 एनपीसीआईएल NPCIL	<b>NUCLEAR POWER CORPORATION OF INDIA LTD.</b>	
	TECHNICAL SPECIFICATION ON TRAVELLING IN-CORE PROBE (TIP) DRIVE MECHANISM	PAGE NO 1 OF 20 REV. NO. : 0

## 1.0 SCOPE

This specification establishes the requirements for design, preparation of detail drawings, manufacturing, inspection, testing, packing, delivery, and guarantee of Travelling In-core Probe (TIP) Drive Mechanism system which includes Drive mechanism, Support housing & sealing arrangement, Local Control Panel, Pendant, spares and related manuals for 700 MWe PHWR Projects. The TIP Drive Mechanism is required to position TIP in Calandria by pushing and pulling of the probe for local neutron flux monitoring and calibration of flux detectors. The TIP drive mechanism shall meet all the requirements specified here in this specification.

## 2.0 CONTENTS

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## 3.0 APPLICABLE FIGURES/SKETCHES, & SPECIFICATION

### 3.1 Applicable Figures/ Sketches

The following figures form the part of this specification and dimensions there in are for reference only.


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Figure Description	Figure Number
Sectional View of VFU Terminal Box and Deck-Plate	Figure-1
Travelling in-core probe dimension detail	Figure-2 *
Electrical Flow diagram of prototype TIP-System	Figure-3
General Assembly of the TIP Drive System	Figure-4
Anti-Twist Mechanism schematic drawing	Figure-5
Mock-up Set-up for the TIP-Drive Mechanism	Figure-6

The dimensions given in the Figure-2 are for reference only. The vendor shall ensure the compatibility with VFU/HFU for ease of insertion, removal and for smoother movement.

### 3.2 Applicable codes/ Specifications


The manufacturing of TIP Drive shall comply with this specification. Nothing in these specifications shall be construed to relieve the VENDOR of this responsibility. This specification is issued to facilitate procurement and is based on NPCIL Technical Specification No. PC-E-903 which was specification aimed at development. The codes & standards applicable to the fabrication or its parts are mentioned hereunder.

#### 3.2.1 Applicable Specifications for Mechanical Components

Documents	Description
ASTM A - 240	- Heat Resisting Chromium and Chromium Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels
ASTM A - 312	- Seamless and Welded Austenitic Stainless Steel Pipes
ASTM A - 479	- Stainless and Heat - Resisting Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels
PP - E - 1209	- NPCIL Spec. - Liquid Penetrant Examination of Metallic Surfaces
ASME Boiler and Pressure Vessel Code - Section III Div.1, Subsection NC.	
ASME Boiler and Pressure Vessel Code - Section V	
ASME Boiler and Pressure Vessel Code - Section IX	

#### 3.2.2 Applicable Specifications for Electrical / Electronics Components



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#### Documents

#### Description

PC-E-709:	Engineering Standard for Grounding & shielding practices.
PP-E-2061:	Technical Specification for Requirements of components/ Equipment for Instrumentation Items. (This specification shall not apply if electronics or electrical modules are pre-designed or COTS)

### 4.0 MATERIAL AND WORKMANSHIP

Materials and components which are necessary for fulfillment of this specification shall be of good quality and in accordance with good industrial practices. Materials and components shall conform to the specifications & standards listed in section-3.0. Each item shall have identification and marking.

The process and workmanship shall be in accordance with high grade practice to ensure satisfactory operation and service life in accordance with the provisions of this specification. The machines and processes used for manufacture shall ensure consistent surface finish and dimensional tolerances specified in the component drawings. All parts shall be free of sharp edges, sharp corners, burrs, nicks, cuts, scratches and other visible defects.


### 5.0 GENERAL FUNCTION & DESCRIPTION

The TIP Drive Mechanism is required to position TIP in Calandria through Flux Units which houses in-core neutron sensors and to enable recording of TIP output and position signal with TIP in moving condition and stationary modes. The TIP is to be driven over at span of about 15 meters with continuous scan movement as well as discrete movement in steps for data recording

#### 5.1 Travelling In-core Probe

TIP is a neutron flux measuring detector, having outer diameter 6.45 mm and 75 mm length as shown in Fig.2. The detector is connected to one end with a Mineral Insulated (MI) cable of 1.6mm dia. The MI cable is placed inside a helical wire wrap cable of 6.3mm dia. and brazed to the cable so that the cable assembly can be moved in and out through a gear mechanism for positioning of TIP inside the reactor. The use of helical wrap allows better positioning as compared to friction based push-pull arrangement. The other end of the MI cable terminates to a LEMO connector, which in turn is connected to flexible co-axial cable with matching cable connector. The TIP movement is required for the measurement of neutron flux inside the reactor core during initial Phase-B experiments after reactor start-up and subsequently for reactor physics experiments at low power when required.



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The Travelling In-core Probe is to be positioned inside Central Carrier Tube (CCT) of Vertical/Horizontal Flux Unit (VFU/HFU) by operation of the TIP Drive mechanism. The signal from the probe is extended through the MI cable to a flexible coaxial cable of type RG-11 A/U mounted on Drum – “C” as shown in Fig. 5. The mounting details of VFU & HFU are similar to that shown in Fig.1, vertical for VFU and horizontal for HFU. The Drive Mechanism shall have provision to mount vertically over VFU Terminal Box without any additional support, but for HFU suitable additional support arrangement shall be provided from floor through use of removable stands externally.

The TIP probe will be used at central tube of six preferred Vertical Flux Units (VFU) locations, namely as VFU# 6, 8, 10, 17, 19& 21 and any two nos. of HFU# out of total nine HFUs. Each of these locations has a CCT in which these probes are to be inserted up to a specified length. Each of the VFU has a terminal box, where all the MI cables of Self Powered Neutron Detectors (SPNDs) from the unit terminate and thereafter signals are sent to control room. At each VFU, the Terminal box is extended above the deck plate up to 210 mm approx.

TIP drive mechanism will be mounted over VFU/ HFU Terminal Box Flange after opening the terminal box cover plate (integral with shielding block) with details as shown in Fig.1.

The Supplier shall arrange for dummy/ replica the helical wire wrap (Fig-2) and flexible cable for demonstration of the functioning of the TIP Drive Mechanism at their works and same should be part of supply.


The TIP Drive mechanism shall be supplied with TIP parked at parking position with bottom flange closed with a protective blank cover. Helium leak tightness of the mechanism shall be ensured in this configuration before shipment.

The entry point of the probe inside the CCT for VFU is at 550 mm approx. vertically below from top of the Terminal Box in all VFU's except in VFU-8, where it is 537 mm below from top of the Terminal Box (Refer Fig-1). The CCT in which the probe is to be inserted and moved up and down has an ID of 7.6 mm (OD of 9.0 mm and wall thickness of 0.7 mm) for all VFU & HFU locations except for VFU-8. The ID of CCT in VFU-8 is 57.5 mm (OD 60.0 mm and wall thickness is 1.25 mm). These locations can be approached through the terminal box located above the deck plate.

TIP shall be inserted inside CCT through a suitable guide tube of inner diameter matching with CCT inner diameter on one end to permit smooth entry of TIP inside CCT and other end of guide tube size shall be to accommodate entry of TIP & helical wire wrap cable from the bottom face of the drive mechanism.

The MI cable is required to be wound on a suitable size drum about 450 mm OD to avoid any damage of MI cable assembly. The drum should be lightweight for ease of handling. Once the TIP is deployed in one VFU, it may get contaminated. So, to use



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this probe in other VFUs, it is to be taken out safely and handled with utmost care to avoid spread of contamination. This will be achieved by having a Shielded Parking Station (as shown in Fig.4) at the bottom part of the TIP Drive mechanism. After completion of neutron flux scan and SPND calibration at VFU/HFU, the Probe will be pulled back in this Parking Station and later the complete TIP Drive mechanism unit will be shifted to the next desired VFU/ HFU. The position of TIP Probe at Shielded Parking Station inside the drive mechanism is called as parking position. The various positions of TIP during its movement after installation at a VFU/ HFU location are as described below.

- a) **PARKING Position:** This shall be a fixed position for the drive mechanism and depends upon the distance of Shielded parking station.
- b) **HOME Position:** This shall be variable and its elevation can be set/ entered manually. This is the position of the TIP at reference position near deck plate elevation.
- c) **START Position:** This shall also be a variable position and can be entered manually depending upon the starting point/ elevation of TIP for neutron flux scanning within any VFU/ HFU.
- d) **STOP Position:** This shall also be variable position and can be entered manually depending upon the desired end position after TIP movement within each VFU/ HFU.
- e) **FULLY IN Position:** Pre-defined (or settable) fully inserted extreme position, beyond which the TIP shall not move. Forward movement of TIP beyond this position may cause hitting of TIP to inner most tip of CCT.

The movement of TIP from Start Position to Stop Position may be forward (Drive Mechanism to reactor core direction) or backward (reactor core to Drive Mechanism direction).

## 5.2 TIP Drive Mock-up Arrangement


The Mock-up Set-up for the TIP-Drive Mechanism is shown in Figure-6 for VFU and is to be manufactured and supplied along with TIP drive. This simulates the VFU terminal Box and CCT arrangement and when mounted over platform, facilitates discrete/ continuous TIP movement inside a dummy CCT.

## 6.0 DESIGN REQUIREMENTS FOR THE DRIVE MECHANISM

### 6.1. Pushing and Pulling Arrangement

The Drive mechanism shall have the arrangement for pushing and pulling the helical wire wrap cable along with the TIP Probe. This can be achieved by providing a helical



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gear matching the pitch of helical wire wrap and is driven with suitable motor. The conceptual scheme is provided in Figure-4. The helical wrapped cable will act as a rack, which traverse axially through the CCT (vertically for VFU) to reach and move TIP inside the reactor.

Provision should be made to ensure that the helical wrapped cable is wound side by side on the main drum and that the winding and unwinding is smooth. The cable drum shall be provided with a torsion spring so that the cable wound on this drum shall always be in tension for pull back mode. The Drive should have a provision to retract back the helical cable manually when the drive motor is not functioning.

Suitable motor along with variable speed control drive shall be used to drive the TIP using helical wrap and gear arrangement. The position and speed of TIP probe shall be controlled through local control panel/ pendant from a distance of 50 m as indicated in Fig 3. The driving torque for movement shall be such that movement of the probe is smooth and in case of obstruction or in fully inserted or retracted position it should not damage the helical wrap/drive unit parts.

The Moving parts should remain locked, in case of power failure. The Supplier should submit the details of scheme, type of motor and its mounting arrangement and same shall be approved by the Purchaser prior to start of manufacture.


TIP drive system shall be designed for variable speed for insertion and retrieval of detector for fast (50mm/sec), slow (5mm/sec) and jog (1mm/sec) modes. There shall be separate stopper provision made preferably to prevent excess movement of TIP detector from fully in position and fully out (Parking) position. It could be mechanical, limit switch or equivalent.

The drive mechanism shall provide a positioning accuracy equal or marginally lower to the accuracy of the wire wrap pitch on the cable. Resolution shall be 2mm minimum. The position signal for the probe position shall be through position sensor viz. position encoder or multi-turn potentiometer with calibration facility on the drive mechanism internally. During operation after installation in reactor position, the drive unit shall provide helium leak tight boundary. The drive shall have provision of positioning the probe with respect to a fixed reference position. The drive shall have provision of replacement of the TIP detector for maintenance/ replacement for which suitable cover shall be provided with gasket. The Supplier shall provide detailed design and demonstrate efficacy of gasket to ensure helium leak tightness after such replacements.

## 6.2. Anti-twisting of Helical Wrapped Cable

If there is a twist in the flexible co-axial cable due to winding / unwinding over the drum, wire may get damaged due to twisting /bending of helical wrapped MI cable. To avoid twist of cable, there shall be an anti-twist mechanism, shown in Fig.5. The



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TIP drive cable is wound on Drum-A within the mechanism. Anti-twist assembly consists of one fixed Drum-C and two internal Drums-A&B that rotate. The helically wrapped drive cable is wound on the rotating Drum-A and flexible cable is distributed between the other two Drum-B&C through a spring-loaded pulley arrangement. The Supplier shall provide details of anti-twist mechanism along with torsion spring to utilize the available space. The drive unit shall be as compact as possible from installation and handling consideration. Efforts shall be made to keep the TIP Drive mechanisms weight low.

The concept specified in this clause is based on functional requirements for anti-twisting during winding and unwinding. Supplier can suggest alternate design with latest technology for improving its operation performance.

### 6.3. Sensing the TIP position

There shall be provision in the drive mechanism for determining the actual position of the TIP Probe attached to the helical wrapped cable. The movement direction (Forward/ Backward) indication and distance traversed by the TIP Probe shall be indicated on the local control panel provided with the drive mechanism.

The position indicator shall have provision to generate proportional signal (4-20mA) to enable recording and storing position signal.

### 6.4. Sealing, Connectors and TIP Drive Power Supply Requirement

TIP drive shall be mounted over terminal box of VFU or in front of HFU terminal box having helium environment. The entire mechanism shall be housed inside seal tight container with provision of venting. A Hansen make or equivalent shut-off Coupling shall be provided on the cover to connect or shut-off a Helium connection or for venting/ purging purpose. All penetrations should be helium leak tight including electrical power connection. Acceptable helium leak rate (Pressure method) for TIP drive Mechanism shall be  $10^{-4}$  std. cc/Sec or less with  $0.75 \text{ kg/cm}^2$  (g) pressure inside. For qualification of helium leak test of TIP drive mechanism, the bottom cover plate shall be arranged by the Supplier. Since the bottom face of the Drive Mechanism assembly is a sealing face for helium boundary, ultimate care shall be taken to protect this face during handling and transportation. A 5 mm downward projection shall be provided on the outer periphery of bottom flange for the same.

The incoming and outgoing connections shall be provided through suitable quick detaching type Circular cable connectors. The Input/ output connections shall be suitably identified. Power and Control signals shall be provided on separate connectors. Suitable protective covers shall be provided for power connections. Mating Cable connectors shall be provided. Standard cable connection shall be provided on the Drive mechanism to enable remote data recording at plant site for TIP position signal and TIP output signal.





The connector between helical wire wrap and flexible cable is given in detector specification. Suitable mounting arrangements shall be made to fix it with drum. Suitable connectors are to be provided on enclosure for extension of flexible wire, motor cable and signal cable of encoder. The connector for the flexible cable shall be of LEMO type and for signal cable of encoder and drive motor power cable, connectors shall be MS Bayonet type. These connectors shall meet the requirements of MIL standard No. MIL-C-5015 or an equivalent. Approval shall be taken from NPCIL while selecting the connectors.

The TIP drive mechanism shall operate with input power supply of 240 V AC, 50Hz single phase.

#### **6.5. Alignment**

Adjustment facility for alignment and mounting of cable externally should be possible. Due to rotation of drum, the position of MI cable cum coaxial helical wire wrap drive cable may move w.r.t. carrier tube axis. Hence, the cable should be directed to the CCT axis from any position of cable over Drum-A by providing funnel or equivalent arrangement.

#### **6.6. Procurement of Standard Items**

The standard items required shall be purchased only from reputed manufacturers and shall be approved by Purchaser in advance.

#### **6.7. Control Requirements**

The control panel for the drive shall provide the following:

- “Power Supply ON and OFF” indication.
- Selection for forward and backward movement.
- Indication of “forward/ backward” and speed selection.
- Speed Selection from 1 to 100mm/sec and particularly for speeds of 1 mm/sec, 5 mm/sec and 50mm/sec shall be selectable directly.
- Independent push switches for inching movement (1 mm/sec movement).
- Provision to move the probe to Parking, Home, Start and Stop positions.
- Emergency stop button.

The control shall be through pendant up to about 50 meter away from drive unit. The display unit shall indicate the position of the probe in mm with respect to the reference position.

The concept specified in this specification is based on functional requirements. Supplier can suggest alternate scheme with latest technology for improving its operation performance.





## **7.0 DETAILED SCOPE OF WORK AND QUANTITY**

### **7.1. Design of the TIP Drive Mechanism and demonstration of its functionality.**

The Supplier shall carry out design and manufacturing of the system to perform the function and meet the design requirements as specified in this specification. The equipment shall be complete with all details required for mounting, cabling, calibration, operation, handling and maintenance requirements. After successful demonstration of functionality of first Drive Mechanism on mockup setup at manufacturer's shop, subsequent Mechanisms shall be taken up for manufacture.

### **7.2. Procurement of Raw Materials, Proprietary Items and Standard Items**

The Supplier shall procure the raw materials, proprietary items and standard items including spares required for manufacturing/ fabrication and assembly of the equipment. Standard items shall be procured only from reputed manufacturers and same shall be subjected to approval by the Purchaser.

### **7.3. Supply of the Equipment**

The Supplier shall do the fabrication, perform the trials & testing, carry out inspection & pack and deliver the TIP Drive system, along with the mock-up in accordance with the requirement cleared by the Purchaser and other requirements specified in this specification.

### **7.4. Quantity**

The total quantity required, along with mock-up structure is as specified in tender document.


## **8.0 DETAILS OF THE BID**

The party has to submit the proposal with the General Assembly drawing along with the offer and indicate the deviations, if any, from tender specification as an annexure. The bidder shall quote for the Design, manufacture, testing, qualification and delivery of the TIP Drive system.

### **8.1. Documents to be Submitted After Placement of Order**

- a) GA and Detailed drawings including BOM of the TIP Drive Mechanism.
- b) Design calculations.
- c) Technical specification for standard items of the Drive Mechanism.
- d) Internal Wiring Diagram covering drive mechanism, local control panel and pendent, power and control cables layout, and other accessories.
- e) Performance test certificates for standard items like motors etc.
- f) One set of full inspection report to be compiled and submitted in an accepted



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format.

- g) Assembly / Disassembly procedures of the system.
- h) Procedure for shop testing.
- i) Operating procedure with check list.
- j) Instruction Manuals for standard items.
- k) History docket covering all stages of manufacturing and testing (refer Para 10.0).

## 9.0 TESTING

Step by step procedure for functional test shall be submitted for approval from Purchaser. The system will be tested as per the procedure in conformity to the specification requirements. The Purchaser before the dispatch of the system will carry out quality surveillance inspection.

A quality assurance plan indicating the schedule shall be submitted to Purchaser before starting the job. Inspection and hold points shall be defined in the quality assurance plan.

### 9.1. Test Requirements

The Supplier shall demonstrate the movement of probe in a straight tube with an ID of 7.6 mm and length of 15 meter. Reading shall be taken at every 50 mm for full travel in both the direction. Comparison of actual position of TIP to the reading of position sensor is to be demonstrated by marking on MI cable. The position of TIP shall be checked by alternative measurement. Testing shall be carried out for horizontal and vertical movements.

Testing procedure to meet the above requirement is to be submitted for approval. Within guarantee period, if the equipment on deployment on mock up channel at site indicates any functional difficulty, the Supplier shall attend same and rectify it.


### 9.2. Mock-up Requirements

For testing the Drive Mechanisms, SS tube of ID about 7.6 mm and of length 15m simulating CCT is required to be kept vertically by using suitable support. Mock-up schematic is given as Figure-6. Detailed scheme shall be submitted by Supplier for approval.

Mock-up set-up will consist of:

- a) Stainless steel tube and tube extension assembly along with supports placed vertically.
- b) 19 meters long helical wrapped cable of diameter 6.3 mm joined at the end with 6.3 mm dia. and 75 mm long SS rod.
- c) Local Control panel and pendant for remote control as per this specification.
- d) Mounting plate of the TIP drive mechanism shall be attached to the top flange of terminal box as shown in fig.-4.



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### 9.3. Performance Test

The completed/assembled Drive Mechanism shall be tested for complete forward & backward movement 5 times in steps of 50 mm and it's multiple. The movement/ Drive Mechanism operation shall be smooth and free of any unintended stop or manual intervention. The test shall be performed as per the procedure approved by the Purchaser.

The Drive Mechanism shall be tested for full up & down movement of cable for 15 times with continuous movement. In case of any modification based on above tests, the full test shall be repeated to ensure satisfactory performance.

## 10.0 INSPECTION, TEST AND REPORTS


The Supplier shall provide detailed Quality Assurance Plan indicating various steps for inspection & testing covering materials, assembly, testing, documentation, packing and delivery to NPCIL and prior approval of NPCIL for the same shall be obtained. The sample QAP for the work attached as Annexure-1 is for the guidance of Supplier and details the minimum requirements for achieving the Quality Assurance required for the assemblies. If deemed necessary NPCIL will have right to specify additional inspection/ testing other than specified in this specification and drawings and cost of such tests/ inspection will be borne by NPCIL.

NPCIL or authorized representative shall have access in the manufacturer's shop and inspection room at all time during manufacture, inspection and testing. The Supplier shall examine all the components and assemblies for full compliance with the drawings and specifications. History docket covering compilation of all approved manufacturing drawings, approved procedures, installation & operation manuals, as-built drawings, and reports are to be given to Purchaser in the form of 2 soft copies in CD and 3 bound hard copies. Editable copy of all procedures, manuals and final drawings in AutoCAD format also shall be provided along with deliverables.

## 11.0 DEMONSTRATION OF THE DRIVE MECHANISM

The Supplier shall demonstrate the working of the TIP Drive Mechanism at their workshop by placing it on the top surface of the mock-up for horizontal as well as vertical movements. This system shall be remotely operable from the local control panel/ pendant kept at a distance of 50 meters from the mock-up.



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## 12.0 QUALITY ASSURANCE

Supplier shall prepare detailed Quality Assurance Plan (QAP) for manufacture and fabrication, inspection, testing, and performance qualification of the TIP Drive Mechanism and shall submit for approval to TDG, NPCIL. Sample QAP is given below as Annexure-1.


## 13.0 PACKING AND SHIPPING

The packing shall be carried out properly and identification labels shall be put on each package. A copy of the shipping release and one set of history docket shall be kept inside the packing.

The assemblies shall be dispatched only after obtaining final clearance from NPCIL in writing, called Shipping Release,. The Supplier shall be responsible for shipping the system along with various modules including spares as specified in the tender.

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## **ANNEXURE-1**

### **SAMPLE QUALITY ASSURANCE PLAN (QAP)**

The following Quality Assurance Plan (QAP) for the work is for the guidance of Supplier and details the minimum requirements for achieving the Quality Assurance required for the assemblies.

A detailed QAP along with manufacturing process plan shall be prepared and submitted by the Supplier for Purchaser's approval. Final QAP, as approved by Purchaser, shall be used during manufacture.

Sr.No.	Control and Tests	Quantum of Check Action by Supplier	Quality Surveillance by Purchaser or his authorized representative
1.1	Submission of Conceptual drawings	I	R, H
1.2	Manufacturing drawings	I	R, H
2.0	Material Inspection		
2.1	Chemical Composition	I	R
2.2	Mechanical Properties	I	R, W
2.3	Non-Destructive Testing - UT for seamless pipes, plates, forgings and bars. - Liquid Penetrant Examination on forgings and bars.	I	R, W
2.4	Dimensions	I	R, W
3.0	Manufacturer's compliance certificate for bought out items	I	R
4.0	Assembling, Final Inspection and Testing		
4.1	Visual Examination	I	R, W
4.2	Dimension	I	R, W
4.3	Helium Leak test set-up and testing	I	R, W, H
5.0	Detailed Test Procedure	I	R
6.0	Functional Test and qualification of TIP Drive System as per Procedure	I	R, W, H
7.0	Test Reports	I	R
8.0	Final Mfg. Drawings / Procedure and inspection History Docket	I	R
9.0	Packing and shipment	I	R, W





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10.0	Issue of shipping release	--	By Purchaser or his authorized representative
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### Legend:

- I - Complete action and inspection by Supplier
- R - Review of test records, test reports, procedures, test certificates, records of process parameters etc by Purchaser
- W - Checking the actual component or witnessing the inspection / testing activity on a suitable percentage / random basis by Purchaser
- H - Hold point

Inspections will be 100% by Supplier and numerical values of all dimensions, geometrical features and surface finish will be recorded. Inspection by Purchaser or NPC-QA will be on random basis.

The Supplier shall examine all the components and assemblies for full compliance with the drawings and specifications. All the inspection reports are to be given to NPCIL. Mock-up performance and qualification performance test reports shall be prepared by vendor and submitted to NPCIL.



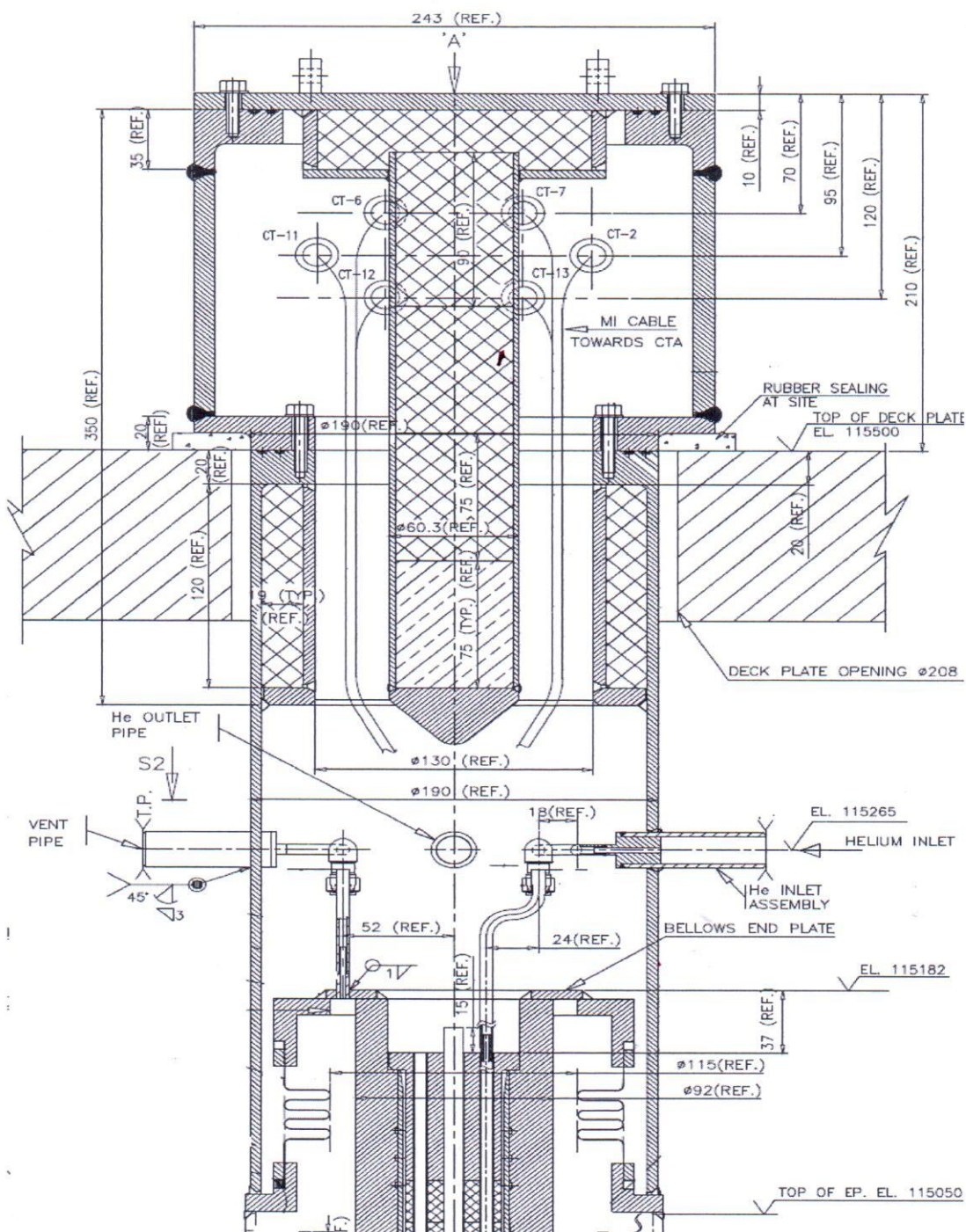


Figure 1:- Sectional View of Terminal Box with Central Carrier tube





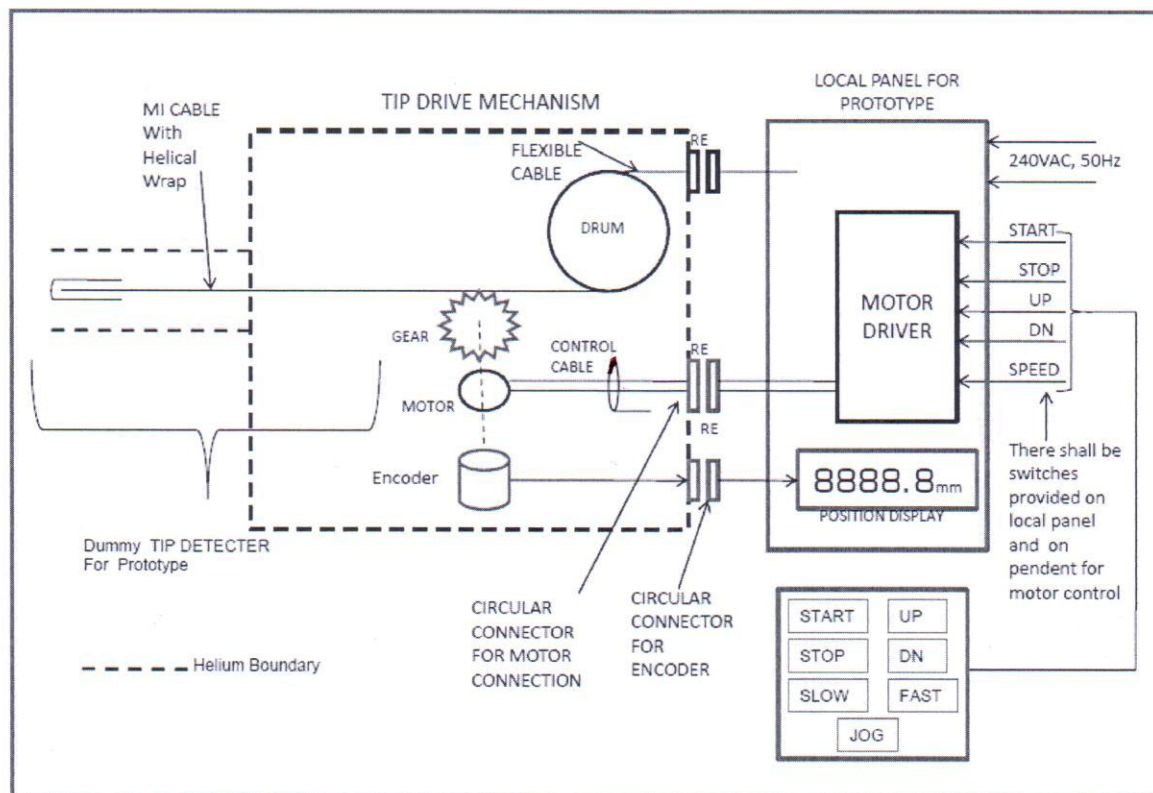
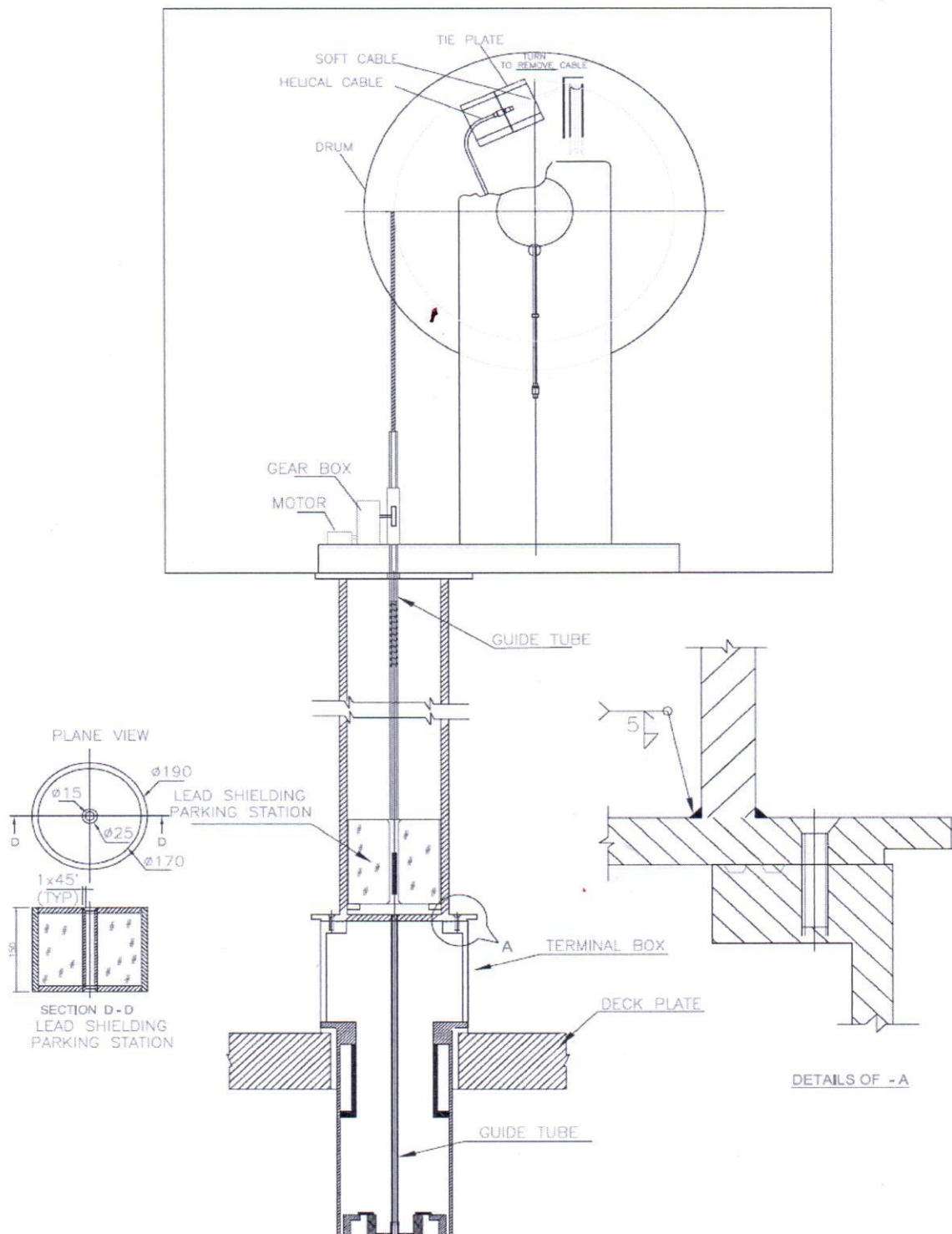
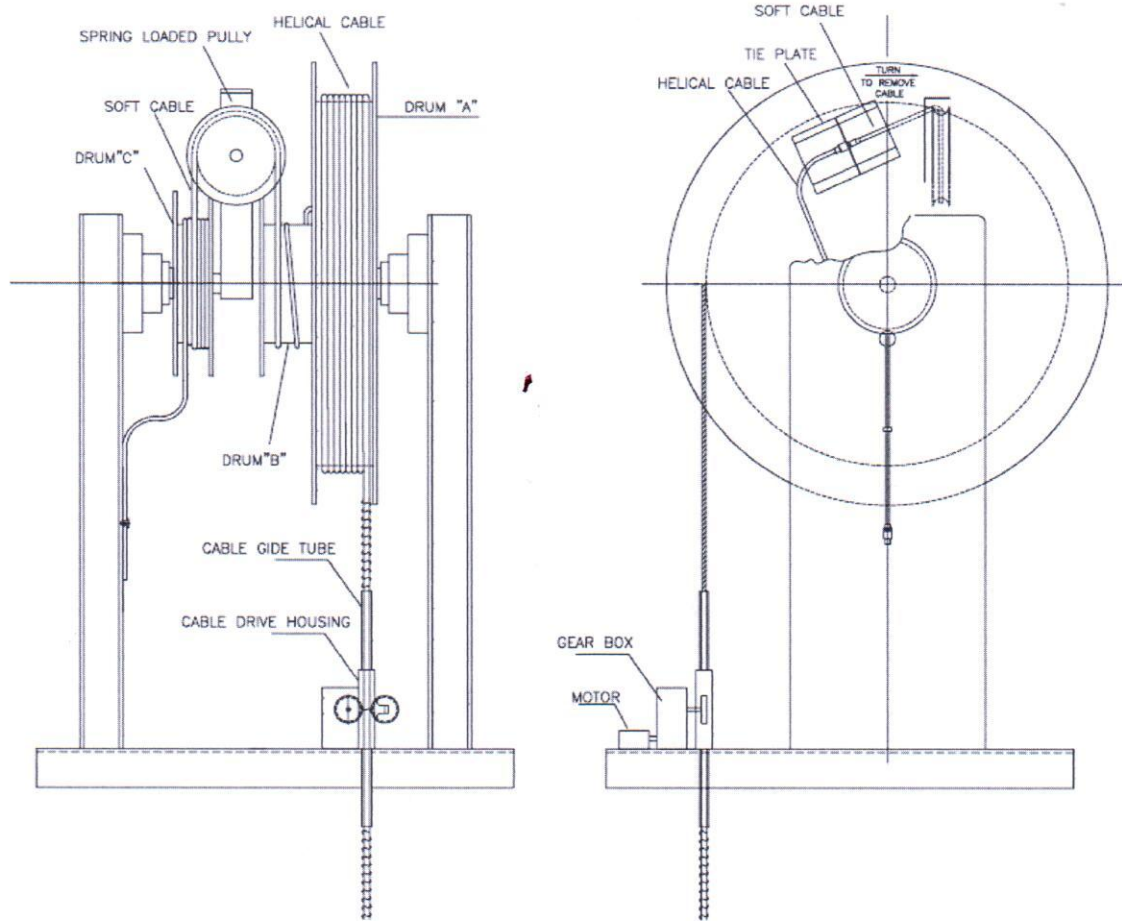


Figure-3: Electrical Flow Diagram of TIP Drive





**Figure-4: General Assembly of the TIP Drive System**



**Figure 5: Anti-Twist Mechanism Schematic Drawing**



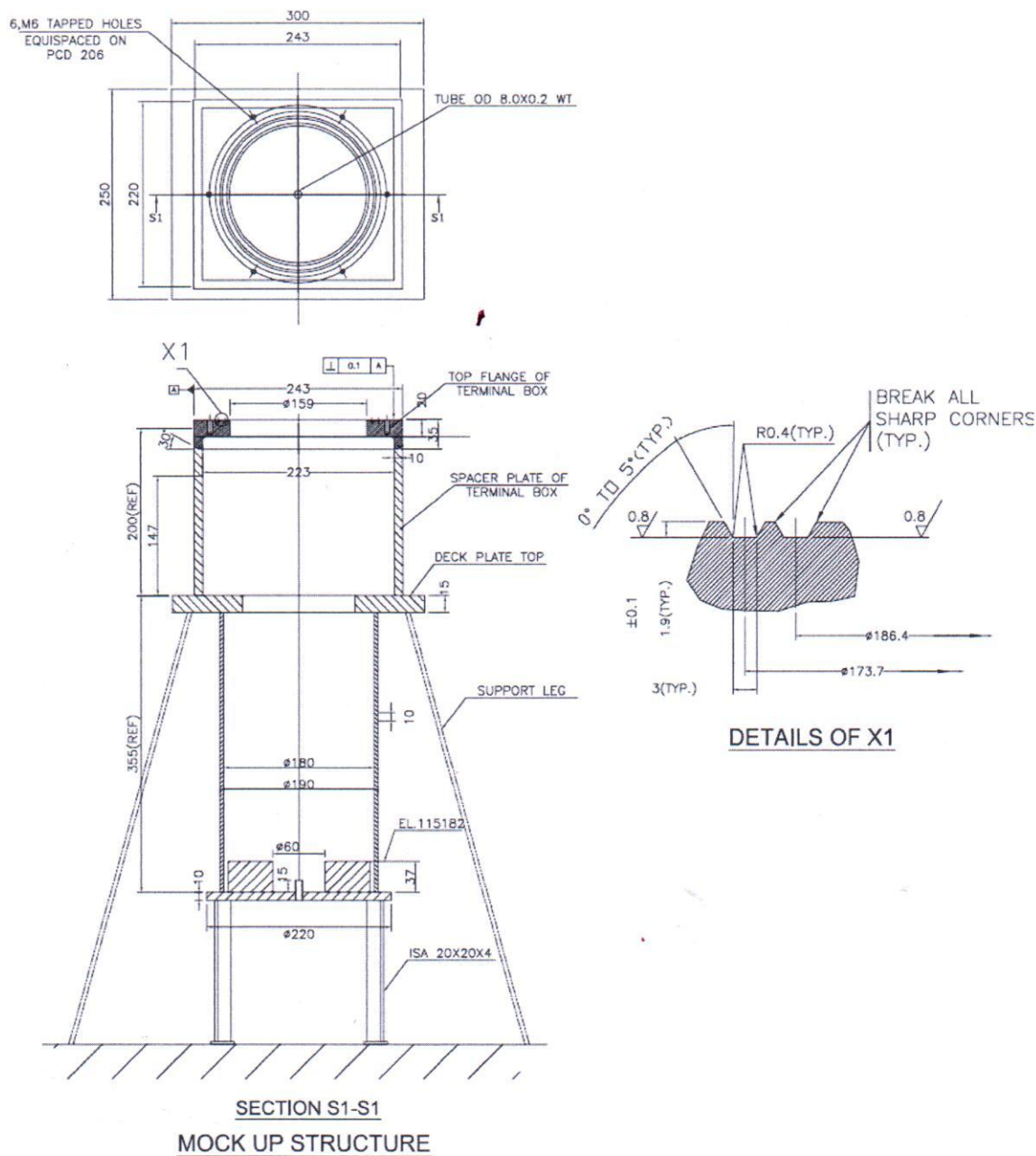


Figure-6: Mock-up Set-up for the TIP-Drive Mechanism