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SALE PROPOSAL

ROBBINS TBM

UG1B-JAIPUR

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INDEX

SPECIFICATION OF TBM ROBBINS

1 DESIGN CONDITION

General Condition

Project Name	East-West Corridor of Jaipur Metro (Phase-1B) at Jaipur India
Site Location	Badi Chouper and reversal line by Shield TBM, Underground Metro Stations as Choti Chouper by Cut & Cover Method on East-West Corridor of Jaipur Metro (Phase 1B) at Jaipur, Rajasthan
Number of TBMs	2
Total distance bored by TBM	1) 1875 meter @ after Refurbishment. 2) 1875 meter @ after Refurbishment.

1.1 Geotechnical Condition

Type of ground	Clay, Silty Sand, Silty Sand with Clay and Gravel, Gravity Sand, Silty Sand with Gravel: Most above the water table
Overburden	13.5 m Approximate (to rail level)
Mucking Type	Muck Cars
Max. Water Level	
Soil Condition	Silty Sand with Clay

1.2 Alignment Condition

Tunnel Length	Approx. 3600m(2 TBM's)
Maximum tunnel to be continuously bored	1875 m
Minimum Curve Radius	
a) Horizontal	125 mR
b) Vertical	1000 mR
Tunnel Depth (Max)	25 m

1.3 Tunnel Segment Lining Condition

Type	Pre-cast Concrete Segments
Number of Segments	5 + 1 (key)
Segment Outer Diameter	ϕ 6350 mm
Segment Inner Diameter	ϕ 5800 mm
Length	1200 mm
Thickness	275 mm
Segment Width	1200 mm
Key Insertion Stroke	500mm
Max. Segment Weight	30kN

2 Technical Specification

2.1 TBM Salient Features

TBM Type	Earth Pressure Balance Machine
Min. Horizontal Curve Radius	125 mR
Min. Vertical Curve Radius	1000 mR

2.2 Shield

Forward Shield Outer Diameter	ϕ 6520 mm
Rear Shield Outer Diameter	ϕ 6520 mm
Rear Shield Inside Diameter	ϕ 6400 mm
Tail Clearance (in radius)	25 mm
Shield Body	
Front Port Diameter	50 mm
Quantity	16
Periphery Port Diameter	50 mm
Quantity	6

2.3 Cutter Head

Type	Spoke Type
Spokes Number	6 units
Excavation Diameter	ϕ 6550 mm
Opening Ratio (approx.)	0.6
Soft Ground Cutting Tools	Knife bits Tungsten Carbide Inserted type
Wear Detectors	Yes
Over Cutter Type	Hydraulic Cylinder Activated Drug bit type over cutter
Over Cut	100 mm from forward Shield
Quantity	1

2.4 Cutter Head Drive

Driving Method	Electric Drive, Bi-Directional, Electric
Maximum Operating Cutter head Thrust	14500 kN
Total Power	810 kW
Number and unit power of drive motors	9 x 90 kW
Speed	0 - 3 rpm
Cutter Head Torque	5148 kNm @100%
Exceptional Torque	6178 kNm @120%
Main Bearing	
Type	3 axis, roller bearing
Lubrication	Re-Circulated Oil, Monitored and Filtered
Seals	Multi row lip seals
Dynamic Pressure Ratting	5 bar
Main Bearing Lube Type	ISO VG 220

2.5 Thrust System

Total Thrust (Max.)	32000 kN
Number of Cylinders	16 nos.
Stroke of Cylinders	1750 mm
Speed (in case all cylinders are extended with full thrust))	70mm/min
Stroke Sensors	4 nos.
Number of Groups Steering	4 nos.

2.6 Articulation System

Type	Active
Articulation Angle	±1.5° (left & right). ±0.5° (up).
Designed Horizontal Curve (Radius)	280m
Correction Curve (Radius)	250m
Total Thrust (Max.)	32000 kN
Number of Cylinders	12 units.
Stroke of Cylinders	250 mm
Stroke Detectors	4 no

2.7 Screw Conveyor

Type	Shaft Type
Drive Type	Hydraulic
Casing Internal Diameter	ϕ 900 mm
Speed	0-13.8 rpm
Shaft Diameter	ϕ 245 mm
Working Torque	93 kNm
Max. Torque	105 kNm
Discharging Earth Volume	292 m^3/hr(n=100%)
Retractable	Yes
Screw Slide Stroke	450 mm
Injection Ports	2
Maintenance Windows	2
Pressure Sensors	2 (fwd and reverse)

Bulkhead Gate	Guikkotine Type
Rear Gate	Guikkotine Type
Rear Gate Opening Sensors	Yes
Rear Gate Emergency closers	Hydraulic Accumulator
Port Diameter	ϕ 50 mm
Quantity	3

2.8 Bulkhead

Port Diameter (Outer Area)	ϕ 50 mm
Quantity	14 nos.
Port Diameter (Inner Area)	ϕ 25 mm
Quantity	4
Probe Drill Type	Hydraulic - Rotary
Location	Fit to Segment Erector
Probe Drilling Ports	Located in Shield Body
Tail Sealing	3 rows of wire brush 1 row of extruder spring plate

2.9 Tail Seal Grease

First Fill Grease	Mapeblox PKG or Equivalent
Operation Type	Mapeblox T or Equivalent
Pump	Pneumatic

2.10 Segment Erector

Type	Rotary, Fixed
Pick-up	Mechanical Grip
Rotation Angle	±200˚
Rotation Speed	0.71-1.42 rpm
Degree of Freedom	6˚
Radial Stroke (in/out)	650 mm
Axial Stroke (fwd and reverse)	600 mm
Control	Radio Control Box, Wired for Emergency
Segment Feeder Capacity	1 Ring

2.11 Man Lock — Manlock +Material Lock

Type	Double Chamber
Working Pressure	3 bar
Main Chamber Capacity	4 persons
Head Clearance	1600 mm
Length	1540 mm
Sub Chamber	
Head Clearance	1600 mm
Length	1000 mm
Access Chamber Capacity	4 persons (Sub chamber)
Air Filters and Regulators	Not Included (Supplied by CEC)
Breathable Air Supply	Not Included (Supplied by CEC)
Dimensions	I.D. Ø1706 mm & Length 2950 mm long

2.12 Back-Up System

Type Of Gantry	Open Style, Rolling on Rail
No of Gantry	5 nos.
Total Length	60 m (approx.)

2.13 Back-up Conveyor

Width	900 mm
Capacity	450 TPH
Speed	1.5 m/s
Belt Weigh System	Included
Quantity	2 nos.

2.14 Backfilling System

Hydraulic Power Unit	
Reservoir	4 m³
Type	HFDU
Viscosity	TBD
Filtration Unit	Included
Backfill Grouting	
Type	Tail Plate Internal Plate
Port Diameter	40 x 65 mm
Quantity	4+4 Spares
Injection Valve	Electric Valve
Liquid	2 Liquid type
A-Liquid System	
Tank	6 m³
Pump Type	Peristaltic
Pump Capacity	18 m³/hr
Quantity	4
B-Liquid System	
Tank	2 m³
Pump Type	Peristaltic
Pump Capacity	1.8 m³/hr
Quantity	4
Foam System	
Agent Pump	
Flow	Maximum 15 l/min
Quantity	1 Located on Back-up
Water Pump	
Flow	Maximum 100 l/min
Quantity	1
Foam Generator	
Quantity	5
Bentonite System	
Reservoir Tank	
Capacity	5 m³
Quantity	1
Pump	
Flow	10.2 m³/hr
Pressure	Maximum 2 MPa
Quantity	2
Installed System	45 kW
Mixing System	Not Included (at portal by customer)
Control Cabin	
Touch Screen Monitor	Yes
Air Conditioned	Yes
Sound Proof	Yes

2.15 Dewatering System

Dewatering Tank Capacity	4.5 m³
Discharge Pump Type	Submersible
Capacity	4 l/s at 15 m
Power	3.7 kW
Quantity	2

2.16 Ventilation System

Duct Cassette /Duct Extender	Not Included - Supplied by CEC
Type	Cassette
Tunnel Air Duct Diameter	1000 mm
Storage Capacity	150 m
Secondary Ventilation	
Duct Diameter	600 mm
Fan	
Reversible	Yes
Capacity	6 m³/s

2.17 Greasing System

Type	Mapeblox H or Equivalent
Pump	Pneumatic
Seal Grease	
Type	Mapeblox EP1 or Equivalent
Pump	Pneumatic

2.18 Electrical System

High Voltage Supply	6600 kV
Power Circuit	400V AC, 50Hz, 3 phase
Control Unit	230V AC, 50Hz, 1 phase 24V AC
Lighting	230V AC, 50Hz, 1 phase
Fluorescent Lights	20 W x100 AC as needed
Emergency Lights	Battery Power as needed
Transformer Type	Air Cooled Open Type
Transformer Capacity	2000 kVA
Power Voltage	6600 KV / 400V
HV. Cable Type	Cable Real
HV. Cable Storage Capacity (Cable excluded)	200 m

2.19 Safety Systems

Gas Detecting System Included	Included
Gas to Detect	O2/CO/CO2/NO2/H2S/CH4
Emergency Stop	Located at Operator Stations and other Locations as needed
Fire Detection & Alarm System	Included
CCTV System	1 Monitor and 4 cameras
Communication	Loud Speaker phone

2.20 Guidance System

Tunnel Guidance System	PPS or Equal
Ring Calculation	Yes
Data Logger	Yes

1 Introduction

This section of the manual provides a description of major structural components and assemblies, operating systems, and auxiliary equipment of the tunnel boring machine.

Sections 4 through 20 contain all assembly, subassembly, component, and installation drawings that make up the machines. In addition, service and parts information is also contained in these sections. While reading the following descriptions, refer to the referenced sections and drawings to provide a more complete understanding of the machine and its operating systems.

2 General Assembly

The TBM general assembly drawing is located in Section 4. The drawing indicates all major assemblies and operational systems with references to applicable The Robbins Company Engineering detail drawings. Section 4 also includes a site and assembly sequence drawing.

3 Cutterhead Assembly

The cutterhead assembly Section 5 is the assembly that accomplishes the cutting of the face. The cutterhead assembly is mounted to the main bearing assembly. Nine, 3 phase, 400 volts, VFD driven electric motors provide drive torque for the cutterhead assembly each delivering 90 kW. These motors, driving through gear reducer assemblies into a main ring gear (bull gear), which is attached to the cutterhead, rotate the cutterhead from 0 to 3 rpm in both directions.

Structurally, the spoke type cutterhead assembly is made of heavy steel plates, with 6 spokes to allow smooth flow of muck to the screw conveyor opening. The cutterhead assembly is the mounting structure for cutting tools, injection ports, and mixing bars.

3-1 Cutting tools

Each cutting tool scribes an individual radial pattern as the cutterhead travels through a revolution. The cutting tools serve a dual purpose of cutting the tunnel face, and protecting the base structure from excessive wear. Cutting tools are spaced to achieve maximum penetration, while avoiding clogging and excessive wear.

3-1-1 Scraper Bit

Scraper bits are mounted on the side of the cutterhead spokes. These bits are used primarily to scrape the excavation face and direct the material into the mixing chamber.

3-1-2 Knife Edge Bits & Fishtail Bit

Knife edge and fishtail bits are mounted on the front face of the cutterhead spokes. These bits cut and loosen ground from the tunnel face to help the scraper bits excavate material from the face more effectively.

3-1-3 Side Protection Bits & Pilot Bits

Side protection bits are located on the outside ring surface, and pilot bits are located on the front face of the cutterhead. These are used to minimize the wear on the cutterhead structure.

3-1-4 Injection Port Protection Bit

Injection port protection bits are located over injection ports. These bits protect the injection ports from damage.

3-1-5 Wear Detection Bits

Three wear detector bits are located on the front face of the cutterhead. These bits have a hydraulic passage that ends 20mm below the tip of the cutting bit. This passage is pressurized from the hydraulic system, and includes a pressure sensor for monitoring purposes. When the bit wears 20mm, the passage will be ruptured, spilling hydraulic oil, and causing a loss of pressure. The pressure loss is detected from the pressure sensor and a warning is displayed on the operators screen.

3-2 Injection Ports

Injection ports are located on the front face of the cutterhead to allow injection of foam & additives for ground conditioning purposes.

3-3 Rotary Union

The rotary union allows passage of fluids from the inside of the machine to the rotating cutterhead. This is equipped to handle fluids for all injection ports, copy cutter, and wear detection bits.

3-4 Mixing Bars

The cutterhead has mixing bars protruding from the back side to help mix any foam & additives into the excavated material.

4 Cutterhead Support Assembly

The cutterhead support assembly Section 6 consists of the main thrust bearing, main drive ring gear, and inner and outer seal assemblies (the inner and outer seal assemblies are used to seal the bearing and gear cavities against loss of lubricating oil, and to prevent introduction of muck into the bearing cavity).

The main bearing assembly is a tri-axis bearing that accepts both radical and thrust loading of the cutterhead assembly. The bearing consists of three bearings that are mounted on the main bearing and held in place by the cutterhead adapter.

The ring gear is an external-toothed gear that is integral to the main bearing.

The seal assembly consists of three inner face seals, three outer face seals, three inner radial and three outer radial seals. All seal groups are mounted to rotating structural components with the lips of the seals providing sealing action against non-rotating components. Both the inner and outer seal assemblies are installed in a specific order (refer to drawings). This order of installation is done to avoid damaging the seal assemblies. Seal assemblies are water cooled, cold water is pumped through cavities in the cutterhead support structure.

The seals are oriented so the lips prevent entrance of contaminants into the cavities. There is space left between the seals, which serves to port grease to the seals. Lubrication for the main bearing and ring gear is provided by the lubrication system, and is pumped to the components through porting in the structure.

5 Forward Shield Assembly

The Forward Shield Assembly Section 7 is the primary support structure of the machine, which allows mounting the cutterhead assembly and the mounting base for the main drive assemblies, and a machined and drilled structure for mounting of the main bearing assembly. This component also includes provisions for mounting of the screw conveyor, man lock, earth pressure sensors, and additional injection ports. The forward shield is completely sealed in order to resist earth pressure, and water pressure. Thrust is transmitted to the forward shield through direct contact with the rear shield, or through the articulation cylinders (section 9).

5-1 Earth pressure sensors

Earth pressure sensors are located on the front bulkhead of the forward shield. These sensors are used by the operator to maintain the correct earth pressure when the machine is excavating.

5-2 Injection ports

Injection ports are located on the front bulkhead, and on the outer circumference of the shield body. These ports can be used for a variety of ground conditioning purposes.

5-3 Man lock

The man lock is mounted in the center section of the forward shield. The man lock allows pressurization and de-pressurization of personnel and equipment required for maintenance inside the pressurized cutting chamber. Access doors are located on the center bulkhead and on the back of the man lock to provide access into the man lock.

6 Main Drive Assembly

The main drive assembly Section 8 is mounted into the forward shield assembly and secured in place using hex head cap screws. The machine is equipped with nine main drive assemblies, each powered by a 90 kW, 400-volt, 3-phase, 50Hz, VFD driven electric motor.

6-1 Gear Reducers

The gear reducers are planetary-type; three stage reduction that provides an overall ratio of 62.28:1. The output pinions of the gear reducer drive into the common main ring gear.

Each gear reducer is equipped with oil fill and drain ports. Recommendations for the lubricants, as well as intervals of service are in the manufacturer's literature, included in Section 8.

6-2 Drive Motors

Each of the cutterhead drive motors, as previously mentioned, is 90 kW, and is water-cooled. Each of the drive motors contains two sets of normally closed temperature switches to protect the motors from being damage each set at 140° C (284° F).

Each motor is equipped with grease fittings and grease relief ports to allow periodic re-lubrication of shaft support bearings. Recommendations for the lubricants, as well as intervals of service are in the manufacturer's literature, included in Section 8.

7 Rear Shield Assembly

The rear shield is the main mounting structure for the thrust cylinders, articulation cylinders, and articulation seals. The rear shield transmits thrust force from the thrust cylinders to the forward shield by direct contact, or through the articulation cylinders. The rear shield is connected to the forward shield by a pinned connection that can react torque, but still allow movement in and out for articulation purposes. The articulation seals are mounted to the rear shield, with the sealing surface located on the inside diameter of the forward shield.

These seals are designed to resist earth and water pressure with and without articulation movements. The rear shield assembly Section 9 includes stroke sensors, thrust shoes, tail seals, grout injection pipes, and rear support frame.

7-1 Thrust Cylinders

Sixteen thrust cylinders are provided. Each cylinder has a thrust shoe attached to the rod end of the cylinder, which reacts against the tunnel lining segments.

The cylinders are mounted through holes in the rear shield, held in place at the aft end by socket head cap screws. The piston rods extend aft and have two functions:

1. They provide main thrust force necessary for propelling the machine forward, and resisting the force from pressurized ground acting on the front of the machine.

2. They serve to force the associated segments into proper position and hold them in place as the complete ring of segments is installed.

7-2 Articulation Cylinders

A total of twelve articulation cylinders are mounted between the forward shield and the rear shield. These double-acting hydraulic cylinders allow the articulation between these shield assemblies.

7-3 Stroke sensors

Eight stroke sensors are provided; four for articulation and four for thrust. Each of these cylinders sends an electric signal to the PLC. These signals are used to calculate the position of both shields for use by the guidance system. The signals are also used to limit the angle of articulation to an acceptable range.

7-4 Tail seals

Three rows of wire brush tail seals are located at the aft end of the rear shield to provide sealing against earth, water, and grout between the outside of the segment lining and the inside of the shield. Grease injection ports are located in the shield structure to allow the injection of grease to the cavities between rows of tail seals. Grease injection directly affects the sealing performance of the tail seals. Drawings for the tail seal grease system are located in section 14 of this manual.

7-5 Grout injection pipes

Grout injection pipes are built into the structure of the rear shield. These passages allow grout to flow out of the aft end of the machine where the segment ring is being pushed out of the rear shield. Each injection location has a spare passage in case the primary passage is blocked. All passages have covers that can be removed for cleaning purposes.

8 Screw Conveyor Assembly

The primary purpose of the screw conveyor is to discharge material while maintaining pressure inside the cutting chamber. The shaft type screw is driven by a hydraulic drive unit located at the aft end. The main structure of the screw conveyor consists of several casings that mount in series to transport muck from the bulkhead gate at the front, to the discharge gate at the aft end. An intermediate support rod is used to transmit the load of the screw conveyor to the forward shield. The screw conveyor assembly Section 10 includes the screw, screw drive unit, and screw gates.

8-1 Bulkhead Gate

The bulkhead gate must always be open during all excavation operations. In an emergency situation, the bulkhead may be closed to isolate the the screw conveyor and the rest of the machine from the pressurized earth and water inside the cutting chamber. In order to close the bulkhead gate, the screw slide cylinders must be extended to move the screw out of the way of the bulkhead gate.

8-2 Screw Gate

The screw gate can be used as an additional sealing barrier against pressurized earth and water, or as a tool to regulate the earth pressure in the cutting chamber. The percentage that the gate is open is detected by a stroke sensor in one of the cylinders, and is shown on the operation panel.

8-3 Screw Conveyor Drive Unit

This unit is located at the aft of the screw conveyor. The screw drive unit consists of two hydraulic motors, pinions, ring gear, and bearings. The shaft type screw is connected directly to the output shaft of the drive unit to transmit torque from the hydraulic motors.

9 Segment Erector Assembly

The segment erector Section 11 furnished with this machine consists of the rotating erector frame, an erector drive system for radial positioning, and hydraulic cylinders for lateral positioning, lifting and lowering, and for slight adjustment of the segments. The erector is connected to the machine by the rotating frame supported on roller assemblies.

9-1 Rotating Frame

The erector rotating frame provides the rotating mounting structure for the rest of the erector structure and cylinders.

The outside of the frame is smooth so that it can easily rotate on the roller assemblies, while the inside has a gear profile that meshes with the drive assemblies. The rotating frame has two cylindrical guide tubes that allow the erector arm to slide in and out in a radial direction.

9-2 Erector Arm

The erector arm structure has two cylindrical tubes that allow it to travel in a radial direction relative to the rotating frame. These two tubes slide inside of the cylindrical guide tubes on the rotating frame. The erector arm also has two additional cylindrical tubes in the horizontal position that allow the grip assembly to slide fore and aft.

9-3 Erector Grip Assembly

The erector grip assembly has two cylindrical guide tubes to allow the erector grip to slide fore and aft along the inner cylindrical tubes on the erector arm. The grip assembly has a locking mechanism to connect to a lifting ball that is inserted into the segment.

9-4 Erector Drive Assemblies

The two erector drive assemblies are powered by hydraulic motors that are coupled to pinions which drive the rotating frame. The motors have internal brakes that require hydraulic pressure to release; therefore, they are locked whenever the erector is not being rotated.

9-5 Radial Extension Cylinders

There are two hydraulic cylinders one on each side of the erector, used for lifting the segments and placing them against the tunnel wall. These cylinders are guided by the cylindrical guide tubes on the rotating frame, and the inner cylindrical tubes on the erector arm. These cylinders are equipped with counterbalance valves in both the rod end and the cap end.

9-6 Slide Positioning Cylinder

This cylinder is connected between the erector arm and the erector grip assembly, and is used to move the grip assembly fore and aft. These cylinders are guided by the cylindrical guide tubes on the grip assembly, and the inner cylindrical tubes on the erector arm.

9-7 Support cylinders

Four support cylinders are used to make slight adjustments to the segment position.

9-8 Rear scaffolding assembly

The rear scaffolding assembly includes platforms to assist personnel in the erection of segment rings, as well as provide a mechanical link and walkway from the machine to the backup.

10 Operator's Station Assembly

The operator's station assembly Section 13 consists of all controls and indicators necessary to operate and monitor the various hydraulic and electrical functions of the machine during normal boring.

This includes all the controls for the various hydraulic actuators and electric motors; controls for setting propel speed and pressure, and pressure gauges, ammeters, indicator lights for monitoring the systems, and the operator panel.

11 Ground Conditioning Equipment

The ground conditioning equipment consists of three separate systems to improve the soil prior to excavation, and stabilize the surrounding ground after excavation. Drawings for these systems are included in section 12 of this manual.

11-1 Grout Injection System

The grout injection system is used to inject single liquid grout into the annulus between the segment outer diameter and the excavated tunnel diameter. The grout is injected through passages in the rear shield structure so that it exits the aft end of the rear shield where the segment ring is being pushed out of the machine. Grouting behind the segments is performed to stabilize and seal the ground around the tunnel segments.

11-2 Additive Injection System

The additive injection system is used to inject bentonite to the front of the cutterhead, mixing chamber, and screw casings. This additive system is used to condition the excavated soil for improved performance.

11-3 Foam Injection System

The foam injection system is used to inject foam to the front of the cutterhead. This foam is used alone, or in conjunction with the additive system to condition the excavated soil for improved performance.

12 Lubrication System

The lubrication system of the machine Section 14 provides the means for lubricating the main bearing and main gear (bull gear).

The closed loop lube system is described as follows; a suction strainer provides filtration to the system, flow to the system is provided by a motor/pump assembly delivering 11 lpm of oil, a needle valve is used to maintain 1 bar (14.5 psi) to 2 bar (29 psi) back pressure in the system, flow oil indicator, a pressure transducer that is set at 1 bar pressure falling, a warning message is displayed at the operator's console if pressure drops below this setting.

A sight gauge provides a visual indication of lube oil level, while a thermometer monitors the oil temperature. Maximum system pressure allowed in the system is 2 bar (29 psi) set by a pressure relief valve and is monitored by a pressure gauge.

12-1 Grease System Assemblies

The grease system assemblies are used to inject grease to several locations primarily to seal against ground mud, water, or hydraulic pressure and leakage. Drawings for the grease system are included in section 14 of this manual.

13 Hydraulic System

13-1 Introduction

A complete understanding of the hydraulic system of the machine, including the inter-relationship of the various hydraulic functions, is essential for proper utilization of these functions.

This understanding is even more essential for proper and efficient maintenance, whether preventive or corrective. The complete hydraulic system consists of many circuits, the hydraulic reservoir and interconnections, and the controls and indicators used by the operator to control and monitor these hydraulic functions. Each is treated as a separate topic.

Most of the directional control valves, check valves, pressure-reducing valves, relief valves and flow control valves are manifold-mounted, and in many instances share common manifold blocks. The primary method of interconnection is by high pressure hoses.

All relief valves, pressure-reducing valves, pressure switches, holding valves, and most flow control valves have manual adjustments along with locking devices to maintain the setting.

Drawings for this system are included in section 15 of this manual.

14 Electrical System

The major components of the electrical system are shown on Drawing 1077600. Schematically, the system is detailed on Drawing 1075425.

Interconnections are shown on Drawing 1078597, Electrical System Cabling, and the layout of the electrical cabinet is shown on Drawing 1077879. Refer to these drawings for analysis of the electrical system circuits and components.

The primary electrical controls and indicators available to the operator for controlling and monitoring the electrical functions of the machine are located on an operator's console assembly. Reference should be made to Drawing 1076257 in Section 13 for details of these items.

Incoming power to the machine is 6.6 kV, 3-phase, 50 Hz; a trailing cable switching equipment on the Backup supplies the power.

One transformer is furnished, T1 rated at 2,000 kVA this transformer is enclosed and fan cooled. The primary side of transformer T1 is delta-connected, while the secondary windings are wye-connected with neutral brought out.

Phase-to-phase voltage at the secondary connections on T1 is 400 volts, 50 Hz.

Taps are provided on the primary side to allow adjustment for voltages above or below the nominal 6,600 volts input level.

Secondary winding connections are made to an electrical cabinet assembly common to each unit.

Electrical Controls and Interlocks

The TBM is controlled via a Programmable Logic Controller (PLC). With the exception of a few hard-wired safety items, all electrical devices on the TBM are routed through the PLC. The operator may, for example, push a button to start a hydraulic pump motor, but the button is not directly connected to the motor. Instead, the button signals the PLC that the operator wishes the pump motor to start.

The PLC then examines the current state of the machine and makes a decision as to whether it is proper to allow the starting of this motor. If all is correct per the PLC's programmed logic, the motor is commanded to start by the PLC.

This is commonly known as the machine interlock logic. The PLC resides primarily in the PLC Cabinet, located in the operator's cabin. It consists of a computer module (CPU), a number of input and output modules, and a number of communication modules.

Additionally, there are a number of remote I/O modules located in the TBM and on the backup decks, which collect and distribute electrical signals to various devices.

The most visible electronic device that the operator sees is the graphical display unit. This is *not* part of the PLC; rather it is a relatively "dumb" device that makes no decisions as to how the TBM is to operate. It is simply an interface device allowing the operator to communicate with the PLC.

It displays a great deal of information about the status of the TBM and it allows the operator to make a number of commands via "soft buttons", or graphical representation of control buttons that the operator can push.

15 Water System Assembly

The machine is equipped with a water system to provide a means to cool the main cutterhead seals, cutterhead motors, VFD cabinets, hydraulic oil, and to direct water the the foam tank and other service points on the back-up.

Drawings for this system are included in section 17 of this manual.

16 Position Monitoring Equipment

The position monitoring equipment provided as a part of this machine consists of the Enzan System. Drawings and operation are included in Section 17 of this manual.

16-1 Enzan System

The Guidance System is designed to provide maximum TBM positional information to the operator of the Tunnel Boring Machine (TBM) while requiring a minimum of attention.

The system will automatically determine the exact position and driving direction of a TBM in three-dimensional space. It also gives the operator complete information about the deviation of the TBM from the designed centerline.

A projected path display is optionally provided to show the operator the optimal course along which to guide a deviated TBM back to the design centerline. For tunnels with segmented liners, ring calculation software is also available.

To measure the location and driving direction of a TBM, at least two defined points on the TBM, together with pitch and roll, must be measured in three-dimensional space. These two points are the two EDM prisms installed in the forward section of the TBM. Their placement positions on the machine are arbitrary as long as a line of sight to the theodolite is available.

After final positioning, the exact location relative to the TBM axis and local TBM co-ordinate system is then measured, with these values becoming part of the one-time TBM setup parameters.

Because the TBM will roll and pitch during boring, the TBM co-ordinate system is usually not parallel to the global co-ordinate system. Therefore, roll and pitch of the TBM must be measured accurately, which is accomplished electronically by the robust two-axis inclinometer mounted on the TBM.

The two prisms on the TBM are automatically measured by a motorized theodolite whose standpoint and orientation have been previously defined. New coordinates for the theodolite standpoint are easily determined by using a standard function of the guidance system.

Orientation of the horizontal angle system of the theodolite is easily accomplished by aiming the theodolite at the reference prism, whose coordinates are known. The Look-Ahead Theodolite Station Setup function of the system then inserts the new station and orientation information into the system computer.

Subsequently, the global co-ordinates of the two primary points on the TBM may now be established by measuring the slope distance and horizontal and vertical angles from the oriented theodolite.

Since the location of the prisms in the TBM co-ordinate system was established at TBM set-up, and the roll and pitch of the TBM are known at all times, any point of the TBM (e.g. the center of the cutter head) can be calculated in global three dimensional space.

The tunnel design centerline is also known in the global co-ordinate system and has been entered into the system computer at the project start. Therefore, horizontal and vertical deviation of the TBM from the design centerline, together with TBM orientation, is calculated and presented graphically to the TBM pilot in real time.

If desired, a projected path can also be calculated and displayed to show the optimum path back to the design centerline, considering parameters such as minimum turning radius, or, related to the geometry of pre-cast liner elements.

The remote prism plays a critical part in the assurance of system accuracy. In addition to providing a reference during the orientation of the theodolite, it also allows automatic on-line detection of potential errors caused by any movement of the theodolite standpoint. Because the theodolite is usually mounted on the wall of the just-bored tunnel, about 25 to 300m behind the TBM, it has a high potential for movement.

Additionally, the platform may be hit and moved by unknown events. Such movement, if undetected, can have an adverse effect on the accuracy of boring.

Consequently, the TBM Guidance System theodolite periodically measures the remote prism to check the stability of the theodolite standpoint and notifies the TBM operator if movement has occurred.

The interval of these reference measurements is fully dictated by the user with password protected parameter menus.

17 Backup System

17-1 Introduction

Refer to the TBM and backup assembly drawing 1076245 (Section 20) for details of the structural components and systems that make up the complete backup equipment assembly.

Most gantries are equipped with structural members to support vent lines, water lines, air lines, cable and hose trays, and more, depending on the location in the string. The backup system provides mounting for transformers, electrical cabinets, water tank, compressor, grease systems, and the ventilation duct cassette.

A description of each of the structural assemblies is included; the structural equipment is covered in order from the front (TBM and backup interface) to the rear.

17-2 Gantry Assemblies

A brief description follows for each of these structural elements that make up the backup equipment. The descriptions also provide identifications of the components mounted on each gantry.

17-2-1 Bridge Gantry Assembly

The bridge gantry assembly includes the bridge gantry structure that provides a mechanical link and walkway between the machine and gantry #1.

17-2-2 Gantry 1

The upper section of this gantry provides support structures for the hydraulic reservoir, ventilation ducting, and backup conveyor.

Lube power unit and hydraulic power unit are located on the lower left side of this gantry. Grease pumps and the operator's cab assembly are located on the right side of this gantry.

17-2-3 Gantry 2

The upper section of this gantry provides support structures for ventilation ducting and backup conveyor.

Grease pump, bentonite tank, and bentonite power unit electrical assembly are located in the lower right side of this gantry. Grout tank A & B is located on the left side of this gantry.

17-2-4 Gantry 3

The upper section of this gantry provides support structures for the ventilation ducting.

VFD assembly is located in the lower right side of this gantry. Grout power unit electrical assembly 1 & 2 and VFD reservoir assembly is located on the left side of this gantry.

17-2-5 Gantry 4
The upper section of this gantry provides support structures for the vent fan assembly, and duct cassette.

The electrical panel is located on the lower left side of this gantry. Foam power unit and foam power unit electrical assembly are located on the right side of this gantry.

17-2-6 Gantry 5
A transformer is located on the lower right side of this gantry. Davit hoist, foam tote, polymer tote, and the hose reel are located on the left side of this gantry.

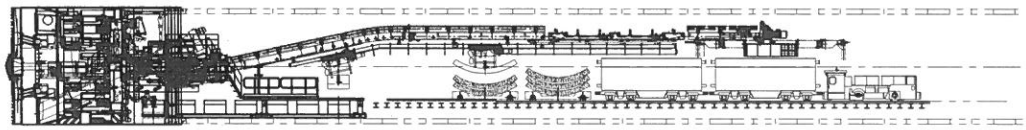
17-2-7 Gantry 6
A dewatering tank assembly and cooling water system are located on the lower right side of this gantry. The hose reel and the cable reel are located on the left side of this gantry.

17-3 Ventilation System
Incoming fresh air is brought in through flexible ducting from outside the tunnel. This ducting is connected through a duct section that is folded into a cassette located on gantry #4; the ducting in the cassette has an appearance similar to an accordion. As the machine advances, this ducting will gradually be pulled from the cassette and hung from the tunnel crown.

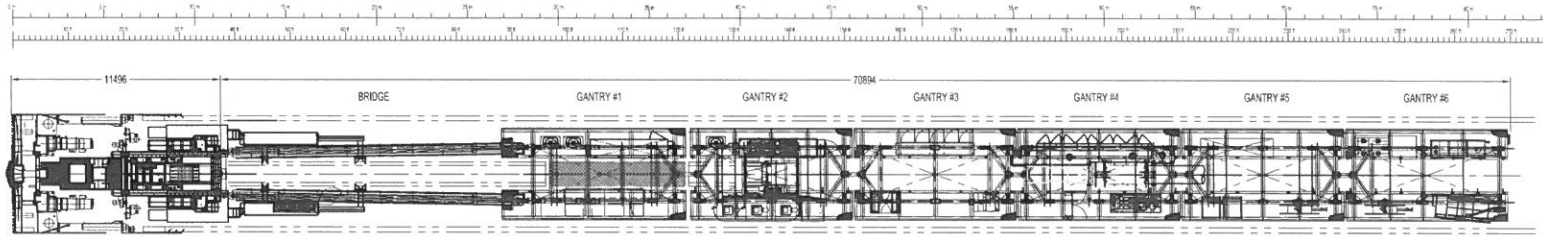
Once this section has been extended to full length, the empty cassette is removed and a full cassette is brought in to continue the ducting. The empty cassette is taken out of the tunnel to be reloaded.

Ducting is provided along the length of the upper section of the backup equipment to allow passage of fresh air to the working environment in the tunnel. The fresh air is forced through the ducts by a ventilation fan that is located on gantry #4.

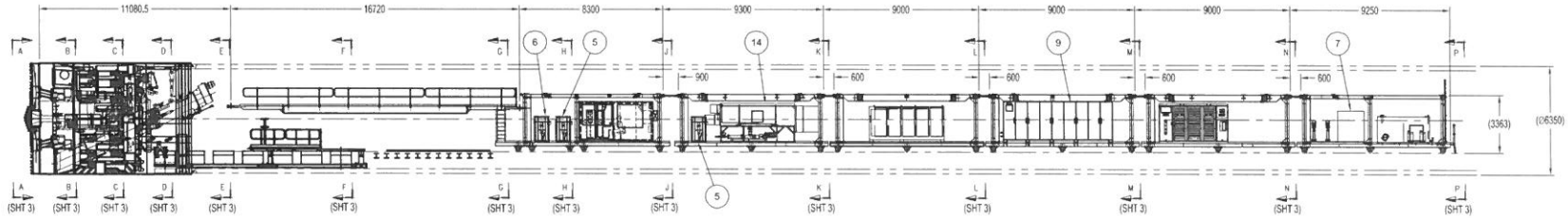
Drawings for the ventilation system are in Section 20 of this manual.



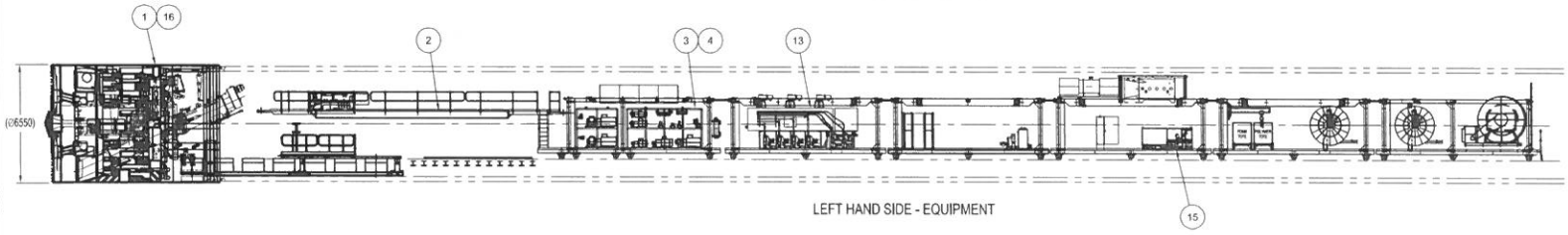
ELEVATION



PLAN VIEW



RIGHT HAND SIDE - EQUIPMENT



LEFT HAND SIDE - EQUIPMENT

TRC P/N: 1075149
JAIPUR #1 - TBM & BACKUP ASSEMBLY

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JAIPUR #1
TBM & BACKUP ASSEMBLY

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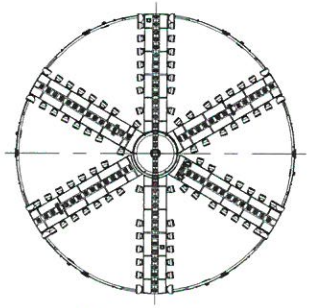
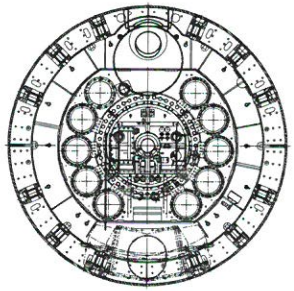


SECTION "A - A" SHT 2



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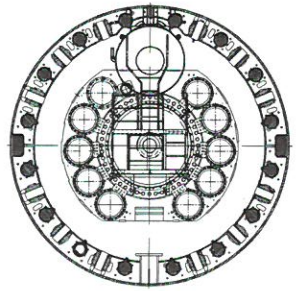

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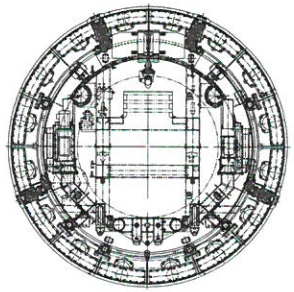

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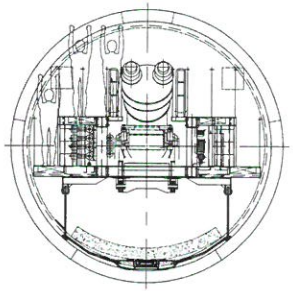

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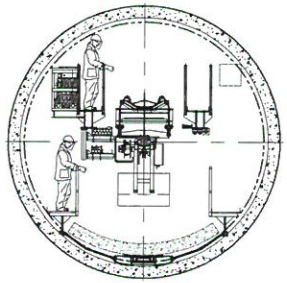
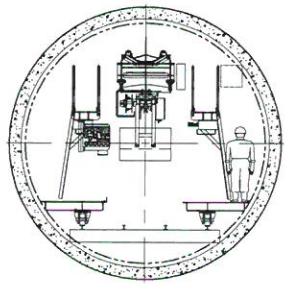
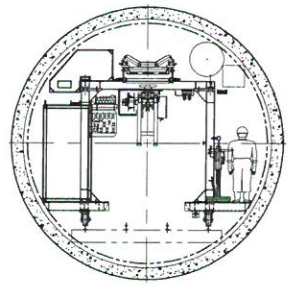


SECTION "F - F" SHT 2
(BRIDGE)



SECTION "G - G" SHT 2
(BRIDGE)



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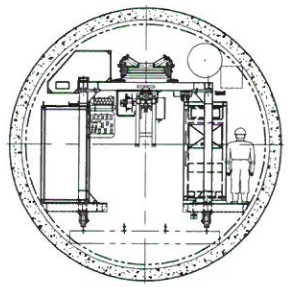
(GANTRY #1)



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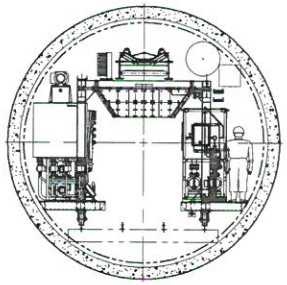
(GANTRY #1)



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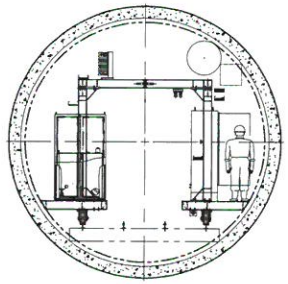

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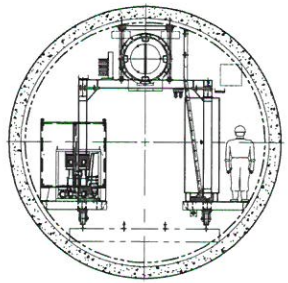
(GANTRY #3)



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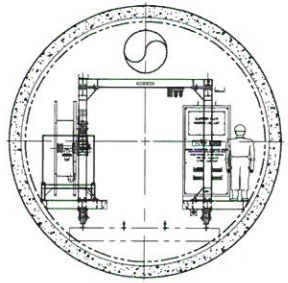
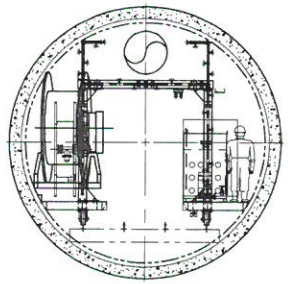
(GANTRY #4)



SECTION "N - N" SHT 2
(GANTRY #5)



SECTION "P - P" SHT 2
(GANTRY #6)

JAIPUR #1
TBM & BACKUP ASSEMBLY

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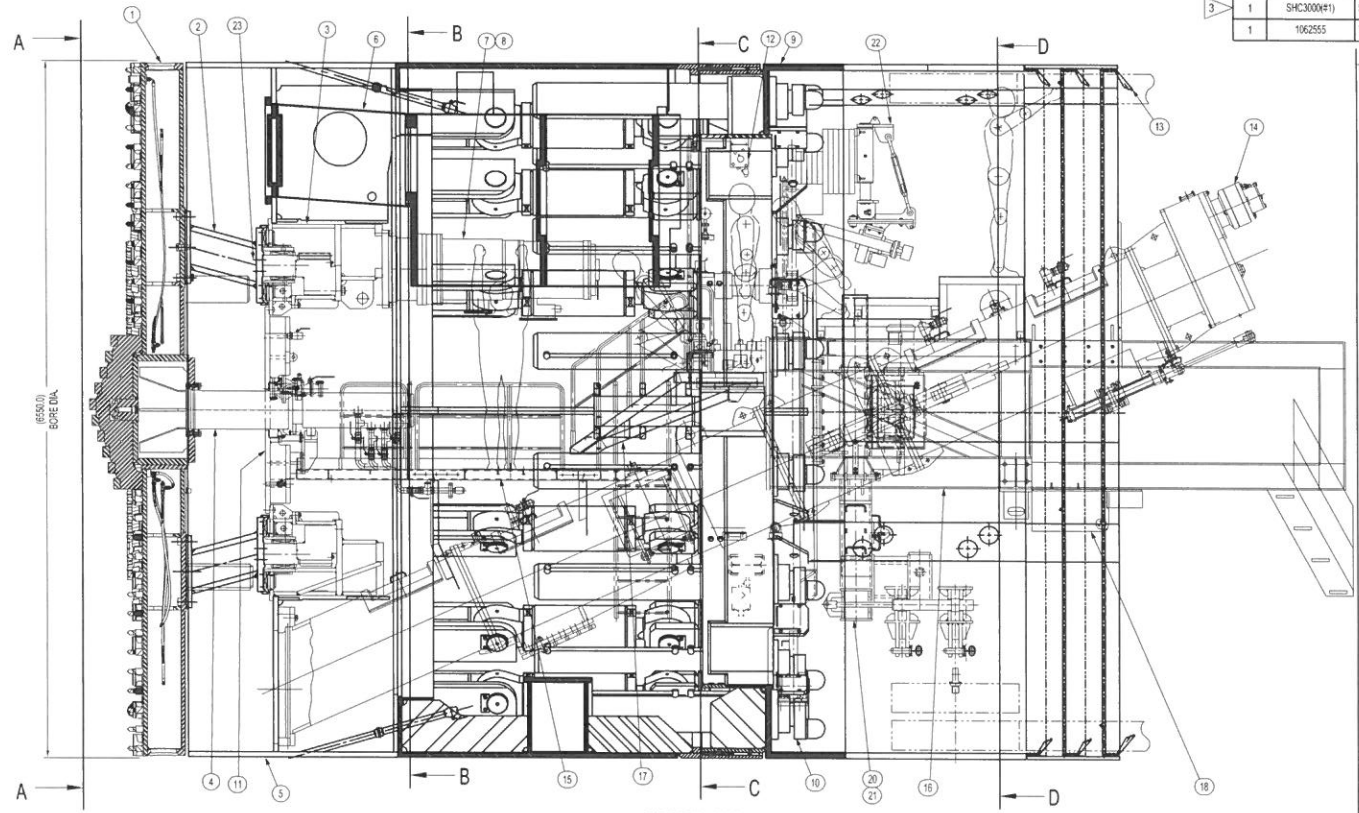
GA REFERENCE DRAWINGS

NAME	TBM #1	NAME	TBM #1
HYDR SYS ASSY	1078249	THRUST CYL HYDR SCHEM	D106939
AUTO OIL LUBRICATION HYDR SCHEM	D106947	ERECTOR ROT. HYDR SCHEM	D106941
AUTO GREASE LUBRICATION SCHEM	D106950	SCREW ROT. HYDR SCHEM	D106942
TAIL GREASE SCHEM	D106951	GATE CYL HYDR SCHEM	D106944
WATER SYS ASSY	1079425	COPY CUTTER HYDR SCHEM	D106945
VFD COOLING / DEWTRG SCHEM	1076971	ERECTOR CYL HYDR SCHEM	D106948
AIR SCHEM	1077630	ARTICULATION HYDR SCHEM	1077026
ELECTRICAL SYS ASSY, JAIPUR, 323-1	1077600	WEAR DETECTION HYDR SCHEM	1078082
ELECTRICAL SCHEM, JAIPUR, 323-1	1075425	WATER SCHEM	D107711
GROUT SYS ASSY	1076534	GROUT SYS SCHEM	1076872
BENTONITE SYS ASSY	1078276	BENTONITE SCHEM	1075708
FOAM SYS ASSY	1076337	FOAM SCHEM CONTINUOUS	1075709

QTY	PART No.	DESCRIPTION	DWG No.	WT. Total	ITEM
3	1	SHF1000(#1)	SCREW CONVEYOR ASSEMBLY	SHF1000	28000	14
3	1	SHC4070(#1)	MACHINE SCAFFOLD ASSEMBLY	SHC4070	1623	15
3	1	SHC4000	REAR SCAFFOLD ASSEMBLY	SHC4000	8884	16
	1	1079891	FORWARD SCAFFOLD MOD ASSY	1079891	51	17
	1	1080664	REAR SCAFFOLD MOD ASSY	1080664	844	18
3	1	SHC4060	REAR SCAFFOLD EQUIPMENT LAYOUT	SHC4060	21	19
3	1	SHG1000(#1)	ERECTOR ASSEMBLY	SHG1000	15500	20
	1	1081734	ERECTOR MODIFICATION ASSEMBLY	1081734	1000	21
	1	1079270	PROBE DRILL ASSY	1079270	947	22
	60	1080884	BEARING BOLT, JAIPUR #1	1080884	324	23

QTY	PART No.	DESCRIPTION	DWG No.	WT. Total	ITEM
	1	1078104	CUTTERHEAD ASSEMBLY	1078104	17342	1
3	1	SHE7200	CUTTER MIDDLE BEAM	SHE7200	5974	2
3	1	SHE1000(#1)	CUTTERHEAD SUPPORT ASSEMBLY	SHE1000	34500	3
3	1	SHE3000	ROTARY JOINT ASSEMBLY	SHE3000	1600	4
3	1	SHC0100A	SHIELD BODY ASSEMBLY (MINUS B & C RINGS)	SHC1030	31240	5
	1	1079542	MANLOCK INSTALLATION, TBM #1	1079542	4550	6
3	REF	SHE6100(#1)	CUTTER DRIVE UNIT ASSEMBLY	SHE6100	26100	7
	9	1081477	MOTOR DRIVE COUPLING ASSEMBLY	1081477	27283.5	8
	1	1072765	SHIELD MODIFICATION ASSY (RINGS B & C)	1072765	109900	9
3	1	SHD1000A	THRUST CYLINDER ASSEMBLY	SHD1000	29528	10
3	1	SHE8000	BULKHEAD RING	SHE8000	868.2	11
3	1	SHC3000(#1)	SHIELD BODY, EQUIPMENT LAYOUT	SHC3000	2500???	12
	1	1062555	TAIL SEAL INSTALLATION	1062555	3060.3	13



TRC P/N 1080517
GENERAL ASSY, EPB215-323-1

NOTES:

1. ALL WELDING SHALL MEET THE REQUIREMENTS OF THE LATEST EDITION OF THE AWS STRUCTURAL WELDING CODE - ALL SECTIONS AS APPLICABLE UNLESS OTHERWISE NOTED. USE E70XX LOW HYDROGEN ELECTRODES OR EQUIVALENT.
2. TORQUE ALL FASTENERS PER ROBBINS SPEC 5750 9900 17.

3 > TBM REBUILD - EXISTING EQUIPMENT.

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GENERAL ASSY, EPB215-323-1

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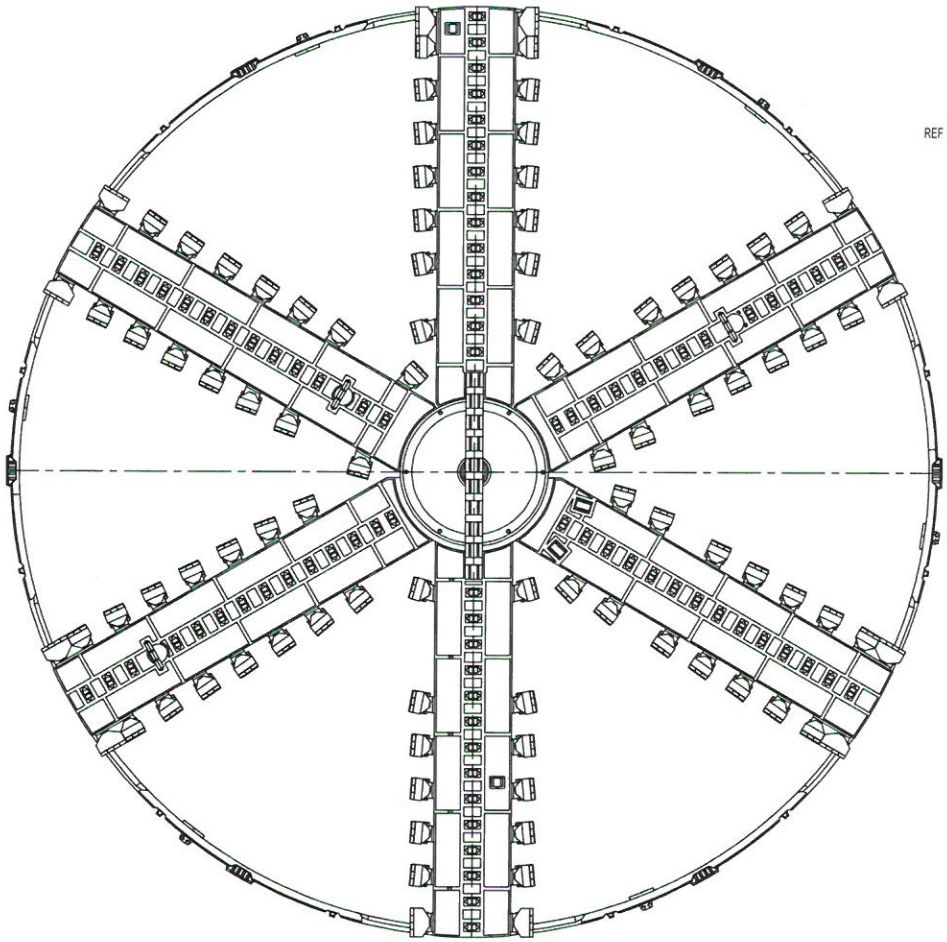

REF

SECTION A - A
(SEE SHEET 1)

GENERAL ASSY, EPB215-323-1

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ROLLING STOCK & OTHER EQUIPMENTS

CEC Rolling Stock Associated to the TBM / Other Equipments

Sl No	Asset / Materials	Name of Equipment	Qty in Nos	Date of Acquisition	Location	Remarks
1	Assets	Bentonite Silo 30 Ton/NMF	1	2015	Jaipur	
2	Assets	Locomotive - Battery Operated	5	2007	Jaipur	
3	Assets	Muck Car with trolley	8	2015	Jaipur	
4	Assets	Flat Car	2	2015	Jaipur	
5	Material	Segment Car	4	2007	Jaipur	
6	Assets	Segment Mould (Make -CBE) (OD6350 +ID 5800 + Width 1200+Thk 275mm	4	2014	Jaipur	
7	Assets	Segment Mould (Make -CBE) (OD6350 +ID 5800 + Width 1200+Thk 275mm	4	2015	Jaipur	
8	Assets	Segment Vaccum lifter	1	2012	Jaipur	
9	Assets	Turning Table	2	2012	Jaipur	