3.2. Material

3.2.1. Material Standards and General Requirements

(1) All materials used in the Crane structure shall be new, of the best quality and suitable for the duty intended. Mill certificates shall be obtained, and records strictly maintained to match these to the various Crane sections produced during crane manufacture.

(2) Structural steel shall conform to the AISC Specification, Allowable Stress Design, chapter 5, sectionA3, Material, except as modified in this Section

(3) Structural steel subjected to a calculated tensile stress, except stairs, ladders, platforms and walkways shall conform to the current ASTM A 709/A 709M, Standard Specification for Structural Steel for Bridges, including the following supplementary requirements:

S60, Frequency of

Tension TestsS93,

Limitation on Weld Repair

and to ASTM A6/6M, General Requirements for Rolled Steel Plates, Shapes, Sheet Piling, andBars for Structural Use

(4) The Charpy V-Notch impact requirements shall be based on the applicable temperature zone, according to ASTM A 709, Table 8, based on the environmental temperature range specified in the PROJECT REQUIREMENTS.

(5) Structural steel made to another specification may be substituted for ASTM A 709 providing it conforms to the specified requirements of A 709 and the other requirements of these Specifications. Acceptable specifications may include the following:

Deutsche Industries

Norman (DIN)British

Standards (BS)

Japanese Industry Standards (JIS)

Alternative steel specifications may be acceptable but will be subject to additional, agreedinspection and testing

(6) All FCM material, plates, sections and weld metal shall comply with AWS D1.5, Section 12. The term "engineer" in the code shall mean the Contractor's responsible structural engineer. The Purchaser will review the decisions of the Contractor's responsible structural engineer for compliance with the AWS Specifications.

(7) Weld electrodes shall meet the requirements for H16 as defined AWS A4.3 (capable of depositing weld metal with maximum diffusible hydrogen content of 16 mL/100g) and be in accordance with Table 3.1 of AWS D1.1, except E60xx rods shall not be used. If welding in accordance to AWS D1.1 "low hydrogen" electrodes requirements, electrodes shall comply with AWS D1.1 Annex XI, section XI-6.2.2(2). Steel that requires Charpy V-notch testing shall be welded with electrodes having Charpy V-notch toughness in compliance with tables 4.1 and 4.2 of AWS D1.5 for NFCMs and FCMs, except that electrodes used for welding FCMs shall have a minimum toughness of 27 J.

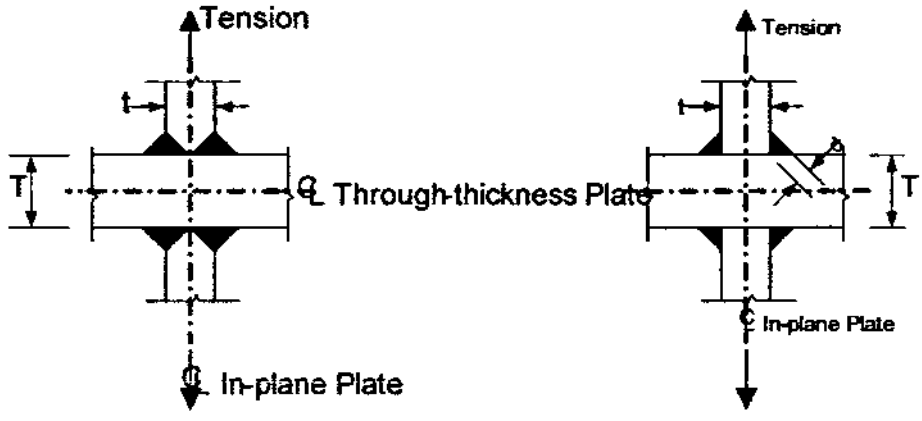
(8) Plates, rolled sections and tubes shall have a minimum thickness of 8 mm unless otherwise noted.

(9) For fracture critical plates, cold bending is prohibited, and a hot-bending procedure shall be submitted for the Engineer's approval. For cold bending of plates in primary structure (non-fracturecritical), bending radii shall be identified on the drawing and be in compliance to AISC standards, or Engineer approved equivalent. For hot-bent plates, a procedure shall be submitted including butnot limited to: heating/cooling times, radii of bending.

(1) Material used for longitudinal structural stiffeners shall be the same material (or have the same material yield strength) as the plate to which it is attached. The use of different grade steels in the cross section of main structural components must be approved by Purchaser.

3.2.2. Plate Through-Thickness Requirements

(1) 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 lamellartearing and give guidance to minimize the probability of occurrence. Table 3.1 lists required UT testing and Z-Steel requirements for tension through-thickness welded connections. "Tension," shall be determined by operating load combinations. "FCM" in the table shall be determined as described in Section 3.1.1(6). See Figure 3.1 for through-thickness plate connection details and nomenclature.



CJP Welded Connection PJP or Fillet Welded Connection

Figure 3.1 Through-thickness plate connection details

Weld	In-plane Plate	Through-thickness Plate	Through-thickness Plate Thickness, T1 (mm)	Z-steel required?	Through-thickness Plate UT Required?	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.
	NFCM	FCM	> 16	Yes[2]	Yes 3	Z 15, ISO-7778
		FCM	≤ 16	No	Yes 3	
		NFCM	All	No	No	

[1]See Figure 3.1 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 and after welding in the region under the welds,extending toward the in-plane plate as much as practical

Table 3.1: Tension Through-thickness Plate UT and Z-steel Requirements

(i) Z-Steel Requirements—As required in Table 3.1, plates subject to through-thicknesstension stress shall be designated "Z-steel" material. Z-steel shall comply with the following in addition to the other requirements of this Specification:

a. ISO-7778: International Standard "Steel plate with specified through-thickness characteristics" using the following requirements:

b. For in-plane FCMs, the requirements of "Z 25" shall be used, as a minimum.

c. For in-plane NFCMs, the requirements of "Z 15" shall be used, as a minimum.

d. The sulphur content shall be a maximum of 0.01%. See AWS D1.5, Section 12.4.4.1 for reference.

e. Each plate with Z-Steel requirements shall be clearly identified in the plan

(ii) Plate UT Requirements—As required in Table 3.1, 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 shallextend the full length of the in-plane plate for a minimum width of (2t+T). See Figure 3.1. Acceptance criteria shall be based on ASTM A 578, Level C, as a minimum.

a. In general, for FCM and CJP connections with through-thickness tension, the through-thickness plates should be UT-inspected according to Section (2). For PJP or fillet welded tension connections with through-thickness plates thickerthan 16 mm or with weld throats greater than 12 mm, the through-thickness plates should also be UT-inspected according to Section (2).

b. These through-thickness plate UT requirements are in addition to the weld NDT requirements specified in Section Table 3.1.

c. Through-thickness plate UT requirements shall be clearly identified in the plan.

3.2.3. Welded Joints

All welded joints shall be carefully designed and constructed to conform to the latest established standards toprevent fatigue failure. Cutting for edge preparation shall be performed by qualified person to achieve the correct angle, shape and smooth finish of the edges without any notches.

Intermittent welding shall not be permitted in areas exposed to the atmosphere (including interiors of non- airtight structures and interiors of structures such as the Machinery House and Electrical House) using continuous welding for those welds exposed to atmosphere.

3.2.4. Bolted Joints

(1) Bolted connections shall be made with high strength bolts. All connections made with high strength steel bolts shall conform to the "Allowable Stress Design Specifications for Structural Joints Using ASTM A-325 or A-490," or Purchaser-approved equivalent. The coefficient of friction shall be determined in accordance with "Allowable Stress Design Specifications for Structural Joints Using ASTM A-325 or A-490."

(2) Structural bolt assemblies made with high-strength 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, asestablished by the supplier are permitted to be installed. Bolted Joints of any box-sectioned structure shall be sealed at its gap between.

(3) two main structuresto prevent ingress of water into the box structure.

(4) The faying surfaces of all main structural friction-type bolted connections shall be machined.

(5) Coatings shall be used on faying surfaces of slip critical connections only if they have beenqualified to provide the slip coefficient required by the connection design. The Contractor shall provide supporting documentation if faying surfaces of slip critical connections are coated.

(6) Installation and testing of high strength bolts shall comply to AISC standards.

3.2.5. Pinned Joints

An effective Auto lubrication and rust preventive system shall be provided for each pin joint to prevent itsseizure throughout the life of the structure.

Lubrication points shall be fully accessible to maintenance personnel utilising access ladders and platforms,alternatively where this is not deemed possible, remote greasing points shall be reviewed by the Purchaser.

3.2.6. Machinery Bases

(1) All main drive machinery bases (Motors, brakes, gearboxes, bearing housings/pedestals, etc.) shall be machined. Further welding in the area of a machined surface shall be prohibited after final machining.

(2) All machinery mounts shall have adjustable locking screws for horizontal adjustment (forward and backwards, side to side) for the purposes of the equipment alignment.

(3) Groups of equipment shall be mounted on rigid base frames with machined support pads, at least 12 mm wider than equipment foundations at all sides and pads supporting electric motors for maindrives shall allow the motors to be pushed backwards to release them from couplings. Stainless steel shims shall be used, when shims are required. A means to achieve a minimum of 6mm of height adjustment shall be provided under electric motors in order to absorb shaft height differences from spare motors.

3.2.7. Edge Finish

All plate edges shall be ground with grinder to eliminate any sharp edges or burrs from cutting work.

3.2.8. Surface Finish

All welding spatters shall be removed from structural surfaces and any other surfaces where weld spatter can bedetrimental to the performance of the crane i.e. windows, hand-rails, trunking, electrical boxes etc.

3.2.9. Draining and Inspection Manholes.

(1) All the structure shall be designed to drain water effectively. Any draining water shall not affect safety of operations or maintenance work during heavy rain conditions. No water traps or pondingshall be allowed in any part of the crane structure.

(2) Appropriately, sized manholes shall be provided in all unsealed members to provide for internal inspection. The manholes shall be positioned such to allow access from each end of any unsealed member and particular attention for safety shall be given to those areas where manholes directly access onto or from vertical ladders.

3.3. Calculations

3.3.1. General

(1) Structures shall be analyzed with the aid of an appropriate computer program.

(2) The mathematical model shall accurately simulate the real structure. When ancillary members are attached to the structure, these members must either be accurately modelled, 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 modelled as pinned, it shall either be actually pinned or connected with aflexible element capable of flexing as required without overstress. The effect of axial load shall be included in the analysis of such flexible components.

(3) P-delta effects shall be included.

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

(5) 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%.

(6) The initial wheel load and stability calculations shall be based on the calculated componentweights. The final calculations shall be based on the weighed data.

3.3.2. Boundary Conditions

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

(2) 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) For Operating and overload modes

(a) For vertical loads:

The wheels shall be modelled as free to spread perpendicular to the rails and free tomove parallel to the rails.

(b) For horizontal loads perpendicular to the gantry rails:
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.

(c) For horizontal loads parallel to the gantry rails:
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.

Load cases to be considered for gantry travel around a curved section of quay rail (including Category 0 emergency stop), minimum radius of rail curvature for landside and waterside rails shall be provided by Purchaser.

(4) For Storm modes

(a) For vertical loads:

The wheels shall be modelled as free to spread perpendicular to the rails.

(b) For horizontal loads perpendicular to the gantry rails:
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.

(c) For horizontal loads parallel to the gantry rails:

The reactions parallel to the gantry rails shall be taken by the stow pins.

The more adverse of the following two boundary conditions, considered separately shallbe used:

i. The wheels restrained perpendicular to the rails at both the landside and waterside rails.

ii. The wheels free to spread parallel and perpendicular to the rails. The designer may restrict the motion of the wheels perpendicular to the rails by considering that the wheel motion will be limited by the clearance between the wheel flange and the rail. If this is done, the amount of motion shall take into account the expected clearances at the wheel to rail interface. Temperature effects may be neglected.

(5) The effect of the horizontal forces parallel and perpendicular to the rails shall be included in thecalculation of truck and equalizer forces.

3.3.3. Submitted Calculations

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

Table of Contents

General description of computer programs used with definitions of any special terminologyListing of the governing specifications

Listing of all loads

Listing of load combinations and corresponding allowable stressesCalculations for determining the magnitude of each design load.

If a dynamic analysis is used to determine impact loads, this analysis may be submittedseparately.

Dynamic analysis for one boom hoist rope failing.

Sketches showing computer input data including geometry, node numbers, membernumbers, global axis, local axis, member properties and boundary restraints.

Stress calculations for members.

Stress calculations for joints and other details.Cumulative damage analysis

Gantry frame buckling analysis

Buckling analysis of plate elements, including stiffener sizingStability calculations

Wheel load calculations

Computer output for the gantry frame and boom including the following information:Echo of input data, including descriptive sketches

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.

Displacements at appropriate joints for each of the specified individual loads

Sum of forces at each node, computer results will not be accepted if this summary showssignificant round-off error.

Period and mode shape for the lowest gantry frame mode of vibration excited when thetrolley stops and starts.

Period and mode shape for the lowest gantry frame mode of vibration excited when thegantry stops and starts with the trolley located midway between the gantry rails.

Support reactions for each of the specified individual loads.

Cumulative damage ratios at critical zones of each connection or change of section.

3.4. Loads

3.4.1. General

(1) The design shall incorporate all loads and load combinations pertinent to all in service and out of service conditions of the crane. The loads due to temperature effects, erection stresses, and others based on the Contractor's experience shall be included in the analysis if they causesignificant stresses. If rational analysis indicates loads larger than specified, the larger loads shall be used.

(2) The Contractor shall comply with F.E.M. 1.001, 3rd Edition Revised 1998.10.01 for impact loading.

3.4.2. Stability

Loads and load factors for which stability shall be calculated are specified in Section 2, Table 2.3.Angled wind effects shall be included in WLO and WLS.

Stools shall be provided between the end of the sill beams and equalizer beams for increasedstability.

3.5. Allowable Stresses

3.5.1. Load Conditions and Corresponding Allowable Stresses

(1) Load combinations are specified in Table 2.1 and Table 2.2. The allowable stresses for operating conditions, overload conditions, stowed conditions and fatigue shall be as specified by F.E.M.1.001 (3rd Edition Revised 1998.10.01).

(2) The basic allowable bearing stresses for pins shall be as shown in the table below. Bushings shall be used as shown below and as required by Section 3.8.4(2).

Pin	Bushing Required?	ALLOWABLE BEARING STRESS			
		Operating		Storm & Overload	
		Rotating Surfaces	Non-Rotating Surfaces	Rotating Surfaces	Non-Rotating Surfaces
Forestays and other components composed of links requiring bushings, boom upper hinge, and trolley girder hanger pins (if applicable)	Required	85 MPa (12 ksi)	0.4 x Fy	0.4 x Fy	0.8 x Fy
Gantry equalizer pins and boom lower hinge	Not Required	85 MPa (12 ksi)	N/A	Section 3.5.1(1)	N/A
Other FCM	Not Required	0.4 x Fy	N/A	Section 3.5.1(1)	N/A
Other NFCM	Not Required	Section 3.5.1(1)	N/A	Section 3.5.1(1)	N/A

(3) For fatigue analysis, secondary effects must be included and there shall be no increase in the allowable cumulative damage.

3.5.2. Combined Stresses:

(1) The equivalent stress, fe, for members subjected to combined shear and axial stress and/orbending stress at a point shall be taken as:

$$f_e = \sqrt{\left(f_x^2 + f_y^2 - f_x f_y + 3f_{xy}^2\right)}$$

Where:

fx and fy are orthogonal axial stresses (tension is positive, compression isnegative) and fxy is shear stress.

3.6. Members Subject to Buckling

The design of columns, beam columns, frames and beams subject to lateral buckling shall be in accordancewith FEM.

(1) Flat and curved plates subject to buckling and crippling shall be analysed using a recognized classical buckling theory. As a minimum, coefficients against buckling and crippling established in the F.E.M. Specifications shall be used.

(2) For all structural plates, the ration of the minimum clear dimension, b, to thickness, t, shall not exceed 60, i.e., 60 • b/t.

(3) 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.

3.7. Fatigue Design Criteria

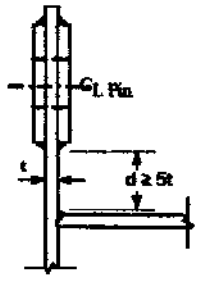
3.7.1. General Design Considerations

Fatigue design shall generally conform to the requirements of F.E.M.1.001 (3rd Edition Revised 1998.10.01).

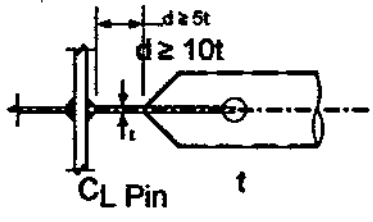
(1) Cumulative damage shall be evaluated for the normal operating conditions. For the gantry frame and boom, only fluctuating stresses due to variations in the lifted load and the trolley motion need to be considered. The effects of dead load, wind load and gantry travel and raising and lowering ofthe boom may be neglected.

(2) Stiffener ends shall be tapered at a slope of 2.5:1 or better. Stiffener fillet welds shall not extend around the ends of the stiffeners. Stiffener fillet welds shall be held back from the toe of the diaphragm weld a minimum of 10 mm or the thickness of the flange plate, whichever is greater.

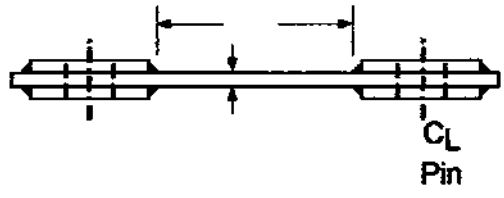
(3) Frame and boom diagonal pipes, backstays, forestays, and other similar members connected at theends with gusset plates shall be designed to include the effects of fluctuating stresses due to weak axis bending. The length of the gusset plate that can flex is the clear distance between the boss plate 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 forestay 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 forestay link plate. See Figure below.



Typical Forestay End and other Pin Connections



Typical Gusset Plates



Forestay Links

3.7.2. Load Spectra and Cumulative Damage Analysis

(1) The load spectra for development of the stress cycle spectra shall be presented by the Contactorfor approval by the Purchaser. The specified loads and cycles shall represent the effects of the actual anticipated operating conditions. The fatigue lifted load (LLF), lifting system (LS), trolley load (TL), and fatigue lateral trolley load (LATF) shall be used for the fatigue calculations of the crane structure.

(2) Definitions for move and cycles are as follows:

(i) One move: Lift the container from the ship, travel the trolley and set the container on the quay; or the reverse operation.

(ii) Single Cycle: Lift the container from the ship, travel the trolley and set the container on the quay with the lifting system supported by the container, pick the lifting system, returnto the ship, set the lifting system on the next container and prepare to lift the container from the ship; or the reverse of the above. There is one move per single cycle.

(3) Double Cycle: Lift the container from the ship, travel the trolley and set the container on the quay with the lifting system supported by the container, pick the container from the quay, return to the ship, set the container on the ship with the lifting system supported by the container and prepareto lift the container from the ship; 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

(4) The range of each cycle shall be as shown in Figure 3.1: Design Cycle Spectrum

To be provided

Fig 3.1 Design Cycle Spectrum

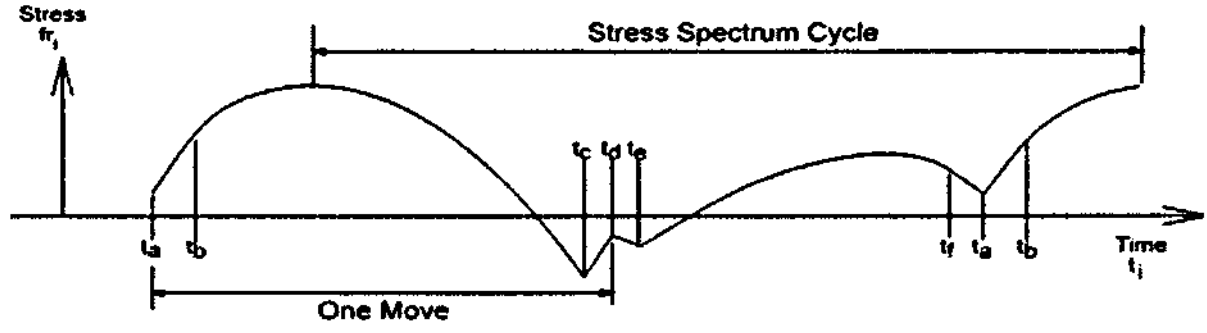


Fig 3.2: Typical Single-Cycle Stress Spectrum

Time

ta	lifting system is set on container; stress is due to trolley only
ta to tb	lifting system and container are lifted; stress is due to trolley plus lifting system and containerplus impact
tb to tc	trolley travels
tc to td	lifting system and container are lowered and set; stress is due
to trolley onlytd to te	lifting system is lifted
te to tf	trolley returns
tf to ta	lifting system is set on container

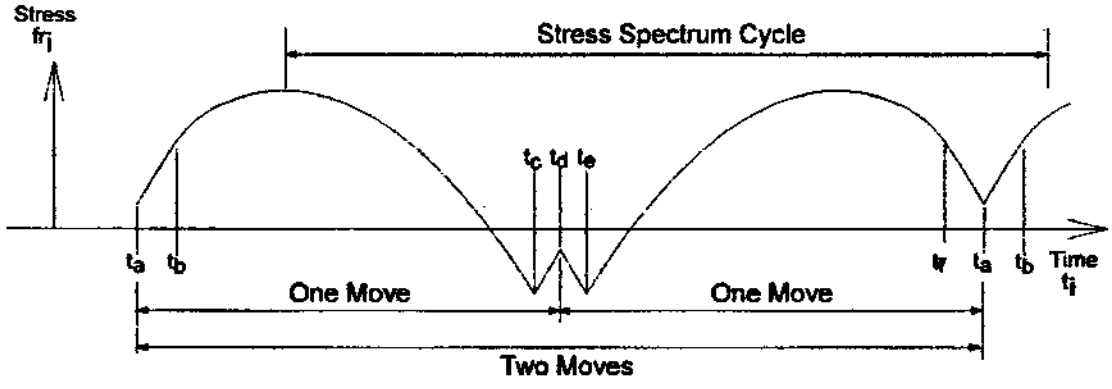


Fig 3.3: Typical Double-Cycle Stress Spectrum

Time

ta	lifting system is set on container; stress is due to trolley only
ta to tb	lifting system and container are lifted; stress is due to trolley plus lifting system andcontainer plus impact
tb to tc	trolley travels
tc to td	lifting system and container are lowered and set; stress is due to trolley only
td to te	lifting system and container are lifted; stress is due to trolley plus lifting system andcontainer plus impact
te to tf	trolley returns
tf to ta	lifting system and container are lowered and set; stress is due to trolley only

3.8. Connection Designs

3.8.1. General

(1) 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 than75% 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.

3.8.2. Welded Joints

(1) 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.

(2) Welded joint design shall conform to AWS D1.1.

(3) 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.

3.8.3. Bolted Joints

(1) Bolted joints shall be provided in accordance with the "Specifications for Structural Joints using ASTM A325 or A490 Bolts" or another PURCHASER-approved recognized international standard. A490 bolts shall be used only with approval of PURCHASER. Bolted joint design shall conform to the AISC Specification using 0.9 times AISC allowable values. Prying action due to distortion of theconnection details shall be considered. Bolts governed by fatigue strength shall comply with ASTM A325, or Purchaser-approved equivalent.

3.8.4. Eye-bars and Pin Joints

(1) Eye-bars and pin connected members shall be designed in accordance with the AISC Specification 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. If the net section is governed by fatigue, then all other proportions shall be increased on a basis consistent with the AISC requirements.

(2) All pinned joints in the forestays and similar members composed of links undergoing constant relative motion shall include aluminium bronze bushings or other equivalent manufactured bearingsat all rotating bearing surfaces. Backstays are not included in this requirement. 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.

3.9. Boom Hoist Rope Failure

(1) The boom structure shall be designed for hoisting with one set of falls in the event the other set fails. The design load shall include the effect of shock loading due to

one rope breaking. The allowable stress shall be 1.5 x basic allowable stress.

3.10. Gantry Structure Stiffness

(1) The structural stiffness of the gantry frame shall be adequate for proper operation of the crane for alldesign load cases. Deflection or oscillation of the structure shall not affect the Crane capacity or operating efficiency.

(2) Deflection shall be defined as the calculated distance the point in question moves from the unloadedstate to the loaded state relative to the global coordinate system. All secondary effects, including catenary action may be neglected. Note that since all secondary effects are neglected, the actual deflections will exceed the calculated deflections.

(3) The calculated vertical deflection at the maximum outreach due to a parameter load equal to (TL + LS
+ LL) applied at the maximum outreach shall not exceed 200 mm. The effect of catenary sag in theforestays may be neglected.

(4) Calculated horizontal displacement of the gantry structure and boom/girder at the boom/girder level due to acceleration/deceleration of gantry or trolley shall not exceed following figures with the trolleyat extreme outreach/back-reach positions:

i) In gantry direction (parallel to gantry rail), due to parameter lateral load of 0.05*(DL + TL + LS + LL) applied in the gantry travel direction with the trolley at the maximum outreach:

a. At the maximum outreach position: ±250 mm

b. At the gantry leg tie beam position: ±100 mm

ii) In trolley direction due to a parameter lateral load of 0.10*(TL + LS + LL) in the trolley travel direction at the boom elevation

a. At any point: ± 15mm

(5) The structural stiffness of the gantry frame shall be adequate for proper operation of the Crane for alldesign load cases

i) Ratio of the natural period of the gantry frame in the trolley travel direction and the naturalperiod of the hanging load shall be designed to prevent the frame from experiencing magnified dynamic displacements due to trolley motion. The natural period of the first mode of vibration in the direction parallel to the trolley shall be less than 1.5 s.

ii) Recent jumbo cranes have experienced magnified dynamic displacements due to gantry acceleration. Gantry acceleration and deceleration times shall be adjusted to an integer multiple of the natural period of the first mode of vibration in the direction parallel to the gantry travel motion to minimize these effects. This does not apply for E-stops.

3.11. Camber

(1) The trolley runway shall be cambered so the trolley path is approximately level when the trolley travels from the maximum back-reach to maximum outreach. Local camber is not required in the followingcases:

The calculated deflection of the trolley runway between supports is less than the span dividedby 800.

The calculated local deflection of the boom runway at the maximum outreach is less than thedistance between the outer forestay pin and the outreach divided by 400.

The calculated deflection of the trolley runway between the forestay connections is less thanthe distance between these divided by 800.

The calculated deflection of the trolley runway between the boom hinge and the inner forestay connection is less than the distance between these divided by 800.

If there is a backstay, the calculated deflection of the trolley runway between the back-reachand the landside trolley girder support beam is less than the distance between these dividedby 800.

If there is no backstay, the calculated deflection at the back-reach is less than the distancebetween the back-reach and the landside trolley girder support beam divided by 400.

(2) The load for camber calculations shall be:

$$DL \cdot TL \cdot LS \cdot \pm \frac{1}{2} LL$$

***CLARIFICATION: For this project the camber shall be achieved by way of forestay adjustment, so the trolley path isapproximately level when the trolley travels from the maximum back-reach to maximum outreach.**

3.12. Trolley Rails & Rail fixing

(1) Trolley rail shall be continuously supported on a structural member with a continuous web centred under the web of the rail. Where the rail will trap water on the girder and/or boom, frequent drains shall be provided through the girder and boom.

(2) Rail support surfaces shall meet the rail levelness and alignment criteria of FEM 8.2.2. Shims shall not be used.

(3) The trolley rails shall consist of a standard rail section and shall be secured with bolted rail clips. Ifwelded studs are used, the studs shall be fillet welded to the structure. The use of resistance "stud gun" welding is not allowed. Gantrex type rail pads shall be installed under the entire length ofthe trolley rails. Alternative systems will be considered according to the Contractor's proven recommended system.

(4) The rail base and mounting surface shall be painted before rail installation.

(5) The rail joints shall be joined with complete penetration welds and ground smooth to accurately machined templates except for the joint at the girderboom transition.

(6) Each rail run shall be secured against axial movement with welded shear bars mating with milled slots in the trolley rail

(7) The joint at the girderboom transition shall be designed to minimize the impact of

trolley wheels crossing over the joint and maximize the life of the rail ends. The rail sections on either side of the boom hinge joint shall be designed to the following requirements:

(i) Material hardness shall be a minimum of 300 BHN. The rail section shall be machined all over to insure solid contact with the supporting rail beam.

(ii) When traversing the hinge point, the trolley wheel shall bear on both rails for a distance equal to at least twice the head width of the rail by means of a square stepped (S) rail cut.

(iii) The rail sections on each side of the hinge shall be supported directly on machined surfaces of the trolley rail support beam to prevent vertical movement of one with respectto the other. The rail support surfaces shall be machined when the boom is fitted to the trolley girder at shop assembly to insure level surfaces. The rail supports shall be designed to transmit maximum wheel load across the rail joint and shall not affect theload on the hinge bearing. The rail sections on either side of the boom hinge joints shall be joined to the trolley rails by welding. The rail joint shall be at least 100 mm away fromthe vertical plane of the closest hinge in the trolley travel direction.

(Iv) The supporting structure shall be as rigid as possible and shall support the rail as close to the hinge point as practical.

(v) In addition, access of maintenance personnel to the boom joint area to safely effect repairs is of prime importance and the access design shall be approved by the Purchaser.

(8) Rail sections shall be readily available in the Purchaser's country of operation.

(9) The rails shall be supported by continuous 7 mm reinforced rail bearing pads with the exception of the area adjacent to the boom hinge joint. Rail support at the boom hinge shall be machined rail support structure bearing on the special machined rail sections as described above. Rail clips and mounting details shall be acceptable to the rail pad manufacturer for use with its product.

(10) In addition, the access of maintenance personnel to the boom joint area to safely effect repairs is ofprime importance and the access design shall be approved by the Purchaser.

3.13. Workmanship

3.13.1. General Requirements

(1) Work shall conform to the requirements of the AISC Specification, Allowable Stress Design, and thecyclically loaded structures requirements of AWS D1.1. Welding procedures and electrodes shall beshown on the drawings.

(2) In addition to these Specifications, 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 Non-Redundant Members."

(3) The whole of the structural fabrication and assembly shall be completed in a thorough, workmanlike manner and shall follow the best modern practices for the manufacture of high-grade structures. The work shall be performed by workmen who are appropriately skilled in theirparticular trade.

3.13.2. Welding

(1) Welders, welding operators and tackers shall be certified, for the material, processes and type of welding being performed, by an independent testing laboratory within 6 months prior to performingsuch work. The certifying laboratory will be subject to approval by the Purchaser.

(2) Certification of the qualifications of each individual welder shall be submitted by the Contractor. Weldsperformed using unqualified procedures or welding completed by non-certified welders shall be subject to removal by the Contractor at his own expense.

(3) The Contractor's Quality Assurance team shall be required to maintain an accurate log of the qualifiedwelders on the job. This log will be subjected to examination at any time by the Purchaser or his siterepresentative.

(4) The Contractor's Quality Assurance team will ensure that all correct welding procedures are strictly followed by the welding personnel. Any welding work being seen to not meet accepted proceduresshall be stopped immediately and logged as a non-conformance report. Continuation of this weldingwill then be subject to approval by the Purchaser's representative on site.

(5) The Contractor's Quality Assurance team will ensure that all welding during low temperatures is carried out, as far as practicable, within an enclosed canopy to provide a controlled environment. Theuse of correct pre-heating procedures and welding rod hot boxes is essential and will be closely monitored by the Purchaser's Representative.

3.13.3. Bolted Joints

(1) To facilitate removal/ replacement or regular maintenance, all unpainted steel fixings shall be treated with an anti-seize compound.

(2) Bolts that are 22 mm in diameter or less may be tightened to the required tension by any standardmethod in the AISC manual.

(3) A325 and A490 bolts greater than 22mm diameter shall be tightened to the required tension by thecalibrated wrench method only. The following supplemental requirements shall apply in addition to the requirements of the Specifications to structural joints using ASTM A325 or A490 Bolts:

(i) Hardened washers shall be placed under the both the head and the nut.

(ii) The Contractor shall notify the Engineer if the highest and lowest torques measured during wrench calibration varies by more than 10 percent of the lowest torque, so they may develop the appropriate solution. If the range exceeds this tolerance, filed tighteningmay be erratic.

(iii) The "snug tight" tension shall be approximately 15 percent of the specified tension and shall be achieved using a calibrated wrench.

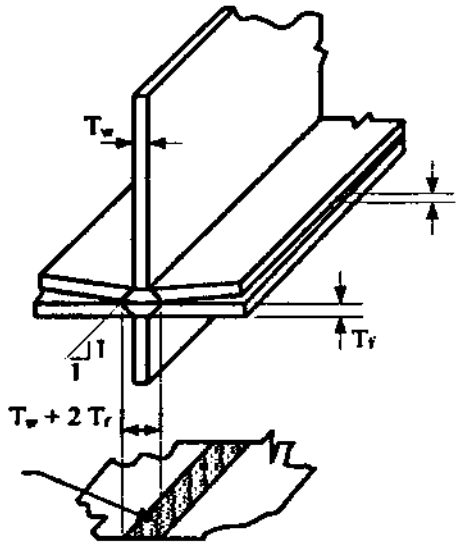
(iv) The sequence of bolt tensioning shall be shown on the drawings.

(v) 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.

(vi) The final tension shall be at least 70% of the specified tensile strength of the bolt.

(vii) 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 Purchaser. The Purchaser and the Contractor will develop the appropriate action.

(viii) 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 for 75% of the length of the edge and not more than 1.0 mm for the remaining 25% of the length, as shown below.



Maximum edge clearance between flanges: 0.25 mm (0.01 in) for 75% of the edge length and not more than1.0 mm(1/32 in) for the remaining length.

Projected flange contact bearing area: 75% firm bearing contact area, minimum

(ix) Bolt tension may be verified at locations selected by the Purchaser's Representative. Bolt tension verification shall be performed by the Contractor in the presence of the Purchaser's Representative and in such a manner that the torque can be wrench gageread during verification.

3.14. Quality Control of Structure Fabrication

3.14.1. General

(1) Quality Control shall be the responsibility of the Contractor. The Contractor must implement a written quality control program and this program shall be submitted to the Purchaser within 1 month of the date of the Agreement.

(2) The quality control program shall follow the applicable requirements laid out in 7.1.4 (Quality Assurance Program). For the structure fabrication this shall include but not be limited to the following:

Inventory of incoming material, consumables, components and machinery

Traceability procedures for materials together with traceability identification codes whichshall be serial and indexed to the controlled manufacturing procedures

Lofting, cutting, fit up, welding, forming and dimensions of structural components

Welding and inspection procedures identifying clearly the type and extent of NDTinspection carried out on the cranes structure.

Welding and inspection personnel qualification and certification (see

3.12 - Workmanship).Welding, machining, measuring and inspection

equipment maintenance and calibration.

Machining, finish surfaces, bolting

Procedures for non-conformance reporting and rectification of defects

Design and manufacturing drawing control and procedures for revisions, updates andreissue of drawings

Procedures for painting

(3) 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

3.14.2. Weld Inspection

(1) All welds shall be subjected to inspection by methods and extent, reflecting the critical nature ofthe welded connection.

(2) Welds shall meet the requirements for cyclically loaded structures of AWS D1.1. The specific method of weld inspections shall be shown on the drawings. Weld inspection procedures shall be submitted to the Purchaser.

(3) The extent of NDT performed by the Contractor, at his expense, 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.

Weld	Type of Testing/ Inspection	Acceptance Criteria
All Welds	100% Visual	AWS 1.1 – 2006
Full Penetration Butt Welds (Compression, Tension, or Alternating stress)	100% UT if possible by joint geometry, 100% MTwhere UT is not possible	AWS 1.1 – 2006
Full Penetration Butt Weldsin Tension Bars (Forestaysand Backstays)	100% UT + 100% MT	AWS 1.1 –2006
Fillet Welds or Partial Penetration Welds: On FCM (forestays, backstays, etc.) On Non- FCM	 100% of length MT 10% of length MT (as selected by the Purchaser's Representativeif present)	 AWS 1.1 –2006

(i) Rejection of any portion of a weld inspected on a less than 100% basis shall require inspection of 100% of that weld.

(ii) 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, asrequired by AWS D1.1, section 6.14.6.

3.15. Temporary Attachments

3.15.1. Sea-Fastening

At least two months before the intended shipment, the Contractor shall submit sea-fastening structure connection details to crane structures for the Purchaser's review and obtain Purchaser's agreement before shipment on temporary structure removal and crane structure clean up procedures at site.

3.15.2. Other Temporary Attachments

(1) Connections details of temporary attachments (such as lifting lugs, etc.) fitted onto OperationallyCritical Components must be approved by the Purchaser.

(2) Temporary attachments shall not degrade the fatigue class of the primary structure.

(3) Any temporary attachments welded to FCMs shall be removed, ground smooth, and MT-inspected.The Contractor shall inform the Purchaser's representative, so he can witness the inspection.

4. FUNCTIONAL SYSTEMS, DEVICES & EQUIPMENT

4.1. Main Hoist

4.1.1. Main Hoist drive

The main hoist drive system for the Crane shall consist of two AC motors with two calliper disc brakesdriving through a foot mounted gear reducer and shall have the following features:

(1) The main hoist drive reduction gearbox shall be a totally enclosed, oil bath lubricated type.

(2) Two Thruster calliper operated disc brakes shall be fitted on the high-speed pinion shaft. Each brakeshall be rated at a minimum of 150% full load motor torque and shall be capable of stopping and holding the maximum rated load from full rated speed

(3) Each Hoist Rope Drum shall have a spring set, electrically or hydraulically released calliper disc brakemounted on the drum flange. Each brake individually shall be capable of stopping the decent of the maximum eccentric rated load without assistance from a maximum over-speed condition. The controlsshall cause the drum brakes to remain released under normal container handling operations.

(4) Over-speed switches shall be fitted to both of the main hoist drums to shut down the drive and set thebrakes if the load exceeds 115% of rated speed. This feature is to protect either hoist drum in case ofdrum coupling failure.

***CLARIFICATION: For this project Hubner Giessen U-One encoders are used for both safe positioning and safedetection of over-speed.**

(5) One heavy duty, absolute position encoder shall be installed on each of the main hoist drums (total oftwo encoders)

(6) Acceleration from zero speed to a maximum speed or deceleration to zero speed shall be smooth andstepless for any load under the head-block.

(7) Frequent inching (low speed) operation and plugging (floating) operation shall be allowed.

(8) The main hoist wire ropes to the head block shall not interfere with the stacked on-deck containerswhen the crane is working on a single slot. Outside wire ropes shall be stationary during hoist andlowering motion.

(9) Any openings on the machinery house wall for the passage of all wire ropes shall be protected fromwater ingress. Protection of the wall against sagging ropes shall be provided.

(10) The main hoist system shall include an overload warning and tripping system. The

system shall detectthe load under the spreader or the load hook of the hook beam in 3 levels and activate a warning signal or trip hoisting motion as shown below:

i) 80% load for over 3 sec. Intermittent warning signal

ii) 100% load for over 3 sec. Continuous warning signal.

iii) 110% load. Trip hoist motion. Allow lowering motion only.

(11) The load sensing system shall include the installation of load cells.

(12) A key switch shall be provided in the E House, which shall permit selection of either hoist motor so thatthe hoist system may operate at 50% load/speed with only one motor operating.

(13) Eccentric Loading conditions shall immediately stop the up motion of the Main Hoist and flag a fault tothe CMS and operator interface panels, and further hoisting shall be prevented. The operator shall beable to lower the spreader at a reduced speed until the condition is cleared.

***CLARIFICATION: For this Project Contractor to specify the maximum load allowed under spreader when operatingone hoist motor at base speed.**

4.1.2. Sway Control

(1) An electronic sway control system shall be provided as an option and priced separately.

(2) The electronic sway control shall be a closed loop system which verifies the no sway condition and provides sway correction where required. Sway correction with a stopped trolley shall not move theload beyond its present sway excursions.

(3) The sway control shall bring the spreader to a stop within +/- 50mm at any lifting height as measured at the bottom corners of the 40' container or the twist lock of an empty spreader. It shallbe capable of bringing the spreader to a stop to within 2 swings.

(4) While operating the trolley drive, the operator may hoist or lower at the same time without affecting load sway.

(5) The electronic sway control system shall be capable of operating in semi-automatic or manualassist modes or being switched off completely.

(6) In the manual assist mode, 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 loadreaches the command speed and the load will respond to the revised speed command with no sway.
In the semi-automatic mode, the trolley is moved automatically to a predetermined position suchas a truck lane or position over a vessel.

(7) Details of the construction and performance of the electronic anti-sway system shall be submitted with the tender documents.

4.1.3. Trim, List, Skew Control

(1) Each of trim, list or skew motion to be controllable independently from two other motions up to its maximum angle as specified, from any attitude of the head-block.

(2) One push button switch on the control console shall automatically reset the spreader position to a 'Zero trim, Zero list, Zero skew' position.

(3) Trim, skew and list indicators shall be installed in the cab. Each indicator shall indicate angle of trim,skew and list.

4.1.4. Snag Control

(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:

i. It shall be of hydraulic type and absorb energy by fluid flow over relief valves or by a functionally similar hydraulic circuit.

ii. It shall allow 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. Resetting shall be by keyed switch in the electrical house.

iii. Automatically compensate for internal leakage. External leakage is not acceptable.

iv. Meet all the requirements of the hydraulic section of this Specification.

v. Snag analysis shall consider the activation time of relief valves. Response time shall be certified by the valve manufacturer.

Snag device shall be set not to trip for any rope load less than 125% of any operatingrope load including design impact and eccentricity.

vi. Electrical Control Supplier/ Designer shall certify motor and brake response times used in snag analysis. Strip chart recording during the Commissioning Test shall verify this data.

vii. 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. 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 hand tools.

viii. The snag analysis shall investigate all possible snag load combinations to ensure sufficientenergy absorbing capabilities. The minimum snag and two-blocking cases to be investigated are:

(1) Two blocking empty spreader and head-block at the full speed; spreader atmaximum trim and list.

(2) Jamming in ship's cell, 18 m above gantry rail elevation of a full speed emptyspreader and head-block for both of the following occurrences:

a. One side only jams, two hoist ropes snag.

b. Both sides jam, four hoist ropes snag.

ix. The Contractor shall provide a method statement showing the system of design of the snag control for review by the Purchaser and the snag device shall be demonstrated at crane Tests on Completion.

(2) Malmedie Snag Overload and ISC Coupling System (SOS) *(Not Required)*

x. Auto wire rope de-tensioning function.

xi. Auto reset of SOS after snag event.

xii. ISC Couplings (motor-reduced coupling)

4.1.5. Catenary Rope Support

(1) The main hoist and trolley towropes (if fitted) 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 catenary trolleys to be out of position by 300mm in either direction before the catenary tow ropes must be adjusted.

(2) The rope supports on the catenary trolleys shall be either sheaves or rollers. Where the rope does not fleet across the surface, sheaves should be used. Means shall be provided to either restrain the rope on the roller or sheaves or provide sufficient gather devices that will ensure that the rope will return to the sheaves or roller surface. Support rollers and sheaves shall be equipped with anti-friction bearings.

(3) The catenary trolley towropes shall be terminated with fully adjustable connectors located within fully guarded access platforms. The towropes shall be automatically hydraulically tensioned to maintain proper rope tension during normal operation and to compensate for rope stretch.

(4) The catenary trolleys shall have hold down brackets which will positively keep the catenary trolleys from jumping the rails.

(5) If the waterside catenary trolley is on the boom when the boom rises, the waterside catenary trolley shall be left hanging from the tow ropes and the tow ropes shall have a minimum safety factor of 8 in this condition.

***CLARIFICATION: In case of trolley encoder failure, the trolley can be moved to the park position using the bypassswitch.**

4.2. Trolley, Trolley Drive, Associated Devices and Operator's Cab

4.2.1. Trolley Frame

(1) The trolley frame shall be fitted with hydraulic buffers in the front and rear directions of motion. These buffers shall be capable of absorbing and dissipating without bottoming, the impact energy of collisionat full speed with rated load.

(2) The trolley frame shall be fitted with safety drop-stop lugs, which shall prevent the trolley from dropping off the girder in case of wheel shaft failure. Appropriate side guide rollers shall also be provided for the main trolley.

(3) The trolley frame shall have adequate jacking points and free access for the replacement of trolley wheels.

(4) The trolley frame shall provide emergency access from the operator's cab to the walkways of thegirder or the boom at any point of trolley travel range including under the machinery house.

(5) Trolley wheel, shaft and bearing systems shall be designed to facilitate fast replacement of components at any point on the girder or the boom.

(6) The trolley frame shall be provided with a safe maintenance platform allowing risk free access to all ofits component parts for maintenance.

4.2.1. Trolley Drive

The trolley drive system design shall be based on a full rope driven system with an option for a direct drive type.Depending upon the submitted design and the system chosen, the following shall be incorporated as a minimum.

(1) Full Rope Driven Trolley *(Required)*

i) The tow rope drive shall be mounted on a rigid base located in the machinery house and shall consist of an AC electric motor and brake driving a grooved drum through a totally enclosed foot mounted helical gear reducer.

ii) A thruster caliper operated disc brake shall be fitted on the high-speed pinion shaft and shallbe rated at 150% full load motor torque.

iii) Trolley Drum shall have a spring set, electrically or hydraulically released caliper disc brakemounted on the drum flange. The brake shall be used to prevent drum movement due to gearbox backlash after service brakes have been applied. The controls shall cause the drumbrake to remain released under normal container handling operations and not be closed under emergency stop conditions.

iv) A power operated automatic rope-tensioning device shall be provided for the trolley drive wire ropes.

v) Heavy duty, absolute position encoders shall be installed on the trolley drums.

***CLARIFICATION: For this project Hubner Giessen U-One encoders are used for both safe positioning and safedetection of over-speed.**

vi) Frequent inching operation and plugging operation shall be allowed.

vii) The trolley wire rope system shall allow simple quick adjustment of alignment of the trolley.

viii) If the Contractors design induces "racking" of the trolley rope drum backwards and forwardscausing impact to the gearbox gears, it shall be prevented by installing a flange mounted brake to the rope drum.

ix) The normal trolley parking position shall be approximately 5-meter waterside of the landsiderail.

(2) Direct Driven Trolley *(Not Required)*

i) The trolley shall be propelled by AC motors and gearboxes mounted onto the trolley and shalldrive the support trolley wheels directly.

ii) Each gearbox input shaft shall be fitted with a thruster caliper operated disc brake rated at150% full load motor torque.

iii) The design of the driving arrangement shall consider the need to minimize or exclude lay-shafts or drive transmission shafts. Preference will be given to a drive system which providesfor reliable operation and ease of maintenance.

iv) The Contractor shall submit, for the review of the Purchaser, details of a trolley positioning system which uses an absolute encoder coupled

directly to an idler wheel. Positive high friction contact with the rail will be essential for use with the direct drive trolley arrangement.

v) The trolley park position shall be as defined in 4.2.2 (1) vii)

4.2.2. Trolley Tow Rope Tensioner

(1) A hydraulically operated towrope tensioning system shall be provided and shall maintain proper ropetension during normal operation and compensate for unequal rope stretch. The tensioning device shall be designed for continuous operation.

(2) The design and installation of the hydraulic system shall meet the requirements outlined in the Hydraulic System section of this specification.

***CLARIFICATION: Trolley rope tension system shall be fully automatic, including over-tension and under tensionprotection/interlocks utilizing inductive proximity switches.**

4.2.3. Semi-Automatic Trolley Operation *(Not Required)*Electronic Load

Control(ELC):

(1) ELC is a closed loop control system for both automatic positioning, and/or sway dampening duringmanual operation, of the hanging load on a container crane.

(2) The ELC system assists the crane operator in order to increase the consistency, safety and speed in thetwo different modes: Sway Control and Position Control.

Sway Control:

(3) The sway control is a mode in the Electronic Load Control application for the Main trolley, utilizing theLPS, in which the system controls the speed reference, given from the Trolley master switch, in suchway that sway on a hanging load will be minimized.

Position Control:

(4) The ELC mode Position Control is a semi-automatic positioning system for both the hoist and trolley,assisting the crane driver to automatically load/unload vessels.

(5) Position control is always turned on but manually activated by means of the foot pedal in the operator's cabin.

Load Position Sensor (LPS):

(6) The LPS measures the position of the spreader relative to the trolley. It consists of a downward facingcamera mounted on the trolley and a transmitter box located on the head-block of the spreader. Theinformation from the LPS, in addition to the known hoisting height, gives the position of the load atany time and makes it possible to calculate the pendulum motion of the load.

Optimum path:

(7) The Path controller finds the path to a given destination reference, it calculates the path based on obstacle profile, drive data and actual position. For more information.

Ship Profiling System (SPS):

(8) A laser scanner on the main trolley continuously scans the vessel to update the actual profile of thestacked containers on the ship.

(9) The SPS system shall be proven, robust and fit for purpose, specifically in relation to

extreme vibrationand varying local temperature conditions (-5°C to +47°C), the Contractor shall provide a comprehensive reference list where an equivalent SPS system has been successfully implemented.

(10) By measuring the stack height on the ship and logging the load position at every twist-lock operationabove the ship, the SPS creates a profile of the ship. The ship profile is used in three ways: As a main

a. hoist slowdown height for ship cells below and above the deck.
b. As a smart slowdown in trolley drive for deck cargo, higher than the spreader load.
c. As a safe path to be used by the ELC (Electronic

Load Control)Skew Control:

(11) The Skew control is designed to control and minimize the skew pendulum of the main spreader without load, using a skew regulator in the crane controller that receives position feedback from thescrew jacks and spreader skew angle measurements from an LPS located on the head-block. The skewregulator uses these values to adjust the rope ends using two frequency-controlled motors, located onthe boom tip, in order to control the load to a desired angle. Skew Control is always turned on but will be interlocked under safe heights and under deck level. However, there will be a possibility for the driver to bypass these interlocks with a "Skew dampening" pushbutton on the trolley master-switch.

Micro-Motion principles of operation.

(12) The micro-motion system consists of two head-block mounted electrically operated screw jacks that can displace the rope termination devices, thus displacing the spreader in gantry direction ±200mm

Micro-Motion in automatic mode

(13) When the crane control system receives a pick-up order from ground, the automatic crane control System (ACCS) will measure the target container. The target position is compared with the actual loadposition when the trolley is over the ideal target and if needed, the ACCS sends a micro-motion request to the crane controller. The crane controller will then signal to the LPS to verify that the micro-motion operation has moved the spreader according to the request and is now within the landing window. It is also possible to operate the micro-motion function manually from the cabin during a manually assisted move.

4.2.4. Remote-control desks (RCS) *(Not Required)*

(1) Three (3) RCS shall be supplied as part of this crane(s) purchase, The RCS desk(s) shall be capable ofoperating any QC or simulator. The RCS desk(s) shall be installed in the operations room, layout/ arrangement of the RCS desk(s) shall be reviewed and approved during design review.

4.2.5. Power Feeder

(2) Power and control cables shall be routed to and from the trolley by a proprietary cable chain or festoonsystem.

(3) The Contractor shall submit design calculations which are approved by the cable chain/festoon manufacturer to demonstrate appropriate considerations in respect of the following parameters:

- Cable clearance and bend radius within each carrier link, inclusive of

manufacturersrecommended allowances.

- Adequate allowance for cavity fill including manufacturers recommended safety factors. Inany case less than 60% of the total cavity cross sectional area.
- Even and symmetric weight distribution within each carrier cavity.
- Appropriate consideration for separation of dissimilar cables and regard for cablereplacement.

(4) Cable carriers shall have extra slots for extra cables (in addition to the specified spare wires).

(5) The cable system shall include 20% spare control wires of each type/size and 6 cores fibre-optic cables.

(6) All cables shall be purchased from the cable carrier supplier and confirmed suitable for the application.

(7) If cable chain is selected, manufacturer shall attend site prior to crane taking over for final inspectionand sign off.

4.3. Gantry Drive

4.3.1. Gantry Drive

(1) The gantry drive motors, and brake system shall provide sufficient thermal capacity, torque and traction for all operating conditions, allowing for reduced speed, gantry operation with any two motorsout of service.

(2) Acceleration and Deceleration forces shall not result in wheel loads which exceed the allowable values defined earlier.

(3) The gantry drive and motors shall be capable of accelerating, driving a distance of 450m and decelerating with and against the operating wind load without adverse heating of any component.

(4) The gantry service brakes shall comprise monitored (open/closed feedback) electromagnetic, springapplied double disc brakes, flange mounted to each gantry motor. The dynamic rating shall be greaterthan 100% of maximum motor torque but not greater than 150% of the maximum motor torque. Thebrake thermal capacity must be sufficient to stop the crane from rated speed with a following maximum operating wind whilst not sustaining damage in the event that an emergency stop button ispressed without any aid of wheel or rail brakes. Each brake shall be supplied with a strong, lightweight,latching rain proof enclosure. Brakes shall set after an adjustable time delay of no gantry operation. The brake rating and design calculation shall be submitted or formally approved by the brake manufacture and submitted to the Engineer for review.

***CLARIFICATION: Gantry motor brakes shall have a quick manual release handle lockable in the brake open position.The handle position shall be monitored by sensors and interlocked with the gantry drive system.**

(5) The gantry drive shall be self-contained within its drive truck, motors shall drive through a totally enclosed, oil lubricated, helical and/or spiral bevel gearbox with one motor and one motor driving onewheel. The motor shall be flange mounted to the reducer. All enclosed gearing shall be oil-bath lubricated. Open gearing shall not be used unless specifically approved by the Purchaser.

(6) Drive components shall be protected by their location or by substantial fenders against damage by vehicular traffic, in addition fenders shall not create trapping points for dockside personnel and shallincorporate a push away system to prevent personnel injury due to dragging, pinching or trapping.

(7) The gantry trucks shall be equipped with safety lugs to support the truck in case of wheel or wheelshaft failure.

(8) Each truck and equalizer beam shall have proper jacking points to facilitate jacking for simple removalof any wheel without dismantling trucks or equalizer beams. Jacking load and position shall be approved by the Purchaser to prevent overloading of quay structure.

(9) Wheels and gearboxes shall be fitted with robust safety guards. The guards or covers shall have inspection windows.

(10) Rail scraper shall be provided in front of the outer and inner wheels at each corner.

(11) Hydraulic Buffers or bumpers shall be installed at 4corners of the crane. These shall be capable of absorbing and dissipating the impact energy of collision at full traveling speed.

(12) Proximity switches shall be fitted to the buffers to detect crane to crane or crane to buffer conditionand inhibit gantry motion in that direction. For gantry anti-collision laser scanner and camera basedsystem such as Cathay Nebula shall be used for this project.

(13) Proximity type limit switches to prohibit gantry travel motion when the stowage pins are inserted intothe ground socket shall be provided.

(14) Gantry motion shall be prohibited whenever the hoist motion is activated.

4.3.2. Stowage Pin

(1) Hand operated stowage pins shall be provided and shall be designed to hold the crane under the wind conditions defined. The design to size the pin and its supporting structure shall not consider the clamping force of the rail brakes or the force of the motor brakes.

(1) The arrangement of the stowage pins shall suit the sockets provided by others in the quay deck.

(2) A suitable latching device shall be provided for securing the pins in their raised and lowered position.

(3) The design of the pin raise/lower system shall reflect the ease of manual operation in one man requiring a minimum of force to complete either the engagement or disengagement of the pin.

(4) Proximity type limit switches shall be installed to detect the position of the stowage pins and the gantrydrive shall be disabled unless all stowage pins are in the raised position.

4.3.2. Wheel Storm Brakes

(1) Wheel brakes shall be provided on sufficient number of idler wheels and be capable of holding the crane under sustained storm wind of 35m/sec with gantry brakes released and stowage pins in thedisengaged condition.

(2) The braking calculation shall assume coefficient of friction between wheel and

gantry rail to be 0.12.The brake spring life shall be greater than 1,000,000 cycles and the brakes shall provide for ±10mmfloat with cleaning pads.

(3) Wheel brakes shall be spring applied and hydraulically released acting upon idler wheel flanges whichare designed for brake installation. The hydraulic power units shall be manufactured and supplied bythe wheel brake manufacturer.

(4) Hand pumps for manually releasing the rail brakes shall be provided.

4.3.3. MV Cable Reel

(1) Cable Reel

(i) The cable reel shall be installed on the right-hand portal beam. The drive control system ofthe cable reel shall be designed to minimize abrupt starting; braking and excessive slack /tension in the cable when the Crane passes the cable feed point. Sensors to detect the aboveconditions shall be provided.

(ii) The cable guide device shall be fitted with a belt-lifting device with nylon rollers to facilitatethe opening of covered cable trench systems such as Panzerbelt.

(iii) The mono spiral cable reel shall be manufactured entirely from stainless steel.

(iv) Cable guide wheels shall be installed near the gantry trucks to keep the high voltage cableclose to the ground level. The cable shall be laid inside the cable slot within the wheelbase ofthe gantry trucks in one corner.

(v) The system shall be well protected from weather especially in the vicinity of the high voltageslip ring components and the slip ring enclosure shall be stainless steel.

(vi) The cable reel drive machinery and slip ring area shall be fenced off to allow access of authorized persons only. A high voltage warning sign in English and local language shall beprovided and fitted to the entrance of the fenced area.

(vii) Maintenance and inspection access to both inboard and outboard of cable reel via walkways/platforms shall be provided.

(viii) A suitably sized space heater shall be provided for the slip ring.

(ix) Limit switches to control gantry motion near the traveling limit (limited by cable length) shallbe provided.

(x) A manual operating station shall be provided to allow operation of the cable reel drive. Thisswitch shall be enclosed in a lockable and weatherproof box mounted at ground level in theproximity of the cable plough arrangement and shall provide controls for forward, reverse andslack cable bypass.

(2) MV Trailing Cable

(i) The cable shall be Prysmian or Tratos (SMK) round type with three conductors, suitable for --kV with ground and embedded fibre optic cables for data transmission. Sufficient length ofcable shall be installed to provide for the full length of crane travel, three dead wraps on thereel plus one safety wrap when full, fairlead from the ground and three turns on the stress relieving drum in the cable pit. A distance of 10m should be allowed from

the stress relief drum to the point of termination to the service cable.

(ii) The composite cable shall incorporate minimum 6 numbers of low loss silica glass optical fibrewaveguide. The cable reel mechanisms shall incorporate low loss connecting devices that allow the use of all waveguide simultaneously linking the equipment on the crane to externaldevices. The standard for the waveguide shall be 62.5/125 micron.

(iii) The medium voltage trailing cable connection at the power feeding pit on the quay shall be aproprietary type of MV cable joint such as Raychem or 3M. The Contractor shall undertaketermination of the MV cable conductors and fibre waveguide at the feeding pit into a specialconnector box provided by the Purchaser for this purpose. The Contractor shall bring the crane trailing cable end to the feeder pit and shall complete the cable connecting work withan approved cable joint kit. The cable joints made at Site and medium voltage wiring shallpass the inspection requirements of the local power supply company and "Hi-Potential or VLF" test results shall be provided.

(iv) The maximum number of MV cables residing in the cable slot shall be three (3).

4.4. Boom Hoist

4.4.1. Boom Hoist Drive

(1) The boom hoist drive reduction gearbox shall be a totally enclosed oil bath lubricated type.

(2) The drive assembly shall include one thruster operated calliper disc brake on the high-speed pinion shaft and one fail safe, spring set disc type friction brake mounted on the boom hoist rope drum flange. The caliper disc brake shall be rated at 150% of full load motor torque. The disc type frictionbrake shall be rated to be capable of arresting and holding the boom in any position. This disc brakeshall be activated in the event of either over-speed of the drum, excessive motor torque, loss of electrical power or operation of a boom hoist emergency stop button.

(3) Two independent wire rope systems shall be installed, and the boom structure shall be designed sothat failure of one rope system does not damage the boom. Spelteredtype rope socket connectionsshall not be accepted.

(4) Sensors shall be provided to detect boom hoist slack rope and stop motion if slack rope occurs otherthan when the boom is in the horizontal position. The slack rope sensor reset button shall be installednear to the boom hoist drum so that rope condition is observed following a slack rope incident and before further hoisting is permitted.

(5) An over-speed switch shall be fitted to the boom hoist drum to shut down the drive and set the brakesif the load exceeds 115% of rated speed.

***CLARIFICATION: For this project Hubner Giessen U-One encoders are used for both safe positioning and safedetection of over-speed.**

(6) A heavy duty, absolute position encoder shall be installed on the boom hoist drum.

(7) All openings in the machinery house wall for the passage of the boom hoist wire ropes shall have protection for rope slapping and from water ingress. Excess water on the ropes shall be suitably trapped on entry to the machinery house and drained to a suitable location.

(8) A facility on the crane and detailed procedure shall be provided in the maintenance manual for inspection, maintenance and replacement of the boom hinge bearings

and pins. This shall include provision for relieving the loads on the bearings, removal of the pins and bearings and support of the boom sections under all maintenance conditions. Permanent platforms shall be provided for access.

4.4.2. Boom Latch

(1) The boom latch system shall include a boom-locking device which will eliminate any relative movementbetween the boom and the mast structure for the wind loading conditions.

This locking device is preferred to be designed as an integral part of the boom latch for normal operating and stowage purposes. The locking operation shall be controlled from the boom operating station.

(2) A set of hydraulic boom buffers shall be provided.

(3) Proximity type limit switches (excluding EE Stop) for control of motions and indication lamps or signalsshall be reliable weatherproof type. The control logic shall be based on a fail safe principle.

4.5. Machinery House, Electrical Control House

4.5.1. Construction

(1) The machinery house shall be designed to provide a weatherproof protected area for the location ofthe major machinery and electrical control equipment on the crane. The major electrical control equipment shall be housed in a separate air-conditioned room (the control panel room) within the machinery house. The machinery portion of the enclosure (not including the electrical room) shall notbe less than 12.0m x 16.0m in size.

(2) The machinery house shall be constructed to maintain an air temperature inside the machinery houseof not more than 5 deg. C above the ambient temperature without air conditioning. The outside surface of the machinery house shall be flat.

(3) Machinery house shall have a minimum of two access/egress ways to/from the exterior, locations shallbe decided during design review.

***CLARIFICATION: 1.4mm galvanized corrugated steel with flat signboard attached for ICTSI logo shall be acceptable.**

(4) The floor of the electrical control room and quiet (PLC) room shall be manufactured fromcomposite fireproof material completely fitted with an approved (UL or equivalent) insulatedflooring material/matting rated at ≥1000 volts to provide anti-static and electric shock protection, ifrubber matting is used this shall be fitted to the room dimensions and fixed securely using non- metallic fastening so as to prevent tripping hazards, any fitted floor matting shall allow for floor panels to be easily removed. Ample space provided for accommodating all the hardware equipmentfor Crane Condition Monitoring System.

(5) Electrical house shall have a minimum of two access/egress ways to/from the exterior, locations shallbe decided during design review.

(6) All electrical cables installed underneath the floor shall be accessible and shall be run in cable tray.

(7) The access doors shall be outward opening metal hinged type with noncorrosive heavy-duty hardwarelocks and safety glass windows in upper panels. The door shall be self-closing. A drip shield shall beprovided over the door. The locations of

doors shall be at the front and the rear wall of the machineryhouse.

(8) An access with permanent ladders to the top of the roof shall be provided. Handrails along the perimeter of the roof shall also be provided.

(9) Equipment or permanent ladders shall be provided for accessing lights and other fittings on the ceilingfor maintenance work.

(10) Ample maintenance space around each piece of machinery shall be provided for its adjustment, inspection and removal or replacement.

(11) A space to place lubricants in drums and pails shall be provided for which the floor shall be raised andsurrounded by a bund wall with facilities for draining accumulated oil into portable receptacles.

(12) A hatch shall be provided in the deck with its size permitting the removal of the largest piece of equipment within the machinery house to the ground level with the aid of the maintenance hoist. Thehatch cover shall be a sliding type with adequate handles for opening and closing by one or two persons easily. If necessary, the removal may be designed to utilize the maintenance hoist. The position of the hatch shall allow for adequate personnel access to all four sides in the opened position. Socketed, removable handrails shall be provided around the hatch opening. Purpose built storage facilities for the handrails when not in use shall be provided adjacent to the hatch. A separate hatchopening on the floor of its position in between two main girders shall be provided to lift components to and from the top of the trolley with the maintenance hoist. This hatch may also be used by theoperator to escape from the cab via the trolley into the machinery house.

(13) A work bench with a 150mm vice shall be provided in the machinery house adjacent to, or with integral power sockets for power tools.

(14) One steel locker with door lock shall be installed in the machinery house to store drawings tools, wear gauges, first aid kit box, cleaning materials – minimum dimensions 1500H x 900W x 400D.In additionone steel locker with door lock shall be provided inside the Control Panel Room – minimum dimensions1500H x 900W x 400D.

(15) A working table (tabletop size minimum 750mm x 1200mm) and a chair shall be provided in the Control Panel Room.

(16) The machinery house shall be provided with an access walkway around all four sides to allow for maintenance.

(17) A removable grease shield shall be provided between the wire rope drum(s) and nearby equipment(motors, brakes, hydraulic units etc.).

4.5.2. Fittings, Facilities

The machinery house shall contain main machineries and a fully air-conditioned Control Panel Room. Push button switches for the main control circuit, the main motion power source, and the lighting control switchesshall be installed outside the Control Panel Room.

Special consideration shall be given to acoustic treatment to reduce noise breakout from the machinery housevia the walls, floor, roof, winch wire rope openings, ventilation air intake/discharges, etc.

(1) Main machinery in machinery house.
The Machinery house shall contain following main equipment:

i) Main high-tension power supply source switch panels and their remote-control switches.

ii) Main hoist drive machinery.

iii) Boom hoist drive machinery.

iv) Trolley drive machinery (if rope towed trolley)

v) Main hoist, trolley, gantry and boom hoist motion drive control panels, cubicles, etc. located in theControl Panel Room.

vi) Transformers.

vii) Auxiliary power source panels. * These are to be located in E-room.

viii) Auxiliary motor starter and control panels.

In addition to (1) above, the following auxiliary equipment and fittings shall be installed in the machinery house:

i) LED Lighting in order to produce sufficient lighting for maintenance work.

ii) A minimum of two (2) ventilation fans (forced draft, with air filter at air intakes)

iii) Maintenance hoist.

iv) Intercom unit

v) Specific meters and counters.

vi) Fire extinguisher,

vii) Welding outlet

viii) Rope Re-Reeving system

ix) Service outlet

x) Workbench.

xi) Air compressor

xii) Locker.

xiii) 300 Amp AC welding set with 75m welding lead.

xiv) Harmonics Suppressor. *Not required if ALM used (Regulated to meet IEEE 519)*

xv) Power factor correction, ALM used but shall maintain near unity power factor when crane is idlewith air conditioning running.

xvi) E-room de humidifier

xvii) Two (2) air conditioners for Control Panel Room.

xviii) Two LED (2) hand lamps (guarded type with hook) complete with 10 m of cable and plug.

4.5.3. Ventilation

Ventilation shall be provided by a sufficient number (minimum of 2) of forced draught ventilator fans to achieveten (10) air changes per hour (ACH), fans shall be mounted in the sidewalls of the machinery house. The ventilation system design shall provide a positive pressure within the machinery house whilst maintaining therequired temperature.

4.5.4. Illumination and Lighting

Internal illumination in the machinery house and electrical control room shall be provided by LED type lightingand shall be arranged to provide a uniform illumination in all areas of not less than 200lux throughout the entirearea as a default condition. A second level of lighting shall be provided to increase the LED lighting level to 400 lux when required for maintenance and inspection functions.

4.5.5. Emergency Lighting System

Emergency lighting operated by individual rechargeable batteries shall be provided in the machinery house. Thebatteries shall have capacity to power the emergency lamps for at least two hours. The lamps shall be turned onautomatically when the electric power supply to the crane is cut off. Battery chargers to keep the batteries incontinuously charged condition shall also be provided.

4.5.6. Air Conditioning and Climate Control

***CLARIFICATION: Air conditioning units shall be available from the Philippines market including spare parts andsupport.**

(1) The Control Panel Room shall be well insulated to keep the inside temperature regulated at 25°C ± 2°Cat all times. Warning of failure of the system shall be indicated as shown in 6.5.6 (Electrical ControlHouse Air Condition Warning).

(2) To reduce the frequency of cutting in/cutting out of the air conditioners, a temperature sensor shall beinstalled in parallel with the main control of the air conditioners. The air conditioner main circuit shallbe powered on with the activation of the main motion control source and powered off with 30 minutestime delay after the main motion control source is cut off. Duplicate air conditioning units shall be provided to ensure that the failure of one unit does not stop the crane operation. Each unit shall be rated to maintain the set conditions independently of the other. CONTRACTOR shall provide (n>=2) sets of flush mount Cassette Type Air Conditioner units as stipulated in components list (through type is not permitted) for the electrical room which are sufficiently rated to maintain Electrical room temperature at 25deg.C or below. CONTRACTOR shall also pre-mount an additional one unit of air conditioner as a spare in case the in-service unit fails. Totaln+1 air conditioner units will be provided for E-room on the crane. One ceiling mounted unit is not rated to maintain the set conditions independently of the others. It is acceptable to allow the air conditioning units to run continuously CONTRACTOR must ensure this does not have a detrimental effect on the power factor the consequence being the consumption of reactive power when the cranesare idle.

(3) To ensure panel room uniform temperature, temperature sensors shall not be installed in one locationor installed in groups.

(4) Air conditioning power and control voltage shall be provided by a stabilized voltage ±5% of supply voltage.

(5) Air conditioning installation shall explicitly follow manufacturer's recommendations and verified by TPI;indoor and outdoor units, including all system components and pipework shall be fully tested and commissioned, free from defects and signed off by manufacturer accredited installation engineer priorto vessel departure.

(6) Contractor shall provide compressor type de-humidifier units controlled by humidistats which are sufficiently rated to maintain an e-room relative humidity of ≤ 65%. Warning of failure of the systemshall be indicated as shown in 6.5.6 (Electrical Control House Humidity Warning).

***CLARIFICATION: De humidifier shall be of a recognized manufacturer available from the Philippine market includingspare parts and support, Chinese de-humidifiers shall not be acceptable.**

4.5.7. Fire Protection

(1) An automatic system to detect and extinguish fire in the Machinery House, Control Panel Room and/orthe Computer Room shall be installed with full legislative compliance in the country of crane destination, in addition full technical and spare part support shall be available in the country of cranedestination.

(2) The system shall include a smoke detector in each individual electrical panel of the electrical room(s) and other smoke detectors positioned according to fire code recommendations in the open spaces or near to sensitive equipment such as transformers and switchgear.

***CLARIFICATION: For this project 3 detectors shall be fitted in E-room and 1 detector in PLC room, in addition 2 detectors shall be fitted in the M-house in close proximity to the transformers and switchgear, no extinguisher systemshall be installed in M-house.**

***CLARIFICATION: Fire alarm systems provided by Chinese manufacturers shall not be acceptable, in addition fire system (detection and extinguisher system) shall be provided by one supplier and not comprise of individual components assembled and commissioned by the Contractor.**

Extinguisher system shall be FM200 or NOVEC1230

Fire alarm and extinguisher system installation, commissioning and testing shall be signed off by Manufacturer's representative at crane manufacturing site as a minimum and at crane destination if required by local legislation.

The Purchaser shall review and approve the fire detection and extinguisher system.

(3) Fire warning messages shall be transmitted through CCMS, RCCMS and to the operator message panelaccording to a predefined escalation procedure which will ultimately shut down the crane automaticallyand safely when critical conditions are reached.

(4) The system shall include an automatic fire extinguisher system within the electrical panel and computer rooms designed for electrical fires without damaging electrical components.

4.5.8. Maintenance Hoist

(1) A maintenance hoist which can vertically lift any fully assembled component in the machineryhouse and lower it to ground level shall be installed in the machinery house. Minimum capacityshall be 10 MT and an overload protection system shall be incorporated.

(2) All the motions of the hoist shall be operated by electric motors, controlled by a pendant switch with ample cable length for handling loads in various locations.

(3) Hoisting and lowering speed for the light load shall be controlled manually to higher speed to shorten the operating time.

(4) The pendant switch shall have push buttons for slow speed hoisting and lowering to allow fine inching control.

(5) Maintenance crane shall have access and maintenance platforms with handrails to facilitate crane maintenance and M-House ceiling lamp replacement.

4.5.9. Rope Re-Reeving System

(1) Power shall be provided by means of a 5HP, drip proof motor (with soft start) in the Machinery Houseand arranged to conveniently re-reeve the main hoist, trolley (if applicable) and boom hoist wire ropes during routine rope replacement.

(2) Power shall be provided by means of a 5HP, drip proof motor with totally enclosed gear case and amotor mounted, magnet release, spring set brake. The re-reeving motor shall be controlled by a portable, remote, wireless control device which will allow the operator to walk from the supply drumto the rewind drum and monitor the re-reeving process throughout the machinery house.

***CLARIFICATION: Reeving motor shall incorporate soft start, with the required current boost for starting a fullreeving reel.**

(3) The supply reel shall have a manually operated friction brake for controlling pay-out of the new ropefrom the supply reel during reeving and an automatic level winding device for level winding the usedcable on to the empty reel during re-reeving. The brake shall be operated from the same level as themotor re-reeving device and shall include an adjustable locking or dogging system to maintain constant wire rope tension without the operator having to continuously use the brake handle. Thebrake shall be located on the side of the supply reel nearest the take-up reel and shall be clearly visible to a person standing next to the take-up reel.

(4) The rope reeving frame and shaft or arbor diameter shall be sized for use with all standard cable reelswhich could typically be supplied by wire rope manufacturers.

(5) The rope re-reeving system shall also include an elevated work platform complete with access ladder,handrails, toe-boards and which provides unrestricted access to three sides of both the powered take-up reel and supply reel. There shall be a minimum of 2m of vertical headroom clearance above theplatform deck.

(6) Conveniently located accessible pad eyes shall be provided for tying off the wire ropes during the re-reeving process.

(7) The cable reel spool shafts shall be designed to ensure that different size (width) cable reels will remain engaged into the drive pins (both powered side and take-up-side).

(8) The supply and rewind drum shafts / arbor shall be provided with greasable bushings. The arbors shall be designed to be easily and quickly removed and replaced when the rope drums are removedand re-installed.

4.6. Operator's Cab, Control Stations, Checker's Cab

4.6.1. Control Cab on Trolley

(1) Operator's cab shall be an "Ergo-Cab" manufactured by Merford, Netherlands constructed of mild steel, double skinned wall, insulated, fully welded, weatherproof and fully air-conditioned. Minimum floor width of the cab to be 2100mm, and length (fore & aft) 2500mm.

(2) The design of the cab shall allow the operator to clean inside and outside of all the windows safely.

(3) Cab access shall be from a hinged door on the side of the cab fitted with a heavy duty lockable stainless-steel handle. The door shall be self-closing, outward opening, with a latch to keep the doorin the open position.

(4) Cab shall be fitted with a permanent escape ladder and access to the trolley.

(5) Cab windows to provide as much view as possible with a single "walkable" bottom window in front ofthe operator and two walkable bottom windows to the rear. Window glass shall be scratch resistantmeeting the requirements of BS6206 class A safety glass with both surfaces being flat, parallel andfine polished, giving clear undistorted vision.

***CLARIFICATION: Operator cabin safety glass must be able to withstand the impact of an operator who is not wearing his seatbelt at the time of a collision or sudden unexpected trolley stop, to be reviewed and approved duringdesign review.**

(1) Wall windows shall be double glazed with tinted safety glass having a hinged window to the front,two sliding (single glazed) windows to the side and fine screen heavy duty industrial type roll up sunshades fitted to all upper windows.

***CLARIFICATION: The hinged window is not referring to the cabin bottom glass panel, this glass panel shall not be possible to open.**

(2) A protective shield shall be fitted above the windscreen to prevent wire rope lubricants from splashingonto the glass.

(3) Particular attention shall be given to isolating the operator from shocks and vibration. The connectionof the cab supports shall incorporate an effective anti-vibration system and the design of the operator's chair shall incorporate a suspension system.

(4) Cabin Electrical Panels shall incorporate adequately sized trunking taking into account additional cables which may be required to interface crane controls.

(5) The operators cab shall be bolt mounted to the trolley and fitted with safety drop stop lugs, which shall prevent the cab from dropping off the trolley in case of support failure

(6) Cab Fittings
The operator's cab shall be fitted with following fittings and shall not obstruct the operator's viewsrequired for crane operations.

i) One righthand and one lefthand control console each with stainless steel hinged top covers. The consoles together with the chair shall be ergonomically designed to minimize fatigue of the operator. Master controllers shall be Spohn & Burkhardt type NS3 with mechanical gate interlock preventing hoist and gantry simultaneous movements.

ii) One upholstered operator's chair with air cushioned seat. The chair shall be a Merford "Ergoseat" suspended from the ceiling with electrical height adjustment of at least 200mm.

The chair height and position (fore and aft movement) shall be adjustable to best suit eachoperator.

The chair shall be equipped with a suitably rated safety belt to restrain the operator during an emergency stop condition with the trolley traveling at maximum speed.

The position and height of the armrest of the operator's chair shall be adjusted independently. Operator controls shall be positioned to provide primary functions within thearmrests and secondary controls within reach within a hinged side panel. Additional controlsmay be mounted in a fixed side panel.

iii) An Indicator light panel shall be mounted in the lower front part of the cab to display the following conditions:

- Spreader 20ft position (Amber)
- Spreader 40ft position (Amber)
- Spreader 45ft position (Amber)
- Twist-locks LOCKED (Red)
- Twist-locks UNLOCKED (Green)
- Spreader LANDED (Amber)
- Hoist Slack Rope (Amber)
- Hoist Overload (Red)
- Hoist Snag Load (Red)
- High Wind (Red)

iv) Window wipers and washers. Wipers and washers to ensure the view angle required for operation. Wipers and washers shall be fitted to front and side windows.

v) Rear view mirrors fitted to both sides of cabin

vi) Communication equipment.

vii) Digital spreader height and load indicator.

viii) Analogue anemometer.

ix) A split unit air conditioning system.

x) Service outlet (two)

x) Interior lighting system shall provide 2 x 18W equivalent LED lights with integrated E-Lightand additional 2 x spotlights integrated into the ceiling panel. Two-way control switches shallbe mounted at the door and one within reach of the seated operator.

xi) Footrests for the operator (positions to be easily adjustable to suit individual operator).

xii) Service Outlets 24 V (10 Amp.) and 12 VDC (20 Amp.) for radio communication equipment.Both DC sources shall be stabilized within + 2.5% and 10% of the rated voltage.

xiii) Safety bars wherever necessary to prevent accidental fall of the operator or maintenance staff.

xiv) Siren switch incorporated into RH Master Controller Joystick.

xv) Fault code and message panel Siemens type MP370 or equivalent which displays graphical image of spreader state and conditions, TLS Position, Alarms, Weight and Encoder Positions

xvi) Isolating switches to isolate:

- Power circuit to head block/spreader.
- Control circuit to head block/spreader.

xvii) Trim, List, Skew angle indicator.

xviii) Fire extinguisher. (Outside of cab, near to the entrance door)

xix) A wall mounted hinged pull-down seat with upholstered swab for use by operator instructorduring training period.

***CLARIFICATION: Boom operation from the operator's cabin utilising a-frame boom latch and forestay cameramonitoring system shall be provided. Camera placement and system design shall be discussed during design review.**

4.6.2. Control Stations off the Trolley

(1) Boom/ Gantry Control Stations

i) A totally enclosed control station sized for a standing operator shall be located in a position sothat the operator can directly watch the movement of the boom, boom latches, ship's structures, and the ground around waterside gantry trucks. The control station shall containthe boom motion controls as defined elsewhere.

ii) The control station shall be provided with a door with weather seals incorporating a fixed safety glass window. The walls and roof shall also incorporate fixed safety glass sized as largeas is practical in order to provide an all-round view. Access to clean all widows is to be considered.

iii) The fittings inside the station shall include a ceiling light, communication equipment and twoservice outlets.

***CLARIFICATION: Boom operation from the operator's cabin utilising a-frame boom latch and forestay camera monitoring system shall be provided. Camera placement and system design shall be discussed during design review.**

(2) Ground Level Station
A gantry control box weatherproof to IP55 shall be installed at the ground level near the landside stowage pin structure facing inside of the crane. This box shall be stainless steel, with a hinged lockable glass fronted door and shall contain the controls and switches to control the functions definedelsewhere. All functions of the Ground Level Station shall be conveniently reachable from an operatorstanding at ground level.

4.6.3. Checker's Cab

(1) A checker's cab fabricated in mild steel shall be provided under the landside sill beam or other safelocation agreeable by the Purchaser. The checker's cab shall be bolt mounted to the sill beam, withaccess and egress available inboard and outboard via self-closing gates.

***CLARIFICATION: The Contractor shall pay particular attention to safe access and egress of the checkers cabin, It shall not be possible for checkers to walk out directly from the cabin into oncoming traffic, guard rails and or gates shall be employed to ensure cabin occupants have to stop or make a left or right turn, causing occupants to assess the traffic situation. During the design review checkers cabin access and egress shall be reviewed and approved by the Purchaser.**

(2) The following shall be provided:

i) Service outlets (2 Units)

ii) Air conditioning system to maintain interior temperature below 25°C ±2°C under the highestambient condition

iii) Ventilation fan

iv) LED lighting

v) Stabilized DC power supply 24V (10Amp) and 12V (20 Amp.) power supply forcommunication equipment.

vi) Handset for communication with other areas within the Crane as specified in 5.6.1 (IntercomSystem).

vii) Fibre optic link.

viii) CMS touch panel (client of main CMS) enabling viewing of CMS from ground level

ix) Connection port (Ethernet or Profibus) for Siemens PG for PLC interrogation/diagnostics

x) Fixed working height desk and swivel chair

4.7. Personnel Elevator

(1) The personnel elevator shall be a soft start/stop, rack and pinion driven type with stainless steel cabin,control panels and fittings.

(2) A representative from the Elevator manufacturer shall visit Site (Visayas Container Terminal, Iloilo, Philippines) to commission the elevator, load test and provide maintenance training. Certified test weights shall be provided by the Contactor for this purpose. All equipment and special tools required to perform remote drop test and any other commissioning functions shall remain on Site following theTaking-Over of the crane.

(3) Lubricants which are recommended by the elevator manufacturer for maintenance of the elevator shallbe provided in sufficient quantities for two years of operation and a complete lubrication shall be performed before Taking Over of the crane.

(4) Elevator automatic lubrication system for rack and pinion shall be offered as an option.

(5) The outside face of one of the landside legs shall be used for installation of a personnel elevator.

(6) All Elevator stations shall be adequately enclosed by manufacturer approved housing to prevent accessfrom elevator platform or walkways to open areas where elevator is running.

(7) The personnel elevator shall have a capacity for four persons with tools. The model shall be approvedby the Engineer and shall meet the requirements of Site country law.

(8) The Contractor shall be responsible for obtaining approval for the installation of the personnel elevatorfrom all Site country authorities and for obtaining and having carried out all permits, consents, certificates, inspections and tests as may be required by or from any such authority or under any applicable law. The Contractor shall pay all fees and charges in for or connection with the same.

(9) The elevator shall be operable by a master key of approved type. Six (6) master keys shall be submitted to the Purchaser at handover of the first elevator.

(10) For unexpected interruption of power or control failure, the personnel elevator shall be fitted with amanually operated constant speed-lowering device inside the car cage. This device shall allow the operator to descend safely to a lower landing platform by controlling the revolution at the end shaft ofthe driving motor. An arrow mark at the wire mesh shall match with another arrow mark to show tothe person inside for the exact location of the lower platform.

(11) A battery-operated siren and a battery-operated revolving light shall be fitted on top of the car cage. The battery supply shall be connected to the battery-operated fluorescent light inside the car cage foremergency calling for help. The battery shall be constantly trickling changed by the AC power supplyto maintain optimal operating condition at all time. A push button shall be fitted inside the car cage forthis purpose.

(12) Emergency push button to stop the motion of the car cage shall be fitted at landing platforms at eachlevel. The push buttons shall be clearly identified as "Elevator E. Stop" to differentiate between crane E stops.

(13) A recommended spare parts list for the personnel lift shall be submitted to the Purchaser together withthe detailed Priced Spare Parts List as set out in the Conditions of Contract for the Purchaser's selection.

4.8. Head-block

4.8.1. Head-block

(1) The head-block shall be designed with longitudinal and lateral Twist-lock centres to permitinterchangeability of spreaders purchased for this project. It is required to maintain interchangeabilitywith existing spreaders operating in the port.

(2) Fittings

The major fittings on the head block are:

i) Main hoist sheave blocks. Arrangement to minimize the spreader rocking motion.

ii) Spreader feed cable connections including tension relief components.

iii) A mancage with Emergency Stop Push Button to carry two men standing with a robust steelplate top and steel mesh side walls for sheave and rope protection and inward opening tubular doors on waterside and landside. Access ladders on both sides which align with theladders on the spreader.

iv) A set of manual twist locks with operating handles and linkage. The twist

locks shall be positively locked in either 'Locked' or Unlocked' position, which shall be clearly indicated onthe frame and visible from outside.

v) An electrical connector for the feeder cable for the spreader.

vi) Antisway or trim/list/skew devices, if any.

vii) Twist lock and slack rope limit switches and stainless-steel junction boxes.

viii) One (1) Emergency Stop push button station.

ix) A dummy plug and socket for the spreader feed cable end protection.

(3) All the fittings shall be securely fitted to the head block to withstand frequent impact of landing.

(4) Head-block design to allow full access to the spreader terminal boxes and spreader hydraulic unit specifically solenoid valves while the spreader is engaged to the head-block.

***CLARIFICATION: The spreader cable (from the reel) connected to the head-block junction box shall use a socketand plug. The location shall be at the side of the junction box. The cable from the junction box to the spreader shall use the cable gland. The location must be at the side of the junction box. All connections shall be reviewed and approved by the Purchaser.**

4.8.2. Crane and Spreader Communication

(1) The communication between the trolley and the head-block shall be via the baloney cable with preferably fiber optic used as the communication medium, a two-wire bus system may may be usedwith approval from the Purchaser. If a two-wire system is chosen it must be fit for purpose and tolerantto the environment in which it shall be used.

***CLARIFICATION: The Purchaser shall review and approve spreader and crane communication protocol and proposed hardware (media converters/gateways) and the location of said hardware during design review.**

(2) CanBus booster shall be used to ensure communication is more tolerant to interference and possibleinterruption.

(3) Gateway shall be provided in the operator's cabin. The cabin gateway shall convert and transmit all thestatus and conditions of the spreader to the crane PLC.

(4) There shall be at least 20% spare I/O ports to allow additional sensors to be added on the spreader.

4.8.3. Spreader Cable Feed

(1) Power and Communication between Trolley and Head-block shall be via a powered cable reel systemfitted with Prysmian or Tratos Cordaflex (SMK) type cable for vertical feeding applications.

*Cable and slip rings (silver plated) shall be suitable for use with CanBus two wire system

(2) Upon loss of power while hoisting and lowering the cable shall not be stressed beyond the cable manufacturer's maximum continuous permitted reeling tension rating. Under all other operating conditions, the cable shall not be stressed beyond 85% of the cable manufacturer's maximum continuous safe reeling tension rating. Over tension of the cable shall be monitored by way of proximity switches mounted

on the cable tension device and shall be interlocked with hoist movement.

(3) Upon loss of power while retrieving cable the hoist will continue to travel until stopped while the cablereel may stop instantly which may cause slack cable sensor indication. The control logic shall recognizethis condition and ensure that the hoist motion is not permitted until the cable is properly tensioned.

(4) The cable retrieval and pay-out shall be electrically powered. The cable reel duty cycle and machineryclassification shall be same as for the main hoist system. The drive shall provide adequate torque and speed to follow the head-block at any specified head-block elevation, acceleration and speed and toprevent slack cable or over-tension of the cable under any operating condition including snag and power failure. A means shall be provided which shall prevent the cable from spooling off the reel whenthe drive is de-energized. A convenient means shall be provided to manually release the cable reel holding device and provide controlled means to unspool the cable from the drum.

(5) The spreader cable slip ring cubicle shall be easily accessible for inspection and maintenance.

(6) The reel shall be manufactured from stainless steel or hot dip galvanized after all fabrication and machining works are completed. Fasteners shall be stainless steel.

(7) The spreader cable reel local control station shall be located on the trolley near to the reel and slip-rings. Space permitting the spreader cable reel inverter will be located in the Operators cabin.

4.9. Spreader

4.9.1. Spreader General

A telescopic twin-lift spreader (with centre spread capability) shall be provided with the crane. The spreadershall have the following general features: -

(1) Spreader Frame

i) The structural frame shall be designed and constructed to have adequate safety factors to prevent premature fatigue failure within 4 million load cycles.

ii) Access ladders to the man cage on the head block shall be fitted to the main frame on eitherside.

iii) Spreader Emergency Stop Pushbuttons at each end of the spreader and on the side of themain junction box.

iv) A drive system Lock Out isolator switch with facility for padlock shall be provided on the sideof the main junction box.

v) Hydraulic oil tank shall be stainless steel.

vi) Flared guides shall be provided at four corners of upper surface of the spreader frame wherethe frame is connected to the head-block. Size of flare to be approximately 150mm.

vii) Laser cut adhesive decals positioned and defined according to the Purchaser requirement shall be applied to the spreader to indicate SWL (Spreader and Pad Eyes), Asset Number and orientation of spreader in respect to the crane.

(2) Spreader Twist Locks

i) The twist lock shape shall fit ISO container corner fittings.

ii) Twist locks shall be floating type and fitted with sleeve type twist lock guides. A grease nipple shall be fitted at a suitable position on the sleeve to inject grease in between the sleeve and the twist lock shank.

iii) The Twist lock mounting system shall be designed to withstand frequent landing of the spreader and head-block on twist locks during handling of hatch covers and top tier containers.

iv) Twist-lock movement from 'Unlock' position to 'Lock' position shall be prohibited by mechanical and electrical interlock unless four twist locks are confirmed to be fully insertedinto corner fittings and the spreader is fully landed onto a container or hatch cover.

v) Twist-lock movement from 'Lock' position to 'Unlock' position shall be prohibited by a mechanical and electrical interlocks unless complete landing of the spreader is confirmed.

vi) Main Hoist motion shall be inhibited unless physical positions of all twist locks match the 'Lock' or 'Unlock' command switch position on the control console. A method of direct twist-lock sensing is preferred.

vii) Indicating lights for spreader twist-lock status may be placed on the spreader or head-blockin clear view of the operator but not in a position where they may be damaged. LED clusters shall be provided in two positions each showing Twist-locks Locked, Twist-locks Unlocked, Spreader Landed and TTDS for their respective twist-lock end beams. The sequence of lightsfrom Left to Right shall be as follows:

- LH Beam Twist-lock UNLOCKED (Green)
- LH Beam LANDED (Amber)
- LH Beam Twist-lock LOCKED (Red)
- RH Beam Twist-lock LOCKED (Red)
- RH Beam LANDED (Amber)
- RH Beam Twist-lock UNLOCKED (Green)
- TTDS (2x 20ft containers detected (Blue)

Indication lights shall also be provided in the Operator cabin.

viii) The solenoid valves for twist-lock control shall be fitted at both topside end beams to minimize hydraulic hoses on the telescopic mechanism. The solenoid valves shall be protected by covers to prevent water ingress but shall not obstruct any maintenance accessibility.

(3) Spreader Flipper

i) The flipper hydraulic system, rotary actuators, pumps, hoses and structure

shall be designedand constructed to have ample gathering capability of the flipper to displace the spreader by150mm and stop swaying in 3 seconds, motor type flipper actuators shall not be acceptable.

ii) Flipper operating time (arm up and down) shall be less than 5 sec maximum in each direction.

iii) Flipper shall be capable of withstanding impact of miss-landing of the spreader where onlyone lowered flipper lands on the top of a container.

iv) The flipper arms will be manufactured from spring steel and shall be connected between theflare and the lower portion by countersunk bolts to provide a flush finish to the inner surfaceof the flipper. A heavy-duty chain shall be welded to the flare and the lower portion as a safety precaution in the event of bolt failure.

v) Flippers shall be colour coded and match activation button colour in the operator's cabin.

***CLARIFCATION: for this project the spreader shall have four (4) flippers mounted at the four (4) corners of thespreader.**

(4) Spreader Telescoping

i) Telescoping guide shoes or rollers shall be designed to allow easy and quick access and simple adjustment.

ii) The guide shoes or rollers must be able to be replaced without dismantling telescopic beamsfrom the main frame.

iii) Positive mechanical stoppers of lock pin type shall be fitted at all incremental telescoping positions.

iv) Load bearing part of each stopper shall be fitted with wearing piece to allow for easy replacement of the piece in case of wear in bearing surface.

v) The operating time for extension or retraction shall be less than 30 sec. for 20'40', and 35sec. for 20'45'.

(5) Spreader Landing Probe

i) The landing probes shall positively detect the landing of the spreader on a container or on ahatch cover which are handled by twist locks.

ii) The landing probe position shall be sensed by individual proximity switches, which shall belocated to accurately indicate spreader landed and container lifted conditions. Each proximityswitch shall be monitored by the PLC/CMS.

(6) Spreader Lifting Lugs

i) Lifting lugs for handling a damaged container or an irregular shaped cargo with slings andshackles shall be fitted at four corners near each twist lock and 2 each at about one third point from each end of the main frame (total 8 lugs on a spreader).

I) Capacity of lugs shall be minimum 12.5 MT/each lug. The capacity shall be clearly indicatedby a decal applied near to each lug.

II) If applicable lugs for installing Stinis Over Height Frame shall be fitted.

(2) Spreader Protection

i) All mechanical, hydraulic and electrical components fitted on the spreader shall be protectedfrom frequent impact and vibration of operation.

ii) All the electrical cables and hydraulic hoses connected to the moving parts of the spreadershall be properly protected from damage due to interference.

iii) All the electrical parts including solenoid valve shall be protected from the weather.

iv) All solenoid valves shall be protected by individual fuses.

v) Each individual proximity switch for twist lock "Locked" or "Unlocked" position sensing shallbe connected to the I/O unit to prevent any miss-indication and unsafe movement of twistlocks caused by short circuit of any of the failed proximity switches. Such short circuit status of any failed proximity switch shall immediately prohibit main hoisting or lowering functionuntil a new replacement proximity switch is in place. A method of direct twist-lock sensing isrequired.

(3) Spreader Meters and Indication.

i) Two non-resettable, vibration damped twist-lock counters shall be fitted on the spreader. Thecounters are required to record actual number of boxes loaded and unloaded by the spreader. As such the counters shall be designed to register one count when the following combinations of motion are detected "Not Landed... Landed... Locked... Not Landed... Landed... Unlocked... ". A separate counter shall count twin-lift operations.

ii) A non-resettable, vibration damped spreader operating hour meter shall be fitted on the spreader (pump electric motor running hours).

iii) All meters shall be located inside the stainless-steel spreader junction box panel which shall be mounted on the side of the mainframe and protected from damage.

4.9.2. Spreader – Twin-lift

(1) The centre twist-lock housing shall be retracted (raised) when not in use. In this position the twist lock and corner plunger limit switches shall be by-passed. When in twin-lift mode, the centre twist-lock housings center gap can be adjusted from 0 to 1600mm either unladen or when lifting two laden 20ft containers. The operator shall be able to adjust the centre gap by means of a single axisjoystick. A memory system to capture the centre gap separation shall be provided. Two push buttons labelled 'Store", and 'Memory' shall be provided near the centre gap separation joystick. When a desired centre gap separation is achieved by the operator, the 'Store' button followed by the 'Memory' button is depressed. This action associates the separation distance with the memory location. Whenever a memory button is depressed the centre gap separation will return to the distance as captured by the memory location.

(2) Twin-lift sensors shall be fitted to the spreader to detect, when in the 40ft operating mode, thatthe spreader is not connected to two separate 20ft containers. If twin 20ft containers are present,the sensors shall prevent the twist-locking function until the correct twin or single 20ft condition is selected and satisfied or the TTDS bypass is pressed.

***CLARIFICATION: Purchaser shall review and approve TTDS and bypass functionality during design review.**

(3) The spreader control system shall provide a minimum of two memory positions and one pre- defined position which can be "learned" by the spreader control system through an operator interface. The two memory positions shall be configured to separate the twin twenty feature according to operator preference and may be selected manually or through an automatic feature which selects Position 1 over a vessel and Position 2 over the quay. The two memory positions maybe "lost" when the crane is powered down, but the pre-defined position shall be retained.

(4) The spreader shall be provided with a feature to permit retraction to a 19ft-6ins position whichmay be selected if the spreader should become stuck in cell guides.

(5) The spreader control interface shall be provided with a permanent display to show graphic images,faults, logs and other data for maintenance application.

4.9.3. Spare Spreader

(1) If required under this contract (refer to Clause 1.4.1 Crane Details and Accessories), spare spreader ofidentical specification to the crane spreader as described above shall be provided with the crane(s).

4.10. Spreader Trailer

(1) If required under this contract (refer to Clause 1.4.1 Crane Details and Accessories), Spreader Trailersfor transferring spare spreaders to and from the crane(s) shall be provided with the crane(s).

(2) Trailers shall be suitable for transporting either QC or RTG spreaders whilst in 20ft position in a cradlewith no other restraint requirements. Trailer must be universally suitable for QC or RTG spreader.

***CLARIFICATION: Contractor shall propose an alternative spreader trailer for review by the Purchaser for transporting spreaders in 40/45ft extended position (extend, retract fault or failure with spreader stuck in extended position)**

(3) Trailers shall be rubber-tired and have a standard 2-inch kingpin hitch for towing with port TerminalTractor.

(4) Trailers shall support the spreader to enable all functions of the spreader, including extend/retract motions to be tested without removing the spreader from the trailer.

(5) Ladders, platforms and handrails shall be provided to permit maintenance personnel to access the head-block to operate twist-locks and safely connect/disconnect electrical cables.

4.11. Hook Beam

(1) If required under this contract, a Hook Beam shall be provided with the crane(s). For details aboutrequired quantity and lifting capacity refer to Clauses 1.4.1 (Crane Details and Accessories) and 1.4.3QC Lifting System).

(2) The Hook Beam shall be attachable to the Head-block through manually operated Head-block twistlocks.

(3) The hook shall be a ram's horn hook, fitted to the beam through a trunnion that allows both swing ofhook shank and 3600 unlimited rotation of the hook. The

trunnion shall have an antifriction thrust bearing to support the hook.

(4) In addition, the Hook Beam shall be fitted with two smaller hooks mounted one at each end of theHook Beam. The lifting capacity of each of the smaller hooks shall be 50% of the lifting capacity of theHook Beam.

(5) Four lifting lugs shall be fitted at the corners of the bottom side of the beam. The lifting capacity ofeach lifting lug shall be 25% of the lifting capacity of the Hook Beam.

(6) The Hook Beam shall be fitted with a pair of support stands as a permanent structure to facilitate transportation and storage of the Hook Beam on the ground. Forklift truck pockets shall be providedfor transportation. In addition, four lifting lugs for lifting the Hook Beam with slings and shackles shallbe provided on top side of the beam.

(7) Maximum width of the Hook Beam structure shall not exceed 2.0 meter.

(8) Flared guides shall be provided at four corners of the upper surface of the beam where the beam isconnected to the head-block. The dimensions of the guides shall interface with the head-block twistlock box with a flare of approximately 150 mm.

(9) Steps to climb up to the top of the beam shall be provided.

4.12. Container Top Safety Frame (Lashing Cage)

(1) If required under this contract, 20-foot Container Top Safety Frames (CTS Frames) shall be providedwith the crane(s). For details about required quantity and storage location refer to Clause 1.4.1 (CraneDetails and Accessories). The design of the CTS Frame shall be reviewed by the Engineer.

(2) The CTS Frame shall be designed to carry personnel from the ground level to the container ship whilstconnected to the mother spreader of the Quayside Crane. The frame shall be so designed that personnel can work safely from within its confines to access twist-lock pockets and lashing equipmentattached to containers on board the vessel.

(3) Connection to the QC spreader will be via the standard twist-locks but a secondary safety fixing method to attach the safety frame to the spreader shall be incorporated which can be automaticallylocked as the spreader lands. A means of safe access to the frame in its stored position from groundlevel shall be provided.

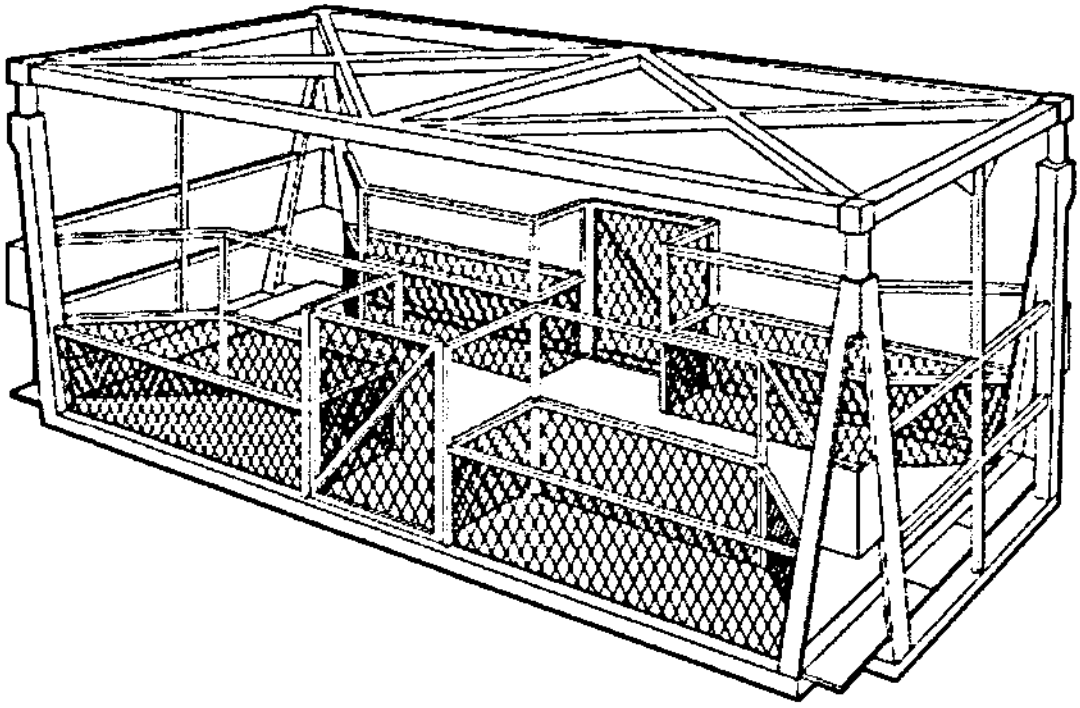
(4) The safe working load (SWL) shall be minimum 7.5 MT, suitable for transporting up to six personnel,twist-locks and tools.

(5) Design standard shall be according to BS2573:1983 Part 1 with the

following classification:
- Class of utilization U7
- State of loading Q2
- Group Classification A7

(6) Decals shall be attached and shall be as per 6.4.4 item 5

(7) The basic design shall comply with "Safety and Health in Ports, International Labor Organization Code of Practice ISBN 92-2-115287-1 (2005)" with general arrangement similar to the following sketch except that protection shall be provided against overhead falling objects and it is preferred that meshbe replaced with sheet steel for improved corrosion protection:



(8) Storage position shall permanently be located on top of the landside sill beam with gather guides onthe sill beam to assist relocation after use and to provide secure storage whilst the crane is operating.

***CLARIFICATION: For this project if location on the LS sill beam is not possible due to the hatch cover platform, the Contractor shall mount on the WS sill beam including access and egress considerations (ladders, stairways and platforms).**

4.13. **Test Weight** *(Required)*

(1) If required under this contract (refer to Clause 1.4.1 Crane Details and Accessories), a certified TestWeight for the load proof tests shall be provided with the crane(s).

(2) The Test Weight shall be in the format of a 45ft container with twist-lock corner castings positioned atthe 45ft, 40ft and 20ft locations. Pad eyes shall also be provided within the envelope of the structurefor proof testing the hook beam with shackles and slings. No protrusions shall exist on the top face.Corner castings shall be fitted to the underside for transport purpose.

(3) The Test Weight shall have facility to apply different loads to each longitudinal end by way of independent blocks having a variety of weights, 5 MT, 3 MT and 1.5 MT. The capacity of the whole unitshall be equal or higher than the maximum proof loads required under this contract.

(4) Test weight frame shall incorporate lockable storage/securing of test weight configuration blocks (5MT, 3 MT, 1.5 MT) to prevent test weight configuration blocks from inadvertently falling from test weight frame.

5. INTER-FUNCTIONAL SYSTEMS & COMPONENTS

5.1. Mechanical System/ Components

5.1.1. Bearing, Seals

(1) All bearings used throughout the Crane shall be supplied from an internationally recognized and approved manufacturer of bearings. All bearings shall have standardized equivalents across a range ofmanufacturers.

(2) All bearings shall be antifriction type except for the shafts or pins with a limited small angle rotation such as the gantry truck equalizer pins or equalizer sheaves. For all types of bearings, an effective means of Auto lubrication and sealing shall be provided.

(3) The bearing design shall be based on following life in accordance with the machinery classification.

For main hoist system	50,000 hours
For trolley travel system	50,000 hours
For gantry travel system	15,000 hours
For boom hoist system	15,000 hours

(4) Bearing housing or retainer shall be a split type or boltdown type to facilitate fast inspection andreplacement work.

5.1.2. Gearing

(1) Gears shall be of helical or herringbone type and designed in accordance with the relevant BS, AGMAor DIN standards.

(2) The durability rating for the main hoist, trolley and boom hoist drives shall be based on a minimumservice factor of 1.5 for rated load and rated speed and a wear factor of 0.7.

(3) All other gearing shall be selected or designed for a minimum service factor of 1.0.

(4) The gearing for all main drives shall be totally enclosed in a split, oil tight steel box with oil bath lubrication

(5) All open gears for the auxiliary drive systems shall be properly covered or guarded with covers or guards for safety. The cover or the guard shall be easily removable and have adequate ports to checkand lubricate the gears.

(6) Oil or grease tray of a removable type under each open gear shall be provided to receive excess lubricant. Prevention against overflow of oily water out of such trays during rainy operational conditionshall be taken into consideration in the design.

5.1.3. Gear Reducers

(1) The gearboxes shall be fitted with effective gear inspection windows and sight glass type oil level gauges. The gearboxes shall be free from oil leakage. A dipstick type oil level gauge system is notpermitted.

(2) The gearboxes shall be designed to allow easy replacement of gears or gear shafts without removingthe whole gearbox assembly from its mounting base.

(3) Drainpipes with shut off valves and end plugs shall be fitted to each gearbox for draining lubricant. Anadequate drain receiving space for each drain outlet shall be provided.

(4) Gear reducer housings shall not be manufactured from cast-iron.

5.1.4. Wire Rope Winch Drums

(1) The main hoist, trolley and boom hoist drums shall be of rolled welded steel construction,dynamically balanced and complete with machined grooves for single layer winding of wire ropes.

***CLARIFICATION: For this project static balancing shall be accepted.**

(1) The grooves on the drum shall be pitched so that there is clearance between the turns of rope on the drum and also clearance between the part of the rope leading onto, or leaving the drum, and the adjacent coil.

(2) The bottom of the grooves should have a circular arc over an angle of not less than 120 degrees and the radius of the groove should not be less than 5% nor more than 7½% larger than the nominal radius of the rope. Rope grooves shall be machined, and surface hardened to HB321 minimum.

(3) The diameter of the drum at the bottom of the groove shall not be less than 30 times the nominal rope diameter.

(4) The maximum angle of fleet between the rope and a plane perpendicular to the longitudinal axis ofthe drum shall not exceed 2.5 degrees.

(5) The drum shall be flanged at both ends.

(6) The wire ropes shall be secured to the drum by a suitable clamping device. The design of this device will be subject to review by the Engineer during the design stage.

(7) The length of the hoist drum and wire ropes shall be such that when the head-block is at its lowestspecified point at least three full turns of rope shall remain on the drum. When the load is at its highest possible point at least one empty groove shall separate two adjacent ropes, depending on the drum configuration.

(8) With the boom in the fully lowered position there should be at least three full turns of each rope remaining on the boom drum, and in the fully raised position at least one empty groove shall separate the two ropes.

(9) The trolley wire rope drums (if applicable) shall retain at least three full turns for each rope end when the trolley is either at the boom end or in the back reach. Three empty grooves minimum shall be maintained between different ropes mounted on the same drum.

(10) Oil or grease tray of a removable type adequately segmented for easy removal by hand shall be provided under each wire drum to receive excess lubricant. Prevention against overflow of oily waterout of trays during rainy conditions shall be taken into consideration.

(11) Heavy-duty clear plastic or steel splashguards shall be mounted in front of hoist (including boom-hoist)drums so as to prevent the covering of motors, reducers and adjacent equipment with excess wire rope lubricant during crane operation.

(12) Tubular Steel heavy-duty wire rope guards shall be fitted at mid-level of the wire

rope winch drum toprotect the wire ropes from entanglement when spreader is at its utmost height emergency position.The clearance between main hoist wire ropes and the surface of the guards shall be equal to half ofthe wire rope diameter.

5.1.5 Wire Rope Sheaves

(13) All wire rope sheaves shall be of fully forged steel construction with smoothly machined grooves, fabricated or cast sheaves shall not be acceptable.

(14) Alternatively, Xtek sheaves can be provided, if not possible to supply fully forged sheaves.The bottom of the grooves should have a circular arc over an angle of not less than 120 degrees, have an included angle of 52 degrees and the radius of the groove should not be less than 7½% nor more than 15% larger than the nominal radius of the rope with 11% being the optimum.

The supplier is to furnish specific details of the proposed sheave profiles.

(15) Minimum design life of the hoist and trolley sheaves, specifically the groove and bearing retainer, shallbe 20,000 hoist operating hours.

(16) The pitch diameter shall be at least 30 times the wire rope diameter. An equalizer sheave may have a smaller diameter provided that the small radius will not reduce the safety factor of wirerope below the specified value

(17) The maximum angle of fleet between the rope and a plane perpendicular to the axis of the sheave shall not exceed 2.5 degrees.

(18) The surface of the groove of the sheave shall have a hardness value of minimum 321 on the BrinellScale. The groove of the sheave shall be hardened to a depth of at least 8mm.

(19) All running sheaves shall be fitted with anti-friction roller bearings with grease fittings for pressure auto lubrication.

(20) In the locations where the wire ropes can jump or ride off the sheave, rope guards shall be fitted.

(21) Rope Sheaves shall include requirement for 100% MT in the rope grooves and provision for one spare sheave of each type so that depth of hardness could be checked by destructive testing.

5.1.1. Wire Ropes

(1) The factor of safety shall not be less than 6 for main hoist, boom hoist, and trolley travel in concentric condition.

(2) All the wire ropes shall be right regular lay (Zlay) EPIWRC 6x36 construction, 1770 N/mm² unless agreed otherwise.

***CLARIFICATION: For this project 8x26WS wire rope construction shall be acceptable, boom hoist wire rope shall be1960 N/mm²**

(3) Wire rope lubricant shall be carefully selected to minimize dripping problems.

5.1.2. Shafts, Axles

(1) Shafts and axles shall be designed to include acceptable allowances and finishes for stressconcentrations at fillets, keyways and lubrication holes. All splines, gear teeth, or threads shall run out smoothly or shall be undercut and surface finish shall be uniformly smooth and free from defects.

(2) For any long driving shaft, the torsional deflection shall not affect the coupling or

gearingassociated with the shaft.

(3) Gearing axle brackets shall be a split type or a bolted type for simple removal of axle and bearing.

(4) Shafts shall be properly covered or guarded for safety.

(5) Mechanical components such as main pins and shafts shall be designed to good notch toughness practices using fine grained steel. The responsible mechanical engineer shall determine therequired fracture toughness. Forging or steel bar's toughness verification testing requirements shall be as per relevant material standards/codes, test temperature shall be as required by FEM for minimum crane ambient temperature specified in the Technical Specification. Fracture critical members shall have a toughness verification testing performed for each heat at a minimum. Samples for non-fracture members shall be selected and tested at random.

(6) Rotating Couplings shall be lubricated with special grease to prevent oil separation and leakage underthe effects of centrifugal force. Rexnord FALK LTG Flexible Coupling Lubricant is approved by the Purchaser for this application.

5.1.3. Steel Wheels

(1) Gantry, trolley, and catenary trolley wheels shall be double-flanged type forged steel wheel with hardened tread.

(2) The hardened wheel tread shall have a hardness value of minimum 50 HRC. The wheel tread shall behardened to a depth of at least 5mm.

(3) The design life of the trolley and catenary trolley wheels shall be a minimum of 25,000 operating hours.

(4) The design life of the gantry wheels shall be a minimum of 10,000 operating hours.

(5) Crane gantry wheels, trolley and catenary trolley wheels shall include requirement for 100% MT onthe wheel tread and inner sides of the flange.

5.1.4. Pins, Pin Brackets

(1) Mechanical components such as main pins and shafts shall be designed to good notch toughness practices using fine grained steel. The responsible mechanical engineer shall determine therequired fracture toughness. Forging or steel bar's toughness verification testing requirements shall be as per relevant material standards/codes, test temperature shall be as required by FEM for minimum crane ambient temperature specified in the Technical Specification. Fracture critical members shall have a toughness verification testing performed for each heat at a minimum. Samples for non-fracture members shall be selected and tested at random.

(2) An adequate auto lubrication system shall be provided for all pins and pin joint locations in order toprevent seizure within the life of the crane.

(3) Suitable access and extraction facilities shall be provided for all removable pins. This shall include jacking and or pulling.

(4) In order to facilitate ease of lubrication and to reduce the possibility of hardening lubricant causing blockage, all pins shall be supplied with single straight-drilled lubrication holes.

(5) The forestay and backstay shaft lubrication design shall be approved by the Purchaser.

(6) The use of oil-less bushes shall not be acceptable.

5.1.5. Bolts

(1) All bolts are to be manufactured to ISOmetric standard.

(2) Tightening torque for all fitting bolts shall be clarified by the Contractor in the form of a bolt list clearlyindicating bolt location, size, material and quantities.

(3) Structural bolts may be tightened by any standard method. The bolt tension may be checked at location selected by the Purchaser's representative. The checking at these locations shall be done bythe contractor and in such a manner that the torque wrench or indicator can be read and verified. Loctite shall not be applied to any fastening, unless approved in writing by PURCHASER.

5.1.6. Lubrication

(1) All the moving parts shall be effectively lubricated.

(2) The Contractor's designated lubricant shall be locally available within the country of operation. The lubricants initially filled in manufacturer's shops shall be preapproved by the Purchaser for their compatibilities with those lubricants to be used by the Purchaser.

(3) Any excess lubricant shall be trapped in removable trays or receivers.

(4) Standard and uniform hydraulic, button head, steel grease nipples shall be used throughout the Crane.

5.1.7. Couplings

(1) All main drive couplings shall be supplied by an internationally recognized manufacturer of couplings.

(2) All main driving shafts shall be fitted with flange type flexible couplings. All coupling bolts shall be locked with a proprietary locking system.

(3) Couplings shall be properly covered or guarded for safety. The cover or the guard shall allow easy access for lubrication of the coupling without removing entire cover or guard.

(4) All spline and barrel couplings shall be fitted with an allowable wear indicator visible without dismantling the coupling. The maximum wear limit shall be clearly marked. The grease nipple for thespline or barrel coupling shall be extended to the edge of the main hoist winch drum to facilitate easymaintenance.

(5) Intelligent (PLC controlled) dual line Auto-Lubrication system shall be provided with all moving parts effectively lubricated, especially hard to reach pins, joints and bearings.

(6) Overall Auto-Lubrication system design and lubricating points to be reviewed and approved by the purchaser.

5.2. Hydraulic System/ Components

5.2.1. Standards

Hydraulic systems shall be designed in accordance with relevant international Standards. All components suchas pumps and valves must be capable of operating continuously.

5.2.2. Components Sources

Main components shall be sourced from internationally approved suppliers and the hydraulic systems shall use components, which are readily available in the country of operation. Main components considered to be:

- Main Valves such as solenoids and relief valves
- Pumps
- Motors
- Couplings

5.2.3. Operating Condition
Under conditions of continuous operation, the pump inlet temperature of the fluid must not exceed 65 degrees

C. The equipment shall operate efficiently in an ambient temperature range of 10 degrees C. to 40 degrees C.The system shall incorporate fluid over temperature protection which shall operate to indicate the fault and stopthe operation of the pump.

5.2.4. Hydraulic Fluid Reservoir
The type of hydraulic fluid for the initial fill by the Contractor must be pre-approved by the Purchaser.

All Hydraulic reservoirs/storage tanks shall be provided with adequate drainage facilities to permit the draining ofthe hydraulic fluid into waste oil receptacles through shut-off valves which can be easily accessed. Space shallbe provided around and below the drain valve to allow this essential maintenance work without spillage.

(1) The capacity of the fluid reservoir shall be sufficient to contain all the fluid that can flow from the system into the reservoir. The fluid level shall be maintained at a safe working height to prevent cavitation in the pump during the operating cycle.

(2) Reservoirs shall be equipped with clearly viewed flush mounted or protected fluid level indicators. They must be provided with markings indicating high level when pumps are stopped and low level when the pumps are in operation.

(3) Reservoirs shall be constructed to prevent entry of foreign matter, including fluid contamination andmoisture.

(4) Both fluid intake and return points shall terminate sufficiently below the minimum fluid level to preventaeration.

(5) Each hydraulic fluid reservoir shall be fitted with a level switch which provides low level warning andalso prevents damage to the system components by switching off the electric pump motor if a seriousssystem leak develops.

5.2.5. Power Unit

(1) Positive displacement pumps and motors of similar type, size and manufacturer are preferred. On noaccount will any immersed pumps be accepted.

(2) Means and good access shall be provided for filling and draining pump and motor casings in accordance with the manufacturer's specifications.

5.2.6. Valve Mounting

Wherever possible, valves shall be mounted so that their removal and replacement can be made without disconnecting pipe fittings. Adjustable valves shall be such that their settings, when made, will be maintainedagainst vibration.

5.2.7. Relief Valve

A pressure relief valve capable of relieving the maximum flow at the outlet of the pump shall be provided on thedelivery side of the pump and there shall be no other valve between the pump and the relief valve.

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 back pressure shall be externally drained. Wherever possible, relief valve shall be used as safety relief's and shall be set a minimum of 10% higher than maximum operating pressure. Solenoid operated directional valves shall haveoil 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 1,000 psi or maximum pressure allowed by manufacturer, whichever is less. External drain lines shall be designed to minimize pressure surges and reduce backpressure. Four-way valves shall spring centre or spring offset to a failsafe position upon electrical failure.

5.2.8. Flow Control Valves

Variable flow control valves shall show direction of operation for increase and decrease of throughput.

Flow control valves shall be pressure and temperature compensated over the full range of flow for which thevalve 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.

5.2.9. Check valves

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.

5.2.10. Servo valves

Servo valves shall be rated for maximum operating flow with a maximum pressure drop of 400 psi 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.

5.2.11. Control Valves

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.

5.2.12. Solenoid Valves

(1) All solenoid valves shall operate from the "Control Voltage" level defined elsewhere and shall bereplaceable without disassembling the valve or removing it from the sub-plate or manifold.

(2) All solenoid valves shall be protected from weather.

(3) Valves including specifically solenoid valves shall be readily accessible to allow for any adjustment,operational check, or manual operation in an emergency.

(4) Solenoids shall have continuous rating and be equipped with an LED indicator for indicating fault.

(5) All solenoids shall be fitted with an independent surge absorber to absorb high voltage spike due to'close' and 'open' of highly inductive load solenoid.

5.2.13. Piping

(1) Welded joints in hydraulic pipe work shall not be permitted. (Except where the hydraulic pipe diameteris 30mm and above)

(2) All rigid piping shall be securely supported to minimize vibration or movement. The length and methodof supporting flexible piping shall be such as to avoid sharp flexing and straining, particularly at theend fittings. The spacing between adjacent rigid pipes and between rigid pipes and the surroundingsteelwork etc., shall be sufficient to allow the pipe couplings to be secured with ease and without damage to adjacent pipes or couplings.

(3) Piping between actuating and control devices shall be as short as possible and pipes must be removable without dismantling equipment, components or adjacent piping.

(4) Rigid hydraulic piping shall be stainless steel.

5.2.14. Hoses

(1) Flexible hoses and couplings shall be in accordance with the requirements of the relevant international Standards and shall be of an approved type and manufacturer.

(2) Flexible hose shall be protected from mechanical damages due to interference with structure, equipment, or any moving parts.

(3) Where the pressure adjustment is critical, a pressure gauge port with shut off valve shall be provided in the line so that the pressure can be checked without disconnecting the lines.

(4) Hoses shall be designed for burst pressures of 10,000 psig and shall be tested at 5,000 psig.

5.2.15. Assembly Test
After assembly, the system shall be hydrostatically tested to 150% maximum pressure.

5.2.16. Catch Basins

(1) All hydraulic power units will have catch basins to collect leakage for the power unit and its components. The basin shall be sized to a minimum of 10% of the reservoir's volume.

(2) Catch basins shall be fitted with a manual valve equipped with drains. The drains shall either be accessible from crane walkways, machinery decks, the wharf, or from the trolley. 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.

5.2.17. Filters

(1) Filters shall be full-flow, non-bypass type complete with visual condition monitoring. The filter may befitted either in the intake, pressure, or return lines and shall have a 10-micron nominal filtration rating. When the filter is installed in the pressure or return lines the pump intake shall be fitted with a wiremesh screen (100 mesh or finer).

(2) The filter shall be easily accessible for element replacement purposes without having to drain the reservoir and/or system.

(3) A suitable magnet should also be fitted in the bottom of the reservoir between the return side of the reservoir and the suction strainers. Magnets shall be easily removable for cleaning.

5.2.18. Gauges

(1) Delivery pressure gauge shall be provided on each system. The gauge shall be connected via a failtosafe valve and damping loop, and rigidly mounted on a structure. It can only be read by operationof a fail-safe valve.

(2) An oil level gauge on the reservoir shall be provided at a location convenient for inspection by directeye-sight.

(3) Quick connect / disconnect gauges shall be provided along with permanent connection points at alllocations in the system where the pump pressure is reduced

5.2.19. Covers

Cover for hydraulic systems shall be designed to permit prompt and direct access to system components.

5.2.20. Hydraulic Fluid

The type of hydraulic oil for the initial fill by the Contractor shall be preapproved by the Engineer.

Hydraulic oil of appropriate grade for the ambient conditions at the Site shall be installed in the hydraulic system by the manufacturer prior to shipment for factory testing purposes and shall remain in the system during transport to site. Prior to filling with hydraulic oil, the entire system shall be flushed to removeforeign materials such as swarf or other contamination. Oil cleanliness shall conform to ISO 4406 Code16/13 or better.

5.3. Electrical & Electronic System/Components

5.3.1. General

(1) The Contractor shall be responsible for the safe and reliable operation of all equipment in accordancewith the requirements of this Specification. The electrical installation shall provide reliable power forthe rapid precise handling of containers in continuous loading and unloading operations.

(2) The drive system vendor shall undertake a complete power system analysis at the crane operating sitethat includes existing or future terminal power distribution systems. The study shall include power flow, voltage drop and short circuit calculations to be used in the selection of the crane power distribution equipment and coordination with the terminal power distribution system contractor or utility company. The results shall be submitted to the Engineer within 90 days of issue of the Letter ofAcceptance.

(3) The drive controls for the Main Hoist, Boom Hoist, Gantry and Trolley drives shall be AC variable frequency type using Insulated Gate Bipolar Transistor (IGBT) technology. The general requirement forthe electrical drive controls is to provide reliable power for the rapid and precise handling of containersthrough the use of power conversion assemblies controlling AC motors for the Main Hoist, Boom Hoist, and Trolley and Gantry motions.

(4) Drive controllers for the Main Hoist and Gantry motions shall be independent but the Trolley motionshall be shared with the Boom Hoist. The Boom Hoist shall only be operable from the Boom controlstation and it shall not be possible to operate any other motion during Boom operation.

***CLARIFICATION: For this project it shall be possible to switch to one independent drive in the event of a drive failure, to recover hoist or gantry for removing from a vessel "make safe purposes" Contractor to propose operating parameters such as drive selection (key switch/selector switch) and speeds and accelerations when utilising onedrive.**

(5) All electrical installations shall be adequately earthed to protect electrical equipment from damage during lightning storm. Lightning arrestors shall be provided at the tip of the boom and mast structure of the Crane. They shall be connected through the structure to the ground by means of separated brushes at the rail. Separate cables shall be connected across bolted joints, pins and bearings.

5.3.2. Power Supply Specifications

(1) Supply Voltage from Crane

Service Pit(2)AC –kV ±10% 60

Hz±2%, 3-phase

(3) Main Drives in IT supply configuration with insulation monitor such as Bender IRDH275

(4) Main drives AC Motor voltage and control power voltage to be proposed by the Contractor.

(5) Control Voltage shall be 120V 1-phase 60Hz.

(6) AC Motors AC 460 V 3phase 60 Hz

(7) Access Lighting shall be 220V 1-phase 60Hz.

(8) Floodlighting shall be 220V 1-phase 60Hz.

(9) Receptacle Outlets shall be 220V 1-phase 60Hz.

(10) Alarm, intercom, and other accessories DC 24V

(11) Air-conditioning system "outdoor unit" stabilized supply voltage is unit/country specific and shall beapproved by the Purchaser.

(12) Air-conditioning system "indoor unit" stabilized supply Voltage is unit specific and shall be approvedby the Purchaser.

***CLARIFICATION: Air conditioning condenser units and indoor units may be different supply voltages (single phase and 3 phase)**

(13) Window wiper and washer. DC 24 V.

(14) Radio communication equipment, stabilized DC 24 V, 10 amp and DC 12 V, 20 Amp

(15) Welding outlet AC 415V 3-phase 60 Hz.

5.3.3. Power Factor and Harmonic Voltage Distortion

(1) Power Factor correction equipment shall be installed on each crane to actively and dynamicallyregulate the power factor according to the following criteria:

- Minimum 0.95 lagging average power factor over 15-minute demand period
- Minimum 0.90 lagging power factor maintained when operating the main hoist and trolleywith rated load at maximum speed.

- Average 0.88 lagging power factor during acceleration and deceleration phase with main hoist and trolley operating simultaneously with rated load in all master controller commandpositions.
- Maintain a 0.99 lagging power factor when all drives are idle, or the

crane is stowed. ■ Minimum instantaneous power factor shall not be

less than 0.45 lagging.

***CLARIFICATION: Power factor of 0.9 shall be maintained when all drives are idle (ALM off) or when the crane is stowed.**

(2) Power factor regulation shall be stepless and shall not introduce voltage transients, line notch transients or line notch ringing into the system. The power factor regulation device shall be capable ofdynamically tracking the transient loading of the drive systems.

(3) Harmonics injected into the system shall be appropriately mitigated on board each crane to preventundesirable harmonic current injection into the power system. As a minimum, total harmonic voltage distortion at the Point of Common Coupling (PCC) shall meet the guidelines defined in IEEE 519-1992(IEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems) Table 11.1 (Voltage Distortion Limits). The PCC is defined as the feeder cable connecting to the container yard switchgear.

(4) Power factor regulation and harmonic voltage distortion shall be verified by monitoring at the PCC ofthe test crane while all other cranes are idle. Power factor and harmonic voltage distortion shall be recorded with the main hoist and trolley operating and accelerating with rated load and maximum speed and with the main hoist and trolley operating with empty spreader to top speed. Power factor recordings and tests shall be performed on each individual crane with the power quality meter on board the crane. Harmonic distortion measurements shall be performed with an analyser located at thePCC. The Contractor shall monitor the incoming bus within 2 meters of the PCC of each crane over the duration of endurance testing and submit a detailed report of the measurements.

***CLARIFICATION: For this project due to the specialist nature of recording harmonic measurements the service shallbe provided by a 3rd party specialist and shall be to the Contractors account.**

5.3.4. Protection against Power Surge

All electrical and electronic equipment shall be protected by transient surge suppressor installed as close as possible to each component which requires protection from the surge in power and control circuit. Any electricalapparatus or device on the Crane which may introduce a surge shall be properly designed to suppress surgewithin its own environment and shall not cause any interference to other equipment or control functions of the Crane. The following are, whilst not limited to, particular areas which require special attention in terms of thetransient surge suppression.

(1) The automatic power factor correcting device and the harmonic suppression device shall be designedto be of solid-state device without contactor to eliminate the surge generated during 'on' and 'off' ofthe contactors which may cause a transient surge in the control circuit and in turn may create erroneous signals to trip off the main drives operating circuitry.

(2) All rectifiers from AC to DC shall be protected by surge absorber on the AC side as

well as the DC sideto have a clean DC output and with a suitable diode to maintain the voltage at optimum level.

(3) All AC contactors, DC contactors and relays shall be connected in parallel with suitable surge absorberto absorb transient surge due to make and break of coils contact and minimize the disturbance of voltage to the sensitive areas within the Crane.

(4) Critical items such as Programmable Logic Controllers, computers and I/O modules shall be protectedfrom external transient surge by independent surge absorber on their power supply line.

(5) Any other items considered vulnerable to any transient surge must be properly protected from transient surge to minimize interruption of Crane operation.

5.3.5. Protection for Power Dip/Power Failure

(1) The high voltage power supply electrical circuit of the crane shall be properly designed to minimizecrane recovery time in case of power supply failure in a form of short duration voltage dip or a complete loss of high voltage power supply.

(2) The AC Inverter Drive for the Crane shall be designed so that in case of power supply voltage dip ora complete power failure when boom is lowering at full speed or when main hoist is lowering at fullspeed with wide range of Empty spreader to full load under spreader, the entire control system shallnot fail and worst case is only to trip out the under voltage protection relay as fitted on the InverterDrive. All fuses and Insulated Gate Bipolar Transistors (IGBT) shall not burn off under any condition during real life operations. If any fuse or any IGBT should fail, the Contractor shall take all responsibilities to change the design to cope with the above-described condition.

(3) The AC line low voltage power supply to the converter shall be connected in series with AC current limiting reactors to limit the short circuit current if there is any such condition when boom is loweringor main hoist is lowering at full speed with and without load under spreader. An adequately sized Moulded Case Circuit Breaker shall be connected in series to trip out the circuit in such case to minimize damages.

(4) The Contractor shall demonstrate to the Purchaser by switching off the high voltage power supply when boom is lowering at full speed or main hoist is lowering at full speed with empty spreader or full load under spreader. Nothing shall burn out except trip of the under-voltage relay as fitted at theAC Inverter.

5.3.6. Wiring

(1) All wiring shall be multi strand; solid core shall not be accepted.

(2) For this project, the minimum wire size shall be 0.75 mm^2 except for factory wired panels which mayinclude smaller size wires and communication cables. In general, minimum 1.5 mm^2 is used (power),
0.75 mm^2 will be used on equipment which does not have sufficient space to allow the use of 1.5 mm^2 such as I/O modules, small limit switches, solenoid valves, encoders etc. The wiring size will bebased on IEC regulations.

(3) Wire shall be connected only at the terminal blocks in panels, control box, joint box, or at the terminal of electrical equipment. Wires shall not be joined other than at proper terminals, any wiringor cables found to be in line spliced shall be replaced.

(4) All conductor wires of 4 mm^2 or smaller shall be terminated at terminal strips or at

components having spring type or screw type terminals, bootlace ferrules shall be used for screw type terminalsonly. Wires of 4 mm² or greater shall be terminated in screw type terminals with bootlace or spadeor ring tongue crimped solder-less lugs. Only one wire shall be permitted in each terminal.

(1) All wires shall be run in trunking or conduit sufficient in size to carry all cables with some capacity forspare cables. It is preferred that wire routing is installed inside the crane box structures. All wires which run through holes or windows in the structure must be protected from insulation damages dueto mechanical contact with structures. Control and signal wires (including encoder cables) shall be separated from power wires and routed through flexible conduit to avoid any interference causing false signals. High-voltage wires shall be run independently. Multicore cables may be run on cabletrays with adequate cable ties and mechanical protection covers.

***CLARIFICATION: Encoder and communication cables such as, but not limited to Profibus/Profinet shall be routed in such a way to prevent EMI either by separation or through UL listed or equivalent flexible conduit. Siemens Cabling and Wiring Guidelines for Cranes shall be strictly followed and enforced.**

(2) At least 10% of control wires as spare wires shall be installed on all routes and specifically labelled assuch. 10% spare communication wires shall be run to each communications point and operations station. All spare wires shall be terminated in the terminal block and marked as spare.
***CLARIFICATION: For this project 10% spare control wires shall be installed to panels and junctionboxes only.**

(3) Vertical long-distance wiring shall be restrained to prevent wire breakage due to suspension of self-weight of wires or cables.

(4) Wiring on the trolley, head-block and spreader shall be designed to withstand continuous vibration and impact.

(5) Each wire shall be cut to an adequate length to avoid any kinks or sharp bends and fitted with terminal lugs and marked at both ends with ferrule with number corresponding to the number in schematic diagram. Tape or indelible markers are specifically not allowed.

(6) Optical fibre cable shall be applied on all communication cable runs in excess of 100m and is mandatory for communication between main PLC and operator's cabin via the energy chain or festoon and between main PLC and gantry I/O stations.

***CLARIFICATION: Long Profibus/Profinet segments in excess of 100m and short Profibus segments of 1m or lessshall not be acceptable.**

(7) If Siemens Drive CLiQ is utilized only OEM cables and connectors shall be used.

5.3.2. Marking and Identification

(1) All conductors (internal and external to panels) shall be labelled at both ends with hot foil printed, plastic tubing wire markers in accordance with the electrical drawings and wire schedules. Colour andalphanumeric identification shall comply with the IEC 60446 code.

(2) All terminal blocks shall be properly marked with the block number and terminal number as shown on the drawings.

(3) All panels, boxes and cabinets shall be marked on the outside using engraved

plastic name tags fastened with stainless steel screws containing unit number and general function, name ordescription.

(4) Individual control devices in cabinets shall be labelled by number description in accordance with thedrawings using durable, heat resistant labels with permanent markings, and fixed in a manner designed to combat extreme hot and cold conditions over long periods.

(5) Major control cabinets shall be labelled with engraved plastic description tags fastened with stainlesssteel screws.

(6) The method of securing cables within the control panels shall utilize a proper and correct method ofattachment. The use of self-adhesive pads to secure cables in any location is strictly not permitted.

***CLARIFICATION: If stick on labels are to be used as an alternative by Contractor to identify power and control items/devices in electrical panels, the labels shall be resistant to high temperatures and be good quality 3M type as aminimum and shall be approved by the Purchaser.**

5.3.3. Conduit, Cable Tray and Junction Box Panels

(1) Rigid conduit, with pull boxes at appropriate locations, shall be water proof and continuous. Inside ofthe conduit must be smooth, and inner edges of both ends must be rounded smooth.

(2) All flexible conduit used shall be UL approved, liquid tight flexible metallic conduits, terminated in approved end fitting from the same manufacturer and installed as per NEC requirements. ImprintedUL approved markings are to be clearly visible at intervals on the external jacket, the flexible conduitand on the end fittings. The use of flexible conduit shall be minimized and occur only where required to accommodate relative motion, etc. All flexible conduit locations shall be submitted to PURCHASER for review. Flexible conduit with proper fittings may be used between end of rigid conduit and pull boxor terminal box of motors, brakes, limit switches and all other independently installed electrical equipment which require adjustment, realignment or removal for maintenance or are subject to vibration.

***CLARIFICATION: For this project IEC shall be acceptable with the provision any local requirements regardingelectrical installation standards are satisfied.**

(3) Rigid conduits shall be rigidly fastened to the crane structures.

(4) All conduits shall be contained within the Crane structure profile for protection.

(5) No conduit is to be installed across /above walkways or working platforms or in any way that could beconsidered to impede safe passage, access, safety of operation etc.

(6) For conduit runs of more than 6 meters a pull wire shall be left in place.

(7) Top entry into terminal/junction boxes shall be avoided.

(8) A drain hole shall be provided at the lowest point in each junction box, and it shall be properly corrosion protected at the point of drilling.

(9) Ladder type, open electrical cable tray shall be stainless steel (T304 Grade) and fixed to the structureusing stainless steel bolts and nuts. The type and fixing of cable tray shall be reviewed by the Purchaser and a procedure for repairing damage

or cut section edges shall be presented for approval.

(10) Ladder type, open electrical cable tray shall be provided with stainless steel cover, secured to tray using stainless steel bolts and nuts. Covers are to prevent mechanical damage to electrical cables and provide additional UV protection.

(11) Ladder type cable tray trunking and conduit must be electrically continuous. (linked by grounding cable)

(12) All exterior electrical panels and junction boxes shall be constructed from stainless steel (T304 Grade)NEMA 4X enclosure of a quality grade which will not display corrosion throughout the lifetime of the crane. Vertically hinged doors shall be provided, having a facility to secure in the open position during maintenance activities. Panels which have doors secured by means of stainless-steel clips and bolt arepreferred. Environmental Protection shall be IP65 minimum and no fixing bolts shall be permitted topass through the walls of the enclosure. It shall be possible to remove and replace all internal components without removing the back panel.

(13) Small junction boxes for electrical equipment and lighting must be manufactured from plastic or composite material of environmental protection IP65 or greater. Pull boxes shall not be used as junction boxes.

5.3.4. Electrical Trunking

(1) Electrical trunking and trunking covers shall be stainless steel (T304 Grade) and shall be free from sharp edges or sharp corners to protect the wires.

(2) Trunking shall have appropriate partitions to separate power and control wires and be fitted with restraining devices to prevent excessive wire movement in the trunking.

(3) Trunking shall be designed so as not to trap any water inside in case of water ingress.

(1) Motor terminal boxes shall be top mounted wherever possible to facilitate interchangeability of motors.

(2) All the main motors shall be fitted with space Heaters.

(3) Motors shall be sized according to FEM 3rd edition Booklet 4 (Selection of Motors). The minimum rating and duty of the motors, designated according to IEC 34-1 standard, shall be as follows:

Motors	Minimum Duty Ratings required
Main Hoist motors	S1 Duty type, Continuous.
Boom Hoist motors	S2 Duty type, 60 minutes rating.
Trolley travel motors	S1 Duty type, Continuous.
Gantry travel motors	S2 duty type, 60 minutes rating.

(4) All motors for the main hoist, boom hoist, trolley travel and the gantry travel system shall be fully supported in catalogue and individually tested in the motor factories; the reports of such tests shall besubmitted with the commissioning reports of each

crane.

(5) Hoisting motors moment of inertia shall be kept to a minimum.

(6) Motor phase to earth (peak to peak) voltage shall not exceed 2200VAC for a Line voltage of <=500VAC

(7) Motor feeder cables shall be symmetric and screened with capacitance equivalent Prysmian ProtoflexEMV

(8) Where possible motor feeder cables shall be routed on open type cable ladder for optimal cooling andminimal de-rating as per IEC60204-32 Annex B.

(9) Termination of motor feeder cables in drive panel and motor terminal box shall use screen clamps andEMI glands.

(10) All DC (if applicable) motors shall be provided with commutator end covers, which are transparent to provide a simple means of inspecting the condition of commutators and brush gear without removingthe end covers.

(11) Indoor motors shall be IP23 protection. Outdoor motors will be IP55 protection.

(12) Forced ventilation equipment on main function motors in the machinery house shall not interfere inany manner with re-reeving operations.

(13) The trolley and boom hoist motors shall be identical and interchangeable, unless trolley is self- propelled.

***CLARIFICATION: For this project motor feeder cables shall be of European or Japanese origin from a recognisedmanufacturer, (Eastern Europe is excluded)**

5.3.2. Brakes

(1) Ample space shall be provided around brakes for inspection and maintenance works, including accessto CMB.

(2) Brake discs shall be dynamically balanced.

(3) Brake discs shall not sustain damages due to an emergency stop operation.

(4) Every brake unit shall be provided with brake lining auto wear compensator.

(5) The main hoist and trolley service brakes shall be provided with condition monitoring with reporting ofstatus through the CMS system in graphical format. The following parameters shall be monitored:

Disc temperature

- Thruster Stroke
- Air Gap (For each Pad 1 & 2)
- Brake Pad thickness (For each Pad 1 & 2)
- Contact Force
- Brake Force

(6) Brake Linings to be of nonasbestos material.

5.3.3. Medium Voltage Panel and Switches

(1) The power shall be separated for auxiliary power and main motions power. Three 13.2kV circuit breaker switches shall be provided as follows.

i) One isolation switch for incomer

ii) One VCB for auxiliary power transformer

iii) One VCB for main motion transformer (Hoist/Gantry, Trolley/Boom power supply).

(2) The Contractor shall submit the tripping characteristics and calculations of the 13.2kV switches protection relay for the Purchaser's review.

(3) The 13.2kV equipment shall be equipped with a Power Quality Meter, GE Type Multilin PQMII with adjustable recording threshold. The device shall display and save results for future retrieval. The PowerQuality monitoring device shall communicate with the CCMS which shall save the annunciated eventsand record the following parameters as a minimum:

- Under Voltage
- Over Voltage
- Power Factor
- Total Harmonic Distortion
- Kilowatt Hours (Active and Reactive)

Power factor and harmonic distortion shall be monitored and trended by the CCMS. The monitoring system shall include the ability to capture historical instantaneous power consumption and power factor data and store for future processing.

(4) The system shall be designed to indicate and log within the CCMS and PLC, the tripping of any vacuumcircuit breaker. All vacuum circuit breaker protection shall be digital type.

(5) Remote control onoff switches with indicator lights for above (1) iii) (main motions) to be fitted at entrance position of machinery house as far as possible from physical switch gear body to switch on/off the power. Operation of this switch shall be allowed only when the motion control circuit power isoff.

(6) Remote control on-off switches with indicator lights for above (1) ii). (auxiliary power) to be fitted inside the Gantry Control Box on the ground level.

(7) Pulse counters shall be installed for each 13.2kVswitchgear shown in 5.3.12 (Medium Voltage Paneland Switchgear) where vacuum circuit breakers are used. These counters to count one for 'ON' and'OFF' for the purpose of maintenance.

(8) The following protection shall be provided

i) Over current protection

ii) Over voltage and under-voltage protection (Setting to be adjustable)

iii) Earth fault protection

iv) Door openingtripping interlock

A system comparable to Kirk Key Interlock system shall be installed for interlocking all MV equipment enclosures including transformer, MV Circuit Breakers (landside and crane),Transformers and MV Slip-Ring cubicle.

(9) The Metering Panel shall be fitted with the following,

i) Voltage meter

ii) Current meter with peak memory

iii) Frequency meter

iv) Power factor meter

v) Power Meter including peak power indication. (at high voltage switchgear panel)

(10) High Voltage switch gear tools to be hung inside a wall mounted box fitted with transparent front cover. Each tool shape to be painted on the inside wall of the box behind its position for easy identification of any missing tool. A Test Probe shall be included in the tool set.

(11) High voltage warning signs in English and local language to be displayed on each panel stating "DANGER – –kV HIGH VOLTAGE"

(12) Adequate space shall be provided around the panel for maintenance of switchgear.

5.3.4. Transformers

(1) All transformers shall be located indoors.

(2) The main transformers shall be dry type and guarded by a wire mesh barrier with a lockable door andwarning signs for high voltage.

*Fully enclosed IP20 transformer housing is acceptable with system comparable to Kirk KeyInterlock system fitted for interlocking all HV transformer enclosures.

(3) The Contractor shall submit the load curves for all transformers for the Purchaser's review. The loadcurves shall define the power consumption at the different loading conditions.

(4) The location of transformers shall be selected not to raise panel temperature.

(5) An interlock system shall be provided on cables/cages to provide high voltage personnel protection.

5.3.5. Resistors and Brake Chopper *(Option)*

(1) Any resistor shall be installed in a position where it will not raise the temperature of electronic controlcomponents.

(2) Resistor banks, if any, shall be fenced off to avoid accidental contact by maintenance staff. The fenceshall be provided with an access door with a lock, and warning signs.

(3) The crane may occasionally be operated from a --kV standby generator of limited capacity but largeenough to operate all the drives at reduced speed.

5.3.6. Enclosures

(1) All electrical enclosures, terminal or distribution boxes in locations exposed to the weather shall be manufactured in stainless steel to a minimum IP55 standard except for small boxes required for lighting which may be plastic.

* The control boxes and junction boxes exposed to the weather will be manufactured in stainless steel (T304 Grade). Other outdoor boxes such as enclosures for lights, switches and small terminal boxes, which are commercial products, will be provided in IP55 rated industry plastic. Top entry shall be avoided.

(2) Stainless steel bolts or screws shall be used throughout to secure the covers, and these shall not penetrate into the box. All panels shall be accessible and removable from the front.

(3) Control panels shall be of steel construction with full access from the front. Each panel with electronic control units and sized above 600mm x 600mm shall be equipped with lights with switch controls inside the panel for facilitating maintenance work.

(4) Panels with electronic control units shall be designed to maintain the inside air temperature below 40 deg. C at all times. Any air inlet for cooling air shall be equipped with air filters.

(5) Each motion control panel shall be fitted with motor RPM meters, ampere meters and volt meters which indicate motor current, field current, reference voltage and motor voltage. Hardwire Meters shall be installed in addition to the information which is available via the CMS. CMS information alone is not sufficient

(6) All control panels; layout drawings shall be submitted and reviewed by the Purchaser before manufacturing.

(7) A minimum of one (I) meter wide passage in front and rear of panels shall be provided.

5.3.7. Meter and Counters

(1) All meters shown in (2) below shall be enclosed in a purpose-built single cabinet mounted within the machinery house at a panel top height not exceeding 1.8m from the floor level and not below 1.4m from the floor level. The cabinet shall be glass fronted and illumination shall be provided with an on/off timer circuit of 15 minutes. The position of the cabinet shall be approved by the Engineer.

(2) The following individual non-resettable meters and counters shall be installed in the machinery house cabinet in addition to ordinary meters on the control panels. The display for all meters shall be of digital mechanical type (Not digital)

i) Main Hoist Drive Hour Meter

ii) Trolley Drive Hour Meter

iii) Gantry Drive Hour Meter

iv) Boom Hoist Hour Meter

v) Control "On" or "Occupied" Hour Meter

vi) 2 x Twist lock counter (twins and main twist-locks) (For function refer to 4.9.1(8)(i) –Spreader meters and Indication).

vii) Main Hoist Service Brake operation counter

viii) Trolley Brake operation counter

ix) Boom Service Brake operation counter

x) Overlapping Main Hoist & Trolley Hour Meter.

xi) Main vacuum circuit breaker switching frequency.

xii) Gantry Wheel brake operation Counter.

(3) In the operator's cab the following meters shall be provided,

i) Anemometer with adjustable interlock alarm function (Analogue display).

ii) Spreader height indicator.

iii) Trim, List, Skew meters.

iv) Load Indicator in MT.

(4) On the spreader mechanical type non-resettable meters shall be provided as follows

i) 2 x Twist lock counter (twins and main twist-locks) (For function refer to 4.9.1(8) (i) SpreaderMeter Indication)

ii) Operating hour meter (hydraulic pump motor operating hours)

5.3.8. Limit Switches

(1) All the limit switches shall be independently accessible easily and quickly for adjustment and maintenance or replacement.

(2) Lever arm type mechanical limit switches shall be avoided where possible, preferred limit switch type isinductive proximity switch.

(3) Application of proximity switch shall be 'failtosafe' application. Short circuit status created within theswitch at the time of failure of a proximity switch must prevent further motion which is controlled bythe switch, and such short circuit fault must be registered for fault tracing.

(3) Special attention is drawn to the twist lock 'Locked' and 'Unlocked' signals from the proximity switches,which may not be 'fail-to-safe'. In order to avoid damage to the spreader and the container by liftingone end only, the proximity switches for 'Locked' and 'Unlocked' signal shall be individually connectedto the PLC through an I/O module. When the PLC detects a short-circuited proximity switch on 'Locked'or 'Unlocked' the hoisting motion shall be immediately stopped. Further motion will be restricted to lowering only.

5.3.9. Space Heaters

(1) Space heaters shall be fitted to the following locations

i) --kV slip ring enclosures

ii) All AC and if applicable DC motors above 7.5kW

iii) All control panels.

5.3.10. DC Power Supply

The DC power supply shall be able to self-regulate the output DC voltages to a constant value against variationsin the input AC supply voltage. There shall be sufficient cooling / heat dissipating ability for the DC power supply.

5.3.11. Encoders

Electronic absolute encoders shall be used for position feedback for main hoist, trolley travel, list and trim systems.

5.3.12. Safety Mechanical Interlock System

Mechanical interlocking shall be provided for all main Medium Voltage circuit breakers, switches and electricalenclosures on each crane to ensure that access to the live parts of the devices cannot be gained until the incoming supply is proved to be de-energized and a safety key has been retained by the person requiring safeaccess. Safety interlocks/keys shall be provided on the landside substation as part of this system. If multipleaccess panels are on the slip ring enclosure, safety interlocks/keys shall be provided for each access.

5.3.13. Name Plates
Electrical equipment shall be supplied with a nameplate immediately adjacent and symmetrical to the equipment. These nameplates shall contain appropriate inscriptions or identification markings to convey all relevant information appertaining to the characteristics of the equipment. The use of adhesive labels as identification shall not be acceptable.

5.3.14. Shore Power (Auxiliary)
Facility to plug in an auxiliary shore power supply shall be provided at ground level. The shore power may beused to supply the following functions and shall be interlocked to avoid co-existence with utility power.

i) Auxiliary Drive Motors Hoist/Trolley/Boom

ii) Air conditioning, Control Room

iii) Elevator

iv) Service outlets

v) Maintenance Hoist

vi) Aircraft warning lights

vii) Access Lighting

5.3.15. Emergency Power *(Not Required)*
It shall be possible to connect an umbilical cable with interlocked plug and socket arrangement between cranesfor the supply of emergency power in the event of crane power failure. The emergency power may be used tosupply the same functions as defined in section "Shore Power" above and shall be interlocked to avoid co- existence with utility power. System design, including interlocks and emergency supply items shall be approved by the purchaser.

5.3.16. Service Outlets

(1) Service outlets (each double socket) shall meet design and voltage standard in the country of operation,with ground, 1phase, 15 Amp capacity (12 units) shall be provided at following locations:

i) Operator's cab.

ii) Work bench in machinery house.

iii) Machinery house on the wall.

iv) Control Room

v) Computer Room

vi) Checkers Cabin

vii) The boom tip.

viii) The back reach.

ix) Ground level, one each under waterside and landside sillbeam, facing inside of the Crane.

x) At the top of the mast.

xi) Adjacent to the cable reeling drum.

(2) Type Model shall be in conformance with locally available fixtures in the country of operation which willbe advised to the Contractor by the Engineer during the design phase.

5.3.17. Welding Outlets

(1) Locations

Welding outlets shall be provided at the following locations: -

i) One on work bench in machinery house.

ii) One on the Back-reach end of girder.

iii) Two at ground level, one each under waterside and landside sillbeam, facing inside of theCrane.

iv) One on the mid outreach point on the boom.

v) At the top of the mast.

Matching plugs of industrial type for all outlets (one plug per outlet) shall be supplied by the Contractor.

(1) Make-Model

Three pole, grounded type, 15 kW welding outlet for local voltage, 3-phase 32 A, 60Hz service shall be provided.All welding outlets installed outdoors shall be weatherproofed to IP55.

(2) Welding Machine

One unit of welding machine shall be provided in the machinery house.

5.3.2. Emergency

DrivesGeneral

Description

Emergency single speed AC drive systems shall be provided to allow safe slow speed operation of various functions by maintenance personnel if a main drive malfunction occurs. The emergency drives shall be configured for maximum reliability and safety and operate regardless of any main control system failure if electrical power from the main high voltage transformers is available. If electrical power from the main high voltage transformers is not available, the emergency drives shall be powered by the shore power supply. Mechanical

drives of the emergency units may be mechanically disconnected from the primary equipment duringnormal crane operation, but, when needed, shall be capable of quick and convenient engagement by means of quick disconnect couplings or similar devices ***(Chains are not acceptable)**. Emergency drives shall utilize dedicated motors for each function, jaw-clutch connect type, no chain drives. Each emergency drive shall operate in conjunction with the primary brakes (and also the drum brakes in the case of the main hoist andboom hoist drives) without the use of CMMS/PLC control. Emergency drives for main hoist and boom hoist shall include appropriate over speed shut down features.

(1) Emergency Main Hoist Drive
An emergency main hoist drive system shall be provided to allow slow speed raising or lowering of full rated load if electrical malfunction of the main hoist drive system occurs or the main power supply fails.The system shall be capable of raising or lowering rated load at 2.5% of rated load speed and shallhave adequate thermal capacity to perform one operation of raising or lowering (one direction only) rated load the total lifting height of the crane without overheating or thermal shutdown. Controls for the emergency main hoist drive shall be in the machinery house emergency control station and via a control pendant attached to an umbilical cable that can be plugged in at two locations (TBD in design review) outside the machinery house.

Shall be interlocked using inductive proximity switches with main drive to prevent dual operation.

(2) Emergency Boom Hoist Drive
An emergency boom hoist drive system shall be provided to allow slow speed raising or lowering of the boom if electrical malfunction of the main boom hoist drive system occurs or the main power supply fails. The system shall be capable of raising or lowering the boom between the operating position and the stowed position in no more than thirty (40) minutes and shall have adequate thermal capacity to perform one operation of raising or lowering the boom (one direction only) between operating and stowed position without overheating or thermal shutdown. Controls for the boom hoist emergency drive shall be located in the boom hoist control booth and the machinery house emergency control station.

Shall be interlocked using inductive proximity switches with main drive to prevent dual operation.

(3) Emergency Main Trolley Drive
An emergency drive system shall be provided to allow slow speed main trolley and catenary trolley travel if electrical malfunction of the trolley drive system occurs, or the main power supply fails. The system shall be capable of travel at 2.5% of rated speed and shall have adequate thermal capacity to perform one operation of travel between maximum back-reach and maximum outreach (one direction only) without overheating or thermal shutdown. Control for the emergency main trolley drive shall be located in the machinery house emergency control station and via a control pendant attached to an umbilical cable that can be plugged in at two locations (TBD in design review) outside the machinery house.

Shall be interlocked using inductive proximity switches with main drive to prevent dual operation.

5.4. Crane Motion Controls

5.4.1. Control System General
The Crane control system design shall be based on a control system which consists of Programmable Logical Controllers (PLC) designed to the latest industrial and safety standards. The Programmable Logical Controllersand satellite stations are to be installed

in the Electrical house, operators cab and other locations to be reviewedby the purchaser which are operated in following environment and operating conditions.

(1) Environment - The entire system shall be designed and operated in the temperature range defined where installations are subject to heavy condensation.

(2) Degree of Protection A minimum IP class (IEC 144 and 529) of IP20 is required for all in house, enclosed installations. Equipment of installations at open, exposed atmosphere shall have an IP classof IP55 as a minimum degree of protection. Finger protection against electrical hazard to operators ormaintenance personnel shall be applied according to the latest industrial standards.

(3) Ambient Temperature the system shall be designed to operate in an ambient temperature betweenthe range -10^{0}C to +40^{0}C. It shall also withstand a storage temperature range between 10^{0}C to 50^{0}C.

(4) Relative Humidity the operating and storage humidity of this system shall have a range from 8% to95% (noncondensing).

(5) Vibration and Shock Resistance The entire system shall be designed and installed with an adequatevibration and shock resistance of not less than 16.7 Hz at a 3-dimensional amplitude of minimum 3mmin vibration and 10G in shocks.

***CLARIFICATION: PLC, I/O modules, media converters and all associated control system components shall be fit forpurpose and suitable for high vibration and shock resistance as experienced in crane/spreader applications.**

(6) Control Voltage the system shall be designed and operated with a power supply as defined with anelectrical potential tolerance of ±10% and frequency tolerance of ±5%.

(7) One unit of Uninterrupted Power Supply (UPS) with a minimum of 30 minutes shall be provided to enable the system to back up all status data for an orderly shutdown in case of power failure so thatall previous status data can be retrieved, and safe operation can be resumed when the power is restored.

The UPS shall support the following equipment during power failure:

(i) PLC and discrete I/O modules.

(ii) Public address system

(iii) Intercom system

(iv) Crane computer system and on-board CCMS.

(v) Trunk radio

5.4.2. Logic Controllers (PLC)

(1) The PLCs shall be of cartridge insert type design with a rack that can provide the installation of powersuppliers, I/O modules (as specified in the related clauses), etc. in a compact and low operating costenvironment.

(2) The PLCs shall be able to intercommunicate with each other through a network following the Open System Interconnection communication architecture. The PLCs shall comply with the requirements ofIEC 11311 – 1 and 11311 – 2 and Profibus installation guidelines.

(1) The racks shall be industrial type with a capability of expansion via simple communication interfacebetween and among the racks. It is preferable to have a

racking system of a minimum slot or cartridge insert space for at least 8 modules which excludes the slots or cartridge insert space for thepower supply and CPUs The racks shall have a backplate communication design and backplate power supply distribution system. This is to achieve maximum feasibility in module replacement as well as minimize the meantime to repair when it is required.

(2) The PLCs shall have multi-tasking, remote communication capabilities and supporting interrupts. Theinput interrupts shall be hard wired to the front of the logic processor module. When triggered, thelogical processor immediately halts the execution of the main control program and executes the interrupt routine associated with the given input interrupt.

(3) The PLCs shall have sufficient memory capacity to hold control algorithms for more than one processplus at least 30% redundant memory capacity. The program shall be stored in EEPROM and RAM. Facilities shall be incorporated on the PLCs to enable programming of the EEPROM. There shall be facilities and space provided for adding memories for future developments.

(4) The controller system shall provide real time display of programs, data and status at remote sites. Thecomplete cycle time of crane software inclusive of scanning all I/O modules as well as execution of control modules in one cycle shall not be more than 30 milliseconds.

5.4.3 Power Supply

(5) The power supply unit shall be a high efficiency, low loss, cartridge insert type design with a fuse protected, surface mount input plug for connecting the main supply mounted to this power supply unit.

(6) LED shall be equipped to show the healthy status of the incoming supply and the outgoing supply. This shall be a standard feature of this power supply unit.

(7) The rating of the power supply shall be at least 25% more than the total normal consumption of all themodules that are connected or that are going to be connected in future.

5.4.2. Discrete I/O Modules

(1) The discrete I/O modules shall be designed from the latest industrial standards with cartridge inserttype installation and the modules are expected to be operated under an environment which is specifiedin 2.9.6 (Climatic Condition).

(2) The discrete I/O modules shall be designed to have an I/O points with 8, 16 and 32 in steps. All the I/O points shall be equipped with screw type terminals. Individual, fused power supplies shall be provided for each module. Common fuse protection system shall not be acceptable. All solid-state output points shall be protected with the installation of switchable relays where the output energizes orde-energizes relay coils, mounted as near to the output module so as to reduce cable runs to a minimum. *All solid-state output points shall be protected with fast blow fuses for system protection ifthis protection is not incorporated into the Output module. Replacement of the fast blow fuse shall require no dismantling or disassembly of modules and racks. The I/O modules shall be equipped withLEDs which show the status of the inputs and outputs.

(3) The maximum signal delay of the 'on' and 'off' status of the output modules shall not be larger than1ms and 9ms respectively. At the same time, the maximum signal delay of the 'on' and 'off' status ofthe input modules shall not be greater than 20ms and 25ms respectively.

(4) The discrete I/O modules shall be equipped with a removable tab that indicates I/O address code and Function. The Contractor shall label all I/O's as per wiring schematics.

(5) There shall be at least 20% spare Input and 20% spare Output ports for each voltage level. Space inthe cubicles or junction boxes for adding I/O modules shall be provided.

(6) Power supply failure to all I/O modules shall be monitored and stop crane functions. Input and Outputsignals shall be monitored and stop crane functions in the event of open circuit failure.

5.4.3. Motion Control Switches in Operator's Cab

Control consoles in the operator's cab. (Consoles shall be combined with the operator's chair)

(1) Main hoist and gantry motion control

One stepless joystick controller of cross-slot universal type on a righthand control console shall controlmain hoist and gantry motion. Fore and aft movement for main hoist, lowering and hoisting, left andright movement for gantry travel. Selection of motions on firstcomefirst served basis. The controllershall be spring returned, positively indented at zero notch and release by push down interlockcatch incorporated into the master controller.

(2) Trolley motion control
One stepless joystick controller with a straight slot in fore and aft direction on a lefthand control console shall control trolley motion. The controller shall be spring returned, positively indented at zero notch and release by push down interlock catch incorporated into the master controller.

(3) Other motion controls
Other motion control switches or control buttons for the following motions shall be ergonomically laidout on the control consoles.

The layout must be approved by the Purchaser.

Right Hand Console

i) Twist lock 'Lock/Unlock' changeover switch. Oversize Large Heavy Duty

ii) Emergency Stop

iii) Lamp Test

iv) Control On

v) Control Off

vi) Audible Alarm Cancel

vii) Fault Reset

viii) Spreader Length Control

ix) T/L/S Controls

x) Wheel Clamp Control

xi) Window wash/wipe Control

xii) Spreader/Hook Block Select