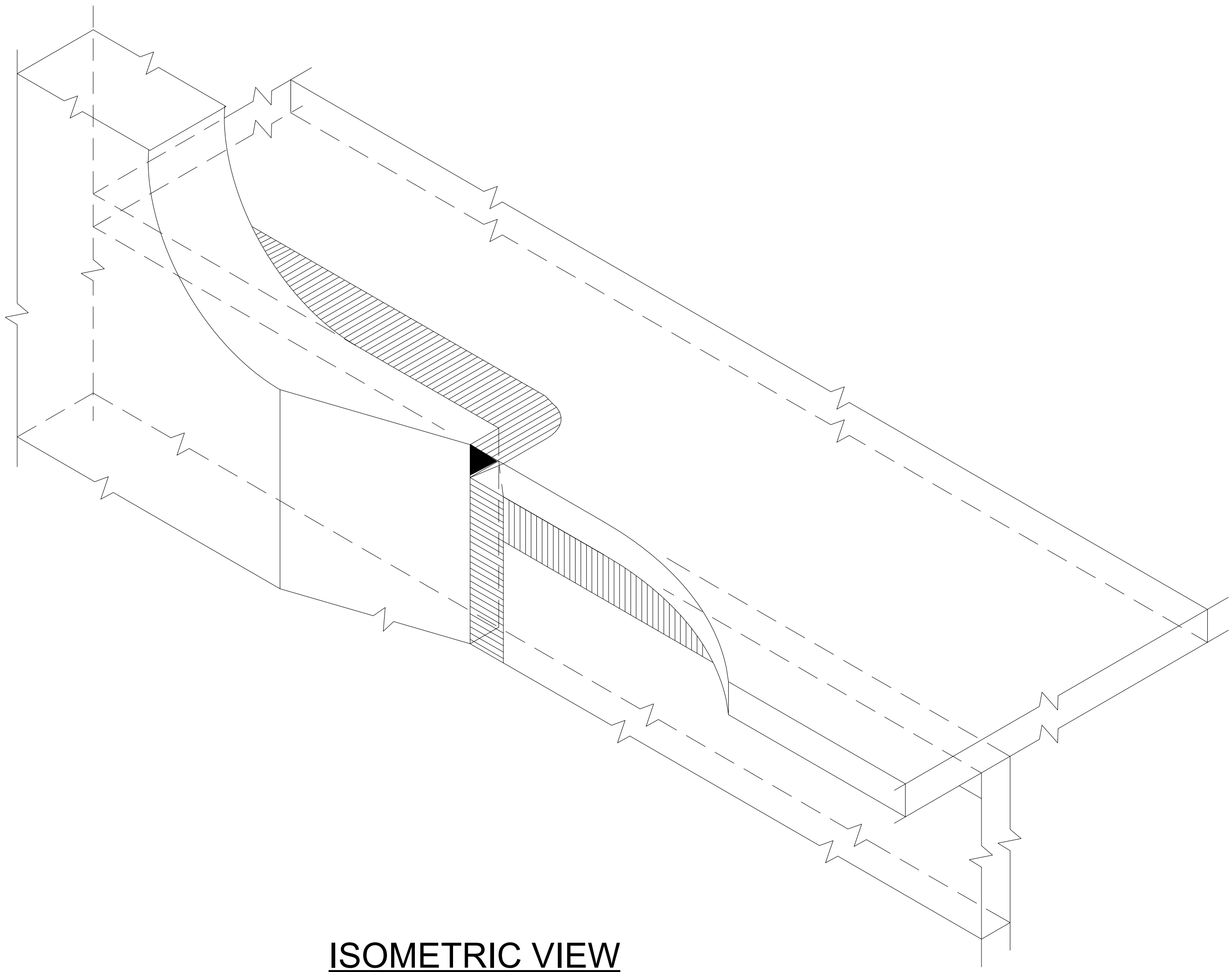
Structural Details

Continued from Sht. 6.

Avoidance of Wraparound Weld
Acceptable

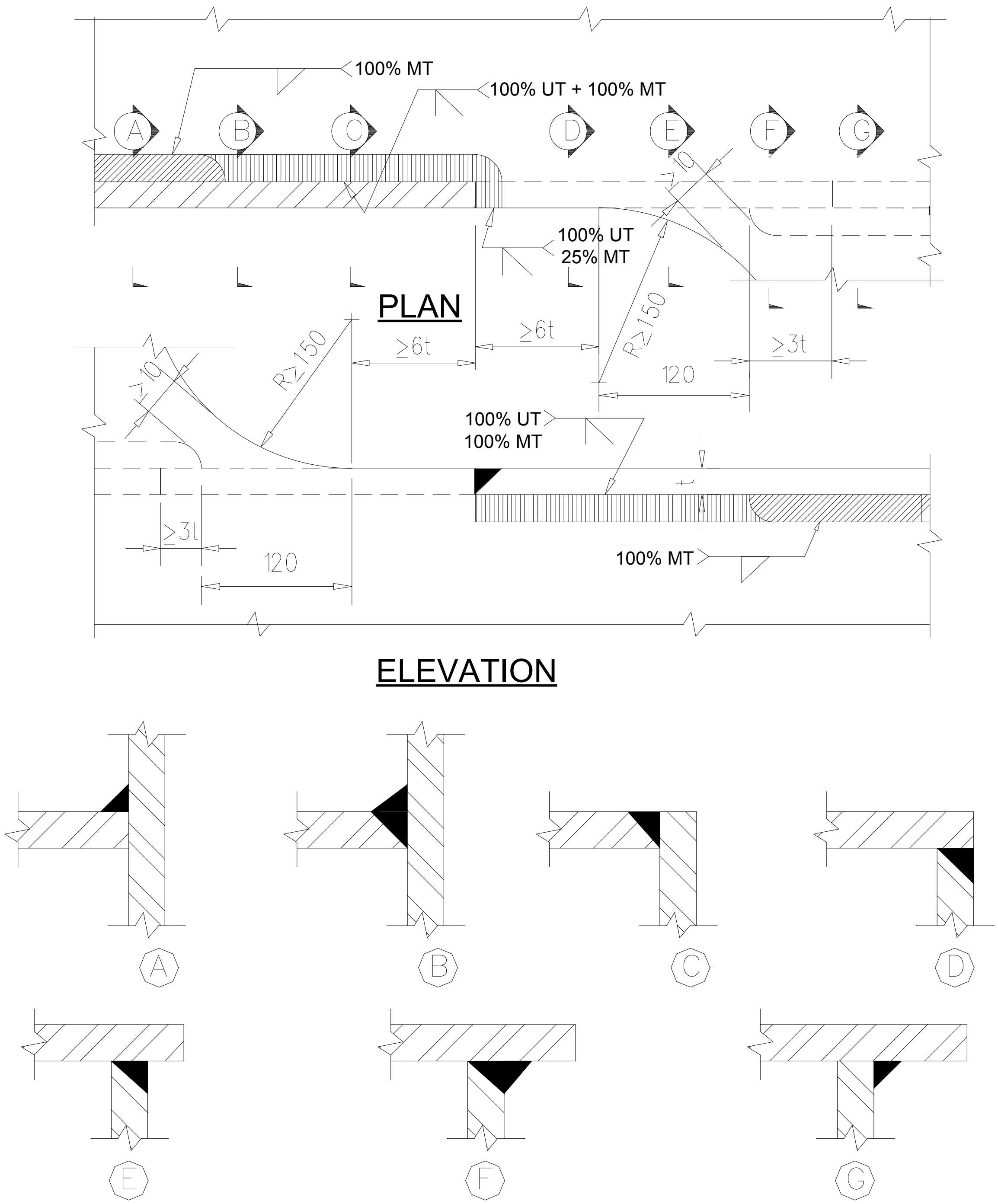


ISOMETRIC VIEW

Structural Details

See Sht. 9 for Isometric View

Avoidance of Wraparound Weld
Acceptable



Note: Welds shall conform to the most recent edition of AWS D1.1, including the requirements for cyclically loaded structures.

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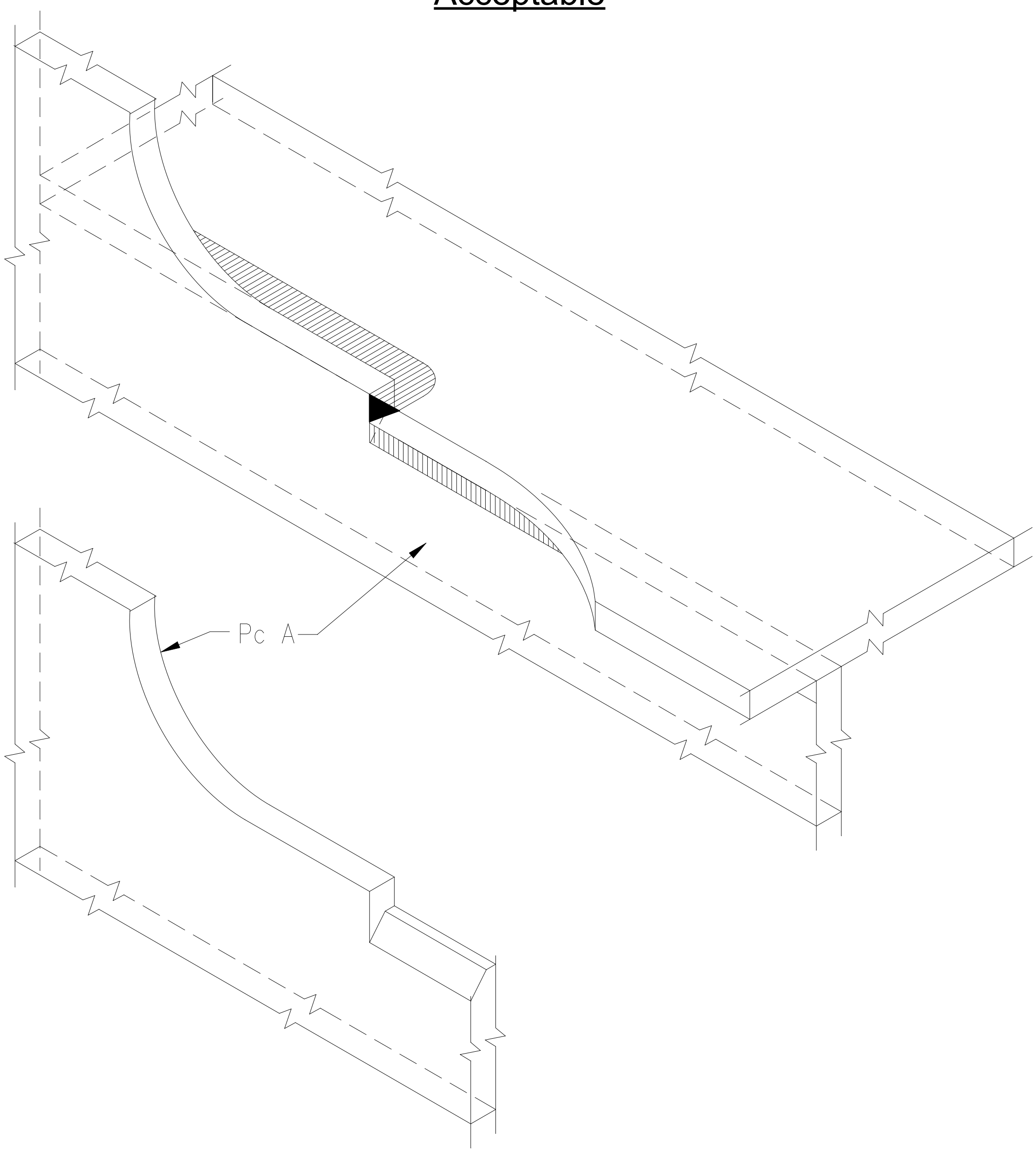
Structural Details

Continued from Sht. 8.

Avoidance of Wraparound Weld
Acceptable



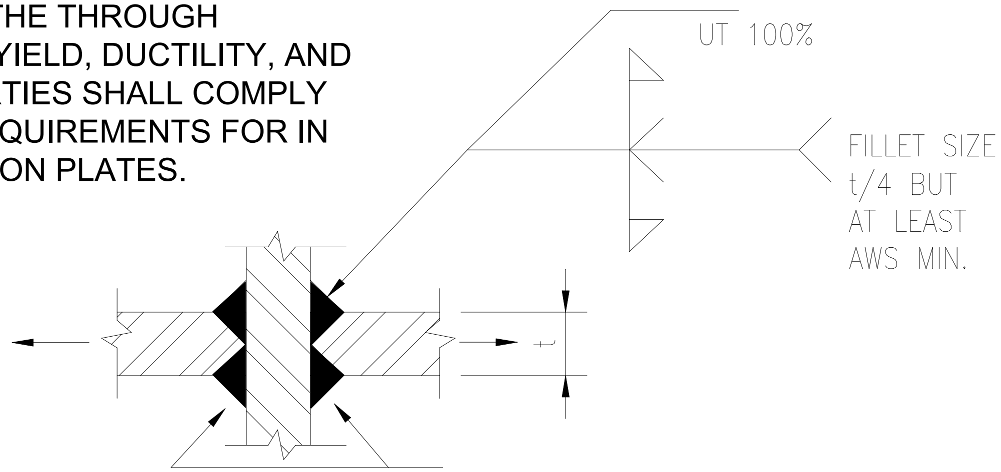
ISOMETRIC VIEW

Structural Details

Cruciform Weld

FOR COMPONENTS
CARRYING CALCULATED
AXIAL STRESS

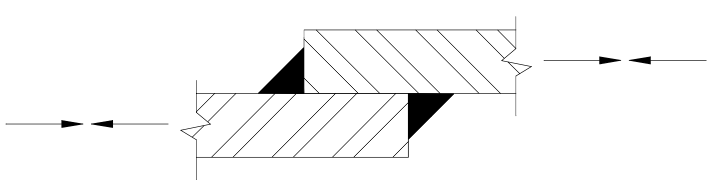
FOR FCMS: THE THROUGH THICKNESS, YIELD, DUCTILITY, AND CVN PROPERTIES SHALL COMPLY WITH THE REQUIREMENTS FOR IN PLANE TENSION PLATES.



U.T. TO CHECK FOR LAMELLAR TEARS BEFORE WELDING AND 36 HOURS AFTER WELDING.

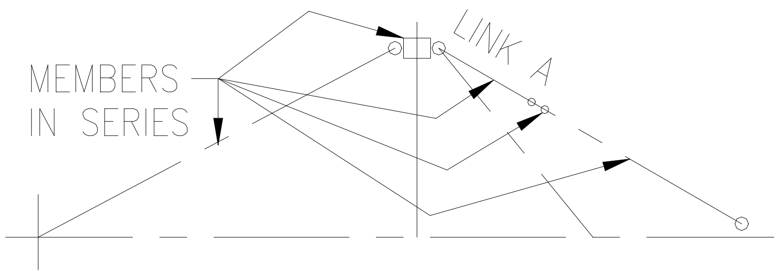
Eccentric Lap Joints

ECCENTRIC LAP JOINTS
BOLTED OR WELDED
ARE NOT ACCEPTABLE
ON COMPONENTS CARRYING
CALCULATED AXIAL STRESS.



NOT ACCEPTABLE

Structural Details
Members in Series



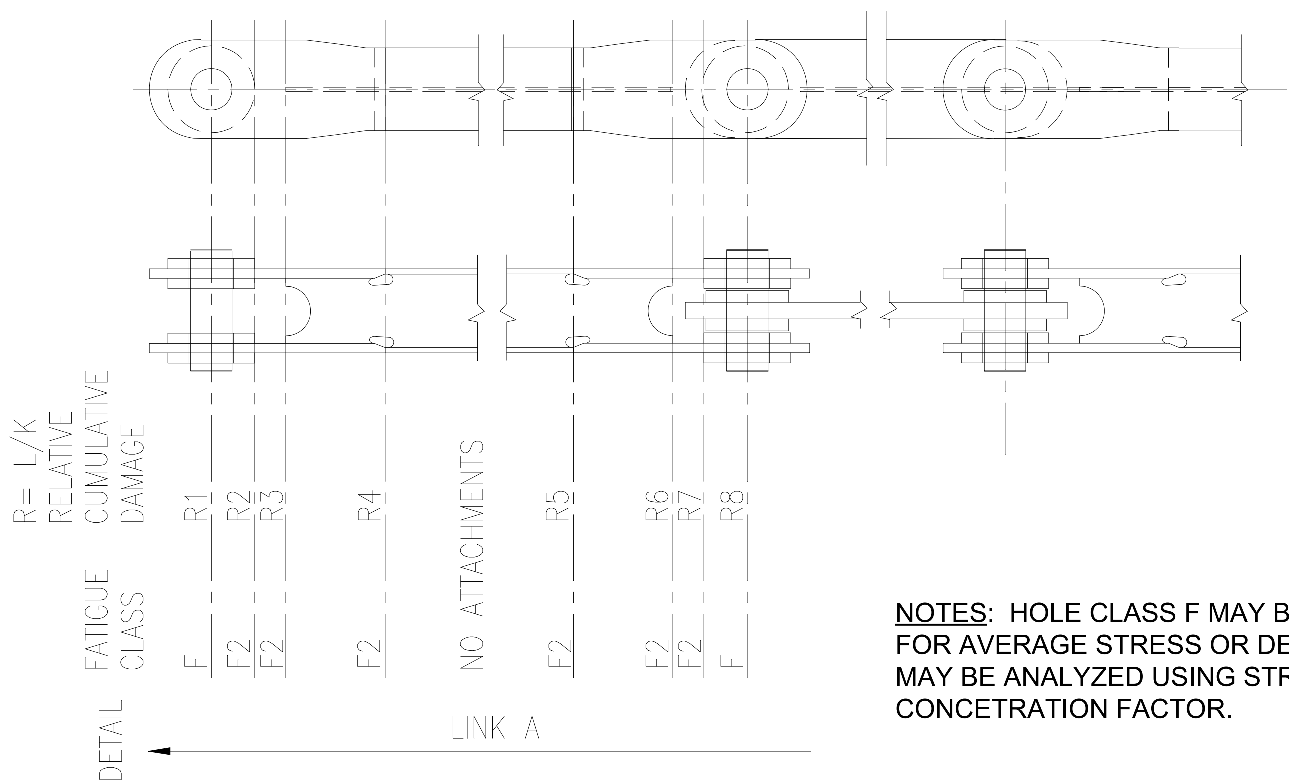
RELIABILITY OF SYSTEM SHALL BE CALCULATED BY DETERMINING THE RELIABILITY "D" OF EACH LINK INCLUDING ALL CONNECTION DETAILS, AND CALCULATING THE RELIABILITY OF THE SYSTEM USING:

$D_{SYSTEM} = D_A \times D_B \times D_C \ldots D_N$

TYPICAL FORESTAY EXAMPLES

FOR EXAMPLE, THE RELIABILITY OF LINK A IS
$D = D_1 \times D_2 \times D_3 \times D_4 \times D_5 \times D_6 \times D_7 \times D_8$
THE VALUES OF D_i ARE FOUND FROM TABLE FOR EACH R_i.

NOTICE WHEN $R \leq 0.4$, $D = 1$
AND WHEN THE CALCULATED STRESS RANGE IS $\leq$ 0.74 X ALLOWABLE STRESS RANGE, $R \leq 0.4$.



NOTES: HOLE CLASS F MAY BE USED FOR AVERAGE STRESS OR DETAIL MAY BE ANALYZED USING STRESS CONCETRATION FACTOR.

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APPENDIX E – BID DATA SHEETS

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BID DATA SHEETS

BIDDER	
BID NO.	
DATE	

Bidder shall submit the completed data sheets with Bid. The data sheets are primarily for bid evaluation, but Bidder may select some of the items and include them in the Contract Documents. Use additional sheets as necessary to fully describe all alternatives and options.

BIDDER'S TEAM	
PROJECT MANAGER	
RESPONSIBLE STRUCTURAL ENGINEER	
RESPONSIBLE MECHANICAL ENGINEER	
RESPONSIBLE ELECTRICAL ENGINEER	

OVERALL CRANE SIZE	
TOTAL CRANE WEIGHT including trolley, headblock, and spreader	
TROLLEY ASSEMBLY WEIGHT with complete cab	
BOOM ASSEMBLY WEIGHT	
HEADBLOCK WEIGHT	
SPREADER WEIGHT	

CRANE COMPONENTS				
WIRE ROPE				
	TYPE e.g. 6 x 37 IWRC XIPS	DIA.	STRENGTH	NO. OF PARTS
MAIN HOIST				
BOOM DRIVE				
TROLLEY DRIVE				
CATENARY TROLLEY				

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CRANE COMPONENTS cont'd.

DRUMS

	DIA.	MATERIAL	METHOD OF MFG. e.g. Cast or Rolled Steel
MAIN HOIST			
BOOM DRIVE			
TROLLEY DRIVE			

SHEAVES

	PITCH DIAMETER	MATERIAL
MAIN HOIST		
BOOM DRIVE		
TROLLEY DRIVE (For RTT Crane)		
CATENARY TROLLEY (For RTT Crane)		

REDUCERS

	MFR.	AGMA RATING w/o serv factors	GEAR TYPE	MODEL	RATIO
MAIN HOIST					
BOOM DRIVE					
TROLLEY					
GANTRY					

BUMPERS

	NO. PER CRANE	COLLISION TYPE	LOAD STROKE	COLLISION LOAD ON EACH
TROLLEY				
GANTRY				
BOOM				

TROLLEY WHEELS

NO. PER CRANE	
DIAMETER	
MATERIAL	

TROLLEY RAIL

SIZE OF RAIL	
TYPE OF RAIL PAD AND RAIL CLIPS	

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CRANE COMPONENTS cont'd.	
BOOM SUPPORT WHEELS	
NO. PER CRANE	
DIAMETER	
MATERIAL	
BOOM TRAVEL RAIL	
SIZE OF RAIL	
BOOM HOLD-DOWN RAIL	
SIZE OF RAIL	
MACHINERY HOUSE SERVICES CRANE	
TYPE	
MANUFACTURER	
MODEL NO.	
CAPACITY	
GANTRY WHEELS	
NO. PER CRANE	
DIAMETER	
WATERSIDE: NO. DRIVEN	
WATERSIDE: NO. BRAKED	
LANDSIDE: NO. DRIVEN	
LANDSIDE: NO. BRAKED	
WHEEL SPACING Include gantry system sketch & horizontal dimensions at one corner.	
MAIN EQUALIZER PIN SPACING	

LIFTECH CONSULTANTS INC.

CRANE COMPONENTS cont'd.
WHEEL LOAD COMBINATIONS
On an additional sheet, provide combined wheel loads and stowage pin loads in accordance with the Specifications wheel load combination tables, Tables 2.10 and 2.11, and provide tie-down loads in accordance with the Specifications stability combination table, Table 2.9. Provide corner loads for the individual loads shown on the following page. Provide the combined wheel loads and individual loading corner loads separately for each crane configuration and each outreach option being proposed. **The Owner may not accept the Bid if the combined wheel loads and corner loads for individual loading is not provided**.

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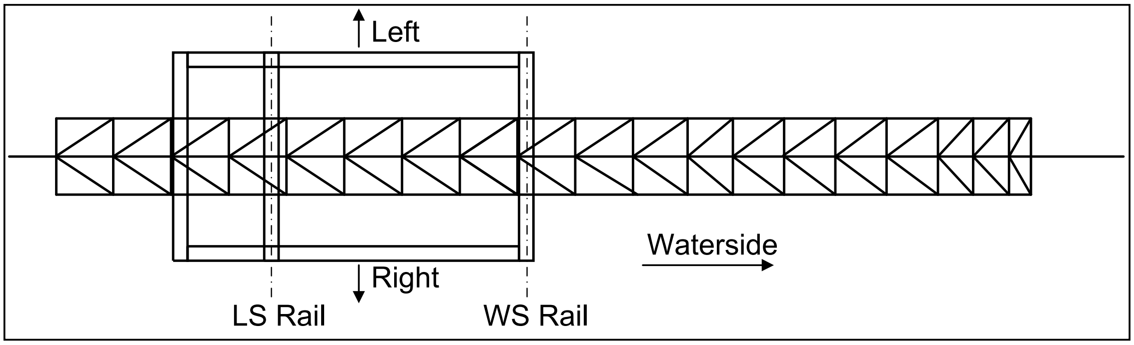

KEY PLAN

CALCULATED CORNER LOADS						
		Total Load (t)	Corner Loads (t/corner)			
			Landside		Waterside	
Basic Load Name	Abbr.		Right	Left	Right	Left
Dead Load, Boom Pos. R	DLR					
Dead Load, Boom Pos. A	DLA					
Dead Load, Boom Pos. B	DLB					
Dead Load, Boom Pos. C	DLC					
Trolley Load	TL					
Lifting System	LS					
Lifted Load	LL					
Impact	IMP					
Gantry Lateral Load, Boom Pos R	LATGR					
Gantry Lateral Load, Boom Pos A	LATGA					
Gantry Lateral Load, Boom Pos B	LATGB					
Gantry Lateral Load, Boom Pos C	LATGC					
Operating Wind Load, Boom Pos. R Trolley Travel Direction (X-dir)	WLORX					
Operating Wind Load, Boom Pos R Gantry Travel Direction (Z-dir)	WLORZ					
Operating Wind Load, Boom Pos A	WLOAZ					
Operating Wind Load, Boom Pos B	WLOBZ					
Operating Wind Load, Boom Pos C	WLOCZ					
Stall Load	STL					
Collision Load, Boom Pos R	COLLR					
Collision Load, Boom Pos A	COLLA					
Collision Load, Boom Pos B	COLLB					
Collision Load, Boom Pos C	COLLC					
Stowed Wind Load, Boom Pos R Trolley Travel Direction (X-dir)	WLSNRX					
Stowed Wind Load, Boom Pos R Gantry Travel Direction (Z-dir)	WLSNRZ					
Stowed Wind Load, Boom Pos A Gantry Travel Direction (Z-dir)	WLSNAZ					
Hurricane Wind Load, Boom Pos A Trolley Travel Direction (X-dir)	WLSHAX					
Hurricane Wind Load, Boom Pos A Gantry Travel Direction (Z-dir)	WLSHAZ					

Provide calculated corner loads for the basic loads shown in the table above. Left and Right are as shown in the Key Plan. Corner loads shall be the maximum for each corner. For variable position loads, such as the trolley load, the landside loads shall be based on the trolley at the backreach and the waterside loads shall be based on the trolley at the outreach. For the operating and stowed wind loads, provide corners loads due to wind in both trolley travel and gantry travel directions.

P:\Specification\Appendix\[Corner load breakdown table.xls]LowProfile

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ELECTRIC CONTROLS, MOTORS, and BRAKES	
SUPPLIER	
DATA for drives by proposed vendors	

CRANE SYSTEMS cont'd.

MOTORS

	NO. PER CRANE	MFR.	FRAME	TYPE	VOLTAGE	H.P.	TIME RATING	SPEEDS Rtd/Max
MAIN HOIST								
TROLLEY								
BOOM DRIVE								
GANTRY								

BRAKES

	NO. PER CRANE	MFR.	FRAME	TYPE e.g. Disc, Caliper	RATING	
					TORQUE	TIME
MAIN HOIST						
TROLLEY						
BOOM DRIVE						
GANTRY						

BOOM DRIVE ROPE DRUM BRAKE	
BRAKE TYPE	
RELEASE DEVICE	
GUARANTEED TORQUE	

MAIN HOIST ROPE DRUM BRAKES (if provided)	
BRAKE TYPE	
RELEASE DEVICE	
GUARANTEED TORQUE	

LIMIT SWITCHES

	MANUFACTURER AND TYPE
MAIN HOIST ROTATING	
MAIN HOIST BLOCK ACTUATED	
TROLLEY SLOW DOWN	
TROLLEY STOP	
BOOM SLOW DOWN	
BOOM STOP	

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CRANE SYSTEMS cont'D.	
ELECTRICAL	
TOTAL ELECTRIC SHORE POWER LOAD PER CRANE	
MAXIMUM INSTANTANEOUS and RMS KVA	
ELECTRICAL SUPPLIER PROJECT MANAGER	
ELECTRICAL SUPPLIER RESPONSIBLE HARDWARE DESIGN ENGINEER	
ELECTRICAL SUPPLIER RESPONSIBLE SOFTWARE DESIGN ENGINEER	
BOOM AND TROLLEY POWER SUPPLY SYSTEMS	
MANUFACTURER	
TYPE	
SPREADER	
MANUFACTURER and MODEL	
INTERCOM	
MANUFACTURER	
TYPE	
AUXILIARY DIESEL GENERATOR SET	
MANUFACTURER	
TOTAL POWER RATING	
EPA TIER RATING	

DRAWINGS

The Bid shall include the drawings listed below. Drawings shall define principal construction and operating features. An individual drawing may contain more than one of the required arrangements. Drawings of previously built equipment are preferred, with a description of what will be changed to meet Purchaser's requirements. Provide photographs of previously built equipment.

Appropriate arrangement drawings shall also be supplied for any optional crane configurations.

	BIDDER'S DRAWING NO.
GENERAL ARRANGEMENT	
STRUCTURAL ARRANGEMENT	
BOOM ARRANGEMENT AND SECTIONS	
WATERSIDE BOOM SUPPORT SYSTEM	

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DRAWINGS cont'd.	
LANDSIDE BOOM SUPPORT SYSTEM	
CRANE AND SHIP CLEARANCES	
MAIN HOIST DRIVE ARRANGEMENT	
MAIN HOIST ARRANGEMENT	
MAIN HOIST DRIVE ARRANGEMENT	
TROLLEY ARRANGEMENT	
TROLLEY DRIVE ARRANGEMENT	
TROLLEY ACCESS ARRANGEMENT	
HYDRAULIC SYSTEMS	
GEAR DESIGN	
ENERGY CHAIN SYSTEM ARRANGEMENTS	
MACHINERY HOUSE ARRANGEMENTS	
ELECTRIC ROOM ARRANGEMENT	
BOOM DRIVE ARRANGEMENT	
BOOM LATCH ARRANGEMENT	
REEVING DIAGRAMS	
SINGLE LINE DIAGRAM	
GANTRY DRIVE ARRANGEMENT	
STOWAGE PIN AND TIE-DOWN ARRANGEMENTS	
HEADBLOCK AND TELESCOPING SPREADER ARRANGEMENT	
TRIM, LIST, AND SKEW ARRANGEMENT	
JUNCTION PULL BOX TYPICAL DETAILS	
CONDUIT AND WIREWAY TYPICAL DETAILS	
LIGHTING FIXTURES AND MOUNTING	
CONTROL CONSOLE ARRANGEMENTS	
CRANE ACCESS AND WALKWAY ARRANGEMENT	
ANTI-COLLISION SYSTEMS	
CAB ARRANGEMENT	
SPREADER CABLE REEL ARRANGEMENT	

DRAWINGS cont'd.	
ELEVATOR ARRANGEMENT	
GANTRY CABLE REEL ARRANGEMENT	
STAIR, ELEVATOR AND GANTRY CABLE REEL INTERFACE	
Z-MOTION LAYOUT	
TROLLEY-HEADBLOCK-SPREADER-BOOM INTERFACES WITH HOIST AT UPPER LIMIT	
GANTRY BUMPER INTERFACE BETWEEN NEW AND EXISTING CRANES	
GANTRY WHEEL DESIGN (CONSIDERING FROG TRAVERSING)	

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DESCRIPTIONS OF SYSTEMS

PERSONNEL ELEVATOR

On additional sheets, provide a detailed description of the Bidder's personnel elevator.

STRUCTURAL MAINTENANCE PROGRAM

On additional sheets, provide a detailed description of the Bidder's approach to the structural maintenance program.

Training and Maintenance Support

On additional sheets, provide

1. A detailed schedule for Warranty Period Maintenance Service
2. Detailed program for the proposed maintenance service
3. Name of maintenance sub-subcontractor and a description of the company and its relevant qualifications
4. Description of sub-contractor facility, manning, spares, and response time

SCHEDULE

On additional sheets, provide a detailed schedule for completion of the work.

SUBCONTRACTORS

On additional sheets, list all subcontractors who provide work valued at more than 5% of the contract amount. Include subcontractor name, location where the work will be performed, and a description of the work.

APPENDIX F – LIST OF DOCUMENTS TO BE STAMPED BY FLORIDA PROFESSIONAL ENGINEER(S)

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Appendix F

Documents to be Stamped by Florida Professional Engineer(s)

F.1 As a minimum, the following Design Documents shall be stamped. Stamped documents shall include relevant drawings and calculations.

F.1.1 Safety Documents

.1 Safety procedures, functions, and systems
.2 Safety interlocks and sensors

F.1.2 Structural Documents

.1 Frame, boom, trolley and other structural design drawings
.2 Structural connections
.3 Boom vertical support and hold down systems at waterside and landside
.4 Boom lateral restraining system
.5 Boom latch
.6 Boom truss manufacturing considerations, including camber
.7 Crane stability
.8 Stowage pin and tie-down arrangements
.9 Crane tie-down system
.10 Wheel loads and crane weight
.11 Crane structural calculations, including FEA (finite element analysis) for load condition, stress, displacements, stability, plate buckling analysis approach, p-delta considerations, and fatigue.
.12 Calculated first mode frequencies in the trolley and gantry travel directions
.13 Structural deflections
.14 Structural inspection plan
.15 Access for structural inspection
.16 Machinery house and control room construction and supports
.17 Voyage conditions and bracing
.18 Crane transport and offload

F.1.3 Mechanical Documents

.1 Cross section through boom showing how lift height under spreader is met.
.2 Machinery arrangements for main hoist, boom travel, trolley, and gantry motions including brakes, couplings, reducers, and sensors
.3 Design calculations for all mechanical systems
.4 Gantry cable reel
.5 Interface between the cable from the gantry cable reel and the elevator at the portal level
.6 Gantry motor torque and brake adjustments with boom in all positions to provide proper traction and to prevent wheel skid
.7 Anti-collision and buffer system for new crane to existing crane interface
.8 Boom travel system
.9 Boom support rollers
.10 Boom hold down rollers
.11 Boom support rail
.12 Boom hold down rail

A California Corporation 344 - 20th Street, Suite 360, Oakland, CA 94612-3593 1-510-832-5606 Liftech@Liftech.net www.Liftech.net

.13 Boom lateral side rollers
.14 Boom latch
.15 Trolley arrangement
.16 Catenary trolleys
.17 Main machinery house arrangement
.18 Trolley machinery house arrangement
.19 Reeving, sheave arrangements, and tensioners
.20 Hoist micro-motions
.21 Headblock and spreader, including headblock platform and access to trolley
.22 Trolley mounted cable reel
.23 Cable chain systems (electrical feed system for boom and trolley)
.24 Gantry wheel design considering frog traverse —see Drawings
.25 Lighting fixture support
.26 Test load
.27 Heavy lift cargo beam

F.1.4 Electrical Documents

.1 Electrical design calculations
.2 Power system modeling and analysis
.3 Protection coordination between substation and Crane
.4 Sizing and detailed specifications of switchgear and transformers
.5 Sizing and selection of inverters and main motors
.6 Drive system vendor's detailed specifications and bill of materials
.7 Power optimization calculations and torque, current, and speed characteristics (curves) of all major drive motors
.8 Theoretical duty cycle and energy consumption
.9 Single line diagram
.10 Electrical room arrangement
.11 Diesel-electric house equipment and arrangement
.12 Panelboard arrangement in electrical control room
.13 Lightning protection system and transient voltage suppression system (TVSS)
.14 Flexible cables and color coding
.15 Cabin drawings including internal arrangement
.16 Operating control stations
.17 Operator control devices
.18 Transponders and other hardware and software for integration with existing TMEIC-Gotting position and crane-to-crane anti-collision system; detailed description of system functionality
.19 Crane-to-crane anti-collision system
.20 Crane-to-ship laser anti-collision system
.21 Anti-rack system to keep gantry frame square
.22 Limit switch, sensors, and protective devices
.23 Flood light and lighting study
.24 Wire label materials and device identification labeling
.25 Wharf power connection
.26 Load weighing systems
.27 Anemometer
.28 Air conditioners
.29 Gantry warning devices
.30 Terminal blocks
.31 Intercom system

F.1.5 Control Documents

.1 Operating modes description
.2 Control functions description
.3 Gantry control to limit deflections;
.4 Functional description;
.5 Description of all CMS and RCMS functions, hardware, and operating systems. Description of integration of RCMS with existing. Description of crane positioning system and equipment.
.6 System architecture, network topology diagrams, and communication methods for all components
.7 Process and Instrumentation Diagram (P&ID)
.8 Local operating station(s)
.9 Description of all safety interlocks
.10 Software architecture
.11 Software security
.12 Software source code control system and revision system
.13 Closed Circuit Television (CCTV) systems and displays

F.1.6 Maintenance and Reliability Documents

.1 Design for reliability
.2 Redundancy of key systems
.3 Maintenance mode description
.4 Limping modes description
.5 Fault monitoring and diagnostics including root cause identification
.6 Maintenance hoists and permanent jib structures for maintenance
.7 Access for maintenance and repair including clearance for accessing and handling all mechanical and electrical components
.8 Methods for leveling and aligning headblock after rereeving

F.1.7 Other Design Documents

.1 Walkways and access including access to and from the trolley by means of the headblock
.2 Detailed paint procedure

At the discretion of the Owner, this list of documents may be expanded to include additional parts of, or the entire design of the cranes.

EXHIBIT B Prevailing Wage Determination
General Decision Number: FL170241 03/10/2017 FL241

Superseded General Decision Number: FL20160241

State: Florida

Construction Type: Building

County: Broward County in Florida.

BUILDING CONSTRUCTION PROJECTS (does not include single family homes or apartments up to and including 4 stories).

Note: Under Executive Order (EO) 13658, an hourly minimum wage of $10.20 for calendar year 2017 applies to all contracts subject to the Davis-Bacon Act for which the contract is awarded (and any solicitation was issued) on or after January 1, 2015. If this contract is covered by the EO, the contractor must pay all workers in any classification listed on this wage determination at least $10.20 (or the applicable wage rate listed on this wage determination, if it is higher) for all hours spent performing on the contract in calendar year 2017. The EO minimum wage rate will be adjusted annually. Additional information on contractor requirements and worker protections under the EO is available at www.dol.gov/whd/govcontracts.

Modification Number	Publication Date
0	01/06/2017
1	02/03/2017
2	02/10/2017
3	03/10/2017

ASBE0060-001 03/02/2016

	Rates	Fringes
ASBESTOS WORKER/HEAT & FROST INSULATOR	$ 34.58	12.57

CARP1809-001 06/01/2015

	Rates	Fringes
CARPENTER (Includes Acoustical Ceiling Installation, Drywall Finishing/Taping, Drywall Hanging, Form Work, Metal Stud Installation)	$ 25.95	8.65

CARP1809-002 08/01/2016

	Rates	Fringes
CARPENTER: PILEDRIVERMAN	$ 25.20	10.36

ELEC0728-008 03/01/2016

	Rates	Fringes
ELECTRICIAN (Including Low Voltage Wiring)	$ 30.00	10.85

EXHIBIT B Prevailing Wage Determination

ELEV0071-002 01/01/2017

	Rates	Fringes
ELEVATOR MECHANIC................	$ 41.77	31.585

FOOTNOTE:

A: Employer contributes 8% basic hourly rate for 5 years or more of service or 6% basic hourly rate for 6 months to 5 years of service as Vacation Pay Credit; Paid Holidays: New Year's Day; Memorial Day; Independence Day; Labor Day; Veteran's Day; Thanksgiving Day; plus the Friday after Thanksgiving; and Christmas Day.

ENGI0487-019 07/01/2016

	Rates	Fringes
OPERATOR: Backhoe/Excavator/Trackhoe.......	$ 23.75	9.20

ENGI0487-020 05/01/2016

	Rates	Fringes
OPERATOR: Concrete Pump.........	$ 26.04	9.23

ENGI0487-021 07/01/2016

	Rates	Fringes
OPERATOR: Crane		
All Cranes 160 Ton Capacity and Over...........	$ 33.05	9.20
All Cranes Over 15 Ton Capacity....................	$ 32.05	9.20
OPERATOR: Forklift..............	$ 23.25	9.20
OPERATOR: Mechanic..............	$ 32.05	9.20
OPERATOR: Oiler..................	$ 23.50	9.20

IRON0272-001 10/01/2015

	Rates	Fringes
IRONWORKER, STRUCTURAL...........	$ 24.21	8.28

IRON0402-001 10/01/2015

	Rates	Fringes
IRONWORKER, ORNAMENTAL...........	$ 22.34	10.15

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* PLUM0719-002 03/01/2017

	Rates	Fringes
PLUMBER.........................	$ 28.25	11.70

PAID HOLIDAYS: New Year's Day, Memorial Day, July 4th, Labor Day, Thanksgiving Day and Christmas Day providing the employee works the scheduled work day preceding and after the holiday.

PLUM0725-001 07/21/2016

	Rates	Fringes
PIPEFITTER (Includes HVAC Pipe, Unit and Temperature Controls Installations)	$ 42.26	11.50

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* SFFL0821-004 01/01/2017

	Rates	Fringes
SPRINKLER FITTER (Fire Sprinklers)	$ 26.98	18.17

SHEE0032-001 12/01/2013

	Rates	Fringes
SHEET METAL WORKER, Includes HVAC Duct Installation	$ 23.50	12.18

SUFL2014-005 08/16/2016

	Rates	Fringes
CEMENT MASON/CONCRETE FINISHER	$ 13.06	0.70
IRONWORKER, REINFORCING	$ 17.72	0.00
LABORER: Common or General, Including Cement Mason Tending	$ 12.79	0.00
LABORER: Pipelayer	$ 13.56	1.34
OPERATOR: Bulldozer	$ 15.40	1.90
OPERATOR: Grader/Blade	$ 18.97	0.00
OPERATOR: Loader	$ 16.00	2.82
OPERATOR: Roller	$ 14.43	4.78
PAINTER: Brush, Roller and Spray	$ 16.00	3.48
ROOFER	$ 19.98	4.77
TILE SETTER	$ 18.01	0.00
TRUCK DRIVER: Dump Truck	$ 13.22	2.12
TRUCK DRIVER: Lowboy Truck	$ 14.24	0.00

WELDERS - Receive rate prescribed for craft performing operation to which welding is incidental.

EXHIBIT B Prevailing Wage Determination

Note: Executive Order (EO) 13706, Establishing Paid Sick Leave for Federal Contractors applies to all contracts subject to the Davis-Bacon Act for which the contract is awarded (and any solicitation was issued) on or after January 1, 2017. If this contract is covered by the EO, the contractor must provide employees with 1 hour of paid sick leave for every 30 hours they work, up to 56 hours of paid sick leave each year. Employees must be permitted to use paid sick leave for their own illness, injury or other health-related needs, including preventive care; to assist a family member (or person who is like family to the employee) who is ill, injured, or has other health-related needs, including preventive care; or for reasons resulting from, or to assist a family member (or person who is like family to the employee) who is a victim of, domestic violence, sexual assault, or stalking. Additional information on contractor requirements and worker protections under the EO is available at www.dol.gov/whd/govcontracts.

Unlisted classifications needed for work not included within the scope of the classifications listed may be added after award only as provided in the labor standards contract clauses (29CFR 5.5 (a) (1) (ii)).

The body of each wage determination lists the classification and wage rates that have been found to be prevailing for the cited type(s) of construction in the area covered by the wage determination. The classifications are listed in alphabetical order of "identifiers" that indicate whether the particular rate is a union rate (current union negotiated rate for local), a survey rate (weighted average rate) or a union average rate (weighted union average rate).

Union Rate Identifiers

A four letter classification abbreviation identifier enclosed in dotted lines beginning with characters other than "SU" or "UAVG" denotes that the union classification and rate were prevailing for that classification in the survey. Example: PLUM0198-005 07/01/2014. PLUM is an abbreviation identifier of the union which prevailed in the survey for this classification, which in this example would be Plumbers. 0198 indicates the local union number or district council number where applicable, i.e., Plumbers Local 0198. The next number, 005 in the example, is an internal number used in processing the wage determination. 07/01/2014 is the effective date of the most current negotiated rate, which in this example is July 1, 2014.

Union prevailing wage rates are updated to reflect all rate changes in the collective bargaining agreement (CBA) governing this classification and rate.

Survey Rate Identifiers

Classifications listed under the "SU" identifier indicate that no one rate prevailed for this classification in the survey and the published rate is derived by computing a weighted average rate based on all the rates reported in the survey for that classification. As this weighted average rate includes all rates reported in the survey, it may include both union and non-union rates. Example: SULA2012-007 5/13/2014. SU indicates the rates are survey rates based on a weighted average calculation of rates and are not majority rates. LA indicates the State of Louisiana. 2012 is the year of survey on which these classifications and rates are based. The next number, 007 in the example, is an internal number used in producing the wage determination. 5/13/2014 indicates the survey completion date for the classifications and rates under that identifier.

Survey wage rates are not updated and remain in effect until a new survey is conducted.

Union Average Rate Identifiers

Classification(s) listed under the UAVG identifier indicate that no single majority rate prevailed for those classifications; however, 100% of the data reported for the classifications was union data. EXAMPLE: UAVG-OH-0010 08/29/2014. UAVG indicates that the rate is a weighted union average rate. OH indicates the state. The next number, 0010 in the example, is an internal number used in producing the wage determination. 08/29/2014 indicates the survey completion date for the classifications and rates under that identifier.

A UAVG rate will be updated once a year, usually in January of each year, to reflect a weighted average of the current negotiated/CBA rate of the union locals from which the rate is based.

WAGE DETERMINATION APPEALS PROCESS

1.) Has there been an initial decision in the matter? This can be:

* an existing published wage determination
* a survey underlying a wage determination
* a Wage and Hour Division letter setting forth a position on a wage determination matter
* a conformance (additional classification and rate) ruling

On survey related matters, initial contact, including requests for summaries of surveys, should be with the Wage and Hour Regional Office for the area in which the survey was conducted because those Regional Offices have responsibility for the Davis-Bacon survey program. If the response from this initial contact is not satisfactory, then the process described in 2.) and 3.) should be followed.

With regard to any other matter not yet ripe for the formal process described here, initial contact should be with the Branch of Construction Wage Determinations. Write to:

Branch of Construction Wage Determinations
Wage and Hour Division
U.S. Department of Labor
200 Constitution Avenue, N.W.
Washington, DC 20210

EXHIBIT B Prevailing Wage Determination

2.) If the answer to the question in 1.) is yes, then an interested party (those affected by the action) can request review and reconsideration from the Wage and Hour Administrator (See 29 CFR Part 1.8 and 29 CFR Part 7). Write to:

Wage and Hour Administrator
U.S. Department of Labor
200 Constitution Avenue, N.W.
Washington, DC 20210

The request should be accompanied by a full statement of the interested party's position and by any information (wage payment data, project description, area practice material, etc.) that the requestor considers relevant to the issue.

3.) If the decision of the Administrator is not favorable, an interested party may appeal directly to the Administrative Review Board (formerly the Wage Appeals Board). Write to:

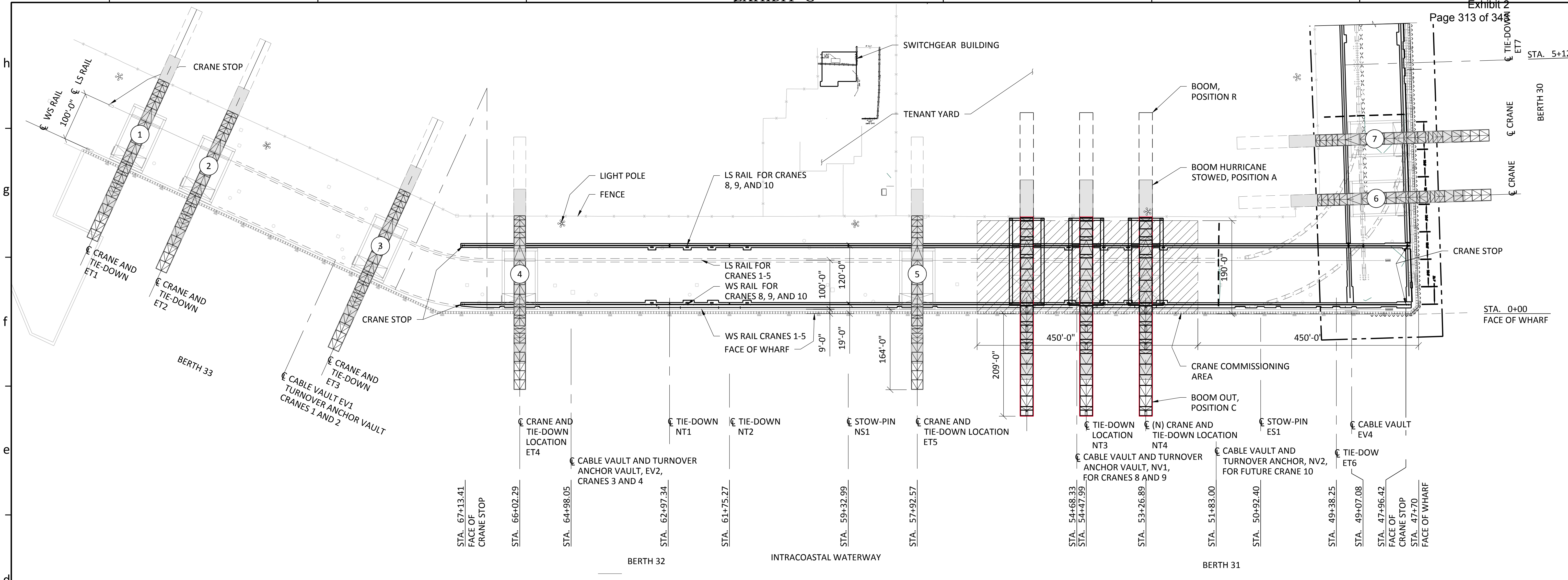
Administrative Review Board
U.S. Department of Labor
200 Constitution Avenue, N.W.
Washington, DC 20210

4.) All decisions by the Administrative Review Board are final.

==

END OF GENERAL DECISION

EXHIBIT C



SITE PLAN (1 / G1.1)
1" = 100'-0"

LEGEND

(N)	NEW
LS	LANDSIDE
WS	WATERSIDE
(#)	(E) CRANE NUMBER
	(N) CRANE NUMBER
	LIGHT POLE
ET	EXISTING CRANE TIE-DOWN LOCATION
ES	EXISTING CRANE STOWAGE LOCATION
EV	EXISTING CABLE VAULT AND TURNOVER ANCHOR
NT	NEW CRANE TIE-DOWN LOCATION
NS	NEW CRANE STOWAGE LOCATION
NV	NEW CABLE VAULT AND TURNOVER ANCHOR

NOTE:

1. CRANE 8, 9, AND 10 ARE NEW CRANES TO BE PROVIDED UNDER BASE ORDER.
2. STA 2+37.23 = 237.23' FROM REFERENCE +0.00.
3. NS1, NT1, NT2, NT3, NT4, ARE FOR CRANES 8, 9, AND 10.

No.	Revision	Date	By	Checked	Approved

0' 100' 200' 300'
SCALE: 1" = 100'

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5/4/2016

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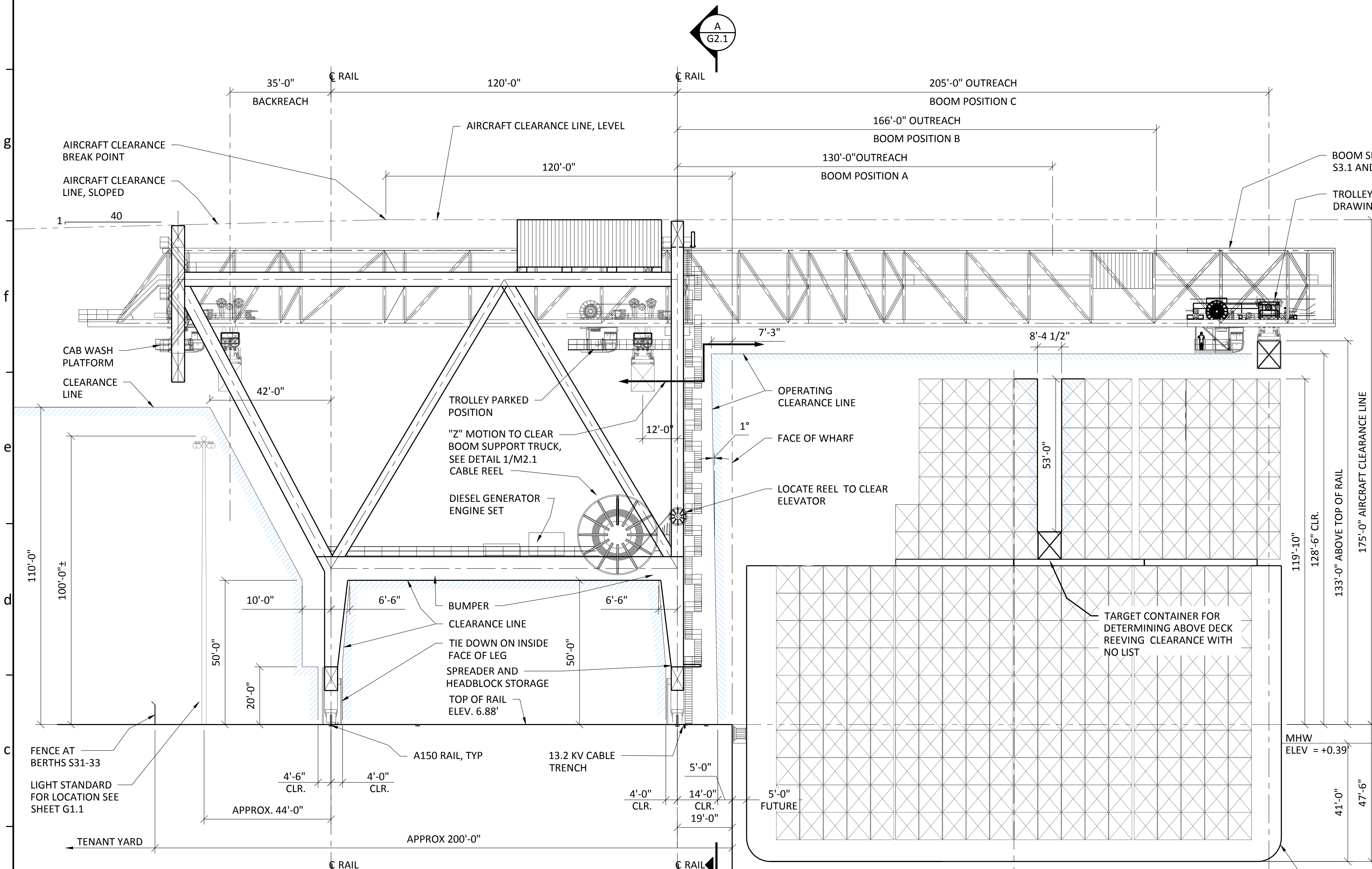
PORT EVERGLADES LOW PROFILE CRANES

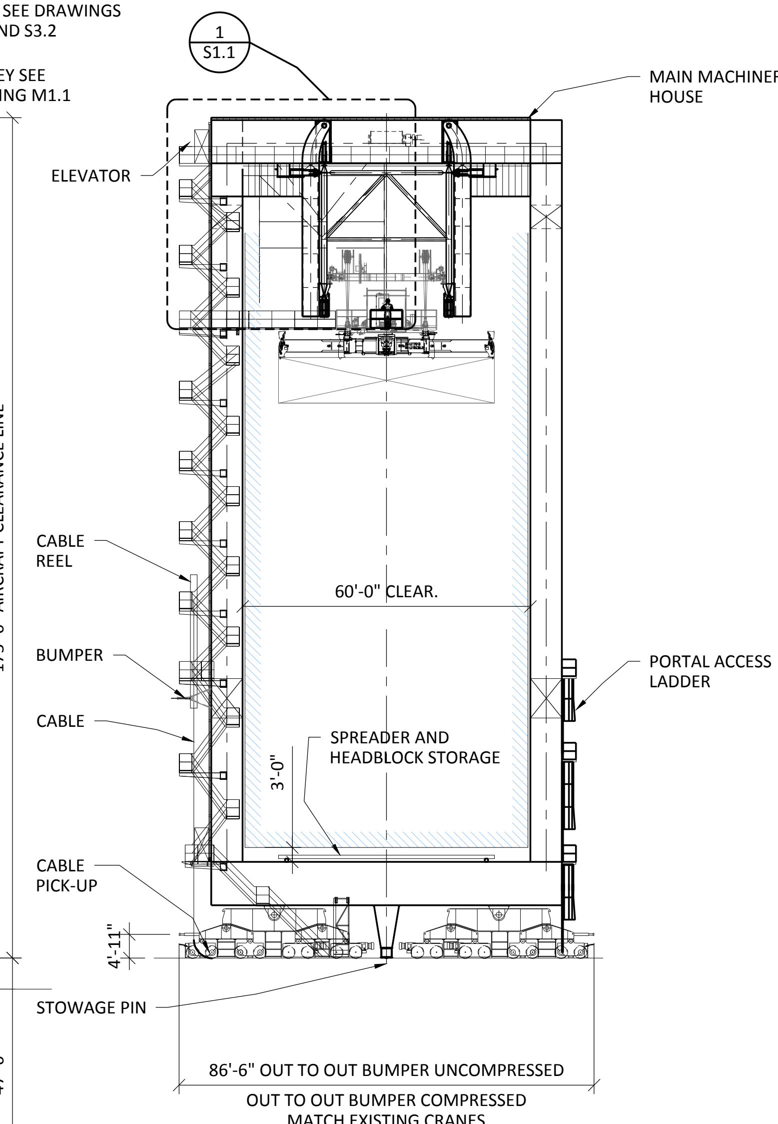
SITE AND CRANE LOCATION PLAN

Project No.	2031				
By	AH	Checked	SH/AB	Sheet No.	G1.1
Approved	MJ			of	14
Date	9/24/14			Revision	----

O:\2031\Dwg\Current\G1.1 Site and Crane Location Plan.dwg 5/4/2016 4:49 PM ALVIN HOFFPAUIR



GENERAL ARRANGEMENT -OPERATING MODE 1/G2.1
1" = 20'-0"



WATERSIDE ELEVATION A/G2.1
1" = 20'-0"

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5/4/2016

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PORT EVERGLADES LOW PROFILE CRANES

GENERAL ARRANGEMENT AND CLEARANCES, POSITIONS A, B AND C

Project No.	2031				
By	AH	Checked	SH/AB	Sheet No.	G2.1
Approved	MJ			of	14
Date	9/24/14			Revision	----

No.	Revision	Date	By	Checked	Approved

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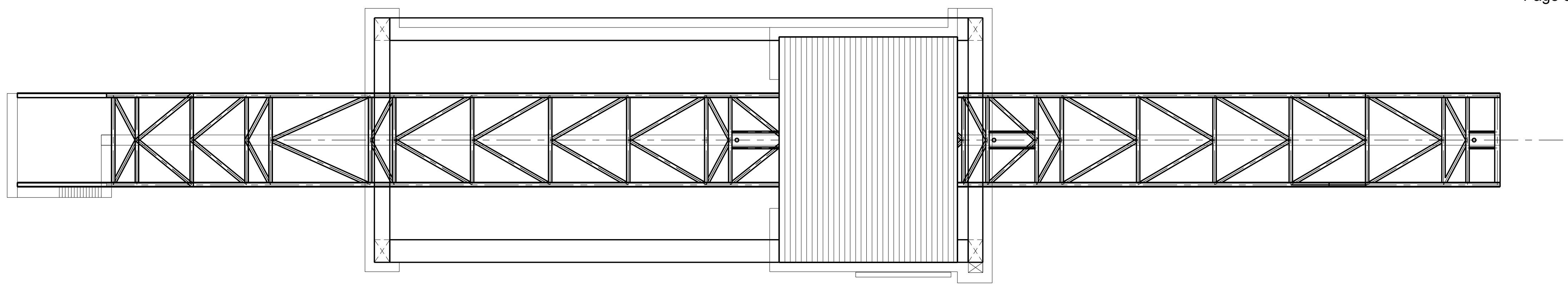
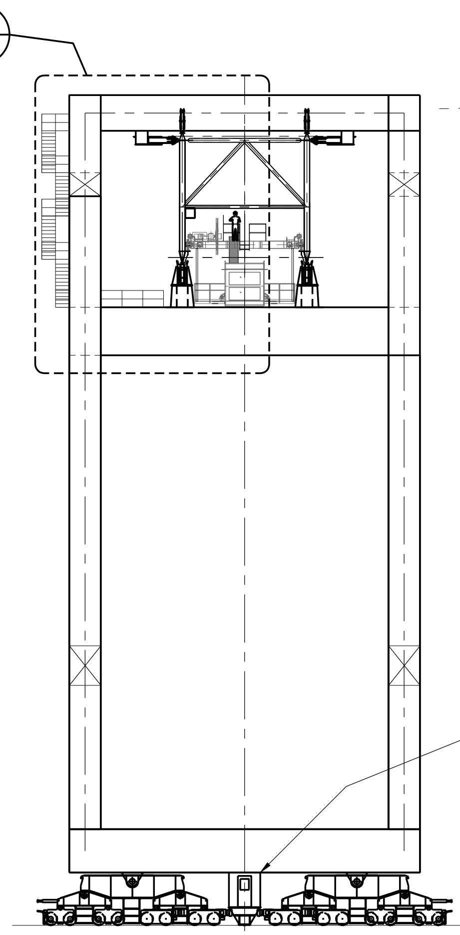
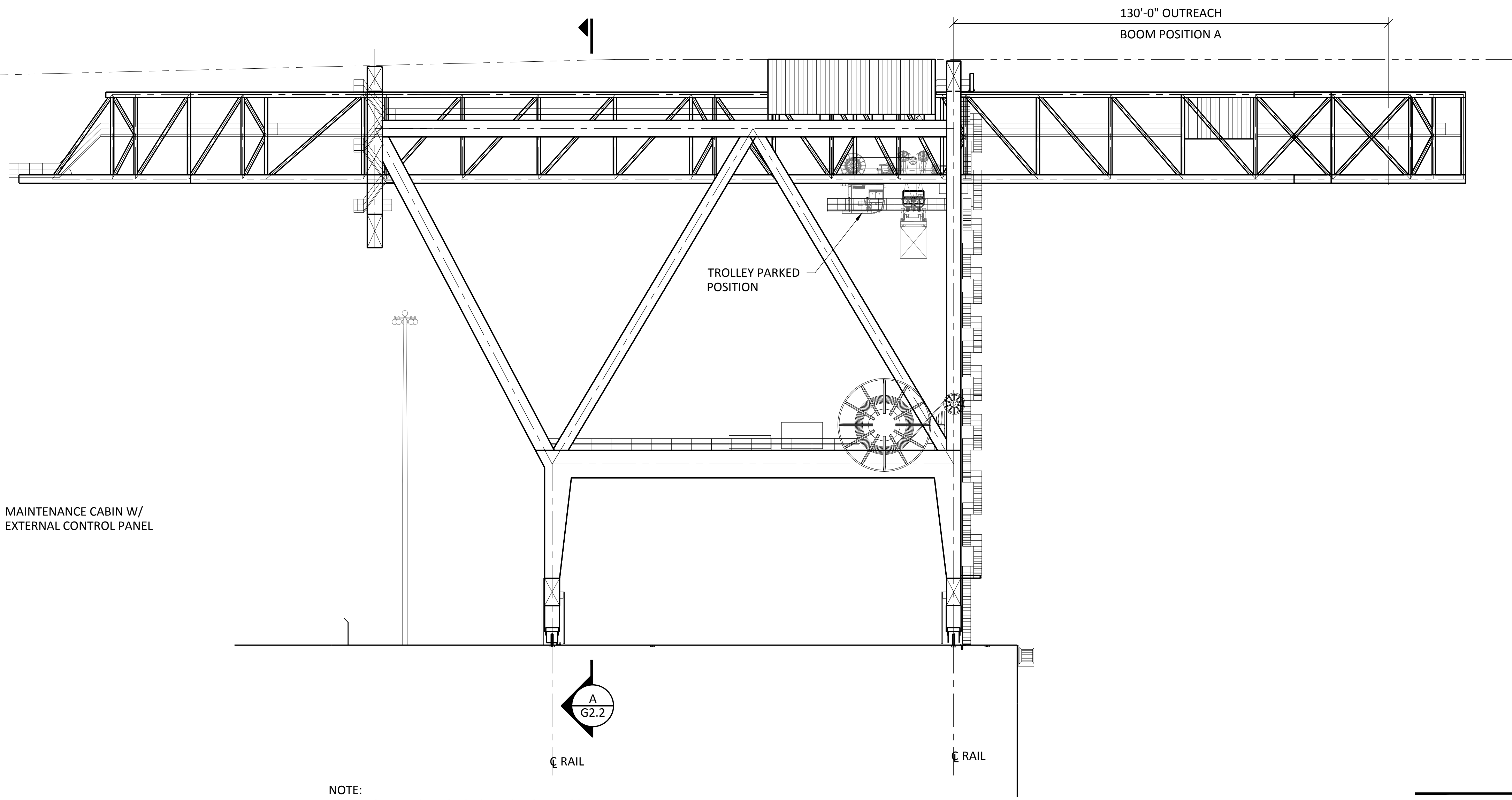




LANDSIDE ELEVATION (A / G2.2)
1" = 20'-0"



NOTE:
FOR INFORMATION NOT SHOWN SEE SHEET G2.1

GENERAL ARRANGEMENT - STOWED MODE (1 / G2.2)
1" = 20'-0"

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5/4/2016

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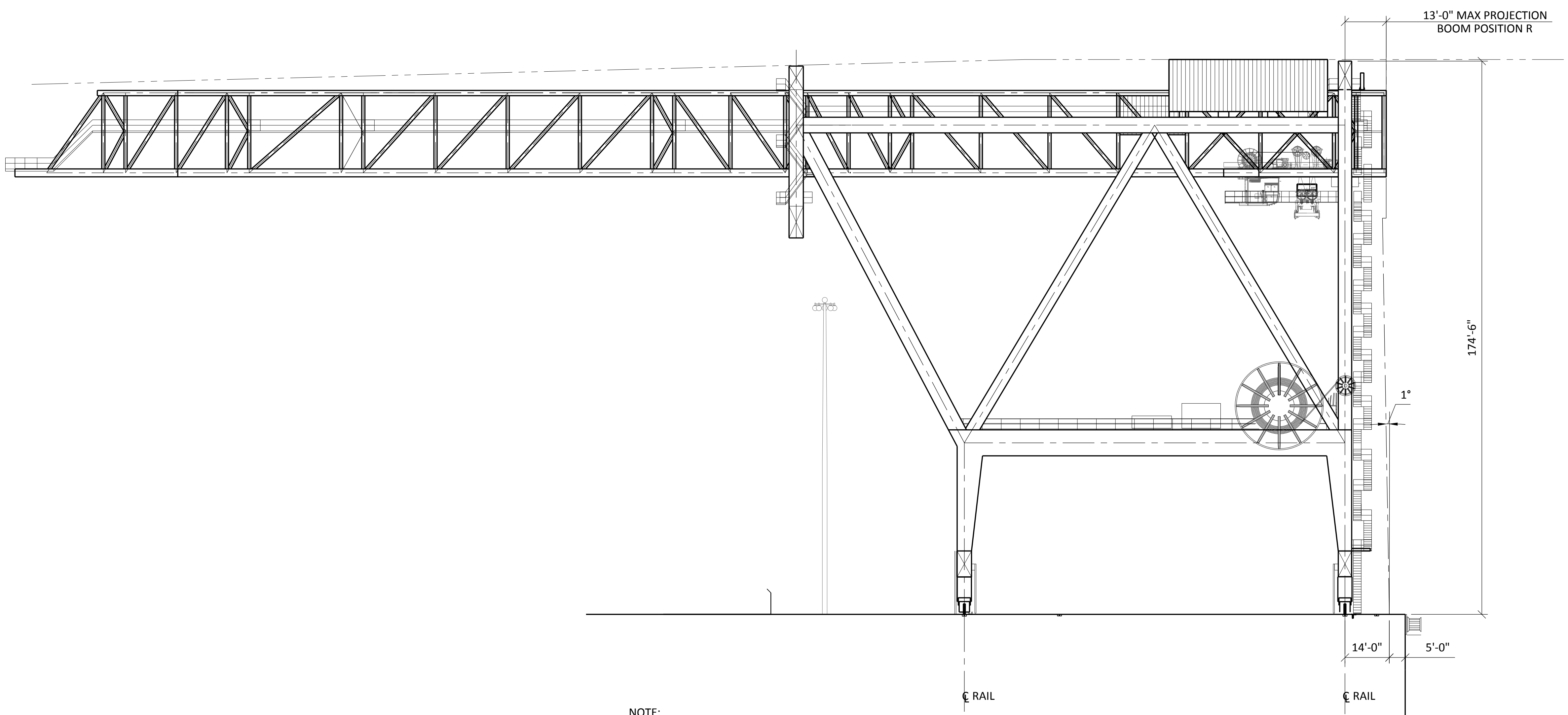
PORT EVERGLADES
LOW PROFILE CRANES

GENERAL ARRANGEMENT,
STOWED MODE - POSITION A

Project No.	2031				
By	AH	Checked	SH/AB	Sheet No.	G2.2
Approved	MJ			of	14
Date	9/24/14			Revision	----

No.	Revision	Date	By	Checked	Approved



NOTE:
FOR INFORMATION NOT SHOWN SEE SHEET G2.1

GENERAL ARRANGEMENT - PASSING MODE 1 / G2.3
1" = 20'-0"

No.	Revision	Date	By	Checked	Approved

PRINTED
5/4/2016

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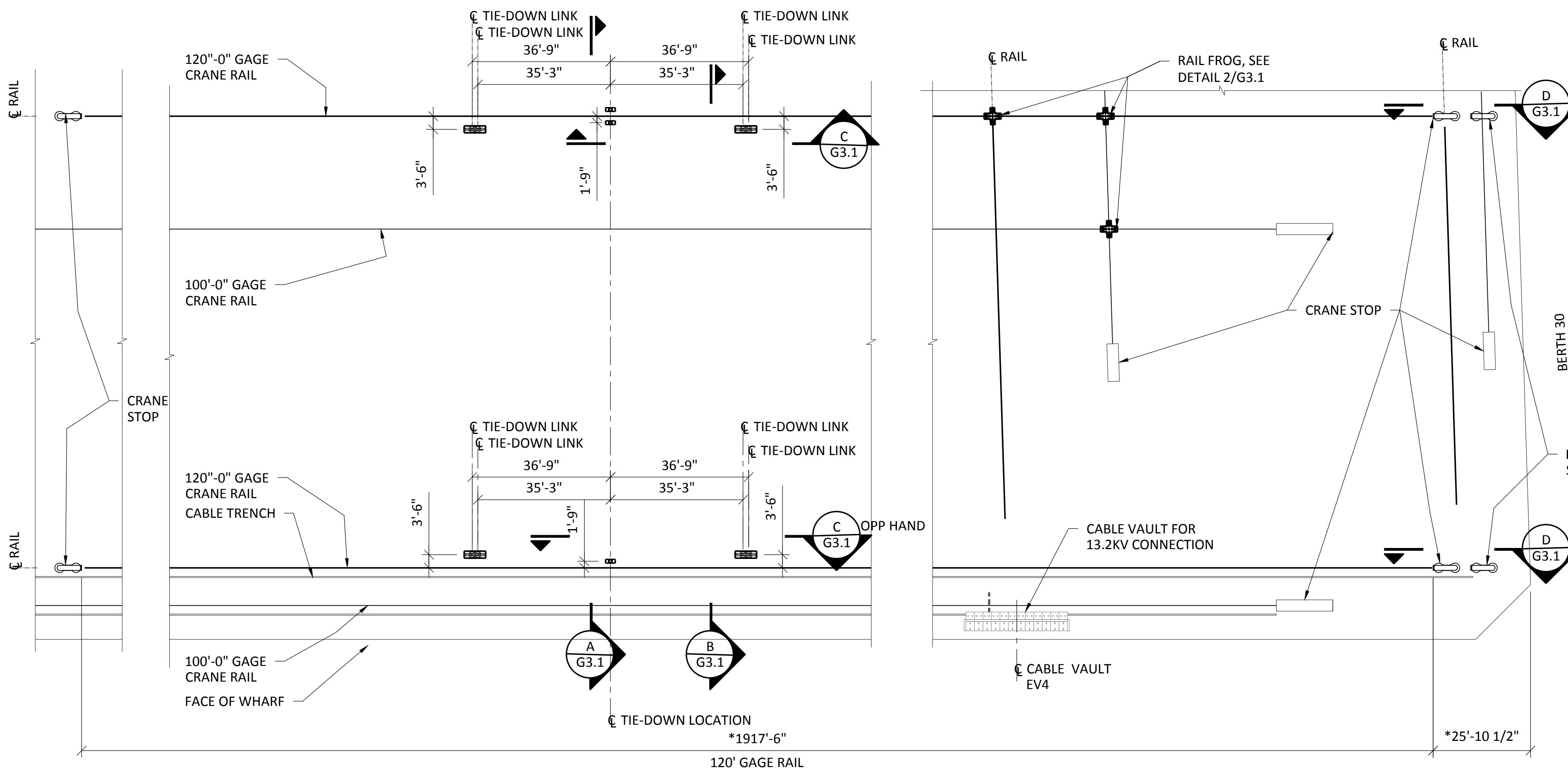
PORT EVERGLADES
LOW PROFILE CRANES

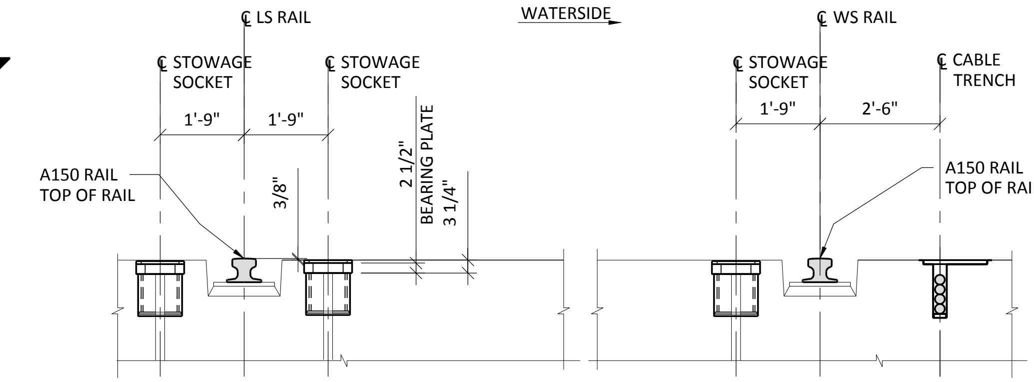
GENERAL ARRANGEMENT,
PASSING MODE - POSITION R

Project No. 2031			
By AH	Checked SH/AB	Sheet No.	G2.3
Approved MJ		of	14
Date 9/24/14		Revision	----

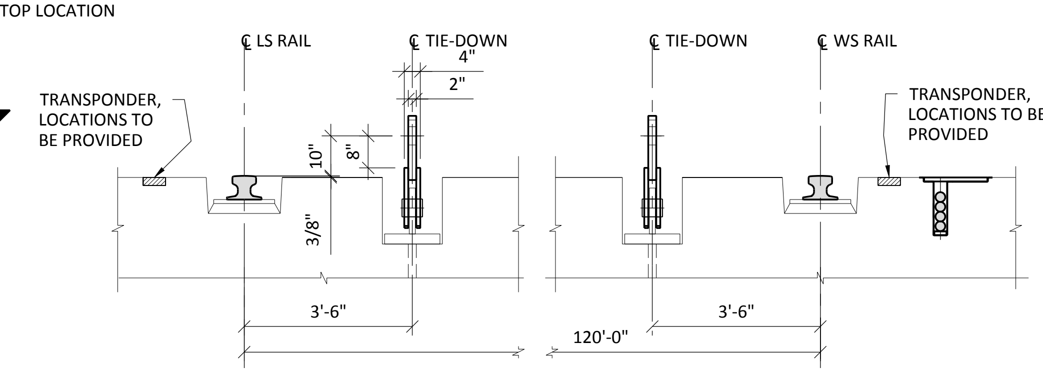
O:\2031\Dwg\Current\G2.3 General Arrangement, Passing Mode - Position R.dwg 5/4/2016 4:50 PM ALVIN HOFFPAUIR



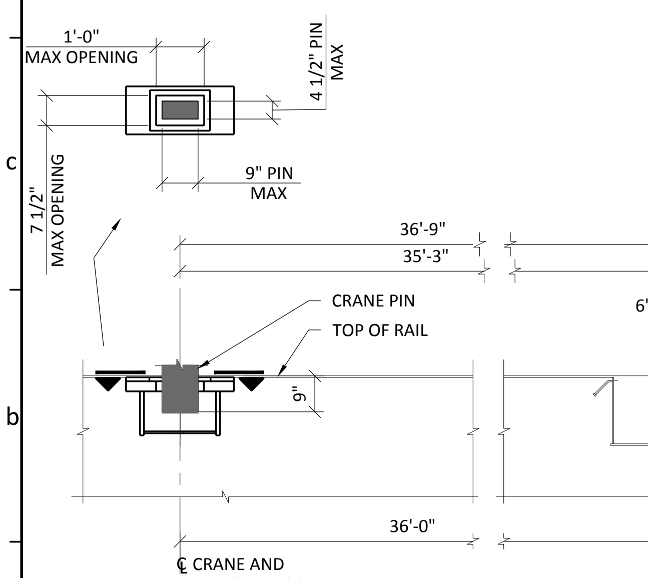
TIE-DOWN LOCATION PLAN 1/G3.1
1" = 20'-0"



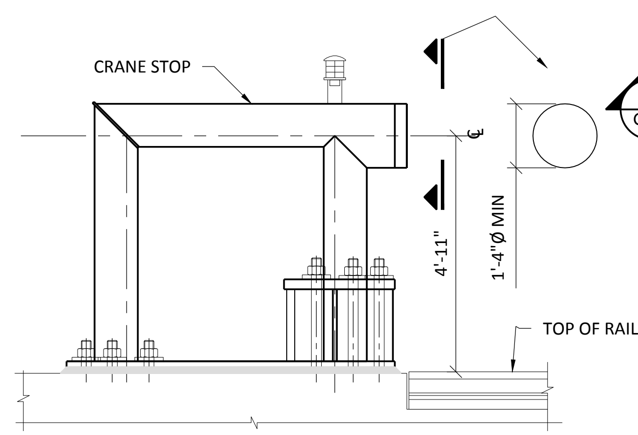
SECTION A/G3.1
1/2" = 1'-0"



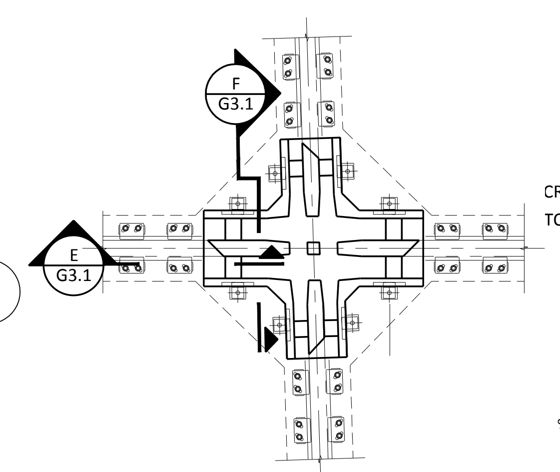
SECTION B/G3.1
1/2" = 1'-0"



SECTION C/G3.1
1/2" = 1'-0"

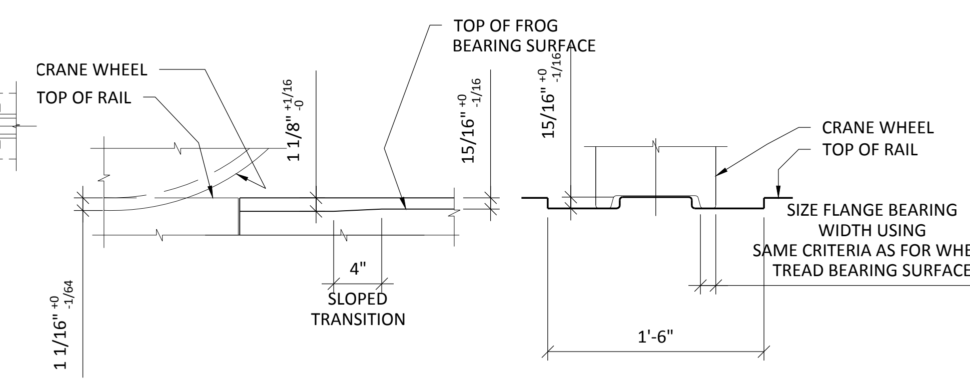


CRANE STOP ELEVATION D/G3.1
1/2" = 1'-0"



RAIL FROG 2/G3.1
NOT TO SCALE

NOTE:
CRANE WHEEL NOTE
SHOWN FOR CLARITY



SECTION E/G3.1
1 1/2" = 1'-0"

SECTION F/G3.1
1-1/2" = 1'-0"

NOTE:
* FOR DETAIL DIMENSIONS SEE REFERENCE DRAWINGS LISTED IN APPENDIX C OF THE SPECIFICATIONS.

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5/4/2016

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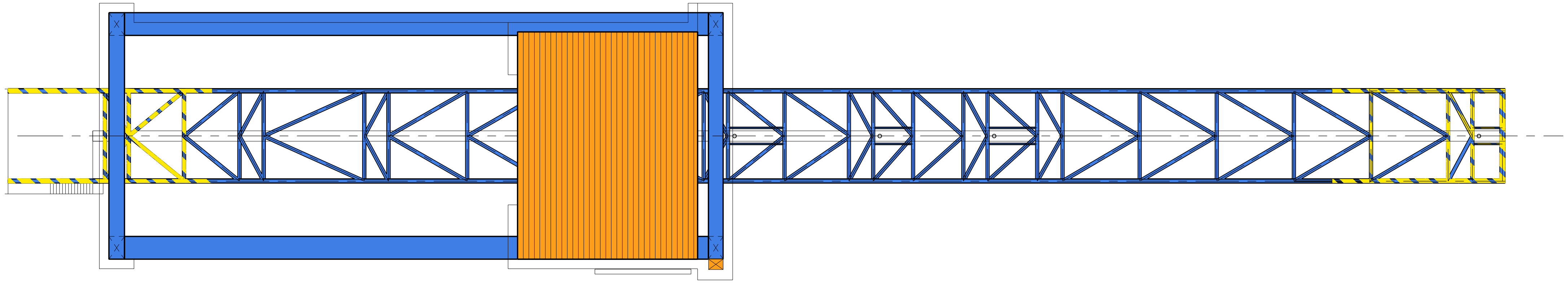
PORT EVERGLADES
LOW PROFILE CRANES

CRANE TO WHARF
INTERFACES

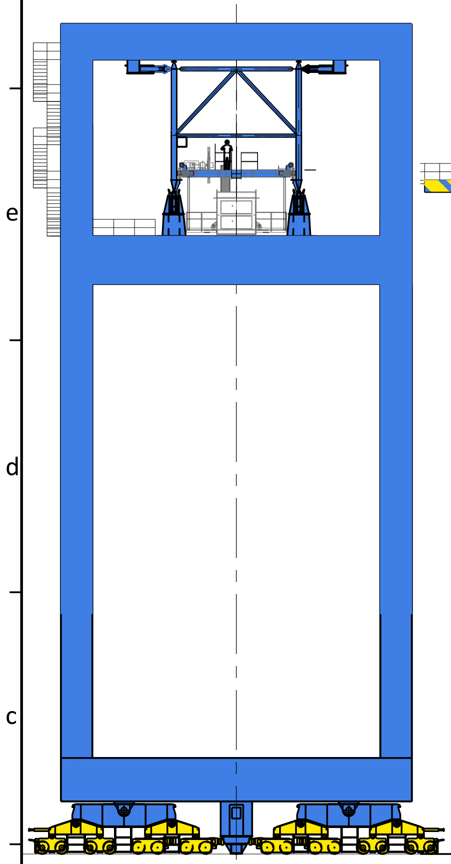
Project No. 2031			
By AH	Checked SH/AB	Sheet No.	G3.1
Approved MJ		of	14
Date 9/24/14		Revision	----

No.	Revision	Date	By	Checked	Approved

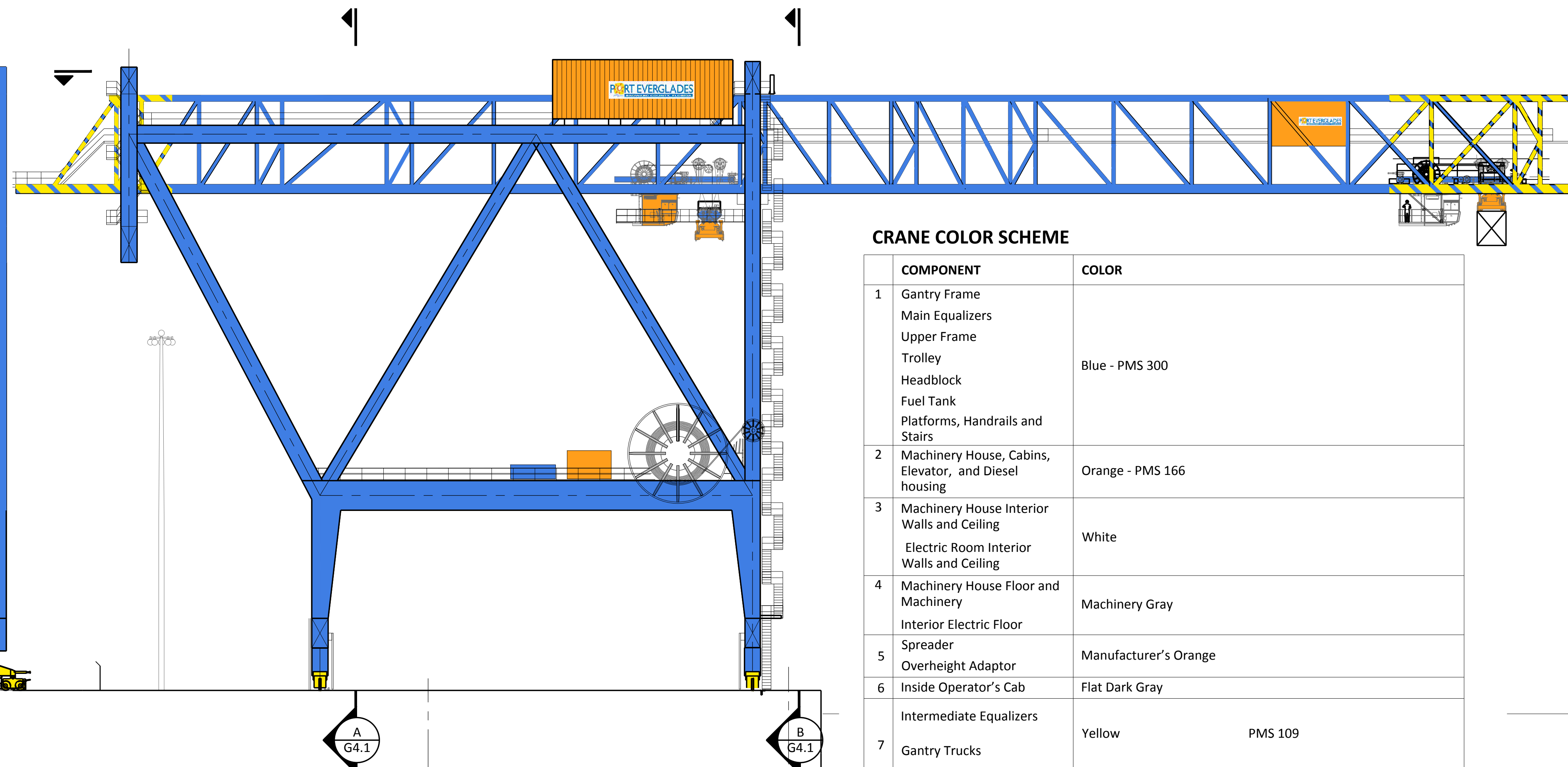
O:\2031\Dwg\Current\G3.1 Crane to Wharf Interfaces.dwg 5/4/2016 4:50 PM ALVIN HOFFPAUIR



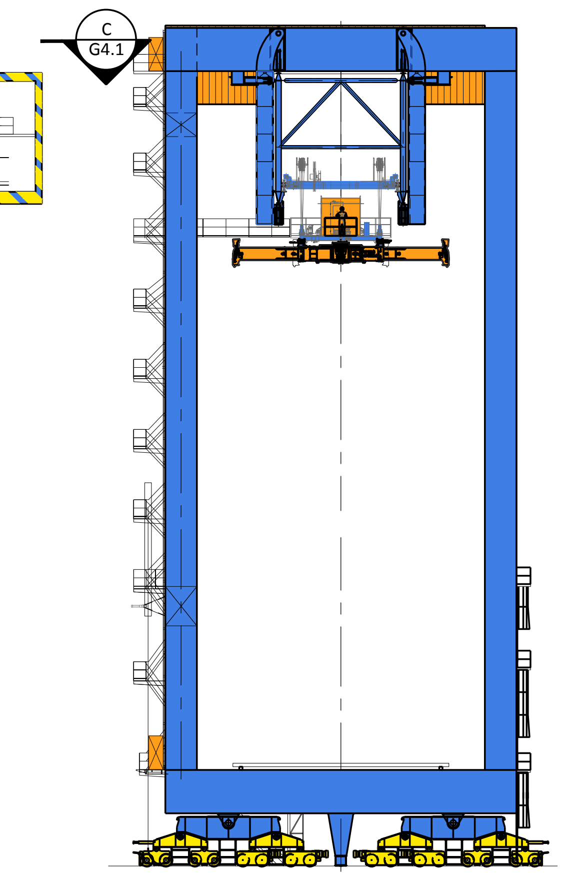
PLAN
1" = 20'-0"
C G4.1



LANDSIDE ELEVATION
1" = 20'-0"
A G4.1



ELEVATION
1" = 20'-0"
1 G4.1



WATERSIDE ELEVATION
1" = 20'-0"
B G4.1

CRANE COLOR SCHEME

	COMPONENT	COLOR
1	Gantry Frame Main Equalizers Upper Frame Trolley Headblock Fuel Tank Platforms, Handrails and Stairs	Blue - PMS 300
2	Machinery House, Cabins, Elevator, and Diesel housing	Orange - PMS 166
3	Machinery House Interior Walls and Ceiling Electric Room Interior Walls and Ceiling	White
4	Machinery House Floor and Machinery Interior Electric Floor	Machinery Gray
5	Spreader Overheight Adaptor	Manufacturer's Orange
6	Inside Operator's Cab	Flat Dark Gray
7	Intermediate Equalizers Gantry Trucks Boom End Sections	Yellow PMS 109 Striped yellow
8	PED Logo PORT EVERGLADES BROWARD COUNTY, FLORIDA	Yellow - PMS 109 - the sun's glow Blue - PMS 300 - the word Broward, the bar containing the word Florida and the wave (The wave has a 30% screen) Orange - PMS 166 - the sun, sun rays and the word County

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PORT EVERGLADES
LOW PROFILE CRANES

CRANE PAINT SCHEME AND LOGOS

Project No. 2031
By AH Checked SH/AB Sheet No. G4.1
Approved MJ of 14
Date 9/24/14 Revision ----

No.	Revision	Date	By	Checked	Approved

O:\2031\Dwg\Current\G4.1 Crane paint scheme and logos.dwg 5/4/2016 4:50 PM ALVIN HOFFPAUIR

DRAWINGS

THE DRAWINGS INCLUDE LAYOUTS SHOWING THE REQUIRED STRUCTURAL FUNCTIONS OF MAJOR COMPONENTS. THE DRAWING NOTES EXPLAIN THE FUNCTIONS AND STATE SOME DETAILED REQUIREMENTS. SOME OF THE DRAWING CONCEPTS ARE COPIED FROM THE SAMSUNG HEAVY INDUSTRIES (SHI) 40 LT EVERGLADES LP C/C DRAWING SET OWNED BY PED. SINCE THE LOADS APPLIED TO THE NEW CRANES ARE LARGER THAN THOSE FOR THE SAMSUNG CRANES, THE NEW SECTIONS WILL BE LARGER.

THE CONTRACTOR MAY USE ARRANGEMENTS OTHER THAN THOSE SHOWN ON THE DRAWINGS, PROVIDED THE FUNCTIONS AND REQUIREMENTS NOTED IN THE SPECIFICATIONS AND ON THE DRAWINGS ARE MET.

DRAWING NOTES

DRAWING NOTES ARE INCLUDED IN THE SPECIFICATIONS, SECTION 3.3, AND REPEATED ON THE DRAWINGS. THE SHI DRAWING SHEET NUMBERS ARE NOTED FOR THE CONTRACTOR'S ASSISTANCE. THESE DRAWING NOTES SUPPLEMENT THE TECHNICAL PROVISIONS, SECTION 4.13.

SHEETS1.1 WATERSIDE BOOM SUPPORT HANGER AND LATCH

1 S1.1 — BOOM SUPPORT HANGERS SHALL CARRY THE DOWNWARD VERTICAL LOADS FROM THE BOOM TO THE SUPPORT BEAM. FULLY EQUALIZED WHEELS SHALL SUPPORT THE BOOM. ECCENTRIC BUSHINGS SHALL ALLOW FOR ADJUSTMENTS IN ROTATION ABOUT THE Y AXIS, IN TRANSLATION ALONG THE Y AXIS, AND IN THE SUPPORT WHEEL GAGE. ROLLING FRICTION LOADS FROM THE BOOM SUPPORT WHEELS AND DUE TO THE INCLINATION OF THE BOOM SUPPORT TRUCKS SHALL ALSO BE TAKEN BY THE HANGER. INCLINATION OF THE BOOM SUPPORT TRUCK ABOUT THE Z AXIS, SHALL NOT EXCEED ONE PERCENT. SEE SHI DRAWING 26276. THE HANGERS SHALL NOT CARRY THE BOOM WIND OR INERTIA LOADS. THESE LOADS SHALL BE CARRIED BY THE SIDE ROLLERS IN THE Z DIRECTION. IN THE X DIRECTION WIND AND INERTIA LOADS SHALL BE CARRIED BY THE TOW ROPES WHEN THE BOOM IS NOT LATCHED AND BY THE LATCH WHEN IT IS LATCHED. THE GAGE OF THE BOOM SUPPORT WHEELS SHALL NOT CHANGE WHEN THE FRAME DEFLECTS. IF A DIFFERENT BOOM SUPPORT SYSTEM IS PROPOSED, IT SHALL BE STABLE, AND SHALL NOT REQUIRE LATERAL SUPPORT AT THE BOOM SUPPORT WHEELS.

2 S1.1 — SIDE ROLLERS SHALL BE MECHANICALLY EQUALIZED AND TRANSMIT BOOM LATERAL Z LOADS FROM THE BOOM UPPER CHORDS, OR FLANGE, TO THE BOOM SUPPORT BEAM. AN ELASTOMERIC PAD SHALL BE PLACED BETWEEN THE ROLLER BASE PLATE AND THE BRACKET PLATE TO CUSHION LATERAL IMPACT FORCES. SINCE THE ROLLERS SHOULD REMAIN IN CONTACT OR NEAR CONTACT WITH THE UPPER CHORD OR FLANGE, SHIM PLATES MAY BE USED TO PROVIDE ADJUSTMENT. AT ALL LATCHED POSITIONS, THE CLEARANCE BETWEEN THE SIDE ROLLERS AND THE CHORD OR FLANGE SHALL NOT EXCEED 1/8 IN. WHEN THE BOOM IS BETWEEN LATCHED POSITIONS, THE CLEARANCE SHALL NOT EXCEED 1/2 IN. SEE SHI 26301 FOR TYPICAL DETAILS.

3 S1.1 — BOOM HOLD DOWN ROLLERS SHALL RESIST UPWARD VERTICAL LOADS FROM THE BOOM. HOLD DOWN ROLLERS SHALL BE FLANGELESS, SO THE LATERAL LOADS IN THE Z DIRECTION WILL BE TRANSFERRED BY THE SIDE ROLLERS ONLY. AT POSITIONS A, B, AND C, THE LANDSIDE HOLD DOWN WHEELS SHALL BE IN CONTACT WITH THE RAIL AND PRELOADED SO THE BOOM DOES NOT LIFT OFF OF THE BOOM SUPPORT WHEELS. THIS HOLD DOWN CONCEPT SHALL BE DIFFERENT FROM THAT ON THE EXISTING CRANES. THE SPACE BETWEEN THE WHEELS AND THE RAIL SHALL BE ADJUSTABLE. THE PRELOAD SHALL BE APPLIED AFTER THE BOOM IS LATCHED, AND RELEASED BEFORE THE BOOM IS UNLATCHED. ONE ACCEPTABLE CONCEPT IS SHOWN. TWO WHEELS ARE SUPPORTED ON AN EQUALIZING LINKAGE. A HORIZONTAL STRUT, CONNECTING TWO LEVERS, PASSES THROUGH THE HEADER BEAM IN A TUBE.TUBE.

4 S1.1 — HANGER SHEAR BLOCKS SHALL FIT NEATLY SO THAT GAP IS SMALL, COMPARABLE TO THAT OF THE EXISTING CRANE. THE STRESSES DUE TO FLEXING OF PLATES, INCLUDING P-DELTA EFFECTS WHEN THE HANGER SHIFTS TO CLOSE THE GAP, SHALL BE INCLUDED. SEE SHI DRAWING 26283 FOR CLEARANCES AND OTHER DETAILS.

5 S1.1 — HANGER PIN IN THE HEADER BEAM AND THE ECCENTRIC BUSHINGS SHALL PROVIDE THE ABILITY FOR THE HANGER PIN TO ROTATE ABOUT THE Y AXIS, TO BE RAISED OR LOWERED, AND TO ADJUST THE SUPPORT WHEEL GAGE. ONCE THE ADJUSTMENTS ARE COMPLETE, THE BUSHINGS SHALL BE LOCKED. SEE SHI DRAWINGS 76272FF.

6 S1.1 — ECCENTRIC BUSHINGS AT THE TRUCK PINS SHALL BE USED TO PROVIDE FOR SMALL VERTICAL ADJUSTMENTS OF THE BOOM SUPPORT WHEEL ELEVATIONS. SEE SHI DRAWING 26273.

7 S1.1 — BOOM SUPPORT WHEELS SHALL BE MECHANICALLY EQUALIZED AND SHALL HAVE ENOUGH WIDTH SO THE FLANGES DO NOT ENGAGE DURING NORMAL OPERATIONS. LATERAL LOADS FROM THE BOOM SHALL NOT BE TRANSFERRED AT THE BOOM SUPPORT WHEELS--SEE NOTE 2/S1.1.

8 S1.1 — BOOM HANGER SIDE SUPPORT ROLLERS KEEP THE HANGERS VERTICAL IF THE BOOM LIFTS OFF THE WHEELS. THE SIDE SUPPORT SHALL BE SPRING LOADED AND EASILY ADJUSTABLE. THE SUPPORT WHEEL FLANGES SHALL NOT ENGAGE DURING NORMAL OPERATIONS. SEE SHI DRAWING 26273.

9 S1.1 — BOOM SIDE GUIDES SHALL PREVENT THE HANGER FROM SWINGING OUTWARD, AWAY FROM THE BOOM, WHEN THE BOOM SUPPORT WHEELS ARE UNLOADED. SEE SHI DRAWING 26273.

10 S1.1 — THE BOOM LATCH SHALL HOLD THE BOOM ACCURATELY IN THE INTENDED POSITION. WHILE THE BOOM IS TRAVELING, THE LOADS IN THE X DIRECTION SHALL BE TAKEN BY THE TOW ROPES. ONCE THE BOOM IS NEAR A LATCHED POSITION, THE LATCH LOWERS INTO THE LATCH SOCKET. AS THE LATCH IS PUSHED INTO THE SOCKET, THE ROLLERS ON THE ENDS OF THE LINKS PUSH THE BOOM LONGITUDINALLY TO THE INTENDED POSITION. ONCE THERE, THE BOOM LATCH IS FULLY LOWERED AGAINST THE STOP BLOCK. SINCE THE BOOM LATCH IS AN OVER CENTER DEVICE, ONCE IT IS FULLY LOWERED, LONGITUDINAL FORCES DO NOT TEND TO DISENGAGE IT. SEE SHI DRAWING 26305. THE DEVICE SHALL BE BOLTED TO THE HEADER BEAM SO IT CAN BE ADJUSTED. SEE SHI DRAWING 26295. ANOTHER DEVICE THAT IS SELF-LOCKING AND FAIL SAFE MAY BE USED, PROVIDED IT PERFORMS AS WELL AS THE SHI DEVICE.

SHEET S2.1 LANDSIDE O-FRAME AND BOOM SUPPORT AND PLATFORM LAYOUT.

1 S2.1 — BOOM SUPPORT TRUCKS SHALL CARRY THE DOWNWARD VERTICAL LOADS FROM THE BOOM. THE DESIGN SHALL COMPLY WITH THE APPLICABLE PROVISIONS FOR THE WATERSIDE BOOM SUPPORT. SOME ABILITY TO ADJUST THE WHEEL ALIGNMENT SHALL BE PROVIDED; HOWEVER, ADJUSTABLE BUSHINGS AND SIDE GUIDES ARE NOT REQUIRED.

2 S2.1 — SIDE ROLLERS: SEE NOTE 2/S1.1

3 S2.1 — BOOM HOLD DOWN ROLLERS: SEE NOTE 3/S1.1. THE RAIL SHALL CONTACT THE LANDSIDE HOLD DOWN ROLLERS WHEN THE BOOM IS IN AN OPERATION POSITION.

4 S2.1 — BOOM SUPPORT WHEELS SHALL BE MECHANICALLY EQUALIZED AND SHALL HAVE ENOUGH WIDTH SO THE FLANGES DO NOT ENGAGE DURING NORMAL OPERATIONS. LATERAL LOADS FROM THE BOOM SHALL NOT BE TRANSFERRED AT THE BOOM SUPPORT WHEELS. SEE NOTE 7/S1.1.

SHEET S3.1 BOOM LAYOUT

1 S3.1 — HANGER FAILURE CRITERIA: THE SPECIFICATIONS REQUIRE THAT THE BOOM WILL NOT COLLAPSE IF ONE WATERSIDE HANGER FAILS. THIS INDUCES TORSION MOMENTS ABOUT THE Z AXIS ACROSS THE BOOM. IF THE BOOM STRUCTURE IS A TRUSS, TORSION FRAMING BETWEEN THE SIDE TRUSSES IS REQUIRED SO THAT THE UNSUPPORTED SIDE TRUSS IS RESTRAINED FROM ROTATING EXCESSIVELY RELATIVE TO THE OTHER TRUSS. THE TORSION FRAMING MAY BE A SPACE TRUSS CONSISTING OF THE UPPER CHORD BRACING, THE VERTICAL SIDE TRUSSES, PANEL BRACING, AND BRACING IN THE PLANE OF THE LOWER HORIZONTAL PANEL BRACE. TORSION FRAMING HAS BEEN USED SUCCESSFULLY ON SEVERAL LOW PROFILE BOOMS. OTHER STRUCTURAL SOLUTIONS MAY BE USED. THE STRUCTURE MAY HAVE ANY COMPLIANT FRAMING AND MAY BE LOCATED ANYWHERE ALONG THE BOOM. THE CRANE DOES NOT NEED TO BE OPERATIONAL AFTER THE HANGER FAILURE EVENT. HOWEVER, THE INTACT HANGER AND THE DIAGONALLY OPPOSITE HOLD DOWN SHALL BE ABLE TO SUPPORT LOADS CAUSED BY THE HANGER FAILURE AND THE BOOM TRAVEL DRIVE SHALL BE ABLE TO BE BRING THE BOOM TO POSITION R.

SHEET S3.2 BOOM DETAILS

1 S3.2 — HOLD DOWN RAILS SHALL BE PLACED ON THE UPPER CHORD. PREFERABLY, IT WILL BE INTEGRAL WITH THE CHORD. THE HEIGHT OF THE RAIL MAY VARY TO SUIT CONDITIONS AT EACH LATCHED POSITION. THE BEARING SURFACE OF THE RAIL SHALL BE SMOOTH, AND A TRANSITION IN HEIGHT SHALL NOT CAUSE IMPACT LOADS. THE BOOM UPPER CHORD RAIL SHALL EXTEND ALONG THE BOOM CHORD FAR ENOUGH SO THE ROLLERS WILL ENGAGE THE RAILS FOR A LOAD DUE TO 0.90 TIMES ALL LOADS THAT REDUCE THE UPLIFT FORCE PLUS 1.10 TIMES ALL LOADS THAT INCREASE THE UPWARD FORCE WITH THE BOOM AT ANY OUTREACH, NOT NECESSARILY AT A LATCHED POSITION, AND THE UNLOADED TROLLEY AND LIFT SYSTEM IN ANY LOCATION.

2 S3.2 — AS DESCRIBED IN NOTE 2/S1.1 LATERAL LOADS PARALLEL TO THE GANTRY TRAVEL DIRECTION SHALL BE TAKEN FROM THE UPPER CHORD TO THE SIDE ROLLERS. THE SIDE ROLLERS MAY BEAR DIRECTLY ON THE FLANGE PLATE EDGE. SEE NOTE 2/S1.1.

3 S3.2 — ALL WELDS ON PRIMARY BOOM MEMBERS SHALL BE ABLE TO BE INSPECTED AND REPAIRED FROM THE OUTSIDE. BUTT WELDS ON PRIMARY BOOM MEMBERS SHALL BE COMPLETE JOINT PENETRATION WELDS WHEREVER A MEMBER IS SPLICED OR WHERE THERE IS THROUGH THICKNESS STRESS. THE WELDS BETWEEN THE BOOM RAILS AND THE FLANGE PLATES MAY BE FILLET WELDS, PROVIDED THE CONTACT BEARING SURFACES HAVE AT LEAST 75% FIRM BEARING.

4 S3.2 — THE WELD BETWEEN THE TROLLEY RAIL BED AND THE VERTICAL WEB PLATE SHALL BE A CJP WELD. THE WELD SHALL BE IMPROVED BY GRINDING. TOE GRINDING SHALL COMPLY WITH BS 7608-2014. THE PORTION OF THE WELD BETWEEN THE TOE GRINDINGS SHALL BE GROUND TO A SMOOTH RADIUS WITH THE DIRECTION OF GRINDING PERPENDICULAR TO THE RAIL AXIS.

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BOOM DESIGN NOTES

Project No. 2031			
By AH	Checked SH/AB	Sheet No.	S1.0
Approved MJ		of	14
Date 9/24/14		Revision	----

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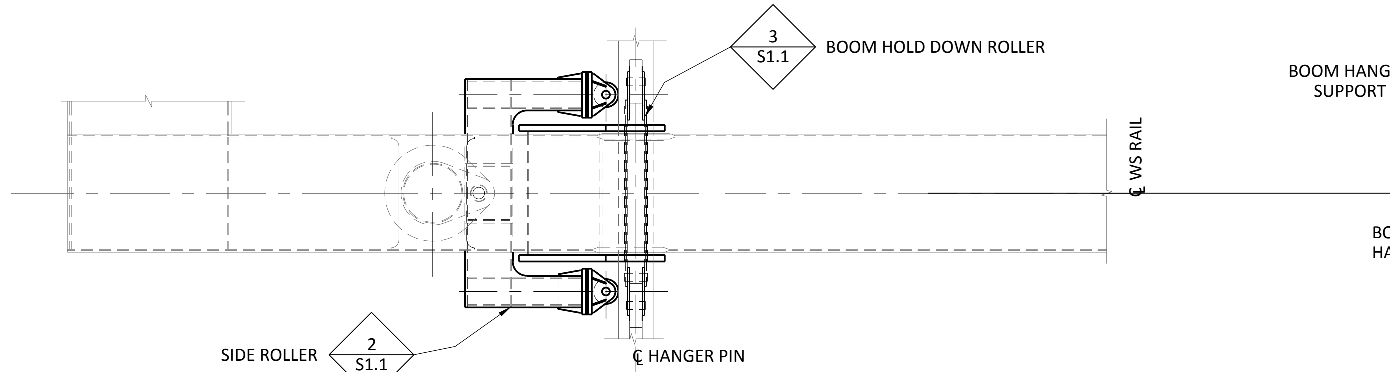
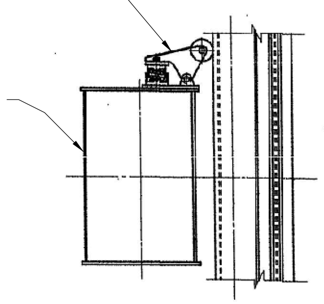


PLAN (A / S1.1)
1/4" = 1'-0"



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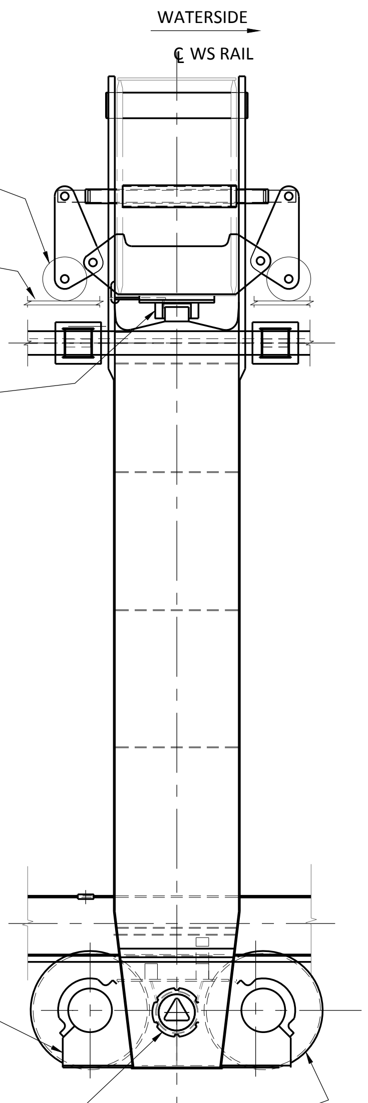
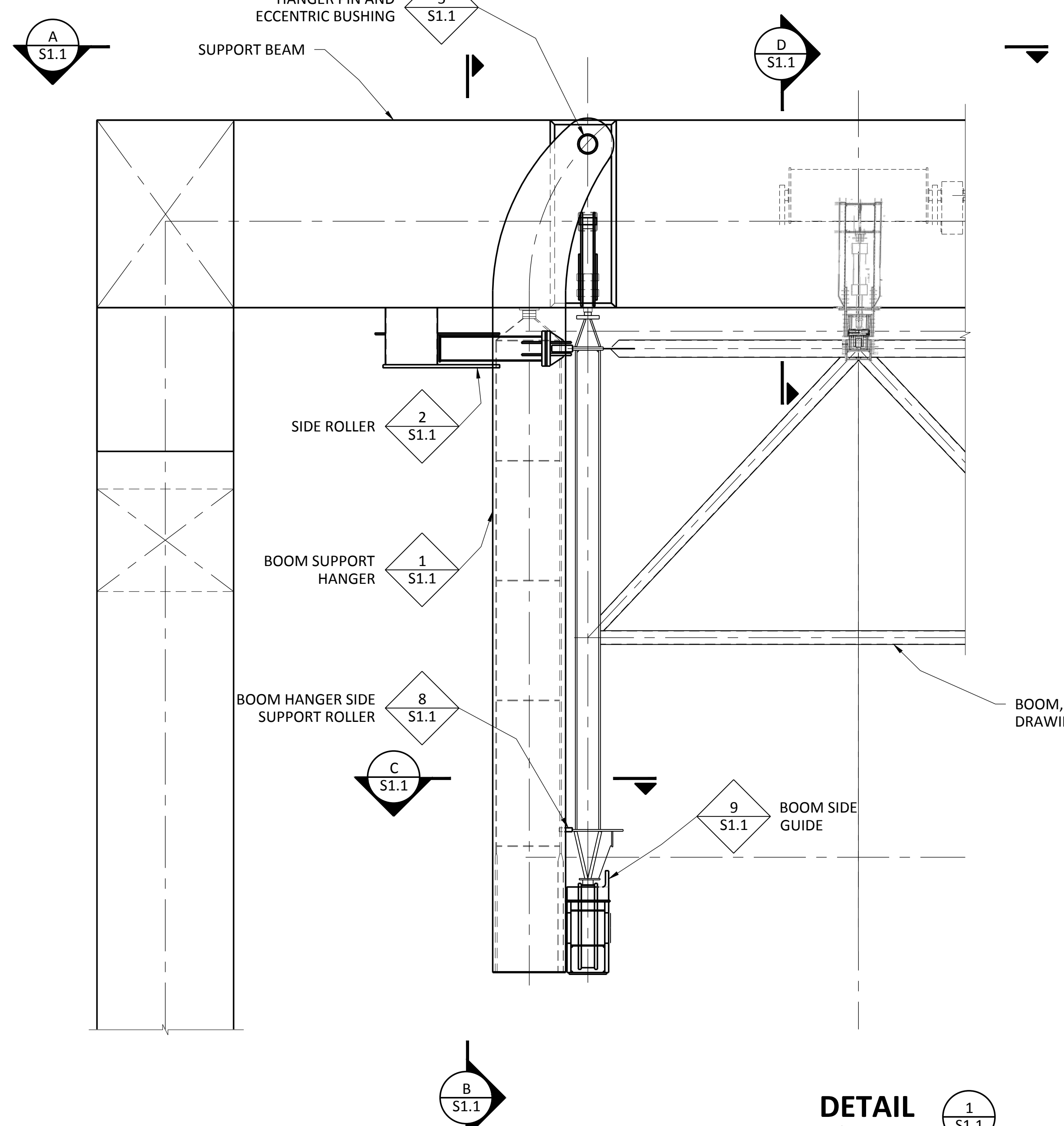
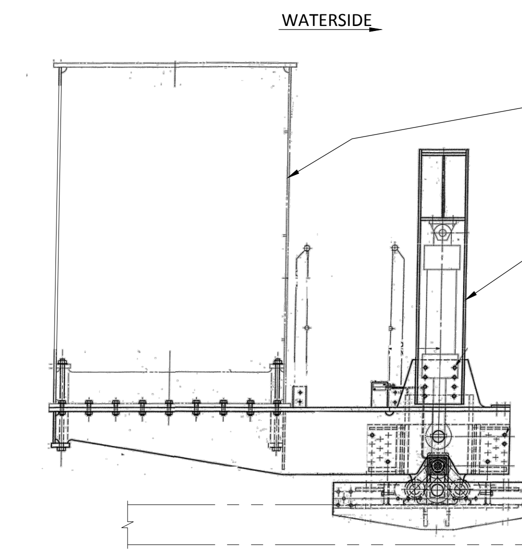
NOT TO SCALE



SECTION (B / S1.1)
1/4" = 1'-0"



DETAIL (1 / S1.1)
1/4" = 1'-0"



NOTE:
SHOWN FOR REFERENCE SEE SAMSUNG DRAWING 26315

BOOM LATCH SECTION (D / S1.1)
NOT TO SCALE

NOTE:
SEE SHEET S1.0 FOR NOTES

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PORT EVERGLADES LOW PROFILE CRANES

WATERSIDE BOOM SUPPORT HANGER AND BOOM LATCH

Project No. 2031			
By AH	Checked SH/AB	Sheet No.	S1.1
Approved MJ		of	14
Date 9/24/14		Revision	----

No.	Revision	Date	By	Checked	Approved

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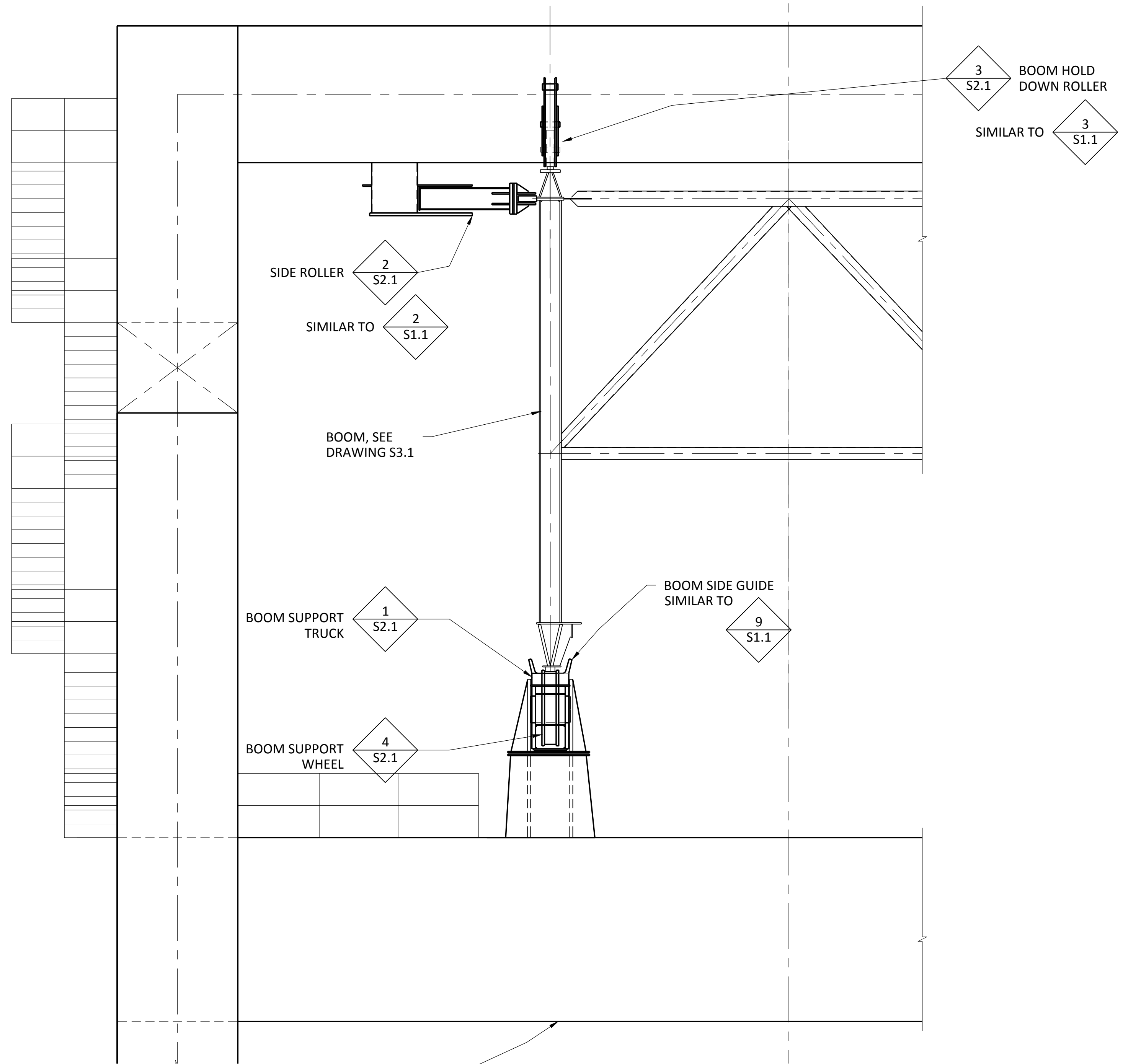

DETAIL 1/S2.1
1/4" = 1'-0"

NOTE:
1. TROLLEY, CAB, HEAD BLOCK AND SPREADER NOT SHOWN FOR CLARITY.
2. SEE SHEET S1.0 FOR NOTES.

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LANDSIDE O-FRAME BOOM SUPPORT

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By AH	Checked SH/AB	Sheet No.	S2.1
Approved MJ		of	14
Date 9/24/14		Revision	----

No.	Revision	Date	By	Checked	Approved

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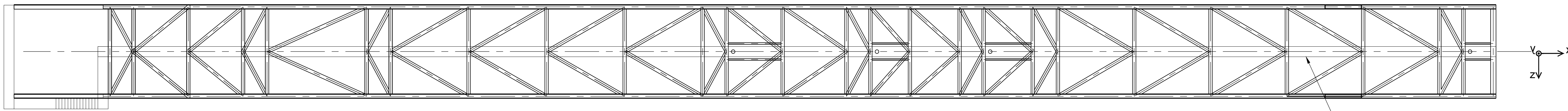
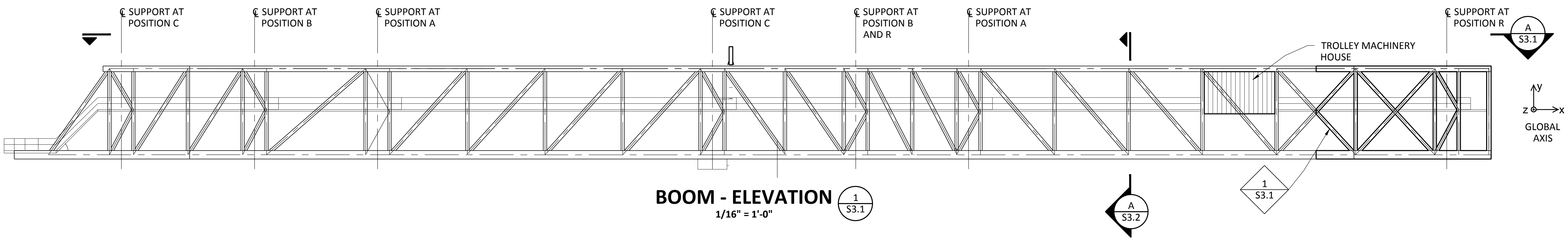
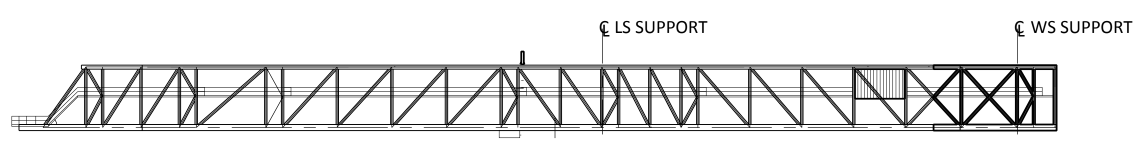


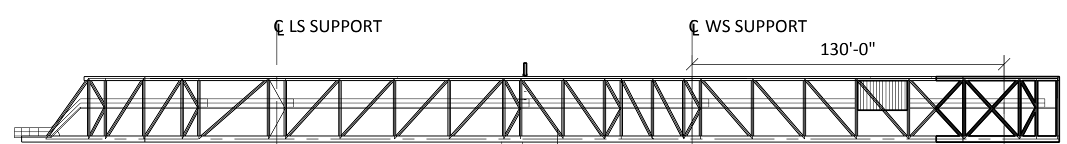
BOOM TOP CHORD PLAN A S3.1
1/16" = 1'-0"



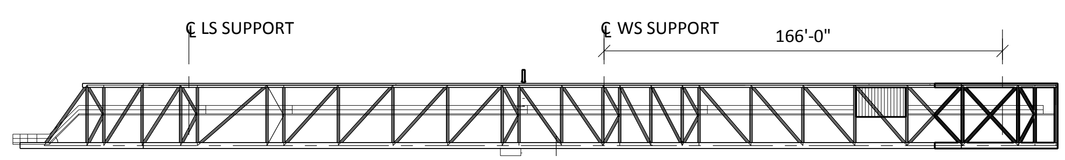
BOOM - ELEVATION 1 S3.1
1/16" = 1'-0"



BOOM RETRACTED - POSITION R

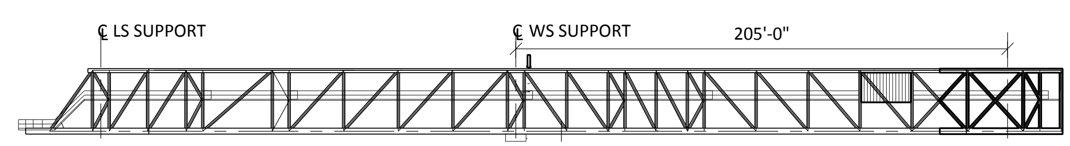


BOOM IN OPERATION AND STOWED - POSITION A



BOOM IN OPERATING - POSITION B

NOTE:
1. SEE SHEET S1.0 FOR NOTES.



BOOM IN OPERATING - POSITION C

ELEVATIONS
1" = 20'-0"

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BOOM LAYOUT

Project No.	2031				
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Approved	MJ			of	14
Date	9/24/14			Revision	----

No.	Revision	Date	By	Checked	Approved

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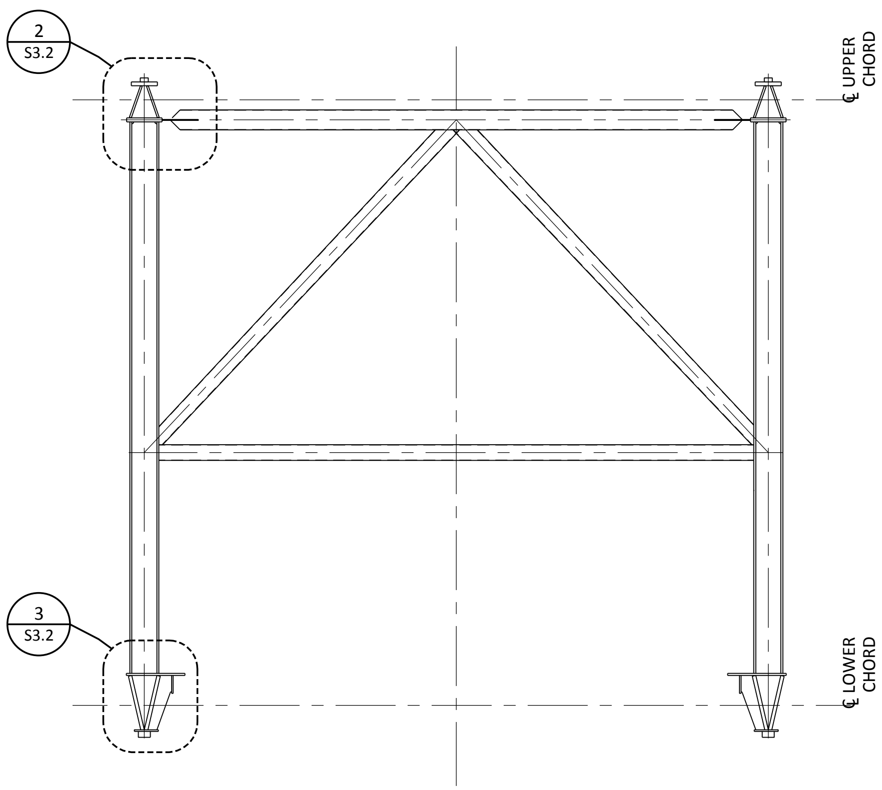
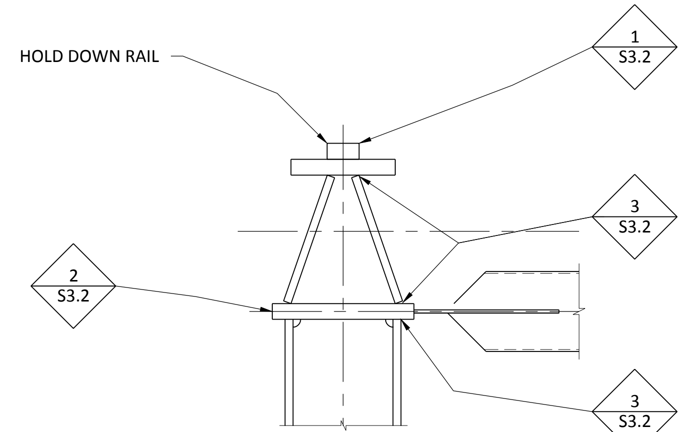
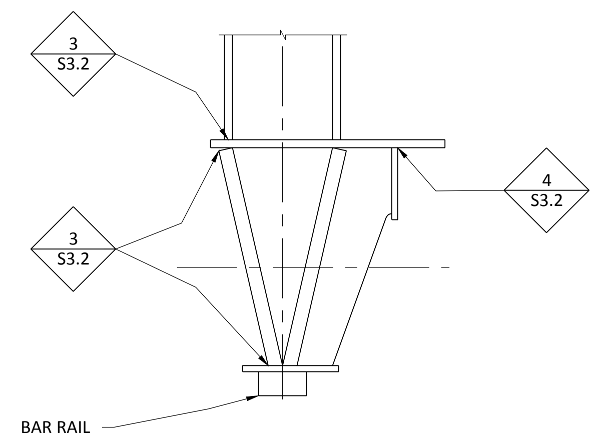


TYPICAL BOOM CROSS SECTION
1/4" = 1'-0"
1 / S3.2



UPPER CHORD SECTION
1" = 1'-0"
2 / S3.2



LOWER CHORD SECTION
1" = 1'-0"
3 / S3.2

NOTE:
1. SEE SHEET S1.0 FOR ◇ NOTES.

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BOOM DETAILS

Project No. 2031			
By AH	Checked SH/AB	Sheet No.	S3.2
Approved MJ		of	14
Date 9/24/14		Revision	----

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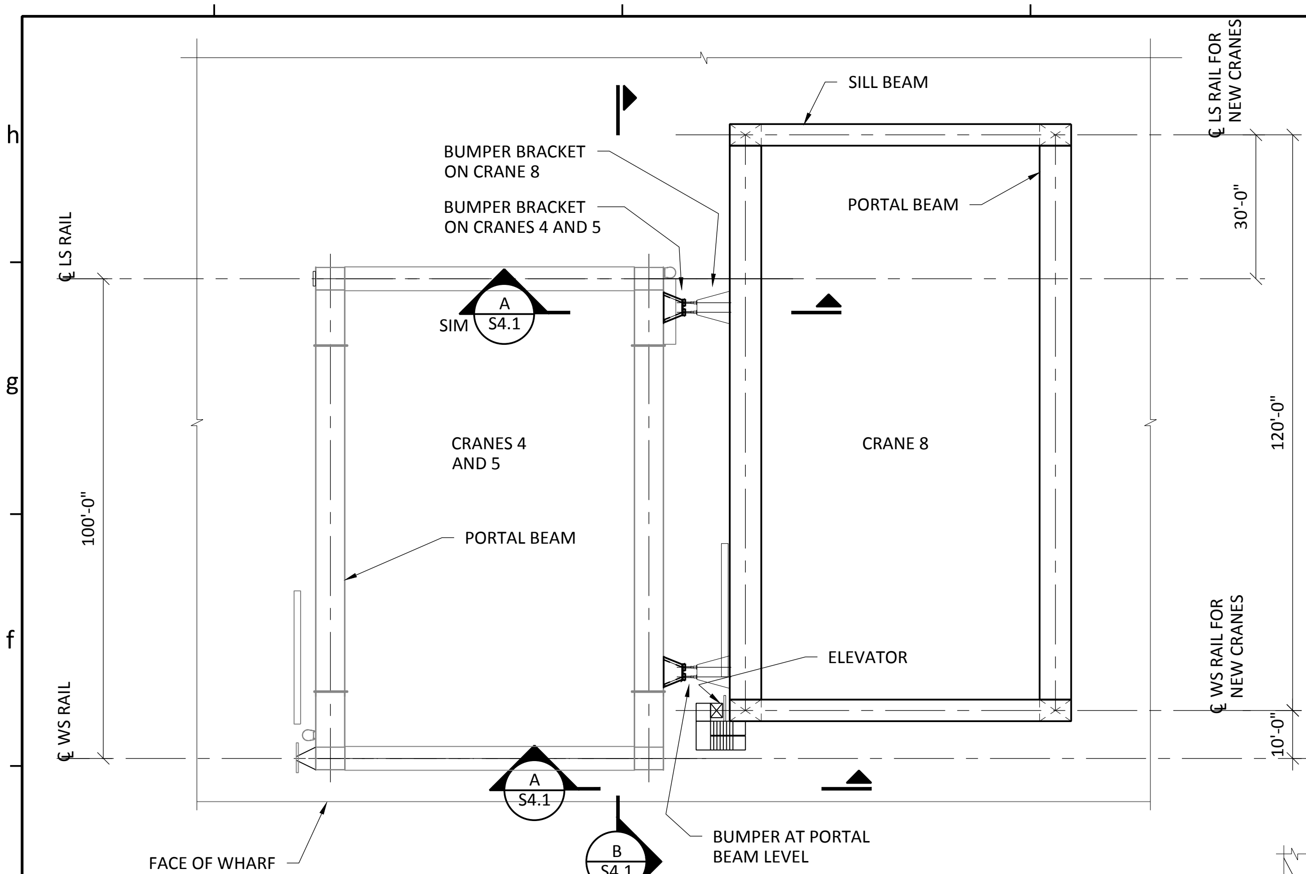
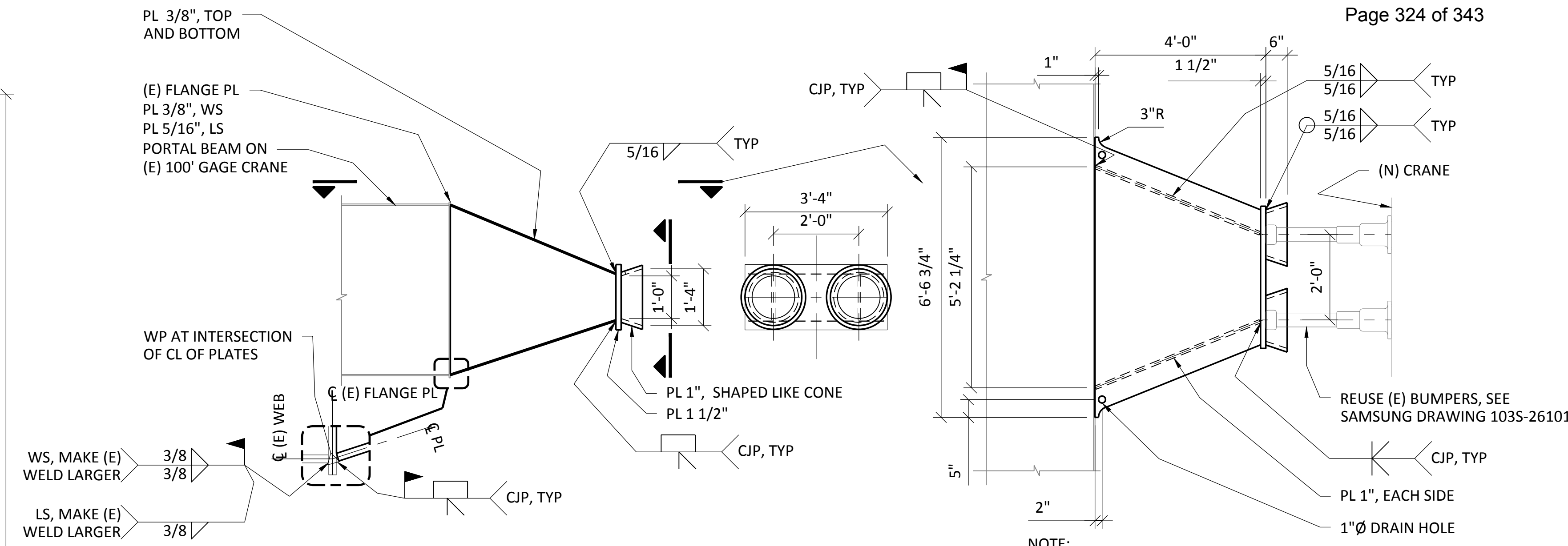
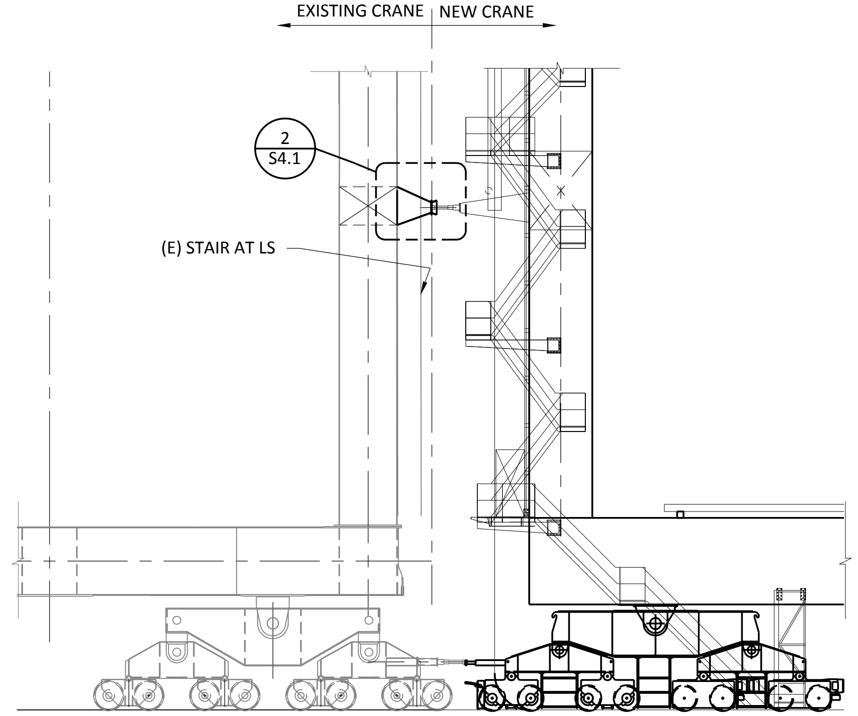


PLAN 1 S4.1
1" = 20'-0"



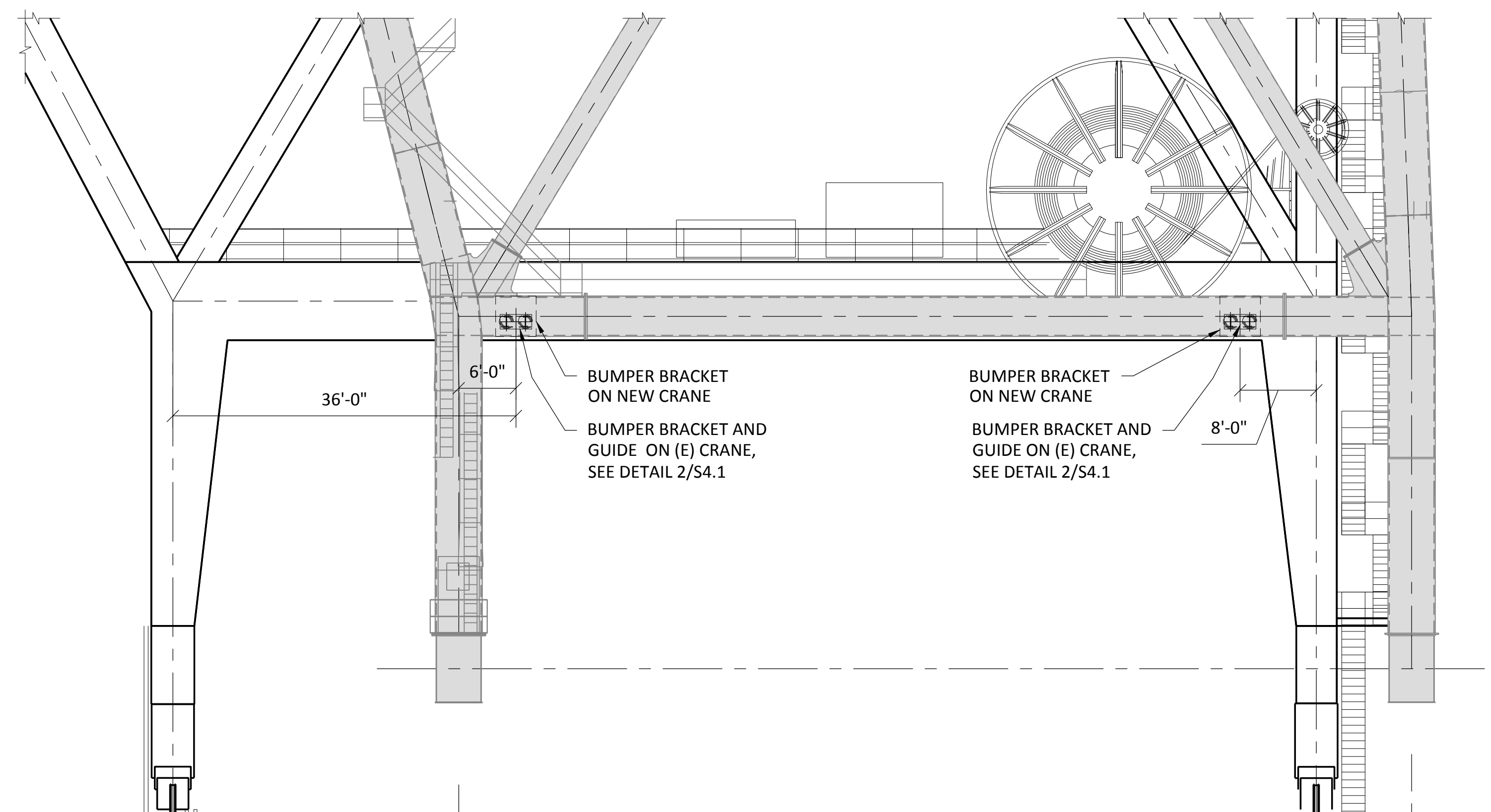
NOTE:
1. ALL STEEL SHOWN SHALL BE ASTM A36.

BUMPER GUIDE ON (E) 100' GAGE CRANE 2 S4.1
1/2" = 1'-0"



NOTE:
BUMPER INTERFACE FOR CRANE 4 AND 5 SHOWN. BUMPER INTERFACE FOR OPTION CRANE 12 IS SIMILAR.

ELEVATION A S4.1
1" = 10'-0"



SECTION B S4.1
1" = 10'-0"

NOTES:
1. CONTRACTOR SHALL DESIGN BUFFER SYSTEM BETWEEN NEW AND EXISTING CRANES.
2. CONTRACTOR SHALL CONSIDER STAIRS, CABLE REELS, AND OTHER OBSTRUCTION IN DESIGN.
3. CONTRACTORS SCOPE OF WORK ON (E) CRANE IS TO MAKE MODIFICATION SHOWN. NO CALCULATIONS REQUIRED.

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PORT EVERGLADES LOW PROFILE CRANES

NEW AND EXISTING CRANE BUMPER INTERFACE

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Date	9/24/14			Revision	----

No.	Revision	Date	By	Checked	Approved

344 - 20th STREET SUITE 360, Oakland, CA 94612, 510 832-5606

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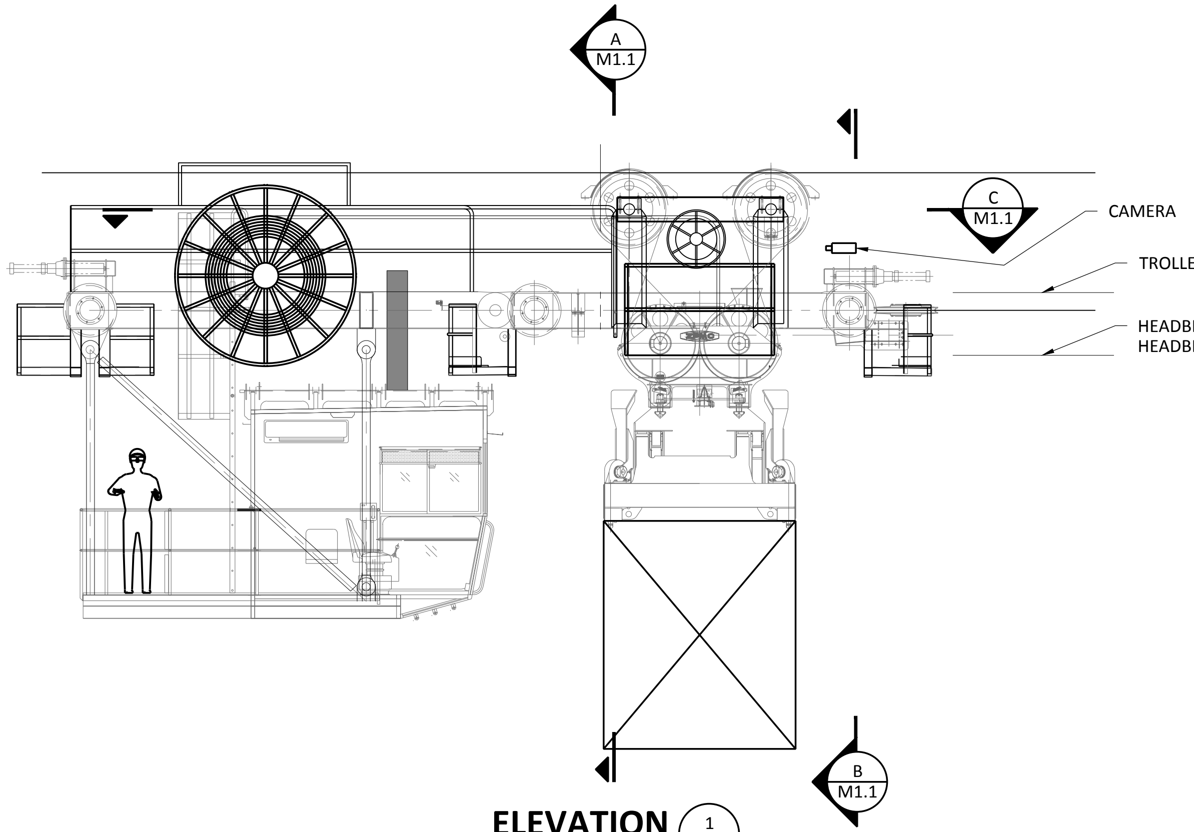
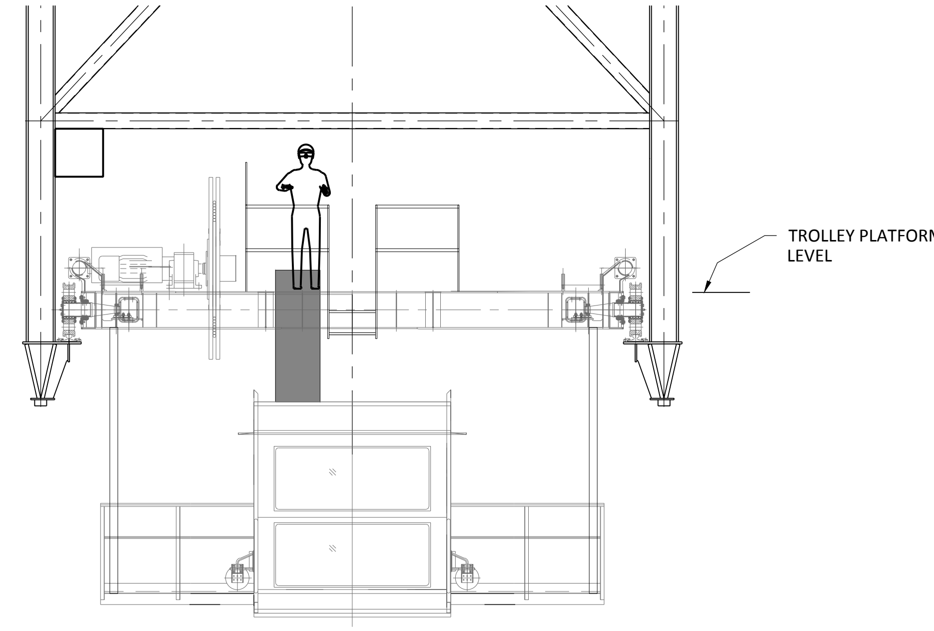
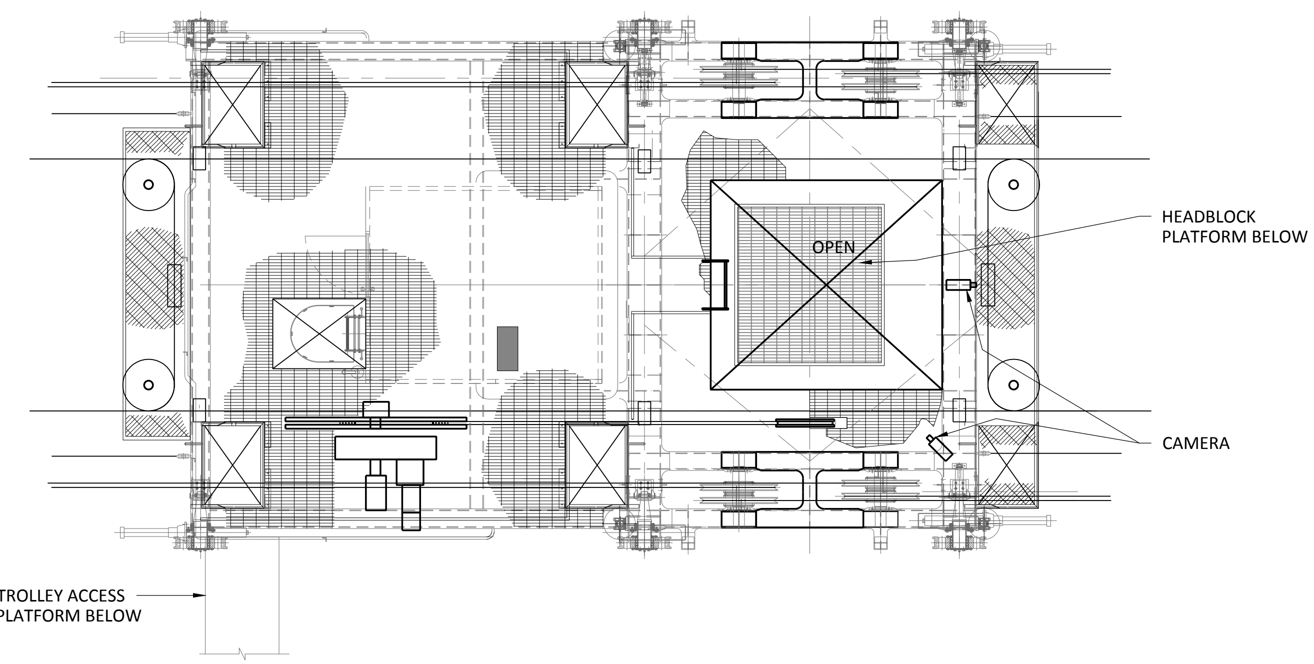


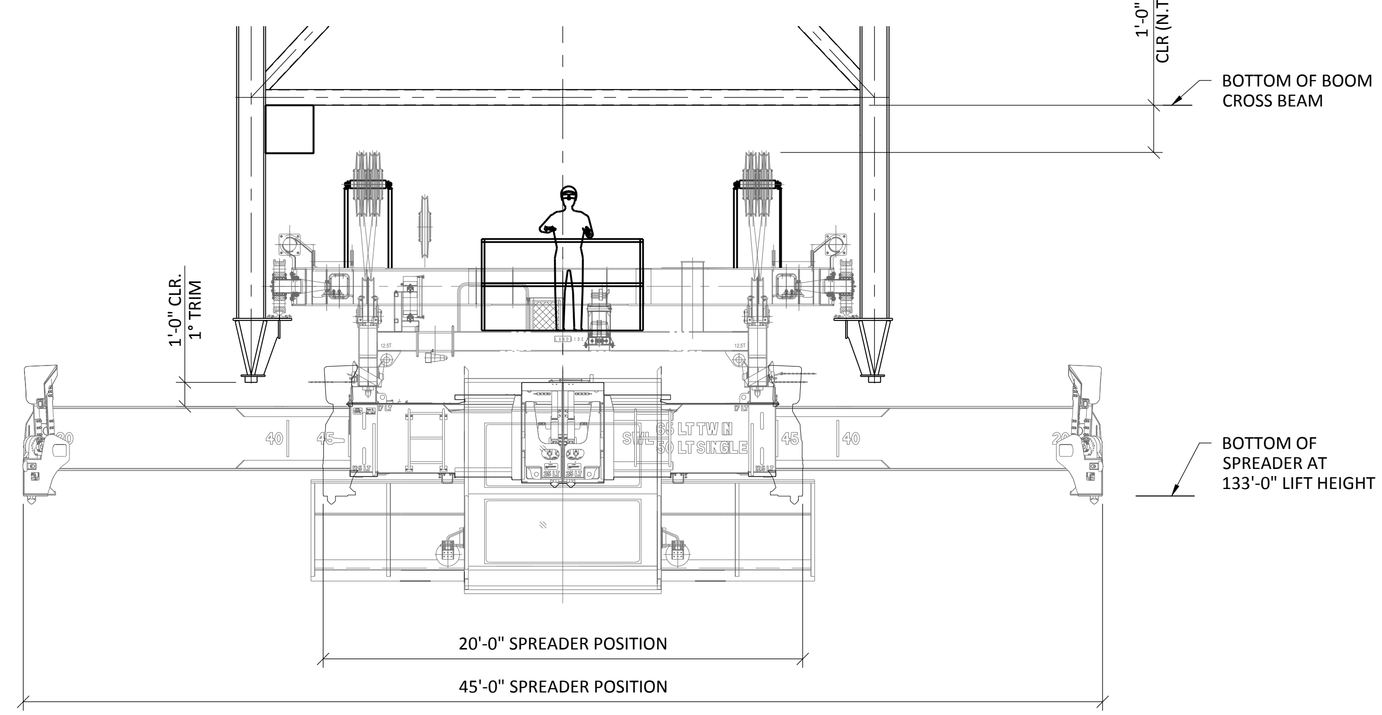
ELEVATION 1/M1.1
1/4" = 1'-0"



SECTION A/M1.1
1/4" = 1'-0"



PLAN C/M1.1
1/4" = 1'-0"



FRONT ELEVATION B/M1.1
1/4" = 1'-0"

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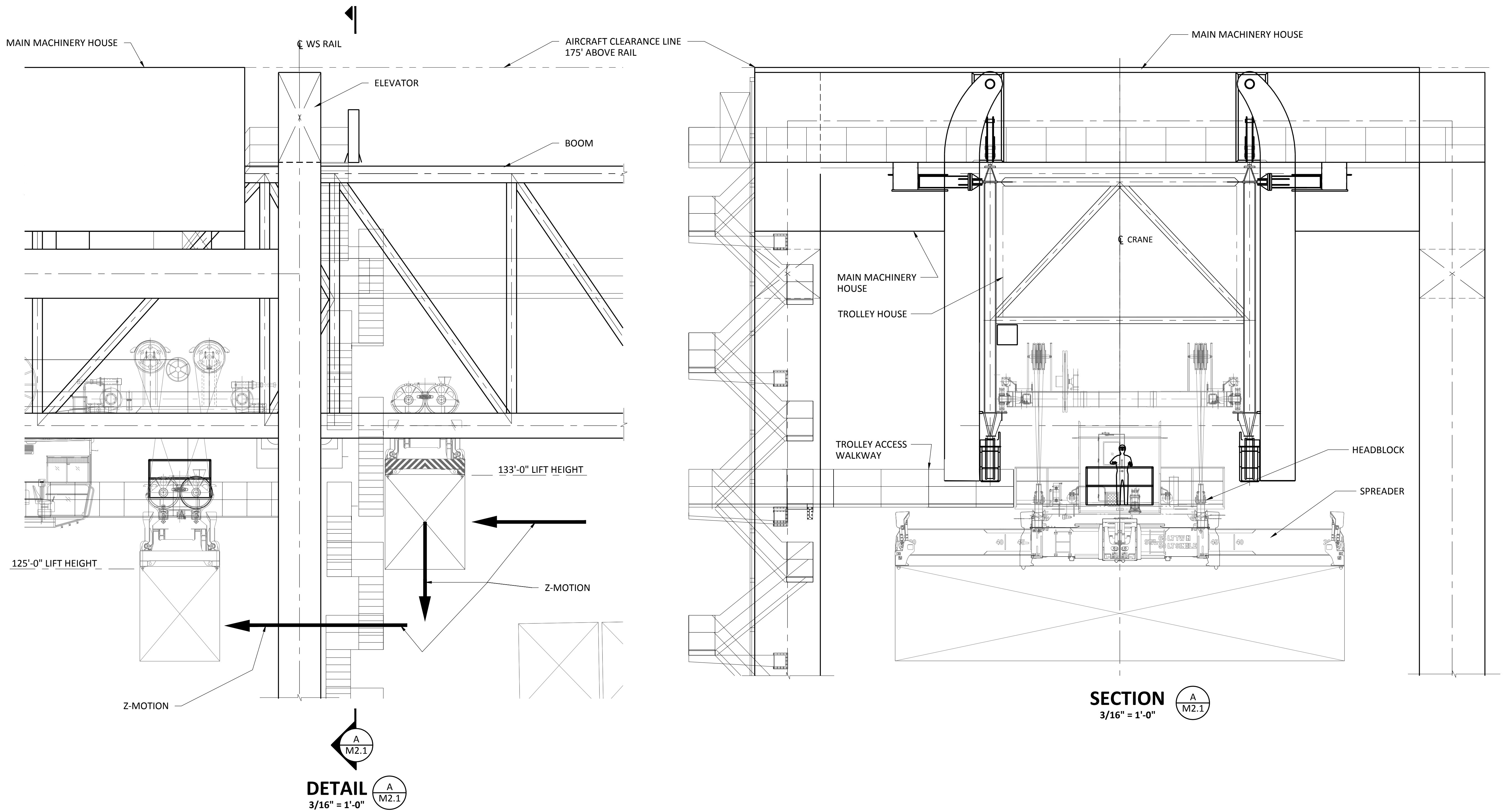
LOW PROFILE CRANES

BOOM, TROLLEY, HEADBLOCK, AND SPREADER INTERFACE LAYOUT

Project No.	2031				
By	AH	Checked	SH/AB	Sheet No.	M1.1
Approved	MJ			of	14
Date	9/24/14			Revision	----

No.	Revision	Date	By	Checked	Approved

O:\2031\Dwg\Current\M1.1 BOOM, TROLLEY, HEADBLOCK, AND SPREADER INTERFACE LAYOUT.dwg 5/4/2016 4:52 PM ALVIN HOFFPAUIR



PRINTED

5/4/2016

100% SUBMITTAL FOR REVIEW

Liftech
LIFTECH CONSULTANTS INC.

PORT EVERGLADES LOW PROFILE CRANES

Z MOTION AT WATERSIDE BOOM SUPPORT

Project No.	2031				
By	AH	Checked	SH/AB	Sheet No.	M2.1
Approved	MJ			of	14
Date	9/24/14			Revision	----

No.	Revision	Date	By	Checked	Approved

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Insurance Requirement

The following coverage is deemed the minimum insurance required for this project. The selected firm must be prepared to provide proof of insurance commensurate with or in excess of this requirement. Any deviation is subject to the approval of Risk Management.

TYPE OF INSURANCE	Limits on Liability		
		Each Occurrence	Aggregate
GENERAL LIABILITY - Broad form [x] Commercial General Liability [x] Premises–Operations [x] XCU Explosion/Collapse/Underground [x] Products/Completed Operations Hazard [x] Contractual Insurance [x] Independent Contractors [x] Personal Injury	Bodily Injury		
	Property Damage		
	Bodily Injury and Property Damage Combined	**$ 10 mil**	**$ 20 mil**
	Personal Injury		
AUTO LIABILITY [x] Comprehensive Form [x] Owned [x] Hired [x] Non-owned [x] Any Auto If applicable	Bodily Injury (each person)		
	Bodily Injury (each accident)		
	Property Damage		
	Bodily Injury and Property Damage Combined	**$ 1 mil**	
EXCESS LIABILITY [ ] Umbrella Form [ ] Other than Umbrella Form	Bodily Injury and Property Damage Combined		
[X] **WORKER'S COMPENSATION**	(each accident)	STATUTORY	
[X] U.S. Longshore & Harbor Workers' Act & Jones Act is required for any activities on or about **navigable water**			
[X] EMPLOYER'S LIABILITY		**$ 1 mil / accident**	
[X] **PROFESSIONAL LIABILITY**	Each accident **$ 10 mil** w/ Extended Reporting Period of **4 yrs.**		
[X] **TRANSPORTATION** Coverage must remain in force until written final acceptance by County.	Maximum Deductible: **$100 k** CONTRACTOR IS RESPONSIBLE FOR DEDUCTIBLE		**Completed Value**
[X] BUILDER'S RISK (PROPERTY) "ALL RISK" WITH WIND AND FLOOD May be provided by the construction contractor. Coverage to remain in force until final acceptance by County	Maximum Deductible: **$10 k** **DED for WIND or WIND & FLOOD not to Exceed 5% of completed value** CONTRACTOR IS RESPONSIBLE FOR DEDUCTIBLE		**Completed Value form**
[X] **POLLUTION LIABILITY**	Claims-made form **$ 2 mil** w/ Extended Reporting Period of **4** yrs. Deductible not to exceed: **$ 100 k**		**$ 5 mil**

Description of Operations/Locations/Vehicles

"Broward County" must be certificate holder and endorsed as an additional insured for general liability, excess liability.

REFERENCE: Purchase and Installation of CONTAINER HANDLING GANTRY CRANES

NOTE: Workers' Compensation: U.S. Longshoremen & Harbor Workers' Act & Jones Act is required for any activities on or about navigable water.

CANCELLATION: Thirty (30) Day written notice of cancellation is required to the Certificate Holder.

Certificate Holder:

Broward County
1850 Eller Drive
Fort Lauderdale, FL 33316
Attn: Arnold Delacruz (PE)

CARLOS DE LA GUERRA
RISK MANAGEMENT & CONTRACTS
BUSINESS ADMINISTRATION DIVISION
PORT EVERGLADES

Digitally signed by CARLOS DE LA GUERRA
DN: dc=cty, dc=broward, dc=bc, ou=Organization, ou=PEV, ou=Users, cn=CARLOS DE LA GUERRA
Date: 2016.05.17 16:34:56 -04'00'

Risk Management Division

InsuranceRequirementForm Revised 2012

VALID FOR ONE YEAR FROM THE DATE OF SIGNATURE

FORM 1: CERTIFICATE OF SUBSTANTIAL COMPLETION

Contract No. ____________________

Project (Name and Address): ____

To (COUNTY): ____

Consultant: ____

Contractor: ____

Notice to Proceed Date: ____

Consultant: ____

Date of Issuance: _____________________

Project or Designated Portion Shall Include:

____

____

____

The Work performed under this Contract has been reviewed and found to be substantially complete and all documents required to be submitted by CONTRACTOR under the Contract Documents have been received and accepted. The Date of Substantial Completion of the Project or portion thereof designated above is recommended as:

DEFINITION OF DATE OF SUBSTANTIAL COMPLETION

Substantial Completion: That date, as certified in writing by CONSULTANT and as finally determined by CONTRACT ADMINISTRATOR in its sole discretion, the Work, or a portion thereof, is at a level of completion in substantial compliance with the Contract Documents such that all conditions of permits and regulatory agencies have been satisfied and the Owner or its designee can enjoy use or occupancy and can use or operate it in all respects for its intended purpose. A Certificate of Occupancy (or a Temporary Certificate of Occupancy (TCO) or other alternate municipal/county authorization for limited or conditional occupancy acceptable to the Contract Administrator) must be issued for Substantial Completion to be achieved, however, the issuance of a Certificate of Occupancy or the date thereof are not to be determinative of the achievement or date of Substantial Completion.

FORM 1: CERTIFICATE OF SUBSTANTIAL COMPLETION (continued)

A list of items to be completed or corrected, prepared by CONSULTANT and approved by COUNTY is attached hereto. The failure to include any items on such list does not alter the responsibility of CONTRACTOR to complete all work in accordance with the Contract Documents.

______________________	______________________	________________
CONSULTANT	BY	DATE

In accordance with the Contract, CONTRACTOR will complete or correct the work on the list of items attached hereto within ______________________ from the above Date of Substantial Completion.

______________________	______________________	________________
CONTRACTOR	BY	DATE

COUNTY, through the Contract Administrator, has determined the Work or portion thereof designated by COUNTY is substantially complete and will assume full possession thereof at ___________________ (time) on __________________ (date).

BROWARD COUNTY BOARD	__________________________	_________
OF COUNTY COMMISSIONERS	By Contract Administrator	DATE

The responsibilities of COUNTY and CONTRACTOR for security, maintenance, heat, utilities, damage to the work and insurance shall be as follows:

FORM 2: STATEMENT OF COMPLIANCE (PREVAILING WAGE RATE)

No. _________________________

Contract No. __________________

Project Title ____

The undersigned CONTRACTOR hereby swears under penalty of perjury that, during the period covered by the application for payment to which this statement is attached, all mechanics, laborers, and apprentices, employed or working on the site of the Project, have been paid at wage rates, and that the wage rates of payments, contributions, or costs for fringe benefits have not been less than those required by Broward County Ordinance No. 83-72 and the applicable conditions of the Contract.

Dated _____________, 20___

____
Contractor

By_______________________________
(Signature)

By_______________________________
(Name and Title)

STATE OF)

)SS.

COUNTY OF)

The foregoing instrument was acknowledged before me this ________ day of __________________, 20___, by ______________________________________ who is personally known to me or who has produced ______________________ as identification and who did/did not take an oath.

WITNESS my hand and official seal, this ______ day of ___________, 20____.

(NOTARY SEAL)

____
(Signature of person taking acknowledgment)

____
(Print Name of officer taking acknowledgment)

____
(Title or rank)

My commission expires:

____
(Serial number, if any)

FORM 3: FINAL CERTIFICATE OF PAYMENT

Contract No. ___________________

Project (Name and Address): ____

To (COUNTY): ____

Consultant: ____

Contractor: ____

Notice to Proceed Date: ____

Consultant: ____

Date of Issuance: ____________________

All conditions or requirements of any permits or regulatory agencies have been satisfied. The documents required by of the Contract, and the final bill of materials, if required, have been received and accepted. The Work required by the Contract Documents has been reviewed and the undersigned certifies that the Work, including minor corrective work, has been completed in accordance with the provision of the Contract Documents and is accepted under the terms and conditions thereof.

_______________________ ______________________________ ___________
CONSULTANT BY DATE

COUNTY, through the Contract Administrator, accepts the work as fully complete and will assume full possession thereof at ____
(time)

__________________________________.
(date)

BROWARD COUNTY BOARD
OF COUNTY COMMISSIONERS _________________________ __________
By Contract Administrator DATE

FORM 4: FORM OF FINAL RECEIPT

[The following form will be used to show receipt of final payment for this Contract.]

FINAL RECEIPT FOR CONTRACT NO. ___________________________

Received this _______ day of ______________________, 20______, from Broward County, the sum of _______________________________ Dollars ($____________) as full and final payment to CONTRACTOR for all work and materials for the Project described as: ____. This sum includes full and final payment for all extra work and material and all incidentals.

CONTRACTOR hereby indemnifies and releases Broward County from all liens and claims whatsoever arising out of the Contract and Project.

CONTRACTOR hereby certifies that all persons doing work upon or furnishing materials or supplies for the Project have been paid in full. In lieu of this certification regarding payment for work, materials and supplies, CONTRACTOR may submit a consent of surety to final payment in a form satisfactory to COUNTY.

CONTRACTOR further certifies that all taxes imposed by Chapter 212, Florida Statutes (Sales and Use Tax Act), as amended, have been paid and discharged.

[If incorporated sign below.]

CONTRACTOR

ATTEST:

____
(Name of Corporation)

____
Secretary

By_____________________________
President/Vice-President

____
(Print/Type Name)

____
(Type/Type Name and Title)

(Corporate Seal)

____ day of _____________, 20____.

[If not incorporated sign below.]

CONTRACTOR

WITNESSES:

____
(Signature)

____
(Business Name)

____
(Print/Type Name)

By_____________________________
(Signature)

____
(Signature)

____
(Type/Print Name and Title)

____
(Print/Type Name)

____ day of _______________, 20___.

FORM 5: PERFORMANCE BOND

BY THIS BOND, We ____, as Principal, hereinafter called CONTRACTOR, and ________________________________, as Surety, under the assigned Bond Number ______________________, are bound to BROWARD COUNTY, FLORIDA, as Obligee, hereinafter called COUNTY, in the amount of _____________________________ Dollars ($__________) for the payment whereof CONTRACTOR and Surety bind themselves, their heirs, executors, administrators, successors and assigns, jointly and severally.

WHEREAS, CONTRACTOR has by written agreement dated the _______ day of __________________, 20____, entered into a Contract, Bid/Contract No.: _____________, with COUNTY, which Contract Documents are by reference incorporated herein and made a part hereof, and specifically include provision for Liquidated Damages, and other damages identified, and for the purposes of this Bond are hereafter referred to as the "CONTRACT";

THE CONDITION OF THIS BOND is that if CONTRACTOR:

1) Performs the CONTRACT between CONTRACTOR and COUNTY for construction of ____, in the time and manner prescribed in the CONTRACT; and

2) Pays COUNTY all losses, Liquidated Damages, expenses, costs and attorney’s fees including appellate proceedings, that COUNTY sustains as a result of default by CONTRACTOR under the CONTRACT; and

3) Performs the guaranties of all work and materials furnished under the CONTRACT for the time specified in the CONTRACT; then THIS BOND IS VOID, OTHERWISE IT REMAINS IN FULL FORCE AND EFFECT.

   Whenever CONTRACTOR shall be, and declared by COUNTY to be, in default under the CONTRACT, COUNTY having performed COUNTY obligations thereunder, the Surety may promptly remedy the default, or shall promptly:

   a) Complete the Project in accordance with the terms and conditions of the Contract Documents; or

   b) Obtain a bid or bids for completing the Project in accordance with the terms and conditions of the Contract Documents, and upon determination by Surety of the lowest responsible Bidder, or, if COUNTY elects, upon determination by COUNTY and Surety jointly of the lowest responsible Bidder, arrange for a contract between such Bidder and COUNTY, and make available as work progresses (even though there should be a default or a succession of defaults under the contract or contracts of completion arranged under this paragraph) sufficient funds to pay the cost of completion less the balance of the Contract Price; but not exceeding, including other costs and damages for which the Surety may be liable hereunder, the amount set forth in the first paragraph hereof. The term "balance of the Contract Price," as used in this paragraph, shall mean the total amount payable by COUNTY to CONTRACTOR under the CONTRACT and any amendments thereto, less the amount properly paid by COUNTY to CONTRACTOR.

FORM 5: PERFORMANCE BOND (continued)

No right of action shall accrue on this bond to or for the use of any person or corporation other than COUNTY named herein.

The Surety hereby waives notice of and agrees that any changes in or under the Contract Documents and compliance or noncompliance with any formalities connected with the CONTRACT or the changes does not affect Surety's obligation under this Bond.

Signed and sealed this ______ day of ____________________, 20_____.

ATTEST:

____
(Name of Corporation)

____
Secretary

By____________________________
(Signature and Title)

____
(Print/Type Name)

____
(Type Name and Title Signed Above)

(Corporate Seal)

IN THE PRESENCE OF:

____
Signature

____
(Print Name)

____
Signature

____
(Print Name)

SURETY:

By____________________________
Agent and Attorney-in-Fact

____
(Print/Type Name)

Address: ________________________
(Street)

____
(City/State/Zip Code)

Telephone No.: ___________________

FORM 6: PAYMENT BOND

BY THIS BOND, We ____, as Principal, hereinafter called CONTRACTOR, located at:

Business Address: ________________________________

____

Phone: ________________________________

And ________________________________, as Surety, located at:

Business Address: ________________________________

____

Phone: ________________________________

under the assigned Bond Number ______________________, and pursuant to Section 255.05, Florida Statutes, are bound to BROWARD COUNTY, FLORIDA, as Obligee, hereinafter called COUNTY, in the amount of ____ Dollars ($________________) for the payment whereof CONTRACTOR and Surety bind themselves, their heirs, executors, administrators, successors and assigns, jointly and severally.

WHEREAS, CONTRACTOR has by written agreement dated the _______ day of __________________, 20____, entered into a Contract, Bid/Contract No.: ________________, with COUNTY, for construction of ____, located at _____________________________________, which Contract Documents are by reference incorporated herein, and for the purposes of this Bond are hereafter referred to as the "CONTRACT";

THE CONDITION OF THIS BOND is that if CONTRACTOR:

1) Performs the CONTRACT between CONTRACTOR and COUNTY, in the time and manner prescribed in the CONTRACT; and

2) Promptly makes payments to all claimants as defined by Section 255.05(1), Florida Statutes, for all labor, materials, and supplies used directly or indirectly by CONTRACTOR in the performance of the CONTRACT;

THEN CONTRACTOR'S OBLIGATION SHALL BE VOID; OTHERWISE, IT SHALL REMAIN IN FULL FORCE AND EFFECT SUBJECT, HOWEVER, TO THE FOLLOWING CONDITIONS:

a) Any notices provided under this Bond must be in accordance with the notice provisions prescribed in Section 255.05(2), Florida Statutes.

b) A claimant, except a laborer, who is not in privity with CONTRACTOR shall, before commencing or not later than forty-five (45) days after commencing to furnish labor, materials, or supplies for the prosecution of the work, furnish the CONTRACTOR with a written notice that he or she intends to look to the bond for protection.

FORM 6: PAYMENT BOND (continued)

c) A claimant who is not in privity with CONTRACTOR, and who has not received payment for its labor, materials, or supplies, shall no earlier than 45 days, or no later than ninety (90) days, after final furnishing of the labor or after complete delivery of the materials or supplies, serve notice to CONTRACTOR and to the Surety, of the performance of the labor or delivery of the materials or supplies and of the nonpayment.

d) No action for the labor, materials, or supplies may be instituted against CONTRACTOR or the Surety unless the notices stated under the preceding conditions have been given.

e) Any action under this Bond must be instituted in accordance with the time limitations prescribed in Section 255.05(10), Florida Statutes.

The Surety hereby waives notice of and agrees that any changes in or under the Contract Documents and compliance or noncompliance with any formalities connected with the CONTRACT or the changes does not affect the Surety's obligation under this Bond.

Signed and sealed this ______ day of ______________________, 20____.

ATTEST:

____
Secretary

____
(Print/Type Name)

(Corporate Seal)

____
(Name of Corporation)

By______________________________
(Signature and Title)

____
(Type Name and Title Signed Above)

IN THE PRESENCE OF:

____
Signature

____
(Print Name)

____
Signature

____
(Print Name)

SURETY:

By______________________________
Agent and Attorney-in-Fact

____
(Print/Type Name)

Address: ______________________________
(Street)

____
(City/State/Zip Code)

Telephone No.: ____________________

Form 7: OFFICE OF ECONOMIC AND SMALL BUSINESS DEVELOPMENT MONTHLY DBE UTILIZATION REPORT

Report No. ___________

CONTRACT#:	**CONTRACT AMT.:**	**DATE FORM SUBMITTED:**
PROJECT TITLE:		**PROJECT COMPLETION DATE:**
PRIME CONTRACTOR:	**PERIOD ENDING:**	**AMT. PAID TO PRIME:**
CONTACT PERSON:	**TELEPHONE #: ( )**	**FAX #: ( )**

SUBCONTRACTING INFORMATION
TO BE SUBMITTED MONTHLY TO BROWARD COUNTY OFFICE OF ECONOMIC AND SMALL BUSINESS DEVELOPMENT

DBE Subcontractor	**Address**	**Description of Work**	**Original Agreed Price**	**Revised Agreed Price**	**% of Work Completed To Date**	**Amt. Paid This Period**	**Amt. Paid To Date**	**Gender**		**Ethnic Category**				
								M	**F**	**B**	**H**	**A**	**NA**	**W**
Total Amt. Paid to DBE Firms														
NON-DBE Subcontractor	**Address**	**Description of Work**	**Original Agreed Price**	**Revised Agreed Price**	**% of Work Completed To Date**	**Amt. Paid This Period**	**Amt. Paid To Date**	**Gender**		**Ethnic Category**				
								M	**F**	**B**	**H**	**A**	**NA**	**W**
Total Amt. paid to Non-DBE Firms														

Black American – B; Hispanic American – H; Asian American – A; Native American – NA; Non-Minority Woman – W

I attest that the information submitted in this report is in fact true and correct to the best of my knowledge

Signature	*Title*	*Date*

Note: The information provided herein is subject to verification by the Office of Economic and Small Business Development.

FORM 8: UNCONDITIONAL LETTER OF CREDIT (PERFORMANCE AND PAYMENT GUARANTY) FORM

UNCONDITIONAL LETTER OF CREDIT

Date of Issue ________________________

Issuing Bank's No. ____________________

Beneficiary:

Broward County, through
its Broward County Board of
County Commissioners
County Administrator
Governmental Center, Room 409
115 South Andrews Avenue
Fort Lauderdale, FL 33301

Applicant: ___________________________

Amount: ____________________________
(in United States Funds)

Expiry: ____________________
(Date)

Bid/Contract Number __________________

We hereby authorize you to draw on ____
(Bank, Issuer name)
at ____ by order of
(branch address)
and for the account of ____
(contractor, applicant, customer)
up to an aggregate amount, in United States Funds, of ___________________ available by your drafts at sight, accompanied by:

A signed statement from the County Administrator of Broward County, or the Administrator's authorized representative, that the drawing is due to default in performance of certain obligations on the part ____ agreed upon by and
(Contractor, Applicant, Customer)
between Broward County and ____ pursuant to the
(Contractor, Applicant, Customer)
Bid/Contract No. ___________________ for ____
(Name of Project)
and Section 255.05, Florida Statutes.

Drafts must be drawn and negotiated not later than _________________________________.
(expiration date)

Drafts must bear the clause: "Drawn under Letter of Credit No.___________________, of
(number)
____ dated ______________________."
(Bank name)

This Letter of Credit shall be renewed for successive periods of one (1) year each unless we provide the Broward County Administrator with written notice of our intent to terminate the credit herein extended, which notice must be provided at least thirty (30) days prior to the expiration date of the original term hereof or any renewed one (1) year term. Notification to Broward County that this Letter of Credit will expire prior to performance of the contractor's obligations will be deemed a default.

FORM 8: UNCONDITIONAL LETTER OF CREDIT (PERFORMANCE AND PAYMENT GUARANTY) FORM (continued)

This Letter of Credit sets forth in full the terms of our undertaking, and such undertaking shall not in any way be modified, or amplified by reference to any documents, instrument, or agreement referred to herein or to which this Letter of Credit is referred or this Letter of Credit relates, and any such reference shall not be deemed to incorporate herein by reference any document, instrument, or agreement.

We hereby agree with the drawers, endorsers, and bona fide holders of all drafts drawn under and in compliance with the terms of this credit that such drafts will be duly honored upon presentation to the drawee.

Obligations under this Letter of Credit shall be released one (1) year after the Final Completion of the Project by the ____.
(contractor, applicant, customer)

This Credit is subject to the "Uniform Customs and Practice for Documentary Credits," International Chamber of Commerce (2007 revision), Publication No. 600 and to the provisions of Florida law. If a conflict between the Uniform Customs and Practice for Documentary Credits and Florida law should arise, Florida law shall prevail. If a conflict between the law of another state or country and Florida law should arise, Florida law shall prevail.

____
Authorized Signature

FORM 9: CERTIFICATION OF PAYMENTS TO SUBCONTRACTORS

Contract No. ___________________

Project Title ____

The undersigned CONTRACTOR hereby swears under penalty of perjury that:

1. CONTRACTOR has paid all subcontractors all undisputed contract obligations for labor, services, or materials provided on this project within the time period set forth in Section 218.735, Florida Statutes.

2. The following subcontractors have not been paid because of disputed contractual obligations; a copy of the notification sent to each, explaining the good cause why payment has not been made, is attached to this form:

Subcontractor name and address	Date of disputed invoice	Amount in dispute

Dated ______________, 20___

____
Contractor

By_______________________________
(Signature)

By_______________________________
(Name and Title)

FORM 9: CERTIFICATION OF PAYMENTS TO SUBCONTRACTORS (continued)

STATE OF)
) SS.
COUNTY OF)

The foregoing instrument was acknowledged before me this ________ day of ___________________, 20__, by ____ who is personally known to me or who has produced _______________________ as identification and who did/did not take an oath.

WITNESS my hand and official seal, this ______ day of ___________, 20__.

(NOTARY SEAL) ______________________________________
(Signature of person taking acknowledgment)

____
(Print Name of officer taking acknowledgment)

____
(Title or rank)

My commission expires: ______________________________________
(Serial number, if any)

Form 10: EMPLOYMENT ELIGIBILITY VERIFICATION PROGRAM CONTRACTOR CERTIFICATION

On January 4, 2011, Governor Scott issued Executive Order 11-02 which requires Broward County as a party to any State funded contracts to participate in the Employment Eligibility Verification Program ("E-Verify Program") administered by the U.S. Department of Homeland Security ("DHS"). The E-Verify Program can be found at http://www.uscis.gov/e-verify.

The County has entered into a "Memorandum of Understanding" with DHS governing the E-Verify Program. As a result of the adopting the terms and conditions of the "Memorandum of Understanding" with DHS and Execute Order 11-02, any Contractor performing work in the United States (State of Florida) pursuant to the State funded contract issued by the County is required to use the E-Verify Program to confirm employment eligibility of its current and prospective employees. The undersigned contractor hereby certifies that it will enroll and participate in the E-Verify Program, in accordance with the terms and conditions governing the use of the program by:

(1) Verifying the employment eligibility of all persons who may legally work in the United States employed during the contract term by the contractor to perform the work under this contract.

(2) Enrolling in the E-Verify Program within thirty (30) days of the effective date of this contract by obtaining a copy of the "Edit Company Profile" page and make such record available to Broward County within seven days of request from the County.

(3) Requiring all persons, including subcontractors, assigned by the Contractor to perform work in the United States under this contract to enroll and participate in the E-Verify Program within ninety (90) days of the effective date of this contract or within ninety (90) days of the effective date of the contract between the Contractor and the subcontractor, whichever is later. The Contractor shall obtain from the subcontractor a copy of the "Edit Company Profile" screen indicating enrollment in the E-Verify Program and make such record available to the County within seven calendar days from the County's request.

(4) Displaying the notices supplied by DHS in a prominent place that is clearly visible to prospective employees and all employees who are to be verified through the system.

(5) Initiate E-Verify verification procedures for new employees who will work in the United States within 3 business days after the actual work start date of each new hire and thereafter shall respond appropriately to any additional requests from DHS or Social Security Administration (SSA).

(6) Maintain records of its participation and compliance with the provisions of the E-Verify Program and make such records available to the County within seven days of County's request.

[Continued on next page]

____
(Contractor's Signature)

____
(Print Vendor Name)

STATE OF _____________
COUNTY OF ___________

The foregoing instrument was acknowledged before me this ___ day of ______, 20___, by ____________________ as ________________ of ______________________, known to me to be the person described herein, or who produced _________________ as identification, and who did/did not take an oath.

NOTARY PUBLIC:

__________________________ SEAL
(Signature)
__________________________ My commission expires:_______________
(Print Name)