Załącznik nr 5

Postępowania nr EU/32/STS/ZZ/ o udzielenie zamówienia w trybie przetargu nieograniczonego na:

DOSTAWĘ 2 Sztuk SUWNIC NABRZEŻOWYCH

Zamówienie na zakup sprzętu w ramach projektu pt:

„Wyposażenie terminalu intermodalnego BCT w nowoczesne urządzenia przeładunkowe”.

Baltic Container Terminal Ltd.

Section 6.1

TECHNICAL SPECIFICATION FOR TWO (2) QUAYSIDE CONTAINER CRANES (QC)

November 2023

Baltic Container Terminal Ltd.

Kwiatkowskiego Str. 60,

81-127 Gdynia,

Poland

PODPIS ZAUFANY
MACIEJ
MALISZEWSKI
17.07.2024 10:46:30 [GMT+2]
Dokument podpisany elektronicznie
podpisem zaufanym

Signature Not Verified
Dokument podpisany przez MICHAŁ KUŻAJCZYK
Data: 2024.07.17 12:05:05 CEST

Signature Not Verified
Dokument podpisany przez Adam Kaliszewski
Data: 2024.07.17 13:11:04 CEST

Blank Page

TABLE OF CONTENTS

1 GENERAL 6
1.1 Project Description 6
1.2 Terminal Site 6
1.3 Overriding Requirement of the Purchaser 6
1.4 Quay Crane Specification Outline 7
2 OVERALL DESIGN CRITERIA 17
2.1 Type of Crane 17
2.2 Type of Cargo 17
2.3 Operating Environment and Design Aim 17
2.4 Mode of Operation 17
2.5 Statutory Requirements and Applicable Standards 17
2.6 Safety of Machinery 18
2.7 Definitions of Load Names and Load, Stability and Wheel Load Combinations 19
2.8 Operating, Stowed and Maintenance Modes 28
2.9 Design Rules 28
2.10 General Design Criteria 29
2.11 Noise Control 32
2.12 Operationally Critical Components 32
2.13 Duty Cycle 32
3 CRANE STRUCTURAL SPECIFICATIONS 34
3.1 General Requirement 34
3.2 Material 37
3.3 Calculations 40
3.4 Loads 42
3.5 Allowable Stresses 43
3.6 Members Subject to Buckling 43
3.7 Fatigue Design Criteria 44
3.8 Connection Designs 48
3.9 Boom Hoist Rope Failure 48
3.10 Gantry Structure Stiffness 48
3.11 Camber 49
3.12 Trolley Rails & Rail fixing 49
3.13 Workmanship 50
3.14 Quality Control of Structure Fabrication 52
3.15 Temporary Attachments 53
4 FUNCTIONAL SYSTEMS, DEVICES & EQUIPMENT 55
4.1 Main Hoist 55
4.2 Trolley, Trolley Drive, Associated Devices and Operator's Cab 57

4.3 Gantry Drive 59
4.4 Boom Hoist 62
4.5 Machinery House, Electrical Control House 62
4.6 Operator's Cab, Control Stations, Checker's Cab 67
4.7 Personnel Elevator 70
4.8 Head-block 71
4.9 Spreader 72
4.10 Spreader Trailer 75
4.11 Hook Beam 75
4.12 Container Top Safety Frame (Lashing Cage) 76
4.13 Test Weight (Required) 77
5 INTER-FUNCTIONAL SYSTEMS & COMPONENTS 78
5.1 Mechanical System/ Components 78
5.2 Hydraulic System/ Components 81
5.3 Electrical & Electronic System/Components 84
5.4 Crane Motion Controls 96
5.5 Operational Safety Interlocks 101
5.6 Communications 106
5.7 Crane Condition Monitoring System (CCMS) 107
5.8 Trailer Positioning System (Required) 115
5.9 OCR System (Not Required) 115
5.10 Vessel profiling & Container Soft-Landing (SPS) (Required) 116
6 COMMON ITEMS 117
6.1 Walkways, Stairs, Ladders and Platforms 117
6.2 Illumination and Lighting 118
6.3 Painting and Protective Coating 119
6.4 Crane Livery, Purchaser's Logo, Asset Numbers, Signs 126
6.5 Alarms, Warning, Signals & P.A. System 129
6.6 Emergency Stop Push Buttons 131
6.7 Fire Extinguishers 132
6.8 Maintenance Tools and Equipment 132
7 PROJECT ADMINISTRATIVE REQUIREMENTS 134
7.1 Document Submission (Project) 134
7.2 Design Drawings and Calculations 136
7.3 Quality Assurance Inspection and Test Protocols 137
7.4 Operation and Maintenance Instructions 139
7.5 Shop Inspection & Tests 141
7.6 Shipment and Delivery 145
7.7 Site Work 146
7.8 Site Inspection and Tests, Certification 148
7.9 Training and Familiarization 149

7.10 Spare Parts 151
7.11 Crane Model 151
8 APPENDICES 152
Appendix 1. Stipulated Components 152
Appendix 2. Crane Livery, Purchaser's Logo, Asset Numbers 155
Appendix 3. Tools List 157
Appendix 4. Documentation Status Control Sheets 159
Appendix 5. Inspection / Test Control Sheets 164
Appendix 6. Standard Structural Details (Liftech) 172
Appendix 7. General Arrangement Drawing 183
Appendix 8. Crane Weights and Declared Wheel Loads 184
Appendix 9. Existing Stow Pin and Tie-Down Details 185
Appendix 10. Existing Quay Details 185
Appendix 11. Crane End Stop Details 185

1 GENERAL

1.1 Project Description

To carry out the design, construction, delivery, installation, testing and completion of rail mounted container handling quayside cranes. The cranes shall be delivered to Purchasers Site as defined in the General Conditions in a fully assembled condition with pre-shipment testing completed at the manufacturer's site.

1.2 Terminal Site

The Cranes shall be delivered, commissioned and completed on the container-handling Berth at Site of BCT - Baltic Container Terminal LTD. (BCT), Gdynia, Poland

1.3 Overriding Requirement of the Purchaser

The Purchaser's overriding requirement is for the Works to be suitable in all respects for safe, efficient and continuous use under actual operational conditions in a modern, large capacity, international container handling facility for a period of not less than twenty (20) years subject to fair wear and tear (excluding categorically any fatigue failure), and routine maintenance.

For the purposes of this Contract acceptable routine maintenance shall be within the following general parameters.

(1) For steel structures and related component parts, fittings and fixings, acceptable routine maintenance shall be limited to the maintaining of the paint system as stated below. Reinforcing, cutting out and/or replacement of any corroded, fatigued or defective steel or its fixings, etc. shall be Defects remedial works and not maintenance.

(2) For the paint system and galvanized components, acceptable routine maintenance shall be:

- Preparing and over coating the existing system at year 20 after the issuance of the Taking-over Certificate.
- Removing defective parts of the protection system back to clean steel and recoating in isolated areas but not exceeding in aggregate more than 1% and 2% of the total surface area at years 5 and 10 respectively.
- The removal of the protective system back to steel and replacement of the coating in areas aggregating more than the above percentages of the total surface area of the coated part of the Crane shall be Defects remedial works and not maintenance.

(3) For items of electrical and mechanical equipment, controls, systems, components, fittings and fixings, acceptable maintenance shall be the periodic and routine maintenance normally carried out on the various parts generally undertaken as established practices of the Purchaser.

(4) The foregoing shall apply notwithstanding any inconsistent requirement or information in any maintenance instructions provided by the Contractor or otherwise put forward by the Contractor and any such inconsistent requirement or information shall not, and shall not be relied on by the Contractor, to relieve, limit or diminish any obligation or liability of the Contractor under the Agreement or otherwise including in relation to Defects.

1.4 Quay Crane Specification Outline

1.4.1 Crane Details and Accessories

SPEC. REF.	ITEM	SELECTION	COMMENT
General Crane Details & Accessories			
	Number of cranes to buy	Two (2)	
	Biggest vessel size to be served	Post Panamax 25 Rows	
	Crane design: • Dual-box boom/girder • Mono-box	Dual box boom/girder	*Manufacturer to propose*
	Trolley type: • Rope towed • Direct-Drive	Rope Towed	*Manufacturer to propose*
4.9	Spreader	Twin-lift	
	Lashing / Hatch cover platform	None	*A hatch cover platform for storing 3 hatch covers. Located LS of LS sill beam*
	Checker's cabin:	Underneath LS Sill beam	*Access to the checker's cabin from inboard and outboard of the crane.*
	Delivery method: • fully erected • semi-erected • erection on site	Fully erected	
Accessories			
4.9.3	Number of spare spreaders	One (1)	*Twin-lift*
4.10	Number of spreader trailers	One (1)	
4.11	Number of hook beams	One (1)	
4.12	Container Top Safety Frame (= Lashing cage)	Two (2) stored on crane	*ICTSI standard: stored on crane* *A 20ft Container Top Safety Frame is typically stored on top of the landside sill-beam. If the CTSF shall be stored on a trailer (not included), BU to indicate the number of CTSF required per project.*
4.13	Test Weight	Required	*A test weight in the format of a 45ft container*
6.8.2	Spreader Test Panel	One (1)	*A test panel for operating and testing spreaders in the workshop.*
6.8.3	Drive Simulator	None	*A drive simulator as training aid to electrical technicians.*
Electrical Details			
	Electrical system and installation standard	IEC	*Local standard is NEC, but IEC is acceptable for this project.*
	Electrical system integration	Crane Manufacturer	
	Trolley Power Supply: • Cable chain • Festoon system	Cable chain	*Renowned global producers type required*
	Remote Crane Condition Monitoring System	Required	*Remote Crane Condition Monitoring via fiber optic link to maintenance workshop.*
	Independent Main Hoist and Gantry Travel Inverters	Required	*None = shared Main Hoist and Gantry Travel Inverters*

SPEC. REF.	ITEM	SELECTION	COMMENT
	Independent Boom Hoist and Trolley Travel Inverters	None	*None = shared Boom Hoist and Trolley Travel Inverters*
	Emergency recovery drives	Independent drive for each motion	*For emergency recovery operation of main hoist, boom hoist and trolley.*
	Emergency Power Supply Socket	Include	*Interlocked plug and socket arrangement between cranes for the supply of emergency power in the event of crane power failure.*
	Load Weighing	*A spreader-twist-lock built-in load weighing system to report container weight(s) to the TOS I* andOverload	*ICTSI Standard: Overload protection only A spreader-twist-lock built-in load weighing system to report container weight(s) to the TOS is an option*
	RFID Access Control	None	*No access to elevator control and e-rooms shall be granted without required coded tag. All requests for access to be logged with date and time stamp and ID tag number.*
5.8	Trailer Positioning System	Two Directions	*Laser scanner system with traffic light indication for stop positions for Terminal Tractors.*
Błąd! Nie można odnaleźć źródła odwołania.	Trailer Anti-Lift Protection System	None	
Automation Features			
5.9	Optical Character Recognition System (OCR)	Container number+container damage	*Complete OCR System Required by renowned global producers*
Błąd! Nie można odnaleźć źródła odwołania.	Twist-lock Coupler Detection System	None	
Błąd! Nie można odnaleźć źródła odwołania.	Container Position Determination System (PDS)	None	

SPEC. REF.	ITEM	SELECTION	COMMENT
5.10	Vessel profiling & Container Soft-Landing	Required	*Container height sensor mounted on the trolley to detect potential container collisions while trolley travelling and soft-landing of spreader and containers.*
Błąd! Nie można odnaleźć źródła odwołania.	Anti-sway System	None	
Błąd! Nie można odnaleźć źródła odwołania.	Semi-Automation	Required	
Błąd! Nie można odnaleźć źródła odwołania.	Automated Back-reach Operation	None	
Błąd! Nie można odnaleźć źródła odwołania.	Fully automated crane operation including Remote Operation Stations	None	
Błąd! Nie można odnaleźć źródła odwołania.	Automated Lashing Platform	None	

1.4.2 QC Principal Dimensions

ITEM	VALUE		COMMENT
Gantry rail span (centre to centre)	30.48	m	
Centre of waterside rail to fender face	5.27	m	
Beam of Design Vessel	63	m	
Outreach from CL waterside rail to the service limit	72,500	mm	*72,500mm to service limit, 73,000 mm to emergency end stop limit switch.*
Back-reach from CL landside rail to the service limit	23,000	mm	*23,000 mm to service limit, 23,500 mm to emergency end stop limit.*

ITEM	VALUE		COMMENT
Minimum clearance required under back reach	N/A	m	*-- mm minimum to avoid collision with high mast lights. A trolley back-reach travel limit, with bypass, is required in each position where the trolley travel would interfere with high mast lights. Gantry travel shall also be inhibited when trolley position would interfere with high mast lights.*
Lift above top of waterside rail to lowest point of spreader twist-locks	55	m	*55,000mm minimum to the lowest point of twist lock.*
Lift below top of waterside rail to lowest point of spreader twist-locks	19	m	*Minimum*
Total lift	74	m	
Clearance height under portal beam above waterside rail	12.5	m	
Usable inside clearance between legs	18.3	m	
Maximum allowed overall crane length with crane bumpers uncompressed.	27	m	*27,000 mm maximum in bumper free condition. The bumpers shall be the widest positions on the crane.*
Maximum width of boom or trolley, whichever the greater	<8,600	mm	*With proposed dimension, it shall be possible to discharge or load a container adjacent to the bridge without interference between boom and bridge.*
Trolley rail gauge	6,000	mm	*Minimum*
Trolley rail gauge (mono-box)	3,700	mm	*Minimum*
Gantry travel distance along quay from crossover feeding point	400	m	

1.4.3 QC Lifting System

ITEM		VALUE		COMMENT
Spreader				
2.1	Twin-Lift	Yes		
2.2	Centre Spread	Yes		
2.3	Compatibility with existing spreaders	Yes		
Loads				
2.4	Container type			*ISO 20', 40', 45' ISO and up to 53' containers with ISO corner fittings at 20', 40' or 45' position.*
2.5	Maximum container load under spreader in twin-lift mode	65	MT	*2 x 25.5MT*
2.6	Maximum container load under spreader in single lift mode	51	MT	*At reduced 60% speed*
2.7	Maximum load under hook beam	75	MT	*At full outreach*
2.8	Test Load for overload test under spreader	81.25	MT	*125% load*
2.9	Test Load for overload test under hook beam	93.75	MT	*125% load*

1.4.4 QC Operational Speeds

	ITEM	VALUE		COMMENT
Note:	Speeds: These speeds must be achieved for Crane operation with or against sustained wind speed of 20 meter/sec. (45MPH) Crane shall be able to be moved to nearest stow pin position with or against sustained wind speed of 25 meter/sec. (55MPH)			
Hoist speeds:				
3.1	With max. container load under spreader	90	m/min	
3.2	• Acceleration time hoisting	2	s	
3.3	• Acceleration time lowering	1.5	s	
3.4	• Deceleration time hoisting	1.5	s	
3.5	• Deceleration time lowering	2	s	
3.6	With empty spreader	180	m/min	
3.7	• Acceleration time hoisting	4	s	
3.8	• Acceleration time lowering	3	s	
3.9	• Deceleration time hoisting	2.5	s	
3.10	• Deceleration time lowering	4	s	
3.11	Cargo beam in any load condition	40	m/min	
3.12	• Acceleration time	3	s	
3.13	• Deceleration time	2	s	
Note:	Speeds for intermediate loads are in relationship to a constant power curve (except for cargo beam). Values for acceleration and deceleration may vary depending on motor and drive characteristics.			
Trolley traverse speeds:				
3.14	With or without maximum container load under spreader	220	m/min	
3.15	• Acceleration / Deceleration Time	4.5	s	
3.16	• Acceleration / Deceleration Time	6.0	s	*Mono-box*
Boom hoist speeds:				
3.17	Time from Stowed Mode to Operating Mode and vice versa	2.5	min	
3.18	Time from Stowed Mode to Maintenance Mode and vice versa	2.0	min	
Gantry travel speeds:				
3.19	With or without maximum Container Load under Spreader	50	m/min	
3.20	• Acceleration / deceleration time up to 50% operating wind load (WLO)	6	s	*Gantry:* *Gantry travel with or against a maximum 50% operating wind load, WLO, with or without rated load, operating, stowed, Or maintenance boom mode. 50m/min.* *Acceleration/Deceleration time 6 sec*

ITEM		VALUE		COMMENT
3.21	• Acceleration / deceleration time at maximum sustained operating wind	10	s	*Gantry travel with or against the operating wind load, WLO, with or without the rated load, operating, stowed, or Maintenance boom mode. 50m/min Acceleration/Deceleration time 10 sec*
Trim / List / Skew:				
3.22	Trim adjustment with maximum container load	+/- 3	deg	
3.23	Trim speed with maximum container load from centre position to maximum trim	5 – 10	s	
3.24	List adjustment with maximum container load	+/- 5	deg	
3.25	Max spreader horizontal drift in trolley direction from zero to max list position.	+/- 150	mm	
3.26	List speed with maximum container load from centre position to maximum list	5 – 10	s	
3.27	Skew adjustment with maximum container load	+/- 3	deg	
3.28	Skew speed with maximum container load from centre position to maximum trim	5 – 10	s	
Note:	Trim and skew adjustment systems shall be capable of changing attitude of a maximum weight container load with 1.6 m eccentricity in load centre.			

1.4.5 QC Design Criteria

ITEM		VALUE		COMMENT
Note:	Below classifications are as per F.E.M. 1.001, 3rd Edition Revised 1998.10.01			
Structures:				
4.1	Class of Utilization	U 8		
4.2	State of Loading	Q 3		
4.3	Group Classification	A 8		
4.4	Maximum Operating Cycles	4	million	
Main hoist mechanism:				
4.5	Class of Utilization	T 8		
4.6	State of Loading	L 3		
4.7	Group Classification	M 8		
Trolley travel mechanism:				
4.8	Class of Utilization	T8		
4.9	State of Loading	L3		
4.10	Group Classification	M8		
Gantry travel mechanism:				
4.11	Class of Utilization	T 5		
4.12	State of Loading	L 3		
4.13	Group Classification	M 6		
Boom hoist mechanism:				
4.14	Class of Utilization	T 5		
4.15	State of Loading	L 3		
4.16	Group Classification	M 6		

1.4.6 Site Environmental Data

ITEM		VALUE		COMMENT
5.1	Maximum recorded ambient temperature	45	°C	
5.2	Minimum recorded ambient temperature	-25	°C	
5.3	Sample period	25	years	
5.4	Maximum relative humidity	100	%	
5.5	Maximum sustained operating wind speed	20	m/s	
5.6	Maximum gust operating wind speed (without warning)	25	m/s	
5.7	Maximum stowed wind speed	44	m/s	
5.8	Tide – Datum reference type	N/A		*Local datum type (Mean Water Low Springs or other)* *CHART DATUM (Mean Low Water =0m)*
5.9	Extreme High Tide		m	*Above datum*
5.10	Extreme Low Tide		m	*Below datum*
5.11	Seismic zone reference			

ITEM		VALUE		COMMENT
5.12	Seismic acceleration (max.)	0.2	g	*The value to be taken into account by the crane designer for estimation of loads.* *Peak Ground Acceleration shall not be less than 0.1g*

1.4.7 Vessel / Cranes Delivery Parameters

ITEM		VALUE		COMMENT
6.1	Minimum draft alongside berth	15.5	m	
6.2	Minimum controlling draft from anchorage	13	m	
6.3	Maximum height restriction (air draft)	N/A	m	
6.4	Bollard separation interval along quay	25	m	
6.5	Bollard load capacity	2X90	MT	

1.4.8 Quay Interface - Mechanical

ITEM		VALUE		COMMENT
Gantry Rail				
7.1	Gantry rail type	A150	Type	*DIN 536:1991 Grade 900*
7.2	Gantry rail weight	150.3	kg/m	
7.3	Gantry rail head width	150	mm	
7.4	Height difference of LS rail above WS rail	0	mm	*The landside rail is lower than the waterside rail by 0 mm. A vertical rail tolerance of ± 50 mm measured at the rail head surface from mean position throughout the gantry rail length shall be permitted.*
7.5	Curved gantry rail	None		*STS crane shall have the facility to traverse around a curved gantry rail.* **CLARIFICATION: Gantry speed whilst traversing curved rail section shall be proposed by the Contractor and approved by the Purchaser.*
7.6	• Minimum radius WS rail	None	m	
7.7	• Minimum radius LS rail	None	m	
Permitted Rail Loads				
7.8	Vertical load limit WS rail – operational	80	MT/m	
7.9	Vertical load limit LS rail – operational	80	MT/m	
7.10	Overload limit WS rail – short duration	100	MT/m	*Short duration impact or wind gust*
7.11	Overload limit LS rail – short duration	100	MT/m	*Short duration impact or wind gust*
7.12	Stowed Condition WS	100	MT/m	
7.13	Stowed Condition LS	100	MT/m	
7.14	Horizontal load limit LS – operational	8	MT/m	
7.15	Horizontal overload limit LS – short duration	10	MT/m	*Short duration impact or wind gust*
7.16	Horizontal load limit WS – operational	8	MT/m	
7.17	Horizontal overload limit WS – short duration	10	MT/m	

ITEM		VALUE		COMMENT
Permitted Wheel Loads				
7.18	Load limit WS wheels – operational	95	MT/wheel	
7.19	Load limit LS wheels – operational	95	MT/wheel	
7.20	Overload limit WS wheels – short duration	115	MT/wheel	*Short duration impact or wind gust*
7.21	Overload limit LS wheels – short duration	115	MT/wheel	*Short duration impact or wind gust*
7.22	Stowed Condition WS	115	MT/wheel	*Short duration impact or wind gust*
7.23	Stowed Condition LS	115	MT/wheel	*Short duration impact or wind gust*
End of Travel Buffers				
7.24	Centre height above rail	1,100	mm	
7.25	Load capacity of existing fixed buffers	TBD	MT	
Stow Pins & Typhoon Tie-downs				
7.26	Stow pin slots - Waterside	Inboard and Outboard		*These can be as per crane manufacture preference with civil work following, or we can follow civil design and issue to crane manufacturer*
7.27	• Distance from C/L to C/L of rail	TBD	mm	
7.28	• Length (parallel with the quay)	TBD	mm	
7.29	• Width (perpendicular to rail)	TBD	mm	
7.30	• Depth	TBD	mm	
7.31	Stow pin slots - Landside	Inboard and Outboard		*These can be as per crane manufacture preference with civil work following, or we can follow civil design and issue to crane manufacturer*
7.32	• Distance from C/L to C/L of rail	TBD	mm	
7.33	Quantity and spacing long quay	TBD	m	
7.34	Stow pin slot horizontal design load	TBD	MT	
7.35	Typhoon Tie-downs	No		*Manufacturer to propose*
7.36	Checker's cabin	Yes		
7.37	Checkers cabin position	Land side With Dual Gated Access/Egress from Inboard and Outboard		

1.4.9 Quay Interface – Electrical`

ITEM		VALUE		COMMENT
MV Power Supply				
8.1	Crane power supply voltage	15	kV	
8.2	Supply voltage tolerance	+/- 10	%	
8.3	Main power supply frequency	50	Hz	
8.4	Supply frequency tolerance	+/- 2	%	
8.5	Supply network short circuit capacity	0.6	MVA	
8.6	Fuse type in MV substation	TBD		
8.7	MV Service cable length	400	m	
8.8	MV Service cable specification	TBD		
8.9	Number and specification of fibre optics at cross-over cable pit	18x62.5/125	Micron	

ITEM		VALUE		COMMENT
8.10	Number and positions of cross-over cable pits assigned for all QC under this project	1		
8.11	Number of MV cable strain relief drums assigned for all QC under this project	1		
8.12	Diameter of MV cable strain relief drum	800	mm	
8.13	MV cable connection method at cross-over cable pit	Termination Cabinet		
8.14	Preferred MV cable type	Renowned global producers with integral FiO		*Cable type to be reviewed during design review.*
8.15	MV cable trench - Position	WS Inboard		
8.16	• Distance from C/L to C/L of rail		mm	
8.17	• Width		mm	
8.18	• Depth		mm	
8.19	MV cable trench protection	None		
8.20	MV cable pick-up position	LHS Portal WS Inboard		*As viewed looking out to water*
Local Electrical Parameters				
8.21	Local Three Phase Voltage	400	V	
8.22	Local Single-Phase Voltage	230	V	
8.23	Frequency	50	Hz	
8.24	Three phase plug type for shore supply and/or welding machines	CEE -4 pin + G		
8.25	Single phase plug type for hand tools	C		
Note:	Refer to http://www.iec.ch/worldplugs for identification of plug types			
Local Specifics				
8.26	Local Language	PolishEnglish		*Signage, labelling, training and Maintenance and Operation documentation/manuals shall be in English and local language.*

2 OVERALL DESIGN CRITERIA

2.1 Type of Crane

The Crane shall be a traveling gantry with a hinged straight boom at waterside, self-driven or rope-towed trolley type. The crane drive and control shall be supplied with a full AC inverter drive, fully digital control with PLC. The proposed drive and control system shall be a proven system successfully operating on a similar-capacity crane in actual container handling operations. The Crane shall be twin-lift, capable of handling 2 x 20 ft. containers in tandem with a twin-lift spreader.

2.2 Type of Cargo

The type of Cargo to be handled by the Crane shall be:

(1) ISO 20ft, 40ft and 45ft containers including high-cube, half-height, flat rack containers.
(2) Other types of container with ISO corner fittings at 20', 40', or 45' position, 48ft and 53ft containers.
(3) 40ft and 45ft containers of weight up to 51 Metric Tonnes (MT).
(4) 2 x 20ft containers of weight each up to 32.5 MT.
(5) Containers with over-height cargoes through an over-height cargo container lifting frame belonging to the Purchaser.
(6) Hatch covers and containers of weight up to 50 MT.
(7) Damaged containers with slings and shackles attached to lifting lugs of the spreader.
(8) Heavy lift cargo
At least 75 MT beneath a Hook Beam attached to the head-block. The heavy lift shall be operable through the full hoisting range and across the full distance of trolley travel with 100 MT beneath hook beam at reduced outreach to be determined by the Contractor. The Contractor shall maximize the load capacity under hook beam according to his design.

2.3 Operating Environment and Design Aim

The Crane shall be operated and maintained on a 24-hour per day basis in all weather conditions. All electrical, electronic, and mechanical equipment shall be non-hygroscopic, non-corroding and tropicalized for use. Special considerations shall be given in all aspects of the design for achieving accurate load spotting ability while ensuring full operational capability and safety for around the clock operations, including operations under heavy rain conditions at night.

The Crane shall be exposed to non-technical personnel specifically at the ground level and passages from ground level to the operator's cab and from the operators cab to the boom operating station. In these areas of the Crane, the Contractor shall ensure that a high degree of personnel safety protection is provided around the equipment and fittings. Ease of maintenance and safety of the maintenance staff shall be considered throughout the entire design to minimize total down time of the Crane.

2.4 Mode of Operation

The Crane shall be manually controlled. All functions on the Crane shall be controlled fully by the operator.

2.5 Statutory Requirements and Applicable Standards

(1) The Crane and its mechanisms shall be designed and manufactured to comply in all respects with the requirements of applicable state and local country laws, ordinances, rules, orders, or other legal or regulatory instruments such as, but not limited to, the following: -

(2) Where items are not covered by statutory requirements the Crane and other Works shall be designed and manufactured to at least the standards as defined in this Specification, and for items which are not so specified to at least the current applicable recommendations of the following organizations: -

AISC	American Institute of Steel Construction – ASD
AISE	Association of Iron and Steel Construction
ANSI	American National Standards Institute
ASNT	American Society for Non-destructive Testing
ASTM	American Society for Testing and Materials
AWS	American Welding Society – Bridges and Dynamically Loaded Structures

BSI	British Standards Institute
DIN	Deutsche Industrie Normen
FAA	Federal Aviation Administration
FEM	Federation Europeane de la Manutention
IEC	International Electro-technical Commission
IEEE	Institute of Electrical and Electronic Engineers
ISO	International Standards Organization
JIC	Joint Industrial Council
JIS	Japanese Industrial Standards
NEC	National Electric Code
NEMA	National Electric Manufacturers Association
SAE	Society of Automotive Engineers
UL	Underwriters Laboratory

**CLARIFICATION: Where the crane or any of its mechanisms/components do not comply with any of the above standards the Contractor must submit each non-compliant item for review and approval from the Purchaser.*

(3) The Contractor shall be required to submit to the Purchaser a full list of applicable standards used in the design of the Crane.

(4) The specifications refer to various U.S. and international standards, materials, and procedures. If the Contractor believes that complying with the references is impracticable, the manufacturer may propose alternative standards. The alternates will be accepted provided they are, in the Purchaser's opinion, at least equal to the referenced standards. The Contractor shall submit the alternatives with the bid including documentation demonstrating equivalence with the references. The Purchaser will review the proposed alternatives and decide if they are acceptable. If the Contractor submits the proposed alternatives four weeks before the bid date, the Purchaser will respond at least one week before the bid date. If the alternatives are submitted later than the four weeks before the date, the Purchaser may accept them, or may not accept them without review of the merits, and the bid shall be based on complying with the references.

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

2.6 Safety of Machinery

2.6.1 Conformity with the EU Machinery Directive

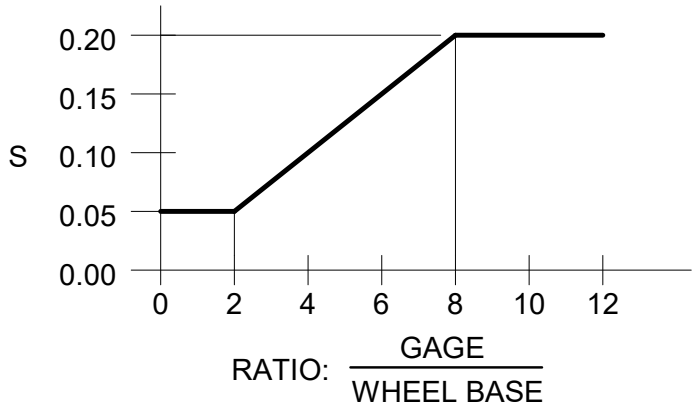
(1) The crane shall comply with the requirements of the European Machine Guidelines, particularly Machinery Directive 2006/42/EC. The cranes shall be provided with a declaration of conformity and the CE marking and symbol according to the relevant Appendixes of the Machinery Directive. The Supplier/ Contractor is solely and entirely responsible for all aspects of this conformity declaration and CE marking. A single electric power, control or hydraulic component failure or malfunction shall not damage the crane or injure personnel. If possible, component failure or malfunction shall safely stop the crane operation. If this is not possible, a redundant system shall be supplied. The redundant system shall both safely stop the crane and prevent operation until maintenance personnel make corrections. A means shall be provided so the maintenance personnel may routinely check each redundant or backup system. The check procedure shall be included in the maintenance manual. No crane component shall change state as a result of a power failure. Powering or repowering the crane or any system within the crane shall not result in an unanticipated or potentially unsafe motion or condition.

2.7 Definitions of Load Names and Load, Stability and Wheel Load Combinations

Name	Load	Description
BHRF	Boom Hoist Rope Failure	The loads, including dynamic effects, due to one of the independent boom hoist ropes failing. The trolley and lift system shall be in the parked position.
CBLS	Cargo Beam Lifting System	The weight of the cargo beam, head-block, portions of the lifting ropes, sheaves and all other equipment which hangs from the main hoist ropes when the cargo beam is connected
CBRL	Cargo Beam Rated Load	The greatest concentric load that can be lifted by the cargo beam without requiring any physical changes in the crane components. CBRL shall be a minimum of 61 metric tons.
COLL	Collision Load	The loads determined by dynamic analysis, assuming that the crane, while traveling at full speed with the power off, hits the crane stops or hits another stopped crane or (not concurrently) that the trolley traveling at full speed with the power off, hits its stops. Bumpers shall be provided so these loads govern only local components.
DL	Dead Load	The weight of the crane's structure including all permanently attached machinery and equipment.
EQO	Operating Earthquake Load	The load imposed on the crane structure by an earthquake occurring during operation. EQO shall be a minimum of: A. 0.2(DL + TL) or B. The load required to tip the crane such that one corner lifts off of the rail Loading shall be applied in the gantry and trolley travel directions, non-concurrently. The trolley shall be assumed to be at the most adverse position.
EQS	Stowed Earthquake Load	The load imposed on the crane structure by an earthquake occurring during stowed condition. EQS shall be a minimum of: 0.2(DL + TL) or B. The load required to tip the crane such that one corner lifts off of the rail Loading shall be applied in the gantry and trolley travel directions, non-concurrently.
F	Fatigue Condition	See Section 3.7, Fatigue Design Criteria.
IMP	Impact	The loads due to vertical acceleration of the lifted load as sensed by the main hoist ropes. Impact loads shall be determined as described in Section 3 (Crane Structural Specifications)
LATF	Trolley Lateral Load	The lateral trolley inertia force applied parallel to the travel direction shall be at least $0.10\times$(TL+LS+LLF) for fatigue combinations. The simultaneous inertia force applied perpendicular to the travel direction shall be one-fourth of the force applied parallel to the travel direction. Stresses due to LATF shall be combined with the stresses due to vertical loads. There shall be two starts and two stops for each cycle.

Name	Load	Description
LATT	Trolley Lateral Load	The loads imposed on the crane due acceleration or deceleration of the trolley. The lateral inertia force applied parallel to the travel direction shall be at least $0.10\times(TL+LS+LL)$ for operating combinations. The simultaneous inertia force applied perpendicular to the travel direction shall be one-fourth of the force applied parallel to the travel direction.
LATG	Gantry Lateral Load	The loads imposed on the crane due to positive or negative acceleration of the gantry. The lateral force applied parallel to the travel direction shall be 1.5 times the maximum inertia force that can be developed due to acceleration or deceleration of the gantry drive system, except the minimum gantry inertia force shall be at least 0.05 times all weights present on the operating crane. The simultaneous inertia force applied perpendicular to the travel direction shall be of one-fourth of the force applied parallel to the travel direction.
LEGL	Leg Lift	The load imposed on the crane due to a 30 mm vertical displacement of one leg relative to the other three legs. This is a parameter load for information only and is not to be used for stress calculations.
LIST	List	The effect of $\pm$5 list of the spreader and rated load.
LL	Lifted Load	The weight of containers plus contents which shall be taken as 50 MT and shall be applied concentric to the geometric center of the container.
LLE	Eccentric Lifted Load	The weight of 41 MT containers applied eccentric to the geometric center of the container 1220 mm toward either end longitudinally and 230 mm toward either side transversely.
LLF	Fatigue Lifted Load	Fatigue design shall be based on an effective container, which, for simplicity, is assumed to be equivalent to the actual spectrum of various weight containers including impact effects. The weight of the container plus its contents shall be taken as 30 MT and shall be applied eccentric to the geometric center of the container 760 mm longitudinally. The eccentricity should be considered at one side of the center of the container for half of the design cycles and the other side of the center for the remaining half of the design cycles. The vertical load does not need to be increased because of vertical acceleration. Forces due to horizontal accelerations shall be based on a container weighing 30 MT.
LS	Lifting System	The weight of the spreader, head-block, portions of the lifting ropes, sheaves and all other equipment, which hangs from, the main hoist ropes and is supported by the container when the spreader is placed upon it.
OL1 OL2 OL3 OL4	Overload Conditions 1, 2, 3 & 4 in the Operating Mode	Refer to Table 2.1 Load Combinations – Operating Modes in this section.
OL1M OL2M	Overload Conditions 1and 2 in the Maintenance Mode	Refer to Table 2.2 Load Combinations – Stowed and Maintenance Mode in this section.

Name	Load	Description
OL1S OL2S	Overload Conditions 1 and 2 in the Stowed Mode	Refer to Table 2.2 Load Combinations – Stowed and Maintenance Mode in this section.
OP1 OP2 OP3	Operating Conditions 1, 2, & 3 in the Operating Mode	Refer to Table 2.1 Load Combinations – Operating Mode in this section.
OP1M OP2M	Operating Conditions 1 and 2 in the Maintenance Mode	Refer to Table 2.2 Load Combinations – Stowed and Maintenance Mode in this section.
OP1S OP2S	Operating Conditions 1 and 2 in the Stowed Mode	Refer to Table 2.2 Load Combinations – Stowed and Maintenance Mode in this section.
RL	Rated Load Container	2 x 20’ long containers, 9'-6" high and 8'-6" wide weighing, with their contents, 50 MT total. The eccentricity shall be considered (see LLE).
S1S	Stowed Condition 1 in the Stowed Mode	Refer to Table 2.2 Load Combinations - Stowed and Maintenance Mode in this section.
S1M	Storm Condition 1 in the Maintenance Mode	Refer to Table 2.2 Load Combinations - Stowed and Maintenance Mode in this section.
ST1O ST2O ST3O ST4O ST5O ST6O	Stability Conditions 1 thru 6in the Operating Mode	Refer to Table 2.3 Stability Combinations in this section.
ST1S ST2S ST3S ST4S	Stability Conditions 1 thru 4in the Stowed Mode	Refer to Table 2.3 Stability Combinations in this section.
ST1M ST2M ST3M ST4M	Stability Conditions 1 thru 4 in the Maintenance Mode	Refer to Table 2.3 Stability Combinations in this section.

Name	Load	Description
SKT SKG	Trolley Skew Load Gantry Skew Load	The loads developed due to wheels rolling along a rail. The force shall be taken as acting normal to the rail and tending to skew the structure. The horizontal force, perpendicular to the gantry rail, at each corner shall be one fourth of the total vertical load due to: $S \times (DL + TL + LS + LL)$. *S* shall be determined from the following graph.  Where gage is the distance between the rails and wheel base is the distance center to center of the outermost wheels for SKT and the main equalizer pins for SKG. If the Contractor demonstrates that the trolley and/or gantry skew load is less than the value shown because of either electrical or mechanical drive controls, then the reduced load may be used accordingly.
SN	Snag Load	The load imposed on the crane due to the head-block and empty spreader traveling at maximum hoist speed becoming jammed in the ship's cell guides or being accidentally two-blocked against the underside of the trolley resulting in the kinetic energy of the rotating equipment being dissipated by elastic deflection of the machinery and the structure and special energy absorbing devices. See Section 4.1.4. (Snag Control)
SPRD	Leg Spread	The load imposed on the crane due to a 25 mm horizontal displacement perpendicular to the rail of the waterside legs relative to the landside legs. This is a parameter load for information only and is not to be used for stress calculations.
STL	Stall Torque Load	The load developed by stalling any motor in the crane. The load shall be due to the stall and/or breakdown torque of AC drives. For the main hoist, stall torque load shall be the load induced by stalling the hoist motors with one end of a container or hatch cover dogged down or with all four corners dogged down concentrically. For the Boom Hoist, stall torque shall be determined based on the reduced stall torque when the boom is fully raised.
TL	Trolley Load	The weight of the trolley including all machinery and equipment permanently attached, but excluding the weights included in LS.
TRIM	Trim	The effect of $\pm$ 3° trim of the spreader carrying rated load.
WLO	Operating Wind Load	The load due to an operating wind speed of 20 m/s assumed uniform over the full height of the crane applied in any direction. The lifted container shall be the rated load container.
WLS	Stowed Wind Load	The load due to a storm wind speed of 28 m/s assumed uniform over the full height of the crane applied in any direction. The trolley shall be in the stowed position.

Name	Load	Description
WOL1 WOL2 WOL3	Wheel Loads for Overload Conditions 1, 2, and 3 in the Operating Mode.	Refer to Table 2.4 Wheel Load Combinations in this section.
WOL1S WOL1M	Wheel Loads for Overload Condition 1 in the Stowed and Maintenance Modes.	Refer to Table 2.4 Wheel Load Combinations in this section.
WOP1 WOP2 WOP3	Wheel Loads for Operating Conditions 1, 2, and 3in the Operating Mode.	Refer to Table 2.4 Wheel Load Combinations in this section.
WOP1S WOP1M	Wheel Loads for Operating Condition 1in the Stowed and Maintenance Modes.	Refer to Table 2.4 Wheel Load Combinations in this section.
WS1S WS1M WS2S WS2M	Wheel Loads for the Stowed Conditions 1 and 2 in the Stowed and Maintenance Modes.	Refer to Table 2.4 Wheel Load Combinations in this section.

Wind loads shall be calculated using force coefficients from engineering references or from wind tunnel tests. Base reactions resulting from applied wind loads shall be equal to or greater than the reactions obtained from wind tunnel tests on suitable models for operating and stowed configurations. Wind tunnel test results shall include angled wind effects for wind from any direction.

Operating Mode Combinations For Stress Calculation—Boom Down								
Condition		Operating			Overload			
Combination name		OP1	OP2	OP3	OL1	OL2	OL3	OL4
Dead Load	DL	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Trolley Load	TL	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Lifting System	LS	1.0	1.0			1.0		1.0
Cargo Beam Lifting System	CBLS			1.0				
Cargo Beam Rated Load	CBRL			1.0				
Lifted Load	LL					1.0		0.5
Eccentric Lifted Load	LLE	1.0	1.0					
Impact	IMP		1.0	1.0				
List	LIST	1.0	1.0		1.0	1.0	1.0	
Trim	TRIM	1.0	1.0		1.0	1.0	1.0	
Trolley Lateral Load	LATT		1.0					
Gantry Lateral Load	LATG	1.0						
Trolley Skew Load	SKT		1.0					
Gantry Skew Load	SKG	1.0						
Operating Wind Load	WLO		1.0	1.0	1.0	1.0		
Stall Torque Load	STL				1.0			
Collision Load	COLL					1.0		
Snag Load	SN						1.0	
Earthquake Load	EQO							1.0

For the special load case when one of the boom hoist ropes fails, combine DL+TL+BHRF with the dynamic effects of the failure.

Table 2.1: Load Combinations – Operating Mode

Stowed & Maintenance Mode Combinations for Stress Calculations						
Condition		Operating		Overload		Storm
Mode		Combination Name				
Maintenance Mode		OP1M	OP2M	OL1M	OL2M	S1M
Stowed Mode		OP1S	OP2S	OL1S	OL2S	S1S
Dead Load	DL	1.0	1.0	1.0	1.0	1.0
Trolley Load	TL	1.0	1.0	1.0	1.0	1.0
Lifting System	LS	1.0	1.0	1.0	1.0	1.0
Gantry Lateral Load	LATG	1.0				
Gantry Skew Load	SKG	1.0				
Operating Wind Load	WLO		1.0	1.0		
Collision Load	COLL			1.0		
Stowed Earthquake Load	EQS				1.0	
Stowed Wind Load	WLS					1.0
Tie-downs in Place?		No	No	No	No	No

Table 2.2: Load Combinations - Stowed & Maintenance Mode

STABILITY COMBINATIONS														
MODE		Operating						STOWED				MAINTENANCE			
Stability Load Name		ST1O	ST2O	ST3O	ST4O	ST5O	ST6O	ST1S	ST2S	ST3S	ST4S	ST1M	ST2M	ST3M	ST4M
Dead Load	DL	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Trolley Load	TL	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Cargo Beam Lift System	CBLS					1.0									
Cargo Beam Rated Load	CBRL					1.15									
Lifting System	LS	1.0	1.0		1.0		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Lifted Load	LL	1.0	1.0		1.0		1.5								
Impact	IMP														
Trolley Load Lateral	LATT	1.0					1.0								
Gantry Load Lateral	LATG	1.5						1.5				1.5			
Operating Wind Load	WLO		1.5	1.0	1.0	1.0	1.0		1.5				1.5		
Stall Torque Load	STL			1.15											
Collision Load	COLL				1.15					1.15				1.15	
Stowed Wind Load	WLS										1.2				1.2
Number of Legs Allowed to lift off		0	0	1	1	0	0	0	0	1	0	0	0	1	0

Table 2.3: Stability Combinations

NOTE: The snag load, SN, is not included in the stability combinations since the kinetic energy of the rotating equipment that is not dissipated cannot topple the crane.

EXAMPLE: ST1O is *1.0 DL + 1.0 TL + 1.0 LS + 1.0 LL + 1.0 LATT + 1.5 LATG* with zero-legs allowed to lift off.

One leg allowed to lift off means one leg may lift off while the other three legs remain in contact with the gantry rail. Zero legs allowed to lift off means no legs may lift. All wheels shall remain in contact with the gantry rail.

The Contractor shall submit calculated corner uplift loads for all stability combinations as described above.

Tie-downs may not be used for the stowed wind load condition.

Wheel Load Combinations—Service (Unfactored)									
Boom Position	Mode	Operating			Overload			Stowed	
Boom Down		WOP1	WOP2	WOP3	WOL1	WOL2	WOL3		
Boom 45°		WOP1S			WOL1S			WS1S	WS2S
Boom Up		WOP1M			WOL1M			WS1M	WS2M
Dead Load	DL	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Trolley Load	TL	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Lifting System	LS	1.0	1.0	1.0	1.0		1.0	1.0	1.0
Lifted Load*	LL	1.0	1.0	1.0	0.5		1.0		
Impact	IMP			0.5					
Gantry Lateral Load	LATG	1.0							
Operating Wind Load	WLO		1.0			1.0			
Earthquake Load	EQO/S				1.0				
Stall Torque Load	STL					1.0			
Collision Load	COLL						1.0		
Stowed Wind Load	WLS							1.0	
Stowed Earthquake Load	EQS								1.0
Allowable Wheel Linear Loads, MT/meter of rail	Land Side	80			100			100	
	Water Side	80			100			100	
Allowable Wheel Loads, MT/wheel	Land Side	95			115			115	
	Water Side	95			115			115	

Example: WOP1 Is *1.0 DL + 1.0 TL + 1.0 LS + 1.0 LL + 1.0 LATG*

The allowable wheel loads shall be calculated by multiplying allowable wheel linear load and average wheel spacing at each corner.

If the wheel loads exceed the allowable values, provide calculated wheel loads with breakdown and proposal to reduce wheel loads.

The Contractor shall submit calculated waterside and landside service wheel loads for the above combinations.

*For the boom 45° and boom up positions, do not include the lifted load.

Allowable Horizontal Loads Perpendicular to rail		
Operating condition	Seaside Rail (MT/m)	Landside Rail (MT/m)
Maximum load under operating condition	8	8
Maximum load under storm condition	10	10

Table 2.4: Wheel Load Combinations

2.8 Operating, Stowed and Maintenance Modes

2.8.1 Operating Mode

In the Operating Mode, the Boom will be in the fully lowered position

The primary operational function of the crane will be to load and unload container ships. The crane will handle containers, hatch covers and lashing gear. A secondary function will be the handling of non-containerized cargo.

2.8.2 Stowed Mode

In the stowed mode the boom will be raised to approximately 45° for clearance of vessels. The trolley shall be at the park position and no other load other than the empty lifting system will be on the hoist.

The Main Hoist drive shall be operational with the trolley at the park position and with an empty lifting system.

The Trolley drive shall be able to operate within the range from boom up normal stop and the extreme back-reach position

The Gantry drive shall be fully operational, and the forestays shall be constrained from lateral movement during gantry operation.

2.8.3 Maintenance Mode

In the Maintenance Mode the Boom shall be fully raised and in contact with the bumpers. The Trolley shall be at the park position and no load other than the empty lifting system will be on the hoist.

The Main Hoist drive shall be operational with the trolley at the park position and with an empty lifting system.

The Trolley drive shall be able to operate within the range from the boom up normal stop and the extreme back-reach position.

The Gantry drive shall be fully operational, and the forestays shall be constrained from lateral movement during gantry operation.

2.9 Design Rules

2.9.1 General

Unless otherwise stated, F.E.M. 1.001, 3rd Edition Revised 1998.10.01, and relevant other design standards noted in these Specifications, shall be used in the design of the crane and its mechanisms.

2.9.2 Structures:

According to F.E.M. 1.001, 3rd Edition Revised 1998.10.01

Class of Utilization	U8
State of Loading	Q3
Group Classification	A8

Fatigue: Fatigue shall be based on cumulative damage analysis according to F.E.M. 1.001, 3rd Edition Revised 1998.10.01. The load spectrum shall consider a minimum of 4.0×10^6 design cycles with a 30.0 MT effective container weight with 760 mm eccentricity along the container longitudinal axis.

Structural Inspection Program: The structural inspection program shall be based on cumulative damage analysis.

2.9.3 Mechanisms:

According to F.E.M. 1.001, 3rd Edition Revised 1998.10.01

Mechanism	Class of Utilization	Service Life (Hrs.)	State of Loading	Group Classification
Hoist	T8	50,000	L3	M8
Trolley Travel	T8	50,000	L3	M8
Gantry Travel	T5	6,300	L3	M6
Boom Hoist	T5	6,300	L3	M6

2.10 General Design Criteria

2.10.1 Quay/Yard Interface

(1) Power Supply

(i) The power supply to the crane shall be 15kV ±5% 3 phase, 50Hz±2%.

(ii) The medium voltage trailing cable connection at the power-feeding pit on the quay shall be proprietary MV cable joint. The Contractor shall undertake termination of the cable conductors and fibre waveguide at the feeding pit. The medium voltage cable shall be supplied by the contractor along with a suitable cable reeling device and cable connection joint. A sufficient length of cable to cover 400 meters' gantry travel range either side of the central feeding point shall be provided by the Contractor. Contractor shall bring the Crane trailing cable end to the feeder pit and shall complete the cable connecting work with an approved interlocked termination cabinet. The cable terminations made at Site and medium voltage wiring shall pass the inspection requirements of the local power Supply Company and Very Low Frequency test results shall be provided.

(iii) The medium voltage trailing cable shall be Prysmian Protolon (SMK) round type MV flexible power cable with integrated fibre optic data cables.

(2) Curved Gantry Rail (Not Required)

(i) Gantry travel around a curved section of quay rail shall be possible, minimum radius of rail curvature for landside and waterside rails shall be provided by Purchaser. The Contractor shall submit proposed method for achieving traverse of curved rail and proposed method including gantry speeds shall be approved by the Purchaser.

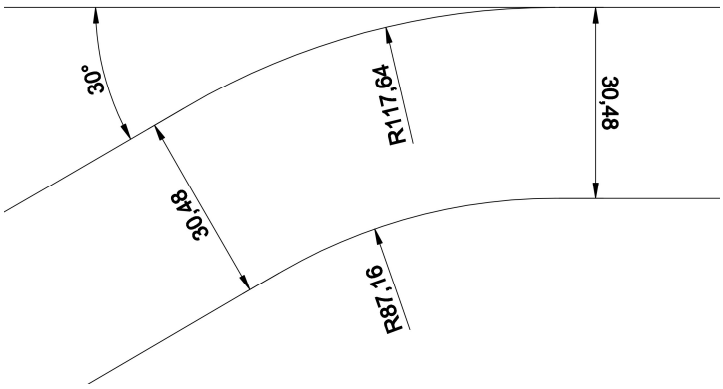


Figure 2.1 Curved rail details

(3) Wheel Loading

(ii) Up-lift load shall not be applied to the gantry rails.

(iii) The Contractor shall submit in its Tender for the Purchaser's review, the Declared Wheel Loads as defined in the Form of Tender to clarify vertical and horizontal loads under operational and stowed conditions.

(iv) The maximum wheel loads shall be calculated with the Trolley in the most severe position and with the wind acting in the most severe horizontal direction.

(v) Wheel Loads shall under no circumstances exceed the Maximum Allowed Crane Loads figures as tabulated in the Form of Tender, DECLARED WHEEL LOADS AND OTHER LOADS OF THE CRANE. Should any or all of such loads exceed such Maximum Allowed Crane Loads figures, this shall constitute a Defect and the Contractor shall not be entitled to dispute this on any grounds or in any circumstances.

(4) Stowage Pins

The Contractor shall submit for the Purchaser's review a design of adequate stowage pins to resist horizontal component of the forces applied to the Crane under its stowed condition. The stowage sockets in the quay deck shall be installed by others in accordance with dimension and load characteristics provided by the Contractor.

(5) Tie-downs

Storm tie-downs facilities shall be provided as permanent fixtures on the crane which may be quickly deployed without requirement for additional equipment. The contractor shall provide a detail drawing of the tie down interface with toleranced dimensions, load magnitudes and directions.

The design of the tie downs shall be such that one person without tools or additional equipment can attach all tie downs on a crane to the mating wharf embedded attachments within 30 minutes. Similarly, the tie downs can be unattached, and the crane made ready for gantry travel by one person without tools or additional equipment within 30 minutes provided there are maximum 4 tie downs per crane. The attachment and disconnection of the tie downs shall be demonstrated by Contractor and timed.

2.10.2 Communication Facility Interface (Radio, Fibre Optic)

The Crane shall be provided with fibre-optic cables and the necessary hardware for data transmission.

2.10.3 Auxiliary Electrical Power Interface

The Purchaser will advise an approved locally available plug and socket arrangement for the shore supply during the design phase.

2.10.4 Climatic Condition

The Crane shall be designed and constructed to be fully capable of operating safely and performing as required by the Agreement (for condition (1) - (5) below) and withstanding the following climatic conditions.

(1)	Ambient temperature	-25 deg. C to +45 deg. C
(2)	Relative humidity	Max. 100%
(3)	Dew point	Max. 30 deg. C
(4)	Sustained wind	20m/s
(5)	Wind gust	up to 25m/s without warning for normal working condition. This must be taken into account with regards to operating stability and gantry power calculations.

More stringent and specific requirements shall apply for individual Crane sub-systems and components, which are separately specified in each relevant clause of this Specification.

2.10.5 Wind Loading Condition

The entire Crane structure with all of its machineries, components, fittings/accessories, and all equipment shall be designed and constructed to withstand the following wind loading conditions.

In the design calculations, the wind pressure for each condition shown below shall be assumed to act as uniformly constant over the total height of the structure in the parallel, perpendicular and angular wind directions.

(1) For operation of the Crane:

Allow for wind loading of sustained wind speed of 20m/second for safe load handling operation of the Crane.

(2) For the stowed condition of the Crane:

A wind loading of wind speed up to 44m/second shall be allowed for the condition that the Crane is out of service, boom in stowed or maintenance mode, gantry wheel brakes engaged, gantry stowage pins located in sockets in the quay with tie downs deployed.

2.10.6 Load Lifting and Stability Condition

(1) One side landing

A normal operating condition shall include the case of a short side landing of a 45 ft.- concentric 41 MT weight container, in which case a set of main hoist wire ropes on the landed side is assumed slack and not carrying the load. Calculation for structural design and mechanical design shall take this case into consideration.

(2) Eccentric container handling

All structural, mechanical and electrical systems and system components shall be designed to take account of the eccentric forces involved in handling containers in the single lift and twin-lift operation in the following combinations.

Single lift condition

(i) 1-unit x 45ft container weighing up to 41 MT with eccentricity of 1.2m in longitudinal (gantry) direction and 0.25m in transverse (trolley) direction.

Twin lift condition

(ii) 2 units x 20ft containers each weighing up to 25.5 MT with eccentricity on each container of 0.6m in the longitudinal (gantry) direction and 0.25m in the transverse (trolley) direction.

(iii) 1-unit x 20ft container weighing up to 25.5 MT with eccentricity of 0.6m in the longitudinal (gantry) direction and 0.25m in the transverse (trolley) direction and 1 unit x 20ft container at 2 MT (empty) concentric.

Under conditions (ii) & (iii) the center distance between containers shall be a maximum of 7700mm.

(3) Fatigue condition

The structural fatigue calculations must include the cases that the Crane will be continuously handing containers configured respectively as outlined in 2.9.8(2), i), ii) and iii) above and the Cranes must be suitable for and able to perform as required for this.

(4) Dynamic snag load

A device shall be incorporated into the hoisting system to provide protection against snagging. The Crane shall not sustain any damage due to dynamic snag load. The Contractor shall submit structural calculations to prove that structures are safe under dynamic snag load.

(5) Stability

The Crane shall be stable with a reasonable factor of safety and shall not sustain any damage when a dynamic snag load is applied to the boom at the maximum outreach position.

(6) Other Loading Conditions

All loading conditions forming design criteria other than specified in this Specification shall be submitted to the Purchaser for review.

(7) Earthquake

The Crane shall also be designed to take account of earthquake loading to 0.2g which may be subjected to the structure both in service and out of service operation. See EQO and EQS loading, section 2.6.

2.11 Noise Control

(1) Special consideration shall be given to acoustic treatment to reduce noise breakout from the machinery house via the walls, floors, roof, winch wire rope openings, ventilation air intake / discharges.

(2) The maximum noise level measured 1 meter outside and under the machinery house shall not exceed 85 dB

(3) The noise level inside the operator's cab, checkers cabin and electrical computer monitoring room shall be below 75 dB during operation, with air-conditioner on, and doors and windows closed.

2.12 Operationally Critical Components

The Contractor shall submit the inspection and replacement schedule for the operationally critical components to the Purchaser. The objective is to assist the Purchaser to establish a standard for maintenance and inspection of operationally critical components (i.e., those components and structural areas, joints, tension bars where failure could have catastrophic consequences). The following items shall be included in the list of Operationally Critical Components:

(1) Drum Couplings for the Main Hoist and Boom Hoist

(2) Service and Emergency Brakes for the Main Hoist and Boom Hoist

(3) Wire ropes

(4) Twist-locks for Head-block and Spreader

(5) Elevator

(6) Structural components as defined by the Contractor.

2.13 Duty Cycle

(1) The Crane(s) shall be capable of continuous duty cycle operation at speeds up to full speed with loads up to 50MT; the Crane(s) need not be capable of continuous duty cycle operation with container loads exceeding 50MT. Performance (speed and accelerations/decelerations) may be reduced at loads exceeding 50MT, but the Crane(s) shall have no other limitations preventing safe and efficient intermittent operation with container loads between 41MT and 50MT and shall be capable of "continuous" duty cycle operation with container loads of 50 MT for not less than one (1) hour. The Crane(s) shall be easily maintained and suitable for operation in the atmospheric conditions described in Section 2.95

(2) The theoretical duty cycle for use in calculating times and equipment ratings of the main hoist and trolley drive systems shall consist of removing and replacing the containers of a typical hatch on vessel 23 containers wide with seven (7) high stowage above deck and nine (9) high below deck. The equipment ratings shall also consider the various worst-case container handling cycle paths encountered in container handling operations.

(3) The calculations shall be based on the following: -

(i) 55MT load each way.

(ii) All loads are lifted 1 meter clear of the highest obstruction in their travel path

(iii) All loads will be lowered to within 1 meter of surface they are to be set upon, stopped and then lowered onto the surface. Similarly, containers to be put in cells will be stopped 1 meter above the cell guides and then lowered into the guides.

(iv) A dwell time of 2 seconds will be allowed for engaging or disengaging twist-locks, and for entering cell guides. These are the only dwell times to be considered.

(v) Each motion accelerates travels and decelerates at the maximum rates for which the system is designed.

(vi) Hoist and trolley travel occur simultaneously whenever the container is clear of a cell. Ambient temperature is between +15ºC and +40ºC plus allowance for solar radiation which may increase surface temperatures to 50ºC.

(vii) The cycle is repeated indefinitely.

(viii) The wind load is 50% of WLO, applied in the least favourable direction.

(ix) The Contractor shall submit for review, the theoretical duty cycle block diagram for the main hoist and trolley drive

(4) The theoretical duty cycle for the trim/list/skew system components shall consider the above main hoist and trolley duty cycle with the trim/list/skew system completing two full-range operations per container cycle.

(5) The theoretical duty cycle for the purposes of calculating times and equipment designs of boom drive shall be based on the following: -

(i) Raise boom from operating to stowed position at rated speed.

(ii) Lower boom from stowed to operating position at rated speed.

(iii) The cycle is to be performed four times with no dwell time.

(iv) The wind load is 50% of WLO, applied in the least favourable direction

(6) For the gantry drive, the theoretical duty cycle for purposes of calculating times and equipment designs shall consist of continuous gantry travel for 60 minutes with empty spreader at any speed to full rated speed against the most severe wind load (including diagonal wind) equivalent to 50% WLO, unless other specified operating modes govern the design.

3 CRANE STRUCTURAL SPECIFICATIONS

3.1 General Requirement

3.1.1 Design

(1) The term "AISC Specification" refers to the *Specification for Structural Steel for Buildings, Allowable Stress Design and Plastic Design, June 1, 1989, with Commentary.* The terms "AWS Specification," "AWS D1.1," and "AWS D1.1/D1.1M-2006" refer to the AWS D1.1/D1.1M-2006*, Structural Welding Code - Steel,* an American National Standard. Provisions for bridges and dynamically loaded structures shall take precedence. The terms "AWS D1.5," and "AWS D1.5M/D1.5:2002" refer to the AWS D1.5M/D1.5:2002*, Bridge Welding Code,* an American National Standard. The structural design shall generally conform to the requirements of the AISC Specification except allowable stresses shall be as specified in this section.

(2) The gantry frame structure shall consist of sections, box or tubular members. The boom and trolley girder shall be either one or two girders. A trussed boom is not preferred but may be permitted with the Purchaser's approval. Cover plates and back-to-back angles or channels shall not be used. Exterior surfaces of structural components shall be accessible for maintenance. Wire rope or strand shall not be used for structural members. Flattening or crimping of tubing will not be allowed unless approved in writing by the Engineer.

(3) Welded joints are preferable. Bolted joints will only be allowed when specifically approved by the Engineer. If the Contractor proposes to use bolted joints, he shall so indicate in his tender. Bolted joints shall be made using ASTM A325 or A490 bolts or bolts complying with equivalent ISO or British Standards. For Operating conditions, the joints shall be designed to meet the requirements for slip critical joints For Overload and Storm conditions the joints may be allowed to slip provided the slipping is not detrimental to the performance of the joint or the structure. Welds and bolts shall not share the load in any joints. The faying surfaces of all main structural friction-type bolted connections shall be machined. Coatings shall be used on faying surfaces of slip critical connections only if they have been qualified 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.

(4) The sill beams, legs and portal beams shall form a continuous rigid frame. The connections between these members shall be welded and be capable of resisting all six components of force. Bolted joints may be allowed as provided above.

(5) The interiors of all members, large enough to crawl through, shall be accessible for periodic structural inspection. Members that cannot be internally inspected because of size or other practical reasons shall be sealed by welding. Sealed members shall be pressure tested at 10 kPa gauge pressure using soap film to demonstrate air tightness. Sections shall be designed to resist the test pressure without yielding. Stresses developed by a 20° C temperature change of the entrapped air shall not exceed 0.10 times the basic allowable stresses.

(6) Fracture critical members or member components, FCMs, are tension members or tension components of members whose failure would be expected to result in collapse of the crane, collapse or dropping of the trolley or operator's cab, or dropping the load. Tension members or tension components include those portions of a flexural member that are subject to tension stress. Examples of FCMs are stays and the tension flanges of the trolley girder, boom, and trolley girder support beams. Stiffeners used to increase plate buckling strength, and which are not used in the calculations as part of the structural section, may be classified non-fracture critical.

(i) The responsible structural engineer shall determine which member or member component is in the FCM category.

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

(ii) All FCMs shall be identified on the drawings.

(iii) FCMs shall be accessible for periodic structural inspections. Non-fracture critical members shall be accessible where practical for periodic structural inspections.

(iv) For FCMs, in-plane longitudinal stresses in cruciform joints shall be carried through a welded joint by a full penetration butt weld, i.e. complete joint penetration weld. The butt weld should be completed by fillet weld reinforcement on both faces of leg length at least equal to one fourth the thickness of the connected plate but not less than the minimum fillet weld size specified in AWS D1.1. The plate running through shall be checked before welding for laminar rolling flaws and after welding for lamellar tears. For FCMs, cruciform joints shall have redundant load paths. The design shall provide an alternate load path that does not rely on the strength of the plate subjected to through thickness stress.

(7) Connections shall be detailed to provide a ductile structure capable of withstanding yielding without brittle failure. Transitions shall be gradual. Changes in thickness or width shall be achieved using tapered or curved surfaces. The Engineer may require redesign of connections that, in his opinion, cause unnecessarily high stress intensity.

(8) Fillet welds deposited on opposite sides of a common plane of contact between two parts, "wrap around welds," shall be interrupted at a corner common to both welds according to AWS D1.1, section 2.8.3.5. The ends of the interrupted welds shall be stopped at least 10 mm from the edge of the connected parts. Connection shall be detailed so wraparound welds do not occur. The faying surface at the weld interruption may be sealed by caulking.

(9) All pinned joints in the forestays and similar members shall include aluminum bronze bushings or other equivalent manufactured bearings at 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.

(10) The structural analysis of the crane shall be performed or reviewed by the Contractor's responsible structural engineer and the structural detail design shall comply with Appendix 5 – " Standard Structural Details".

(11) A design life of four million moves shall be assumed. The assumption of a design life does not necessarily mean that the structure will no longer be fit for its purpose at the end of that period or that it will continue to be serviceable for that length of time without adequate and regular inspection and maintenance.

(12) The Contractor's responsible structural engineer shall be familiar with the following reference documents:

- F.E.M. 1.001, 3rd Edition Revised 1998.10.01
- Maddox, S. J., *Fatigue of Welded Structures*, Edison Welding Institute, Columbus Ohio and Abington Publishing, 2nd ed., 1991.
- Rolfe, Stanley T. and Barsom, John M., *Fracture and Fatigue Control in Structures*, Prentice-Hall, 2nd ed., 1987.
- Structural Stability Research Council, *Guide to Stability Design Criteria for Metal Structures*, Theodore V. Galambos, editor, John Wiley & Sons, 4th ed., 1988.

(13) A large sign shall be placed on the crane's leg near the access ladder In English and Local language stating:

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

(14) Shop and field erection lugs that will not interfere with the operation of the crane may be left on when approved by the Engineer and Purchaser.

(15) The girder and boom design shall allow the operator to escape from the operator's cab to the walkway of the girder and the boom at any point of trolley travel range including under the machinery house in an emergency.

(16) The girder and boom design shall allow trolley wheel replacement works at any position on girder/boom of the trolley. In addition, the Machinery House structure shall be designed to permit the trolley wheels to be raised or lowered by the Machinery House maintenance hoist.

(17) The boom structure shall have sufficient torsional rigidity to avoid torsional deformation or overstress of the boom due to winds as specified and one side landing of container as specified.

3.1.2 Machinery on main structure.

The following machinery shall be fitted to the main structure of the Cranes.

(1) Gantry drive machinery.

(2) Gantry buffers.

(3) Power-operated storm brakes with limit switches.

(4) Cable reel with cable guide and limit switches. (proximity type)

(5) Main hoist sheaves.

(6) Boom hoist sheaves.

(7) Boom latches with limit switches. (proximity type)

(8) Trolley drive sheaves.

(9) Stowage pins with limit switches. (proximity type)

(10) Boom hoist, boom latch and gantry travel control station.

(11) Gantry travel operating station at ground level.

(12) Personnel Elevator.

(13) Trim/List/Skew adjustment devices.

3.1.3 Fittings on Main Structure

The following fittings shall be fitted to the main structure:

(1) Walkways, stairs, ladders and platforms.

(2) Lighting for operation and for walkway, stairs ladders and platforms.

(3) Aviation warning lights.

(4) Wind vane for anemometer at a high level where least affected by turbulence caused by own crane structure during operation.

(5) Intercom system.

(6) Travel warning device.

(7) Two speakers fitted at quay level on waterside and landside facing inside of the Crane.

(8) Welding outlet.

(9) Service outlets.

(10) Emergency stop buttons.

(11) Drive Lock-Out Switches

(12) Fire extinguishers.

(13) Cab window cleaning platform.

(14) Checker's cab.

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, section A3, 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 Tests

S93, Limitation on Weld Repair

and to ASTM A6/6M, General Requirements for Rolled Steel Plates, Shapes, Sheet Piling, and Bars 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, agreed inspection 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-fracture critical), 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 but not limited to: heating/cooling times, radii of bending.

(10) 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 lamellar tearing 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.

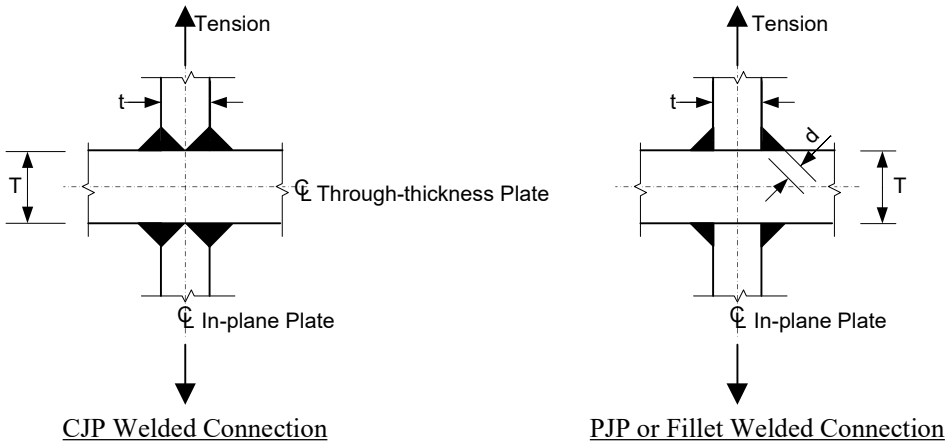


Figure 3.1 Through-thickness plate connection details

Weld	In-plane Plate	Through-thickness Plate	Through-thickness Plate Thickness, T[1] (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-thickness tension stress shall be designated "Z-steel" material. Z-steel shall comply with the following in addition to the other requirements of this Specification:

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 shall extend 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 thicker than 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 to prevent 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, as established by the supplier are permitted to be installed

(3) Bolted Joints of any box-sectioned structure shall be sealed at its gap between two main structures to 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 been qualified 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 lubrication and rust preventive system shall be provided for each pin joint to prevent its seizure 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 main drives 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 be detrimental 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 ponding shall 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 analysed 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 a flexible element capable of flexing as required without overstress. The effect of axial load shall be included in the analysis of such flexible components.

(3) 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 component weights. 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 to move 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 shall be 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 the calculation 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 the Engineer. 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 terminology

Listing of the governing specifications

Listing of all loads

Listing of load combinations and corresponding allowable stresses

Calculations for determining the magnitude of each design load.

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

Dynamic analysis for one boom hoist rope failing.

Sketches showing computer input data including geometry, node numbers, member numbers, 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 sizing

Stability 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 shows significant round-off error.

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

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

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 cause significant 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 increased stability.

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/or bending stress at a point shall be taken as:

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

Where:

fx and fy are orthogonal axial stresses (tension is positive, compression is negative) 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 accordance with 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

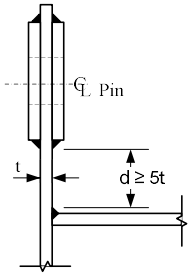
3.7.1 General Design Considerations

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

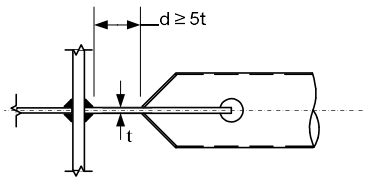
(1) Cumulative damage shall be evaluated for the normal operating conditions. For the gantry frame and boom, only fluctuating stresses due to variations in the lifted load and the trolley motion need to be considered. The effects of dead load, wind load and gantry travel and raising and lowering of the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

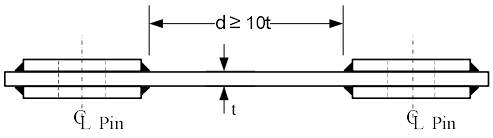
(3) Frame and boom diagonal pipes, backstays, forestays, and other similar members connected at the ends with gusset plates shall be designed to include the effects of fluctuating stresses due to weak axis bending. The length of the gusset plate that can flex is the clear distance between the boss plate or pipe end weld toe to the connecting plate weld toe. The clear flexure distance, d, shall be a minimum 5.0(t), where "t" is the thickness of the flexing gusset plate. For 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 Contactor for 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, return to 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 prepare to 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

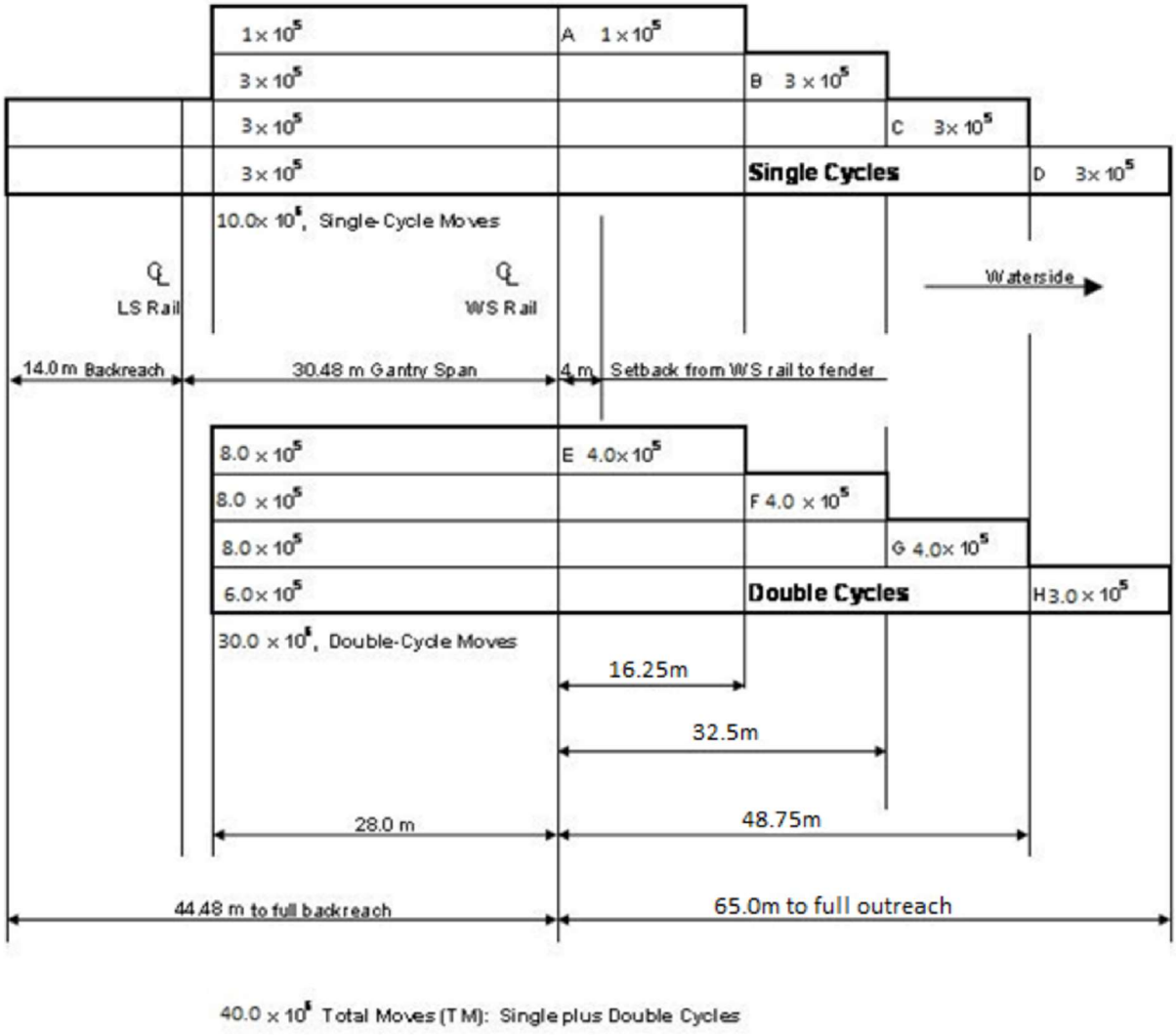


Fig 3.1 Design Cycle Spectrum

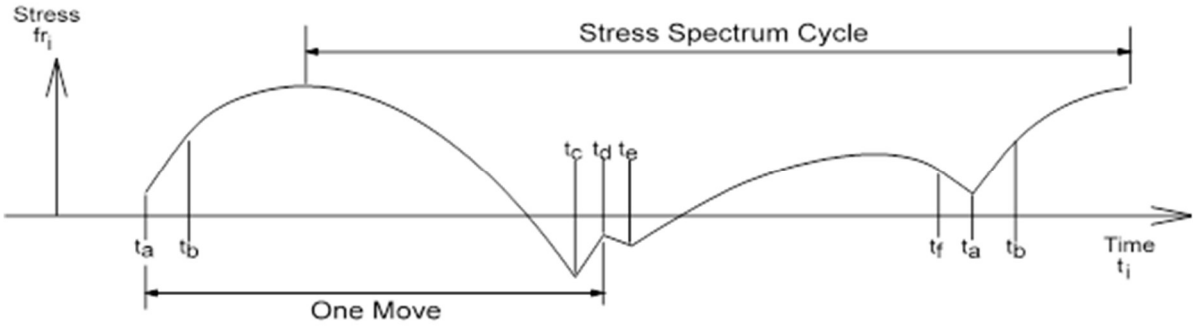


Fig 3.2: Typical Single-Cycle Stress Spectrum

Time

t_a	lifting system is set on container; stress is due to trolley only
t_a to t_b	lifting system and container are lifted; stress is due to trolley plus lifting system and container plus impact
t_b to t_c	trolley travels
t_c to t_d	lifting system and container are lowered and set; stress is due to trolley only
t_d to t_e	lifting system is lifted
t_e to t_f	trolley returns
t_f to t_a	lifting system is set on container

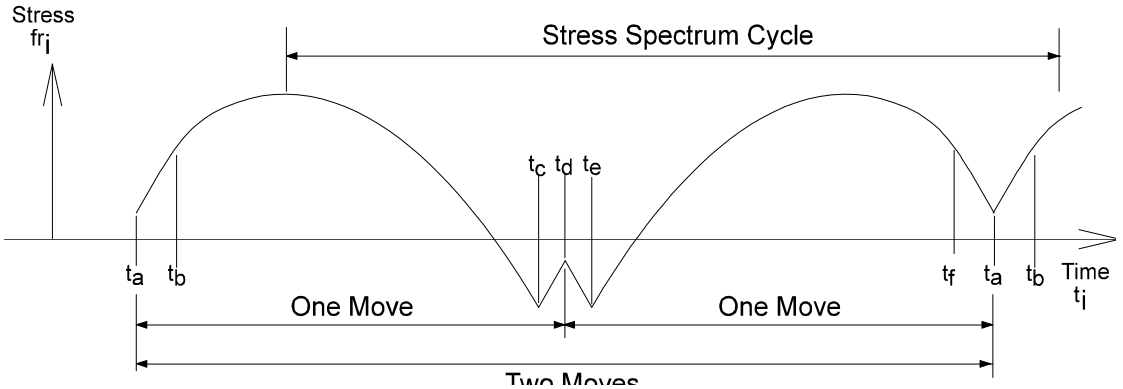


Fig 3.3: Typical Double-Cycle Stress Spectrum

Time

t_a	lifting system is set on container; stress is due to trolley only
t_a to t_b	lifting system and container are lifted; stress is due to trolley plus lifting system and container plus impact
t_b to t_c	trolley travels
t_c to t_d	lifting system and container are lowered and set; stress is due to trolley only
t_d to t_e	lifting system and container are lifted; stress is due to trolley plus lifting system and container plus impact
t_e to t_f	trolley returns
t_f to t_a	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 than 75% of the allowable strength of the member. Notice that whenever the calculated stresses are less than 50% of the allowable stress, the 75% requirement applies.

3.8.2 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 the connection 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 bearings at 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 all design 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 unloaded state 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 the forestays 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 trolley at 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 all design load cases

i) Ratio of the natural period of the gantry frame in the trolley travel direction and the natural period 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 following cases:

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

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

The calculated deflection of the trolley runway between the forestay connections is less than the 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-reach and the landside trolley girder support beam is less than the distance between these divided by 800.

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

(2) The load for camber calculations shall be:

$$DL + TL + LS + \frac{1}{2} LL$$

**CLARIFICATION: For this project the camber shall be achieved by way of forestay adjustment, so the trolley path is approximately 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. If welded 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 of the 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 girder-boom 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 girder-boom 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 respect to 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 the load 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 from the 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 of prime 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 the cyclically loaded structures requirements of AWS D1.1. Welding procedures and electrodes shall be shown 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 their particular 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 performing such 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. Welds performed 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 qualified welders on the job. This log will be subjected to examination at any time by the Purchaser or his site representative.

(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 procedures shall be stopped immediately and logged as a non-conformance report. Continuation of this welding will 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. The use 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 standard method in the AISC manual.

(3) A325 and A490 bolts greater than 22mm diameter shall be tightened to the required tension by the calibrated wrench method only. The following supplemental requirements shall apply in addition to the requirements of the Specifications 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 tightening may 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.

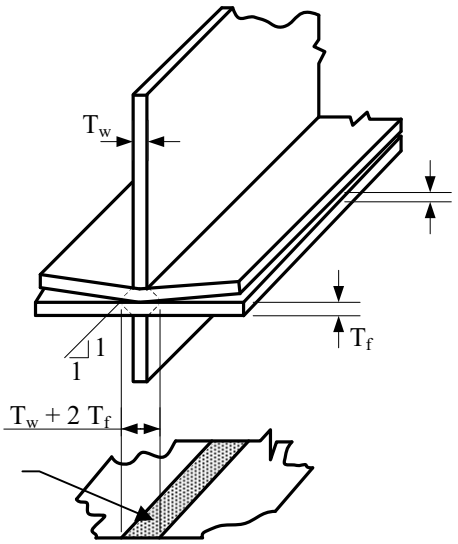
(v) After the snug tight condition is achieved, an initial tension of 75 percent of the final tension shall be developed in all the bolts. Only then shall the final tension be developed.

(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 than 1.0 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 gage read 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 which shall 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 NDT inspection 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 and reissue 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 of the 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% MT where UT is not possible	AWS 1.1 – 2006
Full Penetration Butt Welds in Tension Bars (Forestays and 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 Representative if 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, as required 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 Operationally Critical 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 brakes driving 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 brake shall 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 brake mounted 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 controls shall 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 the brakes if the load exceeds 115% of rated speed. This feature is to protect either hoist drum in case of drum coupling failure.

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

(6) Acceleration from zero speed to a maximum speed or deceleration to zero speed shall be smooth and stepless 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 containers when the crane is working on a single slot. Outside wire ropes shall be stationary during hoist and lowering motion.

(9) Any openings on the machinery house wall for the passage of all wire ropes shall be protected from water 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 detect the 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 that the 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 to the CMS and operator interface panels, and further hoisting shall be prevented. The operator shall be able to lower the spreader at a reduced speed until the condition is cleared.

(14) All points requiring lubrication will be lubricated with the automatic greasing system

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

4.1.2 Sway Control (Not required for this project)

(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 the load 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 shall be 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 manual assist 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 load reaches 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 such as 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.

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

vii. 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.

viii. 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.

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

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

(2) Jamming in ship's cell, 18 m above gantry rail elevation, of a full speed empty spreader 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.

x. 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)

xi. Auto wire rope de-tensioning function.

xii. Auto reset of SOS after snag event.

xiii. 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 bypass switch.*

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 collision at 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 an emergency access from the operator's cab to the walkways of the girder 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 of its component parts for maintenance.

(7) All points requiring lubrication will be lubricated with the automatic greasing system

4.2.2 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

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 calliper operated disc brake shall be fitted on the high-speed pinion shaft and shall be rated at 150% full load motor torque.

iii) Trolley Drum shall have a spring set, electrically or hydraulically released calliper disc brake mounted 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 drum brake 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.

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 forwards causing 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 landside rail.

(2) Direct Driven Trolley (Not Required)

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

ii) Each gearbox input shaft shall be fitted with a thruster calliper operated disc brake rated at 150% 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 provides for 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)

4.2.3 Trolley Tow Rope Tensioner

(1) A hydraulically operated towrope tensioning system shall be provided and shall maintain proper rope tension 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.
(3) All points requiring lubrication will be lubricated with the automatic greasing system

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

4.2.4 Semi-Automatic Trolley Operation

THIS CLAUSE NOT USED FOR THIS CRANE SPECIFICATION

4.2.5 Power Feeder

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

(2) 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 manufacturers recommended allowances.
- Adequate allowance for cavity fill including manufacturers recommended safety factors. In any 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 cable replacement.

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

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

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

(6) If cable chain is selected, manufacturer shall attend site prior to crane taking over for final inspection and 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 motors out 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 400m 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, spring applied double disc brakes, flange mounted to each gantry motor. The dynamic rating shall be greater than 100% of maximum motor torque but not greater than 150% of the maximum motor torque. The brake 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 is pressed 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) 3rd party gantry motors shall be painted in ICTSI livery as per Appendix 2

(6) 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 one wheel. 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.

(7) 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 shall incorporate a push away system to prevent personnel injury due to dragging, pinching or trapping.

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

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

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

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

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

(13) Proximity switches shall be fitted to the buffers to detect crane to crane or crane to buffer condition and inhibit gantry motion in that direction. Radar sensors such as Banner shall be used for crane to crane anti-collision (slow down and stop)

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

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

(16) All points requiring lubrication will be lubricated with the automatic greasing system

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.

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

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

(4) 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.

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

4.3.3 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 30m/sec with gantry brakes released and stowage pins in the disengaged 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 ±10mm float with cleaning pads.

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

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

4.3.4 MV Cable Reel

(1) Cable Reel

(i) The cable reel shall be installed on the right-hand portal beam. The drive control system of the 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 above conditions shall be provided.

(ii) The cable guide device shall be fitted with a belt-lifting device with nylon rollers to facilitate the opening of covered cable trench systems by renowned global producers

(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 cable close to the ground level. The cable shall be laid inside the cable slot within the wheelbase of the gantry trucks in one corner.

(v) The system shall be well protected from weather especially in the vicinity of the high voltage slip 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 be provided 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) shall be provided.

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

(2) MV Trailing Cable

(i) The cable shall be renowned global producers (SMK) round type with three conductors, suitable for 15kV with ground and embedded fibre optic cables for data transmission. Sufficient length of cable shall be installed to provide for the full length of crane travel, three dead wraps on the reel 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 18 numbers of low loss silica glass optical fibre waveguide. 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 external devices. 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 a proprietary type of MV cable termination cabinet. The Contractor shall undertake termination of the MV cable conductors and fibre waveguide at the feeding pit into a special connector 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 with an approved cable connection kit. The cable joints made at Site and medium voltage wiring shall pass 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 friction brake shall be rated to be capable of arresting and holding the boom in any position. This disc brake shall 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 so that failure of one rope system does not damage the boom. Speltered type rope socket connections shall not be accepted.

(4) Sensors shall be provided to detect boom hoist slack rope and stop motion if slack rope occurs other than when the boom is in the horizontal position. The slack rope sensor reset button shall be installed near 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 brakes if the load exceeds 115% of rated 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.

(9) All points requiring lubrication will be lubricated with the automatic greasing system

4.4.2 Boom Latch

(1) The boom latch system shall include a boom-locking device which will eliminate any relative movement between 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 signals shall be reliable weatherproof type. The control logic shall be based on a fail-to-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 of the 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 not be less than 12.0m x 16.0m in size.

(2) The machinery house shall be constructed to maintain an air temperature inside the machinery house of 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 shall be decided during design review.

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

(4) The floor of the electrical control room and quiet (PLC) room shall be manufactured from composite fireproof material completely fitted with an approved (UL or equivalent) insulated flooring material/matting rated at ≥1000 volts to provide anti-static and electric shock protection, if rubber 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 equipment for Crane Condition Monitoring System.

(5) Electrical house shall have a minimum of two access/egress ways to/from the exterior, locations shall be 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 non-corrosive heavy-duty hardware locks and safety glass windows in upper panels. The door shall be self-closing. A drip shield shall be provided over the door. The locations of doors shall be at the front and the rear wall of the machinery house.

(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 ceiling for 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 and surrounded 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. The hatch 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 hatch opening 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 the operator 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 addition one steel locker with door lock shall be provided inside the Control Panel Room – minimum dimensions 1500H 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 switches shall be installed outside the Control Panel Room.

Special consideration shall be given to acoustic treatment to reduce noise breakout from the machinery house via 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 the Control Panel Room.

vi.) Transformers.

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

viii.) Auxiliary motor starter and control panels.

ix.) Automatic greasing system

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 with CE Certyficate

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 idle with 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 achieve ten (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 the required temperature.

4.5.4 Illumination and Lighting

Internal illumination in the machinery house and electrical control room shall be provided by LED type lighting and shall be arranged to provide a uniform illumination in all areas of not less than 200lux throughout the entire area 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. The batteries shall have capacity to power the emergency lamps for at least two hours. The lamps shall be turned on automatically when the electric power supply to the crane is cut off. Battery chargers to keep the batteries in continuously charged condition shall also be provided.

4.5.6 Air Conditioning and Climate Control

**CLARIFICATION: Air conditioning units shall be available from the Polish market including spare parts and support.*

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

(2) To reduce the frequency of cutting in/cutting out of the air conditioners, a temperature sensor shall be installed in parallel with the main control of the air conditioners. The air conditioner main circuit shall be powered on with the activation of the main motion control source and powered off with 30 minutes time 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.

(3) 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. Total n+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 cranes are idle.

(4) To ensure panel room uniform temperature, temperature sensors shall not be installed in one location or installed in groups.

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

(6) 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 prior to vessel departure.

(7) 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 system shall 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 Polish market including spare parts and support,*

4.5.7 Fire Protection

(1) An automatic system to detect and extinguish fire in the Machinery House, Control Panel Room and/or the 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 crane destination.

(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 smoke and thermal detectors shall be fitted in E-room (minimum 3 of each type) and with 1 detector of each type the in PLC room, in addition 2 detectors of each type shall be fitted in the M-house in close proximity to the transformers and switchgear, no extinguisher system shall be installed in M-house.*

Extinguisher system shall be of Aerosol type such as Stat-X

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 panel according to a predefined escalation procedure which will ultimately shut down the crane automatically and 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 machinery house and lower it to ground level shall be installed in the machinery house. Minimum capacity shall 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.

(6) All points requiring lubrication will be lubricated with the automatic greasing system

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 House and 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 a motor 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 drum to 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 full reeving reel, reel control shall be by inching and non-latching.*

(3) The supply reel shall have a manually operated friction brake for controlling pay-out of the new rope from the supply reel during reeving and an automatic level winding device for level winding the used cable on to the empty reel during re-reeving. The brake shall be operated from the same level as the motor 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. The brake 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 reels which 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 the platform 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 removed and re-installed.

4.5.10 M-House Roof Solar Panel System

(1) The Contractor shall provide a proprietary solar panel system mounted on the machinery house roof with the aim of providing auxiliary power to crane, the PV system design shall be reviewed and approved during the design review; for this system, no batteries or power storage shall be required.

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 renowned global producers 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 door in 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 of the operator and two walkable bottom windows to the rear. Window glass shall be scratch resistant meeting the requirements of BS6206 class A safety glass with both surfaces being flat, parallel and fine polished, giving clear undistorted vision.

(6) 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.

(7) A protective shield shall be fitted above the windscreen to prevent wire rope lubricants from splashing onto the glass.

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

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

(10) 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

(11) Cab Fittings

The operator's cab shall be fitted with following fittings and shall not obstruct the operator's views required for crane operations.

i) One right-hand and one left-hand 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 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 renowned global producers 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 each operator.

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 the armrests and secondary controls within reach within a hinged side panel. Additional controls may 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-Light and additional 2 x spotlights integrated into the ceiling panel. Two-way control switches shall be 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 renowned global producers 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 instructor during training period.

**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.*

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 so that 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 contain the 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 large as 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 two service 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 defined elsewhere. All functions of the Ground Level Station shall be conveniently reachable from an operator standing 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 safe location agreeable by the Purchaser. The checker's cab shall be bolt mounted to the sill beam, with access and egress available inboard and outboard via self-closing gates.

(2) The following shall be provided:

i) Service outlets (2 Units)

ii) Air conditioning system to maintain interior temperature below 23°C ±2°C under the highest ambient condition

iii) Ventilation fan

iv) LED lighting

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

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

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 renowned global producers 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 (Lae, PNG) 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 the Taking-Over of the crane.

(3) Lubricants which are recommended by the elevator manufacturer for maintenance of the elevator shall be 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 standard

(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 access from 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 approved by 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 elevator from 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 a manually 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 of the driving motor. An arrow mark at the wire mesh shall match with another arrow mark to show to the 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 for emergency calling for help. The battery shall be constantly trickling changed by the AC power supply to maintain optimal operating condition at all time. A push button shall be fitted inside the car cage for this purpose.

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

4.8 Head-block

4.8.1 Head-block

(1) The head-block shall be designed with longitudinal and lateral Twist-lock centres to permit interchangeability of spreaders purchased for this project. It is required to maintain interchangeability with 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 man-cage with Emergency Stop Push Button to carry two men standing with a robust steel plate 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 the ladders 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 on the frame and visible from outside and monitored/interlocked individually by proximity switches (one or lock and one for unlock)

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

vi) Anti-sway or trim/list/skew devices, if any.

vii) 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.

(5) All points requiring lubrication will be lubricated with the automatic greasing system

**CLARIFICATION: The spreader cable (from the reel) connected to the head-block junction box shall use a socket and 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 Two Wire (Bus) System (*CanBus)

(1) The communication between the trolley and the head-block shall be via the baloney cable with a two-wire (bus) system. The two-wire system chosen must be fit for purpose and tolerant to 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 possible interruption.

(3) Gateway shall be provided in the operator's cabin. The cabin gateway shall convert and transmit all the status 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 system fitted with Prysmian or renowned global producers 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 cable reel may stop instantly which may cause slack cable sensor indication. The control logic shall recognize this 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 machinery classification 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 to prevent 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 when the 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 spreader shall 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 either side.

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

iv) A drive system Lock Out isolator switch with facility for padlock shall be provided on the side of 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 where the 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.

viii) All points requiring lubrication will be lubricated with the automatic greasing system

(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 inserted into corner fittings and the spreader is fully landed onto a container.

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-block in 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 lights from 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 designed and constructed to have ample gathering capability of the flipper to displace the spreader by 150mm 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 only one lowered flipper lands on the top of a container.

iv) The flipper arms will be manufactured from spring steel and shall be connected between the flare and the lower portion by countersunk bolts to provide a flush finish to the inner surface of 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.

(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 beams from 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 35 sec. for 20'-45'.

(5) Spreader Landing Probe

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

ii) The landing probe position shall be sensed by individual proximity switches, which shall be located to accurately indicate spreader landed and container lifted conditions. Each proximity switch 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 and shackles 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).

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

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

(7) Spreader Protection

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

ii) All the electrical cables and hydraulic hoses connected to the moving parts of the spreader shall 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 shall be connected to the I/O unit to prevent any miss-indication and unsafe movement of twist locks 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 function until a new replacement proximity switch is in place. A method of direct twist-lock sensing is required.

(8) Spreader Meters and Indication.

i) Two non-resettable, vibration damped twist-lock counters shall be fitted on the spreader. The counters 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 axis joystick. 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, that the 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 may be "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 which may 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 of identical 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 Trailers for 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 cradle with 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 Terminal Tractor.

(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 about required quantity and lifting capacity refer to Clauses 1.4.1 (Crane Details and Accessories) and 1.4.3 QC Lifting System).

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

(3) The hook shall be a ram's horn hook, fitted to the beam through a trunnion that allows both swing of hook shank and 3600 unlimited rotation of the hook. The trunnion shall have an anti-friction 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 the Hook Beam. The lifting capacity of each of the smaller hooks shall be 50% of the lifting capacity of the Hook Beam.

(5) Four lifting lugs shall be fitted at the corners of the bottom side of the beam. The lifting capacity of each 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 provided for transportation. In addition, four lifting lugs for lifting the Hook Beam with slings and shackles shall be 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 is connected to the head-block. The dimensions of the guides shall interface with the head-block twist lock 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 provided with the crane(s). For details about required quantity and storage location refer to Clause 1.4.1 (Crane Details 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 whilst connected 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 equipment attached 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 automatically locked as the spreader lands. A means of safe access to the frame in its stored position from ground level 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.

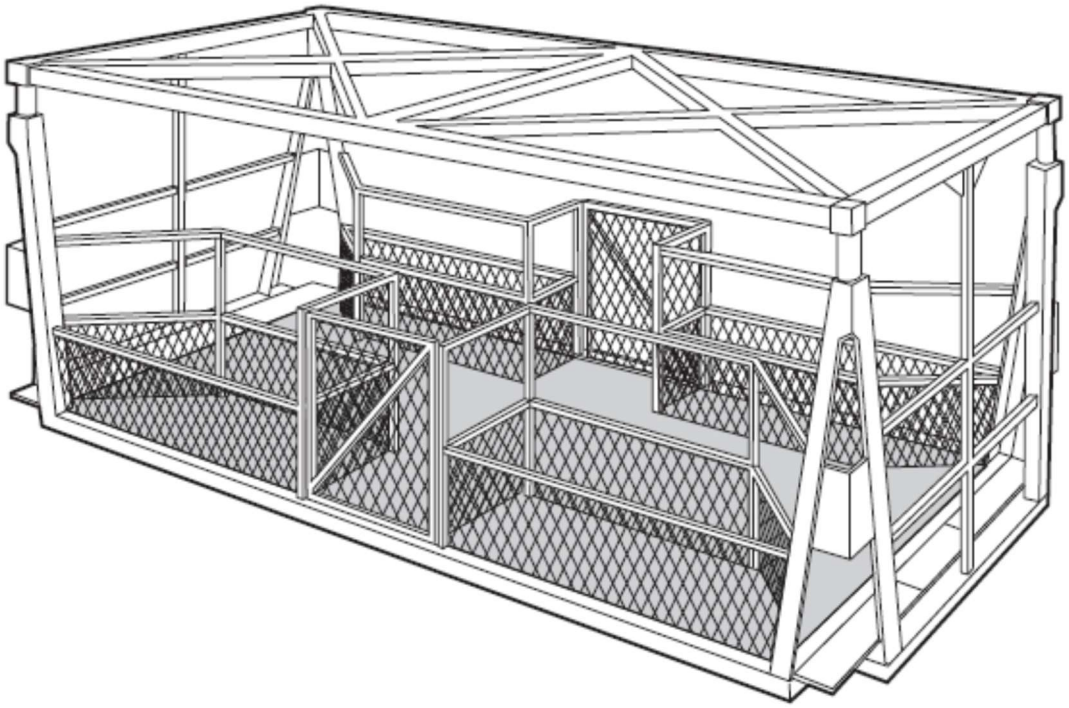
(5) Design standard shall be according to BS2573:1983 Part 1 with the following classification:

- 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 mesh be 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 on the sill beam to assist relocation after use and to provide secure storage whilst the crane is operating.

4.13 **Test Weight** (Required)

(1) If required under this contract (refer to Clause 1.4.1 Crane Details and Accessories), a certified Test Weight 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 at the 45ft, 40ft and 20ft locations. Pad eyes shall also be provided within the envelope of the structure for 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 unit shall 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 (5 MT, 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 of manufacturers.

(2) All bearings shall be anti-friction 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 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 bolt-down type to facilitate fast inspection and replacement work.

5.1.2 Gearing

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

(2) The durability rating for the main hoist, trolley and boom hoist drives shall be based on a minimum service 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 check and 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 condition shall 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 not permitted.

(2) The gearboxes shall be designed to allow easy replacement of gears or gear shafts without removing the 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. An adequate drain receiving space for each drain outlet shall be provided.

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

**CLARIFICATION: Contractor shall provide a list of gear reducers using cast iron housing for review and approval by the Purchaser.*

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.

(2) 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.

(3) 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.

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

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

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

(7) 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.

(8) The length of the hoist drum and wire ropes shall be such that when the head-block is at its lowest specified 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.

(9) 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.

(10) 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.

(11) 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 water out of trays during rainy conditions shall be taken into consideration.

(12) 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.

(13) Tubular Steel heavy-duty wire rope guards shall be fitted at mid-level of the wire rope winch drum to protect 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 of the wire rope diameter.

5.1.5 Wire Rope Sheaves

(1) All wire rope sheaves shall be of fully forged steel construction with smoothly machined grooves, alternatively Xtek sheaves can be provided as per Stipulated components list.

(2) The bottom of the grooves shall 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.

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

(4) 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 wire rope below the specified value.

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

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

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

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

(9) 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.

5.1.6 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 (Z-lay) EPIWRC 6x36 construction, 1770 N/mm² unless agreed otherwise.

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

5.1.7 Shafts, Axles

(1) Shafts and axles shall be designed to include acceptable allowances and finishes for stress concentrations 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 gearing associated 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 the required 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.

5.1.8 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 the spline or barrel coupling shall be extended to the edge of the main hoist winch drum to facilitate easy maintenance.

(5) Rotating Couplings shall be lubricated with special grease to prevent oil separation and leakage under the effects of centrifugal force.

5.1.9 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 be hardened 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 on the wheel tread and inner sides of the flange, provision for one spare wheel of each type, so that depth of hardness could be checked by destructive testing.

5.1.10 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 the required 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 manual lubrication system shall be provided for all pins and pin joint locations in order to prevent 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

5.1.11 Bolts

(1) All bolts are to be manufactured to ISO-metric standard.

(2) Tightening torque for all fitting bolts shall be clarified by the Contractor in the form of a bolt list clearly indicating 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 by the 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.

5.1.12 Lubrication

(1) All the moving parts shall be effectively lubricated by automatic greasing system ensuring uniform lubrication at all points

(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 pre-approved 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.

5.2 Hydraulic System/ Components

5.2.1 Standards

Hydraulic systems shall be designed in accordance with relevant international Standards. All components such as 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 stop the 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 of the hydraulic fluid into waste oil receptacles through shut-off valves which can be easily accessed. Space shall be 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 and moisture.

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

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

5.2.5 Power Unit

(1) Positive displacement pumps and motors of similar type, size and manufacturer are preferred. On no account 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 maintained against 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 the delivery 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 have oil immersed or wet pin solenoids. Each solenoid shall have means for external mechanical actuation for testing. If internally drained, tank ports will not be subjected to more than 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 the valve is rated. Flow setting shall be adjustable and shall have facilities for locking when proper flow setting is reached. Flow control valves must be adjustable to zero flow.

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 be replaceable 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 diameter is 30mm and above)

(2) All rigid piping shall be securely supported to minimize vibration or movement. The length and method of supporting flexible piping shall be such as to avoid sharp flexing and straining, particularly at the end fittings. The spacing between adjacent rigid pipes and between rigid pipes and the surrounding steelwork 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.

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 be fitted 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 wire mesh 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 fail to-safe valve and damping loop, and rigidly mounted on a structure. It can only be read by operation of a fail-safe valve.

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

(3) Quick connect / disconnect gauges shall be provided along with permanent connection points at all locations 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 pre-approved 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 remove foreign materials such as swarf or other contamination. Oil cleanliness shall conform to ISO 4406 Code 16/13 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 accordance with the requirements of this Specification. The electrical installation shall provide reliable power for the 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 site that 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 of Acceptance.

(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 for the electrical drive controls is to provide reliable power for the rapid and precise handling of containers through 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 motion shall be shared with the Boom Hoist. The Boom Hoist shall only be operable from the Boom control station and it shall not be possible to operate any other motion during Boom operation.

(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 15kV ±5% 50 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 110V or 230V 1-phase 50Hz.

(6) AC Motors AC 400 V 3-phase 50 Hz

(7) Access Lighting shall be 230V 1-phase 50Hz.

(8) Floodlighting shall be 230V 1-phase 50Hz.

(9) Receptacle Outlets shall be 230V 1-phase 50Hz.

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

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

(12) Air-conditioning system "indoor unit" stabilized supply Voltage is unit specific and shall be approved by 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 50 Hz.

5.3.3 Power Factor and Harmonic Voltage Distortion

(1) Power Factor correction equipment shall be installed on each crane to actively and dynamically regulate 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 trolley with 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 command positions.
- 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 of dynamically tracking the transient loading of the drive systems.

(3) Harmonics injected into the system shall be appropriately mitigated on board each crane to prevent undesirable 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 of the 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 the PCC. 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 shall be 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 electrical apparatus or device on the Crane which may introduce a surge shall be properly designed to suppress surge within 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 the transient surge suppression.

(1) The automatic power factor correcting device and the harmonic suppression device shall be designed to be of solid-state device without contactor to eliminate the surge generated during 'on' and 'off' of the 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 side to 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 absorber to 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 protected from 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 minimize crane 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 or a complete power failure when boom is lowering at full speed or when main hoist is lowering at full speed with wide range of Empty spreader to full load under spreader, the entire control system shall not fail and worst case is only to trip out the under voltage protection relay as fitted on the Inverter Drive. 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 lowering or 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 the AC 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 mm² except for factory wired panels which may include smaller size wires and communication cables. In general, minimum 1.5 mm² is used (power), 0.75 mm² will be used on equipment which does not have sufficient space to allow the use of 1.5 mm² such as I/O modules, small limit switches, solenoid valves, encoders etc. The wiring size will be based 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 wiring or cables found to be in line spliced shall be replaced.

(4) All conductor wires of 4 mm² 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 terminals only. Wires of 4 mm² or greater shall be terminated in screw type terminals with bootlace or spade or ring tongue crimped solder-less lugs. Only one wire shall be permitted in each terminal.

(5) All wires shall be run in trunking or conduit sufficient in size to carry all cables with some capacity for spare 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 due to 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. Multi-core cables may be run on cable trays with adequate cable ties and mechanical protection covers.

**CLARIFICATION: Encoder and communication cables such as, but not limited to Profibus 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.*

(6) At least 10% of control wires as spare wires shall be installed on all routes and specifically labelled as such. 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 junction boxes only.*

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

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

(9) 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.

(10) 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 segments in excess of 100m and short Profibus segments of 1m or less shall not be acceptable.*

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

5.3.7 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 and alphanumeric 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 or description.

(4) Individual control devices in cabinets shall be labelled by number description in accordance with the drawings 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 stainless steel screws.

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

**CLARIFICATION: If stick on labels is 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 a minimum and shall be approved by the Purchaser.*

5.3.8 Conduit, Cable Tray and Junction Box Panels

(1) Rigid conduit, with pull boxes at appropriate locations, shall be water proof and continuous. Inside of the 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. Imprinted UL approved markings are to be clearly visible at intervals on the external jacket, the flexible conduit and 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 box or 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 regarding electrical 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 be considered 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 in to 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 structure using 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 are preferred. Environmental Protection shall be IP65 minimum and no fixing bolts shall be permitted to pass 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.

5.3.9 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.

5.3.10 Motors

(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 be submitted 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.

(8) Where possible motor feeder cables shall be routed on open type cable ladder for optimal cooling and minimal 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 and EMI 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 removing the 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 in any 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 Hitachi*

5.3.11 Brakes

(1) Ample space shall be provided around brakes for inspection and maintenance works, including access to 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 of status 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 non-asbestos material.

5.3.12 Medium Voltage Panel and Switches

(1) The power shall be separated for auxiliary power and main motions power. Three 15kV circuit breaker switches shall be provided as follows.

i) One isolation switch for in-comer

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 1kV switches protection relay for the Purchaser's review.

(3) The 10kV 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 Power Quality monitoring device shall communicate with the CCMS which shall save the annunciated events and 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 vacuum circuit breaker. All vacuum circuit breaker protection shall be digital type.

(5) Remote control on-off 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 is off.

(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 15kVswitchgear shown in 5.3.12 (Medium Voltage Panel and 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 opening-tripping 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 - 15kV HIGH VOLTAGE"

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

5.3.13 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 and warning signs for high voltage.

*Fully enclosed IP20 transformer housing is acceptable with system comparable to Kirk Key Interlock 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 load curves 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.

5.3.14 Resistors and Brake Chopper (Not Required)

(1) Any resistor shall be installed in a position where it will not raise the temperature of electronic control components.

(2) Resistor banks, if any, shall be fenced off to avoid accidental contact by maintenance staff. The fence shall be provided with an access door with a lock, and warning signs.

(3) The crane may occasionally be operated from a 15kV standby generator of limited capacity but large enough to operate all the drives at reduced speed.

**CLARIFICATION: For this project the quayside container cranes shall be fitted with the latest four (4) quadrant active infeed modules to ensure power generated during lowering of hoist and deceleration (regenerative power) can be returned and consumed within the Purchaser's electrical network, facilitating lower overall energy consumption from the Purchaser's external energy supplier.*

5.3.15 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 (l) meter wide passage in front and rear of panels shall be provided.

5.3.16 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) Spreader Meter Indication)

ii) Operating hour meter (hydraulic pump motor operating hours)

5.3.17 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 is inductive proximity switch.

(3) Application of proximity switch shall be 'fail-to-safe' application. Short circuit status created within the switch at the time of failure of a proximity switch must prevent further motion which is controlled by the 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 lifting one end only, the proximity switches for 'Locked' and 'Unlocked' signal shall be individually connected to 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.

5.3.18 Space Heaters

(1) Space heaters shall be fitted to the following locations

i) 15kV slip ring enclosures

ii) All AC and if applicable DC motors above 7.5kW

iii) All control panels.

5.3.19 DC Power Supply

The DC power supply shall be able to self-regulate the output DC voltages to a constant value against variations in the input AC supply voltage. There shall be sufficient cooling / heat dissipating ability for the DC power supply.

5.3.20 Encoders

Electronic absolute encoders shall be used for position feedback for main hoist, trolley travel, list and trim systems.

5.3.21 Safety Mechanical Interlock System

Mechanical interlocking shall be provided for all main Medium Voltage circuit breakers, switches and electrical enclosures 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 safe access. Safety interlocks/keys shall be provided on the landside substation as part of this system. If multiple access panels are on the slip ring enclosure, safety interlocks/keys shall be provided for each access.

5.3.22 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.

5.3.23 Shore Power (Auxiliary)

Facility to plug in an auxiliary shore power supply shall be provided at ground level. The shore power may be used 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

5.3.24 Emergency Power (Required)

It shall be possible to connect an umbilical cable with interlocked plug and socket arrangement between cranes for the supply of emergency power in the event of crane power failure. The emergency power may be used to supply 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.

5.3.25 Service Outlets

(1) Service outlets (each double socket) shall meet design and voltage standard in the country of operation, with ground, 1-phase, 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 sill-beam, 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 will be advised to the Contractor by the Engineer during the design phase.

5.3.26 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 sill-beam, facing inside of the Crane.

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.

(2) Make-Model

Three pole, grounded type, 15 kW welding outlet for local voltage, 3-phase 32 A, 50Hz service shall be provided. All welding outlets installed outdoors shall be weatherproofed to IP55.

(3) Welding Machine

One unit of welding machine with CE shall be provided in the machinery house.

5.3.27 Emergency Drives

General 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 during normal 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 and boom 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 shall have 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.

**CLARIFICATION: For this project Emergency hoist, trolley and boom operation shall be via M-house local control station.*

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 Controllers and satellite stations are to be installed in the Electrical house, operators cab and other locations to be reviewed by 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 class of IP55 as a minimum degree of protection. Finger protection against electrical hazard to operators or maintenance personnel shall be applied according to the latest industrial standards.

(3) Ambient Temperature - the system shall be designed to operate in an ambient temperature between the range -25^{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% to 95% (non-condensing).

(5) Vibration and Shock Resistance - The entire system shall be designed and installed with an adequate vibration and shock resistance of not less than 16.7 Hz at a 3-dimensional amplitude of minimum 3mm in vibration and 10G in shocks.

**CLARIFICATION: PLC, I/O modules, media converters and all associated control system components shall be fit for purpose 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 an electrical 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 that all 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 power suppliers, I/O modules (as specified in the related clauses), etc. in a compact and low operating cost environment.

(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 of IEC 11311 – 1 and 11311 – 2 and Profibus installation guidelines.

(3) The racks shall be industrial type with a capability of expansion via simple communication interface between 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 the power supply and CPUs.

(4) The racks shall have a back-plate communication design and back-plate power supply distribution system. This is to achieve maximum feasibility in module replacement as well as minimize the mean time to repair when it is required.

(5) The PLCs shall have multi-tasking, remote communication capabilities and supporting interrupts. The input interrupts shall be hard wired to the front of the logic processor module. When triggered, the logical processor immediately halts the execution of the main control program and executes the interrupt routine associated with the given input interrupt.

(6) The PLCs shall have sufficient memory capacity to hold control algorithms for more than one process plus 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.

(7) The controller system shall provide real time display of programs, data and status at remote sites. The complete 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

(1) 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.

(2) 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.

(3) The rating of the power supply shall be at least 25% more than the total normal consumption of all the modules that are connected or that are going to be connected in future.

5.4.4 Discrete I/O Modules

(1) The discrete I/O modules shall be designed from the latest industrial standards with cartridge-insert type installation and the modules are expected to be operated under an environment which is specified in 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 or de-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 if this 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 with LEDs 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 than 1ms and 9ms respectively. At the same time, the maximum signal delay of the 'on' and 'off' status of the 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 in the 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 Output signals shall be monitored and stop crane functions in the event of open circuit failure.

5.4.5 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 right-hand control console shall control main hoist and gantry motion. Fore and aft movement for main hoist, lowering and hoisting, left and right movement for gantry travel. Selection of motions on first-come-first served basis. The controller shall be spring returned, positively indented at zero notch and release by push down interlock catch incorporated into the master controller.

(2) Trolley motion control

One stepless joystick controller with a straight slot in fore and aft direction on a left-hand 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 laid out 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

xiii.) Lighting Control – Trolley, Floods, Walkways and Cabin

xiv.) Other control switches necessary for normal operation and options selected.

Left Hand Console

i.) Emergency Stop

ii.) Spreader Flipper Controls – Raise/Lower & Enable/Disable

iii.) Twin Twenty Memories and Store Positions

iv.) Centre Twist-lock Controls – Up/Down, Extend/Retract & Zero/1600

v.) Spreader Pump On/Off

vi.) Trolley Park

vii.) Bypass Switches – Slack Rope, Twist-lock, Landing, Twin Twenty, High Wind

viii.) Other control switches necessary for normal operation and options selected.

(4) Emergency stop push buttons and Drive Lock-Out Switches on the console

Emergency stop push buttons shall be positioned so they can be pressed with either hand in an emergency, one on each console shall be provided. The button shall be a mushroom type with raised guard to prevent accidental tripping.

A drive Lock-out switch with facility to padlock in the open position shall be provided on one console and may be incorporated into the E. Stop Pushbutton.

(5) Indicating lamps on the consoles.

i) Control power source 'On' indicator.

ii) Main motion power source 'On' indicator.

iii) Spreader position indicator (20' or 40' or 45').

iv) Spreader 'Zero Trim - Zero List - Zero Skew' position indicator.

v) Stowage pin 'Clear' indicator.

vi) Wheel brake 'Released' indicator.

vii) Boom position 'Lowered' indicator.

viii) Other indicating lamps as necessary to indicate operable condition with the lamp 'On'.

ix) Overload indicator.

Twin-lift Indicating Lamps

x) Centre twist lock housing at 0mm gap indicator.

xi) Centre twist lock housing at 1600mm gap indicator.

xii) Centre twist lock housing ‘retracted’ indicator.

xiii) Centre twist lock housing ‘extended’ indicator.

xiv) Twin 20’ containers detected indicator.

(6) Interlock override push buttons

For adjustment and maintenance purposes, interlock override push buttons with cover of approved type shall be installed on the console or near the console apart from normal operational control switch group.

Layout and interlock override type and function shall be approved by the Purchaser.

(7) Labels shall be provided for each push button and indicator in local language. The labels shall be approved by the Purchaser.

5.4.6 Motion Control Switches in Boom Control Station

(1) The controls shall be located within a cubicle as outlined in 4.6.2 (1) (Boom / Gantry Control Station). The following controls shall be provided as a minimum:

i.) Emergency Stop Push Button

ii.) Control On Push Button

iii.) Control Off Push Button

iv.) Fault Reset Push Button

v.) Boom Mode Auto/Manual

vi.) Boom Position – Maintenance, Stowed, Down, Stop

vii.) Trolley Park Position Switch

viii.) Latch Up/Down Switch

ix.) Latch Floodlights On/Off switch

x.) Lamp Test Switch

The following indicators shall be provided as a minimum:

i.) Control On

ii.) Emergency Brake Released

iii.) Boom Slack Rope

iv.) Boom Lowered

v.) Boom Latched

vi.) Boom Latch Up

vii.) Lamp Test

(2) The Control On indication shall inhibit control of any crane function from elsewhere on the crane, except Emergency Stop.

(3) The control station box and all the control switches shall be weatherproof. Automatic acceleration, slowdown and final stop shall be provided for each motion.

(4) An emergency stop push button and indicating lamp shall be installed in the station box in addition to the control push button switches. These indication lamps shall indicate status of boom and boom latch to ensure safe operation.

(5) A hand free intercom telephone unit which allows simultaneous communication with the operator's cab, machinery house and ground level shall be fitted in the control station box.

(6) Labels shall be provided for each switch and indicator in local language.

5.4.7 Motion Control Switches in Ground Level Station

From this station, the following functions shall be controlled.

(1) Remote control switches of 15kV power source for auxiliary systems.

(2) Switch on and off the control power.

(3) Gantry travel each direction at inching speed of 5 m/min maximum.

(4) Wheel brake 'Release' and 'Clamp' operation (Anemometer interlock shall be overridden).

(5) Anchor limit switch overriding for fine adjustment of anchoring position.

(6) Hoist Slow Speed – both directions.

(7) Trolley Slow Speed – both directions

(8) Spreader Pump On & Off

(9) Spreader Extend

(10) Spreader Retract

(11) Twist-lock Lock

(12) Twist-lock Unlock

(13) Flippers Down & Up

(14) All labels for switches and indicators shall be in local language.

5.5 Operational Safety Interlocks

5.5.1 Main Motions Interlocks

The Contractor shall provide hardware/software status and an operational verification on all motion protection devices, such as, but not limited to:- limit switches, proximity switches, cam switches, speed sensors, encoders, brakes, couplings, solenoid coils and solenoid valves.

The Contractor shall display the safety Interlock verification status on the CCMS. Failure of any safety interlock shall inhibit all motions.

In addition to all the necessary protection of structural, mechanical and electrical system components, the following interlocks are required.

(1) Main hoist operation

i) Main hoist (hoisting or lowering) motion to stop:

a. At upper and lower hoist limits

b. With brake malfunction, or not activated or not in correct position.

c. With over-speed.

d. With motor over-heat.

e. Lowering within a certain distance of the landside and waterside sill-beams.

f. Hoisting with an incomplete 'lock' position of twist-lock after the spreader is landed on a load fitted with corner fittings.

g. Hoisting with an incomplete 'unlock' position of twist-lock.

h. When the actual position of any of the twist locks is different from the twist lock switch command.

i. With loss of gearbox lube oil pressure if forced lubrication is utilized. (If Forced Lubrication is not installed for any gearbox this clause may be ignored)

j. When the boom is in motion.

k. With overload of cargo (stop hoisting motion, allow only lowering motion after hoist motion is cut off).

l. With the activation of E-stop.

m. With position check fault.

n. With the spreader interlock incorrect spreader size, unlock & lock signal interlock, twist-lock selector interlock.

o. With the master controller interlock or check fault.

p. PLC / bus transmission error or fault.

q. With Gantry master or in motion.

r. With the wind speed interlock of level 3 or > 24m/s.

s. Drive unit protection on Over-Voltage (OV), Over-Load (OL), Under-Voltage (UV) and Over-Current (OC).

t. Motor side protection on Over-speed (OS), OC, and OV.

u. Speed deviation / control check fault.

ii) Main Hoist (hoisting or lowering) motion to slow down, or in slow speed:

a. Hoisting at near the upper hoist limit, with a safety margin for full deceleration distance under any load condition before hitting the emergency stop limit.

b. Lowering at near the lower hoist limit, when the head block is at waterside of waterside sill-beam.

c. Lowering at the spreader height above quay level is about 4m - 6m, when the head block is at landside of waterside sill-beam. (The height to be adjustable)

d. Hoisting until sag of the wire rope is taken up.

e. With the hoist wire ropes slack.

f. When received the landing signal.

g. Two seconds of hoisting after the landing signal has been switched off.

h. When manual override button is engaged.

iii) Main hoist hoisting and lowering without load shall be allowed while the boom is in raised position. Spreader functions shall also be operable for maintenance work.

(2) Trolley operation

(i) Trolley motion to stop:

a. At travel end limits at max. Out-reach or at max. Back-reach.

b. Where the spreader interferes with sill-beams, with 0.5-1-meter margin. The margin shall be adjustable.

c. Forwards motion at near the waterside end of the girder if the boom is not in fully lowered position with sufficient slack in Boom Hoist wire ropes.

d. With brake malfunction, not activated or not in correct position.

e. With motor overheat.

f. When the boom is in motion.

g. When any one or all of the high wind stowage pins of the trolley is engaged.

h. Entrance door protection/interlock.

i. PLC / bus transmission error or fault.

j. With the E-stop activated.

k. Drive unit protection on UV, OL, and OC.

l. Motor side protection on OS, OC, and OV.

m. With the master controller interlock or check fault.

n. With position check fault.

o. With the wind speed interlock of level 3 or > 24m/s.

p. Speed deviation / control check fault.

q. No boom horizontal signal. (trolley motion should still be available between legs and in back-reach)

r. Low pressure of rope tensioner (if any).

s. Boom master or in motion.

(ii) Trolley motion to slow down, or in slow speed:

a. Near the travel limits forwards and backwards with a safety margin for full deceleration distance before hitting the end limit, when the boom is in lowered position.

b. For trolley motion while the boom is in raised position (between the normal parking position and cab cleaning platform position only).

c. With activation of any override or bypass function.

d. Move to trolley selection

(3) Boom hoist operation

(i) Boom (hoist or lowering) motion to stop:

a. When the trolley is in motion or positioned on the boom.

b. With over-speed.

c. With wire rope slack during lowering motion at a position other than the boom in fully lowered position. (Stop lowering, allow only hoisting motion after stop).

d. Hoisting at upper limit.

e. Lowering at lower limit at boom horizontal position (with ample slack in wire ropes).

f. Lowering at boom latched position.

g. With brake malfunction, not activated or not in correct position.

h. With motor over-heat.

i. With the E-stop activated.

j. Drive unit protection on UV, OL, and OC.

k. Motor side protection on OS, OC, and OV.

l. PLC / bus transmission error or fault.

m. Hoist, gantry and trolley master on or in motion.

n. With the interlock of rope tensioner pressure.

o. Speed deviation / control check fault.

p. Interlock of boom latch and hook signal.

q. Boom Drive Lock-Out switch located near to the access gate.

r. With the activation of the boom latch but the engaged signal was missed or failed.

s. When one boom hoist rope fails and the "boom hoist rope broken limit switch" is activated.

(ii) Boom (hoist or lowering) motion to slow down, or in slow speed:

a. Hoisting at near the upper limit before hitting the boom latch or start hoisting from horizontal.

b. Lowering at near the boom-lowering limit (boom near horizontal).

c. Lowering to final latching position.

d. Lowering from the upper limit position until boom latches are cleared completely.

e. When manual override button is engaged.

(4) Spreader Functional Interlocks.

i) Twist-lock function

a) Interlock 'permit' on the zero notch of all master controllers.

b) Interlock 'permit' on landing delay 'on' signal.

c) Load cell interlock for unlock function.

d) Signal interlock on unlock and lock sensors.

e) Interlock on twist-lock selector and twist-lock signal.

f) Interlock on holding signal.

ii) The Spreader twist lock movement shall be mechanically and electrically interlocked with the spreader landing detection so that 'lock' movement is prohibited unless all the twist locks are confirmed as inserted into the container corner fittings. The landing signal shall allow for a one (1) second time lag to indicate the completion of landing to the operator and to activate the interlock

iii) The 'premature unlocking' movement with a suspended load shall be prohibited by means of an electrical interlock. There shall be no physical movement of the twist locks on the spreader even though the twist-lock switch may be turned to 'Unlock' position. Audible and visual alarms detectable at ground level and at the inside of the operator's cab shall be activated by this premature movement of switches to unlock. Any such premature movement of switches shall deactivate all crane motions. Both audible and visual alarms shall cease when the twist lock switch is returned to its original position. Alarm tone to be approved by the purchaser.

iv) Telescopic function

a. Interlock on the landing or lock signal.

b. Spreader size selector interlock

v) The twist locks and flippers shall remain in their last position after power interruption i.e. when power is resumed.

vi) Spreader oil pump function.

a. Head-block connect interlock.

(5) Gantry travel operation

i) Gantry motion to stop:

a. When the rail brake is engaged.

b. When the stowage pin is engaged to the quay.

c. When the cable reel limit switch for 'Over Paid-out' is activated.

d. With brake malfunction, not activated or not in correct position.

e. With motor overheat.

f. While the main hoist brake is energized.

g. With boom position other than 'fully' lowered' 'stowed' or 'latched' position.

h. When the cable reel limit switch for 'slack cable' is activated.

i. End stopper interlock.

j. PLC / bus transmission error or fault.

k. Drive unit protection on UV, OL, and OC.

l. Motor side protection on OS, OC, and OV.

m. PLC / bus transmission error or fault.

n. With the activate of E-stop

o. With the master controller interlock or check fault.

p. Speed deviation / control check fault.

q. With the wind speed interlock of level 3 or > 24m/s

r. Interlock on gantry collision

s. Boom master or in motion.

t. Over-Tension of trailing cable.

u. Cable reel motor fault.

v. With Buffer switch activated

ii) Gantry motion to slow down, or in slow speed:

a. To half speed when the gantry motion is controlled by the control box at the ground level or the Boom/Gantry control station, or close to or inside the interfered (common) zone.

b. When the Crane is approaching its traveling limit.

c. When the Crane is approaching the end stopper.

d. When manual override is engaged.

(6) Wind Speed-Wheel Brake Interlock

i) Wheel brakes to be normally in engaged position except when the gantry motion control lever is in 'Right' or 'Left' position and gantry motors are energized. Returning the lever to 'Zero notch' shall re-apply the rail brake after the gantry brakes are applied.

ii) Operating time for releasing and engaging the brake shall be within 2 seconds. In normal operational condition at below the wind speed setting as described in 6.5.2(1).i) (Wind Speed Warning), the brake shall be engaged with a 10 second time delay after each time the Gantry motion control lever is returned to zero notch position (to achieve better inching response).

iii) This time delay function for engaging the brake shall be eliminated when the wind speed exceeds the lowest wind speed setting as mentioned in 6.5.2(2) (Wind Speed Warning).

iv) The brake must engage immediately when the Gantry motion control circuit is tripped regardless of the Gantry motion control lever position.

5.5.2 Elevator RFID Access/control (Not Required)

Access control system/reader shall be added inside elevator cabin by way of RFID tag or equivalent system. Without required coded tag no elevator operation shall be available; all requests for elevator operations shall be logged with date and time stamp and ID tag number. Access control/operation system and parameters of operation shall be approved by the purchaser

5.5.3 Cab Access Interlock

Contractor to submit proposal for safe access and egress for the operator's cabin by way of a request and permit locking gate system (industrial) authorized by the crane operator when the trolley and fixed platform

are aligned. Control shall be off, during transfer (when one gate is open control shall not be available) once safe passage has been achieved gates are closed and locked and control system receives all clear signal (pushbutton), allowing operator to enable crane control.

5.5.4 Trolley Access Interlock (Mono-box Boom)

Contractor to submit proposal for safe access and egress for the trolley by way of a request and permit locking gate system (industrial) authorized by the crane operator when the trolley and gate (self-closing with latch) are aligned. Control shall be off, during transfer (when one gate is open control shall not be available) once safe passage has been achieved gates are closed and locked and control system receives all clear signal (pushbutton), allowing operator to enable crane control.

5.5.5 E room RFID Access (Not Required)

Access control system shall be added to e-room access doors by way of RFID tag or equivalent system. Without required coded tag no access shall be granted, all requests for access shall be logged with date and time stamp and ID tag number. Access control system and parameters of operation shall be approved by the purchaser.

**CLARIFICATION: RFID locations, access and functionality shall be reviewed and approved during design review*

5.6 Communications

5.6.1 Intercom System

(1) A voice communication system which allows simultaneous or selective communication among the machinery house, control panel room, ground level and boom control stations, personnel lift and operator's cab shall be installed.

2 - Handsets in machinery house (1 inside the panel room)

1 - Hand-set in operator's cab

1 - Hand-set in boom control station

2 - Handsets at ground level, one on land-side beside the gantry control station and one in the checker's cab.

1 - Boom Tip

1 - Top of A-Frame

1 - On back-reach near to TLS hydraulic cylinders

5.6.2 Fibre Optic Cable

(1) The fibre optic communication module shall be rack mounted design and the connecting device (between Crane's optics cable network to the optics cable network outside the Crane) shall support the use of multimode fibre optic cable (62.5-micron core / 125-micron cladding). All optical fibre waveguide shall be terminated with ST-type connectors unless otherwise specified. The plug and socket assembly for the optics fibre cable shall be of IP55 protection.

(2) The fibre optic communication module shall support a fibre communication distance of 10km in a continuous 62.5/125m fibre optic cable.

(3) The fibre optic cable allowable transmission loss in the cable shall be less than the following:

Multi-mode cable: 5.0 dB/km at 850 nm wavelength

(4) Tests to measure and confirm the fibre optic waveguide requirements above shall be conducted during the acceptance, testing and commissioning stage. The Contractor shall provide the test procedures, all instruments, equipment and qualified personnel for carrying out the tests.

(5) The power supply for the fibre optic communication modules shall be back plated supply with LED indications for the active status of the output or receiving channels.

(6) The insulation and sheath material shall be halogen free and low smoke tested in accordance with IEC 754-2 and IEC 1034-3.

(7) The Contractor shall submit the proposed selection of cables and their test certificates to the Purchaser for review prior to ordering of the cables.

5.6.3 Public Address System

(1) Loud-speakers

i) Two loud-speakers pointing down shall be mounted on the trolley or near the operator's cab. An amplifier and a microphone shall be installed in the operator's cab. The volume adjuster shall be installed in a lockable box to prevent unauthorized volume adjustment.

ii) Two talk-back speakers shall be fitted under waterside and landside sill beams, facing inside to allow communication between operator and ground staff.

5.6.4 Operator Aid Cameras (Required)

(1) The crane shall be equipped with HD operator aid cameras on the back-reach pointing towards WS and on the trolley (PTZ auto zoom ± according to spreader height) pointing down enabling clear view of spreader. The purpose of the system is to provide additional height and depth perception and ultimately improved vision for the operator enabling detection of personnel or obstacles which may otherwise be positioned out of their field of view.

(2) 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.

(3) Two flat screen panels shall be provided, one (1) positioned in the operator's cabin and one (1) positioned in the PLC room. The screen shall be shaded as necessary to ensure clear view in all cabin/room ambient lighting levels. Panel brightness shall be adjustable for day and night time operation and the sensitivity of the cameras shall be suitable for operating efficiently during night time operation to provide good definition down to 10lux lighting level.

(4) Monitor display to be auto-switching (with manual selection also available) depending on input, for example when boom operation selected display to switch to boom latch and forestay feed.

(5) The camera signals shall be recorded on a common data storage device. The data storage shall be sized to store at least 120 hours of the camera signals.

(6) Cameras shall be positioned in a convenient location so that maintenance can be performed without additional access equipment. The cameras shall be adjustable for position, enclosed within a weatherproof, security housing and having an automatic thermostatically controlled condensation heater.

(7) The operator aid camera system layout/functionality and manufacture shall be approved by the Purchaser.

5.7 Crane Condition Monitoring System (CCMS)

5.7.1 General

The Contractor shall supply, deliver, install and commission a Crane Condition Monitoring System (hereinafter referred to as the CCMS). The design of the CCMS shall facilitate future expansion in terms of capacity and functional features. The CCMS hardware and software shall be modular in design and construction to facilitate future expansion. There shall not be major re-configuration of the hardware and software modification and development. System expansion shall not be limited by the capacity of individual On-Board CCMS, RCCMS and PLCs.

The Crane Condition Monitoring System shall be installed in the following locations:

(1) In the electrical room inside the machinery house of each Crane (hereinafter referred to as the On-Board Crane Condition Monitoring System, On-Board CCMS).

(2) In the checkers cabin (CMS client touch-panel)

(3) In the maintenance base at the Engineering office building (hereinafter referred to as the Remote Crane Condition Monitoring System, RCCMS).

5.7.2 CCMS Description

The On-Board CCMS and RCCMS shall incorporate alarm/fault monitoring and graphics display, the condition status monitoring with graphics display, the fault diagnostic functions, Crane operation and shall allow access to the programming logic and software. These functions must be able to be downloaded as a softcopy and printed as a hardcopy. The CCMS shall consist of but not be limited to the following elements:

(1) One (1) set of On-Board CCMS on each crane. This shall consist of a personal computer with monitor, keyboards and necessary associated peripherals and software. All hardware and software required for interface to the communication network and peripheral devices shall be included and reviewed by the Purchaser.

(2) Provision shall be provided at the checker's cab to allow engineering personnel to access the On-board CCMS via a notebook computer supplied by the contractor.

(3) One (1) set of RCCMS. This shall consist of a personal computer together with monitor, keyboard and necessary associated peripherals and software. All hardware and software required for interface to the communication network and peripheral devices shall be included.

(4) A colour laser jet printer to be installed in the Engineering office and its associated peripherals for printing necessary information from the RCCMS.

(5) The Contractor shall provide a cost-free technical training for the engineering staff of the purchaser. The training program shall be submitted in the tender proposal. This training shall be conducted in local language by a competent person representing the Contractor.

(6) The Contractor shall provide 4 sets, cost free, reproducible maintenance manual, operator manual, recommended spare part list and spare part manual to the Purchaser in English and Local Language.

(7) The CCMS shall have proper documentation of circuit diagrams, hardware and software and associated peripheral specifications and network interfaces.

(8) The Contractor shall submit within two (2) months after the date of award of contract, the CCMS system architecture for review by the Purchaser.

5.7.3 Operating Environment and Requirements

The CCMS shall be designed and operated in the following environmental condition:

(1) Environment

The CCMS shall be designed and operated in hot and humid atmospheres where installations are subject to prevailing heavy condensation and light fungi. Equipment shall also be treated to resist attacks and entry of insects. The components shall be suitable for a tropical environment.

(2) Degree of Protection

A minimum IP class (according to IEC 144 and 529) of IP20 is required. Equipment installed in open atmospheres shall have an IP class of minimum of IP55. Finger protection against touching the electrical potential terminals shall also be required.

(3) Ambient Temperature

The system shall be designed and operated in an ambient temperature between 15 ºC to 40 ºC.

(4) Relative humidity

The operating and storage humidity shall have a range from 8% to 100% (non- condensing).

(5) Operating Voltage

The system shall be designed and operated under normal supply voltage defined for receptacle outlets and with a supply tolerance of +/-10% and a frequency tolerance of +/-5%.

(6) Duty Cycle

The system shall be designed to operate 24 hours a day for the whole year round with a Mean Time Between Failure (MTBF) at component level of not less than 30,000 hours and a Mean Time To Repair (MTTR) of not more than 1 hour per component replacement. The operational availability shall be not less than 99.997% per every continuous duration or period of any 3 months. The operational availability is defined as follows:

Operational Availability, Ao% = ((Toc -Tem) / Toc) x 100%

Toc (hrs): Total occupied time (system is turned 'ON')

Tem (hrs): Total time for emergency maintenance

5.7.4 On-Board Crane Condition Monitoring System (On-Board CCMS)

(1) General Specification

The On-Board CCMS is located in the electrical room of the Crane. The On-Board CCMS is designed to provide a diagnostic and condition / status real time monitoring of the crane control system. The On-Board CCMS shall consist of the necessary sensors and transducers to be installed on each crane and in conjunction with the PLCs to provide continuous monitoring, diagnostics, data collection on the Crane's operating systems. The system shall also provide crane operational data that is used to determine crane performance, maintenance scheduling, spare part details and daily/shift reports.

5.7.5 On-Board CCMS Software Requirements

(1) The On-Board CCMS and RCCMS operating system shall be real time, multi-tasking, multi-user operating system. The operating system shall allow the On-Board CCMS and other programs to run simultaneously and allow the user to access any software without affecting the real time condition monitoring of the crane control system and the communication link between the On-Board CCMS and the RCCMS.

(2) The Contractor shall develop a user interface software to meet the following requirements:

i) The software shall be able to run on Windows operating platform. The operating platform and user interface software shall be approved by the Purchaser. The Contractor shall supply a complete back-up system that shall include the operating system and application software.

The back-up system shall be supplied as follows:

a) Spare SSD containing operating system and application software, with all parameters and settings set as required for the crane.

b) Stored in CD-ROM/DVD-ROM/SSD

The Contractor shall confirm that in the event of a system failure, reloading of the system shall be completed in an acceptable time frame, approved by the Purchaser. The operating system shall be an English version with loading instructions in English.

ii) The software shall be commercially available, and it shall serve as an interface to display all the captured data from the On-Board CCMS on a HMI display. The software shall be able to generate but not restricted to historical trend charts/files, trending, alarm management and fault logging, crane maintenance and performance report, planned maintenance information. The Purchaser will release the reporting format and details to the Contractor and the Contractor shall comply with the same as part of the Works. The capacity of the memory shall be able to store not less than 500 fault messages together with the related fault records and at least 3 years of historical productivity data / information. The software shall be able to download or export data files to other commercially available software such as Microsoft Access, Microsoft Excel, Lotus etc. The export data files shall include but not be limited to"txt", "csr", "out" format.

iii) The proposed structure of the database system for storing the CCMS data and information has to be discussed and approved by the Purchaser.

iv) The software shall allow engineers to access (read and write) the PLC ladder diagrams, Boolean logic and other software codes. Forcing-on and forcing-off of switches, contacts and relays on

the PLC ladder diagram shall be available on the On-Board CCMS. Key switch and password shall be available to authorized personnel to carry out any modifications as described above. There shall be three (3) levels of security for accessing to different levels of CCMS software. The exact details will be released to the Contractor by the Purchaser and the Contractor shall comply with the same as part of the Works.

v) The On-Board CCMS shall be able to copy or upload PLC software program to each PLC within 30 minutes. The On-Board CCMS shall be able to download all data files which shall include all real time information of the CCMS and time response graphs. This information shall be able to store in a diskette for printing using Microsoft Excel / Access. Time response graphs displaying different signals simultaneously shall be incorporated in the On-Board CCMS.

vi) The software in the On-Board CCMS shall be made accessible for the Purchaser to include additional or new monitoring points and to modify software for presentation, reports for future enhancements.

vii) Original Licensed software shall be used; these include the operating system application software. One original licensed copy of the software package shall be provided for every computer in the Agreement. All software instructions, including operating systems shall be in English language. All software instructions, including the operating system shall be in English language.

5.7.6 On-Board CCMS Hardware Requirements

(1) The On-Board CCMS shall be mounted in an environmentally controlled, industrial type cabinet that can withstand vibration.

(2) The On-Board CCMS shall consist of but not limited to the following items:

i) Computer

The CCMS computer shall consist of the following minimum specification of hardware:

(1) Processor - dual core 3.2 GHz+ (i5 or i7)
(2) RAM - 16 GB DDR4
(3) Minimum 1TB SSD SATA
(4) Graphics Card - any with DisplayPort/HDMI or DVI support
(5) Monitor - 23" widescreen LCD with DisplayPort/HDMI or DVI support
(6) Gigabit Ethernet, 802.11n Wi-Fi
(7) Minimum 4 USB ports
(8) DVD+/-RW Drive
(9) Portable storage 500GB SSD

It is the intension of the Purchaser to standardize the make and model of the On-Board CCMS computer.

5.7.7 Condition Monitoring

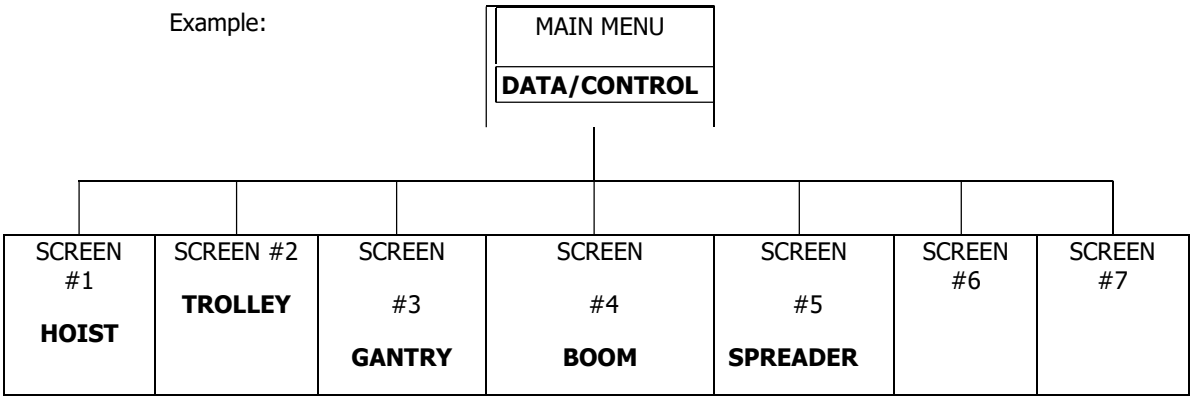
(1) The status and condition for the electrical systems, sub-systems and all the essential components, Electrical, Mechanical and Hydraulic which are critical to the proper functioning of the crane shall be monitored, during all modes of operation and status of power supplies.

The Contractor shall provide a UPS, suitably rated for 30 minutes, to afford access to all information in the event of power failure, either relating to the main generator or shore power.

(2) The CCMS shall present all information, status, graphics and data in easy-to-read window display formats. The Purchasers preferred format for real time data, being graphical displays rather than numerical presentation of the relevant data.

(3) The main screen shall lead the user to separate screens, divided into the following major application screens.

Example:



(4) Principle functions and components, associated with each application shall be displayed, in real time mode, on individual screens, such as, but not limited to:

Motor Feedback Signals, i.e. Speed, Current, Voltage, Frequency, Torque Revolutions, Directions and Temperature

Reference signals of Controller, Ramp Generator and Acceleration/ Deceleration Ramps, Encoders, Pulse Generators.

Performance, Operation, Positioning, Current, Voltage and Speeds of Converters, Inverters, Brake Chopper Units, Brakes, Contactors, Relays and other devices, applicable to the application.

Hardware status of Limit Switches, Interlocks, Cam Switches, Sensors, Encoders, Fuses and other Protection devices shall be monitored and displayed in an approved format.

Data relating to Loads, Component Operational Time and Operational hours of major devices, i.e. Motors, Converters, Inverters, Brakes shall be displayed in an approved format.

Provision shall be made for Status Warning, Alarm Trips and Faults to be displayed at all times on all screens.

The system shall provide sub-windows, where operational performance of sub-assemblies can be monitored, such as, but not limited to:

Shore Supply, Hydraulic Motors and Pumps, Elevator, Cable reel and Spreader Functions.

(5) The Contractor shall provide easy to access data of Systems, Parameter Settings of PLC and/or Drives and Components in easy-to-read formats. These systems and components shall include, but not limited to the following:

Performance of the Drives (Inverters and Converters) which includes the AC Supply, AC Motor Control, DC Motor Control (if any), Operator Control, Motion Interlocks, Safety Interlocks, Sequence Interlocks.

The temperature for all AC Motors, for the Main Hoist, Boom Hoist, Gantry Travel, Trolley Travel.

The operating voltages and currents for all the Converters, Invertors, Braking Chopper Units, Brakes and Motors

The status of the high voltage switches, low voltage switches, protection relays.

A real time update of all Positioning / Distance sensors.

Threshold values for warning and shutdown shall be incorporated in the CCMS. Adjustment of the threshold values shall be made accessible to the Purchaser.

Any abnormality in the Crane’s system and components shall be prompted and immediately displayed on the screen of the On-Board CCMS.

A real time update of all speeds, motions and operations.

All Ramps

Actual Loads

(6) The following, as a minimum, data associated with the Hoist operation shall be displayed:

i.) Controller Position of Forward, Reverse, Hoist, Lower, Left, Right and Zero, shall be displayed. Actual proportional position of Controller reference shall be displayed in an approved graphical format and indicates to the user actual percentage (%).

ii.) Hoist motion interlocks, Spreader interlocks, Slack Rope, Load Cell measuring.

iii.) Hoist Inverter status, interlocks, performance and protection devices.

iv.) Hoist Brake Function, Operation and Brake Proving shall be displayed

v.) Function and Operation of Limit Switches, Cam Switches, Encoders, Tacho-Generators and Pulse Encoders.

vi.) Hoist Speed, Slowdown, Speed Check, Stop and Positioning.

(7) The following, as a minimum, data associated with the Trolley operation shall be displayed:

i) Controller Position of Forward, Reverse, Hoist, Lower, Left, Right and Zero, shall be displayed. Actual proportional position of Controller reference shall be displayed in an approved graphical format and indicates to the user actual percentage (%).

ii) Trolley motion interlocks, Spreader interlocks,

iii) Trolley Inverter status, interlocks, performance and protection devices.

iv) Trolley Brake Function, Operation and Brake Proving shall be displayed

v) Function and Operation of Limit Switches, Cam Switches, Encoders, Tacho-Generators and Pulse Encoders.

vi) Trolley Speed, Slowdown, Speed Check, Stop and Positioning.

(8) The following, as a minimum, data associated with the Gantry operation shall be displayed:

i) Controller Position of Forward, Reverse, Hoist, Lower, Left, Right and Zero shall be displayed. Actual proportional position of Controller reference shall be displayed in an approved graphical format and indicates to the user actual percentage (%).

ii) Gantry motion interlocks, Wheel Turning interlocks,

iii) Gantry Inverter status, interlocks, performance and protection devices.

iv) Gantry Brake Function, Operation and Brake Proving shall be displayed.

v) Function and Operation of Limit Switches, Cam Switches, Encoders, Tacho-Generators and Pulse Encoders.

vi) Gantry Speed, Slowdown, Stop and Positioning.

(9) The following, as a minimum, data associated with the Boom Hoist operation shall be displayed:

i) Actual Command Switch Position.

ii) Boom Hoist motion interlocks.

iii) Boom Hoist Inverter status, interlocks, performance and protection devices.

iv) Boom Hoist Brake Function, Operation and Brake Proving shall be displayed

v) Function and Operation of Limit Switches, Cam Switches, Encoders, Tacho-Generators and Pulse Encoders.

vi) Boom Hoist Speed, Slowdown, Speed Check, Stop and Positioning.

(10) The following, as a minimum, data associated with the Spreader operation shall be displayed:

i) Controller Position of Forward, Reverse, Hoist, Lower, Left, Right and Zero shall be displayed. Actual proportional position of Controller reference shall be displayed in an approved graphical format and indicates to the user actual percentage (%).

ii) Spreader motion interlocks, Spreader Retract and Expand interlocks,

iii) Spreader Motor status, interlocks, performance and protection devices.

iv) Spreader Electrical Function, Operation and Proving shall be displayed

v) Function and Operation of Limit Switches, Cam Switches, Encoders, Tacho-Generators and Pulse Encoders.

vi) Spreader Stop and Positioning.

vii) Spreader Twist-locks, Lock and Unlock, including indication and By-Pass status.

viii) Function clock shall display actual operation time of Expand/Retract, Twist-lock Operation and Flipper Operation.

(11) The following, as a minimum, data associated with the General Crane Control System shall be displayed.

i) Emergency Stop operation where the status of individual stations shall be displayed.

ii) Main Generated Power Supply, Auxiliary Power Supply, Shore Power Supply and UPS function, status and performance.

iii) Function Operation and Status of Circuit Breakers, Fuses, Contactors, Relays and Protection devices, shall be displayed.

iv) Operator Mode Selection, Function and Status

5.7.8 Fault Diagnosis

(1) The faults and status data including historical data shall be stored in the On-Board CCMS database. All the data in the database shall be translated and stored in a suitable text file for a standard editor. All data shall be easily downloaded to removable storage (SSD). A zip function shall be available in the software for file compression.

(2) The objective of the fault diagnosis is to assist Purchaser's engineers to remedy the fault or confirm the exact nature of a fault within a very short time. All faults shall be coded with a suitable numerical code and the first fault causing an alarm, trip or crane stoppage shall be highlighted as first fault. Provision shall be provided that as a minimum the system shall display twenty (20) faults that may occur at any one time.

This first fault shall be displayed clearly to assist the Purchasers engineers on the CCMS and remote display units. Faults interrupting crane operation shall be highlighted, either by flashing or appearing in a "Pop-up" window, regardless of screen selected and fault indication shall be only when crane motion or operation is selected.

(3) The fault diagnosis shall be able to narrow down the faults to the exact components; safety interlocks failures, drive faults, PLC controller failures.

There shall be details and information on faulty component locations and possible remedy actions to be taken. There shall be intermediate fault tracing and measurements checkpoints and these functions shall be made available to Purchaser's qualified personnel to input new parameters for troubleshooting purposes. The resolution and duration of these measurements are 10ms to 100ms and 5s to 50s respectively.

(4) Drawings on electrical circuit, PCB layout, schematic drawing, software ladder and software device listing of crane control, Drives and PLC shall be made available in the fault diagnostic mode. Access to the information shall be easily obtainable on any CCMS screen.

The CCMS shall store all faults in appropriate historic files in daily, weekly, monthly and yearly log

folders, easily accessible and selection of data shall be by selecting a daily, weekly, monthly or yearly option.

5.7.9 Remote Crane Condition Monitoring System (RCCMS)

(1) General Specification

The RCCMS shall allow engineering personnel to perform diagnostic, condition monitoring of the CCMS in the engineering office remote to the Cranes and web-based facility for offsite monitoring. The RCCMS shall be able to perform all the functions of the On-Board CCMS as stated in clause 5.7.4 (On-Board CCMS) and the following additional requirements:

(i) All the information and functions on the Cranes' On-Board CCMS specified in this Specification shall be available for the RCCMS.

(ii) All the alarm and fault messages on the Crane which requires the attention of engineering personnel shall interrupt the RCCMS. The response time for the alarm and fault messages shall be less than 5 seconds. After the interrupt has been acknowledged, the present task shall be able to continue. The fault messages shall include but not limited to the following:

(a) Crane ID

(b) Location

(c) Fault code / messages

(d) Part code

(e) Date/time reported

(iii) There shall be a server for the CCMS by each drive supplier. The RCCMS computers shall be able to access to the On-Board CCMS of any Crane via the respective server and CCMS software.

5.7.10 RCCMS Software Requirements

(1) The RCCMS software shall be able to perform all the On-Board CCMS functions as defined in clause 5-7.5.

5.7.11 RCCMS Hardware Requirements

(1) The RCCMS shall consist of but not limited to the following items:

(i) Computer

The RCCMS computer shall consist of the following hardware:

(1) Processor - dual core 3.2 GHz+ (i5 or i7)
(2) RAM - 16 GB DDR4
(3) Minimum 1TB SSD SATA
(4) Graphics Card - any with DisplayPort/HDMI or DVI support
(5) Monitor - 23" widescreen LCD with DisplayPort/HDMI or DVI support
(6) Gigabit Ethernet, 802.11n Wi-Fi
(7) Minimum 4 USB ports
(8) DVD+/-RW Drive
(9) Portable storage 500GB SSD

It is the intention of the Purchaser to standardize the make and model of the RCCMS computer.

(ii) One unit of UPS with a minimum of 60 minutes

(iii) One unit of colour laser jet printer.

(iv) One unit of server. The function of the server is to allow RCCMS to access to all the information on On-Board CCMS on the cranes specified in this tender. It shall also enable

the On-Board CCMS to send real time information, status and alarms by means of interrupts to the RCCMS.

(v) One unit of standby server. The function of the standby server is to automatically resume the server's function when the server is not functioning.

**CLARIFICATION: For this project cold standby functionality shall be acceptable.*

5.7.12 CCMS Reporting Format

The CCMS reporting format will be released to the Contractor.

5.7.13 CCMS Data Communication

(1) The RCCMS shall allow data to be accessed remotely (outside the terminal). The Contractor shall submit the communication protocol for sending data to these computers and for communication between On-Board CCMS and RCCMS. The communication protocol shall be submitted for the Purchaser for approval.

(2) The data communication between the On-Board CCMS, Server(s) and RCCMS shall be through an optical fibre link data communication media.

(3) The Contractor shall provide and install the following hardware and cables on the Crane for communication among the above servers and computers.

a) Terminating boxes with ST connectors for fibre-optic cables inside the Operator's Cabin and Checker's Cabin.

b) Two sets of six cores multi-mode fibre-optic cable from the fibre-optic termination box in the Electrical House to the terminating boxes inside the Operator's and Checker's Cabins. Size of each core of the fibre-optic cables shall be 62.5/125 microns.

**CLARIFICATION: Landside switch/media converter from FiO to Ethernet shall be provided by the Contractor*

5.8 Trailer Positioning System (Required)

The crane shall be fitted with an indication system to signal to terminal tractor operators that the trailer is correctly parked under the crane during normal operation. The system shall be capable of detecting trailers in following conditions:

(1) Empty trailer.

(2) Trailer loaded with one (1) 20-foot container.

(3) Trailer loaded with two (2) 20-foot containers.

(4) Trailer loaded with one (1) 40-foot container.

(5) Trailer trains (multiple trailer system)

The system shall be based upon Sick technology described in their website: Trailer Positioning System

" The system can detect the trucks entered into the lanes between WS and LS rails in both directions."

5.9 OCR System (Required)

The Crane is equipped with an integrated OCR-system that automatically reads and records the container ISO code numbers as it is handled by the crane. The system links with the Terminal Operating System for triggering and data processing purposes. The OCR system includes all hardware and software components for direct installation on container-handling equipment. The final location of the OCR system will be determined according to the Purchaser's requirements.

The system shall include but not be limited to the following features:

(1) Handle all standard size containers (20', 20'/20', 40', 45')

(2) Read ISO 6346 formats including check digit verifications

(3) Container Seal present (Not required for this project)

(4) Real-time tracking of containers handled by the crane

(5) Read container numbers from both sides

(6) Operation uninterrupted by traffic into loading area

(7) Simple configuration

(8) Minimal equipment

(9) Low maintenance

(10) Superior reading accuracy

(11) Seamless performance guarantee

The locations and positions of OCR cameras shall be according the supplier requirements, but it's envisioned that cameras shall be located at the waterside leg position. The locations shall be fitted with supports, maintenance platforms and ladder for easy access.

5.10 **Vessel profiling & Container Soft-Landing (SPS)** (Required)

The crane shall be equipped with a laser scanner mounted on the main trolley which continuously scans the vessel to update the crane control system of the actual profile of the stacked containers on the ship.

By measuring the stack height on the ship and logging the load position at every twist-lock operation above the ship, the SPS creates a profile of the ship. The ship profile is used in three ways:

(1) As a main hoist slowdown height for ship cells below and above the deck.
(2) As a smart slowdown in trolley drive for deck cargo, higher than the spreader load.
(3) As a safe path to be used by semi-automated hoist and trolley movements (Required)

6 COMMON ITEMS

6.1 Walkways, Stairs, Ladders and Platforms

6.1.1 Applicable Code/ Standard

(1) Walkways, stairways and platforms shall be designed to avoid tripping, skidding, ducking or crawling. Clear headroom of 2.1 meters shall be maintained throughout the walkways, stairways and platforms. Special non-skidding treatment shall be applied for flat structural surface if used as walkways.

(2) The design of walkways, stairs and ladders shall comply with the requirements of OSHA.

6.1.2 Stairway Requirements

(1) Landings shall be provided for ladders or stairs at intervals of between 4 meters and 6 meters.

(2) Stairway treads shall be open grid metal construction, hot dip galvanized. Stairway treads shall be bolted and not welded to the stairway structure.

6.1.3 Ladder Requirements.

(1) Special ladders shall be installed inside all four crane legs for their entire length for inspection of structure, wiring or fittings. Man-holes at the top and the bottom of the legs with hinged doors with seal shall be provided as access ways. The sealing flange of all manholes shall be at least 20mm above the surrounding steelwork to avoid water ingress when the covers are opened.

(2) Vertical or near vertical ladders of over 2-meter length shall be attached with safety hoops. The space within the hoop shall be sufficient for a man with tools to climb up or down the ladder and shall not be smaller than 650mm depth x 600mm width. Vertical straps for the hoops shall be spaced adequately to prevent a human body to fall through.

(3) Access to all ladders in main walkway areas or platforms shall be accessed via hinged self-closing gates; chains across opening are not acceptable.

6.1.4 Walkway Handrail Requirements

(1) For a level walkway the height of the top handrails shall be 1100m with an intermediate rail height of 685mm. The height shall be increased as necessary at the stairway etc., to ensure safety of passage. The handrail shall be constructed with steel tube, all welded joints finished smooth to same diameter as the tube, and continuous along walkways, platforms and stairways. Adequate safety straps or bars shall be installed between the lowest safety hoop of a vertical ladder and handrail for landing wherever there is a wide clearance which may allow a person to fall.

(2) The height of kick plate from the walkway tread level shall be 200mm. The kick plate shall be continuous along walkways and platforms and constructed of minimum 200mm wide steel strip of minimum thickness 4.0mm.

(3) Walkway handrail stanchions shall be bolted to platform structure.

6.1.5 Platforms Requirements

(1) Permanent and safe access platforms shall be provided in all areas requiring inspection and maintenance as outlined in Section 6.1.6 below.

(2) Platform walkways shall be open grid steel construction, hot dip galvanized these shall include but not be limited to the following platforms:

i) At the top end of legs at each connection point of gantry structure and boom/girder connection point.

ii) On each side of the cable carrier system at the back-reach of the Crane.

iii) Around all four sides of the machinery house.

6.1.6 Maintenance Platforms

(1) Stairs, platforms and walkways shall be provided to allow ample and safe access to all sheaves, pins, wheels, MV cable reel, power feeder system, carriers, ropes, machineries, switches and control equipment, etc., where preventive maintenance is necessary. At least 600mm clear passage around any machinery shall be provided. Application of vertical or near vertical ladders shall be limited to places where frequency of usage is less than twice a year.

(2) The Contractor shall provide permanent access ladders and platforms at all inspection locations, with structural maintenance inspection intervals of 12 years or less. Access shall meet applicable safety laws and regulations.

6.1.7 Cab Access Platforms

(1) Walkway shall be provided from the landside leg to enable the operator to enter the cabin from the side through a hinged self-closing gate. The cab access platforms shall be equipped with tubular frame construction, inward opening and self-closing (by gravity) interlocked hinged gates on trolley side and gantry structure side. Opening of the door shall prohibit the trolley motion.

6.1.8 Cab Window Cleaning Platform

(1) A cab window-cleaning platform shall be fitted near the back-reach end of the girder to permit the operator to clean the lower front, bottom and lower window safely. Interlocked self-closing gate access to the cleaning platform shall only be permitted from the operator's cab.

6.2 Illumination and Lighting

As an overriding requirement, preference will be given to those Contractors who are able to offer energy efficient lighting systems for all applications.

6.2.1 Walkways, Stairs, Ladder, Cab Access

(1) The supply voltage for lighting sources shall be as specified in 5.3.2 (Power Supply Specifications).

(2) LED lighting system shall provide adequate illumination for all ladders, platforms, walkways, machinery house and operator's cab.

**CLARIFICATION: LED lighting for walkways, stairs, ladder and cab access, shall be provided.*

6.2.2 LED Work Area Floodlights

(1) A floodlighting system shall provide adequate lighting to all work areas of the crane including penetration into the ship's cell. An average illumination of 300 lux at quay level measured within 10.0m either side of the centreline of the Crane along the entire trolley travel range shall be achieved. The maximum to minimum level of illumination shall be a minimum of 0.7 to one.

(2) To assist the berth operators when working beneath the crane, fixed LED floodlights shall be mounted to the topside of the portal beams of the Crane to achieve the required level of illumination. At least 4 nos. LED lamps with equivalent power of 1000 watt (crane master or equivalent) shall be fitted on top of the portal beam to provide sufficient lighting for landside face of container in each lane.

**CLARIFICATION: LED lighting for work area floodlights shall be provided.*

6.2.3 LED Floodlights on Trolley

(1) Powerful spotlights minimum four (4) of LED lamps with equivalent power of 1000 watt (Philips crane master or equivalent) each shall be mounted near the cab at or below the cab bottom level to provide excellent viewing of the ship's cell or a slot at night when the crane trolley is working over a vessel.

(2) The positioning of all floodlights shall not cause glare for the berth operators or in the Crane operators cab nor shadows which make it difficult for the operator to safely operate the crane.

**CLARIFICATION: LED floodlighting for trolley floodlights shall be provided.*

6.2.4 LED Emergency Lighting for Escape Routes

Emergency LED flashlights operated by rechargeable batteries shall be provided in the operator's cabin, electrical and machinery house. Battery chargers to maintain the batteries in continuously charged condition shall also be provided. Access stairways shall be illuminated by emergency fluorescent fittings.

* Access stairways including operator's Emergency route including route from boom station will be illuminated during power failure by 30% of the LED fittings which shall be equipped with batteries

6.2.5 Lighting Control Switches

(1) Light switches shall be consolidated in several convenient locations to permit centralized control. Three on-off control switches to control all the operational lights including walkway lights shall be located at ground level, machinery house and operator's cab to allow switching from any of these three locations.

(2) A photocell shall be installed to switch off floodlights automatically during daylight hours and an override feature shall be installed to bypass the photocell in the event it fails to the open condition.

(3) The Boom floodlights shall switch to the off condition whenever the boom leaves the horizontal position

6.2.6 Work Area and Trolley Floodlights

(1) All work area lamps and flood lights shall be securely fixed to structures, protected against vibration and fitted with safety ropes to arrest the fall of the lamp should the main fixings fail.

6.2.7 Walkway and Access Lamps

(1) Exterior lighting fixtures shall be specially designed for outdoor conditions and be braced to handrail. Externally mounted lighting fixtures shall have a minimum of IP55 class of protection.

6.2.8 LED Boom Latch Area Illumination

(1) Minimum number of two (2) LED floodlights with equivalent power of 400w each lamp.

(2) The boom latch shall be clearly illuminated from beneath for viewing from the boom control station.

(3) All the light fixtures shall have safe access for replacement of fitting or components

6.2.9 Aviation Warning Lights

Aviation warning lights shall be installed at the following locations: -

(1) At the Boom end:

Two (2) FAA approved 100-watt equivalent LED type strobe lights mounted such that the lights are vertical when the Boom is in the fully raised position.

(2) At the top of the Superstructure (or 'A' Frame):

These Warning Lights shall be energized continuously. To provide continuity when the main supply to these lights is interrupted for any reason a back-up system shall be switched in automatically, it shall be possible to replace bulbs from the normal platforms.

6.2.10 Access for Lights Maintenance

All lights must be safely accessible for maintenance.

6.3 Painting and Protective Coating

6.3.1 Paint System General*Painting of electrical motors and control panels will be according to manufacturer's standard

(1) The Contractor shall submit his proposed specification for the preparation, cleaning, painting and corrosion protection of the crane.

(2) Surfaces not required to be painted, but which are adjacent to steel work which is to be cleaned and painted, shall be protected by appropriate masking during cleaning and painting of the adjacent work.

(3) Special care shall be taken during manufacture to ensure that foreign matter is excluded from all working parts of the Crane.

(4) All parts of the Crane shall be surface treated during manufacture to ensure their protection from the effects of moisture during storage, transport and erection.

All bright surface and machined parts, including gear teeth, screws threads, etc., shall be protected by an approved rust preventive compound. Particular care shall be taken with the protection of anti-friction bearings and enclosed gears and shafts.

(5) All metal surfaces shall be thoroughly cleaned to bare metal, removing rust, loose scale, dirt, grease, oil, dust and other foreign materials in accordance with 6.3.2 and 6.3.3 hereof. Particular care shall be used at joints and all other places to which access for cleaning is difficult.

(6) Faying surfaces of structural members intended to be clamped together by bolts shall be shot blast cleaned as specified in Clause 6.3.3(3) hereof and shall be given one coat of Epoxy zinc rich-primer, 25 microns thick.

(7) Machined mating surfaces of all ferrous components (other than structural members) which are to be clamped together by bolts, in final assembly, shall be protected, as specified in 6.3.1(4) above, after fabrication and just prior to final assembly shall thoroughly cleaned and smoothly coated with a suitable protective compound approved by the Purchaser.

(8) All structural steel plates and sections which shall form sealed internal surfaces shall be blast cleaned and prime coated using "whole of plate" blasting and painting with a suitable weld-through primer. Angle or flat sections used for plate stiffening shall be similarly treated by mechanized treatment methods.

Providing damage to such prime coating during fabrication is minimal, in the opinion of the Purchaser, power brush and cleaning of such pre-primed surfaces with a suitable approved solvent may be accepted in lieu of a second blast cleaning.

(9) For the purposes of this Specification 6.3, the term "External Surface" shall include the following areas:

(i) The exterior surfaces of all structural members.

(ii) The whole of the surface of any object such as an equalizing beam or bogie.

(iii) The whole surface of any component part such as a lug or cheek plate.

(iv) The outside surface of any gearbox, motor, brake, bearing spacer, collar, track wheel (excluding the actual tread), rope drum (excluding the rope groove) or other similar mechanical or electrical part which is not protected from the weather by being enclosed in a cabin or housing.

(v) The outside surface of any guard, cabin or housing.

6.3.2 Surface Preparation

(1) All castings shall be properly fettled and cleaned. All runners, veins, pins, etc., shall be carefully chipped off so that no lumps or rough areas are left.

(2) All welding slag and spatter shall be carefully cleaned off by chipping and power brush and, where necessary, grinding.

(3) All sharp edges shall be smoothly ground to a radius of not less than 1.6 mm.

(4) Any areas of surfaces which are to be blast cleaned as specified in 6.3.3 hereof, and which show any traces of oil or grease, shall be thoroughly degreased prior to such blast cleaning, using an approved solvent.

(5) The outside surface of sheet metal components, such as electrical cubicles, shall be dressed by means of a finishing machine or orbital sander to produce a smooth finish, free from weld protrusions, spatter, surface blemishes, etc. All sheet metal components and thin-walled section (below 3 mm in wall thickness) shall be degreased by an approved process in accordance with BS5493 and shall then be pickled, to remove all mill scale, mill bloom, accordance with BS5493.After

appropriate neutralization and rinsing, such components, with the exception of those which are to be galvanized, shall be given an approved chemical or electro chemical surface passivation and anti-corrosion treatments.

(6) Particular care shall be taken to ensure that surfaces which have been prepared and cleaned for painting, other protective coating or treatment, are not re-contaminated by handling with bare hands or by exposure to any contaminating environment.

6.3.3 Abrasive Blast Cleaning

(1) All un-machined steel and cast-iron surfaces, apart from sheet metal components and thin-walled sections (below 3 mm wall thickness) shall be abrasive blast cleaned, as specified hereunder, after all fabrication and hot work has been completed.

(2) The use of pre-blast pre-painted workshop primed steel plate may be accepted, subject to all mechanical and heat affected areas being suitably re-prepared to the equivalent of the Sa2.5 by either abrasive blast cleaning or other mechanical methods prior to the application of subsequent coatings. The welding on of lugs, brackets etc. after the application of undercoats or topcoats is considered to be poor construction practice, comprises the paint system and must therefore be avoided. Only when it can be shown to be physically impossible to carry out blasting after fabrication will blasting and prime coating prior to fabrication be permitted.

(3) Contractor shall submit details of the blast cleaning proposed to be used, including type of equipment, type and grade of abrasive and profile height expected from use of such abrasive.

(4) External surfaces as defined in 6.3.1(9) shall be dry abrasive blast cleaned to a white metal finish in accordance with SIS005900 Sa2.5.

(5) Internal surfaces to be abrasive blast cleaned shall be dry abrasive blast cleaned to a finish in accordance with SIS005900Sa2.

(6) After blast cleaning, surfaces shall be fibre brushed or blown with clean dry air (provided adequate driers and oil mist filters are used in air lines) or vacuum cleaned to remove all blast products and abrasives from the entire surface, including pockets and corners.

(7) Blast cleaning shall not be performed on surfaces that may in the opinion of the Purchaser's Representative, become wetted after blasting and before painting, or other protective coating, nor shall blasting operations be performed on surfaces the temperature of which is less than 3^{o}C above the dew point of the surrounding air, or when the wet bulb temperature in the immediate neighbourhood, as measured by a standard wet and dry bulb thermometer, differs from the dry bulb temperature by less than seven and one half (7.5) percent of the dry bulb temperature, nor shall blasting operations be performed when the temperature of the metal is higher than 38^{o}C or lower than 10^{o}C. Contractor shall ensure that all measuring equipment is available and tested to record the above conditions. Adequate precautions shall be taken to ensure that no damage to or contamination of partially or entirely completed portions of the work, or to machinery, occurs from blast cleaning.

(8) All free oil and moisture shall be effectively removed from the air supply lines of all blasting equipment, using adequate and approved filters and driers.

(9) Blast cleaned surfaces shall be kept free of all contamination before painting, etc., as required by 6.3.2(5) above

(10) Operators shall wear fabric gloves of an approved type during cleaning operations and any area inadvertently touched by bare parts of the body, shall be immediately solvent cleaned by approved methods.

(11) All items of metal work to be painted shall be so treated not more than four hours after surface preparation of each item has been completed.

(12) Any unpainted surfaces which have been subjected to conditions which might induce condensation of water thereon, or which have been left longer than the above-specified two hours after blast cleaning, shall be again blast cleaned before being painted.

(13) All paint application shall be in accordance with paint manufacturers' recommendations with paint manufacturers' representative present on site during preparation and painting and verified by Third Party Inspection Company.

6.3.4 Painting General

(1) All painting and coating operations shall be performed in a neat, thorough workmanlike manner. All paint and coating materials shall be in a thoroughly mixed condition at the time of application and shall be thinned only in accordance with the manufacturer's instructions.

(2) Paint or coating material shall not be applied unless the temperature of the metal surface and the atmospheric conditions satisfy the requirements specified in 6.3.3(6) above. The mixing, preparation and application of all painting materials shall be in full accordance with the paint manufacturers written instructions which shall be presented for approval of the Purchaser.

The first coating shall be applied as soon as possible after cleaning the surface, but in any case, not longer than 2 hours after cleaning.

(3) All surfaces to be coated shall be completely free of moisture, foreign surface matter and abrasive dust at the time of application of each coat.

(4) Each coat shall be uniform and free from runs, sags and other imperfections.

Limitations on minimum and maximum inter-coat drying periods recommended by the paint manufacturer shall be strictly observed.

(5) All paints shall be of approved colours which will be provided to the Contractor during the design phase.

The colour of each coat shall differ from that of the previous coat to a sufficient extent to enable missed areas and uneven or inadequate covering to be clearly observed. The final coat shall be the specified colour.

(6) All paint shall be applied to the thickness as specified, and such paint thickness shall be gauged by a certified thickness gauge supplied by the Contractor.

Paint shall be applied by approved spray equipment corresponding to the equipment recommended by the paint manufacturer for the particular type of paint.

It is preferred that as far as practicable, semi-hollow components such as switchboard cubicles and consoles and any other smaller items where difficulty could be encountered in obtaining even coverage, be painted by means of electrostatic spray equipment.

All welds and edges shall be double passed with each coat.

(7) The Contractor shall, at his own expense, take all precautions and provide all equipment, including ventilation plant, which may be necessary to obviate health hazards arising from the use of specified paints and coating materials in confined spaces or elsewhere.

(8) All joints, including bolt heads, bolt ends, nuts, washers and attachments, shall be painted, after the connection has been made, to complete the protection in the same system as that specified for the adjacent steel work.

(9) The Contractor shall submit full technical, application and service details from the manufacturer of the paints they propose to use.

(10) Proprietary Equipment

The external surfaces of all mechanical and electrical equipment shall be protected by paint systems having durability comparable with that of the systems specified herein for other steel work in similar environment.

Wherever possible special paint treatment of approved quality shall be specified in the ordering of proprietary items

Any equipment having external surfaces of materials which are subject to corrosion and which shall be exposed to the weather shall be protected by an approved paint system equivalent in durability to that used on the main structures.

(11) Alternative Paint Systems

Contractor may offer alternative paint systems to those specified, but such will only be considered if evidence is submitted to support claims that the systems offered are of at least equivalent durability to that of the system specified.

6.3.5 Paint Systems

(1) External Steel Work

After preparation and cleaning in accordance with 6.3.2 and 6.3.3 above, all external steel surfaces with the exception of (a) galvanized surface and (b) machined surfaces referred to in Clauses 6.3.1(4) and 6.3.1(8) shall be given the following protective treatment:

First Coat:

Apply one (1) coat of a zinc rich primer, to a minimum dry film thickness of 75 microns.

Second Coat:

Apply one (1) coat of epoxy micaceous iron oxide primer / under coat, to a minimum dry film thickness of 100 microns.

Third Coat:

Apply one (1) coat of a high performance anti-corrosive barrier coating based on polyurethane enamel, to a minimum dry film thickness of 50 microns.

The topcoat colours shall meet ICTSI Terminal Equipment Colour Specification. The Contractor shall submit a crane livery schedule drawing and colour samples for the Purchaser's approval

Total Dry Film Thickness of system shall not be less than 225 microns.

(2) Internal Unsealed Surfaces

After preparation and cleaning in accordance with 6.3.2 and 6.3.3 above, all internal surfaces with the exception of (a) galvanized and non-ferrous surfaces (b) machined surfaces referred to in 6.3.1(4) and 6.3.1(8) hereof shall be given the following protective treatment:

First Coat:

Apply one (1) coat of epoxy zinc rich primer, to a minimum dry film thickness of 50 microns.

Second Coat:

Apply one coat of epoxy micaceous iron oxide primer / undercoat to a dry film thickness of 100 microns minimum.

N.B. Total Dry Film Thickness of system to be not less than 150 microns.

(3) Galvanized and Non-Ferrous Surface, both Internal and External

Galvanized and non-ferrous components shall, after appropriate cleaning by an approved method, be given the following protective treatment:

Galvanized and Non-Ferrous Surfaces, both Internal and External

Surface Preparation:

Ensure that all surfaces are free from all grease, oil or other contaminants by application of a degreasing solution formulated from a blend of solvent and emulsifier. Apply Degreaser liberally ensuring that material does not spill on existing paintwork, working well into the surface to be degreased. Allow 5-10 minutes for the solvent to take place. Flush with clean fresh water and allow to dry thoroughly prior to application of the primer coating.

First Coat:

Apply one (1) coat of micaceous iron oxide primer / undercoat to a minimum dry film thickness of 50 microns.

Top Coat:

Apply one (1) coat of a high performance anti-corrosive barrier coating based on polyurethane enamel, to a minimum dry film thickness of 50 microns.

N.B. Total Dry Film Thickness of system to be not less than 150 microns.

(4) Motor, Gearboxes, etc.

The external surfaces of all machinery such as motors, rope drums, gearboxes, couplings in exposed locations shall be given protective treatment as specified for external steel work, galvanized and non-ferrous surfaces in 6.3.5(1) and 6.3.5(3) above. Motors/Gearboxes in outdoor locations shall be painted the same colour as structure.

The external surface of such machinery enclosed in housings or enclosures shall be given the protective treatment specified for internal steel work, galvanized and non-ferrous surfaces in 6.3.5(2) and 6.3.5(3) above.

After preparation and cleaning in accordance with 6.3.2 and 6.3.3 above, all external surfaces of such machinery shall receive the following protective treatment:

First Coat:

Apply one (1) coat of an epoxy zinc rich primer, to a dry film thickness of 75 microns.

Second Coat (Top Coat):

Apply one (1) coat of epoxy-based enamel, to a dry film thickness of 50 microns.

Where it is shown that proprietary items such as electric motors have received preparation and appropriate surface protection, the Contractor may, with the approval of the Purchaser's Representative on submission of technical details, omit any further surface treatment.

The contractor shall remain responsible for ensuring paint system compatibility.

(5) Horizontal Surfaces of Access Ways, etc.

Area: Horizontal Surfaces of Access Ways

All horizontal surfaces used for pedestrian or traffic surfaces for access to any part of the crane for normal operation or maintenance procedures, including such surfaces on structural members, shall be given an approved special paint treatment.

Such special treatment shall provide improved abrasion resistance and non-slip characteristics while providing protection and having durability not less than that of the top coating specified for each relevant environment, i.e. external or internal.

Non-Skid Powder shall be applied to second last coat while still tacky and allowed to set prior to application of final coating.

6.3.6 Galvanizing

(1) General

Components or surfaces required to be galvanized shall be prepared generally as specified in 6-3.2 (Surface Preparation) and shall than be either acid pickled in accordance with BS5493:1997 (Protective coating against corrosion) or abrasive blast cleaned in accordance with Clause 6.3.3. Abrasive blast cleaning shall only be permitted on components or surfaces where there is no likelihood of distortion due to such cleaning method.

After such cleaning, all components or surfaces required by this specification shall be given a hot dipped galvanized coating conforming to the requirements of BS5493.

Galvanizing of any component or surface shall only be carried out after completion of all fabrication work on such component or surface. No welding on any pre-galvanized component or surface will be tolerated unless the component or surface is to be subsequently re-galvanized.

6.3.7 Reinstatement of Protective Coatings at Site

(1) Care shall be taken at all times to ensure that the protective coatings and treatment shall not suffer any damage during handling, transport and erection.

(2) After the components have been transported to the Site, assembled and welded where necessary, all protective coatings shall be carefully inspected and any areas where protective coatings have been damaged or found defective shall be clearly marked with orange coloured spray paint or paint stick or chalk, for ready identification and remedial treatment.

All weld slag and spatter or heat affected coatings on surfaces that have not been adequately protected during field welding, shall be completely removed and any high points on field welds shall be ground completely smooth.

All such areas together with field welds, weld margins and burn marks shall be abrasive blast cleaned as specified in 6.3.3 (Abrasive Blast Cleaning) hereof, with due care of other areas of the coating to avoid further damage.

(3) All site abrasive blast cleaning shall be effected with approval closed cycle vacuum blasting equipment. Within two hours of cleaning as specified in 6.3.7(2) above, and before any contamination or discoloration can take place, the blast cleaned areas shall be recoated with the priming coat and to the thickness specified in 6.3.5 (Paint Systems) hereof for the relevant type of surface and location.

Undercoats and topcoats of the type and thickness, as specified in Clause 6-3.5 hereof, for the relevant type of surface and location shall subsequently be applied, with suitable feathering of coats to avoid ledging. Manufacturer's recommendations regarding application and drying or inter-coat intervals shall be strictly observed.

(4) Damage to paint coatings such as scratches or abrasions which, in the opinion of the Purchaser's Representative, do not penetrate the total paint system may, at the discretion of the Purchaser's Representative, be reinstated by cleaning with a suitable solvent and then touch up painting with the relevant primer(s), intermediate and top coats as directed by the Purchaser's Representative.

(5) For all repair painting, the final coating shall comprise paint from the same batch as that originally used on the particular surface.

(6) Cleaning and repair painting of the crane or its equipment shall be carried out only when the conditions specified for the original cleaning and painting in 6.3.3(6) and 6.3.4(2) hereof, are satisfied.

Painting shall not be permitted if there is dust being deposited on the surface to be painted or conditions are not in accordance with Clause 6.3.3(6).

6.3.8 Inspection and Sample Panels

(1) Attention is drawn to Inspection Control Sheets. Inspection shall take place before and after preparation and coating and also on site.

(2) Before any surface treatment is carried out and within 3 months of issue of the Letter of Acceptance, the Contractor shall supply to the Engineer, free of charge;

a) Samples of each type and color of paint approved for use on the crane for testing. The Engineer reserves the right to call for further random samples during the entire painting operation. Should the tests prove unsatisfactory, the entire batch shall be rejected, and the Contractor shall take corrective action to re-blast and re-paint all sections painted using the rejected batch to the satisfaction of the Engineer.

b) Two sample blast cleaned panels one panel cleaned in accordance with 6.3.3(3) and the other cleaned in accordance with 6.3.3(4) hereof, each panel measuring not less than 150mm x 150mm x 6mm, and adequately protected after cleaning by sealed clean polythene wrapping.

If approved, the sample shall then be retained by the Engineer for comparison with the prepared steel work.

c) Two steel panels for each painting system, at the commencement of painting operations, cleaned and painted in accordance with the relevant requirements of this specification with the exception of any site coat.

One of each pair of panels is to be "stepped" to show the successive build-up of the paint treatment and will be used as a standard of acceptance throughout the painting operations.

6.4 Crane Livery, Purchaser's Logo, Asset Numbers, Signs

6.4.1 Crane Livery

(1) Details of the crane livery are provided in Appendix 2.

(2) The paint colour scheme, which shall be used for the final finish coat, is based on the RAL standard. For comparison, the original register cards issued by RAL (www.RAL-Farben.de) shall be the controlling reference.

(3) Contractor shall supply for review and approval, full colour drawings of all crane livery and signage.

6.4.2 Purchaser's Logo

(1) Details of the Purchaser's logo are provided in Appendix 2.

(2) The logo shall be painted on three sides of the machinery house. Minimum size is 6.4m x 3.5m.

(3) Detailed design and final size to be confirmed during design review.

6.4.3 Language of Signs

(1) The language of all signs shown in this Specification is English, but the actual signs, name plates, labels and caution plates shall be provided in local language

(2) The Contractor shall submit all translations of the crane, spreader, hook beam and test weight signs for approval by the Purchaser prior to manufacture.

6.4.4 Crane Signs

(1) The following signs shall be fitted to the crane(s), spreader(s) and - if to be provided under this Contract - to the Hook Beam, the Container Tope Safety Frame and the Test Weight in the positions defined below using a font of Arial Bold in black colour. Loads and asset numbers in the below tables are for illustrating purpose only. Correct loads and asset numbers are specified in Clause 1.4.3 and Appendix 2.

(2) Crane Signs

Sign	Description / Location	Height
SWL 41 MT SINGLE LIFT	To be applied each outsides of the portal beam.	min. 300 mm
SWL 2 x 32.5 MT TWIN-LIFT	To be applied each outsides of the portal beam beneath the "SWL Single Lift" sign.	min. 300 mm
SWL 75 MT HOOK BEAM	To be applied each outsides of the portal beam beneath the "SWL Twin-Lift" sign.	min. 300 mm
QCXX – QCXX	This is the asset number for the crane. To be applied both inboard faces of the sill beams.	min. 800 mm

(3) Spreader Signs:

Sign	Description / Location	Height
SWL 41 MT SINGLE LIFT	To be applied each side of spreader centre section.	150 mm
SWL 2 x 32.5 MT TWIN-LIFT	To be applied each side of spreader centre section beneath the "SWL Single Lift" sign.	150 mm
SWL 12.5 MT	This is the Safe Working Load of each pad eye. To be applied adjacent to each pad eye.	50 mm
SP-P 3 & 4	This is the asset number for the spreader. To be applied both sides of the centre section towards bottom RH corner.	80 mm
LAND SIDE	To be applied on the cabin side only and directly beneath the SWL signs.	80 mm
WATER SIDE	To be applied on the non-cabin side only and directly beneath the SWL sign.	80 mm

(4) Hook Beam Signs:

Sign	Description / Location	Height
SWL 75 MT	To be applied each side of the hook beam near to the central rams' horn hook to indicate its lifting capacity.	150 mm
SWL 40 MT	To be applied each side and each end of the hook beam near to the smaller hooks to indicate their lifting capacities.	150 mm
SWL 15 MT	To be applied in four positions, one adjacent to each lifting lug to indicate their lifting capacity.	100 mm
HB7	This is the asset number for the hook beam. To be applied both sides of the hook beam towards top RH corner.	80 mm

(5) Container Top Safety Frame / Lashing Cage Signs:

Sign	Description / Location	Height
CONTAINER TOP SAFETY FRAME	To be applied each side of the CTSF in a prominent position.	150 mm
MAX LOAD XX MT	To be applied each side of the CTFS.	150 mm
TARE WEIGHT XX MT	This is the tare weight of the CTFS with no load. To be applied each side of the CTFS beneath the MAX LOAD sign.	80 mm
MAX XX PAX	This is the maximum number of personnel which can be transported with the CTSF.	80 mm
LC1	This is the asset number for the CTFS. To be applied both sides of the CTSF towards top RH corner.	80 mm

(6) Test Weight Signs:

Sign	Description / Location	Height
TEST WEIGHT	To be applied each side of the test weight in a prominent position.	150 mm
MAX LOAD 125 MT	To be applied each side of the test weight.	150 mm
TARE WEIGHT XX MT	This is the tare weight of the test weight with no load. To be applied each side of the test weight beneath the MAX LOAD sign.	80 mm
XX MT	This is the self-weight of each individual weight of the test weight. To be applied to each individual weight.	50 mm
TW1	This is the asset number for the test weight. To be applied both sides of the test weight towards bottom RH corner.	80 mm

(7) All above signs are additional to the manufacturer's serial number plate, safety and maintenance signs.

(8) The Contractor shall submit a drawing showing locations, specification and dimension of all crane, spreader, hook beam and test weight signs for approval by the Purchaser prior to manufacture.

6.4.5 Manufacturer's Logo and Name Plates

(1) Manufacturer's logo and name plate may be placed on the outside of the portal beams only. The Contractor's or any 3rd party logo font size shall not exceed that of the Purchasers logo. The size and location must be approved by the Purchaser.

(2) Stainless steel plates showing year and place of manufacturing, manufacturing number, principal dimensions, speeds and capacity of the Crane shall be fitted below the sill-beam, clearly visible from the first main access stairway, and in the operator's cab.

(3) Each item of machinery shall be properly labelled for its direction of motion or operation and for any precautions to be taken before operation or maintenance.

(4) The components manufacturer's name plate shall be fitted on each major mechanical system or component showing type, capacity, serial number, manufacturing number, manufacturing date, etc., for future reference.

6.4.6 Hazard Signs

(1) Hazards which may result in injury to personnel shall be clearly marked with signs identifying the nature of the hazard, the consequence of not avoiding the hazard, and how to avoid the hazard. Signs shall be permanently secured in a conspicuous location and shall comply with appropriate legislation or, if such legislation does not exist, with ANSI Z535 or ISO 3864.

(2) Equipment which may start automatically shall be marked as a hazard. Hydraulic power units are examples of this type of equipment.

(3) High Voltage warning signs shall be provided for each position where medium voltage connection is made, on each piece of MV equipment and on the MV cable runway at the crane (at every 3 metres).

(4) Standard pictorial symbols indicating the nature of the hazard shall be used. Text shall clearly identify the hazard, the consequences of not avoiding the hazard, and what steps personnel are to take to avoid the hazard.

(5) Where lengthy instructions or procedures for avoidance of hazards are required, the signs shall refer to the appropriate section of the maintenance manuals or operating instructions.

(6) The Contractor shall provide written procedures in the maintenance instructions for the maintenance and replacement of all hazard signs in accordance with the recommendations of ANSI Z535.4 or ISO 3864.

(7) The format, language, graphics, and placement of all hazard signs shall conform to the recommendations of ANSI Z535 or ISO 3864 and shall be approved by the Purchaser. Exceptions are allowed for buyout components.

6.5 Alarms, Warning, Signals & P.A. System

6.5.1 Gantry Travel Warning and Shutdown

(1) Four (4) Red flashing electronic type strobe warning lights shall be installed at four corners of the crane. These lights shall be automatically activated by gantry motion. The Purchaser shall approve the type.

(2) These lights shall be mounted in a position where they can be clearly seen by both pedestrians and by the operators of Terminal Tractors.

(3) The gantry travel warning sound shall be automatically activated by gantry motion. The siren sound shall be activated by the operator pressing down the foot switch on the floor of operator's cab, and when pressed during gantry motion shall override the travel warning sound. The type of sounds to be approved by the Purchaser.

(4) Alarm speakers shall be located at a maximum height of 2.5m above ground level. The alarm speakers shall generate signal level of not less than 95dB at 1 kHz at a point 1m forward (relative to the direction of motion of the Crane) of each of the speaker measured at a height of 1.5m above ground level. In order to minimize disturbance to communities around the terminal, the signal must not exceed the above limit by more than 3dB. The alarm tone shall consist of an intermittent signal, sounding at 1/sec for duration of 0.5 sec.

(5) A collision avoidance system shall be installed to warn of crane to crane and crane to end of travel collisions. The system shall interface with the control system to automatically warn the operator of an imminent collision and slow down the gantry drive system in the collision direction. Upon pre-set condition the crane gantry motion shall automatically stop.

* Photoelectric switches be used for crane to crane anti-collision.

(6) A collision avoidance system shall be installed to warn of the crane boom approaching a vessel such as a bridge or ship mounted crane. The system shall interface with the control system to automatically warn the operator of an imminent collision and slow down the gantry drive system in the collision direction. Upon pre-set condition the crane gantry motion shall automatically stop.

* Boom to ship collision protection shall be achieved by photoelectric switches which activate upon a set proximity causing Gantry motion to Emergency stop.

6.5.2 Wind Speed Warning

(1) The anemometer shall have analogue output to the crane PLC which will provide three independently adjustable outputs to:

i) Activate intermittent audio warning and amber warning lamp in the operator's cab when the wind speed exceeds the lowest setting of the wind speed (setting shall be adjustable).

ii) Activate continuous audio warning and red warning lamp when the wind speed exceeds the middle setting of the wind speed (setting shall be adjustable).

iii) Deactivate motion control while keeping status of (ii) when the wind speed exceeds the highest setting. (Setting shall be adjustable).

(2) Once the above pre-set value (i) is exceeded, the anemometer shall only be capable of being reset manually when wind speed falls below the pre-set alarm value (i).

**CLARIFICATION: The display for the wind speed shall be by analogue meter provided in the trolley cabin, boom cabin and RCS. The anemometer manufacturer shall be Vaisala and shall be submitted to the Purchaser for review.*

6.5.3 Main Hoist Overload Warning

(1) An audible alarm in the operator's cab to be activated and a red warning light for indicating 'Hoist Overload' shall be illuminated when overload is detected on the main hoist system. With 10% overload over 3 seconds the hoisting motion shall be inhibited automatically. After hoisting motion is inhibited, only lowering motion shall be allowed.

6.5.4 Premature Twist-lock Operation Warning

(1) The 'premature LOCKING' movement before the spreader is landed on the container or hatch cover shall be prohibited by means of electrical interlock on the logic control circuitry. There shall be no physical movement of the twist locks on the spreader even though the switch is turned to the 'LOCK' position. Audible and visual alarms discernible at ground level and at inside the operator's cab shall be activated by this premature turning of the lever type twist lock limit switch and all motions of the crane shall be deactivated. Both audible and visual alarms shall cease when the twist lock switch is returned to its original position.

(2) The 'premature UNLOCKING' movement while suspending the load with twist locks shall be prohibited by means of electrical interlock on the logic control circuitry. There shall be no physical movement of the twist locks on the spreader even though the switch is turned to 'UNLOCK' position. Audible and visual alarms discernible at ground level and inside the operator's cab shall be activated by this premature turning of the lever type twist lock limit switch and all motions of the crane shall be deactivated. Both audible and visual alarms shall cease when the twist lock switch is returned to its original position.

6.5.5 By-pass Switch Abuse Warning

(1) Twist lock interlock bypass push button

When the Twist-lock Interlock Bypass push button is depressed to overcome a difficult situation to carry out hoisting or lowering function, an alarm sound shall be broadcast through an independent amplifier through a speaker located outside the operator's cab and facing downward. The hoisting speed and the trolley speed shall be slow-down mode.

(2) Landing bypass push button

When the Landing Bypass push button is depressed to permit the twistlocks to rotate without a landed signal, an alarm sound shall be broadcast through an independent amplifier (same as the one for twist lock interlock bypass push button) through a speaker located outside the operator's cab and facing downward. The hoisting speed and trolley speed shall be at slow down mode since it is a difficult condition and safety is required.

(3) Labels shall be provided for each switch and indicator in local language to be approved by the Purchaser.

6.5.6 Electrical Control House Air Conditioning and Humidity Warning.

(1) Visual and audible warning shall be provided if the temperature of the control panel room exceeds 30 degrees C. The air conditioning system failure shall be indicated by a warning lamp in a location outside of the panel room in the machinery house, and as an alarm condition in the CMS.

(2) Visual and audible warning shall be provided if the humidity of the control panel room exceeds 85%. The air de-humidifier failure or high humidity shall be indicated by a warning lamp in a location outside of the panel room in the machinery house, and as an alarm condition in the CMS.

6.5.7 Fire Warning

(1) Visual and audible warning shall be provided if the smoke detectors in the Electrical rooms or Machinery House are triggered.

(2) Smoke detection shall be indicated by a warning lamp in a location outside of the Machinery House and as an alarm condition at the Operator's panel and in the CMS and RCMS.

6.5.8 Public Address/ Warning

(1) One loudspeaker pointing down shall be mounted on the trolley or near the operator's cab to broadcast the following warning sound:

a. Twist lock interlock bypass push button.

b. Landing interlock bypass push button.

c. Premature 'Locking' switching

d. Premature 'unlocking' switching

6.6 Emergency Stop Push Buttons

6.6.1 Location

A total 23 nos. of emergency stop push buttons shall be installed on the Crane in the following locations:-

2 in Operator's Cab	One on each console
5 in Machinery House	(1-Near Main Hoist motor)
	(1-Near Trolley motor)
	(1-Near Boom Hoist motor)
	(1-Near Front door)
	(1-Near Rear door)
1 Boom Control Station	On Console
1 Gantry Control Station	On Console
1 Headlock Man Cage	
1 Control Panel Room	On Electrical Panel near to CCMS
1 Electrical Panel Room	On Electrical Panel in central location
2 Boom	Boom mid position and boom tip
1 A-Frame	At top of A-Frame
1 TLS	Near to the TLS Hydraulic Cylinders
1 Trolley	On trolley platform
6 Ground Positions	4 – One at each corner of crane, near gantry buffer
	2 - One each at centre of landside and waterside sill beam, at ground level inboard of the Crane to be reached by ground operation personnel

All emergency stop buttons shall be hardwired, connected to individual I/O's and the status shall be displayed on the CCMS and fault display.

Safety PLC's and I/O may be used for safety circuit.

A total of 6 Drive Lock-Out switches shall be installed on the crane in the following locations:

When the drive lockout switch is activated (same circuit and function as e-stop) it enables maintenance engineers to disable and lock out all crane functions during maintenance or inspections. When the switch is activated (switched in the off position) there shall be a facility to attach a padlock and lock the switch in the off position.

1 in Operator's Cab	On Rear panel
1 in Machinery House	Near Main Hoist motor
1 Boom access gate	Boom hoist permit (prevents boom Up when locked off)
1 in E-house	Lockable mushroom head e-stop or traditional rotary type

2 Ground Positions	1 – Waterside 1 – Landside to be reached by ground operation personnel.

All Drive Lock-Out switches shall be hardwired connected to individual I/O's and the status shall be displayed on the CCMS and fault display.

Safety PLC's and I/O may be used for safety circuit

6.6.2 Type

Mushroom head emergency stop pushbutton (self-latch) switches shall be provided. All emergency stop buttons shall be recessed to prevent from being actuated accidentally.

6.6.3 Emergency Stop Signs

Adequate signs shall be provided in local language and English language "EMERGENCY STOP" to clearly identify their locations to ground floor personnel. The size of the signboard shall be 300mm x 300mm minimum.

6.7 Fire Extinguishers

6.7.1 Locations

Each crane shall be provided with fire extinguishers in the following locations as a minimum:

(1) Machinery House - two (2) of 7kg capacity.

(2) Electrical Room - one (1) of 7kg capacity.

(3) Operators Cabin - one (1) of 3 kg capacity.

(4) Checkers Cabin – one (1) of 3 kg capacity

(5) Quay level near the access ladder – one (1) of 7kg capacity.

6.7.2 Type - Model

All the portable fire extinguishers shall be CO_2 type compliant with appropriate laws in the country of operation and shall be locally refillable by approved contractor.

6.8 Maintenance Tools and Equipment

6.8.1 Maintenance Tools

(1) Maintenance tools as listed in Appendix 3 (Tools List) shall be provided with the crane(s). The Maintenance Tools shall be made available to the Purchaser before Taking-over of the first crane(s).

6.8.2 Spreader Test Panel (Required)

(1) If required under this contract (refer to Clause 1.4.1 Crane Details and Accessories), a control panel for operating and testing spreaders in the workshop shall be provided with the crane(s).

(2) The Spreader Test Panel shall incorporate push button switches, selector switches, indicator lamps, PLC, input / output devices, spreader multi-pin connector, cables and all parts and software necessary for operating and confirming all the functions and safety features of the spreader.

(3) A 15 metres power supply cable with plug shall be provided with the Spreader Test Panel.

6.8.3 Drive Simulator (Required)

(1) If required under this contract (refer to Clause 1.4.1 Crane Details and Accessories), a Drive Simulator shall be provided with the crane(s) for the purpose of a training aid to electrical technicians to avoid occupying a crane during training sessions.

(2) The Drive Simulator shall include the following items of identical type to those actually installed on the crane:

- Main Drive rectifiers/inverters – smaller rating than installed on the crane is acceptable
- PLC
- Master Controller
- AC Motor – smallest type installed on the crane, such as spreader cable reel motor
- Switches, terminals, contactors and other components required to operate and test the equipment in a typical crane environment

(3) Software of the Drive Simulator shall be modified according to the hardware configuration required for training.

(4) A 15 metres power supply cable with plug shall be provided with the Drive Simulator.

(5) All equipment shall be mounted on a panel and mobile stand with castors and dust cover.

7 PROJECT ADMINISTRATIVE REQUIREMENTS

7.1 Document Submission (Project)

7.1.1 Submission Schedule

(6) The Contractor shall submit project management and technical information as outlined in this Section 7 and in Appendix 4 (Documentation Status Control Sheets).

(7) The Appendix 4 (Documentation Status Control Sheets) shall be updated from time to time by the Engineer or his representative.

7.1.2 Project Organization Chart (Shop & Site)

(1) The Contractor shall submit to the Purchaser a project organization chart within two (2) weeks after the date of the Agreement.

(2) The Organization Chart shall show the organization of the Contractor's resources, which he intends to employ in the total project from shop manufacturing through to the site commissioning phases. This will clearly identify the departments involved, the people responsible for each element and the number of personnel directly involved in administering the project.

7.1.3 Project Schedule / Programme (Shop & Site)

(1) The Contractor shall submit to the Purchaser a project schedule (program) within two (2) weeks after the date of the Agreement.

(2) The Programme (and any revisions thereof) shall be presented in the form of a logic linked timed schedule covering all activities appertaining to the manufacture of the Crane(s). The contents shall include but not be limited to the following: -

i.) Commencement date.

ii.) Engineering Design Period.

iii.) Submission of Drawing/Design Calculations and operating and maintenance instructions and for the approval thereof by the Engineer.

iv.) Procurement of Materials and Components.

v.) Manufacturing Periods for the main Structural Sections.

vi.) Erection in the Contractors Facility.

vii.) Shop Test and Commissioning.

viii.) Transportation Period.

ix.) Site Commissioning.

x.) Completion Date(s)

xi.) Contractual Payment Milestones (estimated time of invoice issuance)

xii.) Dates when Purchaser supplied information or permits are required

(3) Further the Programme shall include the times by which the Contractor requires the Purchaser:

xiii.) to furnish any drawings or information,

xiv.) to provide access to Site,

xv.) to have completed any necessary civil engineering or building work (including foundations for the Plant),

xvi.) to have obtained any import permits or licences, consents, wayleaves and approvals necessary for the purposes of the Works,

xvii.) to provide electricity, water, gas, air and other services on the Site or any equipment, materials or services which are to be provided by the Purchaser.

(4) The Programme shall be provided in "MS Project" and PDF format and shall be presented in a way that clearly shows each activity connected in a logical program sequence. Each activity shall show the duration, early start and early finish and shall identify the critical path of the project.

7.1.4 Project Progress Report

(1) The Programme shall subsequently be updated and submitted to the Purchaser at intervals of no more than one (1) month throughout the course of the project until the Taking-over Certificate for the last crane has been issued.

(2) The monthly update will show actual progress against the original baseline so that effect of any slip or improvement in progress can be easily identified.

7.1.5 Crane Delivery Method Statement

(1) No later than three (3) months before the arrival of the first Crane(s), the Contractor shall submit a method statement for the Purchasers approval for the roll-off or lift-off or discharge of the crane(s) to the Purchasers quay deck. The method statement shall include:

(i) The total area required for the roll-off or discharge operation.

(ii) Full details of the transportation vessel and the stowage of the crane(s).

(iii) Orientation of the vessel when offloading.

(iv) Number and position of bollards and moor lines.

(v) Length and position of sea anchors (if applicable).

(vi) System of transferring the crane to the quay deck.

(vii) All skid beams and skid beam centres (if applicable).

(viii) All positions and magnitude of loadings applied to the quay deck during the offloading operation.

(2) The proposal shall also show a period of occupancy and the length of the Purchaser's berth required for roll-off or discharge operation.

7.1.6 Site Work Method Statement

(1) No later than three (3) months before the arrival of the first Crane(s), The Contractor shall submit to the Purchaser a site work method statement for the Purchasers approval showing all activities from arrival of the crane(s) through to taking-over.

The method statement shall include:

i.) The total area required to complete the crane(s) and to store the loose items and spare parts. (This will be strictly subject to the Purchasers approval.)

ii.) Roll-off, Lift-off or discharge scheme and date of performance.

iii.) Key activities of the commissioning / completion and duration.

iv.) Number of days required from the date the crane is ready for starting up and load testing.

v.) Date the Crane(s) will be Test Commissioned and handed over to the Purchaser.

vi.) Date the Crane(s) will be finally handed over to the Purchaser.

vii.) Other key dates of significance.

7.1.7 Daily Plan and Report (Site)

(1) For the duration of the period of site work at the Purchaser's Site, the Contractor shall submit, at daily intervals in a form approved by the Purchaser, his progress of activities and tests carried out. This daily plan shall also indicate weather conditions, number of Contractors personnel and sub-contractors engaged at site together with the activities planned for the next day.

7.1.8 Ordered Spare Parts List – not applicable

7.1.9 Training Program

(1) No later than three (3) months before the arrival of the crane(s), the Contractor shall provide a comprehensive training program to cover the theoretical and practical training requirements for the Purchaser's crane operators, electrical and mechanical tradesmen and electronic technicians. The program shall be aimed at all aspects of the crane(s) in the respective disciplines in order to provide the trainees with a sound basic knowledge of the crane systems

(2) The scope of training to be conducted for the disciplines shall be generally as outlined in Section 7.9 (Training and Familiarization)

(3) The training program is subject to approval by the Engineer.

7.2 Design Drawings and Calculations

7.2.1 Drawing Management System

(1) With the submittal of the Conceptual Design, the Contractor shall submit to the Engineer full details of the Contractors system of drawing management, which shall be maintained throughout the project.

(2) The Contractor shall demonstrate that a logical system of drawing administration exists and shall clearly establish to the Engineer, the procedures and current practices in place which deal with alterations, modifications and re-issue of drawings from the design stage through to the as built drawings.

(3) The Contractor shall provide and maintain a drawing register for all submitted, reviewed and re-submitted design documents, including the document numbers, version number and dates.

7.2.2 Design Review

(1) The Contractor's design documents shall be reviewed by the Purchaser's appointed review engineer as outlined in Appendix 4 (Documentation Status Control Sheets).

(2) Design review meeting(s) to further clarify design details and review comments shall take place as outlined in Appendix 4 (Documentation Status Control Sheets). All costs incurred to the Purchaser or his representatives in connection with the design review meeting(s) shall be borne by the Purchaser.

(3) The review engineer's comments on the drawings or submittals shall not waive the Contractor's duties or obligations to achieve satisfactory performance of the crane as set out in the Contract.

(4) The Purchaser undertakes no duty to the Contractor to neither identify nor notify to the Contractor any errors or omissions in the Contractor's design.

7.2.3 Conceptual Design

(1) The Contractor shall submit to the Purchaser a conceptual design, which outlines his proposal for the Crane(s) for his review. The conceptual design shall show clearly by drawings, calculations and descriptions the major design details.

7.2.4 Detailed Design

(1) Following review and acceptance of the conceptual design, prior to the fabrication or ordering of components, the Contractor shall submit detailed drawings and calculations.

(2) General arrangement drawings, calculations and data other than listed in Appendix 4 which clarifies further details, shall be submitted from time to time at the request of the Purchaser for review.

7.2.5 Final Design

(1) Following the review and acceptance of the detailed design, the Contractor shall submit to the Purchaser all documents reviewed and if necessary revised according to the Purchaser comments or for other agreed reasons.

(2) No alterations to the final design shall be allowed unless specifically approved by the Engineer (=Design Freeze).

7.2.6 As-Built Drawings

(1) The Contractor shall submit to the Purchaser three (3) sets full-size hard copies (in the original drawing size) and two (2) sets in CD ROM (PDF format) the following as-built drawings within 30 days after the date of issue of the Taking-over Certificate for the first Crane(s):

(2) All drawings that were previously submitted for the Purchaser's review and revised as built as at the shipment date.

(3) Detailed drawings for wearing parts showing machining tolerances, wherever applicable, and wear limits:

i.) Brake drums (or discs)

ii.) Brake shoes

iii.) Wheels

iv.) Drive Couplings

v.) Sheaves

vi.) Anti-friction bearings

vii.) Bushes

viii.) Bearing plates

ix.) Oil seals and O-rings

x.) Table for consumable parts of electrical machineries

xi.) All other wearing parts.

(4) Detailed electrical control circuit drawings, control logic programs, and wiring diagrams.

(5) Full details of all bought-in equipment, drawings instructions, etc.

(6) List and specification of structural connection bolts and machinery fitting bolts with tightening torque value for each location/size.

(7) The Contractor shall revise and resubmit drawings for replacement in case any modification or revision is made on the Works (as defined in the Agreement) after the initial submission.

7.3 Quality Assurance Inspection and Test Protocols

7.3.1 Quality Assurance Program / Manuals

(1) Contractor shall submit to the Purchaser a quality assurance program for review within one (1) month after the date of the Agreement.

(2) The program shall consist of a General Quality Assurance Program, which states Contractor's general practice and organization to control the quality standard during design, procurement, fabrication and erection periods, and a Specific Quality Assurance Program.

(3) The Specific Quality Assurance Program shall relate particularly to the Cranes and Equipment to be supplied in this Contract and shall include key inspection and test items during fabrication and delivery through to hand over of the Crane to the Purchaser with proposed timing and locations of conducting such inspection and test.

(4) This Quality Assurance Program shall cover all the inspection and review items as set out in Inspection / Test Control Sheets.

(5) Test certificates confirming the material mechanical property of steel plate and forging bars or steel bars shall be submitted.

(6) Mechanical property testing shall be conducted on all critical mechanical fastener systems. These tests shall be conducted in accordance with the mechanical property test requirements. The Engineer shall require records of this testing for review.

(7) An organization chart with names of the quality assurance team personnel for this Contract for each major stage of fabrication, delivery, commissioning and Defects Liability Period shall be included in this Program.

7.3.2 Mechanical Property Testing of Critical Structural and Mechanical Fasteners

(1) The Contractor is to submit all manufacturer's fastener certificates to the Engineer. As a double check, the Contractor shall be required to randomly test the fastener system to verify mechanical properties. This testing shall be performed by an independent testing firm, acceptable to the Owner, commissioned by the Contractor. The sample fastener system shall be tested for proof load, tensile strength (wedge test), and hardness. Samples are to be selected at random from each shipping lot. These samples shall include the entire fastener system. Included in the system are the bolt, nut, and washer. The quantity of samples to be tested per shipping lot are to be determined as follows:

Number of Pieces in Shipping Lot	Number of Specimens
150 or less	1
151 to 280	2
281 to 500	3
501 to 1,200	5
1,201 to 3,200	8
3,201 to 10,000	13
10,001 or more	20

(2) If any fastener in a shipping lot is found to be defective, the entire lot is to be rejected. Records of these tests shall be required by the Engineer for review.

(3) Supplemental Hardness Testing of Critical Structural and Mechanical Fastener Systems

(4) In addition to the test specified by item (1) of this Section, the hardness of one random fastener per connection shall be checked. If the hardness is below tolerance for size and grade, hardness tests on the other fastener in the connection shall be performed. If any others are found to be below tolerance, the entire lot of fasteners shall be rejected, and all fasteners replaced.

7.3.3 Pre-Shipment Inspection and Test on Completion Protocol

(1) No later than four (4) months before the Shipping date of the first Crane(s), the Contractor shall submit to the Engineer for his approval a Pre-Shipment Test and Test on Completion Protocol.

(2) The Testing Procedures shall be in the form of the Pre-Shipment Inspection and Test on Completion Protocol as provided with the Contract Agreement and shall contain detailed field and function check procedure to fully demonstrate the specified requirements and the suitability of the crane for container handling operations. The procedure shall describe the tests to be performed, the indications to be measured and the method by which they are measured. It shall contain the design or acceptable values of each measurement along with blanks in which the tester can enter the measured values.

(3) Provision shall be made within the procedure for the tester and the Engineer’s Representative to initial and date each separate test.

(4) The Testing Procedures shall be duly completed by the Contractor following each individual test or each series of tests conducted at the Contractor's facility and at site. Where necessary the Engineer's Representative shall verify the results.

(5) The Contractor shall submit the completed Pre-Shipment Inspection section of the protocol before loading of the respective crane on to the vessel.

(6) The Contractor shall submit the completed Pre-Shipment Inspection and Tests on Completion Procedure no later than one (1) month after the notification of successful completion of the Test on Completion.

7.4 Operation and Maintenance Instructions

7.4.1 Operation Manuals

(1) The Operation Manual shall clearly state the start-up procedure of every device on the Crane including all bought-in equipment, and all the points to be observed or checked during the start up.

(2) The Operation Manual shall be provided in English and local language.

(3) The Contractor shall provide three (3) sets of each of the required languages of the Operation Manuals to the Purchaser three (3) months before arrival of the first crane(s) at the Site. Receipt of these Operation Manuals is one of the preconditions for the issuance of the Pre-Shipment Certificate.

(4) Corrections shall be made for any changes made in the instructions during the commissioning period, and five (5) sets of each of the required languages of the revised Operation Manuals shall be submitted one (1) month after the notification of successful completion of the Tests on Completion of the first Crane(s)

(5) Two sets of above instructions shall be submitted on SSD.

7.4.2 Maintenance Manuals

(1) The Maintenance Manual shall include maintenance intervals and procedures for all the bought-in equipment, and also calibration instructions and standards for meters, gauges and any components, which require periodical calibration to allow calibration by the Purchaser's maintenance staff.

(2) The Maintenance Manual shall include a complete list of wearing parts showing the allowable limit of wear for each part.

(3) The maintenance instructions shall be based on a scheme which utilizes runtime hours rather than calendar intervals for defining the preventive maintenance tasks wherever possible, Runtime hours shall be those measured by the runtime meters such as Hoist, Trolley, Gantry, Boom and Control-On Hours.

(4) The Maintenance Manual shall be provided in English and local language.

(5) The Contractor shall provide three (3) sets of each of the required languages of the Maintenance Manual to the Purchaser one (1) month before the date of the first crane departure from the Contractor's manufacturing site. Receipt of the Maintenance Manuals is one of the preconditions for the issuance of the Pre-Shipment Certificate.

(6) Corrections shall be made for any changes made in the instructions during the commissioning period, and the five (5) sets of each of the required languages of the revised Maintenance Manual shall be submitted one (1) month after the notification of successful completion of the Tests on Completion of the first Crane(s)

(7) Two sets of manuals on SSD shall be submitted.

7.4.3 Lubricant List

(1) The Contractor shall supply a complete list of oil and lubricants to be used on the Crane three (3) months after the date of the Agreement for the Purchaser's approval.

(2) All the oil and lubricants used for the crane shall be selected from those available locally in the country of operation and used by the Purchaser.

7.4.4 Structural Maintenance Program

(1) The fatigue criteria in this specification are based on producing a damage tolerant design. Because of the variation of fatigue performance and that usage may exceed the design conditions, there is a risk that a structure or component may fail in service. When fatigue cracks develop, the remaining structure should sustain the maximum working load until the cracks are discovered. Satisfactory performance of the damage tolerant design, therefore, depends on adequate methods of fatigue crack detection and the ability to repair or replace the damaged component. The intent of this section is to define a method of routinely inspecting for fatigue cracks to significantly improve the structural reliability.

(2) Periodic structural inspections are required to detect cracks that have developed during d the life of the crane. The inspection intervals defined below are based on fracture mechanics calculations, reliability analysis, and the fact that fatigue cracks can be classified as infant and aging failures. The Delivery Inspection and Warranty Inspection should detect infant failures and subsequent periodic Maintenance inspections should detect aging failures. Infant failures are primarily due to deficient fabrication; underestimation of fatigue damage, which may be due to deficient design or excessive loading; or a combination of these. Aging failures are primarily due to cumulative damage from normal operations and properly designed and manufactured components.

(3) Since the integrity of the structure depends on inspections, interpretation of the results, and the choice of repair, it is important for the Contractor and the Engineer to review all reports.

(4) No later than three (3) months before the arrival of the crane(s) the Contractor shall submit a Structural Maintenance Program for review. The program shall be based on the principles of fracture mechanics and shall include the following information for both infant and aging failures:

- Inspection intervals
- Locations to be inspected
- NDT procedures to be used
- Reporting procedures
- Repair procedures
- Documentation showing the parameters used to determine the inspection intervals in accordance with the criteria specified below

i.) Inspection methods shall be selected to detect fatigue cracks. Only critical locations need to be inspected by NDT methods such as MT, DPT, RT, and UT. Critical locations on all members are those locations where fatigue cracks, if any, would be expected to initiate. The inspected region shall extend a reasonable distance beyond critical points. MT shall be used at critical locations of fillet welds and UT shall be used at critical locations of butt welds. VT shall be used at all locations of potential fatigue cracks.

ii.) Inspection intervals shall be determined according to Table 71. Locations where the cumulative damage ratios are less than those for 24 years need not be included in the Structural Maintenance Program.

iii.) The Structural Maintenance Program shall be reviewed by the Contractor's responsible Structural Engineer and he shall certify in writing that he has reviewed the program and is satisfied with it. The program shall be included in the maintenance and inspection manual.

(5) If a sea state rougher than the design sea state is encountered during the delivery voyage, the Contractor shall inform the Purchaser and Engineer and a Delivery Inspection will be performed. The extent of the Delivery Inspection will be determined by the Engineer. The Delivery Inspection will occur prior to commissioning. Within 30 days after the inspection, the Contractor shall submit a plan to repair any defects found. Upon the Purchaser’s approval of the Contractor’s plan, the Contractor shall repair the defects at his expense. The Purchaser’s independent agency will inspect the repaired defects. If any of the repairs are not acceptable the Contractor shall make additional repairs as necessary. The costs of the inspection and additional repairs shall be borne by the Contractor.

(6) The Contractor’s responsible Structural Engineer or other qualified engineer shall perform a walkthrough visual inspection of the crane after delivery and after removal of all sea-fastening and other temporary attachments and certify in writing that he reviewed the crane and is satisfied with it.

(7) Unless agreed otherwise, Structural Maintenance Program inspections will be performed by an independent agency retained by the Purchaser and in accordance with the Structural Maintenance Program.

i.) The Warranty Inspection will be made prior to the end of the warranty period, but no later than 200,000 moves. All FCM details and all details that are scheduled to be inspected at an interval of 24 years or less shall be inspected. The inspection procedures used for the Warranty Inspection shall be the same as those used for subsequent Periodic Maintenance Inspections.

ii.) Subsequent Periodic Maintenance Inspections will be made according to the recommended inspection intervals from the Structural Maintenance Program. The first Periodic Maintenance Inspection period will begin after completion of the Warranty Inspection.

iii.) Within 30 days after the Warranty Inspection or any Periodic Maintenance Inspection(s) occurring during the structural warranty period, the Contractor shall submit a plan to repair any defects found. Upon the Purchaser's approval of the Contractor's plan, the Contractor shall repair the defects that are not the result of the Purchaser's misuse of the crane, at the Contractor's expense. The Purchaser's independent agency will inspect the repaired defects. If any of the repairs are not acceptable, the Contractor shall make additional repairs as necessary. The costs of the additional inspection and repairs shall be borne by the Contractor.

(8) The Contractor shall provide permanent access ladders and platforms at all inspection locations, with inspection intervals of 12 years or less. Access shall meet applicable safety laws and regulations.

INSPECTION INTERVAL vs. CUMULATIVE DAMAGE RATIO D = L/K_1 OR L/K_2						
DETAIL	24 YEARS		12 YEARS		6 YEARS	
	NFCM	FCM	NFCM	FCM	NFCM	FCM
B	0.21-0.41	0.19-0.38	0.42-0.69	0.39-0.64	0.70-1.00	0.65-1.00
C	0.18-0.36	0.17-0.33	0.37-0.62	0.34-0.57	0.63-1.00	0.58-1.00
D	0.18-0.35	0.16-0.33	0.36-0.61	0.34-0.56	0.62-1.00	0.57-1.00
E	0.15-0.29	0.13-0.26	0.30-0.50	0.27-0.45	0.51-1.00	0.46-1.00
F	0.17-0.34	0.16-0.31	0.35-0.58	0.32-0.53	0.59-1.00	0.54-1.00
F2	0.16-0.32	0.15-0.29	0.33-0.56	0.30-0.51	0.57-1.00	0.52-1.00
G	0.21-0.41	Not allowed	0.42-0.70	Not allowed	0.71-1.00	Not allowed
W	0.20-0.40	0.19-0.37	0.41-0.69	0.38-0.64	0.70-1.00	0.65-1.00
TUBULAR	0.20-0.35	0.15-0.30	0.36-0.64	0.31-0.50	0.65-1.00	0.51-1.00

Table 7.1 Inspection Interval Criteria

7.5 Shop Inspection & Tests

7.5.1 Shop Inspection and Verification

(1) Inspection and testing of the Crane shall be performed to verify or demonstrate the Crane's conformance to this Specification and the Purchaser's Requirement as set out in the other Contract documents, following the approved Specific Quality Assurance Program as stated in 7.3.1(3) above.

(2) Without limitation to the Purchaser's rights under the Agreement, the Contractor and the Purchaser shall agree to the content, nature and extent of the review, inspection and tests to be carried out to any of the Works at each of the following stages:

i.) Design.

ii.) Fabrication and assembly;

iii.) Pre-shipment;

iv.) Upon Delivery;

v.) Tests pursuant to the Conditions of Contract, which, if successful will lead to the issue of a Taking-over Certificate.

vi.) Such further tests as otherwise may be required that in the opinion of the Purchaser is pursuant to the Conditions of Contract.

(3) The Purchaser reserves the right for itself or any party authorized by the Purchaser to inspect the Crane at any time during fabrication and delivery.

(4) The Contractor shall notify the Purchaser, or any party authorized by the Purchaser of the date and place of each key inspection or test, at least three (3) weeks prior to the date when the key inspection or test is to be made.

(5) Inspection and test items shall generally include (but not limited to) the following fundamental items.

i.) Materials and components sources and identification of standards applied.

ii.) Workmanship overall.

iii.) Inspection of Operational and Maintenance Safety, Test of all safety equipment and safety devices.

iv.) Inspection of Operational Efficiency, Functional Test of all components equipped for operation.

v.) Inspection of Maintenance Efficiency, Functional Test and inspection of all equipment for maintainability.

vi.) Rated Load Tests, 1/2 Loads Tests and No-Load Tests including Test and Measurement of Speeds and accelerations.

vii.) Overload (Proof Load) Tests including Stability Test and Measurement of Structural Deflection.

viii.) Accessories and Spare Parts Inventory.

ix.) Operating Instruction and Maintenance Manual Review.

x.) Weight verification as necessary.

xi.) Statutory inspection and tests.

(6) Static wheel load verification. Any inspection or test results verified by the Purchaser shall not waive Contractor's duties or obligations to achieve satisfactory performance of the Crane in actual operation as set out in the Conditions of Contract.

(7) The Contractor shall submit to the Purchaser a list of designed weights of the moving loads, namely, the trolley, head block and spreader, and any other moving loads, when the design of these components are completed.

(8) At the same time, Contractor shall submit a list of calculated maximum structural stresses at critical points of the Crane structure.

(9) The Contractor shall verify the calculated stress level by actually weighing these moving weights after the fabrication and assembly are completed.

(10) The weight of trolley assembly, head block assembly and spreader assembly shall be weighed by the Contractor and witnessed by the Purchaser’s Representative. A Certificate shall be submitted to the Purchaser.

(11) The Contractor shall be responsible for maintaining the calculated stress level within allowable limits. If there are differences between the designed weights and the actual measured weights, the

Contractor shall re-submit calculations of all stress levels based on the true weights to show that the levels are maintained within requirements. Any stress levels over the allowable limit will require a redesign to be carried out by the Contractor.

(12) The recalculation and if necessary, the redesign plan shall be submitted to the Purchaser for review no later than commencement of the pre-shipment Crane assembly load test.

7.5.2 Pre-Shipment Inspection and Test

(1) Cranes, which according to the Agreement, shall be fully erected in the Contractor's facility, shall be tested prior to shipment. Component and sub-assembly testing will be permitted if the cranes are to be delivered in knock down form to an acceptable erection site.

(2) The Contractor shall prepare a shop assembly and Crane erection program including all tests and dimensions to verify the proper installation and assembly of the crane's components. The drawings shall include assembly procedures, drawings, dimensional acceptance criteria, structural member dimensional checks, structural frame alignment dimensions, structural pin and bore fits, structural bolt torques and machinery alignments.

(3) The Contractor shall inspect the assembly of components and Crane erection throughout the process to verify and to be satisfied that the requirements of the Specification are being fully complied with in all respects.

(4) The Crane shall be fully lubricated in accordance with the manufacturer's recommendation prior to any shop testing. A lubrication checklist shall be included in the test documentation.

(5) The assembled crane shall be inspected and tested at the Contractor's assembly facility. All installations and functions shall be verified for compliance to the Specification. The Crane testing shall follow the Pre-Shipment Inspection and Test on Completion Protocol as stated in 7.3.3 above and as a minimum include the following:

(i) Verify trolley speed, acceleration according to Specification with Rated Load.

(ii) Verify hoist speeds, accelerations according to Specification with Rated Load.

(iii) Verify gantry motor rotation direction and other gantry and gantry cable reel functions to the extent possible (typically limited due to space limitations at the Contractor's erection location).

(iv) Boom travel sufficient to verify the hinge geometry. Boom hoist under crane power from operating to the stowage position and from stowage position back to operating position using automatic controls for slowdowns and stops. The boom shall hang on the disc brake at highest load position as a verification of disc brake operation.

(v) The sway control and anti-sway system shall be set up and tuned under a range of load conditions. Verify the sway control and the effectiveness of the electronic anti-sway. (If applicable)

(vi) Snag system release under reduced load. Snag load trip of hoist utilizing a lower than normal snag setting.

(vii) Trim, list and skew motions.

(viii) All interlocks and limit switch settings, and software logic.

(ix) Safety and protection systems

(x) Function tests of all systems.

(xi) Rated load and proof load tests

(xii) Function test of jib cranes and all service cranes

(xiii) Brake dynamic torque values shall be verified for each drive by driving through each brake and calculating the braking torque from the current draw. Thermal capacity of the brakes shall be verified in the same manner with torque, time and brake revolutions recorded. All

brakes shall have their linings properly burnished or seated to the manufacturer's recommendations prior to conducting these tests.

(xiv) Check structural alignment and integrity.

(xv) Inspect and demonstrate that all electrical wiring and wiring components are installed and properly marked.

(xvi) 24-hours heat run test of all systems using rated load. The heat run test is not required in case the Endurance Test is performed at the Contractor's site.

(6) The Crane's static wheel loads shall not exceed the wheel loads referred to in this Specification. Should any Crane's static wheel load exceed any such wheel load this shall constitute a Defect and the Contractor shall not be entitled to dispute this on any grounds or in any circumstances. The Contractor shall be required to carry out appropriate and accurate tests in order to identify the static wheel loads of the completely assembled Crane complete with the rated load at the maximum outreach, in between the legs and at maximum back-reach. A procedure for performing the tests shall be submitted to the Engineer for his approval prior to the tests being performed. These tests shall verify that the static wheel loads do not exceed the declared wheel loads shown in the Form of Tender. These tests shall be carried out in the presence of the Purchaser or his representative.

7.5.3 Purchaser Representatives (Shop)

(1) Purchaser representatives shall attend the Contractor's works from start of fabrication until shipment of the last crane(s).

(2) The Contractor shall provide for the Purchaser representatives at the Contractor's site(s) appropriately sized and air-conditioned office(s) with working desks & chairs, and access to the site office communication, electricity and water supply, as well as the staff's canteen and restroom facilities.

(3) The Contractor shall provide transportation for the Purchaser representatives between their accommodation and the Contractor's site(s).

(4) The Purchaser representatives shall adhere to the Contractor's site safety and health regulations.

7.5.4 Defects List / Punch List / NCR

(1) The Purchaser or his representatives shall be allowed to gain access to any part of the Crane(s) during their assembly at the Contractors facility and during the site-commissioning period for the purposes of inspecting part or completed works. If in their opinion certain parts of the Works does not meet with the requirements of the Agreement, or is deemed as bad practice or poor workmanship, then these shall be noted as a defect and informed to the Contractor in a list.

(2) The compilation and provision of this list by the Purchaser or his representative will in no way relieve the Contractor from his obligation to provide defect free crane(s).

(3) The Contractor shall be obliged to correct these defects and any other defects according to the set milestones below, prior to performing Tests on Completion, heat run (manufacturing site endurance test) and crane loading.

i. Tests on completion (65% punch-list completion)

ii. 24 hr heat run test, also referred to as manufacturing site endurance test (85% punchlist completion)

iii. Loading (98% punch-list completion)

In exceptional circumstances an alternative appropriate punch-list completion rate may be approved by the Purchaser.

(4) The rectification of defects in the defects list shall be carried out in a thorough and workmanlike manner. The Contractor shall prepare and submit to the Purchaser a rectification report that confirms defect completion together with a description of the action taken.

7.6 Shipment and Delivery

7.6.1 Clearance for Shipment

(1) Each crane shall be tested for functions of all the devices and systems in the Contractor's yard before shipment in accordance with the approved Pre-Shipment Inspection and Test on Completion Protocol as set out in 7.3.3.

(2) The Engineer (and/or Engineer's Representative) shall work with the Contractor to witness pre-shipment tests. The Engineer will issue a "Pre-Shipment Certificate" to the Contractor when tests and punch-list have been completed to his satisfaction.

(3) Pre-shipment tests which are not completed because of late performance by the Contractor may be conducted at the Site. In such case, no Pre-Shipment Certificate shall be issued by the Engineer and the Contractor shall bear all costs for the Purchaser's representative and third-party inspectors to attend the Site until the last crane has been taken over.

7.6.2 Notification of ETA Site.

(1) The Contractor shall notify the Purchaser of the estimated time of arrival of the marine transport vessel ("ETA"), which is carrying the Goods (or any part of the Goods) at least six (6) weeks prior to such ETA. Upon receiving such notice, the Purchaser shall tentatively allocate a berth at Site for delivery and unloading of the Goods. The Purchaser shall inform the Contractor of any restricted berthing periods which may exist one (1) week before and after the notified ETA.

(2) The Contractor shall confirm to the Purchaser the date of actual departure of the vessel from the loading port and thereafter without fail the daily Noon position of the vessel together with an up-dated ETA by daily Email transmission to the Purchaser to include but not limited to the following information:

(a) Call Sign/Vessel Name

(b) Condition of sea fastenings

(c) Speed in Knots

(d) Latitude

(e) Longitude

(f) Weather including wind-speed

(g) Sea conditions and swell including wave height (Beaufort scale)

(h) Time: LT/UTC

(i) ETA (LT):

(3) The exact berthing time and berthing position for the vessel shall be agreed and fixed at least one day prior to the ETA between the Purchaser and the Contractor based on the Contractor's daily position and ETA report

7.6.3 Navigation Requirement

(1) The Contractor shall be responsible for following all necessary procedures to ensure the safe passages of vessels whilst navigating in the Port. The Contractor shall maintain close contacts with the relevant Maritime Authority in the country of operation.

(2) The Cranes aviation warning lights shall be kept illuminated continually from the time the vessel carrying the crane approaches the Harbour. The temporary power source for the warning lights shall be provided by the Contractor.

7.6.4 Berthing and Roll-off Requirements

(1) The Crane shall be rolled off or lifted off from a vessel onto the designated position of the quay, then shifted to a designated test position by the Contractor. Such operations shall in no way over-stress

any part of the piled quay deck and the yard. Specifically, any loads on the quay apron, waterside of the waterside crane rail beam (overhung slab) are prohibited.

(2) The time allowed for the vessel to stay at the Purchaser's berth for the delivery and unloading of the Goods shall be as defined in the Conditions of Contract from the agreed time of berthing as set out in 7.6.2 notwithstanding the actual time of the berthing of the vessel.

(3) The vessel must leave the berth as soon as practicable after completion of the unloading regardless of the above time limit. The Contractor shall inform to the Purchaser the estimated time of departure ("ETD") of the vessel at least four (4) hours before such ETD.

(4) All the necessary calculations, design, engineering, preparation works and clean up works for the roll-off and shifting the Crane to a designated test position and testing at the site shall be the responsibility of the Contractor. The preparation works shall include obtaining necessary technical information of the quay from outside consulting engineers and obtaining necessary clearance or permit for the works from government offices concerned.

(5) The Contractor shall have obtained all necessary approval, clearance, permits, etc. required for the site works prior to the vessel departing from the Contractors facility.

7.6.5 Customs Clearance

Refer to the Conditions of Contract.

7.7 Site Work

7.7.1 Work Permits

(1) All engineer/supervisors dispatched for start-up, testing and training shall obtain proper working visas for the country of operation, which must be valid for entire estimated period of stay.

7.7.2 Site Safety and Security

(1) The Contractor shall comply with the Purchaser's security requirements for making entry or exit to and from the Terminal, and inside the Terminal.

(2) The Contractor and its subcontractors shall be responsible for protecting their own plants, tools, temporary site offices and other belongings from weather, fire or theft. The Contractor shall be responsible for sufficient fencing, guarding, lighting and watching of all the Works on the Site until taken over. The Contractor shall not use any naked light on the Site without the specific consent of the Engineer or the Engineer's Representative.

(3) The Crane(s) shall be protected by the Contractor from typhoon, fire, collision and any other possible risks until the Crane or other Works are Taken-over by the Purchaser.

(4) Erection All Risk insurance, Third Party Liability insurance, Workmen's Compensation insurance and other necessary insurances shall be secured and maintained by the Contractor in accordance with the Conditions of Contract.

7.7.3 Site Erection area and Facilities, Access

(1) The Purchaser shall make available to the Contractor the agreed area required to complete the crane(s), and for the Contractor’s office and storage containers.

(2) The Contractor shall at his own cost provide for the installation of office and storage containers.

(3) For access requirements: Refer to the Conditions of Contract.

7.7.4 Site Office Communication, Electricity and Water Supply (Utilities)

(1) The Contractor shall at his own cost provide for the installation of a telephone line for outside call, internet and facsimile purposes.

(2) The Purchaser shall make available on the Site for use by the Contractor for the purposes of the Works the supply of electricity and (if available) water. The supply points shall be located in the vicinity of the Contractor’s site office. The supply of electricity (and water) to the Contractor for the said purpose shall be free of charge.

(3) The Contractor shall provide any apparatus necessary for the use of such supplies of electricity (and water). At the end of the site works, the Contractor shall remove any apparatus installed by the Contractor and safely close the supply points.

7.7.5 Power for tests on site

(1) For cranes with electrical power supply: Electrical power supplied from the MV cable connection point to the crane(s) for conducting the final commissioning and Tests on Completion of the crane(s) shall be made available from the Purchaser to the Contractor free of charge.

(2) For cranes with diesel-electrical power supply: Diesel Fuel (including the required re-fuelling equipment) for purpose of conducting the final commissioning and Tests on Completion of the crane(s) shall be provided by the Contractor. Neither diesel fuel nor the required re-fuelling equipment may be stored at the Purchaser's Site without the written consent of the Purchaser.

7.7.6 Clearance of site

(1) From time to time during the progress of the Works the Contractor shall clear away and remove from the Site all surplus materials and rubbish and, on completion, all Contractor's Equipment. The Contractor shall at all times leave the Site and the Works clean and in a safe and workmanlike condition to the Purchaser's reasonable satisfaction.

(2) Upon completion of the site works, the Contractor shall remove any office and storage spaces, equipment, apparatus, etc. from the Site and clean the area occupied by the Contractor during the site works to the reasonable satisfaction of the Purchaser.

7.7.7 Contractor's Representatives

(1) One English speaking principal site engineer shall be dispatched prior to arrival of the Crane(s) to the Site to plan and coordinate the work and to communicate with and report to the Purchaser. He shall stay in the Purchasers locality for the entire period from delivery to Taking-over of the Crane(s) to the Purchaser.

(2) A sufficient number of qualified start-up engineers and training engineers shall be dispatched to the Purchaser's Terminal to handover the Cranes in an expeditious manner.

(3) The Contactor shall provide a qualified and competent Electro/Mechanical Service Engineer to remain on Site for a period of twelve (12) months after issue of the Taking-over Certificate for the final crane. The Contactors Service Engineer will be required to provide support to the Purchaser's maintenance engineers, assist with fault diagnosis and identification and to liaise with the Contractor's office

7.7.8 Purchaser Representatives (Site)

(1) One ICTSI representative shall attend the Purchaser's site two days prior to vessel arrival and will remain onsite until the issue of the Taking-over Certificate of the last crane(s).

(2) The Contractor shall provide for the ICTSI representative at the Contractor's site office an air-conditioned workspace with a working desk & chair, and access to the site office communication, electricity and water supply.

(3) The Contractor shall provide a pick-up truck from a local car hire company for the duration of stay until last crane has been taken over.

7.7.9 Purchaser's lifting equipment

(1) Any lifting equipment, as it may be required by the Contractor in connection with the Works, shall be provided by the Contractor. No lifting equipment belonging to the Purchaser will be provided by the Purchaser and none may be used by the Contractor in connection with the Works.

7.7.10 Test Weight (Required)

(1) Certificated load test weights shall be provided by the Contractor for the load testing and adjustment of the Crane.

(2) If a Test Weight as set out in 4.13 is included in the Contractor's scope of supply, such Test Weight shall be used for the load testing and adjustment of the crane(s) and shall become the property of the Purchaser after Taking-over of the last crane which is to be supplied under the Agreement.

7.8 Site Inspection and Tests, Certification

7.8.1 Tests on Completion

(1) The Crane(s) and other Works shall be verified at Site as operational and safe under any load conditions prior to the Tests on Completion. Only minor items pertaining to maintainability which do not affect the safety of operations or maintenance work may be allowed by the Purchaser as a pending item for correction at the time of the Taking-over Certificate. These items shall form part of the Defects List (=Punch List / NCR).

(2) The Tests on Completion will be as defined in the approved Pre-Shipment Inspection and Test on Completion Protocol as set out in 7.3.3. The Contractor shall show the Purchaser by documentation or by physical demonstration (in either case as determined by the Purchaser) that all functions of the Crane(s) or other Works are safe and conform to the Agreement. The Contractor shall correct or modify whatever aspect is found unsafe. The Crane(s) and other Works shall pass the statutory tests, which will be carried out and witnessed by the Purchaser's Representative.

7.8.2 Proof Load Test

(1) The Proof Load Test forms part of the Tests on Completion. The Crane(s) shall be required to undergo a test to demonstrate the stability of the Crane(s). The proof load shall comply with Country Law and shall be at least 100% of maximum lifted load for the dynamic test and 125% of maximum lifted load for the static test. Details of the Proof Load Test will be as defined in the approved Pre-Shipment Inspection and Test on Completion Protocol as set out in 7.3.3.

(2) If required by Country law, the Contractor shall be responsible for the issuance of a Proof Load Certificate from an inspection authority acceptable to the local authorities in the country of operation

(3) The test load for the Proof Load Test shall be provided by the Contractor.

7.8.3 Endurance Test

(1) The Endurance Test forms part of the Tests on Completion. The Crane(s) shall be required to undergo a test to demonstrate the combined operation of all Crane systems and the reliability of the components. The endurance test shall consist of repetitive cycling as follows whilst handling the Crane's rated load.

i) Pick up the container at the halfway point of the full back-reach of the crane.

ii) Hoist up above half of the crane maximum lifting height.

iii) Trolley forward to the centre between the crane rails.

iv) Lower to approximately 1-meter height above quay level.

v) Wait 30 seconds.

vi) Hoist up above half of the crane maximum lifting height.

vii) Trolley forward to halfway position of the crane full outreach.

viii) Lower to approximately 1-meter height above quay level.

ix) Wait 30 seconds.

x) Hoist up above half of the crane maximum lifting height.

xi) Trolley back to the centre between the crane rails.

xii) Lower container to ground.

xiii) Unlatch the container.

xiv) Hoist up to approximately 5 metres below the crane maximum lifting height.

xv) Trolley back to the halfway point of full back-reach.

xvi) Lower to approximately 3 metres above quay level.

xvii) Repeat cycle in reverse order.

xviii) After each 30-minute operation the crane(s) shall gantry for a minimum of 30 metres to a new position and the cycle repeated. The crane shall then gantry back to the original test position.

(2) This cycle is a preliminary proposal, and the final test cycle shall be determined by the crane configuration and in agreement with the Purchaser.

(3) The endurance test shall be continued for a period of 24 hours. During the initial 16 hours, faults eliminated within 15 minutes shall not result in the failure of the endurance test, with the provision the total amount of downtime in the first 16 hours does not exceed 30 minutes. In the event of a malfunction in the final 8 hours of the endurance test, the endurance test shall be continued until 8 hours of trouble-free operation have been logged.

(4) Throughout the period of testing the current, voltage, speed, main drive mechanism temperature, noise and vibration shall be recorded at intervals of 1 hour. Any malfunctions or problems and any remedial action taken during the test shall be recorded.

(5) The crane operators for the Endurance Test shall be provided by the Contractor.

7.8.4 Oil Sample Test

(1) Oil samples shall be taken from each gearbox and hydraulic unit after the completion of the endurance test for verification of proper lubricant, freedom from contamination, and absence of deterioration of the lubricated device.

(2) Samples shall be analysed by a local qualified independent laboratory at the cost of the Contractor. As a minimum, tests shall include:

i) Kinematic Viscosity @ 40ºC

ii) Particle Count

iii) Water by Karl Fisher

iv) Metals by Spectroscopic

(3) Test results demonstrating the proper lubricant / hydraulic oil, lack of contamination, and absence of deterioration shall be provided to the Engineer with the Pre-Shipment Inspection and Test on Completion Protocol.

7.8.5 Taking-over Certificate

(1) The Taking-over Certificate will be issued on successful completion of the Tests on Completion (including the Endurance Test and Proof Load Test), and training as defined in 7.9. The Taking-over Certificate shall include the Punch List as defined in 7.8.1(1).

**CLARIFICATION: Any outstanding training at the time of taking over shall be completed within two (2) months of the date specified in the taking over certificate. A detailed training schedule for shall be provided prior to taking over.*

7.8.6 Remedial Work

(1) Outstanding items (also called "punch list items") shall be rectified by the Contractor after the Taking-Over within eight (8) weeks or a period as agreed by the Purchaser and the Contractor. The Purchaser shall give the Contractor access to the Works as necessary to resolve the punch list items.

7.9 Training and Familiarization

7.9.1 Design Review

(1) The Contractor shall provide the following for the Purchaser's engineering personnel, as defined below, to attend two (2) one (1) week STS crane design review meetings, at the Contractor's manufacturing facility or an alternative mutually agreeable location. All associated costs shall be at the Contractor's account, including Business Class airfare, local transportation, daily subsistence, and accommodation at an International 4-Star rated hotel.

For clarity each design review meeting shall allow for a seven (7) day hotel stay.

a. Three (3) attendees from BCT, Poland

b. One (1) attendee from ICTSI, Manila

7.9.2 Training and Familiarization Off-Site.

(2) The Contractor shall conduct off-site training and familiarization for the Purchaser's maintenance personnel as defined below. This training shall be at the Contractor's account, including Premium Economy class airfare, local transportation and boarding at an International 4-Star rated hotel. The Overseas Training shall be conducted in English language.

(3) Training off-site is dedicated to crane PLC (one week) and drive application training (one week). Training shall be conducted by drive system supplier at dedicated regional (Purchaser's location) training centre.

For this project, PLC and drives application training shall be provided for 4 attendants.

(4) During crane manufacturing, the Contractor shall facilitate familiarization and inspections at his works.

For this project, familiarization during manufacturing shall be provided for 4 attendants for 6 weeks per attendant.

(5) During crane commissioning and testing, the Contractor shall facilitate familiarization and inspections at his works.

For this project, familiarization during manufacturing shall be provided for 4 attendants for 6 weeks per attendant.

7.9.3 Training On-Site (Maintenance)

(1) The Contractor shall carry out the maintenance training of the Purchaser's staff during the commissioning period and following the Tests on Completion of the Crane. The training shall be conducted by suitable Contractor and Crane component supplier trainers and in local language.

(2) The training shall be by way of classroom and practical sessions and the content of the training shall include but not be limited to the following:

i) Instruction and hands-on training of starting and shutdown procedure.

ii) Instruction and explanation of all the devices on the Crane (separately for electrical and mechanical staff).

iii) Instruction of Start-stop procedure and checking points of all the devices or systems on the Crane.

iv) Lectures on electrical/electronic control systems of the Crane and adjustment method/standards both in a classroom and on the Crane.

v) Lectures on mechanical/hydraulic systems of the Crane and adjustment method/standard both in a classroom and on the Crane.

vi) Lectures on Condition Monitoring System on the Crane and in a classroom.

vii) Inspection and Maintenance of Operationally Critical Components.

viii) Instruction on trouble-shooting and repair.

ix) Instruction on emergency equipment and procedures, such as Emergency stop buttons, Escape route, Firefighting equipment

x) Instruction on the use of equipment for Communication

xi) Instruction on routine maintenance of devices and preventive maintenance plan, including explanation of special tools, gauges or jigs.

For this project, mechanical maintenance training shall be provided for 2 groups of 5-8 maintenance staff per group, for 1 week per group. Electrical maintenance training shall be provided for 2 groups of 5-8 maintenance staff per group, for 1 week per group

(3) Specialist training on the following operationally critical components shall be arranged by the Contractor and to be provided by the component suppliers representatives:

i) Telescopic Spreader (min. 2 days)

ii) Elevator (min. 1 day)

iii) MV and Spreader Cable Reels (min. 1 day)

iv) Cable chain (min. 1 day)

v) Cabin

vi) Service and Emergency Brakes

vii) Wire ropes

7.9.4 Familiarization On-Site (Operators)

(1) The Contractor shall carry out the operator familiarization of the Purchaser's staff during the on-site commissioning period following the Tests on Completion of the Crane(s) or other Works. The familiarization shall be conducted by suitable Contractor personnel and in local language.

(2) The familiarization shall be by way of classroom and practical sessions and the content shall include but not be limited to the following:

i) Instruction and hands-on training of the cranes start-up procedure.

ii) Instruction on lighting control.

iii) Instruction and hands-on training of normal container handling operation in the cab.

iv) Instruction and hands-on training of normal shutdown procedure.

v) Instruction on the use of equipment and procedures for emergency, such as Emergency stop buttons, Escape route, Firefighting equipment

vi) Instruction on the use of equipment for Communication

For this project, operator's familiarization shall be provided for 4 groups of 3-4 operators per group for 2-3 days per group.

7.10 Spare Parts

7.10.1 Ordered Spare Parts – not applicable

7.10.2 Spare Parts for Commissioning Work – not applicable

7.11 Crane Model

(1) The Contractor shall provide two (2) scale models of the crane(s). The models shall be 1:200 scale and shall bear the specified crane livery and logos.

8 APPENDICES

Appendix 1. Stipulated Components

Note: * denotes the items which constitute "Major Stipulated Components" for purpose of milestone payment triggers.

Item No.	Description of Stipulated Component	Stipulated Suppliers for Item	Tenderer's Preferred Supplier Chosen from Stipulated Suppliers
(1)	Structure Steel, main structures ▪ Plates and structure sections ≥35mm thickness	Renowned global producers Renowned global producers	
(2)	Structure Steel, secondary structures	Renowned global producers	
(3)	Paint	Renowned global producers	
(4)	Spreader *	Renowned global producers	
(5)	MV switchgear *	Renowned global producers	
(6)	MV transformer(s) *	Renowned global producers	
(7)	Drive Inverter System *	Renowned global producers	
(8)	PLC & Remote I/O's	Renowned global producers	
(9)	LV switchgear components	Renowned global producers	
(10)	Electrical System Integration	Crane manufacturer, System Supplier	Crane Manufacturer
	Drive Motors *		
(11)	▪ Main Hoist	Renowned global producers	
(12)	▪ Boom Hoist	Renowned global producers	
(13)	▪ Trolley	Renowned global producers	
(14)	▪ Gantry	Renowned global producers	
	Gear Reducers *		
(15)	▪ Main Hoist	Renowned global producers	
(16)	▪ Boom Hoist	Renowned global producers	
(17)	▪ Trolley	Renowned global producers	
(18)	▪ Gantry	Renowned global producers	
	Brakes *		
(19)	▪ Main Hoist (Service)	Renowned global producers	
(20)	▪ Main Hoist (Emergency)	Renowned global producers	
(21)	▪ Boom Hoist (Service)	Renowned global producers	
(22)	▪ Boom Hoist (Emergency)	Renowned global producers	
(23)	▪ Trolley (Service)	Renowned global producers	
(24)	▪ Trolley (Holding brake)	Renowned global producers	
(25)	▪ Gantry (Service)	Renowned global producers	
(26)	▪ Gantry (Wheel)	Renowned global producers	
(27)	▪ Hydraulic Power Packs	By brake manufacturer	
	Couplings		
(28)	▪ Main Hoist Drum	Renowned global producers	
(29)	▪ Boom Hoist Drum	Renowned global producers	
(30)	▪ Trolley Rope Drum	Renowned global producers	

Item No.	Description of Stipulated Component	Stipulated Suppliers for Item	Tenderer's Preferred Supplier Chosen from Stipulated Suppliers
(31)	▪ Brake Disc Couplings	By the stipulated brake supplier	
(32)	▪ Other transmission couplings	Contractor to propose	
	Hydraulic systems (other than brakes)		
(33)	▪ Main components	Renowned global producers	
(34)	▪ Cylinders	Contractor to propose	
(35)	▪ Hydraulic system integration	Contractor to propose.	
	Bearings	Renowned global producers	
(36)	▪ Main hoist, trolley, boom hoist and gantry reducer		
(37)	▪ Main hoist, trolley and boom hoist sheaves		
(38)	▪ Catenary trolley sheaves		
(39)	▪ Main hoist drum pedestal bearing		
(40)	▪ Trolley drum pedestal bearing		
(41)	▪ Boom hoist drum pedestal bearing		
(42)	▪ Trolley wheels		
(43)	▪ Trolley horizontal wheels		
(44)	▪ Catenary trolley wheels		
(45)	▪ Catenary trolley horizontal wheel		
(46)	▪ Gantry wheels		
(47)	▪ Other bearings	Contractor to propose	
(48)	Auto-Lubrication System	Renowned global producers	
(49)	Intelligent Status Monitoring System	Renowned global producers	
(50)	Lightning and surge protection	Renowned global producers	
(51)	Rail Clips	Renowned global producers	
(52)	Buffers	Renowned global producers	
(53)	Wire Rope	Renowned global producers	
(54)	Wire Rope Sheaves 100% Forged	Contractor to propose.	
(55)	Wire Rope Rollers	Renowned global producers	
(56)	Personnel Elevator*	Renowned global producers	
(57)	Maintenance Hoist including the overhead traveling girders	Renowned global producers	
(58)	MV Cable Reeling System *	Renowned global producers	
(59)	MV Trailing Cable	Renowned global producers	
(60)	Trolley Energy Cable Chain	Renowned global producers	
(61)	Trolley Energy Cable Chain Cables	Renowned global producers	
(62)	Spreader feed cable reeling system *	Same as MV cable reel system	
(63)	Spreader Feed Cable	Renowned global producers	
(64)	Spreader Cable Plug/Socket	Renowned global producers	
(65)	Electrical Cables – Drive Motors	Renowned global producers	
(66)	Electrical Cables – Fixed & Flexible	Renowned global producers	
(67)	Operator's Cabin *	Renowned global producers	

Item No.	Description of Stipulated Component	Stipulated Suppliers for Item	Tenderer's Preferred Supplier Chosen from Stipulated Suppliers
(68)	Driver's Seat & Consoles *	Renowned global producers	
(69)	Master Controller	Renowned global producers	
(70)	Air Conditioning Units	Renowned global producers	
(71)	LED Floodlights	Renowned global producers	
(72)	LED Walkway lights	Renowned global producers	
(73)	Communications	Renowned global producers	
(74)	Overload Protection & Alarm	Renowned global producers	
(75)	Anemometer	Renowned global producers	
(76)	LED Aviation Light	Renowned global producers	
(77)	Gantry Warning Alarm/Light	Renowned global producers	
(78)	Drum Encoders	Renowned global producers	
(79)	Limit Switches (Small)	Renowned global producers	
(80)	Limit Switches (Large)	Renowned global producers	
(81)	Gravity Limit Switch	Renowned global producers	
(82)	Magnet operated Limit Switches	Renowned global producers	
(83)	Proximity Switches	Renowned global producers	
(84)	Photoelectric Switch	Renowned global producers	
(85)	Vessel Profiling System	Renowned global producers	
(86)	Chassis Positioning System (CPS)	Renowned global producers	
(87)	Narrow Beam Radar Sensors (Gantry anti-collision)	Renowned global producers	
(88)	Fire Suppression System for E-rooms	Renowned global producers	
(89)	Cabin Access and Gate Interlock	Renowned global producers	
(90)	Operator Aid and Boom Latch Camera and Monitor	Renowned global producers	
(91)	CCMS & Remote CMS	By electrical system integrator	

Appendix 2. Crane Livery, Purchaser's Logo, Asset Numbers

The following table shall be read in conjunction with Clause 6.4 (Crane Livery, Purchaser's Logo, Asset Numbers, Signs).

	ITEM	Location	PAINT COLOR
(1)	Main Steel Structure		Traffic Orange RAL 2009
(2)	Operator's Cabin	Exterior	Traffic White RAL 9016
(3)	Checker's Cabin	Exterior	
(4)	Machinery House	Exterior & Interior	
(5)	Operator's Cabin	Interior & Floor	Traffic Grey A RAL 7042
(6)	Checker's Cabin	Interior & Floor	
(7)	Machinery House	Floor	
(8)	Trolley		Traffic Yellow RAL 1023
(9)	Spreader	Excluding Flippers	
(10)	Head-block		
(11)	Stairways, Ladders, Platforms & Handrails	Treads of stairways and grids of platforms shall be left in galvanized condition	
(12)	Buffers	Trolley and Gantry End of Travel	
(13)	Guards	Around machinery, wheels, couplings etc.	
(14)	Container Top Safety Frame		
(15)	Hook Beam	(if applicable)	
(16)	Test Weight	(if applicable)	
(17)	Spreader Trailer	(if applicable)	
(18)	Flippers on Spreader	With colour coded paddles	Traffic Red RAL 3020
(19)	Junction boxes	Stainless steel, protected by a translucent protection layer (film or lacquer)	None
(20)	Cable runways – external	Cable trays/covers, cable ladders, conduits	Same colour as the surrounding structure or the structure they are mounted to
(21)	Major component – external	Reducers, motors, hydraulic power packs and cylinders	
(22)	Major component – internal	Reducers, motors, hydraulic components	Original equipment manufacturers' colour
(23)	Other components – internal and external	Brakes, limit switches, lights, etc.	
(24)	Company Logo	Mounted on the sides of the M-house	As per logo definitions



	ITEM	Location	PAINT COLOR
(25)	Crane designations	Numbers will be attached to the equipment	*TBD*
(26)	Spreader designations	Including spare spreader	*TBD*
(27)	Cargo beam designations		*TBD*
(28)	CTSF designations		*TBD*
(29)	Test Weight designations		*TBD*

Appendix 3. Tools List

The following table shall be read in conjunction with Clause 6.8.1 (Maintenance Tools).

	ITEM	QUANTITY	COMMENT
	Mechanical Maintenance Tools		
(1)	Stainless steel wear gauges for: ▪ Each of the sheave grooves ▪ Trolley and gantry wheels ▪ Each of the wire rope winch drum grooves	1 (one) set per crane	Each wear gauge shall be clearly marked with the component name to be gauged.
	Hydraulic Maintenance Tools		
(2)	Digital manometer complete with remote tubes and adaptors for each of the hydraulic systems	2 (two) set per crane	
(3)	Long access Allen keys to adjust hydraulic pumps, fit solenoids and maintain other hydraulic components	2 (two) set per crane	
	Electrical / Electronic Maintenance Tools		
(4)	Siemens M4 Premium PG laptop computer preloaded with all software necessary to interface with PLC's, Drives, CCMS, Spreader and/or other devices requiring program reload, data download or fault diagnostic tracing with external computer.	1 (one) set per contract	Laptop computers provided shall be fit for purpose for the rugged environment in which they are to be used. Laptop specifications to be reviewed and approved by the Purchaser.
(5)	Interface components such as cables, converters or plugs and sockets necessary to connect the PG shall be supplied.	2 (two) set per laptop computer	
(6)	Original software to operate the computer or communicate with devices, along with any instructions for use.	1 (one) set per laptop computer	The operating license shall be assigned to the Purchaser.
(7)	Autem Pro 5 PLC analyser software installed on Field laptops	1 (one) set per laptop computer	
(8)	Multi-meter – Fluke Type 289 to include frequency and max/min function fitted with "Fluke-289TPAK" and "Fluke C781 Carrying Case" accessories, with electronic test probe sets "Fluke TL 90".	2 (two) set per contract	
(9)	Oscilloscope – Fluke Type 190 -204 series II fitted with "Fluke VPS410 Kit".	1 (one) set per contract	
(10)	Clamp Ammeters – Fluke Type i1010 to include AC, DC, Voltage and Current	2 (two) set per contract	
(11)	Fibre Optic cleaning and testing kit such as Kingfisher KI2000 or SimpliFibre® Pro Optical Power Meter and Fibre Test Kit	1 (one) set per contract	
(12)	Profibus analyzer such as Procentec ProfiTrace Ultra Plus	1 (one) set per contract	
(13)	Insulated Electrical Tool sets (VDE Type) including: ▪ Screwdrivers ▪ Side Cutters ▪ Combination Pliers	2 (two) set per crane	
(14)	Lux Lighting measurement meters	2 (two) set per contract	

	ITEM	QUANTITY	COMMENT
(15)	Noise Meters	2 (two) set per contract	
(16)	Vibration Measurement Meters	2 (two) set per contract	
(17)	Infra-Red Thermal Imaging Tool Type FLK-Ti25 9 Hz	1 (one) set per contract	
(18)	Insulation Resistance Testing Meter – Type 1555 with 10KV Insulation Tester Kit "Fluke-1555".	1 (one) set per contract	
(19)	High Quality Ratchet Crimp Tool Set for RYB crimps and bootlace ferrules	2 (two) set per contract	
(20)	Gas soldering iron	2 (two) set per contract	
(21)	Tachometers	2 (two) set per contract	
(22)	Laser Alignment system such as TKSA 80	1 (one) set per contract	
(23)	Very Low Frequency (VLF) test equipment f	1 (one) set per contract	
(24)	Label printing machine and 3M tapes for replacement of labels	1 (one) set per contract	

Appendix 4. Documentation Status Control Sheets

Item	Description	Due / Actual Dates	Comments
1.	**Submittal of Project Documents**		
(a)	Project Organization Chart (Shop & Site) → 7.1.2	2 weeks after contract award	
(b)	Project Schedule / Programme (Shop & Site) → 7.1.3	2 weeks after contract award	
(c)	Project Progress Report → 7.1.4	Monthly until taking-over of last crane(s)	
(d)	Ordered Spare Parts List → 7.1.8	not applicable	
(e)	Training Program → 7.1.9	3 months before arrival of first crane(s)	
2.	**Submittal of Conceptual Design Drawings**	1 month after contract award	PDF-files, plotted in original document size, black & white
(a)	Drawing Management System details → 7.2.1		
(b)	Crane General Arrangement with overall/main dimensions and speeds of operation		
(c)	Trolley General Arrangement		
(d)	Head-block General Arrangement		
(e)	Head-block Twist Lock Assembly		
(f)	Spreader General Arrangement		
(g)	Spreader Twist Locks Assembly		
(h)	Gantry Trucks & Equalizers General Arrangement		
(i)	Machinery House General Arrangement		
(j)	Operator's Cab General Arrangement		
(k)	Control Consoles & Chair Layout in the cab		
(l)	Operator Visibility Diagram		
(m)	Tie Down Equipment (Gantry, Trolley)		
(n)	Wheel Clamp Arrangement		
(o)	Boom Hinge and Support Details		
(p)	Wire Rope Support for Stowed Boom		
(q)	Boom Latch Locking Device		
(r)	Trolley Rail and Transition at Girder / Boom		
(s)	Walkways, Stairs & Platforms (Layouts and Details)		
(t)	Rope Reeving Diagram with Rope End Fixing Details		
(u)	Main Hoist Drive Arrangement		
(v)	Trolley Drive Unit Arrangement		
(w)	Boom Hoist Drive Unit Arrangement		
(x)	Gantry Drive Arrangement		
(y)	Trimming Device Arrangement		
(z)	Listing Device Arrangement		
(aa)	Skewing Device Arrangement		
(bb)	Wheels (Gantry and Trolley) Detail		
(cc)	Sheaves Detail with material, treatment and profile		
(dd)	Emergency Motors Calculations		
(ee)	Maintenance Hoist Detail and General Arrangement		
(ff)	Personnel Elevator Arrangement and Access Details		
(gg)	Checker's Cab General Arrangement		

Item	Description	Due / Actual Dates	Comments
(hh)	Electrical One Line Diagram		
(ii)	Typical electric details such as support of boxes, lights, and conduit/tray arrangements/segregation		
(jj)	Crane Livery, Purchaser's Logo, Asset Numbers, Signs drawings → 6.4		
3.	**Submittal of Calculations and Data**	1 month after contract award	PDF-files, plotted in original document size
(a)	Stability Calculations (including Dynamic Snag Load Condition)		
(b)	Wheel Loads and Typhoon Tie down Loads Calculations including wind load analysis		
(c)	Stress Calculation for Critical Areas of Structure		
(d)	Fatigue Analysis for Crane Structure		
(e)	Design calculations for the hoist, trolley, gantry, and boom hoist main motion component parts		
(f)	Gearbox sizing calculation		
(g)	Brake sizing calculation with approval from the brake supplier		
(h)	Drive motor sizing calculation		
(i)	Manufacturer motor data sheets for selected application		
(j)	Converter and Motor Module sizing calculations with approval from drive system supplier		
(k)	Main Hoist Load/Speed Curve		
(l)	Trim list, skew and snag component sizing and selection		
(m)	Hydraulic system component sizing calculation		
(n)	Gantry Buffer Load Calculations (Boom Lowered and Boom Stowed)		
(o)	Trolley Buffer Load Calculations		
(p)	Rail Clamp Capacity Calculations		
(q)	Gantry Braking Capacity and Braking Distance Calculations (under various wind load conditions up to braking limit)		
(r)	Wire Rope Fleet Angle Calculations		
(s)	Electrical load calculations inclusive Peak Power Consumption and voltage drop over crane supply cables		
(t)	MV switchgear data sheets		
(u)	Transformer sizing calculations and transformer data sheet		
(v)	Harmonics and Power Factor Calculations		
(w)	Electrical room(s) cooling and heating calculation		
(x)	Lighting calculations		
(y)	Noise calculations		
4.	**Review of Conceptual Design Drawings, Calculations and Data**	2 weeks after receipt of concept. design	Marked-up PDF-files
(a)	Review of Conceptual Design Drawings		
(b)	Review of Calculations and Data		
5.	**First Design Review Meeting**	Following review of conceptual design	At Contractor's design office

Item	Description	Due / Actual Dates	Comments
6.	**Submittal of Detailed Design Drawings, Calculations and Data**	1 month after first design review meeting	PDF-files, plotted in original document size
(a)	All revised design documents as required during the first design review meeting		
(b)	All remaining main structure general and detailed drawings		
(c)	All remaining mechanical general and detailed drawings		
(d)	Power Cable Reel and Slip Ring data sheets		
(e)	Power Cable Specification and Sectional Dimension Drawing		
(f)	Trolley Cable Chain specification		
(g)	Spreader cable reel system and spreader cable data sheets		
(h)	Electrical Circuit Diagrams		
(i)	Crane control interlocking and safety function description		
(j)	Communication system drawings and data sheets		
(k)	CCMS/RCMS system drawings and function description		
(l)	Control Panels/Operation Stations General Arrangement		
(m)	Switchgear General Arrangement		
(n)	Cooling system design and Air Conditioners data sheets		
(o)	Cable laying detailed drawings and description		
(p)	All other structural, mechanical and electrical general and detailed drawings as requested by the Engineer.		
(q)	All other structural, mechanical, and electrical calculations as requested by the Engineer		
7.	**Review of Detailed Design Drawings, Calculations and Data**	2 weeks after receipt of detailed design	Marked-up PDF-files
(a)	Review of Detailed Design Documents		
8.	**Second Design Review Meeting**	Following the review of detailed design	At Contractor's design office
9.	**Submittal of Final Design Drawings, Calculations and Data (=Design freeze)**	2 weeks after second design review meeting	PDF-files, plotted in original document size
(a)	All revised design documents as required during the second design review meeting		
(b)	All other structural, mechanical and electrical general and detailed drawings as requested by the Engineer.		
(c)	All other structural, mechanical, and electrical calculations as requested by the Engineer		
10.	Quality Assurance Inspection and Test Protocols		
(a)	Quality Assurance Program / Manuals → 7.3.1	1 month after contract award	PDF-file
(b)	Pre-Shipment Inspection and Test on Completion Protocol → 7.3.3	4 months before shipment of the first crane(s)	PDF-file
(c)	Complete set of the Contractor's QC documentation of the crane(s)	Before loading on to the vessel	PDF-file (scanned copy of original documents)

Item	Description	Due / Actual Dates	Comments
(d)	Static wheel load verification / Weight reports → 7.5.2(6)	Before loading on to the vessel	PDF-file (scanned copy of original document)
(e)	Completed Pre-Shipment Inspection Protocol (of each crane)	Before loading on to the vessel	PDF-file (scanned copy of original document)
(f)	Completed Pre-Shipment Inspection and Test on Completion Protocol (of each crane)	1 month after taking-over of each crane	Original protocol and PDF-file (scanned copy of original document)
11.	**Submittal of Crane Shipment and Site Activity Documents**	3 months before arrival of first crane(s)	
(a)	Crane Delivery Method Statement → 7.1.5		
(b)	Site Work Method Statement → 7.1.6		
(c)	Daily Plan and Report (Site) → 7.1.7	Daily (upon Site activities commenced)	
(d)	Voyage route, Sea-state loads, design waves, accelerations, vessel sailing schedule, justification for criteria (DNV)		
(e)	Crane transportation Stability Calculations including corner loads and led loads for the design criteria		
(f)	Sea fastening calculations including allowable stress, safety factors		
(g)	Off-Loading Calculations including dock structural stress analysis, jacking loads, rolling/skidding loads		
(h)	All loading, shipping, sea-fastening, and unloading drawings (arrangements and details)		
12.	**Submittal of Operation and Maintenance Instructions**		
(a)	Preliminary Operation Manuals (English) → 7.4.1	3 months before arrival of first crane(s)	3 sets hardcopy and 2 sets SSD
(b)	Preliminary Operation Manuals (local language) → 7.4.1	3 months before arrival of first crane(s)	3 sets hardcopy and 2 sets SSD
(c)	Final Operation Manuals (English) → 7.4.1	1 month after Taking-over of the first crane(s)	5 sets hardcopy and 2 sets SSD
(d)	Final Operation Manuals (local language) → 7.4.1	1 month after Taking-over of the first crane(s)	5 sets hardcopy and 2 sets SSD
(e)	Preliminary Maintenance Manuals (English) → 7.4.2	3 months before arrival of first crane(s)	3 sets hardcopy and 2 sets SSD
(f)	Preliminary Maintenance Manuals (local language) → 7.4.2	3 months before arrival of first crane(s)	3 sets hardcopy and 2 sets SSD
(g)	Final Maintenance Manuals (English) → 7.4.2	1 month after Taking-over of the first crane(s)	5 sets hardcopy and 2 sets SSD
(h)	Final Maintenance Manuals (local language) → 7.4.2	1 month after Taking-over of the first crane(s)	5 sets hardcopy and 2 sets SSD

Item	Description	Due / Actual Dates	Comments
(i)	Operationally Critical Components with inspection and replacement schedule → 2.12	1 month after Taking-over of the first crane(s)	PDF-files, plotted in original document size
(j)	Lubricant List → 7.4.3	3 months after contract award	PDF-files, plotted in original document size
(k)	Structural Maintenance Program → 7.4.4	3 months before arrival of first crane(s)	PDF-files, plotted in original document size
13.	**Submittal of As-built Design Documents**	1 month after Taking-over of the first crane(s)	
(a)	As-built structural, mechanical and electrical drawings		
(b)	Detailed drawings for wearing parts		
(c)	Control logic programs and parameter settings		
(d)	Full details of all bought-in equipment, drawings, instructions, etc.		
(e)	List and specification of structural connection bolts and machinery fitting bolts with tightening torque value for each location/size.		

Appendix 5. Inspection / Test Control Sheets

The following six sheets provide a guide to the minimum inspection, test, reports and certifications which are required by the Purchaser.

Codes depicted in the Inspection / Test Control Sheets are defined as follows:

By the Contractor

M	=	Mill Certificate to be submitted
R	=	Inspection Report to be submitted
T	=	Test Report to be submitted

By the Purchaser, Engineer or Engineer's Representative

C1	=	Certificates or reports to be produced
W1	=	Inspection / Test to be witnessed for 100% of the Works
W3	=	Inspection / Test to be witnessed at random for 5% - 20% of the Works

Quayside Crane
Inspection Sheet (1 of 7)

I) **Main Structure**	Chemical Properties	Mechanical Properties	Welding Process and Welder Qualifications	Edge Preparation check & Visual Inspection of Welds	Non-Destructive Test	Hardness	Visual Inspection and Weather Protection Check	Dimensional Check	Proof Load Test	Breaking Test	Function or Heat Run Test	Dielectric Test	Insulation Test	Characteristics Test	Painting	Weighing	Load Test (Note)	Deflection Measurement	Inventory	Preparation work for Ship/Pack
Portal Frame (Sill beam, Legs, Portal Tie, Diagonal Beam and Girder Support Beam	M	M			M			R												
	C1	C1	C1	W3	C1		W1	W3							W3					
Trolley Girder	M	M			M			R												
	C1	C1	C1	W3	C1		W1	W3							W3					
A - Frame	M	M			M			R												
	C1	C1	C1	W3	C1		W1	W3							W3					
Boom	M	M			M			R												
	C1	C1	C1	W3	C1		W1	W3							W3					
Back Stay & Forestay	M	M			M			R												
	C1	C1	C1	W3	C1		W1	W3							W3					
Bogie & Equalizer Beam	M	M			M			R												
	C1	C1	C1	W3	C1		W1	W3							W3					
Trolley Frame	M	M			M			R												
	C1	C1	C1	W3	C1		W1	W3							W3					
Machinery House & Machinery House Fittings								R												
							W1	W3							W3					
Typhoon Tie Down Gear (if applicable)	M	M			M			R	T											
	C1	C1	C1	W3	C1		W1	W3	W1						W3				W1	W1
Spreader Frame and Headblock Frame	M	M			M			R												
	C1	C1	C1	W3	C1		W1	W3							W3					

Note:

Quayside Crane
Inspection Sheet (2 of 7)

II) Machinery Equipment	Chemical Properties	Mechanical Properties	Welding Process and Welder Qualifications	Edge Preparation check & Visual Inspection of Welds	Non-Destructive Test	Hardness	Visual Inspection and Weather Protection Check	Dimensional Check	Proof Load Test	Breaking Test	Function or Heat Run Test	Dielectric Test	Insulation Test	Characteristics Test	Painting	Weighing	Load Test (Note)	Deflection Measurement	Inventory	Preparation work for Ship/Pack
Rope Drum	M	M			M			R												
	C1	C1	C1	W3	C1		W1	W3												
Pinion & Gear	M	M			M	T		R												
	C1	C1			C1	C1	W1	W3												
Rope Sheave	M	M				T		R												
	C1	C1				W3	W1	W3												
Wheels (Gantry & Trolley)	M	M				T		R												
	C1	C1				W3	W1	W3												
Reducer	M	M																		
	C1	C1	C1	W3		W1	W1	W1			W1									
								C1			C1									
Wire Rope (Main Hoist, Boom Hoist & Trolley)	M	M						R	T	T										
	C1	C1					W1	C1		C1										
Hydraulic Unit (Spreader, Rail Clamp, Boom Latch, Rope Tensioner & Antisway)								R			T									
							W1	W3			C1									
Twistlocks (Headblock & Spreader)	M	M			M			R	T											
	C1	C1			C1		W1	W3	W3											
Hook	M	M			M			R	T											
	C1	C1			C1		W1	W1	W3							W3				

Note:

Quayside Crane
Inspection Sheet (3 of 7)

III) Devices Subassembly (Sheet 1 of 2)	Chemical Properties	Mechanical Properties	Welding Process and Welder Qualifications	Edge Preparation check & Visual Inspection of Welds	Non-Destructive Test	Hardness	Visual Inspection and Weather Protection Check	Dimensional Check	Proof Load Test	Breaking Test	Function or Heat Run Test	Dielectric Test	Insulation Test	Characteristics Test	Painting	Weighing	Load Test (Note)	Deflection Measurement	Inventory	Preparation work for Ship/Pack
Gantry Drives								R			T									
							W1	W3			W3				W3					
Cable Reel								R			T									
							W1	W3			W3				W3					
Rail Clamp and Stowage Pin								R			T									
							W1	W3			W3				W3					
Main Hoist Drive								R			T									
							W1	W3			W3				W3					
Head Block								R			T					T				
							W1	W3			W3				W3	W1	W1			
Anti-sway Device (NOT APPLICABLE THIS CONTRACT)								R			T									
							W1	W3			W3				W3					
Separate Trolley Drive								R			T									
							W1	W3			W3				W3					
Trim / List / Skew Device								R			T									
							W1	W3			W3				W3					
Boom Hoist Drive including Emergency Brake								R			T									
							W1	W3			W3									
Boom Latch & Lock Device								R			T									
							W1	W3			W3				W3					

Note:

Quayside Crane
Inspection Sheet (4 of 7)

III) Devices Subassembly (Sheet 2 of 2)	Chemical Properties	Mechanical Properties	Welding Process and Welder Qualifications	Edge Preparation check & Visual Inspection of Welds	Non-Destructive Test	Hardness	Visual Inspection and Weather Protection Check	Dimensional Check	Proof Load Test	Breaking Test	Function or Heat Run Test	Dielectric Test	Insulation Test	Characteristics Test	Painting	Weighing	Load Test (Note)	Deflection Measurement	Inventory	Preparation work for Ship/Pack
Trolley Drive								R			T						(T)			
							W1	W3			W1									
Festoon Cable Carriers								R												
							W1	W3			W1									
Trolley Rope Tensioner								R												
							W1	W3			W1						(T)			
Spreader								R			T					T	(T)			
							W1	W3			W1				W3	W1				
																	(W1)			
Heavy Lift Beam								R								T	(T)			
							W1	W3							W3	W1			W1	W1
																	(W1)			
Air Conditioner in Operators Cab & Machinery House								R			T									
							W1	C1			C1									
													T							
Operators Cab, Cab Fittings and Control Stations																				
							W1	W3							W3				W1	
Ventilation Fan in Machinery House											T									
							W1				W1									
													T							
Maintenance Hoist								R			T			T						
							W1	W3			C1			C1			(W1)			
													T							
Trolley Assembly								R								T				
							W1	W3							W3	W1				W1

Note: 1. Item in ( ) shall be carried out at Purchaser's Site.
2. Load Test includes Rated Load Test, Overload Test and Intermediate Load Test

Quayside Cranes
Inspection Sheet (5 of 7)

IV) Electrical Equipment	Chemical Properties	Mechanical Properties	Welding Process and Welder Qualifications	Edge Preparation check & Visual Inspection of Welds	Non-Destructive Test	Hardness	Visual Inspection and Weather Protection Check	Dimensional Check	Proof Load Test	Breaking Test	Function or Heat Run Test	Dielectric Test	Insulation Test	Characteristics Test	Painting	Weighing	Load Test (Note)	Deflection Measurement	Inventory	Preparation work for Ship/Pack
HV Slip Ring								R				R			R					
							W1	C1				C1			W3					
												T	T							
HV Incoming Panel												R								
							W1	C1			W1	C1								
												T								
HV Distribution Panel								R				R								
							W1	C1			W1	C1								
												T*	T							
Transformer								R			R			R						
							W1	C1			C1	C1		C1	W3					
												T	T							
SCR Unit								R				R		R						
							W1	C1				C1	C1	C1						
													T							
AC Motor								R					R	R						
							W1	C1					C1	C1						
													T							
Magnetic Brake								R					R							
							W1	C1					C1							
													T							
Resistor								R					R	R						
							W1	C1					C1	C1						
													T							
Induction Motor								R			R		R	R						
							W1	C1			C1		C1	C1						
													T							
Control Panel								R					R							
							W1	C1					C1							
													T							

Note: * Fault Level Report shall be submitted

Quayside Crane
Inspection Sheet (6 of 7)

IV) Electrical Equipment (Cont'd)	Chemical Properties	Mechanical Properties	Welding Process and Welder Qualifications	Edge Preparation check & Visual Inspection of Welds	Non-Destructive Test	Hardness	Visual Inspection and Weather Protection Check	Dimensional Check	Proof Load Test	Breaking Test	Function or Heat Run Test	Dielectric Test	Insulation Test	Characteristics Test	Painting	Weighing	Load Test (Note)	Deflection Measurement	Inventory	Preparation work for Ship/Pack
Power Cable								R				R	(R)	R						
							W1	C1				C1	T1	C1			T*			
													(W1)							
Limit Switches													R							
							W1	C1					C1		W3					
Electrical Ground System																				
							W1						W1	W1						

Note: 1. Item in ( ) shall be carried out at Purchaser's Site.

Quayside Crane
Inspection Sheet (7 of 7)

V) Total Crane Assembly, Spare Parts, Accessories and Manuals	Chemical Properties	Mechanical Properties	Welding Process and Welder Qualifications	Edge Preparation check & Visual Inspection of Welds	Non-Destructive Test	Hardness	Visual Inspection and Weather Protection Check	Dimensional Check	Proof Load Test	Breaking Test	Function or Heat Run Test	Dielectric Test	Insulation Test	Characteristics Test	Painting	Weighing	Load Test (Note)	Deflection Measurement	Inventory	Preparation work for Ship/Pack
Air Compressor											(T)									
Crane Assembly											T		T	(T)			(T)	(T)		
							W1	W3			W1		C1		W3					W1
							(W1)	(W1)			(W3		(W1	(W1	(W1)		(W1	(W1		
Spare Parts – not applicable																				
							W1								W3				W1	W1
							(W1)												(W1)	
Accessories Wear Gauges																				
							W1								W3				W1	W1
							(W1)												(W1)	
Ro-Ro Method Statement & Program																				
																			W1	
Operating Instructions																				
																			W1	
Maintenance Manual																				
																			W1	
Oil & Lubricant List																				
																			W1	

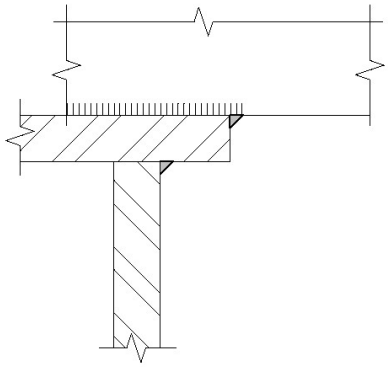
Note:
1. Item in ( ) shall be carried out at Owners Site
2. Load Test includes rated load test, overload test and intermediate load test.
3. The vertical deflection of the boom and the girder shall be measured or rated load and overload. Horizontal deflection of the boom shall be measured with rated load. Both vertical and horizontal measurement of trolley rails and girder and boom straightness at no load shall be recorded.

Appendix 6. Standard Structural Details (Liftech)

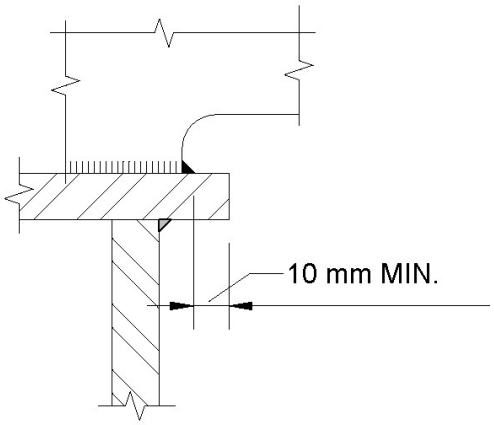
LIFTECH CONSULTANTS INC.

By PWM Approved AB

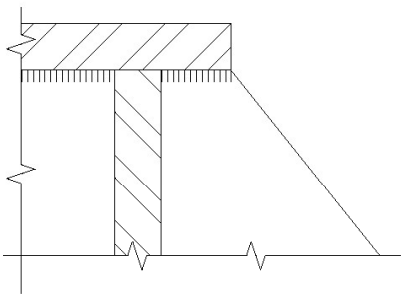
Structural Details



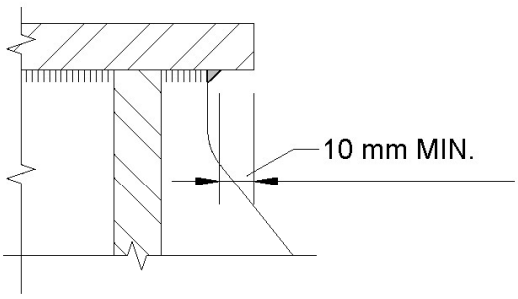
Not Acceptable



Acceptable



Not Acceptable



Acceptable

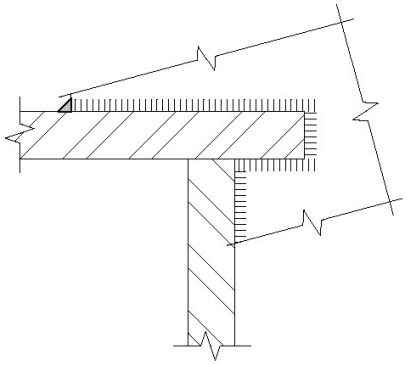
T:\Specifications\Std-Working_PWM\Appendix\Structural Details\StructDetl1-6_BLANK.vsd

Liftech Standard Structural Details. Copyright ©1995, 2000, 2015 Liftech Consultants Inc. Sht. 1 of 11

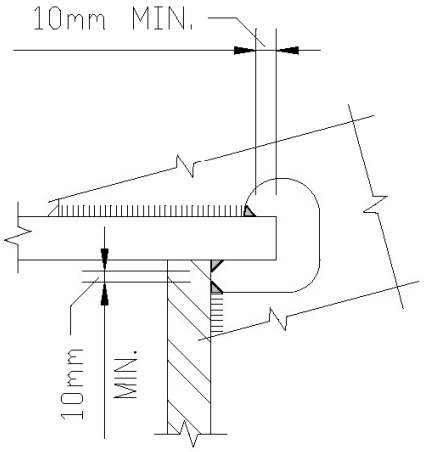
LIFTECH CONSULTANTS INC.

By PWM Approved AB

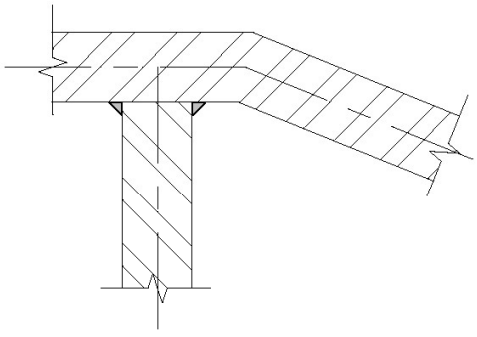
Structural Details



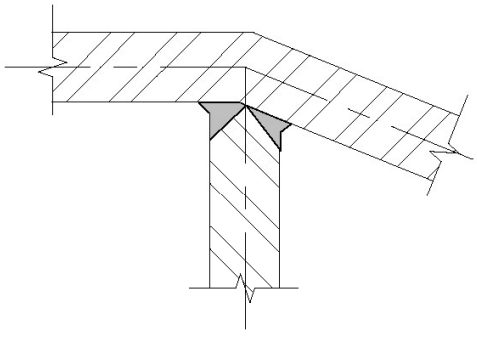
Not Acceptable



Acceptable



Not Acceptable



Acceptable

T:\Specifications\Std-Working_PWM\Appendix\Structural Details\StructDetl1-6_BLANK.vsd

Liftech Standard Structural Details. Copyright ©1995, 2000, 2015 Liftech Consultants Inc. Sht. 2 of 11

LIFTECH CONSULTANTS INC.

By PWM Approved AB

Structural Details

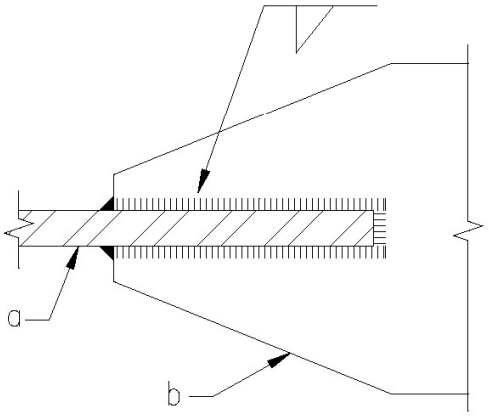


PLATE b SLOTTED

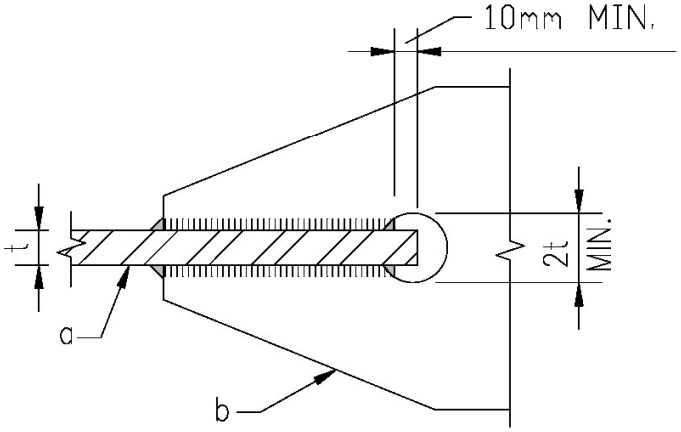
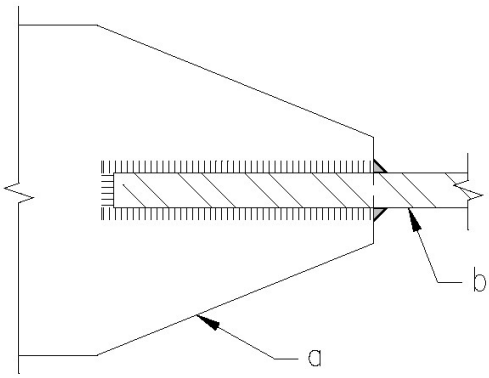
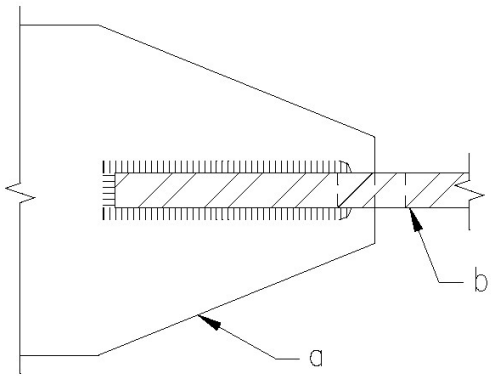


PLATE b SLOTTED



Not Acceptable



Acceptable

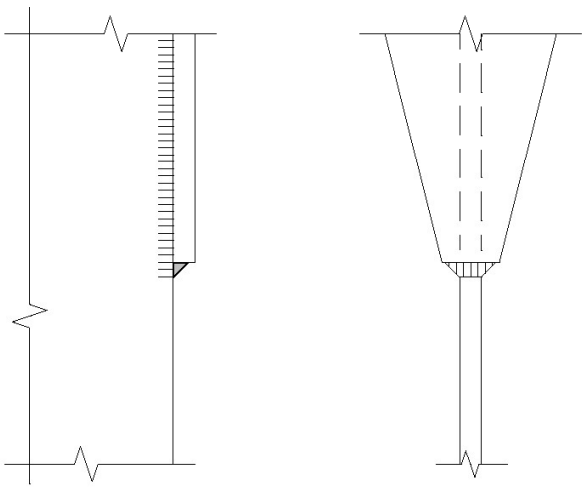
T:\Specifications\lStd-Working_PWM\Appendix\Structural Details\StructDetl1-6_BLANK.vsd

Liftech Standard Structural Details. Copyright ©1995, 2000, 2015 Liftech Consultants Inc. Sht. 3 of 11

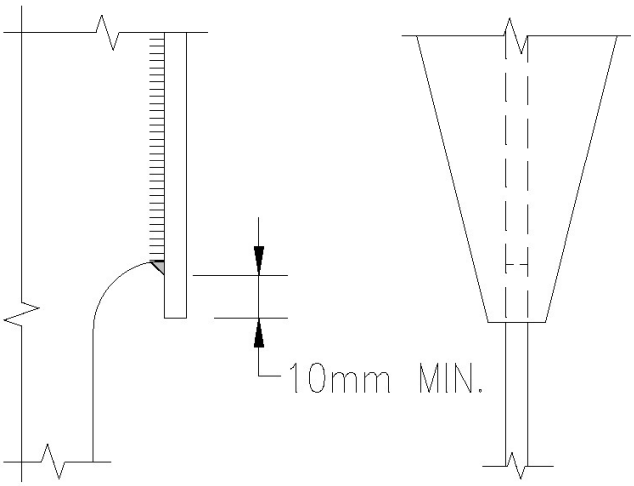
LIFTECH CONSULTANTS INC.

By PWM Approved AB

Structural Details



Not Acceptable



Acceptable

T:\Specifications\lStd-Working_PWM\Appendix\Structural Details\StructDetl1-6_BLANK.vsd

Liftech Standard Structural Details. Copyright ©1995, 2000, 2015 Liftech Consultants Inc.

LIFTECH CONSULTANTS INC.

By PWM Approved AB

Structural Details

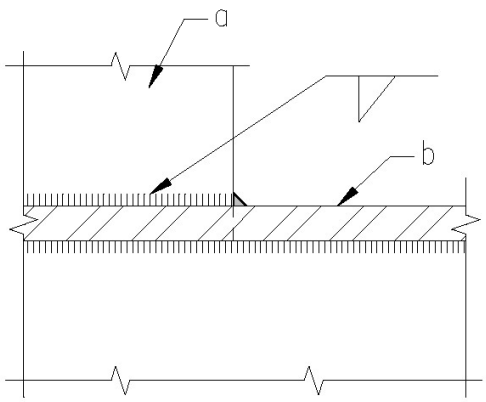


PLATE b SLOTTED

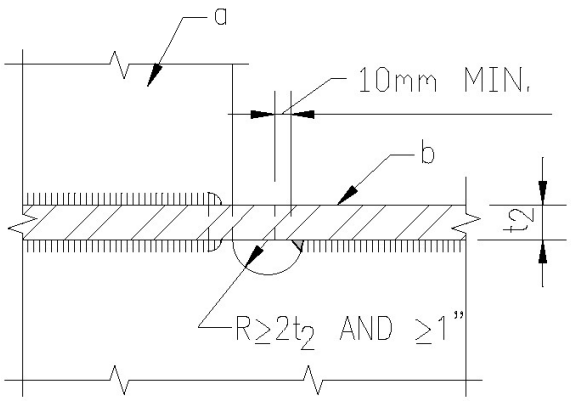
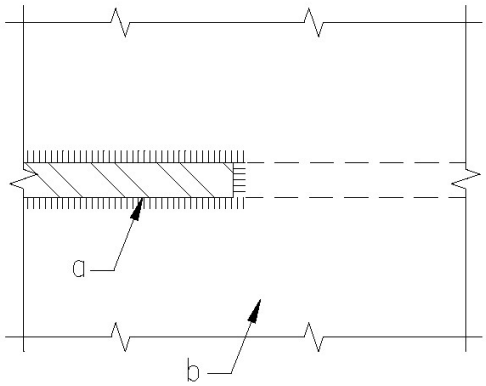
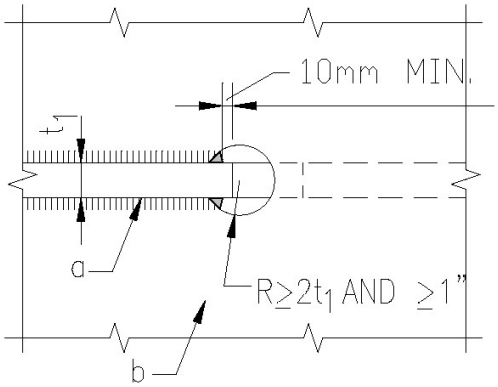


PLATE b SLOTTED



Not Acceptable



Acceptable

T:\Specifications\IStd-Working_PWM\Appendix\Structural Details\StructDetl1-6_BLANK.vsd

Liftech Standard Structural Details. Copyright ©1995, 2000, 2015 Liftech Consultants Inc. Sht. 5 of 11

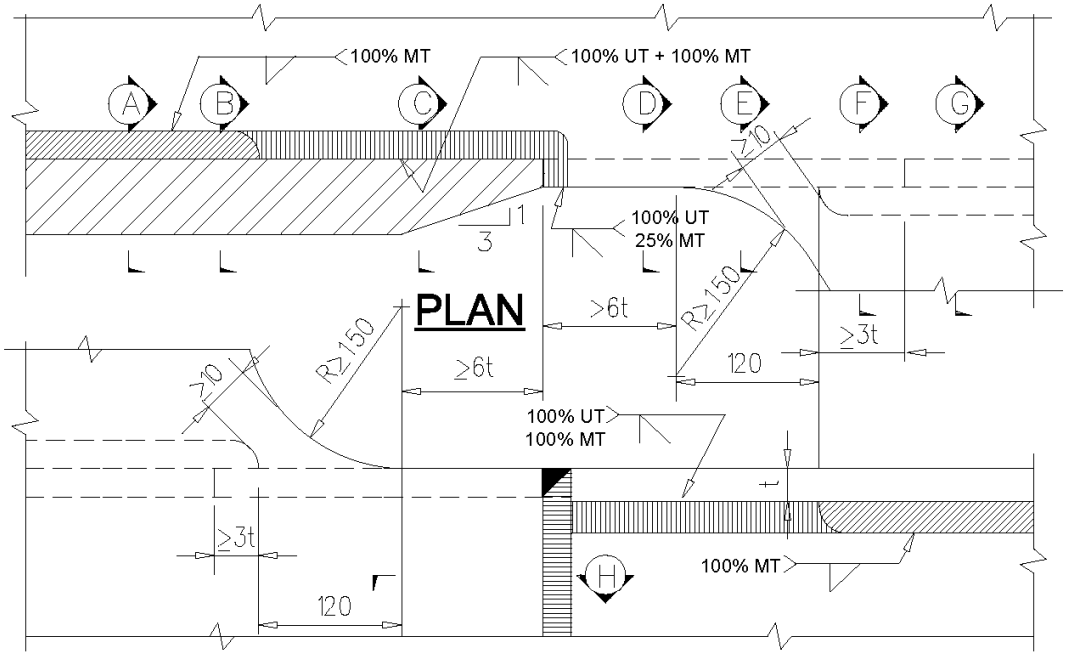
LIFTECH CONSULTANTS INC.

By PWM Approved AB

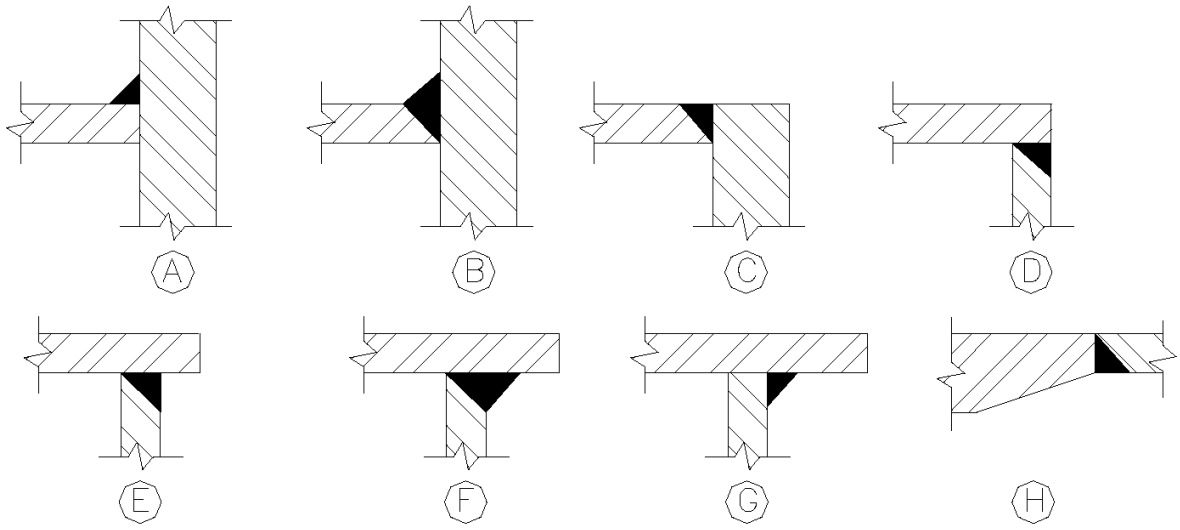
Structural Details

Avoidance of Wraparound Weld Acceptable

See Sht. 7 for isometric view.



ELEVATION



Note: Welds shall conform to the most recent edition of AWS D1.1, including the requirements for cyclically loaded structures.

T:\Specifications\lStd-Working_PWM\Appendix\Structural Details\StructDetl1-6_BLANK.vsd

Liftech Standard Structural Details. Copyright ©1995, 2000, 2015 Liftech Consultants Inc. Sht. 6 of 11

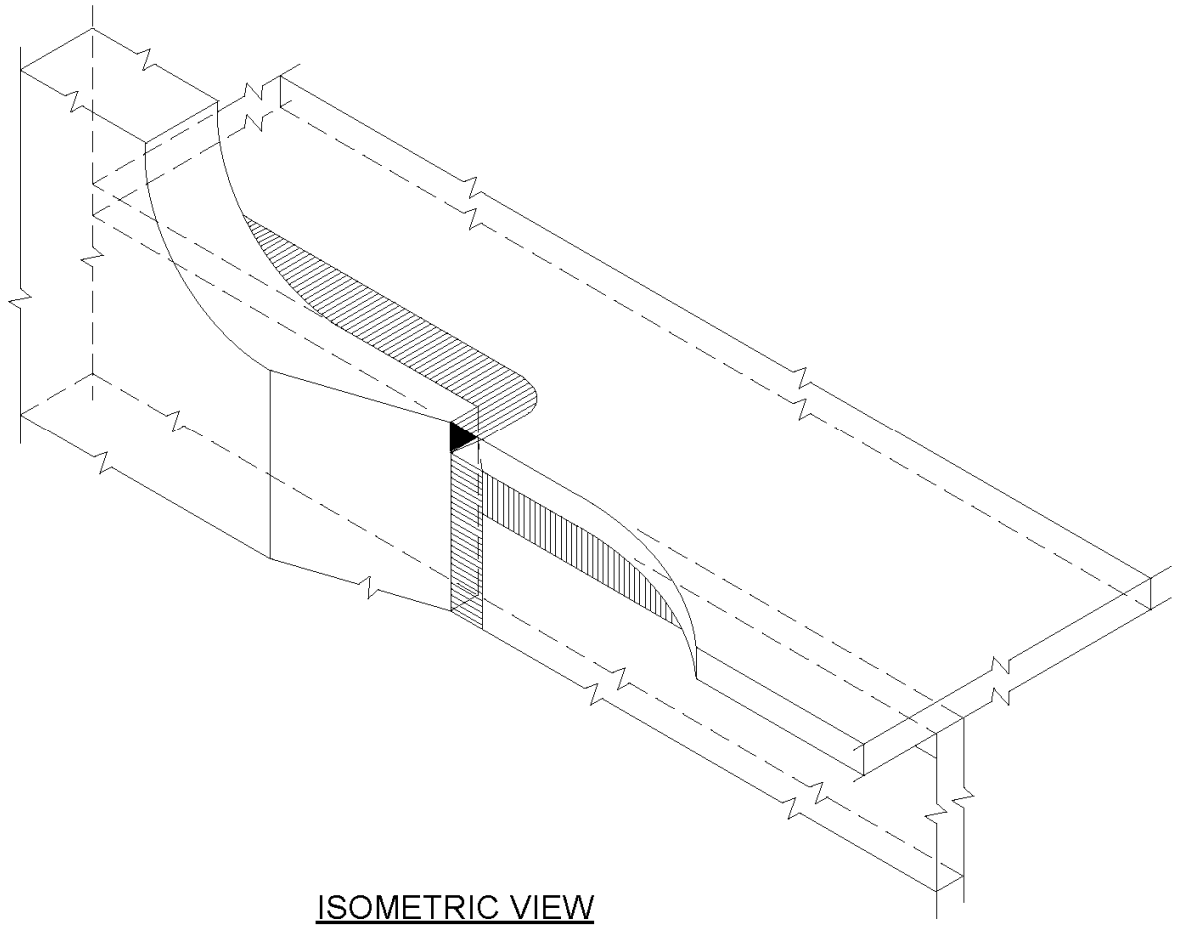
LIFTECH CONSULTANTS INC.

By PWM Approved AB

Structural Details

Continued from Sht. 6.

Avoidance of Wraparound Weld
Acceptable



ISOMETRIC VIEW

T:\Specifications\Std-Working_PWM\Appendix\Structural Details\StructDetl7-11_BLANK.vsd

Liftech Standard Structural Details. Copyright ©1995, 2000, 2015 Liftech Consultants Inc.

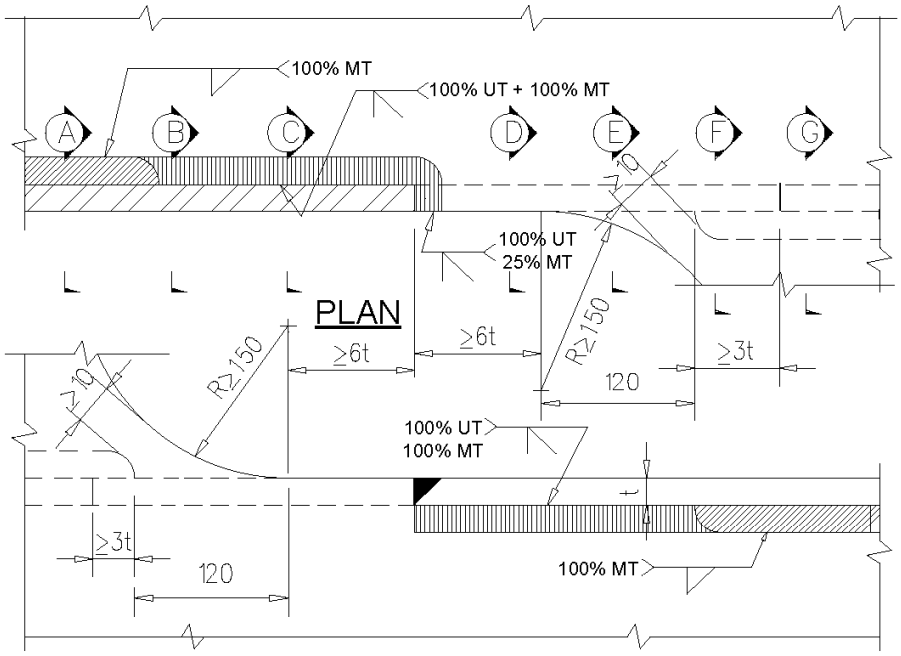
LIFTECH CONSULTANTS INC.

By PWM Approved AB

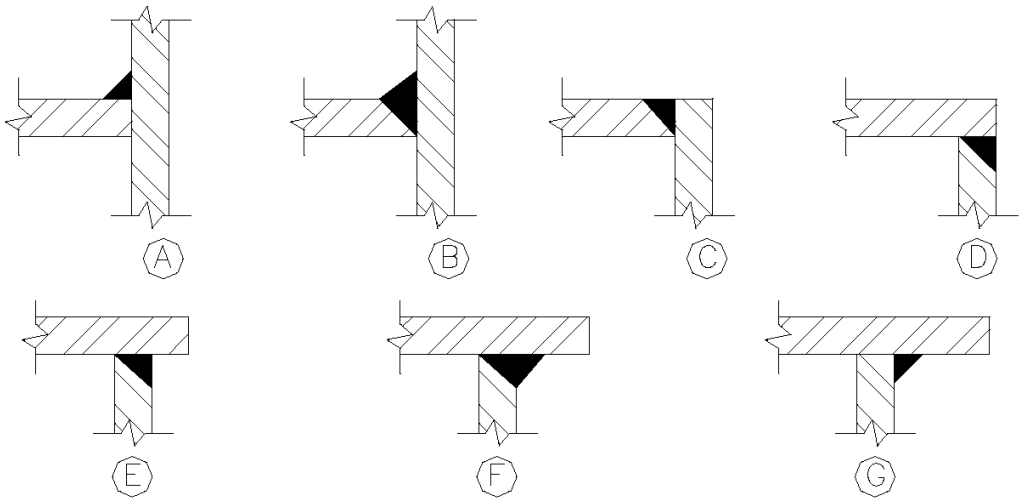
Structural Details

See Sht. 9 for Isometric View

Avoidance of Wraparound Weld Acceptable



ELEVATION



Note: Welds shall conform to the most recent edition of AWS D1.1, including the requirements for cyclically loaded structures.

T:\Specifications\lStd-Working_PWM\Appendix\Structural Details\StructDetl7-11_BLANK.vsd

Liftech Standard Structural Details. Copyright ©1995, 2000, 2015 Liftech Consultants Inc.

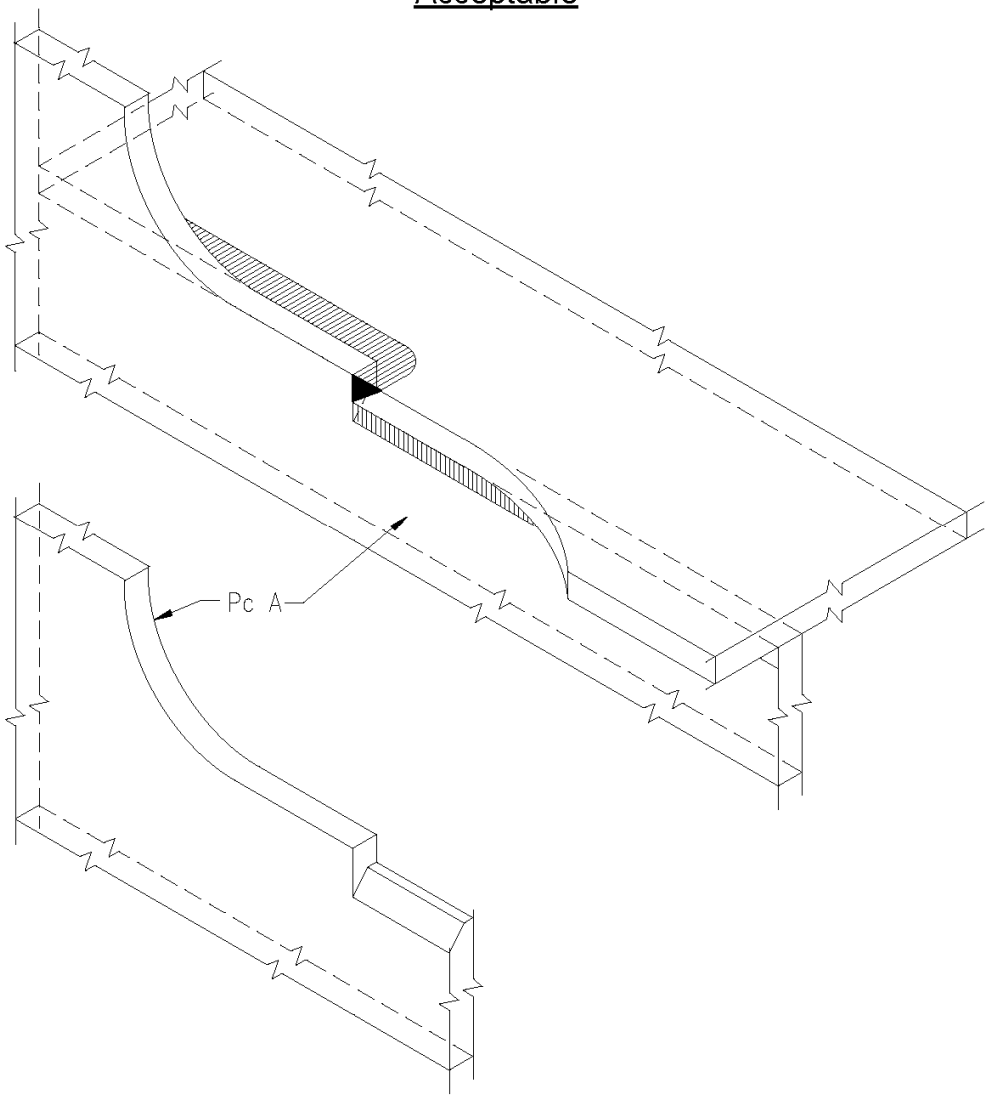
LIFTECH CONSULTANTS INC.

By PWM Approved AB

Structural Details

Continued from Sht. 8.

Avoidance of Wraparound Weld
Acceptable



ISOMETRIC VIEW

T:\Specifications\Std-Working_PWM\Appendix\Structural Details\StructDetl7-11_BLANK.vsd

Liftech Standard Structural Details. Copyright ©1995, 2000, 2015 Liftech Consultants Inc.

LIFTECH CONSULTANTS INC.

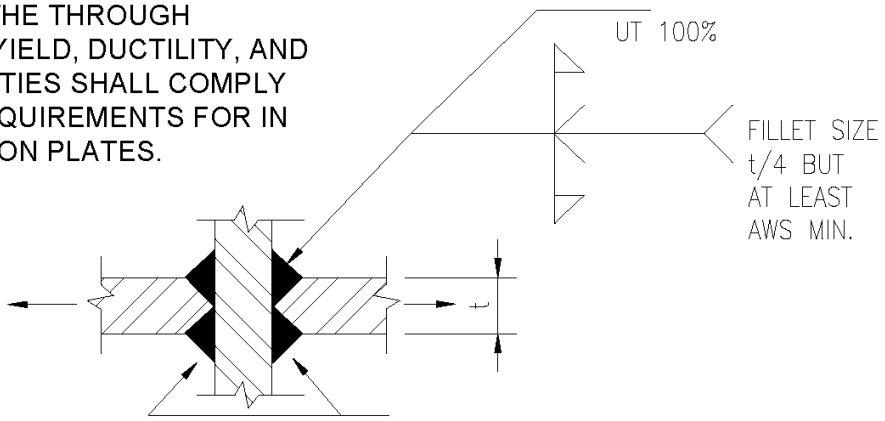
By PWM Approved AB

Structural Details

Cruciform Weld

FOR COMPONENTS
CARRYING CALCULATED
AXIAL STRESS

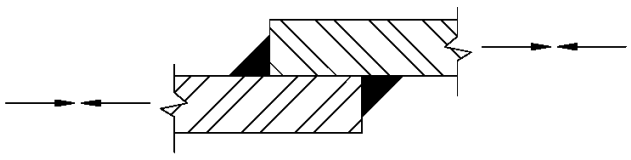
FOR FCMS: THE THROUGH THICKNESS, YIELD, DUCTILITY, AND CVN PROPERTIES SHALL COMPLY WITH THE REQUIREMENTS FOR IN PLANE TENSION PLATES.



U.T. TO CHECK FOR LAMELLAR TEARS BEFORE WELDING AND 36 HOURS AFTER WELDING.

Eccentric Lap Joints

ECCENTRIC LAP JOINTS
BOLTED OR WELDED
ARE NOT ACCEPTABLE
ON COMPONENTS CARRYING
CALCULATED AXIAL STRESS.



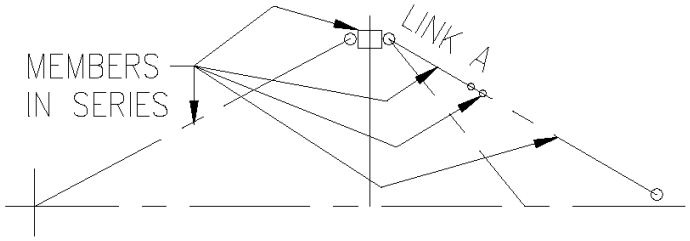
NOT ACCEPTABLE

T:\Specifications\Std-Working_PWM\Appendix\Structural Details\StructDetl7-11_BLANK.vsd

Liftech Standard Structural Details. Copyright ©1995, 2000, 2015 Liftech Consultants Inc. Sht. 10 of 11

LIFTECH CONSULTANTS INC.

By PWM Approved AB



Structural Details
Members in Series

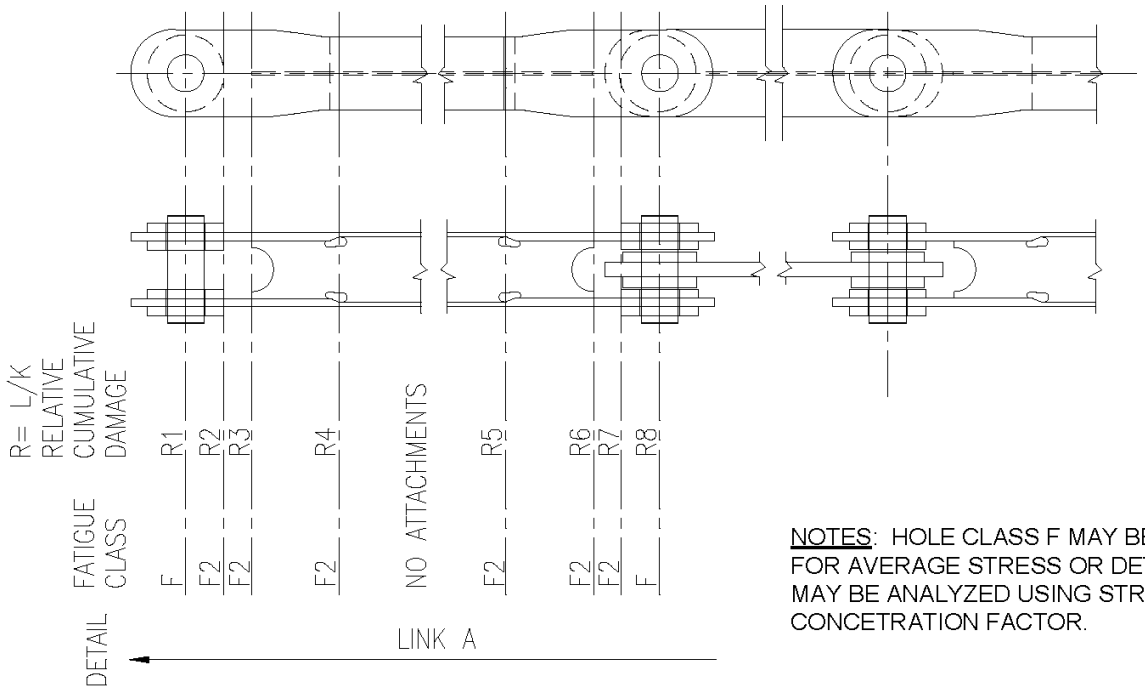
RELIABILITY OF SYSTEM SHALL BE CALCULATED BY DETERMINING THE RELIABILITY "D" OF EACH LINK INCLUDING ALL CONNECTION DETAILS, AND CALCULATING THE RELIABILITY OF THE SYSTEM USING:

$D_{SYSTEM} = D_A \times D_B \times D_C \ldots D_N$

FOR EXAMPLE, THE RELIABILITY OF LINK A IS
$D = D_1 \times D_2 \times D_3 \times D_4 \times D_5 \times D_6 \times D_7 \times D_8$
THE VALUES OF D_i ARE FOUND FROM TABLE FOR EACH R_i.

NOTICE WHEN $R \leq 0.4$, $D = 1$
AND WHEN THE CALCULATED STRESS RANGE IS ≤ 0.74 X ALLOWABLE STRESS RANGE, $R \leq 0.4$.

TYPICAL FORESTAY EXAMPLES



NOTES: HOLE CLASS F MAY BE USED FOR AVERAGE STRESS OR DETAIL MAY BE ANALYZED USING STRESS CONCETRATION FACTOR.

T:\Specifications\Std-Working_PWM\Appendix\Structural Details\StructDetl7-11_BLANK.vsd

Liftech Standard Structural Details. Copyright ©1995, 2000, 2015 Liftech Consultants Inc. Sht. 11 of 11

Appendix 7. General Arrangement Drawing

To be provided

Appendix 8. Crane Weights and Declared Wheel Loads

To be provided

Appendix 9. Existing Stow Pin and Tie-Down Details

To be provided

Appendix 10. Existing Quay Details

To be provided

Appendix 11. Crane End Stop Details

To be provided

-- END OF TECHNICAL SPECIFICATION --