

TENDER DOCUMENT
FOR
80 K HELIUM GAS SUPPLY SYSTEM

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1. INTRODUCTION

The Institute for Plasma Research is establishing a large Cryopump System This system has many subsystems/components like large radiation shield, baffles etc. These subsystems and components are to be continuously cooled and maintained at the nominal temperature of 80 K absorbing all the heat transmitted to them. In order to meet this requirement, an 80 K Helium Gas Supply System is to be established near to the Cryopump system at IPR. It is proposed to establish this system by competent outside agency. This document gives the functional requirement, description of the envisaged system, salient specification of the major equipments & components, the requirement of establishing and commissioning the system, the quality assurance plan etc.

2. FUNCTIONAL REQUIREMENT

The helium supply system shall be designed to following requirements. The system to be cooled such as radiation shield, baffles etc are hereafter referred as Thermal System (TS).

Inlet temperature of GHe to Thermal System	: 80 K
Maximum outlet temperature oh GHe from TS	: 85 K
Operating Heat Load on Thermal System	: 5 kW
Operating flow rate of GHe	: 200 g/s
Design flow rate of GHe	: 220 g/s
Operating Pressure in helium circuit	: 1.5 MPa (g)
Pressure drop in the system load at 200 g/s	: 0.05 MPa.

In addition to the heat load of Thermal System, the heat in-leak to the helium supply system through the helium circulator, the lines, valves & components etc are to be accounted in the design of cooling system. The heat leak load from the helium circulator is about **8.5 kW** and that from the pipelines & valves etc shall be limited to **1.5 kW**.

SYSYEM REQUIREMENT

Typical Heat load are –

Sr No	Description	Heat Load
1	System Load (Cryopump)	5 KW
2	Heat load from Cold Helium Circulator	8.5 KW*
3	Transfer line(Maximum)	0.5 KW*
4	Heat Loads from Valve etc	1KW*
5	Total	15 KW

The system shall be designed for a heat load of 20KW. The 80K circulator shall typically operate at nominal flow rate of 200 g/s.

**Nominal (Vendor to confirm and design the total system based on actual heat loads with 10 % margin.)*

The proposed system shall have provisions to regulate the flow rate of helium gas through the Thermal System from 20 g/s to the design flow rate of 220 g/s. During initial cooling of the system, the helium flow rate shall be kept in the lower range to avoid undue thermal stress as well as pressure oscillation in the Thermal System. The flow rate shall be increased slowly as the system gets cooled and shall reach the rated operating flow rate when the system is completely cooled. To meet this requirement, the helium circulator needs to have variable speed drive as well as the circuit shall have necessary flow control devices. During cooling of circuit, Thermal System and fluid in it with the approximate volume of 750 liters, cooled helium gas has to be supplied to the circuit.

The fluid circuits shall have provisions to clean the entire circuit including the Thermal System to bring down the moisture, nitrogen and oxygen contents compatible to helium circulator. The circuit shall have necessary safety provisions to protect circuit as well as the Thermal System from excessive pressure build up due to inadvertent heat in-leak or any other possible reasons. All the equipments, pipelines and components shall have the best thermal insulation so that the heat load on the cooler and thereby the consumption of coolant fluid during operation is kept minimum. The circuit will have an online moisture analyzer to analyze the moisture content in the gas being circulated. Though the operating pressure is 1.5 MPa, the circuit shall withstand the maximum possible delivery pressure of the circulator but the safety devices shall be rated for the operating pressure.

The helium supply system shall be designed in such a way that the entire operations except initial preparatory works can be carried out remotely from the command & control panel. The system shall have adequate instrumentation such as pressure transmitters, temperature sensors, flow meter etc so that the entire operations can be commanded from the console and the performance of all the equipments as well as the system can be remotely monitored from the control panel. The circuits shall have necessary built in control system to ensure smooth performance as well as safe functioning of the system & equipments.

3. SCHEMATIC DIAGRAM

A preliminary schematic diagram of the helium supply system is given in the annexure. This has to be developed into a complete working Process & Instrumentation Diagram (P&ID) incorporating all the functional requirements by the vendor while submitting the tender. The major subsystems are the following.

- Helium gas storage
- Helium circulator
- Helium gas circulator
- Liquid Nitrogen storage
- Fluid circuits comprising SI lines & flow components
- Command & control system

4. DESCRIPTION OF SUBSYSTEMS

4.1 Helium Storage

The helium gas is stored in required number of cylinders. The capacity of helium storage shall be sufficient for 5 filling of the entire circuit including the Thermal System at 80 K taking into account the

minimum required pressure in the storage cylinders to supply the make up fluid during cooling. The storage system shall have necessary pressure regulation & monitoring systems to maintain the required operating pressure in the circuits. Supply of required number of helium cylinders as well as helium gas for commissioning of the system is in the scope of bidder. Since the helium gas is passed through the circulator at 80 K, this gas shall be of high purity suitable for trouble free operation of helium circulator at 80 K. The required specification of the helium gas is given below.

Total purity	: $\geq 99.995\%$
Ne	: ≤ 23 ppm
N ₂ + Ar	: ≤ 14 ppm
H ₂ O	: ≤ 9 ppm (DPT 212 K)
Hydrocarbons as CH ₄	: ≤ 5 ppm
O ₂	: ≤ 3 ppm
H ₂	: ≤ 1 ppm
CO ₂	: ≤ 1 ppm
CO	: ≤ 1 ppm
Oil	: ≤ 3 mg/Nm ³

This specification is in line with Grade A of MIL- P-27407-A except for the additional spec on oil. Particulate matter shall be as per class 6.

4.2 Helium Circulator

The helium circulator is required to circulate the cold helium gas through the entire circuit including the Thermal System and the heat exchanger. It shall develop adequate DP to compensate for the pressure loss in the complete circuit at the design flow rate. It shall be directly driven from motor without coupling. It shall be hermetically sealed which eliminates the need for mechanical seal and ensures containment of process fluid and maximizes reliability. The circulator shall be located in a separate vacuum enclosure to minimize the heat in-leak in to the cold helium fluid during operation. It shall have required built-in safety system & sensors which ensure its safe operation. The details of built-in safety systems are to be brought out while bidding. The cold circulator shall be provided with a variable speed drive for remote step less control of the helium gas flow rate in the cooling loop. The electrical supply to the motor will be from 415 V / 240 V, 50-60 Hz AC supply. The power connection to the motor, signal from the sensors of the circulator shall be routed through prewired electrical feed thro connectors mounted on the vacuum chamber. Salient specifications of the circulator are given here.

Fluid : Single phase Helium

Operating suction pressure : 1.5MPa (g)

Operating delivery pressure : 1.65 MPa (g)

Maximum suction Pressure : 1.7 MPa (g)

Maximum delivery pressure : 1.8 MPa (g)

Operating flow rate	: 200 g/s
Maximum flow rate	: 450 g/s
DP at design flow rate	: 0.15 MPa.
Operating temperature	: 80 K
Compatible Temperature	: 80 K to 300 K.
Duty Cycle	: Heavy duty. The circulator will be required to operate for a month continuously.

Note: Though operating suction pressure & flow rate are only 1.5 MPa. & 200 g/s, higher maximum suction pressure & flow rate are given keeping future requirements in mind.

4.3. LN2 Heat Exchanger

The warm helium gas coming out from the Thermal System is at about 85 K and this will be further heated up to higher temperature depending upon the heat load in the helium circulator and the pipeline. This warm gas has to be cooled in the LN2 exchanger to a temperature less than 80 K so that the gas enters the Thermal System at 80 K. The required inlet & outlet temperatures are to be finalized by the bidder taking into account these heat loads. The design flow rate is 220 g/s. In addition, this exchanger has to cool the make up helium gas from 300 K to 80 K. This helium flow will be required during cooling of circuit & Thermal System. The required flow rate of this helium gas has to be estimated by the bidder.

The heat exchanger is suggested to be pool type where the cooling coil is immersed in LN2 pool. The volume of the bath shall be adequate to ensure complete immersion of the cooling coils and to hold adequate liquid for 8 hours of operation without filling LN2. The pool is kept at atmospheric pressure and hence the LN2 is at its boiling point at atmospheric pressure. The boil off nitrogen due to the heat load from the exchanger coil as well from the heat in-leak in to the exchanger is let into atmosphere. In order to minimize the heat in-leak to the exchanger, the bath shall have vacuum jacketed multilayer super insulation. It is provided with a level sensor of differential pressure type. The LN2 level in the bath is to be always maintained above the surface of the cooling coils by automatic filling system using the level sensor. Make up liquid nitrogen to the bath should be added from a stationary liquid nitrogen tank through an electro-pneumatic ON / OFF or control valve.

The bath will have pressure transmitter, overflow line, drain line etc. It shall have built-in safety systems such as relief valve & rupture disc. Though the operating pressure of the bath is atmospheric, it shall be designed for an internal pressure of 3 bar (g). The vacuum jacket should have static vacuum level better than 0.10 Torre at ambient temperature and expected to be less than ~0.005 Torre in operating condition filled with liquid nitrogen.

It is the scope of the party to supply a proper venting system with vaporizer to vent the cold gas, elevated to room temperature while venting to atmosphere.

4.4. LN2 Storage

The liquid nitrogen storage and its pressurization system from which the LN₂ is fed to the heat exchanger are in the scope of IPR. However the super insulated LN₂ lines along with necessary valves from the storage to the heat exchanger is in the scope of bidder. The distance between the storage and heat exchanger is about 60 m.

4.5 Flow Components and Pipelines

The valves such as manual, electro-pneumatic and control valves shall be from reputed manufacturers such as Velan, Burkert etc. All the valves are to be globe valves. The salient specifications for them are as follow.

Manual Valves

Size : As per line size
Type : Globe valve.
Pressure Rating : Based on MAWP given, supplier shall specify.

Stem extension: As per BS 6364 for all cryogenic valves.

Stem Seal (Dynamic) : By Bellows with redundant gland packing for all helium valves.
By gland packing only for LN₂/GN₂ valves

Jacket All cold helium and LN₂ lines shall have vacuum jacket with multilayer insulation.

Permissible leak across:
body 10^{-9} Pa – m³ / s for bellow sealed globe valves
 10^{-07} Pa - m³ / s for valves with gland packing.

Permissible leak : 10^{-07} Pa – m³ / s for resilient seated globe valves.
across seat

Material of Construction:

Body : ASTM A 182 F 304 L / A 351 CF 3
Bellows : Stainless steel 316 L / 316 Ti / 321/
Gland packing : PTFE
Plug and seat inserts : PCTFE (KElf) / Vespel / Polycarbonate

Design Code & Mfg : ASME B 16.34
Test code : ASME B 16.34
Tests : The valves shall have certificates for material, bellow cycle life test, hydraulic test, pneumatic test, MSLD leak test and function test

- Cleanliness: All the interior flow surfaces of the valves shall be degreased and cleaned for oxygen service..
- Marking: All the valves shall be assigned a tag number and the same shall be legibly attached to each valve.

Electro-pneumatic Valves

Every electro-pneumatic valve shall have the valve, pneumatic actuator, solenoid valve and two limit switches with the following salient specifications.

- Valves** : The specifications are as above.
- Actuator** : Single acting, spring return, diaphragm type. Normal instrument pressure is 0.45 to 0.6 MPa (g). Stroking time (full open to full close travel time and vice versa) for the valves shall be between 3 to 5 sec. Each actuator shall have a filter suitable for the actuator.

Solenoid Valve:

- Voltage: 24 +- 3 volt DC
Service gas: Air at 0.45 to 0.7 MPa.
Response time: 100 msec (max).
Current : 500 mA (max)
Service life: > 50,000 operations.
Time for continuous operation: 24 hours.
Operating temperature: 0 to 45 deg. C
Manual override: To be provided by a screw.

Limit Switch

Every valve shall be provided with a pair of switches for ON/OFF positions. The limit switch shall be actuated by valve stem position. Each limit switch shall have two pairs of change over contacts; each rated for interrupting 1 amps at 240 V AC & 48 V DC. Contact capacity is 0.25 An on resistive circuits for at least 1 million operations. The limit switches shall be housed in weatherproof NEMA 3 enclosures with gasket covers. Enclosure classification shall be of IP-65. These limit switches shall be suitable up to 70 C.

Control Valve

The control valve shall have a valve, actuator, two limit switches, air filter & regulator, electro-pneumatic convertor and electronic position transmitter. The specification for valve is same as before except that the leak tightness across the seat is class VI for the resilient seat and the valve plug is of equal percentage characteristics. Specifications for actuator and limit switches are same as above.

Air filter & Regulator: Diaphragm relieving type, 5 micron & case is as per IP 54.

Electro-pneumatic Converter: The valve positioner shall operate in conjunction with pneumatically operated control valve and its pneumatic actuator. Its features shall match the requirements of the control valve. The positioner shall have the flexibility of changing its action from direct to reverse and vice versa at site.

Accuracy-0.5 % of span, linearity- 0.25 % of span, repeatability- 0.25 % of span, response time \leq 0.2 s, input resistance \leq 200 ohms, case is as per IP 65 vide IS 2147, air supply 1.4 bar, output air capacity 6 Nm³/hr.

- i. The positioner will be supplied with dry compressed air at 1.4 kg.cm² (gauge) pressure under normal condition, but be capable of full stroking of the valve even when the supply pressure drops to 1.1 kg/cm² (gauge). The positioner shall balance the input signal with the valve stem position to obtain accurate positioning action.
- ii. Electro-pneumatic positioners shall be suitable for input signal range of 4-20 mA DC unless otherwise mentioned in the valve specification sheet. The maximum input impedance shall not exceed 600 ohms.
- iii. The output signal shall be proportional to the input signal through out the range. Linearity shall be better than \pm 1% of the output span.
- iv. Repeatability and threshold sensitivity shall be better than \pm 0.05% of the output span.

Electronic Position Transmitter

The position transmitter shall be as per the following specifications.

- i. Two-wire position transmitter shall deliver 4-20mA DC output into a load of 500 ohm (min.) at 24V DC supply
- ii. Protection class shall be of IP 65.
- iii. Material (base) shall be of Aluminum alloys.
- iv. Sensing device shall be of LVDT type.
- v. This electronic position transmitter should qualify 70 ° C operations. Tests shall be done as per IS 9001.

Pipelines

All the cryogenic pipelines shall be vacuum jacketed super insulated lines. The material of construction is SS 304 L. They shall be provided with bellows in the inner line to compensate for thermal contraction of the lines during low temperature operation. The line shall be provided evacuation cum vacuum measurement port. From the application to the circulator, approximate distance is about 50m, hence vendors can quote for pipelines about 150 m considering inlet, outlet and safety factor.

4.6. Transmitters & Sensors

The P&ID for the helium supply circuit shall have the required monitoring instruments such as pressure transmitters, temperature sensors, flow meters, level sensors, moisture meter etc so that the entire operation can be carried out remotely and its performance can be continuously monitored and recorded. Also the helium circulator shall have tachometer to monitor its speed. Salient specifications of some of these instruments are given for reference. However, detailed procurement specifications need to be generated by the successful bidder and got them approved by IPR before procurement.

Pressure Transmitters

Type	: 2 wire electronic smart type.
Accuracy	: $\pm 0.25\%$ of calibration span.
Long term reproducibility	: $\pm 0.25\%$ of upper range.
Repeatability	: 0.05 % of span
Case	: IP 65 as per IS 13947.
Power finish	: 24 V DC over Hart $\pm 2\%$
Output signal	: 4-20 mA DC @ 60 Ohm load.
Sensing element	: SS 316/304
Wetted Parts	: SS 316/304
Make	: Rosemont/MDF or equivalent.

Temperature Sensor

All the temperature sensors are surface mounted sensors mounted on the inner pipelines.

Type	: General purpose Resistance Temperature Detector
R ₀ (Nominal)	: 100 ohms
Sensing Element	: High purity platinum wire of 100 ohms at 0 C with a temperature coefficient of 0.00385 ohms/ohm-C (IEC 751)
RTD assembly material:	Stainless steel and flexible polyimide insulation.
Accuracy	: RTD assembly accuracy of ± 0.50 ohms or 0.50 % of temperature whichever is more.
Response Time (65 % response)	: 0.2 0 second on material surface
Self heating error	: ≤ 1 C with dissipating power of 25 mW (ASTM-E-44)
Insulation Resistance	: The resistance between outer sensor insulation and the common lead wire is 50 mega ohms minimum with 50 V DC as per ASTM-E-644.
Lead Wire	: 3 wire configuration. 26 AWG standard nickel plated copper conductor of required length, PFA Teflon insulated 3 conductor ribbon cable.
Make	: Rosemont, Scientific Instruments, RdF, Auxitrol or equivalent

Flow meter

Flow meter is required to measure the flow rate of helium gas being circulated.

Type : DP type, mass flow meter or vortex meter suitable for 80K.

Fluid : Helium gas at 80 K
Flow range: 30 to 250 g/s at 80 K & 15 bar (g).
Accuracy : ± 1 % of full range.
Make : Micrometer, Rosemont, GE Sensing Technology, Endress + Hausser

4.7 Safety Aspects

The helium supply system shall have the following built in safety systems for its safe operation –

- Relief valves and rupture discs on the cooler rated for the design pressure of the vessel.
- Relief valves in the segments of lines where entrapment of cold fluid is possible.
- The electro-pneumatic and control valves shall take the safe position in case of power failure.
- In addition following parameters are to be monitored and if they go beyond said values which may result in failure of the system, they shall trigger to shut the operation –
 - Low/high voltage supply to circulator
 - Degrading vacuum level in the vessel containing the circulator
- Continuous monitoring of moisture level in the helium fluid
- Oxygen monitor in the building housing the system

4.8 Control System

The system shall be equipped with an automated control system with display which shall allow following function to be performed.

- Cool down of components from room temperature to 80 K in controlled manner.
- Filling and draining of liquid nitrogen
- Start, stop and speed variation of the cold helium gas circulator
- Liquid nitrogen level in the heat exchanger
- Nitrogen pressure in the heat exchanger
- Temperature and pressure of the recirculating helium gas in the circuit at strategic mutually decided locations
- The supply of operating panels includes within its scope all the pressure and temperature and level sensors as may be required for smooth and safe operation of the complete helium gas recirculating system

5. SUPPLIER'S SCOPE OF WORK

The scope of works for the supplier consists of the following tasks.

- i. Process Design: Design and estimation of process parameters for the 80 K helium system. Development of detailed P&ID. Selection of required instrumentation in terms of pressure, temperature, flow measurements with proper justification. The P&ID must contain all the safety aspects for the systems and for power failure mode.

- ii. Engineering and Design: Design of the complete system including the design of cryogenic lines, vessels, heat exchangers etc, design of mounting structures & supports, flexibility analysis of complete piping networks during cooling & steady state operations. Generation of procurement specifications for all the equipments, components, pipelines etc.
- iii. Procurement and Supply: Vendor shall procure all the required material and equipments including sensors, transmitters, instrumentation, cables etc. Supply of spares for two years of service of the system is also in the scope of the vendor.
- iv. Fabrication, Installation & Commissioning of the entire system including the required modifications.
- v. Codes and Standards: For the design, fabrication and testing of equipments, components & pipelines, the corresponding sections of ASME code shall be followed.
- vi. Quality Assurance and Quality Control: The bidder shall submit Quality Assurance plan (QAP) to IPR for the approval with detailed time schedule for entire scope of work. The quality assurance plan shall include all the stages starting from specification and covering material procurement, identification of raw material, fabrication of equipments and up to final acceptance. Design & engineering, fabrication, testing, inspection, erection etc shall be covered in Quality Assurance plan (QAP) which will be submitted to IPR for final approval. IPR reserves the right to appoint a third party for inspection/testing of work done. Contractor shall have no objection for third party inspection and testing. The cost for third party inspection will be borne by IPR. Sub contractors (if any) are required to be appraised and approved by IPR before placement of contract job to the sub contractor.

The commissioning of 80 K system will include achieving vacuum in the order of 1×10^{-8} mbar lit/sec and thermal cycling followed by leak tests. In case of non-achievement of desired vacuum level, it is contractor's responsibility to check for any source of leakages in welding or any other area and rectify it.

In case of unsatisfactory work, deviations from actual desired parameters after inspection and testing stages, they need to be rectified by rework by contractor on their own expense and keeping in mind that those re-works shall not delay the scheduled activities.

- vii. Acceptance Criteria: The vendor is responsible to achieve the performance of the 80 K helium system as per the specification of the system. Final performance test shall be carried out under the supervision of IPR representatives. Results of the final performance test along with evaluation of the performance from the test results shall be submitted by the vendor to IPR for their approval. Once the rated performance of the entire assembly is achieved with Thermal System, the 80 K helium supply system is treated as accepted by IPR.
- viii. Guarantee: Vendor shall give guarantee for the performance of the equipments, components and pipelines of the entire system as per their specifications for a period of 18 months from the date of final acceptance. During this period, if any fault occurs, vendor shall rectify it at no extra cost.

6. GENERAL TERMS AND CONDITIONS

The successful bidder shall submit detailed design of the system with appropriate calculation and data sheet to IPR for approval.

Detailed manufacturing design will be submitted to IPR subsequently for approval before fabrication.

The successful bidder shall take approvals for purchase items like Cold Circulator, valves, sensors etc from IPR. For this purpose data sheet for these items shall be submitted to IPR. The items shall be procured from parties approved by IPR.

The bidder shall make the provision /arrangement for the required pumping system, leak detector, liquid nitrogen etc in-house or through outsourcing agency for conducting acceptance test at their factory. After the completion of inspection and testing of manufactured system, complete inspection and test report shall be submitted to IPR for issuing dispatch clearance.

Any deviation / discrepancy / change by the bidder should be submitted to IPR. Bidder shall submit to IPR a list of material, design, inspection plan, quality assurance plan, material procurement schedule, manufacturing schedule and release for fabrication. Procurement of all equipment's, material, etc required for the fabrication, inspection and testing shall be in the scope of bidder. IPR authority / representative shall have access to all manufacturing facilities, inspection and testing facilities, tools, drawings etc.; during all stages of manufacture. IPR / its authorized representative reserve the right to add any supplementary requirements like random sample testing of raw material.

Safety issues: bidder shall submit the details of Safety norms/precautions followed for site activities.

Various inspection stages will be identified jointly by IPR and contractor and will be followed throughout project till its complete execution.

Spares for all the equipments and components required for successful operation of the system for 2 years shall be provided by the bidder.

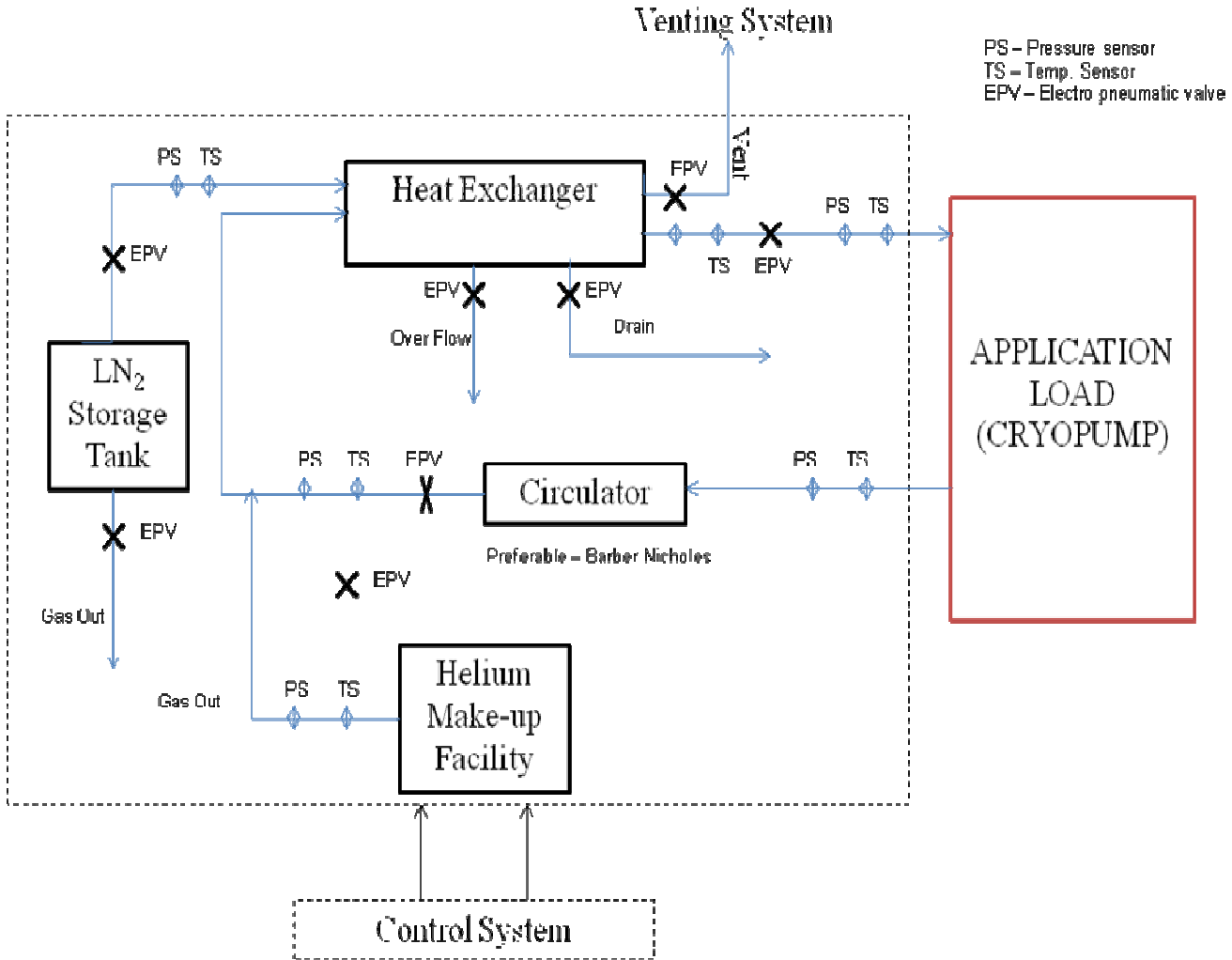
7. DELIVERY

Six months from the time of order placement.

8. ELIGIBILITY

- i. Vendor should have the technology, knowledge and background in Cryogenic systems, transfer lines, vacuum technology and in all the relevant fields /areas covered in the scope of work.
- ii. Prior experience of similar nature of job covering the scope of work as stipulated herein namely Design, Analysis, Fabrication, testing, installation and commissioning of similar system is a must. They shall have executed similar jobs with a single purchase order of Rs. 40 lakhs or more in last three years and shall attach copy of purchase orders
- iii. Vendor must have supplied similar systems to reputed government organizations such as ISRO, DAE, DST etc.

BLOCK DIAGRAM FOR 80 K HELIUM GAS SUPPLY SYSTEM



Note: All transfer Lines are vacuum jacketed transfer lines