REVISION CONTROL SHEET

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1. INTRODUCTION TO [redacted] MANIPULATOR CRANE SYSTEM

The equipments included in the [redacted] manipulating system of [redacted] are designed to minimize operation errors and non conformances that lead to [redacted] damage and [redacted]. Design of these systems also ensures safe, reliable and fast [redacted] operations. The [redacted] manipulating system is mainly situated in two operating areas and each area equipped with proper tools and equipments.

[redacted] Manipulator Crane [redacted] is one of the main equipments of [redacted] manipulating systems located in [redacted] Building operating area. It spans over the [redacted] in the [redacted] building for the loading, unloading of [redacted] assemblies in [redacted].

1.1 FUNCTION

The main function of this crane is to accurately locate any position in the [redacted] and transport [redacted] assemblies between [redacted] and [redacted] storage system, via Upending Device [redacted] in [redacted] Building [redacted] to [redacted] Building [redacted], or to [redacted] and [redacted] Changing Fixtures in [redacted]. During [redacted] operations this crane moves on the [redacted] along X and Y direction of the [redacted] with the help of Bridge [redacted] and Trolley [redacted] and can accurately locate over the [redacted] assemblies.

In integral [redacted] mode, this crane is used to unload and load [redacted] assemblies from [redacted] to Upending Device [redacted], while in partial [redacted] mode this crane is used to unload and load [redacted] assemblies from [redacted].

This crane can also be used for rotation of [redacted] assemblies. The Monorail cranes installed on the Bridge of [redacted] Manipulator Crane are used for:

- Unlatching and latching of [redacted] from [redacted] Internals.
- Removal and installation of [redacted] from [redacted] Internals.

[redacted] Manipulator Crane also serves as operating platform for [redacted] verification.

1.2 [redacted]

The general layout of [redacted] is shown in Figure 1-1:

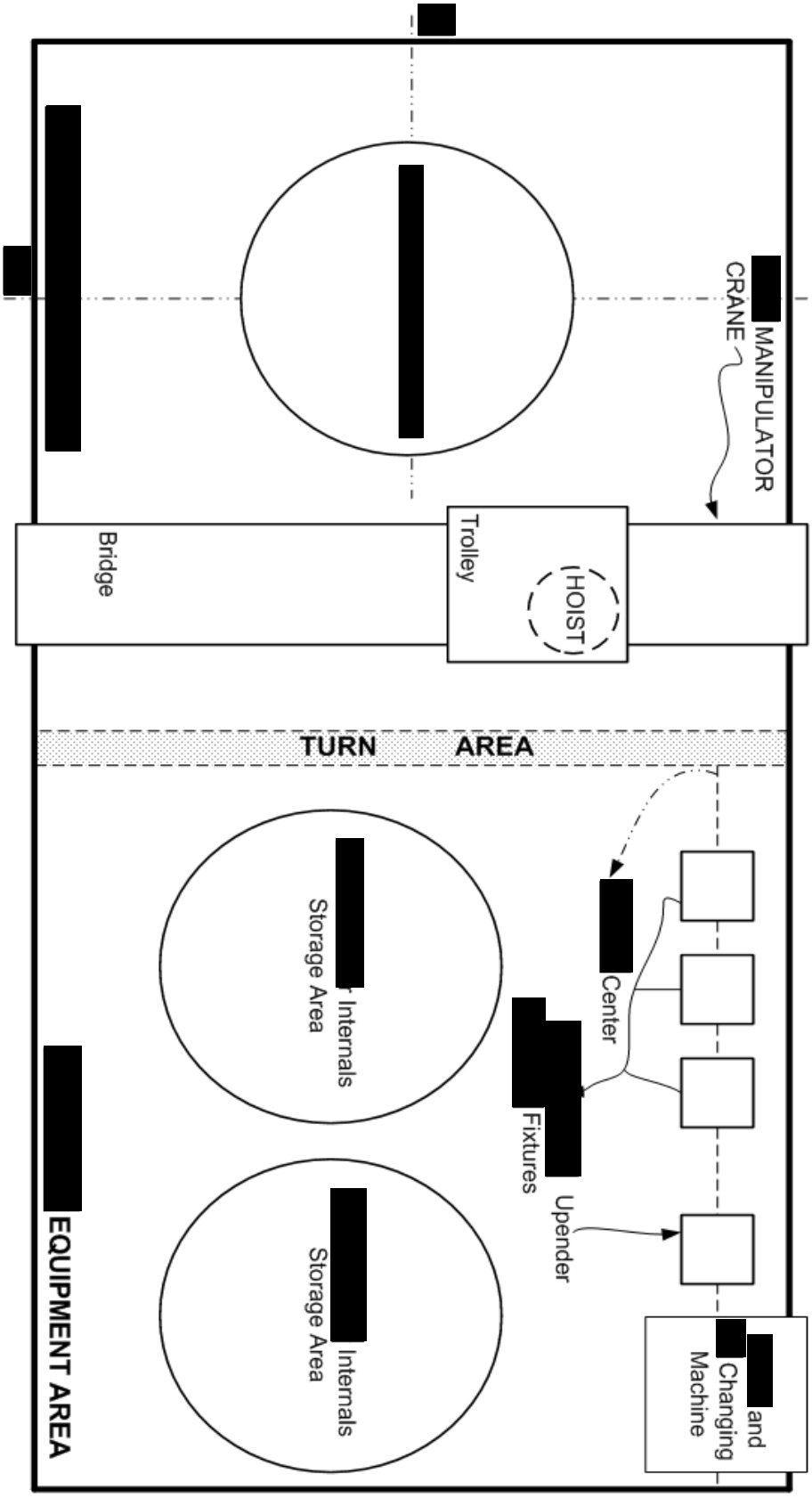

Figure 0–1: Layout of [redacted] Pool

The Bridge of [redacted] Manipulator Crane moves along [redacted] of [redacted] while the Trolley moves along [redacted] to [redacted] of [redacted]. Through movement of these two mechanisms the [redacted] Manipulator Crane can accurately be positioned over [redacted], [redacted] and [redacted] Changing Fixtures and Upending Device.

[redacted] is divided into three areas:

- [redacted] *Area* [redacted]*:* [redacted] is located in this area
- [redacted] *Equipment Area* [redacted]*:* This area stores [redacted] Internals, [redacted] and [redacted] Changing Fixtures, Upending Device and [redacted] changing machine.
- *Turn Area:* This area is used to control the movement of [redacted] Manipulator Crane. If [redacted] Manipulator Crane is moving from [redacted] to [redacted] of the [redacted] then Bridge will stop in *Turn Area* and can only move backward [redacted] if Trolley is aligned to Channel Centre. Similarly if [redacted] Manipulator Crane is moving from [redacted] to [redacted] of [redacted] then Bridge will stop in Turn Area and can only move forward [redacted] when Trolley leaves the Channel Centre. However once the bridge is out of Turn Area then Trolley can move from [redacted] to [redacted] in the [redacted] only.

1.3 [redacted] LAYOUT AND [redacted] HANDLING PATTERNS

[redacted] loading and unloading patterns are prepared to minimize travel of [redacted] Manipulator Crane over [redacted] assemblies in the [redacted] for [redacted] safety. These are shown in Figure 1-2 and 1-3.

[redacted]

Figure 0–2: [redacted] Unloading Scheme

Figure 0–3: [redacted] Loading Scheme

1.4 MAIN COMPONENTS OF [redacted] MANIPULATOR CRANE SYSTEM

[redacted] Manipulator Crane is main equipment. It consists of Bridge, Trolley, Hoist, Telescopic Tube, Mast, Gripper, auxiliary Monorail cranes, safety and control related equipments. Operator panel is located on Trolley.

1.4.1 Hoist

The function of Hoist is to lift Telescopic Tube, Gripper and [redacted] assembly. It consists of:

- DC Motor
- Shaft Couplings.
- Two Electro Hydraulic Brakes on High Speed Shaft (Drum Brakes)
- Worm Gear Reducer
- Wire rope Drum
- One Safety Brake on Low Speed Shaft (Disc Brake)
- Load Cell
- Balance Beam
- Hoist Position Measurement Encoder
- Hand Operated Mechanism

To follow the single failure criteria, two wire ropes on the Drum are connected with a weight sensor through moveable Pulley and are fixed with Balance Beam. A wire rope break is detected by Balance Beam. Single wire rope can carry [redacted] load.

Two electro hydraulic brakes are mounted on the high speed shaft of the Reducer. To ensure safe and smooth braking, one brake acts as main brake while the other acts as redundant brake. There is [redacted] seconds delay between main brake and redundant brake. One disc brake, i.e. safety brake, is installed on the flange of the Drum. During normal operation of Hoist, Drum brakes operate prior to operation of Safety brake to prevent descending of load under its own weight. To prevent falling of load under fault conditions PLC actuates Safety brake to stop Wire rope Drum.

Hoist travel distance is measured by position measurement encoder mounted on the shaft of Wire rope Drum which gives signal to PLC. PLC displays the Hoist position and stops the Hoist at UP/DOWN limit positions. PLC also slows the Hoist down in predefined slow areas based on Hoist height.

Hand operated mechanism is set at the high speed shaft of Reducer. This mechanism is interlocked with the motor drive mechanism in such a way that only one of them can be operated at a time. This mechanism can be used in case of power failure or equipment failure.

1.4.2 Mast

Mast is installed on the Trolley platform through rotary bearing. Mast can be rotated [redacted] about its axis along with Hoist, [redacted] and [redacted] using hand operated mechanism.

Mast is divided in two parts:

- Upper Part: Flange on upper part is connected to Hoist.
- Lower Part: Used as a guide for [redacted].

The upper and lower parts are connected by rotary bearing. The position of Mast is sensed by PLC through limit switches and each position of Mast can be mechanically locked by aligning pin. A pair of one meter long anti-sway frame is installed at the bottom of Mast to prevent [redacted] from swinging during loading/unloading operations. Up/down travel limit switches, over travel protection limit switches and power supply cut off switch are installed on Mast.

1.4.3 [redacted]

[redacted]

1.4.4 Gripper

Main function of Gripper is to hold [redacted] assemblies during transportation. There are cylinder and piston rod on the upper section of [redacted] which is connected to the slide of the Grippers through linkage tube.

Action of the Gripper is controlled by piston rod of the cylinder. When Gripper descends to the lower working position, the locating pin on the Gripper is inserted into the upper nozzle of [redacted] and presses the spring to release the mechanical self-lock. At this moment the piston rod can perform vertical movement under the compressed air pressure.

The slide connected to the piston rod opens or closes the Gripper to release or hold the [redacted] assembly. The piston rod moves downwards to open the grip under the compressed air pressure and hold the [redacted] assembly;

on the contrary, the piston rod moves upwards to close the grip under the compressed air pressure and releases the [redacted] assembly.

When the Gripper rises, mechanical self lock ensures that the [redacted] assembly will not drop during the operation due to accidental air charging. If Gripper control mechanism fails or air or power supply is cut off, the Gripper can be opened or closed with manual operating tool.

1.4.5 Bridge

The Bridge of [redacted] Manipulator Crane moves along [redacted]. The forward movement of Bridge is towards [redacted] while the backward movement is towards Upending Device [redacted].

Walkway on one side on Bridge is equipped with centralized driving mechanism. DC Motor drives the Bridge driving wheels on both ends through Reducer and universal couplings.

Hand operated mechanism is set at the high speed shaft of Reducer. This mechanism is interlocked with the motor drive mechanism in such a way that only one of the two can be operated at a time. This mechanism can be used in case of power failure or equipment failure.

1.4.6 Trolley

The Trolley of [redacted] Manipulator Crane moves on Bridge rails along [redacted]. The LEFT movement of Trolley is towards [redacted] internal storage side [redacted] while the RIGHT movement is towards Upending Device in [redacted]

Trolley is equipped with centralized driving mechanism. DC Motor drives the Trolley driving wheels on both ends through Reducer and universal couplings.

Hand operated mechanism is set at the high speed shaft of Reducer. This mechanism is interlocked with the motor drive mechanism in such a way that only one of the two mechanisms can be operated at a time. This mechanism can be used in case of power failure or equipment failure.

1.4.7 Monorail Cranes

The Monorail Cranes installed on the Bridge of [redacted] Manipulator Crane are used for:

- Unlatching and Latching of [redacted].
- Removal and installation of [redacted]

1.4.8 [redacted] Control System

The existing control system of [redacted] is based on [redacted] series PLC. The control system is housed in one operator panel, one PLC panel and one electrical panel. Operator panel is installed at the working platform of Trolley while the other two panels are installed on Hoisting device platform of Trolley.

One-Line diagram of existing control system is shown in Figure 1-4. DC motors are controlled by [redacted] DC motor speed controllers. DC motor speed controllers are enabled by PLC. Speed signal to DC motor speed controller is given by single / double axis control grips on operator panel and speed feedback is given by [redacted] encoder mounted on the motor. A two line dot

matrix display gives Hoist motor speed and position of selected traveling mechanism. All these components are on [redacted] bus.

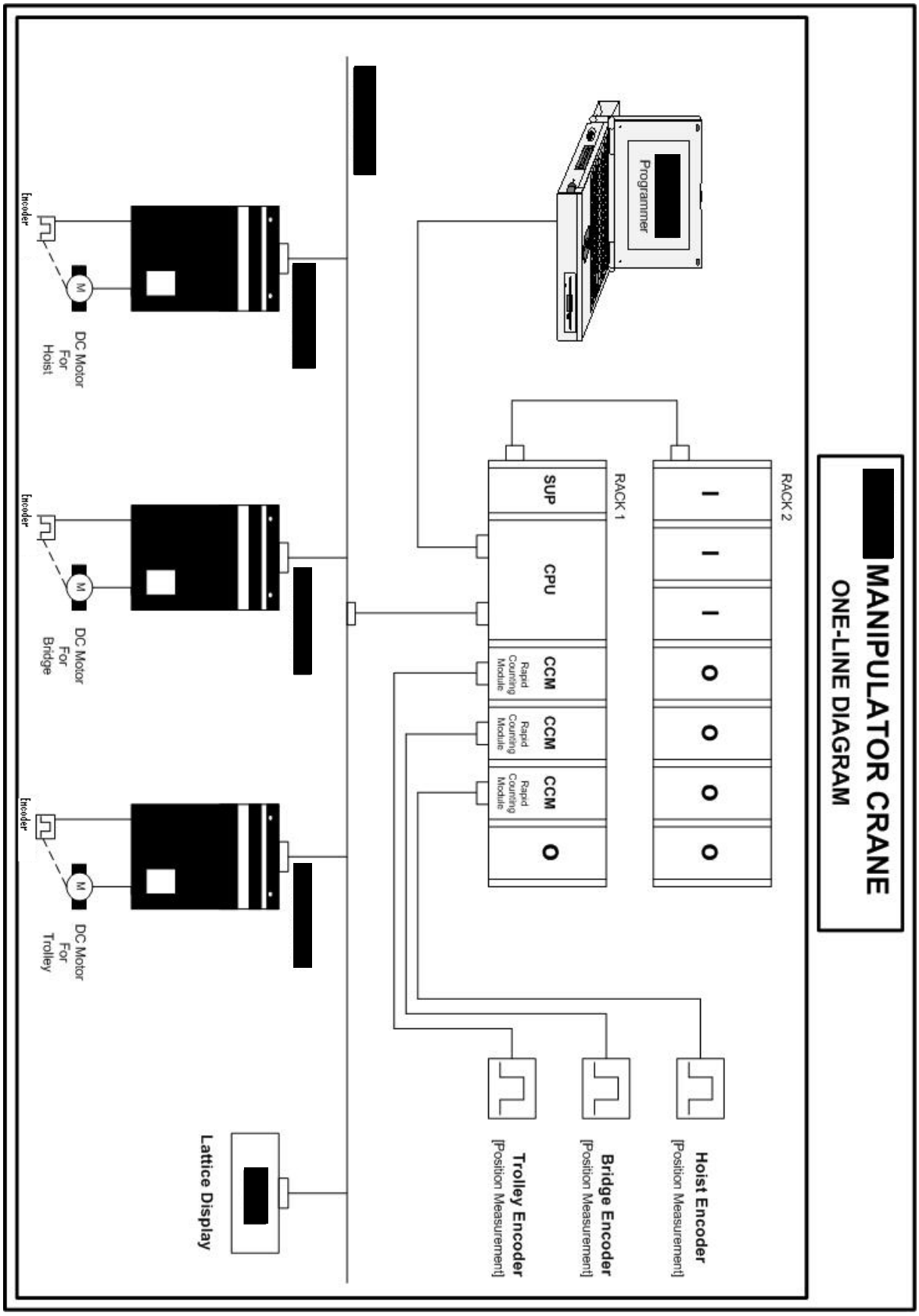

Figure 1–4: One Line Diagram of Present Control System

All of the three driving mechanisms have [redacted] PPR encoders for position measurement. These encoders give signal to respective rapid counting modules in PLC, which in turn calculates the position and displays it on the dot matrix display.

Weight on Hoist is measured by load cell which gives signal to electronic weighing device i.e. [redacted] Terminal made by [redacted]. [redacted] Terminal has programmed preset weights and gives contact outputs to PLC which monitors no-load and over-load condition on Hoist.

All limit switches, operator pushbuttons, selector switches are input signals to PLC which control the operation of crane.

2. CONTEX OF THE PROJECT

The problem of spares, obsolescence, especially [redacted] Control System of [redacted] Manipulator Crane was identified in [redacted]. In this regard a [redacted], was approached and they proposed a solution in [redacted] for replacement of [redacted] Control System at approximate cost [redacted].

During [redacted] severe maintenance problems were experienced in control system of [redacted] Manipulator Crane and due to poor and error prone documentation, the maintenance lead time increased significantly. This Control System is also obsolete and needs replacement to avoid the breakdown of the system, altogether.

2.1 ONE LINE DIAGRAM OF PROPOSED CONTROL SYSTEM

The one-line diagram of proposed control system which is based on [redacted] PLC is shown in Figure 2-1.

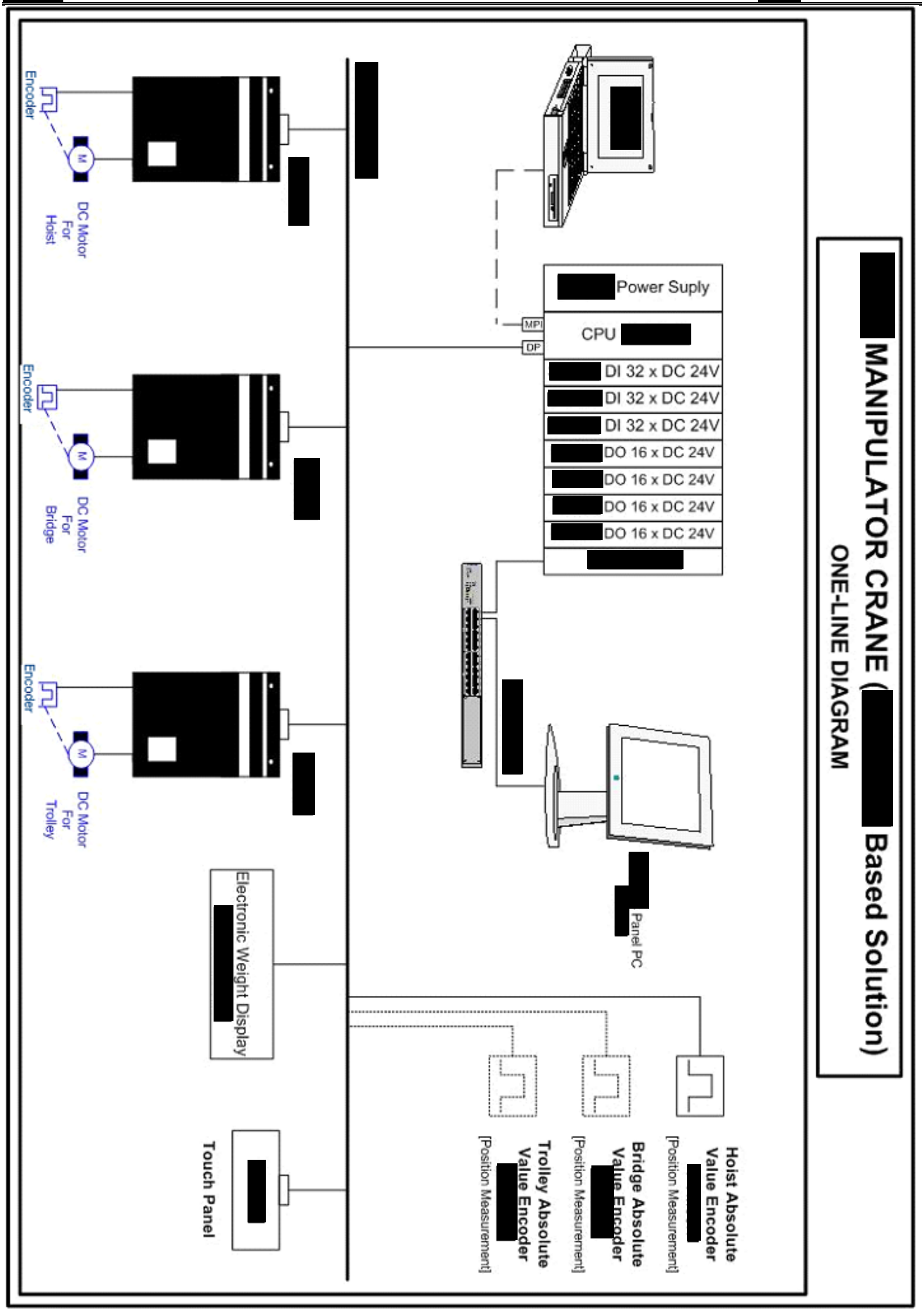

Figure 2-1: One-Line Diagram of New Control System

2.2 THE BOUNDARY OF CHANGE

The existing three panels of control system will be replaced by three new detachable panels, including new electrical and electronic equipments, while the DC motors, respective speed encoders and mechanical components will not be replaced as shown in Figure 2.1.

The incremental encoders (for position measurement) mounted on three axes will be replaced by Integrated Absolute Value Encoders.

Additionally, new wiring in the field is to be laid which will terminate into new Detachable Panels for [redacted] building maintenance and storage[redacted]

The new Control System will follow the [redacted] Manipulator Crane architecture for compatibility in hardware.

3. MAIN COMPONENTS OF NEW CONTROL SYSTEM

New control system of [redacted] Manipulator Crane will be based on [redacted] PLC with DC Motor Speed Controllers, Absolute Value Encoders and HMI displays. As shown in the Figure 2-1, the system will be built on [redacted] and [redacted] bus architecture.

3.1 OPERATOR AND CONTROL PANNELS

One detachable Operator panel will be installed on the working platform of Trolley. This panel will house:

- Single Axis Control Grip for driving Hoist mechanism.
- Two Axis Control Grip for driving Bridge and Trolley mechanism
- HMI screen (one [redacted] PC and one [redacted] Touch Screen)
- Electronic Weighing Device Terminal
- Selector Switches
- PLC
- Pushbuttons and Indication Lamps
- Key operated Switches
- Alarm Devices
- CCTV displays for [redacted] camera, Bridge and Trolley

One Detachable PLC panel will be installed on Hoisting device platform of Trolley. All field mounted limit switches will terminate in this panel. The main components in this panel will be:

- Power Supplies
- Safety Relay
- Circuit Breakers and Contactors
- Relays

Another Detachable power panel will be installed on Hoisting Device platform of Trolley. The main AC power supply will be distributed through this panel. Main components inside this panel will be:

- Main Power Supply Contactor
    - DC Motor Speed Controllers

- Circuit Breakers and Contactors
- Relays and Fuses

3.2 PROGRAMMABLE LOGIC CONTROLLER (PLC)

Main control element of the system will be [redacted] PLC. All the Operating Logic and Safety Interlocks will be implemented in PLC. Input modules of PLC will receive signals from limit switches and operator controls and send command signals through output modules.

The CPU module of PLC will be Master of [redacted] network, while the [redacted] module of PLC will control communications on [redacted].

3.3 HUMAN MACHINE INTERFACE (HMI)

There will be two HMI displays installed on operator Panel.

- [redacted] touch screen, on [redacted] network, will display essential information like Hoist height, selected mechanism speed and basic alarm. This screen will also be used for user authentication.
- [redacted] touch screen, on [redacted] network, will be used for the detailed process displays such as core loading and unloading patterns, crane components speed and their positions on area map, descriptive indications and alarm management. This touch screen will also have maintenance screens, user authentications screens, Hoist load profile screens in addition to System Diagnostic Screens etc.

3.4 DC MOTOR SPEED CONTROLLERS

[redacted] DC Motor Speed Controllers will be used to drive DC motors of Hoist, Bridge and Trolley. These controllers will receive control commands (RUN, Direction signals, Slow Speed signals etc.) from PLC (Relay Contacts) while the speed command signal will be from respective control grip on operator panel. Speed feedback will be provided by [redacted] encoders mounted on respective motor shaft.

These controllers will also control Drum Brakes of respective mechanisms to ensure safe and smooth braking at the desired locations. This feature also ensures the safety of the structure.

Speed Controllers are connected to [redacted] network. PLC fetches important operating information from these controllers and displays them at relevant HMI screens.

3.5 ABSOLUTE VALUE ENCODERS

[redacted] Absolute Value Encoders will be used for moving mechanisms' (Bridge/Trolley/Hoist) speed and position feedback to PLC. These encoders communicate with the PLC's CPU on [redacted] network. One encoder is installed on the Hoist Drum while other two encoders are mounted at the main wheels of Bridge and Trolley.

3.6 WEIGHING SYSTEM

Weighing system will consist of load cell (a field device installed in Hoist) and [redacted] Industrial Terminal made by [redacted]. Load cell will directly send the weight signal to the [redacted] Terminal which processes this signal and send weight information to PLC via [redacted] network. PLC will calculate Overload and Weight Loss conditions based on this information.

3.7 SAFETY RELAY

E-STOP pushbutton is being monitored by [redacted] safety relay [redacted] and PLC. The safety relay functions are redundant with PLC and will be used to

- Cut off main power
- Actuate safety brake of Hoist.
- Send E-Stop signal to DC motor speed controllers.
- Send Fault signaling for PLC

Safety relay will be reset by RESET Key Switch on the Operator Panel and by PLC output.

4. CONTROL SYSTEM SPECIFICATION

The control system shall be able to accurately locate Hoist over [redacted] assemblies in [redacted], Upending Device and [redacted] changing fixtures, by independently moving Bridge and Trolley. All safety and control interlocks shall be implemented to prevent operator errors and minimize probability of [redacted] damage.

All the driving mechanisms can be operated independently with only one mechanism running at a time. All the driving mechanisms can also be operated by their respective hand drive mechanisms and are interlocked with their respective electrical drive mechanisms.

Operator identification and authentication shall be required for crane operation. For operating crane under any safety function bypass condition shall require Supervisor authentication via key operated switches. Maintainer authentication will be required to access maintenance/diagnostic screens of HMI. Control and Safety Interlocks are discussed in subsequent paragraphs.

4.1 HOIST

The main control parameters of Hoist are

- Maximum Lifting Height [redacted] m
- Traveling Speed [redacted] m/min
- Positioning Accuracy [redacted] mm
- Inching Step [redacted] mm

4.1.1 Slow Speed Areas

Slow speed areas will be designed as per profile given in Figure 4-1. These areas ensure protection of [redacted] assemblies during their lifting and lowering. Hoist speed will slow down automatically as it enters slow areas. In these areas hoisting control grip can only be used for direction signals.

Slow rising areas at the top position ensure safe and smooth stopping of Hoist at the top most position

During lowering of Hoist in [redacted] area the Hoist will slow down automatically at [redacted] mm, as it enters the [redacted]. During lowering of Hoist in Upending Device the Hoist will slow down automatically at [redacted] mm, as it enters the Upending Device. The maximum lowering position of Hoist will depend upon position of [redacted] Manipulator Crane. If [redacted] Manipulator Crane is in [redacted] area then maximum lowering height will be [redacted] mm, while if crane is in Upending Device area the maximum lowering height will be [redacted] mm. Hoist will not descend beyond these maximum lowering heights. Slow rising area at the bottom will ensure hindrance free lifting of [redacted] assembly. Speed set-point in Slow Areas is set in DC motor speed controller.

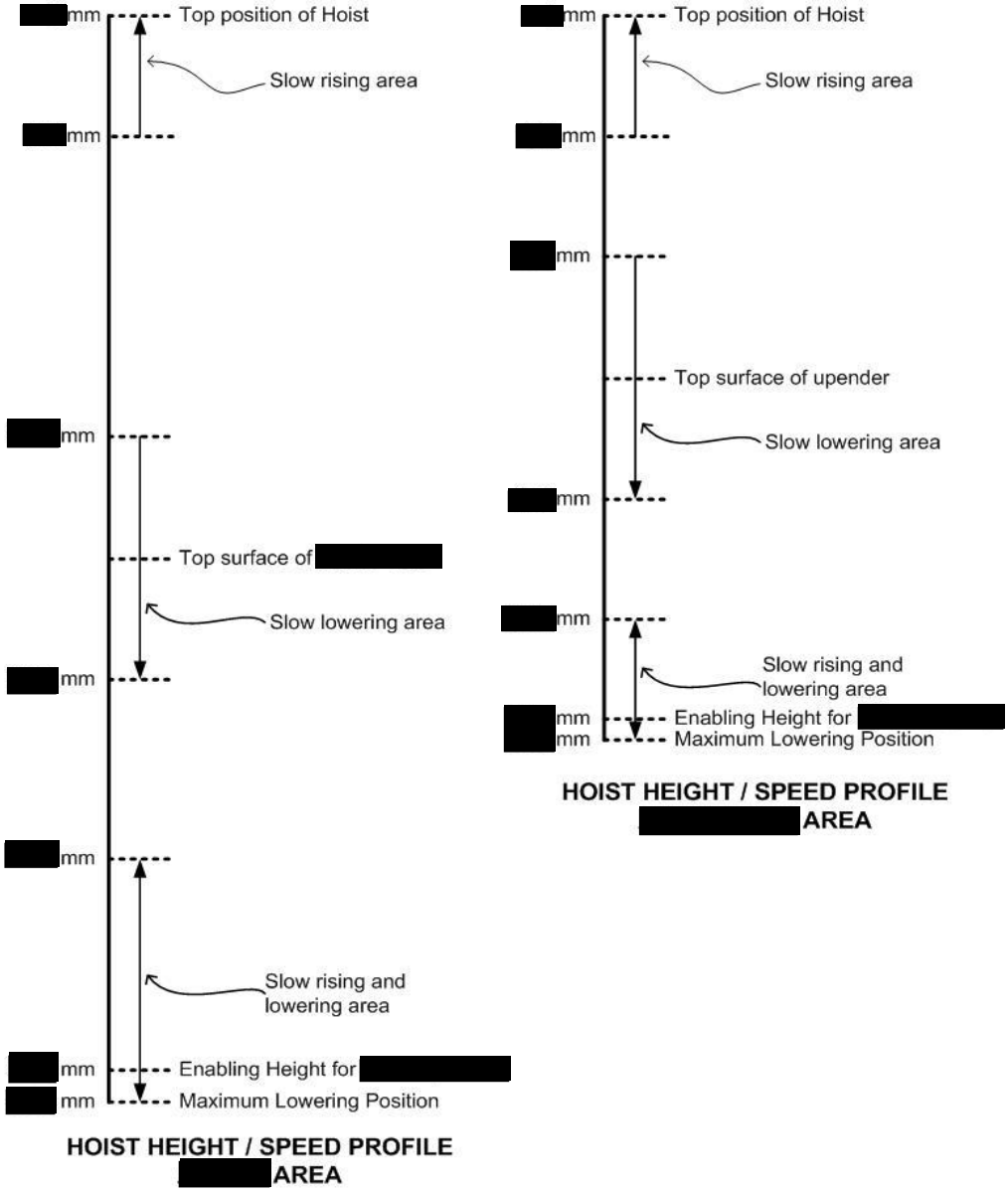

Figure 4-1: Hoist Height versus Speed Profile

4.1.2 Weight Protections

The [redacted] Terminal will send weight information to PLC .Weight information will be used for calculating weight protection set points and will also be displayed on [redacted] touch screen by PLC. The weight protections set points are

- ***Loose Load Protection*** [redacted] During placement of [redacted] assembly and Hoist has reached

its normal placement height then if weight becomes less than [redacted] kg then Hoist will stop descending. This indicates that [redacted] assembly has been correctly placed on desired location. System will annunciate Loose Load, Grippers can now be actuated.

- ***Gripper with [redacted] Assembly [redacted]*** While lifting of [redacted] assembly if Hoist weight is more than [redacted] kg then it ensures the [redacted] assembly is properly latched by Gripper.
- ***Weight Loss at Abnormal Height [redacted]*** During placement of [redacted] assembly if Hoist weight is less than [redacted] kg and Hoist has not reached at its proper lowering height then Hoist will automatically stop descending.
- ***Overload [redacted]*** During lifting of [redacted] assembly if Hoist weight reaches to [redacted] kg then Hoist will automatically stop lifting. In overload condition Hoist can only descend.

4.2 BRIDGE

The main control parameters of Bridge are:

Traveling Span	[redacted] m
Traveling Speed	[redacted] m/min
Positioning Accuracy	[redacted] mm
Inching Step	[redacted] mm

4.2.1 Slow Speed Areas

As Bridge reaches forward or backward travel limits, the limit switches for forward or backward deceleration are turned ON and the Bridge will automatically slow down. In forward slow speed area Bridge can move at regulated speed in backward direction and vice versa. In slow speed area Bridge control grip can only be used for direction signals, while the slow speed is maintained by relevant speed controller.

4.3 TROLLEY

The main control parameters of Trolley are:

Traveling Span	[redacted] m
Traveling Speed	[redacted] m/min
Positioning Accuracy	[redacted] mm
Inching Step	[redacted] mm

4.3.1 Slow Speed Areas

As Trolley reaches left or right travel limits, the limit switches for LEFT or RIGHT deceleration are turned ON and the Trolley will automatically slow down. In left slow speed area Trolley can move at regulated speed in right direction and vice versa. In slow speed area Trolley control grip can only be used for direction signals, while the slow speed is maintained by relevant speed controller.

4.4 CONTROL INTERLOCKS

- ***Drive Mechanism Interlock:***
  - Only one driving mechanism (Hoist, Bridge or Trolley) can work at a time.
- ***Hoist Position Interlocks:***
  - If Hoist has not reached top position [redacted] neither Bridge nor Trolley can be moved.
  - If Hoist is not at specified lowering position the Grippers cannot be operated.
- ***Position Interlocks of Bridge and Trolley:***
  - Bridge cannot enter [redacted] Equipment Area unless the Trolley is at the Channel Center.
  - Trolley cannot move in Upender Area until Bridge reaches the Turn Area.
- [redacted] ***Manipulator Crane and*** [redacted] ***Changing Machine Interlock:***
  - Bridge cannot enter the [redacted] equipment area unless the [redacted] Machine is at its parking position.
  - [redacted] Changing Machine cannot leave its parking position as long as [redacted] Manipulator Crane is in [redacted] Area.
  - Bridge cannot enter [redacted] Equipment Area unless Upending Device is at vertical position (not programmed in existing PLC application).
  - Upending Device cannot be operated unless the Hoist reaches [redacted] mm.
  - When [redacted] Manipulator Crane is in [redacted] Equipment Area the Hoist cannot descend until the Upending Device is in vertical position.
- ***End Limit Protection of Hoist:***
  - Hoist cannot rise beyond [redacted] mm height.
  - Hoist cannot descend beyond specific height.
- ***End Limit Protection of Bridge:***
  - Bridge cannot move forward from its forward travel limit.
  - Bridge cannot move backward from its backward travel limit.
- ***End Limit Protection of Trolley:***
  - Trolley cannot move left from its left travel limit.
  - Trolley cannot move right from its right travel limit.
- ***DC Motor Over Speed Protection:***
  - All three drive mechanisms will stop if their respective motor speed increases from preset rpm value.
- ***Balance Beam Protection:***
  - In case of hoisting wire rope break the Balance Beam protection limit switches will stop hoisting mechanism and also actuates safety brake.
- ***Hand Operation Interlock:***
  - If any of the three drive mechanisms is selected for hand operation then none of the

drive mechanisms can be operated electrically. This interlock is in consistence with Drive Mechanism Interlock and is introduced as a new interlock.

- ***Speed Mismatch Protection of Hoist High Speed Shaft and Low Speed Shaft:***
  - If speed difference between Hoist High Speed Shaft and Low Speed Shaft increases to [redacted] rpm then it will stop hoisting mechanism and also applies safety brake.
- ***Prohibit Upender Operation***
  - If Bridge is in Upender Area and Hoist Height is greater than [redacted] upender operation is prohibited.

4.5 BYPASS OPERATIONS

- ***Telescopic Tube Up Bypass:*** This bypass enables lifting of Hoist beyond [redacted] mm position to Telescopic Tube Up Limit Switch position or maximum up to power cut off switch position.
- ***Mast Turn Bypass:*** This bypass enables operation of Hoist if Mast is turned at [redacted] or [redacted]. System will only operate in slow speed mode.
- ***Overload Bypass:*** In Hoist overload case the Hoist will continue operation under Overload Bypass.
- ***Loose Load Bypass:*** In Hoist loose load case the Hoist will continue operation under Loose Load Bypass.
- ***Hoist Height Interlock Bypass:*** This bypass enables movement of Bridge and Trolley if hoist height is [redacted]. Both Bridge and Trolley will move in slow speed mode. This bypass will only be available in [redacted] Area [redacted].
- ***Wire Rope Break Bypass:*** This bypass enables movement of hoist in case of single wire rope break.
- ***Special Bypass:*** This bypass enables the movement of Bridge into Upender Area while Upender is not vertical.

Hoist Height Interlock Bypass and Wire Rope Break Bypass are introduced in new control system, as a functional replacement of Other Bypass (in existing Control System).

5. OPERATOR INTERFACE

Operator interface is realized through one single axis control grip, one double axis control grip, pushbuttons, selector switches, key operated bypass switches, indication lamps, two touch screen displays, three CCTV monitors for Bridge/Trolley position scale and underwater camera, and [redacted] Terminal.

5.1 CONTROL GRIPS

- Single Axis Control Grip: Used to give direction signals, UP or DOWN, and speed reference signal for Hoist motor.
- Double Axis Control Grip: Used to give direction signals, FORWARD or BACKWARD for Bridge and LEFT or RIGHT for Trolley along with speed reference signals for their

respective motors.

5.2 HUMAN MACHINE INTERFACE

There will be two HMI displays installed on operator Panel.

- [redacted] touch screen, on [redacted] network, will display essential information like Hoist height, selected mechanism speed and basic alarm management. This screen will also be used as user(s) authentication.
- [redacted] touch screen, on [redacted] network, will be used for the detailed process displays such as core loading and unloading patterns, crane components speed and their positions on area map, descriptive indications and alarm management. This touch screen will also have maintenance screens, user authentications screens, Hoist load profile screens in addition to System Diagnostic Screens etc.

6. DOCUMENTS AND RECORD

Following documents will be generated during the course of the project and these will be kept as permanent record.

S. No.	Code	Title
1	[redacted]-BD-01	Design Specifications for Proposed Control System on [redacted] Manipulator Crane
2	[redacted]-BD-02	PLC and I/O definitions
3	[redacted]-BD-03	Analysis of Existing PLC Application
4	[redacted]-BD-04	Control System Network
5	[redacted]-BD-05	Basic HMI Design of Proposed Control System
6	[redacted]-BD-06	Basic Design of Electrical System
7	[redacted]-BD-07	Tentative Scheme of Panels
8	[redacted]-DD-01	Detailed Electrical System Diagram
9	[redacted]-DD-02	Detailed PLC I/O Diagram
10	[redacted]-DD-03	DC Motor Speed Controllers Connection Diagram
11	[redacted]-DD-04	Control Network connection Diagram
12	[redacted]-DD-05	Field I/O Routing Diagram
13	[redacted]-DD-06	Integrated Software Report
14	[redacted]-TP-01	Procedure for PLC and HMI Testing
15	[redacted]-TP-02	Procedure for No Load Testing of DC Motor Speed Controllers
16	[redacted]-TP-03	Procedure for Load Testing of DC Motor Speed Controllers
17	[redacted]-TP-04	Procedure for Integrated Testing of HMI and DC Motor Speed Controllers
18	[redacted]-IC-01	Procedure for Removal of Existing Control System of [redacted] Manipulator Crane
19	[redacted]-IC-02	Procedure for Installation of New Control System of [redacted] Manipulator Crane
20	[redacted]-IC-03	Procedure for Commissioning of New Control System
21	[redacted]-OM-01	Operation and Maintenance Manual

ANNEX-1

LIST OF ABBREVIATIONS

[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted] Manipulator Crane
UD	Upending Device
[redacted]	[redacted] Building
[redacted]	[redacted] Building
[redacted]	[redacted] Assembly
[redacted]	[redacted]
[redacted]	[redacted] Area
[redacted]	[redacted] Equipment Area
PLC	Progammable Logic Controller
E-Stop	Emergency Stop
PPR	Pulse Per Revolution