Technical Specification
Quayside Container Cranes
Single-Hoist Twin-Lift for THPA

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1 SCOPE OF SUPPLY

1.1 Main scope of work

To design, manufacture, install, erect, deliver to site, test, commission and handover of two (02) container cranes to the Buyer and to provide technical service in compliance with the Technical Specifications.

1.2 OPTIONS

1.2.1 Option 1: Spreaders

The cranes are delivered with one (01) identical twin-lift spreaders.

Technical specification is provided in section 12.2.

1.2.2 Option 2: One Cargo Beam (with Motorized Slew Ring)

One Cargo beam (with motorized slew ring) - 85 Ton heavy hook required to be rams horn shape. with ability to rotate and lock position of swivel. Rams Horn Hook shall have an independent motorized power pack (energized from the headblock to spreader cable). Operation of the Slew function shall be available from four locations:

- Operator's cabin
- Landside Ground Control Station
- Remote Control Desk
- Wireless Remote Control Panel

1.2.3 Option3: Semi-Automation / Operator's Assistance

The Seller shall propose the following systems as assistance to the crane operator in order to optimize the crane safety and productivity.

Each system can be ordered separately by the Buyer.

Option 3.1: Seaside Anti-Collision System / Vessel Profiling:

The main element to assist the operator to avoid collisions and improve productivity on vessel is the 3D ship profiling which shall provide the following functionalities:

- Anti-collision in any trolley and hoist direction

- Catwalk and overlapping container detection
- Detection of ship longitudinal displacement
- Cell guide detection for fast approach
- Spreader height detection and tracking
- Container height detection & hatch cover detection
- Soft landing both on the seaside and landside
- Traffic detection between the rails
- Ship Profiling (Optimum path) – used also for automatic sequence for loading / discharge.

Combining these elements the system will detect possible collisions which may occur and alert the driver while also slowing the trolley and/or hoist speed in order to avoid the collision.

With 2&3D laser scanners strategically installed on the trolley, a snap shot of the containers is taken during the first manual travel of the trolley over the bay the crane will work at. In addition since the spreader is in the view of the scanners and by comparing the actual load position (spreader with/without container) with the profile of the stacks collision prevention is ensured.

The system is to be also capable of knowing that the snap shot is a valid one provided it satisfies certain criteria to avoid collisions and to be able to use this snap shot for the semi-automation cycle for the loading and discharge of containers to and from the ship.

The supplier has to clearly specify how the above can be achieved, giving a detailed operational description outlining all the components making up each system and any limitations. The design of the system should be such that it would require minimum input from the operator. The description should also include maintenance and calibration manual. Preferably the supplier is to specify the extra move per hour gained when the system is utilised corroborated with references.

Option 3.2: Anti-Skew & Anti Sway Functions:

The crane shall be equipped with devices needed to allow for the automatic skew and sway control under any loading conditions independent of the load distribution inside the container, whether in single or twin mode and independent of hoisting and trolley speeds.

Such system shall enabling the positioning of the load with an accuracy of +/- 5 cm of target position.

The supplier shall give a detailed description of the proposed system outlining all the components used, specifying the reaction time to eliminate the skew / sway under all possible operating conditions. Sway from all other external forces such as wind, inclined lift etc., are also to be eliminated / compensated.

In addition, the system must be such that should any component malfunctions or is temporarily disabled an algorithm is used to calculate the anti-skew & sway function.

1.2.4 Option 4: Truck/straddle positioning system

In order to avoid gantry movements to position the load/spreader on the trailer, the cranes will be equipped with a Truck/straddle Positioning System to guide the terminal tractors to position their trailer accurately between legs.

The system shall indicate to the truck or straddle driver by means of visual display monitors (or other approved method) that truck/straddle carrier is in the correct position so that the crane can pick up/land containers without any gantry motion. The display should indicate in which direction and the distance the truck has to be moved to arrive at the correct location. System accuracy shall be +/- 25mm.

The system should be able to operate over the entire operational range between the crane legs. System shall work irrespective of the different types of terminal tractors / trailers utilized and for any type of containers.

The scanner(s) shall be easily accessible and installed in weather tight enclosures. Easy access to maintain the scanners shall be provided. The Truck Positioning System shall be independent from the crane control system.

The design of the system shall be such that it will require minimum input from the operator. The only input from the operator will be the initial lane/s selection/s. As regards traffic directions, load/unloading, container size, terminal tractor and trailer type etc., have to be handled automatically by the system. In addition, the system must cater for a double cycle operation (loading and discharge in one cycle) and the buyer can easily re-program / adjust settings should there be the need. The system shall be designed for 8 lanes of terminal tractor-trailers, where the 1st and 8th lanes are not used for traffic, however 2 or 3 out of these 8 lanes might be underlying the hatch cover platform.

If the option is not chosen, the system might be installed by the Buyer in the future. The manufacturer must provide the power supply, crane off/on signal (relay or contact), cable path and steel structure for the system, any communication cables (preferably fibre optic) and power supply cables.

1.2.5 Option 5: Emergency shore power

As an option, a switched shore power supply outlet to supply power to neighbouring crane with identical specification as the shore power inlet shall be provided adjacent to the shore power inlet. The shore power outlet socket shall mate with the shore power inlet plug. The shore power outlet shall be interlocked with the crane control.

Shore power cable cross section shall accommodate for the voltage drop caused by the cable length from one crane to another, and for the load it needs to cater for.

The supplier will provide the interconnecting cable from one crane to the other (at least 50m, however if the sockets and plugs are mounted at the adjacent ends of the gantry legs of the crane then this distance can be shorter).

This supply, 400VAC, 3 phases+N+PE, 50Hz, is to power emergency drives, obstructions lights, elevator, and gantry cable reel.

1.2.6 Option 6: Anti-Snag System

Options for an Anti-snag system that can operate without the need for the TLS hydraulic cylinders system should also be offered. Only proven and tested systems shall be considered.

1.2.7 Option 7: Crane Life monitoring system

The crane has to be equipped with a monitoring device to collect data and store crane parameters to:

- Determine its index of fatigue.
- Conduct investigations in case of major failure by monitoring critical parameters.
- Verify the integrity based on use.

The following data shall be recorded and storage shall be guaranteed for the duration of crane lifetime:

- Record of each cycle including trolley positions, loads, mode (single or twin), speeds
- Record of essential parameters for 5 s (after and before the event) in case of incident (any snag event, motion failure, breakdown)

The system can be Digilife (Aquass) or any equivalent system.

The system shall be installed on the RCMS server.

1.2.8 Option 8: Test Weight

Containers & concrete block test weights shall be provided as part of the delivery and capable of carrying out all tests required for commissioning purposes.

The blocks shall include calibration certificates, all weights to be noted in tons. Size of each block to be suitable for 2.5ton / 5ton forklift to load.

The test weight containers must be protected with the same painting system as for the quay crane.

1.2.9 Option 9: Fire Suppression

The electrical room and the CMS room shall be provided with FM200 or Novak fire suppression system with sensors located within the rooms. In case the fire suppression system is triggered during operation, then the crane operation shall be stopped via the PLC and warnings activated.

As the electrical room shall have to withhold overpressure in case of fire suppression action, cables entry must be fully sealed by Roxtec systems or similar where cables are required to enter the room.

The electrical room is to be integrity tested due to fire system installed. This shall be carried out both at manufacturing plant and again during commissioning at Buyer's terminal. A certificate shall be given to the Buyer after each test is completed. The tests shall be witnessed by third party inspector.

1.2.10 Option 10: Operator Visual Aid

Cameras are to be installed to ease the operator's view: for capturing the look over / beyond the head-block, and for capturing the look at the area between the gantry rails.

Technical specification is provided in section 6.9.13.

1.2.11 Option 11: Mancages

Man cages for safe lashing of containers onboard vessels are to be supplied and installed on landside sill beam of each crane.

Technical specification is provided in section 6.14.

1.2.12 Option 12: After Sale Service

The Seller provides on-site assistance for a period of 3 months after the final acceptance of the cranes.

1.2.13 Option 13: Spare Parts

The cranes are delivered with a set of spare parts, including the anticipated wear parts for 2 years of operations and the critical parts the Seller recommends the Buyer to have for high availability of the cranes.

1.2.14 Option 14: RCMS

RCMS (Remote Crane Management System) is to be installed on 2 PCs in the engineering offices. Same functions will be available at the RCMS as available as on the crane CMS.

RCMS PCs to be connected via fiber optic.

2 MAIN CHARACTERISTICS AND PERFORMANCES

	Item	Requirement
	Lifting capacity	
	Load capacity	Under spreader: 65t in twin-lift mode (the "Rated Load Under Spreader") and 50t in single-lift mode Under hook beam: 85t (the "Rated Load Under Hook")
	Type of containers to be handled	ISO containers of 20'/40'/45'
	Type of spreader	20' /40' /45' telescopic spreader for handling any ISO containers 20' /40' /45' and simultaneously handling 2*20' containers (= twin-lift mode)
	Geometry	
	Rail gauge	20 m
	Outreach	50 m from waterside rail centre line to spreader centre line
	Back reach	25m, for efficient straddle carrier operations
	Lifting height	Above rail top: 38 m Below rail top: 16 m
	Gantry travel distance	500m on either side of the connection pit
	Clearance between gantry legs	Not less than 17.5m
	Clearance height under portal tie beam	>16.5m
	Crane overall height	No special requirement
	Crane overall width (buffer uncompressed)	Not more than 27.0m

	Gantry buffers height from rail top	1200mm
	Trailing cable position	Along the right Water Side leg (when facing the water), and along the water side of the Water Side rail
	Gantry drives position	On the landside of each rail
	Operating conditions	
	Wind conditions	Crane fully operational, at nominal speeds and accelerations, under wind up to 28m/s velocity for 3s gust, from whatever direction (the "Maximum Operating Wind")
	Speeds	
	Main hoist	90 m/min with Rated Load Under Spreader 180 m/min with 25t under spreader 200 m/min with empty spreader
	Trolley	240 m/min /
	Gantry	50m/min against Maximum Operating Wind 25m/min against wind of 125% Maximum Operating Wind speed
	Boom hoisting (0º-80º)	Not more than 5min
	Acceleration/Deceleration	
	Main hoisting	Not more than 2.5s with Rated Load Under Spreader Not more than 5.0s with empty spreader
	Trolley	Not more than 5.0s
	Gantry	Not more than 8.0s
	Lifting System Adjustments	
	Trim	±3°

	List	±5°
	Skew	±5°

3 DESIGN CRITERIA

3.1 Applicable standards and codes

The followings international recognized standards and codes shall be used and complied with for designing and construction of the cranes:

- For structure: FEM
- For Structural steel: EN 10025, S235JR, S355J2 G3, E295, E335, E360, JIS G3101, G3106
- For stability: FEM
- For mechanical: FEM
- For gearing: ISO, AGMA, BS
- For electrical: IEC
- For painting: SSPC
- For welding: AWS
- For Access: ISO 14122-2,3,4
- For hydraulic: ISO 5781, ISO 4406 (fluid contamination), ISO 11218 (fluid contamination), ICS 23.100.20,
- For noise: ANSI S12.33 or EN 15011, Noise test code
- For measuring unit: International unit system
- For HSE: OSHA, ISO 1182, ISO 2631,
- For air obstruction lighting: ICAO Annex 14 to the Convention on International Civil Aviation
- European Harmonised Colour Code (Document HD308 S2)
- Industrial IT Security IEC6244 3-2-1
- Machinery Directive 2006/42/EC
- Low Voltage Directive 2006/95/EC
- EMC Directive 2014/30/UE
- For transformers: EU directive 548/2014 for implementing the Ecodesign guideline 2009/125/EG

These compliances will be checked by third party.

The Seller is responsible to deliver the cranes in accordance with all national and local technical norms and safety regulations.

3.2 Crane classification

3.2.1 Structure

The crane design life is 25 years.

Class of utilization	U8 – (4,000,000 cycles)
State of loading	Q3
Group classification	A8

The vertical deflection at boom tip with the Rated Load Under Spreader at max outreach shall not exceed 300mm.

The relative horizontal displacement of the end of the boom only or the girder only shall not exceed 100mm under the effect of normal gantry stoppage from 50% of nominal speed with the trolley at the end of the boom and 50% of the Rated Load Under Spreader.

During gantry travel inching (small gantry movements for fine positioning) the relative horizontal displacement of the end of the boom only or the girder only shall not exceed 200mm. Any oscillation movement of the boom shall not take more than 30s to reduce to less than 30mm amplitude.

3.2.2 Mechanical

Description class utilization state of loading group classification:

Main hoist	T8	L3	M8
Trolley traverse	T8	L3	M8
Boom hoist	T5	L3	M6
Gantry travel	T6	L2	M6

3.3 Environmental conditions

The crane shall be designed and constructed to be fully capable of operating safely under the following climatic conditions:

- Ambient temperature range: -5 to +55 degrees Celsius (in the shade).
- Relative humidity: Max >99% & salt laden atmosphere
- Dust atmosphere

- Maximum Operating Wind as provided in Section 2. Main Characteristics and Performances.

The crane shall be designed and constructed to be fully capable of safely withstanding the following storm conditions:

- wind velocity of mean recurrence interval of 50 years (i.e. with annual probability of exceedance of 0.02), (the "Storm Wind")

3.4 Environment Interfaces

3.4.1 Wheel Interface

Type of rail on the terminal is A100. Crane loads in any wind conditions shall not exceed the maximum acceptable load for this type of rail.

Maximum wheel load in any condition shall not exceed 52t per linear meter in the in service and out of service conditions.

Wheels must be compatible with both A100 and A120 rails.

3.4.2 Power Interface

The cranes will normally be powered by electricity from the public mains, of voltage 20kV and frequency 50Hz.

The crane low voltage power will be of voltage 230V for 2-phase and 400V for 3-phase, frequency 50Hz (the "Crane Low Voltage").

The Seller must propose a suitable design for the connection pit.

3.5 Noise and vibration

The maximum acceptable noise is as follow:

1) Less than 70 dB (LA eq measured) with door closed, heaters and or AC systems running at medium speed. Reverberation time maximum 0.5 seconds.
2) Less than 95 dB(A) inside the machinery house with ventilators in operation.
3) Less than 80 dB(A) inside the machinery house when no crane motion in operation

4) Less than 85 dB(A) inside the electrical room
5) Less than 70 dB(A) inside the CMS room

The Seller shall devote itself to reduce noise and vibration through reduction of the affect from rotating parts and components on supporting structure. In this respect the use of thick shims underneath rotating machinery should also be avoided / minimised. Where applicable e.g. on motors, gearboxes, wire rope drum pedestals etc, secondary blocking systems such as dowels or others should be installed to assist the primary securing arrangements in withstanding the accurate positioning and alignment of the component in question.

Isolate the vibration source, for example, suspended mountings between the operator's cabin and the trolley, for transformers, rigid common base is used for gear reducer etc.

4 MATERIAL

The whole of the materials and articles incorporated in the work shall be new and of the best quality and description of their respective kinds to the satisfaction of the Buyer. All materials shall be of current design and of recent manufacture.

Unless otherwise specified herein, any materials or articles to which F.E.M. specifications can apply, shall be supplied in accordance with the provisions of all such standards and their addenda and any modifications thereof.

Seller who wants to use other internationally established National Standards shall demonstrate that proposed standards are as a minimum equal to F.E.M. in all aspects. These shall require the written approval of the Buyer.

Plate's bars and castings

All plates, bars and sections shall be well and cleanly rolled to the full sections, free from cracks, surface flaws, laminations, roughness and other defects. All forgings and castings shall be sound, clean, fair, free from flaws and blowholes. All steel castings shall be properly annealed. Test certificates for castings including where relevant hardness test results shall be provided to the Buyer.

Welding

Qualified welders shall carry out all welding. Copies of the welders' qualification certificates shall be made available to the Buyer on demand.

All welds shall be of sound construction and of the dimensions shown on the drawings or specified. They shall be free from porosity, slag inclusions, undercutting and other defects and shall be of clean and regular appearance throughout. The execution shall be such as to ensure that the parts connected are properly aligned and positioned, free from distortion and so fixed together as to produce a homogeneous section of the correct dimensions.

All butt welds shall be full penetration. Fillet welds shall complete butt welds in T joints. All fillet welds shall be continuous and all joints shall be completely sealed. Intermittent welding will not be permitted.

As much of the shop welding as is practicable shall be executed by means of automatic or semi-automatic processes to the extent that the type of work and the dimensions thereof permit. So far as is practicable, welding shall be executed in the down-hand position.

Non-Destructive Testing Of Welds

The Supplier shall be responsible for carrying out non-destructive testing of welds on completed members and joints. Defective welds shall be cut out and re-welded.

The Supplier shall test and record designated weld areas of high stress concentration where permanent records are required.

Gantry travel and traverse trolley wheels shall also be tested ultrasonically to establish any faults such as porosity in the casting.

The Supplier shall submit a copy of each examination.

5 STEEL STRUCTURE

The crane structure has adequate strength and rigidity with a smooth appearance. All the bearing bars, diagonals and the mast frame are to be of tube-type construction. The tube is formed from steel plate by spirally rolling and welding on both sides. Drainage holes are provided where water may build up. Sealed and bolted hatch covers are provided on all box-section members for interior inspection. Crane structure connections are performed by welding, hinge-pins and high-strength bolts.

The A-frame is made of spirally welded tubes.

Adjusting eccentric pin sleeves for the forestays: The two forestays of the boom are welded or rolled "H"-section construction and are provided with adjusting eccentric pin sleeves to ensure even load on both them. Adjusting eccentric sleeves shall be detailed and designed in such a way to reduce the possibility of seizure making future adjustments impossible to achieve.

Upon installing quay cranes on the Buyer's rails, measurements shall be taken by a local surveying company to confirm perpendicularity of crane installation : the boom axis will be perpendicular to the gantry rails with a tolerance of +/-20mm.

The crane structure shall be designed for shock loads imposed during collision with adjacent crane or end stop at 100% of nominal gantry speed with the power off and under energy absorbing effect of the buffer without damage of any member and/or part. Corresponding end stop is designed on the same base.

5.1 Gantry Frame

Gantry frame is to be of welded box structure. Connection between the upper part of the gantry frame and the crane girder is to be made by welding to ensure adequate rigidity of the crane and to reduce the trolley sway and keep deflection of structure within allowable limits. On one of the landside gantry legs the elevator and access stairways is to be installed.

5.2 Boom and Girder

The boom and the girder are to be welded twin box type structure or lattice structure and rail support beam is to be installed on the lower part of the girder and boom. Rail support beam is made of "H" type or "T" type welded section steel, the surface has perfect levelness and durable fatigue resistance.

The section of trolley rails shall be no less than A75 profile.

Trolley rail is joint less and lays on rail support beam of the girder and the boom.

Accuracy of rail installation must meet FEM standard.

Strengthened rubber pads and rail clips are used between the rail and rail support beam to reduce and isolate vibration. Suppliers to ensure all rail clips are torqued correctly at time of handover. (No splice joint at the boom hinge area)

All welded rail with the exception of the short rails shall also be accepted. Short rails that do not need to be welded to the rest of the rails when being replaced shall be also accepted. This shall enable a brief duration in case of a short rail replacement.

The design of the Short rail shall enable extended lifetime and minimize the vibrations at hinge point crossing. The technical solution shall include:

- A careful preparation of the support beam and machining of the surface before the installation of the pad for a perfect alignment of the beam
- A final machining of the trolley rail for a perfect alignment
- A square profile for the short rails

Shimming of the short rails shall be avoided and if deemed necessary only one stainless steel shim shall be accepted.

On the girder and the boom walkways, stairs and platforms are provided for safe, easy maintenance of equipment attached on the girder and the boom.

Safe escape from the trolley/cabin shall be provided for the operator any point on the girder or the boom.

Ample steel protection is to be installed on the outboard of the waterside and landside sill beams to protect the cable trunking against accidental damage by a container or spreader in the single 20, twin 20, 40 or 45 ft positions.

In addition all anchoring bolts and important structural welds especially at critical nodes are to be easily accessible such that inspections can be carried out without the need of additional equipment or rope access.

5.3 Painting specifications

5.3.1 Site Conditions

The paint system shall offer protection against marine salt spray, intense solar radiation and humidity in marine and severe marine environments as classified to ISO Categories 3,4 &5 for degrees of corrosivity.

5.3.2 Coating System / Material Supplier

All painting materials to be used in the protective coating shall be purchased from an approved paint supplier, one that has product and technical service available worldwide.

5.3.3 Primer

The steelwork primer shall be Epoxy Zinc Rich of not less than 50 microns dry film thickness (DFT). Minimum volume solids shall be 53% and minimum re-coat time at 23 degrees Celsius will be one and half hours.

5.3.4 Intermediate Coatings

The intermediate coatings shall be amine cured surface tolerant epoxy mastic having minimum volume solids of 82%. Minimum dry film thickness shall be 225 microns.

5.3.5 Top Coating

The top coating shall be one coat of Recoatable Acrylic Modified Polyurethane, not less than 50 microns DFT. The minimum volume solids shall be 50%. The colour of the final coat will be advised to the Seller after an order has been placed.

5.3.6 Box Sections

For enclosed box sections the internal surfaces shall, as a minimum, have shop primer not less than 25 micron DFT.

5.3.7 Preparation of Steel before Cleaning

All metal surfaces to be painted shall be blast cleaned to Grade Sa 2.5.

Blast cleaning of any steelwork shall not be commenced until:

- All welding slag and spatter, snags and strikes have been properly removed,
- All edges of all sections and plates have been dressed to leave no sharp arises or burrs
- Any oil or grease on the surface to be cleaned has been properly removed

5.3.8 Humidity during Coating

Coating shall not be carried out when:

- The ambient temperature is below 2 degrees Celsius.
- The surfaces are wet
- The humidity in the vicinity is such that dewpoint could readily occur before or during the coating. A margin of 3 degrees Celsius above dewpoint is required.

5.3.9 Clean Surfaces

Neither initial coating nor any subsequent applications shall be made unless the surface to be treated is clean dry and dust free and has been passed for painting.

5.3.10 Weld Areas

For each application, all weld areas, angles and edges shall be stripe coated, then the coating shall be applied generally over the whole area.

5.3.11 Continuity and Thickness

Wet thickness gauges shall be used continuously by the Seller during application to ensure that the dry thickness requirements will be met.

5.3.12 Multiple Coats

Where more than one coat is to be applied each shall show a clear change of colour from the preceding coat.

The intervals between coats shall normally be as recommended by the manufacturer.

5.3.13 Damaged Surfaces

Any coated surface damaged at any stage of the Work shall be repaired immediately by re-coating as specified by the coating manufacturer.

5.3.14 Special Primer on Exposed Surfaces and Connections

After tightening of bolts all exposed surfaces, bolts, nuts and washers and 25 mm overlap to any adjacent galvanised steelworks shall be cleaned and degreased and carefully painted by brush with an approved special primer following which they shall receive the protective coat or coats of paint.

5.3.15 Painting Damaged By Welding

When metal coating is damaged by welding the damaged zone and an area 80mm around the zone shall be made good by blast cleaning and painting with a Coating System giving the same protection as the metal coating.

In case of access issue an alternative solution can be proposed by the Seller and shall be approved by the Buyer.

5.3.16 Colours

The colors of the crane will be defined by the Buyer at the Design Review.

6 MAIN ASSEMBLIES SPECIFICATIONS

6.1 Main Hoisting

Main hoist consists of:

1) Two AC electric motors
2) Two caliper disk brakes (sets) on high speed shaft(s)
3) Two caliper disk brake (emergency braking) sets on the hoist drum(s) (low speed shaft),
4) Gear box,
5) Electrically insulated flexible couplings
6) Machine grooved main hoist drum(s)

6.1.1 Layout of Main Hoist Mechanism

1) The drive end of the rope drum(s) is directly connected to and supported by the low speed shaft of the reducer. The connection is made by a flexible coupling, bolted to the diaphragm of the drum(s)
2) The idler end of the drum(s) is supported by a self-aligning anti-friction bearing
3) Service brake discs are mounted directly on the high speed shaft of the reducer independent of the motor couplings.
4) Independent emergency caliper disk brakes are connected to the hoist drums.

6.1.2 Brake

1) Service brake: Braking torque of each brake is not less than the torque required to hoist the Rated Load Under Ropes at the shaft where the brake is mounted.
2) Emergency brake: Emergency brake is rated for not less than 150% of the torque required to stop the Rated Load Under Ropes. Emergency Disk surfaces shall be ensured to be kept clean and rust free by installing disc brushes which apply slight pressure during drum rotation. This helps to keep surfaces clean and reduce risk of slippage on rust in Emergency braking conditions.

6.1.3 Limit switches

The following limit switches are provided for main hoist:

1) Limit switch for automatic stop activated at normal upper end limit of the headblock travel (cam type);
2) Limit switch for automatic emergency stop at extreme upper end limit of the headblock travel (hard wired);
3) Over-speed protection device which automatically stops hoisting when spreader lowering speed exceeds rated speed by 15%;
4) Limit switch for slack wire rope;
5) Single layer rope winding protection on hoist drums, installed at position lower than shaft level.

6.1.4 Trim, List, Skew & Anti snag

To meet the container handling requirement the spreader is provided with listing, trimming and skewing adjustment, angle ranges for each move adjustment are provided in Section 2. Main Characteristics and Performances.

Control elements to operate these three TLS movements are provided in the operator's cabin.

TLS motions can be individually operated from a control station close to them.

If located at the boom tip the TLS system will be a motor driven worm gear system (No hydraulic).

A jib crane, bridge crane or lifting arm shall be installed to ensure safe and easy handling of all components of the TLS system. Its capacity must be sufficient to handle any components or main assemblies at the backreach.

Anti-Snag system shall be included.

6.1.5 Emergency Drive Main Hoist

Emergency drive from LV AC motor shall be provided to allow slow lowering or raising up the spreader and load. AC power may be fed from the crane auxiliary transformer or from shore emergency power.

Drive connection shall be dog clutch type. Control from local panel in machinery house and also from operator's cabin. Emergency drive shall be capable of handling the Rated Load Under Spreader. Crane Seller is to provide the rated power of this LV motor and hoisting speed with emergency drive.

One (1) set of emergency drive LV motor shall be provided for all cranes. The settings for alignment of the motor will be blocked in the position set for satisfactory alignment of the provided motor set.

6.2 Trolley

The trolley is of the four (4) wheeled rope towed or self-propelled type with the hoist sheaves supported on a welded steel structural frame carried on steel wheels with replaceable axles. Fixing of wheel assemblies by half moon shaped brackets shall be avoided.

The trolley's center distance shall be greater than its wheelbase. To limit trolley skewing phenomena, the Seller shall provide for the installation of side wheels.

The trolley structure shall be sufficiently rigid to prevent any alteration to its geometry under the effect of the load. The maximum overall and local deformation shall be less than 1/2500 of the trolley span.

A safety device shall protect the trolley against derailment, falling and lifting off the rails.

The trolley is provided with four (4) buffers at the extreme ends of the trolley travel path to absorb the dynamic energy of the trolley with Rated Load Under Spreader traversing at nominal speed. Limit switches are fitted before end stop has been reached, i.e. slow down, automatic stop and emergency stop limit switches.

Jacking lugs are provided which shall allow axle replacement at any point of trolley travel.

In the case of rope towed trolley, removable and vertically adjustable trolley guide rollers are mounted at the four corners of the trolley. Each of these guide rollers shall be fitted with an anti-fall protection system. Ease of access to the wheels and guide rollers for maintenance and/or replacement shall be ensured with trolley located in any position.

The trolley frame is fitted with access walkways, platform and railings for maintenance and allowing for safe method for wheel replacement. Clearance between side rollers and rail clips shall not be less than 15mm.

Access to and from the fixed walkway on portal to the operator's cabin shall be via double gates controlled by failsafe access control locks and that access is only allowed when the trolley is at park position. Special attention to alignment and fixing of these control locks shall be undertaken by the Seller.

Safety access is provided between the operator's cabin and the trolley to ensure that in any trolley position the operator is able to escape from the cabin through the crane girder or boom. Operator must be able to escape safely from cabin at any position, unaided (i.e. alone and without harness) along the whole girder including under the machinery house and along the boom. The deck shall be covered with galvanized industrial platform grating secured by welding. The welds shall be cleaned and coated.

The trolley is equipped with manual centralized greasing facilities.

The trolley will include two trolley stowage pins, one at each side, for high wind stowage.

Adequate and certified safety harness hookup points shall also be provided on at least 4 locations on the trolley.

The Seller may propose its preferred and recommended design regarding the trolley drive system: rope-towed trolley or self-propelled trolley are both accepted solutions.

Trolley shall be equipped with a plug via which a remote-control pendant can be connected to move the trolley and hoist up to 5 / 10% of speed plus e-stop for maintenance purposes. Pendant with controls shall be provided and stored in the Operator cabin.

6.2.1 Layout of Rope-Towed Trolley Mechanism

Drive unit consists of:

1) AC electric motor
2) Caliper disc brake directly mounted on high speed shaft
3) Independent caliper disc brake (to assist during emergency braking and also reduce effect of trolley sway on gearbox backlash when trolley is in stationary condition) on the trolley drum (low speed shaft),
4) Gear box,
5) Flexible couplings.
6) Machine grooved drum(s): The drive end of the rope drum(s) is directly connected to and supported by the low speed shaft of the reducer. The connection use a flexible coupling, bolted to the diaphragm of the drum(s). The idler end of the drum(s) is supported by a self-aligning anti-friction bearing.

Trolley shall have rope tensioning system (non-hydraulic tensioner system can be considered).

Solid stick lubricant to lubricate the wheel face and flanges shall be installed and have a minimum lifetime of 50,000 trolley cycles.

6.2.2 Layout of Self-Propelled Trolley Mechanism

The main trolley is self-powered by cross travel drive electric motors fitted on each side of the trolley. The trolley incorporates the trolley drive motors, gear units, trolley wheels and the hoist pulleys including hoist rope support rollers. Each corner of the trolley will be equipped with at least one independent drive mechanism.

Each drive configuration consists of the following mechanical components:

- Independent trolley motors. The trolley motors shall have IP55 protection index.
- Individual double flanged wheels, all trolley wheels are driven and braked and include shrink fit axles.
- The wheels are mounted on outboard bearings on live axles and include a locked shimming facility at the bearing housings for future wheel realignment in the event of a trolley collision or rail replacement.

- Bevel/helical gear reduction units enclosed in cast iron housings.
- Thruster type, drum brakes. Fail-safe spring-applied & electro-hydraulically released with mechanical control valves. The trolley brakes must necessarily be engaged in the event of a power failure. The trolley motors shall have IP55 protection index.
- Solid stick lubricants to lubricate the wheel flanges shall be installed and have a minimum lifetime of 50,000 trolley cycles.

A rubbing block will be installed at each corner to clean the rail.

6.2.3 Emergency Drive for Trolley

Emergency drive from LV AC motor shall be provided to allow slow trolley traversing motion. AC power may be fed from the crane auxiliary transformer or from shore emergency power.

Drive connection shall be dog clutch type and to provide adequate interlock between the two systems. Control from local panel in machinery house and also from Operator's Cabin. Emergency drive shall be capable to move the trolley with the Rated Load Under Spreader.

In case of Rope-Towed trolley, one (1) set of emergency drive LV motor shall be provided for all cranes. On all cranes the settings for alignment of the motor will be blocked in the set position for satisfactory alignment of the provided motor set.

In case of Self-Propelled trolley, each crane trolley shall be equipped with one (1) emergency drive motor.

6.3 Catenary trolleys

Catenary trolleys shall be provided to reduce the unsupported length of the main hoist ropes (and trolley tow ropes if any). There are two catenary trolleys, one is at the landside of the load trolley, and another is at the waterside of the load trolley. The catenary trolleys would be propelled by two sets of towing ropes. Power to drive the auxiliary trolleys would be provided by the load trolley drive by connecting the catenary trolley with the load trolley by reeving. Side guider rollers shall be provided at each side of the trolleys to minimize skewing tendencies.

Catenary trolleys shall have maintenance platforms to enable maintenance on them at the front reach and back reach and location of wire rope roller guards should not hinder in any way the removal / reinstatement of the side guide rollers. Platforms at boom tip and backreach shall be adequately sized to to allow for safe and easy servicing/replacement of wheels and side rollers.

Handrailed edges must be a minimum of 100 cm away from the edge of the catenary trolleys being serviced.

In case however that the catenary trolleys need to be accessed in situ without the possibility of moving them at front or back reach position, then a means of installing / erecting of a temporary handrail system shall be provided to reduce the risk of personnel falling off. Adequate and certified safety harness hookup points shall also be provided on at least 2 locations on each catenary trolley.

Removable and vertically adjustable trolley guide rollers are mounted at the four corners of the catenary trolleys. Each of these guide rollers shall be fitted with an anti-fall protection system. Ease of access to the wheels and guide rollers for maintenance and/or replacement shall be ensured with trolleys located in any position. Should safe access to enable wheel / guide roller replacement necessitate the temporary installation of lightweight platforms then such designs must be provided for review and approval and actual platforms provided included with the delivery.

If applicable, catenary trolleys will be equipped with rollers to allow both catenary trolley wire ropes to be replaced at the same time.

6.4 Boom Hoisting

Boom hoisting drive unit consists of:

1) AC electric motor
2) Service Caliper disk brake on high speed shaft
3) Emergency caliper disk brake on the boom drum (low speed shaft)
4) Gear box
5) Flexible couplings
6) Machine grooved boom hoist drum(s)

6.4.1 Layout of Boom Hoist Mechanism

1) The drive end of the rope drum(s) is directly connected to and supported by the low speed shaft of the reducer. The connection use a flexible coupling, bolted to the diaphragm of the drum(s).
2) The idler end of the drum(s) is supported by a self-aligning anti-friction bearing.
3) Service brake disc is mounted directly on the high speed shaft of the reducer independent of the motor couplings.

4) Independent emergency caliper disk brake(s) are connected to the boom drum(s).
5) A pair of automatic hook latches is fitted on the top beam of seaside mast frame to secure the raised boom. Side guides are fitted so that with boom up sideways movement is prevented. Different design with single automatic hook latch might be accepted.

6.4.2 Brake

1) Service brake: Braking torque of the brake is not less than 150% of the torque made by the boom ropes tension in the most adverse boom angle and wind condition.
2) Emergency brake: A spring set, hydraulically released caliper disc brake shall be mounted on the rope drum. The brake shall be capable of stopping the descent of the boom at any point in its travel without assistance, from over-speed condition. This capability shall be demonstrated during commissioning. Emergency caliper disk brakes are rated for not less than 150% of the torque made by the boom ropes tension in the most adverse boom angle and wind condition. Emergency disk surfaces shall be ensured to be kept clean and rust free by installing disc brushes which apply slight pressure during drum rotation. This helps to keep surfaces clean and reduce risk of slippage on rust in Emergency braking conditions.

6.4.3 Rope reeving

The boom hoist reeving consists of two independent equalized sets of falls, either of which can hold the boom without damage in the event of failure of one set. The remaining set of rope is capable of raising or lowering the boom to a secure position. Balance sheaves are provided to equalize the loads between the two falls. During normal operation, the two sets of ropes run synchronously.

6.4.4 Boom emergency drive

The crane shall be supplied with an emergency drive from LV AC motor to allow slow boom hoisting or lowering (approximately 40~50min). AC power may be fed from the crane itself or from shore emergency power. This set of drive (dog clutch) is disconnected with boom hoisting normally and may be connected to the mechanism in case of drive system failure (and to provide adequate interlock between the two systems.). Control from local panel in machinery house.

6.4.5 Limit switches

The following limit switches are provided for the boom hoisting motion:

1) Limit switch for automatic stop of the boom at its normal uppermost position (cam type);
2) Limit switch for automatic emergency stop of the boom at its extreme uppermost position (mechanical lever operated limit switch hard wired); For recover the by-pass button must be pressed.
3) Limit switch for slack rope at apex. When the boom rope is slackening, the limit switch shall be activated. Limit switch shall also activate in case of rope breakage.
4) Limit switches for upper and lower position of the boom latch hooks
5) Single layer rope winding protection on boom hoist drum, installed at position lower than shaft level. Physical 'Home" flag at upper and lower (but not extreme) ends of the boom travel for resetting "home" positions

6.4.6 Boom Control Station

A boom operation control cabin is located on waterside cross beam of trolley girder and it is weather-proof.

Boom Control Station shall provide clear visibility of the operation of the whole boom and latch area. A glass pane shall be installed within its roof structure to improve visibility.

Access shall be via a self-closing sliding door.

6.5 Gantry travelling

6.5.1 Layout of gantry travelling mechanism

Gantry travelling mechanism consists of bogies, AC motors, reducers, coupling and brakes. The gantry legs are supported on travelling wheels through hinge pins and equalizer beams that ensures the corner load is evenly distributed between the wheels at the same corner. The Bogies and equalizer beams are provided with jacking pads for maintenance.

As a minimum, half of the gantry wheels shall be driven.

Traveling mechanism is able to be started / stopped normally against Maximum Operating Wind, and the crane must be able to travel at 50% of nominal speed against

higher wind of 125% the Maximum Operating Wind speed to the stowage position in both directions.

The cranes are equipped with buffers at the outermost bogies, matching the rail end stops or adjacent crane buffers. The buffers are able to absorb the dynamic energy of the crane traveling at 100% nominal speed with Rated Load Under Spreader.

Rail sweeps are provided under the outermost bogies to clean off debris on the rail track.

The design of the gantry mechanism and structure shall include the possibility to replace boogie wheels, with all necessary jacking points. Jacking procedure shall be provided by the manufacturer.

6.5.2 Rail Brakes

Rail brakes shall be provided to prevent crane runaway under gust wind during normal operation. The crane is to be provided with a maximum of 4 rail brakes, which are able to hold the crane in conjunction with the motor brakes under a wind up to 150% the Maximum Operating Wind speed.

The rail brakes are electrically interlocked with gantry travelling. When the crane has stopped travelling or when the crane control power is off the rail brakes shall be automatically set (after some pre-defined time working with clamp in release mode). Rail brakes are to be rated to remain released with crane on. In addition, when the crane control power is cut off the rail brakes can be released manually.

Tools for the latter are to be provided.

Gantry rail brake can be friction or clamp type. The design must reduce the required maintenance (coil spring rail brake).

6.5.3 Stowage Device

The crane is provided with four (4) stowage devices. The storm-stowage device is designed to match the stowage socket on the Buyer's dock and to resist the Storm Wind.

There is interlock between stowage device and gantry traveling to ensure that gantry traveling cannot be started until all stowage pins are lifted up from the stowage sockets.

6.5.4 Checker's Cabins

2 identical units shall be supplied: 1 to be installed 1m above ground level under the landside Sill beam and similarly another one at the ground level under the waterside sill beam.

Cabins shall have at least the following dimensions:

- Length: 1600 mm
- Width: 1300 mm
- Height: 2370

Side windows must be installed to give clear view of oncoming traffic from the seated position of the clerk with at least2 windows of following dimensions:

- L-1300 mm x H-800 mm
- L-600 mm x H-800 mm

AC unit and all installation, indoor units shall be protected by a steel mesh. AC Control from wired in unit (no remote controller).

Landside cabin shall have Ethernet connection to enable connection from laptop to CMS station.

1x 12v & 1x 24v power supplies for radio & LXE are provided in the landside cabin.

6.6 MV cable reel system

The cable reeling drum is mounted on the crane structure near the waterside rail between the leg . The cable reel system is mono-spiral, bi-directional and constant cable tension heavy-duty type specifically designed for quayside container crane application. Cable reel to have manual control station at ground level near cable guide. Cable guide shall also be installed with an attachment for raising of the panzerbelt installation located on top of the cable duct.

Distance between cable and rail is 1110 mm

The cable reel is driven by AC motor. The drive system is designed to minimize abrupt starting, braking and excessive slack of the cable as the crane passes the cable feeding point. No magnetic coupling shall be used.

The design also ensures that there is no undue mechanical and electrical strain on the cable. The motor is provided with over-current protection, which shuts down the system and prohibits crane gantry travel when overheating occurs.

The reel is made up of hot dip galvanized steel material (smoothed – no sharp edges) and is properly earthed. No part of the system will protrude into the container handling operation paths nor protrude beyond the gantry buffers.

The reel is able to coil and uncoil automatically and be synchronized with the crane gantry travel.

Over-tension and under-tension detection devices are provided. On detection of over-tension or under-tension of the cable, gantry travel in either direction is prohibited.

The system must be controlled by variable frequency inverter and fitted with encoders. The encoder signal can be used to indicate crane position, displayed in the operator's cabin, in the main CMS, and to the TOS.

Gantry travel distance required along the quay is as provided in the Section 2. Main Characteristics and Performances. Sufficient cable length for 3 dead turns remain on the reel at the end of the nominal gantry travel distance.

6.7 Personnel Elevator

The crane shall be equipped with outdoor rack & pinion driven elevator with capacity of 4 persons and 400 kg lifting capacity. Radio to communicate with the existent THPA radio system and alarm shall be provided in the elevator car.

There are four (4) elevator landings, located at ground level, access to the cable reel, access to the operator's cabin and machinery house. At these four landings the catwalks and stairways accessing / leading to the elevator are to be at the same level as the elevator car exit (door). The elevator car has an emergency exit to enable personnel to escape in case of power failure.

The elevator shall be fitted with automatic rack lubrication system. The elevator car shall include emergency stop, lighting and emergency lighting. Testing equipment for certification purposes and any other specialized tools are to be provided.

Elevator will be equipped with a maintenance platform to allow safe access to any locations where extraordinary maintenance works to be performed.

The wind proof channel / canopy surrounding the landings shall not be constructed by expanding or perforated metal sheets.

A safety locking pin is to be provided at the lowest landing to mechanically secure the car during maintenance. The lift drop cable junction box shall be located in such a way that it can be easily and safely accessible from the crane stairway.

6.8 Machinery house

Machinery house accommodates main hoist, trolley (if rope-towed type), boom hoist mechanisms and electrical control equipment. General layout and construction of the machinery house shall be such that maintenance, inspection and removal of equipment can be easily performed. Space of not less than 1m shall be provided around the equipment in the house and space of not less than 1m shall be kept between the machinery and machinery house wall for personnel passing through. Access for easy maintenance of roof lights shall be provided.

All the walls and the ceiling are clad with corrugated steel. The doors in machinery house are provided with sealed windows for natural lighting in case of emergence exit. A sealed window shall be strategically installed so that the A-Frame can be seen from the machinery house control station.

Air exhaust fans, thermostatically controlled, to be installed in sidewalls of machinery house and shall be able to change the air in the house 30 times per hour. The fan control shall have a selection for "Manual – Off - Automatic" mode. These fans shall not produce noise exceeding 80 dB(A) at 1m distance. A washable air filter is provided at the intake of each of the exhaust fans. During operation the heat generated electrically and mechanically shall be dissipated completely to outside atmosphere.

Rain shade is provided outside the fan. The machinery house roof is made with a slope to drain water. The wall and roof of machinery house shall be made of steel corrugated plates. The machinery house has sufficient vertical height to allow lifting and movement of components by the maintenance hoist within the confine of the machinery house.

A workbench with bench vice, a locker for tools, an air compressor with air dryer, welding machine, service sockets and fire extinguishers etc. are provided in the machinery house.

The machinery house is equipped with at least two access galvanised marine metal sliding doors, which are fitted with locks, handles and the width of is not less than 0.8m. The height of the door is not less than 2.0m. Each door must have a safety glass window recessed in its frame. Four other separate doors shall be installed as follows.

- Electrical Room to Machinery House
- Electrical Room to outside
- CMS Room to Electrical Room
- CMS Room to outside

Machinery House shall have strategically placed hatch covers one of which will allow the largest component to be able to be lowered to the ground. Other hatches will be located to coincide with maintenance activity required to be carried out eg, replacement of a bogey wheel. A specific hatch centrally located within the machinery house shall be provided. This would be required in case of the need to lift a special trolley rail servicing platform onto the trolley rails from the ground.

Access to and from the underneath of the machinery house should be secured by providing a safety lifeline on either side to enable safe attaching of safety harnesses. Hook up points for safety harnesses shall be clearly identified within the manuals and on the crane itself.

Safe access to machinery house lights and emergency lights is to be provided for ease of maintenance. If possible this access shall be from the machinery house service crane catwalk (for maintenance of its hoist).

Access and handrails are also to be provided to and for the roof of the electrical room.

Both medium voltage transformers and their respective protective switchgear shall be placed in separate well lit (fitted with emergency lights too), lockable rooms / compartments inside the machinery house.

6.8.1 Machinery House Control Stations

The machinery house will include control stations enabling manual operation of the main crane motions.

A glass panel shall be also inserted within the machinery house wall so as to enable operator at the boom function control panel to view the boom wire rope slack and the rear end of the A-Frame.

6.8.2 Rope Re-Reeving System

A twin motorized rope re-reeving arrangement shall be installed. Braked motors shall be independently controlled via dedicated local panel which shall enable independent individual and / or twin operation of the motors in any direction required and at rated safe working load when operated individually.

The operation of the rope reeving mechanism used for the wire rope replacements shall be operated either from a fixed station or from a removable wired pendant connected close to the machinery house hatch. Length of flexible cable shall be around 10m. Machinery house shall be equipped with lugs to enable supplied sheave blocks to be fitted when rope reeving is taking place. The operation of all rope reeving shall be made as simple as possible and all working stations shall be readily accessible.

Buyer will appreciate solutions by which more than one wire rope may be reeved at the same time. This would simplify and shorten wire rope replacement durations when more than one wire rope needs to be replaced at the same time.

Diagrams in 2mm engraved plastic A3 version shall be installed in machinery house showing wire rope reeving

6.8.3 Air Compressor System

An AC electric motor driven air compressor shall be installed in the machinery house. The compressor shall supply 10L of dry air per second at 10 bar pressure. All safety devices including over temperature protection shall be provided. Automatic moisture discharger at suitable rating shall be included, as well as retractable hose reel for machinery house of suitable length to reach all points. Regulators, filters, and oilers shall be of the highest quality to prevent damaging when under full pressure. The unit shall be mounted on anti vibration dampers. Compressor and air receiver test certificates shall be displayed on board adjacent to the units.

Compressed air is used for:

1) Cleaning machinery
2) Supplying pneumatic power
3) Operating small auxiliary units
4) Powering pump at centralized greasing points

Air compression system shall be supplied to all areas requiring maintenance on boom, girder, A-frame etc.

6.8.4 Electrical and CMS Rooms

The electrical room is in the machinery house and it contains major control equipment. The walls and the ceiling of the control room are plated with sound insulation and fire-resistant material. Proper vibration isolation ensures that noise level in the room is lower than 85dB. A safety glass window is provided on the wall between the control room and machinery house for viewing all machinery. The floor of the room is overlaid with anti-electrostatic material.

Adjacent to the Electrical Room will be the CMS Room where the CMS and the PLC are located. All crane CCTV cameras can be viewed on a separate monitor in the CMS room to assist personnel during troubleshooting.

The CMS room will be provided with a desk, folding chair and cabinet for files.

The electrical room is to be provided with several split type air conditioners capable to keep room temperature between 20 degrees Celsius and 22 degrees Celsius and control relative humidity. The indoor units shall be embedded into the electrical room ceiling. Minimum two additional air conditioner units (same size and type as the others) shall be installed as redundant units. The temperature of the electrical room is to be monitored by the PLC and reported on the CMS.

CMS room will also have a separate split type air conditioner.

6.8.5 Service Crane

A service crane is to be provided in the machinery house and capable of lifting the heaviest piece of equipment in the machinery house. The service crane is able to handle each piece of equipment out of the house to the ground for repair. The service crane shall be capable of motorized vertical, longitudinal and transverse motions.

The crane is able to travel and traverse across the whole machinery house.

A simple and reliable means of overload protection shall be provided.

A hatch cover is provided on the floor of the machinery house for handling large piece of equipment from or to the machinery house. Handrails are to be provided around the hatch to ensure safety.

The service crane structure must have a locking system to prevent movement during crane operation. A secure parking position is to be provided and its hook shall be kept stationary via a securing means to avoid any dangerous swinging.

A safe means of access to the hoist is to be installed so that this machinery can be easily accessible for maintenance without the need of other devices such as free standing ladders etc.

The wire rope supplied with the hoist must be non-rotating and non-tangling throughout the whole traveling distance of the hoist with or without load. The hoist must have slow and high speed control for hoist motion and single speed for the other motions.

Floodlights are to be installed under / at each corner of the trolley of the service crane. These will be powered on from the crane pendent.

6.9 Operator's cabin

The operator's cabin shall be designed based on ergonomics to give an all-round comfortable environment for the operator. Operator shall have a simple and safe means of cabin exit by the operator in case of an emergency should the door become locked for any reason.

Different console and seat arrangements shall be considered. Cabin shall be well suited and adapted according to the console and seating arrangement selected.

The operator cabin, control station, seat and the cabin components to be of original European make.

6.9.1 Design and Layout

The design of the cabin, layouts, control station including all display positioning etc shall be executed in close cooperation with the Buyer, crane manufacturer, drive supplier and cabin manufacturer. 3D drawings of the cabin, control station, consoles and panels to be provided for the end-users approval.

6.9.2 Attachment to the Trolley

The operator's cabin is secured under the trolley and mounted with suspended fail safe 3D anti-vibration mountings. No rigid connections between the cabin and trolley are allowed. The anti-vibration mounts to be designed in a way they can be replaced 1 by 1 without demounting the cabin. Access for simple mounting replacement shall be optimised. The main cabin structure at 4 points to be connected to the trolley by means of safety (secondary) suspension. The type and location of the suspension

points to be calculated based on the static loads of the cabin, the walkways, other possible equipment and based on the dynamic loads because of crane operation.

Safety Chain shall also be provided.

Unless not possible, Buyer requests to utilize conical mountings from ANGST PFISTER reference 12.2138.1004 (786030 70Sh) for standardization purposes.

6.9.3 Dimensions

The minimum dimensions of the operator's cabin will be:

Length: 3000mm

Width: 2000mm

Height: 2500mm

6.9.4 Structure

An all welded cabin structure from folded sheet metal shall be utilised. The outside shall be fully welded. Cabin shall be of a double skinned structure with a minimum of heat / cold transition contacts between the outer and inner skin.

The cabin to be provided with a sloping roof structure, fully welded at the outside with rain gutters at the front and both sides of the cabin, connected to a stainless steel drain pipe at both sides at the rear of the cabin.

The double skinned walls and roof to be isolated with water-repellent and fire resistant isolation material (ISO 1182).

6.9.5 Painting

The cabin structure to be shot-blasted Sa 2.5 at the inside and outside. A hot metal spray process will be applied to seal the steel pores prior to commencement of the painting cycle. The outside of the structure to be provided with a 3 layer painting system, total 225 micron, the inside with a 2 layer painting system, total 150 micron. 5 years minimum guarantee on sliding scale, certificate to be provided.

6.9.6 Vibrations

The maximum vibration level will be 0,5m/s2 in X, Y and Z axis, measured according to ISO 2631-1. Evaluation of human posture to whole body vibration (at the cushion at the main operator seat, calculated at 35 moves per hour).

6.9.7 Windows

The cabin to be provided with an electrically heated sloping main bottom window (1 piece) at the front of the cabin width a minimum length of 1000mm, non-tinted (heating Capacity: 4 W/dm2, thermostatic controlled).

2 extra bottom windows next to the seat for visibility back / downwards.

The 3 bottom windows to resist a concentrated load of 2500N/ft^2 and a divided load of 1500N/10ft^2 at the same time. A load-certificate to be part of the delivery. No safety bars are allowed to avoid visibility obstructions. All three windows mentioned to be provided with a sacrificing layer on top.

The cabin to be provided with lifting lugs in the roof of the front part of the cabin to makes it possible to lift the main bottom window if needed.

The lower side and front windows of fixed type, double glazed safety glass, green tinted, 67% light transmission, to be fitted from the inside.

The upper side and front windows shall be of the sliding type, double glazed safety glass, grey tinted, 45% light transmission, to be fitted from the inside of the cabin. All windows shall be possible to be replaced from the inside.

A protection railing is provided in the front of the cab to increase safety for the operator.

Rain shade and sun shield are also provided at the window.

All the windows glass can easily be cleaned from the inside and from the platform.

Bottom glass shall be equipped with a heavy duty type of straight line wiper wash and wipe system.

6.9.8 Cabin Access

Access to the cabin is through a hinged type entrance door as a one-part welded structure provided with a heavy duty locking mechanism and welded stainless steel hinges provided with grease nipples.

The position of the door shall be optimised to the landing platform of the crane to create easy access, and shall also allow for a stretcher to remove an injured person.

The entrance door to be provided with a double glazed upper window and a single glazed lower window useful as emergency exit.

6.9.9 Cooling

Cabin provided with a local brand split type AC unit. Capacity calculation to be provided by the cabin supplier, maintaining the inside temperature at maximum 22°C in the

hottest environment conditions. Temperature of 22°C is to be reached within 10 minutes after starting up.

Heating / De-Misting

Cabin provided with an integrated heating / demisting system to maintain the inside temperature at a minimum of 21°C during an outside temperature of 0°C. 21°C reached maximum after 10 minutes after starting up. This shall be optimised with the flow directed so that no fogging occurs on the glass panes.

In the case of Cooling and Heating / Demisting functions, all measurements with closed door and windows, a possible fresh air supply of 50m^3/h to take into account. The calculation to be provided for approval.

Fresh-Air Supply / Over Pressure

The cabin to be provided with an overpressure / fresh air supply unit to provide the operator with a minimum of 50m^3/h fresh air per hour. However, the airflow to be as low as possible to avoid loss of heating / cooling energy and loss of life time of the filters. The incoming air to be filtered via a combination of active carbon and chemical filters. The overpressure / fresh air supply unit to be provided with sensors to indicate the overpressure and the status of the cabin. In cold outside circumstances, the incoming air needs to be automatically heated.

6.9.10 Operator's Seat Arrangement

Alternative arrangements must meet the standards ISO 11226 Ergonomics, Evaluation of static working postures as well as ISO 2631-1 Evaluation of human posture to whole body vibration.

The lay-out of control components to be approved by the Buyer.

The seating arrangement has to be provided with an upper body support by means of two fully adjustable armrests, one on each side of the driver. Both the armrests will include comfortable ergonomic cushions.

Both the armrests have to be adjustable in height, in a fore-backward direction, and they must be able to pivot and slope. All adjustments have to be adjustable by operating one single lever at one side of each armrest. Furthermore the seat needs to be provided with a unique suspension system for both the seat and the consoles.

Both the armrests have to be provided with integrated controls. The size of the levers and the location of the controls need to be designed in such a way that the upper body support via the armrests will be maintained.

The seat itself to be provided with the following adjustments:

- Seat forward and backward
- Seat cushion forward and backward
- Lumbar support

- Backrest in height and inclination
- Seat inclination

The seat arrangement has to be provided with:

- 4 points safety-belt and a head rest
- Rotation table with a positive locking system in the forward working position
- Motorized height adjustment of 200mm and a mechanical / pneumatic suspension system to absorb low frequency shocks
- Ergonomic training and users instructions
- Maintenance instructions

6.9.11 Consoles Arrangement

The consoles contain at minimum the following equipment:

1) Main hoist/gantry shared controller
2) Trolley traverse controller
3) Power switch with "on/off" indicator light
4) Spreader pump button switch with indicator light
5) Spreader "extending/retracting" selector switch with indicator light
6) Spreader normal trim, list and skew controllers
7) Spreader twistlock "lock/unlock" selecting switch
8) Flipper "raise/lower" selecting switch
9) Rail clamps "apply/release" selecting switch with indicator light
10) Indicator light for stowage state
11) General Fault indicator light
12) Emergency stop push-button
13) Acoustic alarm reset push-button
14) Indicator light for slack rope
15) Indicator light for telescopic spreader length
16) Other facilities necessary for normal crane operation
17) Touch panel for operator CMS interface – to include screens for floodlight status; fault screen; motion permissive etc. Outlet for Ethernet connection to laptop. To include similar options as in the existing touch panel units.

Auxiliary control units are installed at side of the operator for convenient viewing and operation.

1) Walkway lighting control switch
2) Operator's cabin lighting control switch
3) Switches for floodlights
4) Various switches for alarms and loud speakers system

The following indicator lights are fitted in the front of the operator in the cabin at bottom glass level and referred to as a Spreader Indication Panel:

a. The spreader is landed on the container (yellow)
b. The spreader twistlocks are in unlocked position (green)
c. The spreader twistlocks are in locked position (red)
d. The spreader in twin lift mode (blue). Indicators for hoist height & load

The master controllers are maneuverable with accurate positioning and without jamming. Their parts and components are wear-resistant and easy for replacement.

Description related to operation and application will be identified adjacent to the operation handle (joystick and push-buttons.)

Plates with instructions are fitted adjacent to the instruments and indicator lights. All the plates and identifications are in English.

Full review of layout shall be carried out at Design Review during which the cabin supplier must be present.

6.9.12 Miscellaneous

1) Portable fire extinguisher(s) is installed in the cabin
2) Blinds are to be installed in cabin, 6 in number, with minimum of 60% light absorption
3) Public address system
4) An additional fixed foldable chair with seat belt chair for trainer is provided in the cabin
5) User log on/log off system, configurable for operators and maintenance personnel to allow control power. Operating times would be logged and saved by the cranes CMS
6) Small locker for operator
7) Two (2) Earth nuts M16, close to the rear suspension points, fully welded at the roof structure

8) Integrated speakers in the ceiling for communication radios
9) Cup holder for 2 sizes of cups / bottles
10) Three (3) pieces of double power outlets
11) Main light, integrated in the ceiling, provided with emergency battery and integrated spotlights with dimmer, lighting the consoles
12) Integrated electrical cabinets with lighting inside
13) Integrated spotlights with dimmer, lighting the consoles
14) Clear shield coating to decrease pollution at the outside of all windows
15) Extra gutters at roof level to prevent pollution at the front- and sidewalls from grease. A protective "skirt" at the outside of the cabin, around the bottom window to protect the window against pollution. The skirt will not decrease visibility from the operator's viewpoint
16) Two sliding safety grating 200mm width shall be installed on a channel over the bottom window which will allow the operator if required to step onto them for alighting from the seat while the same sliding gratings shall also allow adjustable footrests to be installed. Foot pedals shall also be located on these adjustable gratings
17) USB charging station for mobile phone 2 way
18) Emergency escape route: Cabin shall be installed with a clearly legible pictorial showing possibilities for safe escape route from cabin onto trolley to boom / girder or machinery house in case trolley is unable to be moved to parking position. Location of such a diagram shall be next to an emergency light

6.9.13 Operator Visual Aid (optional)

At least two 4K cameras are to be installed to ease the operator's view. One is to be installed on the trolley overlooking the over / beyond the head-block and shall be capable of automatically zooming with hoisting. The other to be installed on one of the portal beams (preferably the right) overlooking the area between the gantry rails. Both views are to be displayed on a 17 inch HD color monitor installed in the cabin with HDMI connectors. Views are to be either automatically switched depending on the crane motion or manually selected by the operator.

Additional screens are installed in the operator's cabin to view the images captured by cameras mounted at various points on the crane.

Monitors with highest possible Brightness shall be provided – not less than 1500 cd/m.

6.10 Platforms, walkways and stairs

Stairs rather than ladders shall be included in the crane wherever practicable.

Floors shall be designed for the dead load of the structure plus a superimposed live loading of not less than 2.5 kPa uniformly distributed, or a concentrated loading of not less than 1 kN at any point, whichever produces the most adverse effect.

Operator's cabin platform and any other platforms considered as critical and which may require a limitation of loading capacity should be installed with clearly visible signs indicating maximum load and number of persons permissible.

Where galvanized/painted piping is used for guardrails or posts, it shall be seamless, welded and the wall thickness shall not be less than 2.5mm.

Vertical clearance above platforms and walkways shall not be less than 1900mm.

The toe-board shall be firmly attached to the floors or posts, and any gap between the toe-board and the floor shall not exceed 10 mm. The top of the toe-board shall not be less than 100 mm above the top of the floor.

Stairways shall not be less than 600mm wide measured between the inside edges of the handrails. The angle of slope between the stiles and the horizontal shall be not less than 26.5° and not greater than 45°.

The number of rises in any flight of stairs shall not exceed 14, and where there is more than one flight, adjacent flights shall be connected by landing.

All rises and all goings, in the same flight of stairs shall be of uniform dimensions within a tolerance of +/-5 mm.

Each rise shall not be less than 150 mm and not greater than 215 mm.

Each going shall not be less than 215 mm.

The handrail shall be parallel to the angle of slope of the stairway and the height measured vertically above the nosing of the tread shall not be less than 800 mm and not greater than 1000 mm.

Clearances between the ladders and all permanent objects not being part of the ladder installation shall not be less than the following:

- At the back edge of the rung ladder, 200mm
- From the nosing of the tread in step ladders, 150mm
- In front, from the nosing of the rung measured normal to the slope of the ladder, 750 mm when the ladder is vertical or inclined at not less than 75deg to the horizontal, increasing proportionately to 1000 mm when the slope of the ladder is 60deg to the horizontal.

Ladders shall be provided with safety cages as per the requirements of F.E.M. 1.001.

All stairs, ladders hand railing and access platforms and floor grids located externally shall be galvanised by the hot dip process.

Access platforms and stairs shall be constructed of grid steel flooring. All gates shall automatically close and lock to safety.

Where vertical ladders are used, each rung shall be fitted with non-slip surfaced material. Use of deformed construction steel as "non-slip surfaced material" will not be acceptable.

6.11 Lashing platform

A lashing platform shall be provided to reduce risk to lashing personnel from the straddle exchange area. Its design aim at handling around the container by means of inserting/removing twistlocks, checking seals, tallying and so forth, is no longer performed on the ground but on the platform on the crane.

The platform is installed on sea side and can support the fall and the occasional landing of 1x20', 1x40' or 2x20' containers. This frame must be designed as to withstand frequent impact from the headblock/spreader combination.

The platform frame will be connected to the sill beam and to each cross beams with drawbars. Pin connections are recommended to the sill beam and the cross beams.

Grating must be installed on the platform's walkway floor to prevent from slipping.

On each side of the frame, the Seller must install handrail to prevent from falling.

The Seller must provide safe access to the frame by stairways and runways from the ground level.

Two checkers' rest cabins to be positioned at each side of the frame (leftside and rightside). Front side of the cabin shall have no wall or door for the checkers to easily enter into the walkout of the rest room. The floor of the rest room shall be of the same level as the lashing platform. Inside each room, the Seller must install florescent lighting, a rest bench, an emergency-stop button and a circulation fan.

The Seller must provide guides to the twistlock boxes.

Painting, steel grating, and fixing should be according to the crane standards.

The Seller must provide FEA analysis of lashing platforms design showing stress calculations deflections for the platform brackets, seats, pins on the sill beams and the drawbars connections to the cross-beam.

6.12 Spreader support on the Sea Side beam

A storage platform shall be provided on the waterside sill beam to store a spare spreader or other lifting device as required. The platform must be positioned in the center of the sill beam so that it can be lifted by one of the crane spreaders.

Guiders must be installed for 40’ or 2x20’ positions.

The structure must be built as to withstand frequent impact from the headblock/spreader combination.

Depending on the lashing platform design, this storage area can cover the lashing frame and the sill beam.

The storage platform must be accessible from the lashing frame.

6.13 Mancage support on the Land Side beam

A storage platform shall be provided on the landside sill beam to store a lashing mancage. The platform must be positioned in the center of the sill beam so that it can be lifted by one of the crane spreaders.

The storage platform must have the length of a standard 40’ ISO container and include 4 guides at each corner.

The structure must be built as to withstand frequent impact from the mancage/spreader combination.

6.14 Mancages (optional)

Modulated man cages 20’ & 40’ with guides are to be supplied and installed on the landside sill beam of each crane.

Design of guides and cages should be discussed with the Buyer before manufacturing.

6.15 Service cranes

Service cranes shall be installed at the following strategic locations:

- A lifting arm should be provided at the 1st or 2nd landing above the elevator ground position. This shall enable to lift loads from ground and lower into the elevator car through its roof emergency hatch. It shall include an electric chain hoist with 250kg Safe Working Load, to be stowed in a dry and safe box adjacent to the lifting arm. An electrical interlock shall prevent the elevator motion if this the arm is not correctly stowed. The electric winch is to be powered from an adjacent 16A socket outlet and operated from a hand held pendent type control, both having an IP rating of 65.
- A lifting arm at cable reel areas
- A lifting arm at back reach area
- A lifting arm at front reach area and at all locations installed with rope sheaves on the boom
- A lifting arm at the A-Frame
- At other locations requiring maintenance

The Seller must provide the relevant CE Certificate for each of these service cranes supplied including proof load certificates and to provide means / tools for periodically re-certifying these service cranes without the need of weights.

7 MECHANICAL SYSTEMS

7.1 Wire Rope Drums

The drum is of welded construction. The thick steel plate is rolled to form a circle tube-shaped drum and the drum is tested after welding and stress relieved. Then wire rope grooves and fitted surfaces are to be machined. Following machining of grooves, necessary heat treatment shall be carried out to ensure the required amount of hardness. The grooves depth is equal to about 35% of rope diameter. The length of the drum is designed for one layer of winding rope. Wire rope ends are secured through bolts and clamps. Three unclamped full dead wraps of rope shall be always left as a minimum on the drum besides the secured wraps. The drum is supported by anti-friction bearings.

The ratio of the drum diameter to the rope diameter is greater than 30 for main hoist and trolley towing drum if any, and 30 for boom hoist drums. The drum shall be statically balanced.

After machining the rope grooves shall be hardened to a minimum of HB280.

Appropriately sized hot dipped galvanised drip pans are to be placed under each wire rope drum.

7.2 Sheaves

All rope sheaves shall be manufacturer from rolled steel, machined all over and mounted on ball or roller bearings. Hardness of groove will be not less than HB350 or equivalent, to the depth of not less than 4mm.

Effective heavy-duty rope guarding shall be provided to prevent the ropes leaving the sheaves.

Pitch diameter shall not be less than that stated in F.E.M. Sheave guards shall be installed with maximum allowable gap of 2mm from sheave to reduce risk of wire rope coming out of the sheave and onto the shaft.

7.3 Wire Ropes

All steel wire ropes shall be made in one piece. Rope selection shall be based on F.E.M. requirements clause 4.2.2. Manufacturer's test certificate of the quality and breaking strength of each rope shall be provided. Safety factor shall be based on F.E.M. 4.2.2.1.2. All wire ropes to be galvanized to prevent rusting. Also ropes to be factory treated with long life grease by applying hot grease during the spinning process and then through a hot bath at the end of the cycle preferably using Nyrosten T55.

7.4 Rope Rollers

All rope rollers installed shall be of the light weight and durable Innollan polyurethane type. Material utilised shall be compatible with all possible wire rope lubricant possibilities amongst which the use of Nyrosten T55.

7.5 Gear Reducers

All gearing shall be machine cut and shall comply with the appropriate F.E.M., BS or AGMA Standards.

All gears shall be enclosed in oil baths. Each oil bath enclosure shall include an oil filling, an oil draining and an oil level point. Access to these 3 points shall be allow easy inspection and maintenance. Next to the drain shall also be located a magnetic gearbox drain plug. Adjacent to each oil filling point shall be a permanently fixed label indicating the type and quantity (volume in litres) of oil to be used.

It is required that Seller obtains written confirmation from the manufacturer stating that the manufacturer approves reducer size selection for the duty.

7.6 Couplings

7.6.1 High Speed Couplings - Main Hoist, Boom and Trolley Mechanisms

High speed couplings shall be flexible, non-lubricated and not of the gear teeth type. In case however that couplings are of the gear teeth type, adequate guards shall be installed to reduce the risk of grease from the coupling contaminating the brake disc and brake pads.

High speed shafts couplings shall electrically insulate the connected motors and gearboxes.

7.6.2 Drum Couplings – Main Hoist, Boom and Trolley Mechanisms

Low-speed shafts shall be provided with lubricated gear drum couplings. Lubrication of such couplings shall be enabled by installing one greasing nipple and grease one relief plug for the other end. Long life grease shall be applied.

Drum couplings shall have both axial and angular wear indicators.

7.6.3 Drum Encoder Couplings – Main Hoist, Boom and Trolley Mechanisms

Fine tooth coupling shall be provided at the encoder, cam limit and overspeed connection for the drums. This to enable fine adjustment of hoist ropes after stretch without disturbing cam limit & encoder settings.

7.7 Brakes

Brakes used on the crane are to be of disc type. The brake shoe lining is made of asbestos-free material. The brake discs are all machined and balanced.

Brakes shall have status indication (open/close).

7.8 Travelling Wheels

The trolley and gantry travelling wheels are to be machined from forged steel with double flanges.

Service life of the wheels shall be more than 20,000 hours.

The wheel shafts are to be supported on anti-friction bearings.

The width of gantry wheel tread shall match the rail on the Buyer's dock.

7.9 Bolts and Nuts

All threaded connections on the crane are metric threads and meet ISO standard. Bolts and nuts are provided with anti-loosening or dropping-resistant means.

Widely used nylon lock nuts are used at essential locations to withstand vibration and alternate load.

High-tension bolt connections coated are used for main structure.

Bolts and nuts are all galvanized, or dacromet coated or made from stainless steel.

Large and exposed bolts are coated with anti-corrosion paint.

7.10 Bearings

All rotating parts are supported on anti-friction bearings except pin connections where plain bearings are used. Calculations for selection of the bearings shall be in accordance with FEM recommendations. Buyer requires traceability for all bearings purchased and installed on its cranes. This traceability will then be performed directly by the bearing manufacturer going through the feedback provided by the Seller during the fabrication stage. Seller shall provide full cooperation in this respect.

7.11 Safety Guard

All exposed rotating parts are to be provided with safe guards and shall comply with Machine Directive.

7.12 Lubrication system

1) All gear reducers are lubricated by oil bath.
2) Sheave anti-friction bearings: grease lubricated. Where two and more sheaves are installed on the same shaft respective grease filling hole shall be provided for each bearing to ensure proper lubrication.
3) Hinge pins: grease lubricated. Lubrication points located on top or upper portion of the crane may be led to lower position with steel tubes.

All the rotating parts shall be effectively lubricated. The lubrication points located at higher position shall be lubricated in concentration mode, i.e. many lubrication points are concentrated to a part with obvious identification. Adequate spaces are provided for all lubrication points for easy to operation of the maintenance staff.

Before handover greasing of all crane points and wire ropes is to take place again in Buyer's premises and witnessed by Buyer's representative. All points are to be greased by compressed air pumps. Flexible hoses for greasing lines are to have improved connection crimp points.

8 HYDRAULIC SYSTEMS

8.1 General

The design of the installation will take account of servicing and repair requirements.

The Seller will provide the following information:

- Calculation of the transmission, both for the mechanical and hydraulic section
- Cylinder strength and rod buckling calculations
- Speed and pressure of the receivers and generators
- Motor torque and power calculations
- Working and peak pressure
- Calculation of the overall efficiency (mechanical and volumetric) of the installation as well as the installed capacity
- Lifetime of the installation's components

The Seller will also state the characteristics of the components proposed as well as the safety factors considered in the dimensioning of the equipment.

The Seller will install devices to carry out servicing and maintenance operations in accordance with the class of equipment use.

The hydraulic diagrams of the installations will be supplied by the Supplier together with a full, detailed parts list, including:

- Exact part numbers
- Names of manufacturers or suppliers
- Flow rate for all piping
- Component setting pressure
- Pressure tapping point on the circuit
    - High pressure
    - Low pressure
    - Boost
    - Pilot
    - Return
    - Drain
- Dimension of the pipes
- Fluid sampling point for physical and chemical inspection
- Component labeling for quicker identification on servicing or troubleshooting. These same identifications will also be used on the installation

- Filling and drainage points. A color identification system will be used to denote these same points on the installation
- Safety features implemented (blocked filter, tank level and temperature)

The Seller will specify:

- The provisions taken to prevent contamination of the components
- The degree of oil contamination accepted to guarantee the good working order of the hydraulic equipment as per ISO 4406.
- The cylinder characteristics
- Types of piping and minimum inside diameter

8.2 Power Units

Each power unit will group together all of its components as compactly as possible; these components will however remain accessible for maintenance operations.

Filling will be done via a permanently installed filter.

The filters will be equipped with blockage indicators. The Supplier will state whether these indicators trigger a warning sound and/or light and if they cause the equipment to stop.

The drain hole will be equipped with a magnetic plug and a manual valve situated at 2/3 of the normal oil level will enable samples to be taken. Full provisions will be made to limit the oil temperature to the value compatible with fluid quality, taking account of the distribution diagrams and the working spectrum.

A secondary containment tray will be placed under each hydraulic unit with oil recovery. These trays will be equipped with a calve-type drainage system to evacuate the drips.

The minimum and maximum level indicator lamps will be installed in a visible position protected from impacts.

The pumps will not be immersed.

A minimum level detector shall be installed. This detector will trigger an alarm and stop the installation.

The grade of oil will be determined by the Seller with the agreement of the installation component suppliers. Flushing and first-fill oils will be supplied by the Supplier.

The Seller will provide a table of corresponding oils for the main suppliers.

The classes of purity to be adopted will be indicated by the Seller with the agreement of the installation component supplier. The cleaning and/or filter replacement intervals will be specified by the Seller. Similarly, the oil sampling frequency will also be specified by the Seller.

The cooling system shall be over rated to ensure proper cooling of the hydraulic oil and shall be positioned to allow air to pass through without obstruction. This shall be designed for any possible ambient temperature.

Local operating station is to be provided adjacent to the Trim/List/Skew system for operating individual cylinders, in case of hydraulic TLS system at the back reach.

The oil change frequency will be indicated in the service manuals.

8.3 Distribution

The distribution components will be grouped together as much as possible on manifold block systems to avoid a multitude of pipes. The electro valves will be of the sealed, oil-bath type and fitted with mechanical push control. Mechanical push control points shall be equipped with a rubber pouch which will allow manual activation without the need to remove rubber pouch by pressing with a finger.

A stainless-steel plate with engraving showing a clearly legible and labelled schematic of the hydraulic circuit on each hydraulic pack shall be present on the crane.

8.4 Cylinders

The cylinder rods will be protected against corrosion by a nickel-chromium treatment (40 + 20 microns) on copper.

A safety block with non-return valves will be flanged onto the body of the cylinders to enable load retention and lock the cylinder in position should the supply lines break.

The chambers will be equipped with bleed valves purges to open their exhaust.

Insofar as is possible, the cylinder rods will be normally retracted into their home position to protect them.

The cylinder clamps and their linkages will be designed such that any transverse strain causing abnormal buckling, bending or twisting effects will be negligible.

They will comply with all ICS standards under code 23.100.20.

8.5 Pipelines

Flexible pipes are recommended. They will be tied every 0.50m.

Rigid piping will be in stainless steel grade 316L for exterior lines.

The weld-free type of rigid pipe will be used and the necessary pickling, cleaning and passivating operations will be carried out prior to assembly.

The pipes will be plugged during assembly operations to avoid the introduction of foreign matter.

All hydraulic circuits, once connected, will be tested and flushed at 1.5 times the maximum service pressure before they are put into operation. The spacing between the pipe attachment supports will be such that any harmful vibration will be avoided.

The supports will be welded onto the structures by qualified welders.

The pipe-to-apparatus connections will be flanged.

For small-diameter pipes, couplings other than flanges will be submitted to the Buyer for prior approval.

The hoses will have JIC/BSPP or JIC/JIC tapered couplings. Crimped "olive" type fittings are prohibited.

The circuits will have numerous testing points (pressure, flow rate and temperature).

If installed outdoors, the power units, valves and pipes will be protected by a casing.

8.6 Accumulators

Accumulators will be equipped with a membrane; if this is destroyed, a device will prevent circuit contamination by debris.

A valve shall create the accumulator vacuum.

8.7 Filtration

The filters will be chosen according to the equipment installed on the hydraulic circuits such that the filtration threshold is lower than the nominal clearances of the components.

The filters will necessarily be equipped with a device to measure Δ P (input pressure – output pressure).

Exceeding the Δ P value recommended by the manufacturer will generate an alarm for the operator's attention.

8.8 Tank

The reservoirs shall be in 316L stainless steel.

8.9 Manual Operation

Manual hand pump operation shall be provided to allow for emergency operation in case of failure eg. in the case of the need to release an emergency brake or rail clamp or for other reasons.

9 SAFETY SYSTEMS

9.1 Emergency Push Buttons

Emergency push buttons shall be mounted on the crane. The location of them includes as following:

- Two units located for quick access in the electrical room
- One in the CMS room
- Two minimum in the machinery house
- One in the operator's cabin (on the operator console)
- One in the Boom Control Station
- One at the boom tip, one at middle section of boom, one at the back reach
- One on the trolley
- One on the A Frame
- At gantry level: two inside the legs, near centre point (one on waterside + one on landside), two on the landside of the landside bogies (one at each end), two on the waterside of waterside bogies (one at each end)
- One at the MV cable reel platform
- One at the main stairway at ground level – recessed mounting
- One at the landside Ground Control Station and one at the waterside Ground Control Station
- Two units at the lashing platform (inside rest rooms)

All the emergency stops shall require positive resetting.

Emergency stop push buttons shall have two contacts : one contact hardwired for safety relay control and the second contact wired to the PLC for fault indication.

9.2 Alarms and Protection Systems

Alarm devices are provided as follows:

1) Gantry travelling alarm

   Electrical acoustic alarms are fitted on crane legs, one for each side. They are activated in 2 sec. before the gantry motors are rotated. Decibel level of alarm must be adjustable from 0db to maximum. In particular the acoustic sounders/alarms are to emit a sound level of 15dB above ground noise. However during night time the noise from these alarms must not exceed 45dB

and must not be audible at a distance of 200m forward from each unit. These sounders are to comply with relevant requirements of EN ISO 7731:2008.

To consider that sounders will operate depending on the direction of gantry travel. If travelling towards right, only right side sounders will operate and so on.

Noise levels have to be adjustable.

The manufacturer shall include test results of actual noise levels during commissioning with the handover documents.

Rotary flashing strobe lamps are fitted at outer side of every leg, one for each and they are turned on at the same time as the acoustic alarms.

2) Wind alarms

An anemometer is fitted at an adequate location on the crane to measure the wind velocity, with no obstacle or turbulences for any wind direction. The speed shall be displayed in the operator's cabin and the checker's cabin at ground level landside. Visual warning is given when wind speed reaches 80% of the Maximum Operating Wind velocity and all crane motions stop when wind reaches 120% of the Maximum Operating Wind velocity. Anemometers can be ultrasonic type.

3) Overload protection device

When the load under spreader reaches the Rated Load Under Spreader or reaches 40t under spreader in single-lift or reaches the Rated Under Ropes, indicator light is flash in the operator's cabin. When the load under spreader reaches or exceeds 110% of the Rated Load the lifting is stopped immediately, and acoustic alarm is given the operator. Signal and alarm device is installed in the operator's cabin.

9.3 Lockout System

A lockout system designed to deliver isolation of crane main functions for the safety of maintenance operation shall be provided.

The Seller shall provide all means designed to lock out and tag out the entire gantry crane. Furthermore, following instructions are applicable:

- each movement shall be able to be locked out and tagged out individually;
- the equipment designed for this purpose must be able to be padlocked;
- this locked out and tagged out function will be placed in the electrical room;
- locking out and tagging out a movement shall not prevent the operation of the other movements.

9.4 Fire Extinguishers

CO_2 dry chemical or equivalent manually operated fire extinguishers with CE compliance markings compliant with ISO 5923 and ISO 7165 are installed in:

1) Operator's cabin – 1 unit 2.5kg CO_2,
2) Machinery house – 2 unit 5kg CO_2 – adjacent to access doors,
3) Machinery house – 2 unit 5kg CO_2 – adjacent to MV Transformer & switchgear,
4) Electrical room – 2 unit 5kg CO_2, (one at either end)
5) Boom Control Station – 1 unit 5kg CO_2,
6) Gantry level – 1 unit 2.5kg CO_2 at seaside & waterside

More fire extinguishers shall be provided by applicable safety regulations.

9.5 Fire Detection

A smoke detection alarm system shall be installed inside the machinery house and shall operate alarms in the operator's cabin, machinery house and landside sill beam. Strobe lights shall be mounted on the landside sill beam and outside the machinery house access door.

9.6 Anti-collision Crane/Vessel

To prevent risks of collision between lowered boom and ship superstructures, an anti-collision prevention system shall be installed.

It will be built based on laser scanners.

The scope of supply shall include:

- 2x heavy duty laser scanners with inox connectors (The laser scanners must have various filter technologies and an internal heater)
- 2x heavy duty weather hood protection for the scanners
- Central safety controller for both sensor (comprising the main module and an I/O expansion module)
- Cabling and mounting accessories

- Software, pre-configured logic files
- System manual and maintenance manual
- Cable laying and connection to the crane PLC
- PLC software modifications

The collision protection system shall reduce the gantry travelling speed when detecting a crane/object (thresholds to be confirmed during design review) and shall bring the crane to a complete stop at 1m distance from the object.

A warning must be active when gantrying at reduced speed.

Further travel towards the object is prevented, but the crane can gantry away from the object and the collision protection system will automatically reset when clear of the object.

A bypass switch, within reach of the operator shall allow gantry travel in the detected direction with a maximum of 5% nominal speed (to be confirmed during design review).

The gantry alarm shall activate during the bypass mode. The bypass switch must be pushed during the motion.

The scanners must be located to best suitable position for preventing collisions (on the boom, girder or legs of the crane).

Access for maintenance will be possible using the crane catwalks.

9.7 **Anti-collision Crane/Crane**

To prevent risks of collision between cranes, and between cranes and other terminal rolling equipment, an anti-collision prevention system shall be installed on the landside legs.

The distance set points shall be adjustable. The first set point shall reduce the gantry travelling speed - the second set point shall stop the gantry travelling with alarms.

10 ELECTRICAL SYSTEMS

10.1 Power supply

The crane is normally fed by 3-phase medium-voltage power through a medium-voltage cable. The cable is wound on the crane cable reel.

The crane can also be fed by a 3-phase "shore power" at the Crane Low Voltage +/- 10%, supplied from a mobile generator, enabling to power: emergency drives, obstruction lights, elevator, and gantry cable reel. An appropriate power inlet will be mounted at gantry level to connect this shore power supply.

10.1.1 MV cable

The crane MV trailing cables shall extend to crane connection pits where they will be connected to a junction box to be provided and installed by the Buyer.

The Seller shall give due consideration to voltage drop, grouping affects and fault levels for the selection of the cable. Necessary calculations are to be provided to the Buyer.

The MV cable must have a minimum of 12 count of single mode fibre optic embedded in its construction. The minimum cross section for the power conductor shall be 35 mm^2.

10.1.2 Transformers

Two MV transformers shall be installed in machinery room. One is supplying the power to drive section and the other is supplying the auxiliary equipment. Both transformers shall be no less than IP20 and there are special HV transformer and switchgear rooms with suitable cover to prevent moisture falling onto the transformers. The transformers shall be appropriately protected against human entry. This shall be by locked cage around each transformer or by approved locked transformer housings as per IEC 60529. The design of cage or housing shall ensure proper ventilation of the transformers. Maintenance free switch gear is to be provided for the incomer, main and auxiliary transformer. Switchgear is able to be operated outside the room.

Resetting of auxiliary transformer after power loss shall be carried out from Ground Control Station. Both transformers are to have temperature monitoring device interfaced to the PLC and transformers' switchgears.

The transformers shall be cast resin dry-type, minimum insulation class F.

The transformer must meet the following requirements:

- No risk for humans and the natural environment due to contamination

- Non-explosive and flame-retardant
- Heavy load cycles (cold start to maximum load)
- High short-circuit withstand capability
- Stress due to tough ambient conditions
- Stress due to harmonics
- Suitable for invertor applications
- Overvoltage peaks
- Variable power factor control
- Minimized maintenance
- Ideal for use in applications involving high mechanical stresses / vibrations.
- Compliant with EU directive 548/2014 for implementing the Ecodesign guideline 2009/125/EG

The transformers shall have two 2.5% full capacity taps above and below the rated primary voltage. The main drive transformer shall be braced for the drive systems utilized. Consideration shall be given to the thermal winding stress due to harmonics injected by converter operation. The main drive transformer shall be monitored for ground faults. Transformers are to conform and tested to the international standards, IEC 60076-11, ANSI or IEEE. Insulation test rating shall be according to IEC60071 List 1. Type of auxiliary transformer shall be Dyn 11. Connection cable bolts shall be appropriately torqued and marked. Seller is to handover all testing results and certificates to the Buyer for both transformer and switchgear.

10.2 Trolley Cable Chain

Power and control wiring shall be running in flexible cables from junction boxes on the landside end of the girder via an energy/cable chain or festoon system to the trolley. The Seller may propose its preferred and recommended design regarding the trolley cables system: Cable Chain or Festoon System are both accepted solutions.

Power, control and data cables shall be highly flexible cable for energy chain systems. Cables shall be blocked in place so as not to overlap or slip inside the chain. Cables entering and leaving the cable chain shall be fixed by cable clamps.

Cable chain shall be of durable plastic and very high UV resistant.

Cable chain shall run in stainless steel trough and shall be mounted underneath the girder to be covered by the crane structure. Additionally, a wind shield shall be provided on the outside.

All fittings shall be stainless steel.

Special attention shall be put to proper alignment of the cable chain trough especially at the boom hinge.

The towing arm shall be of floating type to accommodate the offset between trolley and crane structure.

The cable chain system shall be designed to minimize noise.

All parts of the energy chain shall be safely accessible from normal access catwalk of the crane without the need for any other additional devices such as stools, free standing ladders etc. and without the need for maintenance employees to wear safety harnesses.

10.3 Trolley Cable Festoon System

Power and control wiring shall be running in flexible cables from junction boxes on the landside end of the girder via an energy/cable chain or festoon system to the trolley. The Seller may propose its preferred and recommended design regarding the trolley cables system: Cable Chain or Festoon System are both accepted solutions.

Festoon cable carriers run on a rail mounted under the boom and girder. The cable carriers are provided with roller bearings. To reduce noise level, the carrier wheels are covered with wear-resistant polyurethane plastic nylon. Horizontal wheels and bumpers are provided in the cable carriers. The bumpers are made from elastic polyurethane to absorb collision energy. The carriers are driven by flexible muscles.

All the festoon cables are bound in sections to prevent the cables from hitting the crane structure.

The effect of operating wind speeds shall be considered in designing clearances for festoon system.

A large service platform shall be provided at rear part of the crane for easy maintenance and replacement of the cable festoon parts. Each part/trolley/roller must be accessible and the platform must also allow changing of cables with no additional equipment.

The design of the carriers allows the replacement of carrier bearings without removing the cable.

10.4 Spreader Cable and Cable Reeler

Multi-core cable is used to supply power and control signals from the trolley to the spreader. The cable shall be protected against over tension in the event of loss of power, snag or other overload condition. Connection boxes with high IP rating &

vibration proof locking are to be used for the spreader cable. The cranes shall be compatible with the spreaders currently in use at THPA. There are at least 10% cores for spare use.

The headblock / spreader cable coming from trolley shall be connected to the junction box on the headblock and to the spreader by a plug (identical for both ends).

The spreader and headblock signals shall communicate with crane control system via two-wire system.

Spreader cable reel shall be provided on the trolley. The cable reel inverter and controls shall be in the operator's cabin.

The selection of the slip ring device shall ensure a reliable system that can operate with minimum maintenance.

The replacement of the multi-wire system with only two-wire system will also result in shorter cantilever type slip ring shaft.

10.5 Main drives

The control system components, including converter, inverter units, PLC and I/O modules, are supplied and integrated by the electrical supplier. The main drives are specified to be AC with an Active Front End system

The complete electrical system integration has to be done by the European branch of the system manufacturer.

The indoor panel shall be no less than IP20, while the outdoor panel shall be no less than IP55 & made of 316L stainless steel.

A common DC bus shall be used for the electrical drive system.

The main hoist has two sets of inverters (one for each hoist motor), while the trolley and boom hoisting share one set of inverter. Half of the gantry traveling motors will share with one of the main hoist inverters whilst the other half will be controlled by a separate inverter identical to the trolley/boom inverter. The other hoist inverter will control the second hoist motor only.

The shared inverters shall be on a first come, first served basis. The main hoist function shall employ master slave technology with two inverters to drive separately two AC motors. For the gantry application, the hoist/gantry inverter and the other gantry invertor shall drive half of the gantry motors each. The hoist inverters and the active line module (or AFE) are to be identical for parts interchangeability. In case of Gantry inverter failure, then the motors driven by it shall be driven by the Hoist inverter. Whilst in the case of a Trolley/Boom inverter failure then the Gantry inverter will be used to operate either the trolley or boom motor.

The main hoist nominal speeds are provided in Section 2. Main Characteristics and Performances. Intermediate speeds shall be load dependent according to the Torque – Speed characteristics. This data shall be made available to the Buyer at design review.

Crane shall be able to operate the main hoist continuously and simultaneously with the trolley, under following conditions:

- One power supply only
- One main hoist motor only
- One main hoist inverter only

at a reduced speed and with limited capacity. The capacity, the speed and acceleration/deceleration time must be specified while operating under these conditions.

The gantry motion will be possible, at a reduced speed of 80% of the nominal travel speed under following conditions:

- One power supply only
- 20% of the motors out of operation
- One inverter only

Preferably the Trolley/Boom and Hoist/Gantry contactors shall be interchangeable.

Gantry cable reel and spreader cable reel shall have same motor and same inverter rating.

All drive units should be supplied with all the necessary accessories required for service or repairs together with a complete parts lists of every component, with quantities, making up the drives.

10.6 **Motors**

The main motors being: main hoist, trolley, boom hoist and gantry traveling motors are squirrel cage AC motors. All the motors shall be sized based on the actual torque required to operate the crane motions and shall be suitable for operation to meet acceleration and peak torque requirements.

The main motors and emergency motors shall be equipped with anti-condensation heaters and protected by thermostats.

All the main motors shall have a minimum insulation class F. All exterior mounted motors shall be no less than IP55, while motors mounted inside the machinery house shall be no less than IP23. All motors' connection boxes are to be located at top centre of motor so that motors can be interchanged.

In case of rope-towed trolley, the trolley and boom motors shall be identical. Both hoist motors shall be forced ventilated from an auxiliary blower, filtered and having air flow sensors as protection. Hoist motors are to be also sized for continuous dual cycle operation.

10.7 Panel boards

All the medium voltage switchgear, drive panel, panel board, control panels are of integrated protection type with protection grade of IP20 or higher. All the doors on panels are lockable to ensure personnel safety and good performance of electric system.

The medium voltage switchgear shall be located in the machinery house.

PLC panel and inverters panels shall be located in air-conditioned electrical room.

10.8 Illumination

10.8.1 Main Requirements

Illumination power source is separate from the main power circuit. Illumination circuit is divided into several independent sub-circuits. Each of the circuit is provided with short circuit protection.

Floodlight control shall be separated as per the following circuits:

- one for floodlights on boom and girder
- one for floodlights on trolley
- one for floodlights at portal beam level.

Floodlight circuits are to be separated into branches. Each branch shall be protected by its own circuit breaker in the electrical room or in the operator's cabin.

All the lighting fixtures shall be of the LED type with full cut-off.

All the lighting fixtures are accessible for maintenance purposes (Access platforms to be fitted to provide access to floodlight in the backreach area or other positions).

All the outdoor lighting fixtures are waterproof, anti-vibration and anti-corrosive.

The lighting appliances will be of IP65 protection rating. The glands shall be sensibly positioned to avoid water infiltration (especially in stairways).

Floodlight fixtures shall be:

- Of heavy duty type suitable for marine and high salt laden environment
- Mounted on fail safe damping mountings
- Installed with safety chains and accessories made of stainless steel 316L to prevent the floodlight from falling
- Symmetrically installed

10.8.2 Control Switch

Switches for access lights shall be located in front of each elevator landing level, at electrical room and machinery house exits, at the bottom of the crane and at Boom Control Stations.

Switches for the boom latch illumination will be located in the Boom Control Station, in the Ground Control Stations and in the Machinery House Control Station.

Switches for the floodligths will be located in the operator's cabin, in the Ground Control Stations and in the Machinery House Control Station.

The controls at the ground level are only active through a key switch and when there is no other control station selected on the crane.

An override switch is located at the electrical room for maintenance purposes.

For the operator's cabin, electrical room, CMS Room and machinery house, lighting shall only be manually controlled from location only.

Each control panel in electrical room and operator's cabin is provided with lighting (door controlled) inside.

Additionally, an automatic command is provided to power off all external lighting except for portal and sill beam floodlights after 20 min the crane is turned off.

Boom floodlights shall turn off when the boom is not fully down.

10.8.3 Illumination

Illumination levels will be not less than:

- 30 lux for access stairs, ladders, walkways etc.
- 50 lux in the operator's cabin, measured on the control console surface.
- 150 lux on the boom latch
- 200 lux on machinery house logo
- 200 lux for the machinery house, electrical room, measured at 0.8m above the floor
- 300 lux for the quay work area (between the crane legs)

- 200 lux under the girder and boom, over 7.5 m on each side of the girder/boom axis, at wharf level
- 300 lux under the trolley, over 7.5 m on each side of the girder/boom axis, at wharf level

Lights are not required within boom, girder and crane structures.

10.8.4 Emergency Lighting

The crane shall be provided with battery powered emergency egress lighting to allow personnel to safely exit the crane from the operator's cabin, and the machinery/electrical house to the ground.

The egress route from the operator's cabin is via normal access and via trolley, whole boom and whole girder to the frame access stairs. Special attention shall be paid for the case that the trolley stop position is under the machinery house.

At least 30 % of the lights of the respective areas shall be emergency lights. Emergency lighting may be implemented in the access and walkway lights.

Additionally, emergency lighting shall be installed in the elevator. This lighting shall sufficiently illuminate the elevator cabin and the mechanism for the manual lowering of the elevator. If the elevator is built inside a leg, the egress route from the elevator ground stop to the ground shall also be equipped with emergency lights.

Exit doors shall be marked by exit signs according to local standards. These exit signs shall be clearly visible under emergency lighting condition and might additionally be illuminated.

Emergency lights power supply shall have enough capacity to power the lights for at least one hour after the power failure.

Emergency lighting shall comply with standards ISO 30061 et IEC 60598-2-22.

10.8.5 Air Obstruction Light

Four (4) air obstruction red lights, and visible under fog / low visibility conditions, are installed on the crane, two of them are mounted at 2m above the A-Frame and the other two are at the boom tip.

These obstruction lights are optically controlled. Air Obstruction lights shall be LED type and powered by UPS during power failure. The obstruction lights shall be equipped with a failure warning system with visible alarms on the CMS.

10.9 Auxiliary Power Supply Equipment

10.9.1 Power Outlet Receptacle

All socket outlets which are exposed to the weather shall be weatherproof type, IP67.

All single phase and three phase sockets shall be protected by earth leakage protection. Protection devices for the 3 phase sockets shall be of the 4 pole type (3P+N).

The crane shall include the following receptacle sockets:

1) Socket receptacles delivering the Crane Low Voltage, single-phase, 50Hz, 16A (2P+E) at following locations:

- Two in the machinery house
- Two in electrical room and one in CMS room
- One in operator's cabin
- Two on the landside ground level
- Two on the waterside ground level
- Two on boom (one at tip, one in the middle near sheave assemblies)
- Two on girder
- One at the festoon cable access platform
- One on trolley, one at Boom Control Station, one at back reach, one at HV cable reel area, one at Apex, one at Window Cleaning Platform and one at elevator ground landing.
- Three in landside Checker's cabin
- Three in waterside Checker's cabin

Socket receptacles Crane Low Voltage, single-phase, 50Hz, 13A (2P+E) are provided at following locations:

- Two in CMS room
- Two in electrical room
- Three in operator's cabin
- Three in landside Checker's cabin
- Three in waterside Checker's cabin
- One in window cleaning platform
- One in Boom Control Station

Crane Low Voltage supply joint box protected by 16A double pole miniature circuit breakers in the machinery house located at:

- MV Cable reel area
- landside Checker's cabin
- Backreach area

2) Socket receptacles delivering the Crane Low Voltage, 3-phase, 50Hz, 32A (3P+N+E) at following locations:

- Two at ground level Landside
- Two at ground level Waterside
- Two in the machinery house
- One at trolley platform, one at boom tip, one at Boom Control Station, one at back reach, one at MV cable reel area

In addition, socket receptacles delivering the Crane Low Voltage, 3-phase, 50Hz, 63A (3P+N+E) at following locations:

- One in the machinery house
- One at ground level Landside

10.9.2 Heating Equipment

All main motors, panel boards and control panels are provided with thermostatically controlled anti-condensation heaters to prevent condensation during non-operation period of the Crane. There shall be anti-condensation heater in slip ring boxes of the spreader and gantry cable reels respectively, and in MV switchgear.

10.10 Cabling and Wiring

All the cables applied on the crane shall be suitable for the port crane installations, the ambient temperature, and voltage level. Cross-section area of the conductor shall meet the thermal capacity, voltage drop, mechanical strength and impedance requirement in case of single phase short-circuit depending on the circuit applied and components used. As the electrical room may have to withhold overpressure in case of fire suppression action, entry must be fully sealed therefore the use of Roxtec systems or similar shall be used where cables are required to enter the room.

As far as possible all cable runways shall be located inside the structural members for maximum protection. Cables for outdoor installation must be resistant against sun and radiation (UV-light) and chemical corrosion (ozone). Power and control cables for fixed installations shall be CJV/DA or approved equivalent. Power and control cables for

flexible installations shall be H07RN-F, or approved equivalent. Exceptions are allowed for standard buy-out components. Data cables shall be shielded and have twisted pairs. Wires within control panels shall be VDE certified. Power and control cables for fixed installations shall be JZ-600, H07RN-F, NSGAFOU, as applicable or approved equivalent.

Wire sizes shall be in accordance with IEC 60204-32 Section 13.4 except as noted in this specification. The voltage drop over any cable run shall not exceed 5% in accordance with IEC 60204-32. The current rating of each conductor shall be derated as prescribed in the IEC 60204-32.

Parallel wires shall not be used to meet the circuit current requirement, except for the connection from the trolley to the spreader pump, or unless approved in writing by the Buyer. This requirement does not apply to the necessary use of parallel cables, e.g. connection from MV transformer to electrical room or from electrical room to the main motor drives.

All cables are to be multi stranded type and cable colours are to be according to the applicable standard European Harmonised Colour Code (Document HD308 S2).

Rated voltage of all fix installed low-voltage cables (power and control) are 600/1000Vac. All conductors shall be copper. Signal cables used for signal detecting and intercom (such as signal wires of tachometer, load cells, PC communication, load signal transfer, telephone wires etc.) are of shielded cables to ensure that the signal transferring accuracy is not affected externally. The section of wires shall not be less than $1.5mm^2$.

Control cabling shall have a minimum of 20% spare conductors between panels and junction boxes (including for cable chain or festoon cables, as applicable), for the trolley to spreader cable, and 100% spare for fibre optic cables.

All the wires connecting the limit switches have a certain allowance of length. All multi-conductor cables are provided with permanent identification marks to facilitate the electrician and maintenance personnel to wiring and inspect. The conductors shall be identified with wire numbers at both ends with heat-shrinkable sleeves, including spare conductors. Insulation colour of grounding conductors shall be green and yellow. Where insulation colours are not compatible, coloured synthetic tubing or sleeves with a minimum length of 40mm shall be used at conductor ends.

All the cabling of the crane is designed for safety, reliability, convenience and good appearance and strictly in compliance with IEC standards. External Cables shall be easily accessible from staircases, walkways or with a mobile lift.

Indoor cables (such as in the machinery house, electrical room, Boom Control Station and operator's cabin) run in cable tray, cable ladder or conduit; Outdoor cables shall run in the closed type conduits or closed trunking wherever as practical. All cables are secured with plastic cable ties firmly and laid neatly. Vertical cabling must be secured with steel cable ties at an interval of 1.2 m max. Bending radius of the cable is not less than 8 times cable diameter. Bending radius of the conduit is not less than 6 times conduit external diameter. The cable to the final components (such as limit switches, lightings, socket, auxiliary motors, etc.) shall use cable gland if it is applicable.

The cables of different voltage level (medium voltage, low voltage or signalling) are laid and installed separately.

All the cable trays, steel conduits, cable ladders are hot dipped galvanized. The cable occupied space in the cable tray shall not be greater than 60% of cross-section of the cable tray. The cable filling capacity of the conduit shall not greater than 40% of cross-section of the conduit. All cable outlets are guarded with sleeves. Outdoor junction boxes are made of stainless steel grade 316L.

External cable routes shall be hot dipped galvanized of the closed type cable trays and conduits external mounted to the structure due to the effects of dust, heat, sunlight and mechanical protection. If this is not possible at some areas, at least cable outer sheeting should be UV resistant. Cable ties shall be UV resistant plastic covered stainless steel type. All galvanized metal conduits, cable trays and cable trunking must be earthed and earth links must also be installed between each jointing point.

Special attention shall be paid to the cabling of variable frequency AC motors. Grounding and cabling of the variable frequency AC motors shall be in accordance with the drive manufacturer's recommendations. Exact cable type might depend on the location and distances of the motors from the power source. Proper termination as per drive manufacturer recommendation shall be adhered to. The drive manufacturer shall sign off the correct selection of motor cables types with a copy of that approval sent to the Buyer.

10.11 Fiber optic

Adjacent to the three Crane Low Voltage Supply joint boxes mentioned in 10.8.1, fibre optic termination boxes are to be installed for an 8 count single mode fibre optic cable. The other end of these fibre optic cables are to be terminated in the electrical room in a clearly labelled fibre optic connection box.

10.12 Terminals

Connection terminals of the outgoing lines at the panel boards and control panels are installed in a place where maintenance is easily to be conducted. All the terminals of the motors, switchgears, controls and panels shall be identified. Terminals of the control panels and junction box have the number greater than practically required by 10% as spares. When the terminal board is screw type, there is connector/ferrule or lug as appropriate on the conductor for connection.

10.13 Electrical Protections

10.13.1 Ground Protection and Lightning protection

All the electrical equipment, mechanical structure, metal supporters of electric equipment, mechanical structure, panel boards and control panels are reliably grounded. Metal protection jacket of armoured cable and metal mesh of shielded cable will be earthed reliably.

Connection between the earthing line and the equipment will be bolt type and provided with anti-loosening and anti-corrosion measures, and the connections should be free from painting.

All the electrical equipment will be reliably earthed to protect the equipment against lightning damage. The crane structure will be electrically connected to the gantry rail properly. Two grounding shoes, at waterside and landside separately, will be installed on the gantry structure. The metal cable will span over the structural flange and bearing point additionally.

10.13.2 Other Electrical Protection

The following electrical protections are provided for the crane.

1) MV power loss protection, which is able to automatically turn off the MV switchgear outgoing section in case of power supply is cut off;
2) Various motors and powered machine are provided with short-circuit protection. Motors for every crane movement have over-current protection;
3) Neutral position protection. When starting or when power is recovered after power loss the master controller must be put in the neutral position first then the motor can be energized and started.
4) MV cable length protection. The MV cable system is equipped with an over tension and breakage protection system.

11 AUTOMATION AND CONTROL SYSTEMS

11.1 Programmable Logic Controller (PLC)

The PLC system on the crane can process all system control signals.

It receives data from input device (switch, limit switch etc.), executes logic judgment determined by the program stored in memory and gives control output signal to the electrical equipment and electrical components.

PLC must also be linked to the spreader PLC.

All interlock and logic control functions, except a few hardware interlocks, are performed by the PLC.

PLC unit is specially designed for a rough industrial environment application.

The input / output devices should be easily accessible for maintenance without the need of lifting equipment or ladders; a minimum of 10% of spare inputs and outputs shall be provided at each I/O station.

11.1.1 PLC Power supply

PLC system has reliable power failure protection. The PLC's power is supplied from separate control transformer and the distributed I/Os shall be supplied by a regulated power supply.

11.1.2 PLC Program

Crane program is to be written in Ladder logic.

The logic will be identical for all cranes, clearly commented to be easily understood without documentation and every variable used defined.

PLC code shall be readily available for monitoring through the CMS.

Logic shall be locked for changes with the possibility to force inputs, outputs, memory contacts and register values for troubleshooting purposes.

Any software changes can only be done through a password. Such changes will be automatically logged with a time stamp and author’s name.

All software, PLC and automation systems should be proven solutions.

The supplier shall provide a laptop for the whole project including all necessary software (fully licensed versions of PLC software, CMS, drive monitoring software, latest OS, etc) and cables / adapters required to connect to the different components

such as PLC etc. if installed and need adjustment. Licences must be transferable in the event of failure and replacement of the laptop.

A back up cd of this laptop and all other crane's PC is to be handed over after commissioning. In addition to this all original cds of operating systems and other installed software on PCs and laptop are to be handed over too. (minimum RAM for each crane PC and lap top – 8GB)

11.2 Limit switches

Limit switches located outdoor are to have protection of no less than IP56.

Proximity switches shall be used wherever possible, with the exception of safety critical limit switches such as end-stop and over-travel limit switches for trolley and boom hoist. Wherever proximity sensors are utilised a clamp type of arrangement is utilized.

Tachometer(s) are fitted on the motors of the main hoist, trolley, boom hoist, gantry travel.

Cam switches are fitted on the main hoist and boom hoist rope drums.

11.3 Main Hoisting Interlock & Protections

The cam limit switch and tachometer They have the following functions:

1) Lifting stop at the spreader's max. lifting height.
2) Slow down before reaching the travel end.
3) Slow down before reaching the landside lowering end.

When the setting is activated, the spreader slows down automatically from full speed in the same mode as in case of lifting. The height of is adjustable.

4) Lowering stop at landside, the height of is adjustable.
5) Slow down at waterside lowering end. The spreader is slowed down automatically from high speed when the setting is activated when lowering at waterside in the same manner as during hoisting.
6) Stop at waterside lower end, i.e. the lowest position of the spreader.
7) Protection at landside sill beam elevation, which is used for prevention of the spreader with/without container from collision with sill beam. When it is activated, the trolley cannot traverse from landside to waterside or vice versa.

8) Main hoisting is interlocked with boom hoisting so that when the boom is raised up, the main hoist can be operated with no load and at low speed.

A look ahead function is implemented for the main hoist motion: the slowdown will start according to the motion actual speed and required associated stopping distance.

In addition to above stated safety protections, the main hoisting is provided with other interlock functions:

1) Upper extreme end limit switch of gravity type, which is mounted on the trolley. When the spreader is lifted up and overrides the stop limit switch (cam type is in failure) it hits the counter lever of the gravity type limit switch. The gravity type limit switch is activated and cuts off control circuit power. This activation of gravity type switch is abnormal, its activation is referred as a fault and it is necessary to press the by-pass button to re-start.

2) Interlock between the spreader and main hoist:
    a. Connection between the spreader and head block has four (4) twist lock limit switches. When one of the switches is not activated, the main hoisting is not operative. In this case main hoist may be operated through the by-pass keyed button
    b. When the spreader is at the position of landing or slack rope, the main hoisting lowering motion cannot be operated. If necessary, it can be operated by a dedicated by-pass button.
    c. Main hoist is operative with the spreader twistlocks fully disengaged or fully engaged. When holding a container, twistlocks cannot be unlocked.
    d. The cable connection between headblock and the spreader is performed through multi-core cable with quick disconnected plug. The plug must be inserted back to the headblock junction box receptacle when spreader is disconnected from headblock; otherwise main hoist cannot be operated.
    e. When twistlocks are locked on, the spreader cannot be telescoped. An Over-Head Frame (OHF) bypass allows to expand and retract it when the spreader is locked on an OHF
    f. When TTDS detects two 20’ containers below the spreader in 40’ position, the twistlocks locking on cannot be operated. A bypass allows locking on special cargo, OHF, open-top containers, etc
    g. Lashing cage mode including an indication light under the trolley to show that this mode is selected. This mode is selected by the operator and is used when the lashing cage carrying personnel is under the

spreader. Hoist and trolley speeds are limited to 10% of nominal speeds

h. Other functions which will be discussed during the design review

3) Overspeed protection:

An electronic overspeed switch is fitted concentrically with the main hoist drum and is set at 115% of the maximum operation speed of main hoist. Whenever this overspeed switch is activated, the power of control circuit is cut off and alarm is turned on. For re-starting, a reset is required by pressing the reset button.

4) Overload protection:

The crane is provided with load cells to sense the lifted load. When the load reaches 110% of the maximum load under spreader or cargo beam, acoustic alarm in operator cabin is turned on and hoisting is stopped automatically. Only lowering can be operated in that case.

Load sensing monitoring is active at all times, when the spreader twistlocks are locked or unlocked.

5) Slack rope protection

The crane is provided with a permanent slack rope protection irrespective of spreader condition/position.

11.4 Trolley Motions Interlock & Protections

The limit switches for the trolley are all securely installed on the trolley girder and an encoder is fitted on the motor. All are of non-contacting type proximity switches except over-travel limit switches, and have the following functions:

1) Stop the trolley at waterside and landside travel end and this is trolley normal stop
2) Slow down before end is reaches, slow down to 15~20% of nominal speed
3) Stop the trolley at waterside and landside over-travel position (by mechanical lever operated limit switch). For recovery, the by-pass button must be pressed
4) Sill beam protection. This protection is mainly for preventing the load suspended under the trolley to collide with the sill beam.
5) Operator's access gate interlock: when the gate is not properly closed the trolley cannot be moved. During the trolley running, if the gate is opened, the

trolley shall stop operation. Trolley access gates must be spring set and self-closing with positive force required to open it.

6) Trolley traversing is interlocked with boom hoisting so that when the boom is raised up, the trolley can be operated only with no load and at low speed.

A look ahead function is implemented for the trolley motion: the slowdown will start according to the motion actual speed and required associated stopping distance.

11.5 Gantry Travelling Interlock & Protections

The gantry travelling is provided with the following interlocks:

1) The Crane is provided with rail clamp, which is provided with limit switch. The gantry can be operated only when the brake is released
2) Storm stowage limit switch, which is activated when the stowage pin is engaged, and gantry travelling cannot be operated
3) When the boom and gantry collision system is active, gantry travelling is not allowed, except in the opposite direction
4) If boom is raised up and not properly latched gantry travel shall be at 5% speed of nominal speed. Full speed gantry to be allowed with boom latched only.
5) When the trolley is located on the boom, the gantry travel will be limited at 50% of the nominal speed.

11.6 Boom Hoisting Interlock & Protections

The boom hoist has interlocks as following:

1) Slow down settings before the upper and lower end;
2) Interlock between the boom latch and boom hoisting to ensure that the boom cannot be lowered until the safety latch is disengaged;
3) Overspeed protection: When boom hoisting operation speed reaches 115% of nominal speed, the electronic overspeed switch fitted with the boom hoist drum activates and emergency stop is triggered. For restarting, a reset is required by pressing the reset buttons.

4) Access to and from girder onto boom shall be via gate controlled by failsafe Access Control Lock that shall only enable access in case boom is in the operation position and prevent booming motion if open.
5) Boom hoisting is interlocked with trolley traversing so that the boom hoisting is not operational when the trolley is not positioned at parked location on the girder and with all gates positively locked.

11.7 Control Stations

Control stations are the operator's cabin station, Boom Control Station, Machinery House Control Station, Ground Control Stations.

No motion of the crane or the spreader shall start upon recovery of an emergency stops, failure, breakdowns, etc. Any motion of the crane or the spreader has to be the consequence of a manual control action.

All control stations are interlocked so that when one control station is switched on, all the other control stations cannot be active.

Boom Control Station is provided to locally control the boom hoisting.

Machinery House Control Stations shall include isolation key switches and enable manual operation of main hoist, trolley and boom functions. Manual operation panel shall allow possibility of different speeds for each motion.

Ground Control Stations are provided on a suitable location at landside sill beam and waterside sill beam to control gantry travel, main hoist and trolley, spreaders, at limited speed for main hoist and the trolley. Waterproof push-buttons are fitted on the control station.

11.8 CMS & RCMS

11.8.1 CMS

CMS (Crane Management System) will be supplied on the crane and will be accessible from two different places:

- One CMS is to be installed in the CMS room and shall be accessible through a PC (the CMS PC)–
- One CMS is installed at the landside Gantry Control Station and shall be accessible through a 15 inch touch panel. This touch panel should mirror the crane's CMS with the possibility to do timed bypasses. The installation location

should be at a height that is easily accessible, able to view the screen without the need of step tools etc., sheltered to avoid the glare and rain. Through this touch panel certain overrides and/or timed overrides via passwords should be possible.

Overrides and panel screens' design to be submitted to the Buyer for approval.

All programmable or software configurable components / devices, including spreader, scanners, loadcells, etc. installed on the crane shall be interfaced with the CMS so that any troubleshooting, configuration, programming, communicating with, etc, will be done through the CMS PC.

The CMS will fulfil but not be limited to the following functions:

- Display the status of the crane.
- Display the event log (this shall include such things as hoist activated etc)
- Display the fault log & history
- Diagnostics of all crane faults
- Black box function
- Link drive faults to drive manuals for quick reference
- Link faults to circuit diagrams and PLC logic
- Fault displayed will be actual faults and consequential faults should not be displayed. (i.e. one fault per event)
- Link to drive software to carry out trends together with PLC signals (i.e. able to trend any signal from PLC; I/Ps references etc)
- Display the temperature in the electrical room, transformers, drives and other areas where signals are coming back to the PLC
- Showing the production data on each crane (should also record the number of boxes per weight (0-10t, 10-20t, 20-30t, 30-40t, etc…) and the medium reach per weight, the numbers of cycles with the type of container (twins are not considered in the 20' containers but as separate class of containers) in order to calculate crane fatigue during lifetime of the equipment)
- Storing full data of all containers handled with individual weights, log each move in terms of from where containers were loaded / unloaded etc. plus whether twin or single lift etc., for each crane and for the lifetime of the crane.
- Display the usage hours for each function
- Crane Power Utilization monitoring: kWh, MW, MVA, power factor read out. All can be plotted in time graphs and data can be extrapolated to excel format.
- Display the vibration monitoring system

The messages shown on the CMS will be English.

All CMS computers are to be equipped with raid drives.

11.8.2 RCMS

An enhanced remote control system diagnostic, monitoring and management system shall be provided. Fiber optic cables in the cable reel shall be provided for communication between the Crane(s) and the remote sites. All necessary equipment and installation shall be provided by the Seller including desk-mounted computer, color printer, communication devices, etc.

As a minimum the following information shall be provided:

- Centralizing of the fault/diagnostic messages including automatic update to CMS.
- Centralizing equipment configuration data.
- Centralizing documentation (drawings and manuals etc)
- Centralizing software (PLC programs, drive parameters etc)
- Collecting history data (faults, counters, running hours, moves, trace) for connected
- equipment.
- Maintenance of fault/diagnostic messages and configuration data.

The RCMS is to be configured as a redundant data-base server system. All equipment is to be connected via standard interfaces. (ODBC, FTP, XML web services).

The RCMS has to present the same information as available on the CMS as well as additional overviews of clustered information (per equipment type or berth etc). A simple user-friendly interface is to be provided in which all presented data can be saved to Microsoft Office applications. (Excel, Word etc)

The RCMS-Clients are standard Microsoft Windows based PCs on which no preinstalled software other than basic Windows components are available. In case the RCMS-Clients needs additional software/settings to be installed these must be done automatically. The user does not require administrator rights to automatically install necessary RCMS-Client software components.

No additional licenses are required for RCMS-Clients.

All RCMS functions must be available via a dedicated Web-based user interface. It must be possible to work in parallel on the RCMS-Clients without interfering with other RCMS-Clients and/or without creating performance related problems (locking, speed

etc).

12 SPREADER & HEADBLOCK

12.1 Headblock

The crane will be equipped with one quick change headblock permanently reeved into the hoisting ropes with easily removable sheave guards. Design of sheave guards must be capable to withstand rough handling.

The headblock will be hoisted and lowered via the hoist control.

Each spreader cable will have a sufficient tension relief device.

1) The headblock is provided with personnel platform capable of carrying two standing persons and enclosed by handrails with gravity closing gates. Access ladders to the personnel platform on the headblock are installed on the main frame matching that of spreader.
2) Screens are provided to prevent personnel contact with running ropes and rotating sheaves.
3) The structure frame is designed and constructed with adequate safety factor without fatigue fracture. Outside surface will be smooth and without discontinuities to prevent snagging on adjacent containers, cell guides or other structures
4) The spreader is attached to the headblock through manual vertical pins (or twistlocks) actuated through hydraulic cylinders.
5) Flared guiding bores are provided at the bottom surface of the headblock at four corners where the spreader is attached to.
6) Headblocks will have guides for easy positioning of headblock on the spreader when connecting.
7) Headblocks shall be compatible with the Buyer's existing spreaders and hookbeams, if any.
8) Headblock dimensions between the twistlocks shall be same as on other existing cranes at Buyer's site, if any.
9) Headblock shall be equipped with 22t capacity Eye plates at the outer edges. 10t capacity emergency eye plates shall also be provided at the midpoint of the headblock (for example to provide connection point for securing containers in case of picking up 2 x 20ft boxes from outer twistlocks only).

12.2 Spreaders

The Buyer shall provide three spreaders as follow:

The spreaders will be telescopic and capable to handle ISO containers of size 20', 40', 45', as well as two ISO 20' containers simultaneously (the twin-lift mode).

Safe Working Load of the spreader shall be 40 tons in single-lift and 65 tons in twin-lift mode.

The spreader is hydraulically operated with all functions of the spreader controlled from the crane operator's cabin.

When operating in twin lift mode, a long-twin function allows the spreader center gap to be adjusted allowing two 20ft containers to be handled with a separating gap.

The center gap can be adjusted from zero to 800mm. The center gap can also be adjusted when the spreader is either unladen or is lifting two 20ft containers.

The spreader shall be equipped with TTDS (Twin Twenty Detection System).

When operating in twin-lift mode, a function allows the spreader center gap between the two 20ft containers to be adjusted from zero to 800mm, when the spreader is either unladen or is lifting two 20ft containers. The spreader can perform all operations with such adjustable separating gap.

The X1 cabinet should be facing outside so it can be easily reached by maintenance personnel.

Crane to spreader communications interface must not be brand specific such that any spreader capable of serial communication can be connected and operated. This is to enable access to the logic of the spreader PLC directly from the crane.

Spreader must have 8 lifting lugs.

Spreader shall have 4 flippers, one at each corner.

Spreader must have overheight latching bracket compatible with overheight frames used by the Buyer.

Spreader Twistlock counter shall be provided.

Electric enclosure shall be IP65 minimum.

Hydraulic tank shall be made in stainless steel (SS316 minimum)

Spreader should provide Spreader ID information to crane so that event of each spreader installation and removal from crane would be registered in crane's CMS log.

One (1) unit of spreader test panel shall be provided to allow full testing of the spreader in the workshop.

Depending on the spreader supplier, the Seller must provide a specific diagnostic application dedicated to the Spreader (in case of Bromma Spreader, Green Zone will be considered). The application will enable a remote diagnosis of the source of faults when spreader downtime occurs. This enables service technicians to find and resolve problems more quickly so that spreader downtime can be minimized, and spreader change-outs eliminated.

Additional fixtures must be considered for enabling safe maintenance and efficient operations:

- Flared guide for headblock connection
- Hand rail brackets
- Motor and space heater
- Access ladder
- Low level and high temperature gauges
- Shock damper protection
- Dummy socket for headblock connection

13 LOGOS AND NAMEPLATES

The supplier shall furnish various metal nameplates to be installed respectively on the gantry frame and other places designated by the Buyer. Nameplates will bear the following data:

- Buyer's name and crane No.;
- Rated Load Under Spreader capacity;
- Manufacturer's name and date of manufacture.
- A plate showing crane principal data will be installed at a notable location in the operator's cabin.
- Line Marking – The supplier shall supply markings on the landside of seaside sill beam and the inboard vertical plates to mark the single 20, 40, and 45 ft container positions with white paint.
- Buyer's main logo painted on machinery house to be lit by appropriate lighting.
- A plate showing the maximum number of persons and total weight that catwalks are capable to carry.
- Maximum number of persons / max weight inside the operator's cabin.
- Any danger / warning signs as per Machinery Directive.

14 DESIGN REVIEW

The purpose of the Design Review is to allow the Buyer to verify whether the design drawings are in compliance with technical parameters and standard required by the Buyer and whether easy maintenance is taken into account. The review criteria is this Specifications document and the minutes of any meeting held before the Design Review (such as the Kick Off meeting for instance).

During Design Review phase the supplier shall supply 3 (three) copies of the following listed primary design drawings and technical documents in accordance with the time schedule agreed by both parties of the contract.

The Buyer will study the primary design and notify the Seller to discuss design problems & changes.

During Design Review stage the Seller shall meet with the Buyer to review design drawings and will present the arrangement of construction, installation and testing and purchase of the key mechanical and electrical equipment:

- Present key mechanical and electrical equipment for the crane and new technology, new process, new material etc, to be used for the crane
- Present work progress schedule and quality assurance system

All comments on the proposed design shall be duly minuted and signed by both Buyer and Seller representatives.

Drawings submittals during design review are as follows:

- Crane general arrangement
- Trolley general arrangement
- Catenary trolleys arrangement
- Catenary Trolley wheel and shaft assembly
- General layout of machinery house
- General layout of the operator’s cabin
- Operator’s console
- Gantry structure
- Girder structure
- Boom structure
- Boom hinge structure
- Head block assembly
- Spreader assembly
- Cargo hook beam assembly

- Layout of Checker's cabins
- Layout of boom operation cabin
- Main hoisting assembly
- Trolley traversing assembly
- Gantry traveling assembly
- Boom hoisting assembly
- Main hoist rope reeving
- Boom hoisting wire rope reeving
- Stowage device assembly
- Cable reel assembly
- Stairs, ladders, walkways and platforms arrangement
- Elevator general arrangement
- Shipment procedure of fully erected crane
- Spreader trimming, listing and skewing device arrangement
- Power supply single line diagram
- Circuit diagrams and software documentation – explanations of main logic blocks and interlocks
- Cable routes, trunking positioning etc
- CMS pages and demo
- Control station layout

Technical documents submittals during design review are as follows:

- Calculation of mean crane operation cycle time
- Calculation of stability and wheel load of the crane
- Calculation and selection of the main movement's motors and brakes
- Calculation and selection of steel wire ropes
- Calculation and selection of the main and auxiliary transformers and the MV cable sizing
- Thermal calculation for the sizing of all AC units
- Noise levels calculation
- Electrical wiring diagrams
- Lighting photometric simulation and simulation test results both in 2D and 3D graphical and data format.

- list of major components and their manufacturer (encoders, PLC, drives, overspeed devices, contactors, mccbs, etc.

15 SUPERVISION

The Buyer or his representatives shall be allowed to visit the site during manufacturing process to witness and review the progress and quality.

The Seller shall provide full cooperation and make at least the following information available:

- Design drawings, working schedule, material technical description, test report, inspection certificates, inspection records, and quality control report, Bearing Authenticity verification.
- Installation process and drawings, inspection and test steps to be taken, documents related to tests;
- Installation and test records.

16 COMMISSIONING, TESTING & ACCEPTANCE

16.1 Testing

Various tests of the crane, to be agreed between both parties, shall be conducted at the Seller's construction site before shipment. The crane will be delivered to the Buyer's terminal as fully erected.

The Seller shall submit a draft Test Protocol at Design Review stage which shall include all tests to be carried out at the construction site and at the terminal site so as to be reviewed by the Buyer and then forwarded back to the Seller with any changes required.

The Buyer reserves the right to appoint third party inspectors to supervise / monitor all the production process and carry out tests at the Seller's site.

3 months before shipment the Seller shall:

1) Notify predicted ship schedule and relevant matters;
2) Provide shipment and erection procedure of the crane and request Buyer's co-operation;
3) Provide Test Program including detailed field tests and test record forms.

16.2 Documentation Submission

The following documentation will be submitted before field testing and commissioning:

1) Test reports and qualification certificates of various materials used for the crane;
2) Test reports and qualification certificates of purchased mechanical and electrical equipment;
3) Test reports and qualification certificates of main load bearing elements such as twistlocks, high-strength bolts, wire rope fittings etc.;
4) Qualification certificates of welds;
5) Qualification reports of assembly quality;
6) Painting qualification certificates.
7) Noise measurement reports for Operator's cabin, Electrical Room, CMS room and Machinery House;
8) Alignment reports for Main Hoist, Trolley and Boom drive mechanisms, related to gearbox to motor(s) and gearbox to drum(s)

9) Vibration Analysis reports for main hoist, trolley and boom drive mechanisms, related to individual motor, gearbox and drum support bearing housings. Method of test shall be elaborated and agreed during design review meeting.

16.3 Medium Voltage Insulation Test

The crane shall have MV insulation undertaken by the Seller.

This test shall be done twice: at the Seller's construction site, and at the Buyer's terminal.

16.4 Crane Performance Tests & Performance Clause

16.4.1 Static Load Test

The purpose of static load test is to examine the load bearing capability of the crane and its structural members and components. The test is considered successful if there is not any crack, permanent deformation, painting peeling off and/or any damage that affect the crane performance and safety, not any loosening or damage at joints and connections after test.

1) Before static test, the trolley is traversed along full length of its rail to and from for several times with load 0.7P (P is the Rated Load Under Spreader) and at speed 0.75V (V is the nominal speed of trolley traversing). After the load is removed, the trolley is positioned at several points mentioned below to determine measuring base points:
    a. At max. outreach measured from seaside rail centerline;
    b. At mid-point of girder measured from seaside rail centerline;
    c. At max. backreach from landside rail center line.
2) The trolley is positioned in turn at the above said three points and the load is gradually increased from 0.75P up to 1.25P without any shock or impact. The load is lifted to 100~200mm above ground and is held for 10 minutes. Then the trolley traverse away and the actual deflection of the girder is measured.

    The vertical deflection at boom tip with the Rated Load Under Spreader at max outreach shall not be more than 200mm.

This test shall be done twice: at the Seller's construction site if the crane is shipped fully erected, and at the Buyer's terminal.

16.4.2 Horizontal Boom Deflection Test

Crane is gantried at nominal speed with empty spreader at maximum outreach and joystick at maximum reference is released suddenly. After completion of deceleration process, maximum horizontal deflection from datum to be measured and to take note of the time required for this horizontal oscillation to complete.

The relative horizontal displacement of the end of the boom only or the girder only shall not exceed 100 mm under the effect of normal gantry stoppage with the trolley at the end of the boom.

In case of inching situation during gantry travel the relative horizontal displacement of the end of the boom only or the beam only shall not exceed 200 mm, with empty spreader and up to the Rated Load Under Spreader.

This test shall be done at the Buyer's terminal only.

16.4.3 Crane Perpendicularity Test

Upon installing quay cranes on the Buyer's rails, measurements shall be taken by a local surveying company to confirm perpendicularity of crane installation when compared with gantry rail installation. Out Reach and Back Reach alignment shall be measured and compared with the perpendicular to the gantry rail orientation.

This test shall be done twice: at the Seller's construction site if the crane is shipped fully erected, and at the Buyer's terminal.

16.4.4 Dynamic Load Test

The purpose of the dynamic load test is to verify the crane operation and performance as well as capability of every movement and brakes.

The test is considered successful if there is no permanent deformation of structure, no abnormal activation of protection devices, no loosening or damage at joints and connections, and all electrical switches are activated normally, after the test. During test the crane is operated in accordance with normal operation procedure and at the speed, acceleration and deceleration adjusted within normal operation range.

1) Each motion operated individually

   Main hoisting is tested with Rated Load Under Spreader P and load 1.1P respectively at the above stated points a, b, and c. The load is lifted and lowered repeatedly for 3 times and relevant data is recorded. Then the trolley traversing is tested, and the spreader trimming, listing and skewing, gantry traveling etc. are also tested, with speed and other related parameters measured and recorded.

2) Simultaneous motions

Main hoisting and trolley traversing are simultaneously operated with rated load P, speed and other related parameters being measured and recorded.

3) Eccentric load test by using ISO 40ft container

   The ISO 40ft container is loaded eccentrically with the center of gravity shifted longitudinally by 1200mm and transversely by 200m from the geometry center of container. The trolley is positioned at the above mentioned a, b and c points in turn and main hoisting, spreader trimming, listing and skewing and then trolley traversing will be dynamically tested respectively.

   Relevant data of electrical equipment are measured and recorded.

4) Boom raising and lowering tests

   The crane operation cycle time is measured.

   The crane operation cycle will be performed in the specified load handling paths. The measured time for each path will be filled in the table chart.

5) Brake performance test.

   Examine whether braking torque of the brake arches 150% of rated load torque by using motor analogy method.

This test shall be done at the Buyer's terminal only.

16.5 Crane endurance Test

The purpose of this test is to examine the motor temperature rise and operating current, as well as the reliability of every mechanism and component under continuous operation. The noise level is measured at the same time.

The endurance test consists in running the following cycle with empty containers and containers weighed 80% of load capacity in Single-lift mode and Rated Load Under Spreader:

- 1 full container is picked up at the end of backreach
- the load is lifted and the trolley traverses to the boom end and the load lifted up to 3m away from max. lift position
- the load is lowered to close to the water level and is stopped for 30 sec. / the load is returned to its original ground position
- Repeat the above cycle continuously for 1 hour
- Then the gantry travels 100m and returns to original position
- Then repeat the above cycle with 1 empty container for 1 hour
- Then repeat the cycle with 2 full containers handled in twin-lift for 1 hour,
- Then repeat the cycle with 2 empty containers handled in twin-lift for 1 hour,

- The above 4 cycles are repeated for an overall duration of 16 hours
- During these 16 hours the boom hoisting is operated two times

If during the 16 hours the crane breaks down then the test shall restart from beginning at an agreed time. In this case the Seller will be responsible for another endurance test.

During the test, the gearboxes, motors, brakes and other equipment shall be observed for overheating, excessive vibrations, oil leaks, etc. Oil samples will be taken from gearboxes before and after the tests. Temperatures of each samples will be monitored.

The test is passed if the 16 hours test is conducted without any fault or breakdown, without overheating, excessive vibrations or deterioration of gearboxes oil.

This test shall be done at the Buyer's terminal only.

16.6 **Acceptance Report**

After all above tests have all been successfully completed and passed an acceptance report will be prepared and the tests results and conclusion will be listed.

The report will show the tested crane performance, test date, test place and the witness(es)' name.

17 DOCUMENTATION

At the time when the crane is delivered, the supplier will submit to the Buyer 2 (two) copies of drawings and documents in two CD sets for maintenance and repair work.

17.1 Drawings

1) Complete electrical circuit diagram; wiring list, complete spare parts list, cable lists, electrical material list, circuit diagram of crane manufacturer's standard style is acceptable.
2) As-built drawings of crane structural, mechanical parts and electrical for maintenance and repair use.

   These will be in PDF edition and in more detail than the drawings for review. As built mechanical drawings in particular showing all individual items to enable buyer to order necessary items for stock holding must be supplied. Drawings must identify items at component level.

   Inside the machinery house, diagrams in 2mm engraved plastic A3 version shall be installed showing all lubrication point information, wire rope reeving, hydraulic circuit diagrams indication views showing mounting and identification of hydraulic components on the packs etc.

17.2 Technical Documents

1) Crane Instructions
2) General arrangement scheme;
3) Performance data;
4) Detailed description of mechanisms and structure;
5) Detailed description of electrical controls and software logic; Soft copy of circuit diagram that can be edited by the Buyer.
6) Description of hydraulic systems;
7) Operation Manual
   a. Operator's duty;
   b. Operation method and sequence;
   c. Cautions for safe operation;
8) Structural Maintenance Program in the Format of a SIM (Structural Inspection Manual to be provided).

   To come out with the SIM, the Supplier shall base this upon a detailed study considering the calculation of the crane, FEM analysis and identification of the FCM (Fracture Critical Members) and non FCM. SIM shall be detailed on a

simple template with relevant columns for the Item, Item Description, Inspection Period, Inspection Type and whether item is FCM or not. SIM Template shall be approved by the Buyer.

The Seller should make all efforts to select inspection techniques that are non-invasive on the painting system. In the respect, apart from VT, inspection techniques such as ACFM and others wherever possible should be given preference over MPI or Traditional UT. MPI utilization should only be carried out then to confirm flaws detected by the ACFM process.

SIM shall be reviewed and approved by the Buyer's third party consultants.

9) Maintenance Manual;
10) Schedule and task of regular maintenance;
11) Steps of assembly and disassembly of major components and procedure of wire rope replacement;
12) Installation procedure of main mechanisms;
13) Adjustment method and data;
14) Points for attention in maintenance work;
15) Table of trouble shooting ;(any calibration procedures for load cells, drive tuning etc);
16) Lubrication method;
17) Lubricant (oil) specification, index and limit for replacement;
18) Lubricant (oil) type used for crane and its manufacturer;
19) Manual for the buy-out mechanical and electrical equipment, including seals, bearings, high-strength bolts, bolts of large diameter, special bolts, wire ropes, special cables, sensors, lightings, MV equipment and other components;
20) Manual for quickly worn-out parts and spare parts, including name, size, quantity, material, special requirement and shop drawings of the parts;
21) Manual for the elevator, including: the drive (if installed) manual and commissioning parameters; complete spare parts list, any drive interface tools and monitoring software. In addition manual shall include or be complimented with detailed procedures for replacing / repairing all major components such as but not limited to motor, gearbox, safety device, pinion, rack, rollers. Procedures should also include Standard Operating Procedure with location where the work must be carried out etc in order to ensure that safety is not compromised at all times.
22) Excel sheet with all crane components locations and references

All technical documentations shall be in English.

18 After Sales Service (Optional)

The following after sale service will be provided to the Buyer by the Seller:

During the first period of crane normal operation of 3 months after final acceptance of the cranes, the Seller shall have one relevant engineer at the Buyer's site, helping the maintenance and the troubleshooting on normal work hours and upon call on 24 hour.

The Seller's engineer providing the after sale service will (informally) train the Buyer's personnel by involving them in any of his operations.

19 TRAINING

The following training will be carried out on site after acceptance of the cranes.

- Electrical –2 separate Electrical training sessions of one week for each group (4 groups total) of approximately 12 persons each group. - Training will be conducted by the commissioning engineer and will include training on drives, PLC, CMS, all software, general electrical etc
- Mechanical – 2 separate Mechanical training sessions of one week for each group (4 groups total) of approximately 12 persons each group
- Drives - 2 separate Drive training sessions of one week for each group (4 groups total) of approximately 12 persons each group – Training will focus on targeting repairs, troubleshooting, tuning, etc.
- Operation – 1 Operation training session of one week for a group of no more than 4 persons.

Each training session will include document supports specially made for such training sessions.

The supplier shall supply full details of training plan within 90 days after the contract is awarded.

Language shall be Greek or in English with Greek translator.

20 List of Authorised Suppliers

The systems, components, parts listed in the below table shall be supplied exclusively by suppliers listed in the table for the considered system, component, part.

Item	Authorized Supplier
Main Motions Systems:	
PLC and drive systems	Siemens, ABB, Liebherr, TMEIC
Motors	ABB, Siemens, Wölfer, Liebherr /LDW
Gearboxes and reducers	Falk, Flender, SEW, Woorim (gantry)
Couplings	Bubenzer, Malmedie, Sibre, Gosan
Brakes (including Rail Brakes)	Bubenzer, Sibre, Liebherr, Hillmar, Rima
Mechanical Systems and Components:	
Spreader	Bromma, Stinis, RAM
Mancage	WCS, Fargamel, TEC, Simars, Stinis
Cable reels	Specimas, Stemmann, Wampfler, Cavotec, Vahle
Energy chain systems	Brevetti, Igus, Conductix
Festoon system	Conductix, Vahle, Stemmann
Trolley rails clips and short Rail	Gantrex, Gantrail, BEMO
Hydraulic bumpers	Bubenzer, Oleo
Hydraulic components	Atos, Parker, Rexroth, Vickers
Machinery house service crane	Kone, MHE-Demag, Verlinde
Elevator	Alimak
Wire Rope Rollers –	Innodock Support
Laser Scanners	Lase / Sick
Air Compressor	Ingersoll Rand, Kaiser, Hydrovane

Bearings	SKF, FAG
Electrical Systems and Components:	
Power transformers	ABB, GE, Schneider, Siemens, Sanil, Hyundai
Switchgear	ABB, Schneider, Siemens
MCCBs, MCBs, Contactors, etc	Schneider, ABB, Siemens, TemBreak, Mitsubishi
Power supply cables	Nexans, Prysmian, Tratos
Control cables	Oelflex
Floodlights	Philips, Sfigligoi SRL, Phoenix, Nanhua
Spreader cable connection	ODU, Harting, Proconnect
Air conditioners	Carrier, Daikin, Panasonic, Mitsubishi
Control and Instrumentation:	
Operator control station	Spohn+Burkhardt,
Control Buttons	Schneider, IDEC
Limit switches	Schmersal, Telemecanique, Schneider, Allan Bradley, Omron, Honeywell
Proximity limit switches	IFM, Schmersal, Turck, Allan Bradley, Schneider
Encoders	Hübner Giessen, Posital, NSD
Load cells / Weighing system	PAT Krüger, Brosa
Cabins:	
Operator cabin	Merford, Brieda
Seat	Merford, Brieda, Spohn+Burkhardt, Gessmann
Other systems:	
Wire ropes	Casar, Tokyo, TESAC Shinko, Diepa, Pfeifar
Painting	Jotun, Hempel, International

Telephone	AI Phone, Nanhua, Panasonic