

**DESIGN, SUPPLY, INSTALLATION AND
COMMISSIONING OF DIGITAL RADIOGRAPHY AND
INTEGRATED CT (COMPUTED TOMOGRAPHY)
SYSTEM FOR 6 MeV LINAC WITH FLAT PANEL
DETECTOR & OBJECT MANIPULATOR**

SPECIFICATION
FOR
DESIGN, INSTALLATION AND COMMISSIONING OF HIGH
ENERGY DIGITAL RADIOGRAPHY & 3D CT WITH OBJECT
MANIPULATORS, FLAT PANEL DETECTOR AND INTEGRATED
COMPUTED TOMOGRAPHY SYSTEM FOR 6 MeV LINAC

NON DESTRUCTIVE TESTING FACILITY
ROCKET PROPELLANT PLANT
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SPECIFICATION FOR HIGH ENERGY DIGITAL RADIOGRAPHY (6 MeV LINAC) SYSTEM WITH OBJECT MANIPULATORS, FLAT PANEL DETECTOR AND INTEGRATED COMPUTED TOMOGRAPHY SOFTWARES

1. GENERAL

- 1.1. The specification covers the design, manufacture/fabrication, supply, handling at site, erection, commissioning and performance test of High Energy Digital Radiography & Computed Tomography for 6 MeV LINAC at RPP,VSSC Thiruvananthapuram. The system consists of precision Object Manipulators, Flat Panel Detector, CT software, High End Workstations with high resolution monitors and associated systems for Digital Radiography and 3D Computed Tomography. The 6 MeV LINAC will be provided by VSSC(Varex make LINATRON M6 already available).
- 1.2 The system should have capability to carryout both Digital Radiography and CT Inspection of the Objects in Automated mode. The system should have capability to take multiple projection shots upon initial setting by triggering the LINAC Automatically and reconstruct the CT Image. Since most of the objects inspected are of relatively bigger size, provisions should be there to stitch the images.
- 1.3 The Object Manipulator consists of a LINAC handling system on the front side and an FPD Handling System at the back side and both of them can be moved on a set of rails. A Rotary Table and an Object Rotator is placed in between these systems and jobs will be positioned on them. A manually operated Film handling unit is to be provided adjacent to the FPD Handling system on the same rails. The FPD handling system and Film Handling system are common for the both Rotary Table and Object Rotator.
- 1.4 All items of equipment shall be complete in all respect and any equipment not covered in the specification but essential for proper installation, operation and maintenance shall be included by the party.

2. DESIGN AND EQUIPMENT DETAILS

Design and all other equipment and associated system and software particulars are furnished in Annexure-1

3. SCOPE OF WORK

- 3.1 The scope of work includes materials, equipment and services for Object Manipulator, Flat Panel detectors with associated software and systems for Computed Tomography and Digital Radiography as mentioned in this specification. The material, equipment and services to be provided shall include, but not be limited to the following.

- 3.1.1 Design, Procurement, manufacture/fabrication, supply and erection of equipment with all accessories, auxiliaries, electrics and control devices etc. to make the installation complete in all respect.
- 3.1.2 Supply, erection and commissioning of all technological structures related to the equipment operation and maintenance.
- 3.1.3 Packing, forwarding, transport, insurance, loading, unloading, precaution against damage during transit and installation at site etc.
- 3.1.4 The scope for Automatic System for Object Manipulator shall include the following:
 - 3.1.4.1 Supply, factory testing packing, and dispatch to site of the following instruments & accessories:
 - i. Field mounted instruments suitable for Class 1 Division 1 or Zone 1 Hazardous areas with Gas group A,B,C,D or IIA/IIB, Temperature rating of T5 or maximum 100 deg C and IP65 or better ingress protection rating, Flameproof /Explosion proof or Intrinsic safe (Ex “ia/ib”) comprising of primary measuring elements, junction box, evaluation unit, digital display, switches, induction/servo motors shall be flame proof (Ex “d”). If any of these components flame proof grade is not available, explosion proof grade can be used with prior approval from the purchaser. For others area it shall be industrial type. Sensors shall be Intrinsically safe (Ex ‘ia/ib’) type.
 - ii. FRLS armored power, screened and Control cables. All cables must be provided with braided sheathing.
 - iii. All indigenous FLP/Explosion proof/ Intrinsic safe electrical fittings should have approval of CMRI, Dhanbad or ATEX / ICEX/NEMA or corresponding Government bodies in case of import.
 - iv. Programmable Logic controller along with visualization system installed in a console, and associated peripherals for the complete systems.
 - v. Power Distribution Panel comprising set of double pole MCBs for powering of Automation system.
 - 3.1.4.2 The Object handling system which includes LINAC Handling system, Object Rotator, Rotary Table and FPD Handling System shall be controlled and monitored/visualized by a Programmable Logic Controller with SCADA based HMI. The SCADA system shall be OPC compliant for transfer/receipt of data to/from other automation system procured by the purchaser separately. All the controls will be from the adjacent control room dedicated for Digital Radiography/Computed Tomography system. The above Programmable Logic Controller along with the HMI stations will be within the scope of supplier. Suitable Digital Control Transferring system from Radiography Hall to/fro Control Room shall be provided to toggle the Control of all automated system from inside control room or from the radiography hall for setting the components.
 - 3.1.4.3 A manually operated Film Handling System is provided which can be used for both Rotary Table and Object Rotator by manually moving on the rails.

- 3.1.4.4 Detailed engineering and system design of the offered system along with preparation of functional and the logic diagram documents for operation of the Manipulator systems.
- 3.1.4.5 Preparation of Input-Output list for the Automation system and the functional and logic documents for the development of software.
- 3.1.4.6 Supply of all tools required for erection and commissioning.
- 3.1.4.7 Cable engineering including interconnection, cable schedule and cable layout including laying, termination of all interconnecting control, screen & special cables. All control, screen and power cables including special cables shall be supplied by the party, of required quantity for the equipment covered under their scope of supply.
- 3.1.4.8 Laying, dressing and clamping on trays/over ground cables and termination of instrument power, control, screen and special cables from individual measuring and control points to the junction boxes including supply and fixation of cable lugs, printed ferrules (at both ends) with engraved numbers with double compression type cable glands at both ends. i.e, the instrument end and the junction box end. Supplier shall supply, lay and terminate the control and screen cables from the above junction boxes to the marshalling cabinet or PLC Cabinet.
- 3.1.4.9 Supply/erection of hardware as required for installation of field instruments & accessories.
- 3.1.4.10 Supply and installation of field instruments & Junction boxes. Erection of all field mounted instruments, cabling etc. to be completed in all respects in accordance with the contract.
- 3.1.4.11 Pre-installation testing of all offered instrumentation items shall be carried out to ensure that each individual item is functionally correct and correctly calibrated and programmed. Calibration certificates from government approved testing agencies/NABL accredited labs for all instruments. Testing of instrument cables including proper termination as per circuit diagrams, as well as pre-commissioning including loop testing for checking for correct operation of all instrumentation and control system for commissioning is under the scope of work.
- 3.1.4.12 In the interest of standardization, party shall offer equipment of makes as mentioned in the list of preferred makes.
- 3.1.5 All cabling work between the mains room, housing power distribution board (PDB)/MCC room housing motor control centre (MCC), located adjacent to the process room, shall be included in the scope of work of the successful party. **The minimum length of cables required shall be around 80 m to connect from the control room to hall through trenches provided in the building with proper routing.**

- 3.2 6 MeV LINAC(Varex Make) with collimator will be provided by the purchaser. Detailed weight and dimensions of the LINAC with collimator will be provided for design of LINAC Handling System
- 3.3 All rail design, laying, alignment & testing shall be included in the scope of work of the party. The foundation for the fixed structure on FFL & rail mounting for film handling is also in the scope of work of the party.
- 3.4. Time period of completion of the project is from the date of approving of last design documents and drawings to installation, commissioning and trial run of the complete system from the party. The period of submission of drawings should not exceed by 4 months. Party has to submit their QA plans along with the design drawings for all mechanical, electrical / instrumentation items.
- 3.5 All the dummy loads and objects required for testing of equipment at manufacturers premises shall be arranged by the party

4. ELECTRICS

- 4.1 Electric power will be available in the main room at 415 V 3 Phase, 50 Hz with system fault level of 36 MVA(50 kA). The 415 V System will be solidly grounded at the transformer neutral.
- 4.2 If the party requires any other voltage, it shall provide the necessary conversion equipment.
- 4.3 The control circuit voltage adopted for the 415 V MCCs shall be 110V, AC for contactors with AC coils, auxiliary relays etc. which shall be obtained by the adaptation of 415/110 V control transformer of adequate capacity. Clustered LED's for indication lamps shall be suitable for 110 VAC. Control voltage for all field-mounted devices located in the process room shall be 24 V DC.
- 4.4 Control transformer shall have shielding between primary and secondary windings to limit transferred surges from the primary as well as to obviate flashover between primary and secondary terminals.
- 4.5 List of IS specification is detailed in Annexure – 2

5. OTHER REQUIREMENTS

- 5.1 **ACCESSIBILITY REQUIREMENTS AND INTERCHANGEABILITY:** All working parts, as far as possible, are to be arranged for convenience of operation, inspection, lubrication and ease of replacement with minimum down time. All like parts of the equipment furnished are to be interchangeable.

For each sub system, for easy maintenance, greasing points to be identified and all the sub systems should be easily amenable for assembling and disassembling

- 5.2 **QUALITY AND WORKMANSHIP:** Workmanship and materials shall be first class quality suitable for the purpose intended and in accordance with the highest standards and practices for equipment of the class covered by the specification.
- 5.3 **PAINTING:** All items of manipulator system shall be thoroughly cleaned and painted as per the steps given below
- i) Sand blasting over the surface
 - ii) Degreasing/dewatering of surfaces to be painted
 - iii) Epoxy primer coating (2 coats)
 - iv) 40micron thick epoxy paint coating (I coat)
 - v) 30 micron of epoxy paint coating (II coat)
- 5.4 Noise level of all the components of the object manipulator system together should not exceed 80 dB at 1 meter distance.

6. SPARES:

- 6.1 Party shall provide list and quantity of all maintenance spares and spares parts which are required for three years of normal trouble-free operation of the equipment after final acceptance of the equipment.
- 6.2 List and quantity of all insurance spares which shall not be required due to any routine replacement but may be required out of any error or omission on the part of Purchaser including his operating and maintenance personnel, shall be recommended on the basis of experience of the party after final acceptance of the equipment-

7. TOOLS

The party shall provide all tools as per Para 3 of Annexure-1.

8. CONSUMABLES AND SUPPLIES

- 8.1 The party shall supply the first fill of consumable and supplies along with the main equipment.
- 8.2 Detailed specification and make of recommended consumable and supplies required for THREE years operation of the equipment shall also be furnished by the party after final acceptance of the equipment.

9. SAFETY

All equipments shall be complete with approved safety devices, wherever a potential hazard to personnel exists, and with provision for safe access to personnel to and around equipment for operational and maintenance functions. These items shall include not only those usually furnished with elements of machinery, but also the additional covers,

guards, crossovers, stairways, ladders, platforms, handrails, etc. which are necessary for safe operation. The party shall provide safety items such as coupling guards, belt guards, gearing and chain guards, etc., wherever required. Wherever Automated movements are there, suitable sensors with sufficient redundancy and mechanical stoppers shall be provided so as to prevent accidental hitting on any items being tested.

10. TIME FOR COMPLETION

Party has to submit the detailed design drawings for our approval within 4 months of order placement, delivery of items within 12 months from the date of approval of drawings and complete the installation and commissioning in 4 months (ie. Total 16 months after approval of design drawings)

11. TESTING AND INSPECTION

11.1 All supply items of equipment under the scope of this specification shall be inspected by us at the supplier's premises.

11.2 After placement of order, for final acceptance, party shall submit proposed Inspection Procedure and Quality Assurance Plan of all mechanical, electrical/instrumentation items in agreement with the purchaser. However, inspection/test procedure for mechanical equipment at manufacturer's works shall be as indicated in Annexure-4.

12. STANDARD AND OTHER REQUIREMENTS

12.1 All equipment and their accessories shall be designed, assembled and tested in accordance with the relevant standards published by the Bureau of Indian Standards wherever applicable so that specific aspects under Indian conditions are taken care of. Where suitable Indian Standards are not available, other International Standards such as IEC, BS, ASTM, ANSI, ASME and DIN may be adopted with the prior approval of the Purchaser.

12.2 For the safety of the electrical installations the party should follow the general instructions for electrical installation as per Bureau of Indian Standards detailed in Annexure-2.

12.3 The equipment shall also conform to the latest Indian Electricity Rules as regards safety, earthing and other essential provisions specified therein for installation and operation of electrical equipment.

12.4 All items shall comply with the regulations and stipulations of applicable statutory bodies of Government of India and State Government where Project site is located, wherever applicable. When required by regulations, the party will have to obtain the necessary approval from the statutory authorities and other concerned agencies. All costs on this account shall be borne by the party.

- 12.5 All equipment shall be designed for smooth, efficient and trouble free operation in tropical humid climate of 45 deg C ambient on a 24 hour average and a humidity of 95 percent.
- 12.6 The panels shall be properly ventilated/air-cooled to enable proper functioning with the panel doors closed.

13. DRAWINGS AND DOCUMENTS

The party shall submit the following documents.

- a. The party shall get approval of the purchaser on design document, all fabrication and bought out item drawings, certified detail foundation drawings.
- b. Single-line diagram of the electrical equipment indicating power and control devices and Control scheme drawings.
- c. Motor and Component List.
- d. GA drawing of the control panel
- e. Layout drawings, General arrangement drawing of equipment showing overall dimensions, clearances, elevations, sections and plans.
- f. Design document to support the suitability of the equipment.
- g. Input/output list for the PLC.
- h. Loop schemes and cable interconnection drawing.
- i. Assignment drawings showing cut out requirements, trench layout, embedded conduit etc.
- j. Cable schedule and cable routing drawings.
- k. Process hook-up drawing.
- l. Bill of material for erection hardware.
- m. Junction box schedule General Arrangement, terminal assignment
- n. Functional Description, Block Logic Diagram, Control Schematic drawings
- o. Interconnection Diagram
- p. Earthing scheme drawings.
- q. GA drawings of electrical equipments.
- r. All necessary documents for Automation system.

14. PREFERRED MAKES

All items of equipment shall be of preferred makes as per Annexure - 3. Any deviation from the preferred makes has to be approved by the purchaser.

15. PRE-DELIVERY INSPECTION: Pre-delivery Inspection at manufacturer premises shall be carried out by VSSC team upon completion of each sub system. Party shall intimate VSSC regarding readiness for PDI as soon as sub systems are ready for inspection.

16. SITE READINESS: Site Readiness for erection and commissioning shall be informed by VSSC upon completion of final PDI at Site.

17. DISPATCH CLEARANCE

The vendor shall deliver the equipment to RPP/VSSC Thiruvananthapuram only after obtaining clearance for dispatch from purchaser.

18. ERECTION & COMMISSIONING

It is to be noted that supply and erection of the system with all accessories, auxiliaries, piping, structures, platforms, staircases, electrics and controls as specified including motors, controls, cables, earthing connections, field mounted control devices, etc. and any equipment not covered in the specification but essential for proper installation, operation and maintenance of the system shall be included and executed by the party.

The supply will not be deemed complete until the commissioning and trial of the whole system is carried out by the vendor with 6 MeV LINAC head at RPP/VSSC site successfully.

19. WARRANTY

The party shall provide 36 months warranty for complete system from date of completion of installation, commissioning and acceptance for its performance.

20. AMC SUPPORT

The party shall provide AMC support for 5 years after completion of warranty for which a separate contract will be made.

ANNEXURE-1

EQUIPMENT DETAILS AND DESIGN BASIS

1. OBJECT MANIPULATOR SYSTEM

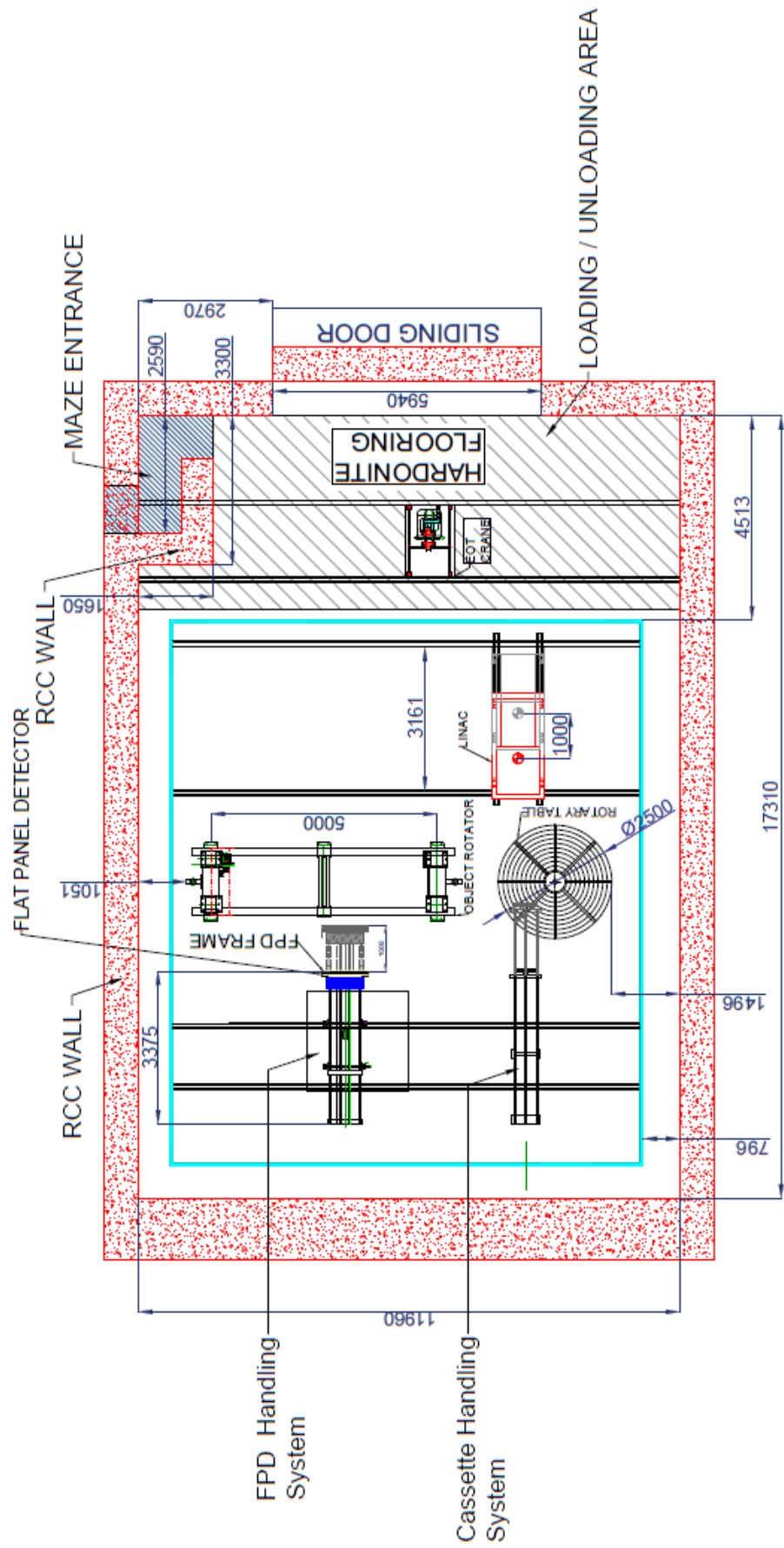
6 MeV Linear Accelerator (Varex make) is a source of high energy X-ray radiography used for Non-Destructive Testing(NDT) of different type of objects. For inspection using it, the object is kept at a distance of 3-5m from the focal spot in line with the X-ray beam. The Flat Panel Detector (FPD)/X-Ray film cassette is positioned behind the object which is rotated for taking radiography of different regions. The FPD holder shall have a shutter system with sufficient lead thickness for preventing direct exposure during digital radiography. The Film Cassette unit can be moved on the rails and the cassette handling arm is to be moved up & down and to & fro for film radiography by manual movements.

The system shall be operated in both Auto and Manual Mode. The entire system is to be operated in automated mode through PLC/SCADA from the adjacent control room. The provision to be given to operate it manual mode as well from the LINAC hall/Control room. For automated mode, the entire sequence of movement inside the hall shall be simulated and visualized by the operator from Control room. A suitable centralized handling system for the LINAC head, Objects and the FPD along with a central PLC/SCADA setup is required. A local push button control post (pendant based) digital display for operation of all motions along with an emergency POWER-OFF to be provided in the LINAC hall in addition to the control room for setting the components for radiography.

The system envisaged should have necessary precision for CT inspection by CT reconstruction from the digital images. For this, CT acquisition & reconstruction software with separate high end workstations for image acquisition & reconstruction should be provided. As the object handled are bigger (varying from 300 mm to 1500 mm), digital images are to be stitched for CT image reconstruction. The system shall consist of the following subsystems:

- 1.1 LINAC handling system
- 1.2 Rotary Table-for positioning the jobs vertically
- 1.3 Object Rotator- for positioning the jobs horizontally
- 1.4 Flat Panel Detector handling Unit with Shutter system
- 1.5 Film Cassette handling unit by manual operations
- 1.6 CT acquisition & reconstruction software with high end work stations

6 MeV LINAC HALL PLAN



1.1 LINAC HANDLING SYSTEM

The LINAC handling system is required to position the LINAC X-ray beam aligned with the object center. The exact dimensional details of LINAC with collimator system will be provided. LINAC is mounted on a ground based system with movement in X-axis and Y-axis on Rails. The system shall provide up/down movements (Z-axis), back/forth movement w.r.t the object, swiveling of the LINAC carriage horizontally and vertically (pan & tilt) for accurate centering of the LINAC X-ray beam with respect to Object and FPD system and also for taking angular shots. The system should be suitably guarded against vibrations to LINAC and suitable damping systems are to be provided. Proper mechanism is to be designed for smooth movement of electrical high power cables, cooling water lines etc along with LINAC head when it is moved in X,Y and Z directions.

1.1.1 LINAC AND SECONDARY COLLIMATOR PARAMETERS

Weightof LINAC with collimator	2000 kg (Approx.)
Dimension of LINAC with Secondary Collimator	1.92 m (L) X 0.73 m (W) X 0.92 m (H)

1.1.2 DESIGN REQUIREMENTS

Parameter	Description
Horizontal movement along object length (X-axis) along rails	9 m
Back/Fro Movement (Y axis) along rails	Upto 1000 mm
Vertical movement(Z-axis)	Upto 4000 mm from FFL
Vertical(Z-axis) Speed	50 to 500 mm/min (any speed with min and max speeds shown)
Horizontal(X-axis) Speed	100 to 1000 mm/min (any speed with min and max speeds shown)
Across horizontal(Y- axis) Speed	100 to 1000 mm/min (any speed with min and max speeds shown)
Accuracy of Movement (X,Y& Z)	± 0.25 mm
Mechanical drive (X-axis)	Rail(suitable CR profile) & Wheel(double flanged), Hardened steel(BHN-250 to 300)
Mechanical drive (Y-axis)	Rail(suitable CR profile) & Wheel(double flanged), Hardened steel(BHN-250 to 300)
Mechanical drive (Z Axis)	Double nut recirculating Ball screw with guide rods (hardened steel with HRC-50 (min.)/suitable lifting mechanism having provision to stabilize LINAC at a particular height in less than 30 sec.

	Provision to arrest the LINAC in position while taking CT projections
Rotation of LINAC carriage Horizontal swivel(pan)	$\pm 15^\circ$ (From Mean Position) with resolution less than 0.05°
Rotation of LINAC carriage Vertical swivel(tilt)	$\pm 15^\circ$ (From Mean Position) with resolution less than 0.05°
Electrical Drive (X,Y and Z axis)	Flame Proof Servo Motors (suitable for zone 1) with absolute encoder for Automation
Position Feedback	Absolute Encoders in addition to electro-mechanical devices such as proximity/limit switches are to be provided for fault diagnosis & safety.
Material of construction	IS 2062- Grade E250 Steel for general structural purpose-

1.1.2.1. System shall have provisions for two speeds ie. micro and macro and also all speeds selectable in between in order to achieve required X, Y and Z position. This speed shall be controllable from remote HMI station in the hall and from Control Room and the speed of the movement shall be displayed on either of the systems whichever is being operated

1.1.2.2. Vibration arresting mechanism for LINAC shall be designed to dampen the vibration of LINAC within 30 seconds.

1.1.2.3. Remote HMI station in the Hall/Control Room shall have interchangeable provision to control and display of X, Y, Z location of LINAC, tilt, pan and speeds in X, Y, Z direction. Display of both units shall show the parameter whichever is under operation.

1.1.2.4. Limit switches shall be provided at extreme positions of X, Y, and Z motions. Mechanical stopper also may be provided for additional safety.

1.1.2.5. Range of vertical motion for regular operation of LINAC shall be 750 mm to 4000 mm so that lower most beam exit point shall be at 1000 mm from FFL.

1.1.2.6. All the LINAC positions shall be controllable from Control room with exact position feedbacks (X, Y and Z) with Initial position (home) of LINAC set at one corner of the Rail.

1.1.2.7. Provisions for controlling/integrating the LINAC positions and swivel angles by the Computed Tomography/Digital radiography acquisition Software shall be given for automation.

1.1.2.8. Home Position for X, Y and Z axis shall be provided to retain the Default values. Only Administrator shall have provisions to Reset the Default values.

1.2 OBJECT ROTATOR

Object rotator is required for the radiography of cylindrical objects of Diameter 500 mm to 1500 mm. The cylindrical object will be rotated over four numbers of antistatic rubber lined roller sets of suitable diameter, with each roller mounted on individual roller stand. The gap between rollers should be adjustable to accommodate object of variable diameter (500 mm to 1500 mm).

The gap between a pair of rollers should be adjustable to accommodate object of variable length (1500 mm to 5000 mm). The roller stands shall be mounted over a suitable platform structure.

1.2.1 Specification for Object Rotator

Parameter	Description
DIMENSIONS OF OBJECT	
Diameter	500 mm to 1500 mm
Length	5000 mm
Max. weight of the object	8 T
DIMENSIONS OF ROTATOR	
Length	5000 mm
Width	1400 mm
Roller center Height from FFL	1000 mm
JOB ROTATION	Absolute Encoded rotation about axis of object. (If found essential Incremental Encoders may also be used)
Rotational Speed of job	0.2 to 1 rpm- System controllable
Rotational accuracy	±0.5 mm on job surface of 1 m diameter
Roller	Roller of approximate 300 mm dia and 250 mm width with hard rubber of minimum thickness 30 mm to be provided to accommodate the object. Roller shall be designed so as to provide a clearance of 50 mm between object surface and roller supporting bracket after full load compression of roller rubbers.
Lateral Distance between rollers	Should be manually adjustable for diameter range of 500 mm to 1500 mm of the object.
Separation between rollers	Manually adjustable for a length range of 1.5 m to 5 m of the object.
Lateral movement arrestor	Suitable self-arresting mechanism to be provided on the rotator to prevent lateral movement of object and maintain the set position after any rotation. It shall be roller type to prevent friction.

Electrical Drive	Flame Proof Servo Motor(suitable for zone 1)
Position Feedback	Absolute Encoders in addition physical devices such as proximity/limit switches are to be provided for fault diagnosis & safety.
Material of construction	IS 2062- Grade E250 Steel for general structural purpose

1.2.1.1 There shall be provision to rotate the object to the required angle. Auto Calibration and setting the object to Home Position (ZERO) shall happen after positioning the object on object rotator. Further positions on rotation shall be based on the set Home Position. Suitable braking system to ensure positional accuracy is to be given. Drifting or Lateral movement of object along the roller during continuous rotation shall be arrested fully.

1.2.1.2 Remote HMI station in the Hall/Control Room shall have interchangeable provision to control and display the angle of rotation and speed of rotation of the object and real-time feedback of the positions shall be available to the system. Local HMI in hall shall display the parameter whichever is under operation.

1.2.1.3 Provisions for controlling/integrating the object rotator positions by the Computed Tomography/Digital radiography acquisition Software shall be given for automation.

1.2.1.4. Roller material shall be radiation compatible and shall not be worn out easily.

1.2.1.5. Suitable lifting lugs may be provided at the ends for shifting the object rotator using crane for maintenance.

1.3. ROTARY TABLE:

Rotary table is required for rotating the object w.r.t vertical axis during radiography. Object should rest on the table without any relative movement. Suitable T-slots/clamping mechanism is to be provided. Maximum height of the item expected to be positioned for radiography is 3 m.

There should be mechanism for accurate positioning/auto centering of the job with respect to the table centre.

1.3.1 Specification for Rotary Table

Object Diameter- 150 to 2000 mm

Object Height- 3000 mm

Maximum Weight – 8 T

Parameter	Description
DIMENSION OF THE ROTARY TABLE	
Table diameter	2500mm
Height from FFL	750 mm

Surface flatness	0.2 mm
Job Rotation	Absolute Encoded rotation about axis of object from Home Position
Rotation about Z axis	0 ⁰ to 360 ⁰ in steps of 0.05 ⁰ (micro) to 1 ⁰ (macro) (Whole range)
Rotation speed	0.05 to 1 rpm- System controllable
Rotational accuracy	± 0.1 ⁰
Mechanical drive(rotation) and its control	Any suitable mechanism that could deliver accurate rotation.
Electrical Drive for rotation	Flame Proof Servo Motors(suitable for zone 1)
Position Feedback	Absolute Encoders
Material of construction	IS 2062- Grade E250 Steel for general structural purpose

NOTE:

1.3.1.1 For rotary table flame proof absolute encoder is required to provide feedback to the Control system. Once object is positioned, auto centering options shall be given (optical provisions) and Default Home Position may be attained. Accuracy of motion shall be demonstrated at work site in presence of VSSC person.

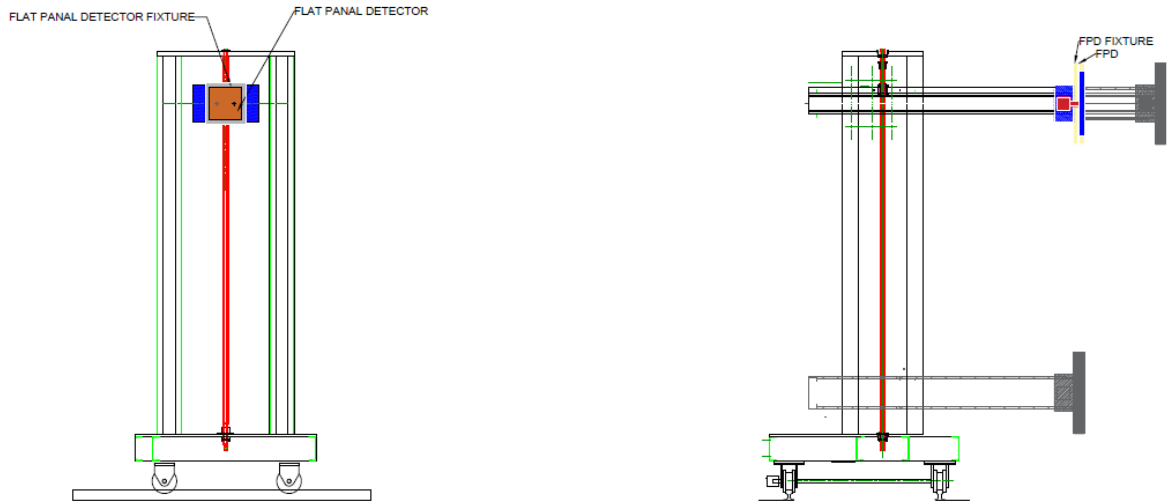
1.3.1.2 Remote HMI station in the Hall/Control Room shall have interchangeable provision to control and display the angle of rotation and speed of rotation of the object and real-time feedback of the positions shall be available to the system. Local HMI in hall shall display the parameter whichever is under operation.

1.3.1.3 Provisions for controlling/integrating the rotary table positions by the Computed Tomography/Digital radiography acquisition Software shall be given for automation.

1.3.1.4. Two triangle finish over rotary table-the better Face-out (<0.1 mm) and run-out (<0.1 mm) for rotary table is preferable.

1.3.1.5. Markings of concentric circles of various diameters shall be made on the surface of rotary table which shall be laser etched. The concentric circles shall be provided for diameters 150, 300, 500, 750, 1000, 1250, 1500, 1750, 2000, 2250 mm respectively.

1.4 FLAT PANEL DETECTOR HANDLING SYSTEM



Flat Panel detector (FPD) of approx. size 420 mm (l) x 420 mm (b) x 30 mm (t) shall be used for Digital radiography as per the specification provided. The FPD has to be positioned safely in a Holding mechanism that is shielded by around 110 mm thick lead block at front side and back side and by around 50 mm thick lead blocks at sides, top and bottom with provisions for smooth cable entry. The overall weight of FPD with its holder and lead shielding could be around 600 kg approx. (Actual Weight may vary slightly based on shielding weight). The FPD Handling system shall be designed to move in desired horizontal (to &fro from the object(Y) and across the job (X)) and vertical direction (Z). The FPD positioning may be done with HMI in hall/remote HMI from control room. Provisions for controlling the whole motion by a centralized system that can be synchronized with the movements of LINAC, Object rotator and Rotary table is required with precision mentioned in movement under each system for automating the whole system to carry out Computed Tomography/Digital Radiography.

1.4.1 Specification for FPD Handling Unit

Parameter	Description
Vertical up/down(Z-axis) movement	750 mm to 4000 mm from FFL
Speed of Z-axis movement	50 mm/min (micro) to 1000 mm/min (macro)
Accuracy of movement	±0.25 mm
Horizontal movement along length of object (X-axis)	9000 mm
Speed of X-axis movement	50 mm/min (micro) and 1000 mm/min (macro)
Accuracy of movement	± 0.25mm

Movement, to &fro (Y-axis)	1300 mm
Speed of Y-axis movement	50 mm/min (micro) and 1000 mm/min (macro)
Accuracy of movement	± 0.25 mm
Mechanical drive(X-axis)	Rail(suitable CR profile) & Wheel(double flanged), Hardened steel(BHN-250 to 300)
Mechanical drive (Y and Z Axis)	Double nut recirculating Ball screw with guide rods (hardened steel with HRC-50 (min.))/ any other suitable mechanism that can provide accurate movement. There should be provision for locking the position in Z axis during CT image capturing
Electrical Drive (X,Y and Z Axis)	Flame proof Servo Motors(suitable for zone 1)
Position Feedback	Absolute Encoder in addition to physical devices such as limit/proximity switches are to be provided for fault diagnosis & safety.
Material of construction	IS 2062- Grade E250 Steel for general structural purpose
Anti-Vibration Requirements for Radiography	Visco-elastic padding can be used in structure for damping vibration towards avoiding image blurring.

NOTE:

1.4.1.1.HMI station in the Hall/remote HMI in the Control Room shall have interchangeable provision to control and display the position and speed along X, Y & Z directions.

1.4.1.2.HMI controlled motorised shutter system with lead shielding and swiveling option from 0⁰ to ±90⁰ w.r.t Y axis.

1.4.1.3. Anti-collision interlock to avoid collision between FPD and Object Rotator/Rotary Table/Job. Required sensors for maintaining min gap between FPD and Object Rotator/Rotary Table/Job shall be there and motion controlled through software. Minimum gap shall be mentioned specifically and cut off shall happen once that gap is reached.

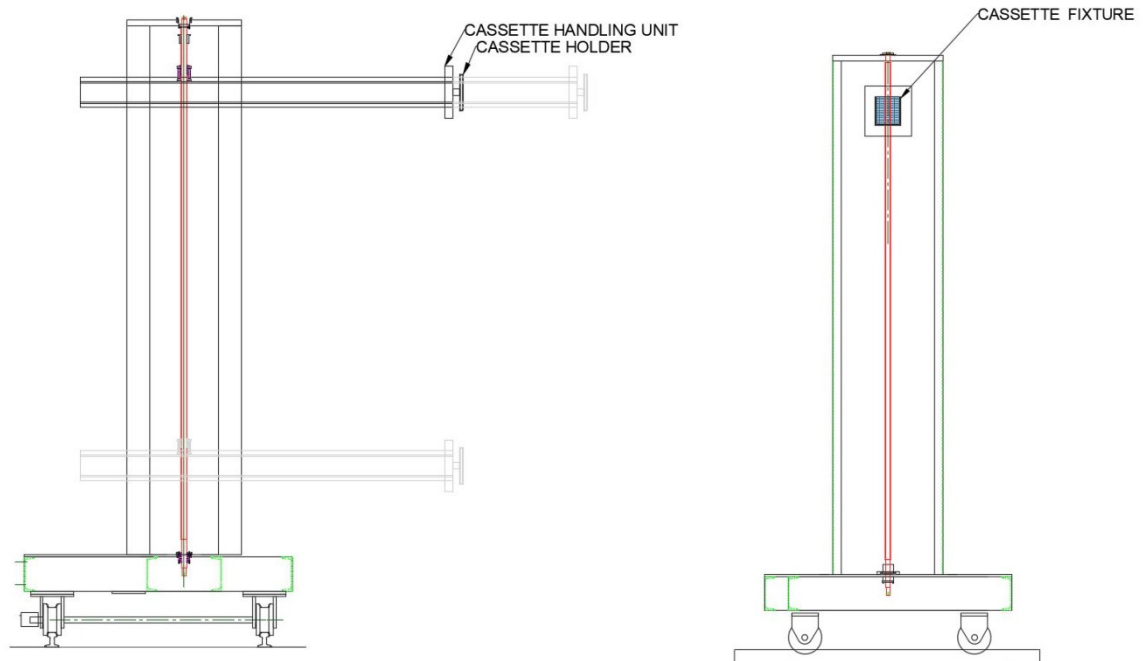
1.4.1.4. Limit switches at the extremities of X, Y and Z travel. Mechanical stopper wherever possible.

1.4.1.4. FPD handling system shall be designed preferably for an SWL of 600 kg approx. Proper counter balancing positions at extreme points shall be defined.

1.4.1.5. Vibration arresting mechanism is to be designed to dampen the vibration in 30 seconds.

1.4.1.6. Suitable Templates made of lead plates should be provided to shield the directly exposed areas of FPD during radiography. (For non uniform job peripheries, as per the profiles given by VSSC).

1.5 FILM CASSETTE HANDLING UNIT



A Film Cassette holder unit with arm is to be provided that can be moved manually for positioning the X-Ray film cassette. The movement of the cassette in X direction will be achieved by the movement of the unit on the rails, Y movement by up and down movement of the arm and Z movement by the telescopic movement of the Cassette holder. The cassette holder shall have two separate grooves for inserting X-Ray film cassette of dimension 420 mm X 310 mm X 20 mm (thk.) and weighs around 5 kg. The cassette holder shall have rotation option through 180⁰ for changing the orientation of the cassettes.

1.5.1 Specification for Film Cassette Handling Unit

Parameter	Description
Vertical up/down(Z-axis) movement	750 mm to 3000 mm from FFL
Horizontal movement along length of object (X-axis)	9000 mm
Movement, to &fro (Y-axis)	1300 mm
Material of construction	IS 2062- Grade E250 Steel for general structural purpose

2. FLAT PANEL DETECTOR FOR HIGH ENERGY RADIOGRAPHY WITH INTEGRATED COMPUTED TOMOGRAPHY

2.1. The digital flat panel detector of X-rays shall be based on Amorphous Silicon sensor operating as a two dimensional photodiode array.

2.2. Flat panel detector shall be suitable for static/dynamic digital X-Ray imaging of objects and X-ray energies up to 16 MeV.

2.3. The detector shall be capable of usage for Digital Radiography and Computed Tomography applications.

2.4. FPD shall have motorized shutter system operated from remote HMI in the Control room for preventing direct exposure of active area of detector. Motorized movements of four jaws system for opening and closing of shutter system. Swiveling provision of entire shutter system from 0 deg. to +/- 90 deg. shall be given..

2.5. Lead template plates of sufficient thickness of various curvatures shall be provided to shield the detector area where direct exposure may fall during radiography of curved or smaller components. Suitable provisions for attaching the same shall also be provided in the collimator setup.

2.6. Specification of Flat Panel Detector

a)	Detector	: a-Si (Amorphous Silicon)
b)	Scintillator screen	: DRZ Plus or higher
d)	Pitch	: $\leq 140 \mu\text{m}^2$
e)	Active pixel area	: $\geq (420 \text{ mm (horizontal)} \times 420 \text{ mm (vertical)})$
f)	ADC	: ≥ 16 bits
g)	Data Output	: Gigabit Ethernet
h)	Dynamic range	: ≥ 77 dB
i)	Response non uniformity	: $\pm 2 \%$
j)	Total number of underperforming pixels	: $\leq 0.5 \%$
k)	Image Resolution	: ≥ 3 lp/mm
l)	Frame rate per second	: 4fps @ 1x1 binning and 15 fps @ 2 x 2 binning
m)	X-ray Radiation energy range	: 20 kV – 16 MV or above
n)	Cable length from Detector to Computer	: ≥ 60 m

2.7. IMAGE ACQUISITION SYSTEM FOR DIGITAL RADIOGRAPHY/COMPUTED TOMOGRAPHY

2.7.1 The softwares for image acquisition and CT reconstruction features are to be provided with following capabilities.

2.7.2. The software shall support functions for acquisition of a single frame/sequence of frames/or continuous frames.

2.7.3. It should have provision for Automated acquisition of projection data from CT manipulators for performing 3D reconstruction. It should support cone beam, fan beam & parallel beam CT.

2.7.4. It should have provision for stitching the 2D images for bigger objects (objects handled mostly is 300 mm to 1500 dia) for CT reconstruction.

2.7.5. The imaging software shall have provisions for cross-sectional imaging of components for carrying out 3D Computed Tomography. This cross-sectional imaging software may have individual modules as given below:

- i. **Acquisition Module:** Shall be compatible with standard flat-panel detector (FPD) available in the market and interface with motion controllers and other electronic control systems. Other provisions may include (a) configuration and storage of scan settings for given imaging setup, (b) on-line visualization of projections acquired during scanning, and (c) storage of acquisition parameters and projections for post processing & analysis.
- ii. **Calibration Module:** It should be able to retrieve all geometrical parameters required for CT reconstruction. Should have built in calibration features like offset correction, gain correction, bad pixel correction, automatic scan geometry corrections (horizontal, vertical detector offset and axis tilt correction) etc.
- iii. **Reconstruction Module:** It should have provisions for pre-processing and image reconstruction: (a) loading of stored projections for pre-processing, (b) availability of 2D imaging filters to preprocess acquired projections before reconstruction, (c) attenuation image computation, (d) correction for beam hardening, scatter, misalignment, denoising metal & ring and other software based artifact corrections, etc. (e) quick reconstruction using cone beam Reconstruction algorithm and (f) reconstruction using Iterative algorithms.
- iv. **Visualization Module:** It should have provisions for (a) simultaneous rendering of Front, Side, Top and 3D volume views, (b) easy opacity and transparency manipulation, (c) synchronized volume slicing at arbitrary angles, radial and spherical cropping in 3D, choice of rendered views, measurement tool, generation of video etc.
- v. **Analysis Module:** It should have provisions for (a) Interactive length measurement with line and box cursors (b) Interactive analysis - region of interest, operations on individual points, statistics etc. (c) volume manipulation with filters related to noise reduction, edge detection, segmentation, volume enhancement, registration etc.

2.7.6. It should have Line Profile tool -To plot the variations of intensity along a line helpful for examining boundaries of components, and quantifying the magnitude of intensity variations.

2.7.7. All standard image processing tools such as-Interactive windowing, Grayscale invert, Zooming, Flip/Rotate, ROI tool, Magnifier, Pointer, BNC, Reference image viewer, thumbnail views & 3D plotting etc.

2.7.8. Provision for selection of integration times, selection of gain setting, selection of trigger modes, calibration procedures to acquire offset and gain correction files and perform real-time (On-Board) corrections for offset correction, multiple gain correction with up to 10 signal levels and Pixel correction. The First Image shall be omitted while CT reconstruction takes place. The

software also should have image quality improvement provisions like beam hardening correction (in single material or multiple material jobs) and Artifact Reduction tools such as Iterative Artifact Reduction (IAR).

2.7.9. The software shall have provisions for dimensional measurement of features and defects from images.

2.7.10. The images should be DICONDE compatible with provision for storing in multiple formats. It should have the facility to calculate detector characterization parameters such as SNR, CNR etc.

2.7.11. For detector calibration and qualification viz., bad pixel map, gain-offset correction, the FPD shall comply with ASTM E 2597, 2736.

2.7.12. Software shall have features in compliance with ASTM E2699, 2339 for image archival, sharing, image tag and storage.

2.7.13. Supplier shall demonstrate radiographic sensitivity of 1-2T and image resolution with 6MeV X-ray system available at the site.

2.7.14. The software also shall have provision to confirm the details of underperforming pixels as furnished in the Test certificate for FPD.

2.7.15. The supplier shall extend necessary support for interfacing with the standard microcontroller of an object manipulator of the purchaser

WORK STATION AND IMAGE DISPLAY REQUIREMENTS

1) Acquisition Module Work Station configuration		
a.	Processor	4th Generation Intel Xeon Scalable Processors
b.	Board	Asus Rampage V Edition 10 or better
c.	RAM	128 GB RAM (PC will be mostly involved in Digital radiography and image processing for interpretation)
d.	GPU	NVidia Quadro RTX 6000, 24GB dedicated video memory GPU or better (4 nos)
e.	Storage cabinet	8TB SSD (2 TB * 4) in the RAID 1 configuration and a normal optical 2TB HDD for regular usage. (Essential since Digital Radiography involves continuous imaging and storage of images). Each image (flight data) to be stored for min. 5 years.
f.	Operating System	Windows 10 ultimate or Windows 11 or better
g.	Monitor	Standard LED Colour Monitor-27 inch, Dual video display provisions – 2 Nos. with Display sharing options
h.	DVDRW drive	With DVD writer
i.	Essential ports	USB 3.0 ports or better , Video Input terminals: DVI-D (dual Link)x 1, Display Port x 2, HDMI port

j.	Additional Storage of Data and back up	Suitable Multi Bay Network attached Storage (NAS) with 256 TB(16 x 16TB) storage with RAID 10 configuration.
k.	Warranty	3 years onsite warranty shall be provided
l.	Microsoft Office and Adobe Acrobat Reader latest with license installed	
m.	Computer Table for positioning the Acquisition Workstation	
n	Provisions to transfer data to 3D CT Reconstruction Work Station or a Super Computer System	

2) 3D CT Reconstruction Work Station configuration		
a.	Processor	Intel Xeon Platinum 8460Y processor. Min. 105MB Cache, 40 Core, 4 th generation scalable processor
b.	Board	Asus Rampage V Edition 10 or better
c.	RAM	768 GB RAM or better, provisions to improve RAM capacity to be given.
d.	GPU	NVidia Quadro RTX 6000, 24GB dedicated video memory GPU or better (4 nos)
e.	Storage cabinet	8TB SSD (2 TB * 4) in the RAID 1 configuration and a normal optical 2TB HDD.
f.	Operating System	Windows 10 ultimate or Windows 11 or better
g.	Monitor	32" 4K Colour Monitor for Dektop Interpretation and 55" 4K Colour Monitor for displaying large group of images mounted on the wall. 55" Monitor shall be a mirror of 32" screen.
h.	DVDRW drive	1 No. with DVD writer
i.	Essential ports	USB 3.0 ports, Video Input terminals: DVI-D (dual Link)x 1, Display Port x 2, HDMI port
j.	Additional Storage of Data and back up	Suitable Multi Bay Network attached Storage (NAS) with 256 TB(16 x 16TB) storage with RAID 10 configuration.

k.	Warranty	3 years onsite warranty shall be provided
l.	Microsoft Office and Adobe Acrobat Reader latest with license installed	Yes
m.	Computer table for positioning 3D reconstruction Workstation	
2) Display system for X-ray images		
a.	Display system.	12 MP Colour Diagnostic High-resolution LCD Display Monitor (31")
b.	Native resolution	4200 x 2800 (3 : 2 Aspect Ratio)
c.	Viewable Image Size-	650 x 430 mm or better
d.	Brightness	1200 cd/m ²
e.	Viewing Angles:	178° (Right/Left)/178°(Up/Down)
f.	Contrast ratio -	1500 : 1
g.	Essential ports	Video Input terminals: DVI-D (dual Link)x 1, Display Port x 2, HDMI port
h.	Interfacing Cables	Suitable interfacing cables are to be supplied to connect to PC to transfer Data and Power
i.	Screen	Anti-Glare and Anti Reflection coated for continuous interpretation by operator.
Essential CT modules with artifact reduction, scatter correction and beam hardening correction tools		
a.	CT Reconstruction Basic	CT Reconstruction Basic including a three-year update/service agreement.
b.	CT Reconstruction (Cone Beam, Fan Beam, Parallel Beam)	CT Reconstruction (Cone Beam, Fan Beam, Parallel Beam) including a three-year update/service agreement.
d.	CT Reconstruction modules for Composites & Plastic, Dongle License	Composites & Plastic Dongle License, the add-on modules Coordinate Measurement, Nominal/Actual Comparison, Wall Thickness Analysis, Porosity/Inclusion Analysis, Fiber Composite Material Analysis, and a three-year update/service agreement.

3. GENERAL

3.1. All mechanical structure and components shall be designed with factor of safety of 3 (min.) on yield strength. Factor of 3 can be shown in calculations however load test has to be carried out at 1.25 times of SWL. Design of all the structural members shall confirm to IS 807 and 3077.

All the movements in horizontal, vertical & curved paths (except rail-wheel) are to be provided via Linear Motion (LM) guides. The LM guides shall be of good quality conforming to THK C5 or equivalent standards. The grooves for fixing the LM guides should be such that required parallelism can be achieved. The LM guides are to be covered with bellows for protection against dust. All the rail sections where movements using rail-wheel is to be used shall conform to IS 3443. All LM guides shall have foldable flop type coverings.

3.2. All the vertical and horizontal movements are to be achieved by flame proof Servo Motors with absolute encoders. Proximity & safety limit switches and end building blocks/stoppers are to be provided at extreme ends.

3.3. All the motions has to be such that all manipulator subsystems can be moved to any distance required within the specified range by giving proper commands through PLC/SCADA.

3.4. There shall be a provision of brass etched scale with LC 5 mm to read the position of all movements wherever possible.

3.5. Each system shall be provided with proper lifting arrangement through lifting lugs/eye bolts to lift the entire manipulator by an overhead crane.

3.6. All support structure has to be properly grouted and leveled during installation.

3.7. All electric connection shall be flame proof/enclosed type for field mounted accessories and installation. Insulation class of all the electrical motors shall be F or better and Duty:S4.

3.8. All the motors shall be flameproof Ex-d and confirm to hazardous area classification i.e. zone 1, Group IIA, IIB. Temperature classification T4 with inverter duty, embedded thermistor in the motor winding.

3.9. All the motors used should be designed to consume only upto 80% of rated current. All the electrical motors used in each sub system shall be able to achieve the required speed of motion in addition to bearing the load. If it fails during testing and installation it shall be completely replaced by motor of higher grade along with all the required accessories.

3.10. All details/dimensions are given for reference purpose only. The actual dimensions will be as per final design drawings submitted by the party.

3.11. Encoder shall be flame proof. It shall be absolute encoder/resolver to show the position. If absolute flame proof encoders are not available party can use explosion proof absolute encoder.

3.12. Proximity limit switches (Sensor) of intrinsically safe with suitable IS barrier interface. Soft limit using encoder information can be redundant limit switch for hard wired (Through PLC software). (One important point which needs to be taken care in this issue is both L/S shall not be in series, and operate one relay. Both the L/S shall form two independent circuit

and operate two relays. This is required because in case of malfunctioning of relay the purpose of redundant L/S gets defeated.)

3.13. For all the subsystems of the manipulators, the operation philosophy should be Local (by portable pendant/HMI) and remote selection (by PLC/SCADA screen in Control room) through key way switch. Key shall be available in that particular mode to avoid duplicate operation and digital control switching to Hall/Control room shall be adopted.

3.14. For each sub system, proper cable management system shall be designed. Cable chain system shall be of IGUS make.

4. CONTROL SYSTEM

4.1. The system shall have two HMI units to control the operation of the manipulator system one inside the equipment bay (Local control) and another one in the control room (remote control) which is few meters away from the equipment bay. The local control system (HMI) situated inside the equipment bay shall be either pendant type or a fixed installation. Control room manipulator motion may also be integrated with Computed Tomography Acquisition system software for automated capture of images as per requirements of CT system.

4.1.1 Control philosophy:

Command from SCADA and local HMI (local control station inside equipment bay) should be given as input to PLC and command from PLC drives the motor. The system shall be designed such that the PLC shall monitor and control the individual system associated with the manipulator system. Process will be monitored through the graphic and data display of the HMI station located in the adjacent control room and from the equipment bay. The system shall also be designed so as to ensure high system availability, easy maintainability and build in safe operation and fault diagnosis facility. Provisions to link the SCADA system to CT software and use the manipulator system for Automated capture of CT images shall be adopted.

4.1.2 Emergency stop push buttons shall be provided inside the equipment bay and in control room.

4.1.3. All control circuit in local HMI and DPM/display shall be of intrinsically safe (EX-i) with suitable IS barrier (P&F and MTL or equivalent make).

4.1.4. Master license for PLC & SCADA development along with detailed program documentation is to be supplied.

4.2. Visualization system

The visualization system (HMI station) shall be two (2) nos. non – industrial and shall serve as operator interfaces for control, monitor and data acquisition of the system. The visualization unit shall communicate with the processor of the PLC on Ethernet communication bus through the layer – 2 switches.

The HMI station shall be provided with Ethernet card. The HMI station shall perform all functions of operator station as well as engineering station. It shall have provision of HMI development and PLC programming facility.

The party shall supply three numbers of cloned hard disks (same model and make with software loaded) and mother boards each as standby to the remote control station i.e PC based HMI station. Party shall also supply 3 Nos. of local HMI stations with software pre-loaded as standby.

Party shall provide upgradation of HMI software as and when available for a period of atleast 3 years.

6. ELECTRICS

6.1 SCOPE

6.1.1 The linac manipulator system and its PLC/SCADA based control system will be in two separate rooms. There will be a main room where the required power supply will be available. PLC/SCADA control system and motor control centers (MCC) will be housed in control room. The specified distances indicated in the layout drawing of the building.

Local control stations shall be provided as required for local operations as well as to meet regulations as per IE rules.

6.1.2 The surface temperature of electrical equipment, located inside process/storage plant unit, shall not exceed 100 °C.

6.1.3. The description of the electrical equipment is as in subsequent clauses.

6.2 FLAME PROOF SERVO MOTOR

6.2.1 All motors are essentially to be enclosed, flame proof and dust tight type.

6.2.2 The motors shall have standardized dimensions and ratings strictly conforming to IS 1231 for foot mounted, IS2223 for flange mounted and IS2254 for vertical shaft motors.

6.2.3 The technical features of Servo Motors shall be as specified below:

Parameter	Description
Quantity	As required
Type of motor	Flame proof Servo Motors with absolute encoders
Encoder	Intrinsically safe absolute encoder /resolver
Duty class	As required
Rated voltage	415 V, 3 – PH, 50 Hz
Maximum rpm of motors	1500

Class of insulation	F
Temperature rise	95° C by resistance method above an ambient temperature of 45 ° C
Degree of protection	Type B dust tight enclosure as per IS 11005 for motors located in process room with brake and other attachments.(IP 65 or better)
Form of construction	IM 1001 for motors without attachments and IM1002 for motors with brake and other attachments.
Accessories	As required including suitable guard or free shaft ends and couplings.
Other requirements	<p>The surface temperature of the motors located in the process buildings shall not exceed 100 °C.</p> <p>Adequately sized terminal box suitable for terminating, 1.0KV PVC insulated, PVC sheathed, multicore cables with aluminium conductors considering derating for cables in air as per IS 3961</p> <p>Motors shall be provided with integral feet.</p> <p>Dust tight terminal box as per type B enclosure conforming to IS 11005 shall be provided</p> <p>Two earthing terminals shall be provided</p> <p>Lifting hooks/lugs shall be provided.</p> <p>Motors shall be dynamically balanced to comply IS 12075, including the amplitude of vibration.</p>

6.2.4. Proximity limit switches (Sensor) of intrinsically safe with suitable IS barrier interface. Soft limit using encoder information can be redundant limit switch for hard wired (Through PLC software). (One important point which needs to be taken care in this issue is both L/S shall not be in series, and operate one relay. Both the L/S shall form two independent circuit and operate two relays. This is required because in case of malfunctioning of relay the purpose of redundant L/S gets defeated.)

6.3 CABLES AND CABLING ACCESSORIES

6.3.1 All power and control cables essentially to be radiation shielded.

6.3.2. All power and control cables shall be 1.1 KV grades, PVC insulated and PVC sheathed with special flame retardant smoke less properties, conforming to IS:1554 Part 1.

6.3.3 The power cables shall have electrical grade purity standard aluminium conductors and all control cables shall annealed high conductivity standard copper conductors.

6.3.4. All special cables including screened cables, twisted pair cables etc. required for signals, sensors, instruments, etc. along with the termination accessories as required shall be included in the scope of supply.

6.3.5. The cables shall be suitably derated for site ambient of 45° C and cable grouping as per IS:3961. Cabling materials and accessories shall include supporting steel work, racks, trays, cables identification tags, cable jointing and termination kits, clamps, pipes and fittings as required for complete installation of the equipment covered by this specification. No cable joints shall be provided.

6.3.6. Cable harnessing for field wiring is through connectors

6.4. EARTHING MATERIALS AND ACCESSORIES

6.4.1 Equipment earthing shall be provided as per IS 3043 and shall meet the stipulations of IE Rules. Insulated cables shall be used as earthing conductors. Conductors for equipment earthing shall be provided by the purchaser, running along the building periphery.

6.4.2. All equipment shall be earthed by connecting it to the nearest earth grid by two separate conductors.

6.5. MAKE OF ELECTRICAL EQUIPMENT

Recommended makes of electrical equipment are given in Annexure -3

6.6 TOOLS

All tools as specified below shall be provided. All tools shall be of preferred makes as per Annexure – 3.

- i. Soldering Gun (1 No.)
- ii. Greasing Gun and oiling Gun (1 No. each)
- iii. Double Ended spanner set (1No.)
- iv. Ring Spanner Set (1No.)
- vi. Allen Key Set (1No.)
- vi. Socket Spanner Set (1No.)
- vii. Socket accessories such as Ratchet handle, T-handle, Extension bar 6', Universal Joint (1No. each)
- viii. Torque wrench (Ratchet Type) 0-250Nm capacity (1No.)
- ix. Tool box for proper storing & handling of all above tools.

ANNEXURE-2

LIST OF RELATED REGULATIONS STANDARDS AND CODE OF PRACTICE

S. No.	CODE number	Title
1	IS: 2062-1992	Steel for general structure purpose
2	IS : 1239 (part 1) 1990	Mild steel tube, tubular and other wrought steel fittings
3	IS : 1239 (part 11) 1992	Mild steel tube, tubular and other wrought steel fitting
4	ANSI B 16.9-1993	Forged steel fitting socket welding fitting
5	Electricity rules and acts	Indian Electricity rules 1956 and Indian electricity act 1910 with amendment issued time of time .
6	IS : 3034 - 1993	Fire safety of industrial building : Electricity act 1910 with amendment issued time to time
7	IS : 9537 (Part1)1981	Conduits for electricity installation part 1 general requirement
8	IS : 732 – 1989	Code of practice for electricity wiring installation
9	IS : 994 – 1990	PV insulated cable for working voltages up to and including 1100 V.
10	IS : 9537 (part 2) 1981	Conduits for electricity installation part 2 rigid steel conduits.
11	IS : 1554 (part 3)1988	PVC installation (heavy duty) Electric cables: part 1 for working voltages up to and including 1100 V
12	IS : 2309 – 1989	Conduits for electrical installation : part 3 rigid plain metallic conduits for insulating materials.
13	IS : 3070 (part 1) 1985	Practice for the protection of building and allied structure against lightning – code of practice
14	IS : 3070 (part 1) 1985	Lighting arresters for alteration current system : part 1 Non liner resistor type lighting arresters
15	IS : 8239 – 1976	Classification of minimum surface temperature of electricity equipment for the use in explosive atmospheres
16	IS : 7389 – 1974	Pressurized enclosure of electric equipment for use in hazardous areas.
17	IS : 7389 – 1980	Intrinsically safe electrical apparatus send circuits
18	IS : 7689 – 1989	Guide form control of undesirable static electricity
19	IS : 3043 – 1987	Guide for control undesirable static electricity
20	IS : 8374 – 1977	Bitumen mastic anti static and electrically conducting grade
21	IS : 5571 – 1979	Guide for selection electrical equipment for hazardous areas
22	IS : 6381 – 1972	Construction and testing of electrical apparatus with type of protection ‘e’
23	IS : 8289 – 1976	Electrical equipment with type of protection “n”
24	IS : 11005 – 1984	Dust tight ignition proof enclosure of electrical equipment.
25	IS : 3443 – 1980	Specification for rail sections

ANNEXURE – 3

PREFERRED MAKE OF ITEMS

The recommended makes of the equipment are given below:

1	MECHANICAL		
	LM Guides	:	THK/STAR/WARNER or equivalent
	Ball screw with nut		THK/SKF or equivalent
	Bearings	:	SKF/NEI/ABC/THK or equivalent
	Steel	:	TISCO/SAIL/JINDAL or equivalent
	Nut & Bolts	:	TVS/UNBRAKO/LPS or equivalent
	FRL	:	SHAVO-NORGEN/NUCON/VELJAN or equivalent
			HYDAIR/FESTO/ROTEX or equivalent
	Tools	:	TAPARIA/KPT/VENUS/NORBAR or equivalent
2	ELECTRICAL		
	Servo motors	:	SIEMENS/PARKER or equivalent
	Control Post	:	ABB/L&T/SIEMENS or equivalent
	Isolators	:	ABB/L&T/SIEMENS or equivalent
	Contactors	:	ABB/GE POWER/ L&T/SIEMENS or equivalent
	Bimetallic overload relays	:	ABB/L&T/SIEMENS or equivalent
	Electronic overload relays	:	SIEMENS/ROCKWELL/ABB/L&T or equivalent
	Cables	:	RPG/UNIVERSAL/FINOLEX/HAVELLS/TORRENT CABLES or equivalent
3	INSTRUMENTATION		
	PLC	:	SIEMENS-S7 300 or better
	HMI-PC	:	HP/IBM/DELL/SONY/SIEMENS or equivalent
	Proximity Switches	:	TELEMECHANIQUE/P&F/AG SYSTEMS or equivalent
	Encoder/Resolver	:	P&F/ROCKWELL/HUBNER or equivalent
	Flame Sensor/Detector	:	HONEYWELL/FIRE-EYE/KROM SCHODER or equivalent
	I/P Converter	:	YOKOGAWA/EMERSON/ABB/MOORE or equivalent
	Instrument Fittings	:	SWAGELOCK/FLOTECH/FCPL0 or equivalent
	Pendant display & indication lamp	:	BEKA or equivalent

ANNEXURE – 4

INSPECTION/TEST PROCEDURE FOR MECHANICAL EQUIPMENT AT MANUFACTURERS WORKS

Project : RPP/VSSC

Vendor's Name :

Supplier PO No. :

Specification No. :

Equipment Item/Description	Manipulator System
Quantity	
Lot No.	
Visual/Dimension Check	
Inspection during stages of manufacturing and assembly including checking of weld quality, parallelism of guide ways, planer checks	
Inspection during installation of equipment including parallelism check for guide ways, leveling of guide ways, dimensional checks	
Installation and commissioning: Test run with/without load To check the full range of motions on the guide ways Speed of motion on guide ways RPM check of rollers and objects of different dia and length Calibration of the equipment for required speed, roller synchronization, LINAC beam and film centre synchronization	
Submission of certificates for materials, NDT, stress relieving, bought out items from manufacturers, etc	
Submission of certificates from statutory authority	To be submitted by vendor

*= Report to be submitted duly endorsed by Supplier

0 = Inspection to be done by the inspection agency (Consultant/client)

Legends

1	Material test certificates for components showing chemical composition and physical properties shall be submitted
2	Manufacturer's test certificates for standard/proprietary/bought out items shall be submitted.
3	Welding Procedure Specification (WPS), Procedure Qualification Record (PQR), Welder's Performance Qualification Record (WPQ), Weld NDT History Record (WNHR)/Non-destructive test reports (NDT) including radiographic films showing location & sketch, Heat treatment/Stress relieving certificates showing Time-temperature Curve as per governing specification shall be submitted.
4	All stage inspection reports including material identification, stamp transfer, weld joint fit up, material and weld traceability sheets shall be submitted.

General notes:

1. Split-up of cost should be provided for the following sub-systems as per template attached in E-procurement portal.
2. Painting Certificates to be submitted.
3. Valid calibration certificate for inspection, measuring and test equipment used during inspection and traceable NPL/ERTL shall be submitted along with Inspection Call or during inspection.
4. Party shall demonstrate the Digital radiography and 3D Computed Tomography on items at VSSC.
5. Three sets of test certificates duly verified and signed by the Supplier shall be furnished prior to / during/ after inspection.
6. Party shall have experience in executing projects related to Low Energy/High Energy 3D Computed Tomography systems for industrial applications. Party shall submit a list of projects executed at various organizations with details of its performance

-----END-----