EOI Document

Design, Fabrication, Supply, Installation, Commissioning and Testing of Liquid Nitrogen Boosting System

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Institute for Plasma Research, Bhat, Gandhinagar

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1. Introduction to 80 K Booster system using Liquid Nitrogen (LN_2)

The SST-1 machine consists of superconducting (SC) magnets system operating at 4.5 K. This SC magnets system is thermally shielded by the 80 K shields system in order to protect the magnets from exposure to room temperature (300 K). Theses thermal shields will be cooled using forced-flow liquid nitrogen (LN_2) circulation in a closed loop. Here, we envisage the circulator as a Booster pump, which will operate at 7 bar (a) / 80 K. This typical operation can be achieved by providing appropriate LN_2 sub-cooler and make up vessel arrangements. The steady state heat load during normal operating conditions of SST-1 machine is 20 kW at 80 K. This demands a supply of single phase forced flow circulation of LN_2 flow rate of about 10000 l/h in order to maintain the individual shields temperature uniformity of 5 K i.e. 80 – 85 K. This huge flow rate will be used in circulation mode during the steady state. The steady state heat load of 20 kW at 80 K will be dumped into LN_2 sub-cooler Dewar through Heat exchangers. The typical cool-down time of the 80 K thermal shields system is expected about 8 – 10 days. The cooling scheme of the Booster system will have basically two modes of operation as mentioned below.

(i) Cool-down mode from 300 K to 80 K

(ii) Steady state operation mode at 80 K [in closed loop]

<u>Cool down mode</u>: [300 K down to 80 K]

Initially, the 80 K thermal shields system will be at 300 K, we propose to cool-down the system gradually in order to protect the system from the unwanted thermal stress. Depending upon the system hydraulic resistance, the system will be cool-down to 80 K using the required amount liquid nitrogen (LN_2) from the existing LN_2 storage system. Particularly, we envisage using the existing LN_2 storage tanks for cool-down purpose and it is sufficient and capable of delivery of required LN_2 during the cool-down phase. As during the cool-down mode of operation, the system does not require the higher flow rate of LN_2 due to its hydraulic resistance. During the cool-down phase, the latent heat of vaporization of LN_2 will be used so that at the outlet only we have choice to vent it to atmosphere after using its latent heat of vaporization. Refer Figure 1, which describes the Process Flow Diagram (PFD) of cool-down mode of the 80 K thermal shields system along with the 80 K Booster system. Here, the 'blue' line indicates the continuous filling up of LN_2 in the LN_2 sub-cooler Dewar and then make up vessel. The 'green' line indicates the path of cool-down from the existing LN_2 storage system. The cool-down mode of operation is clearly understood from Figure 1.

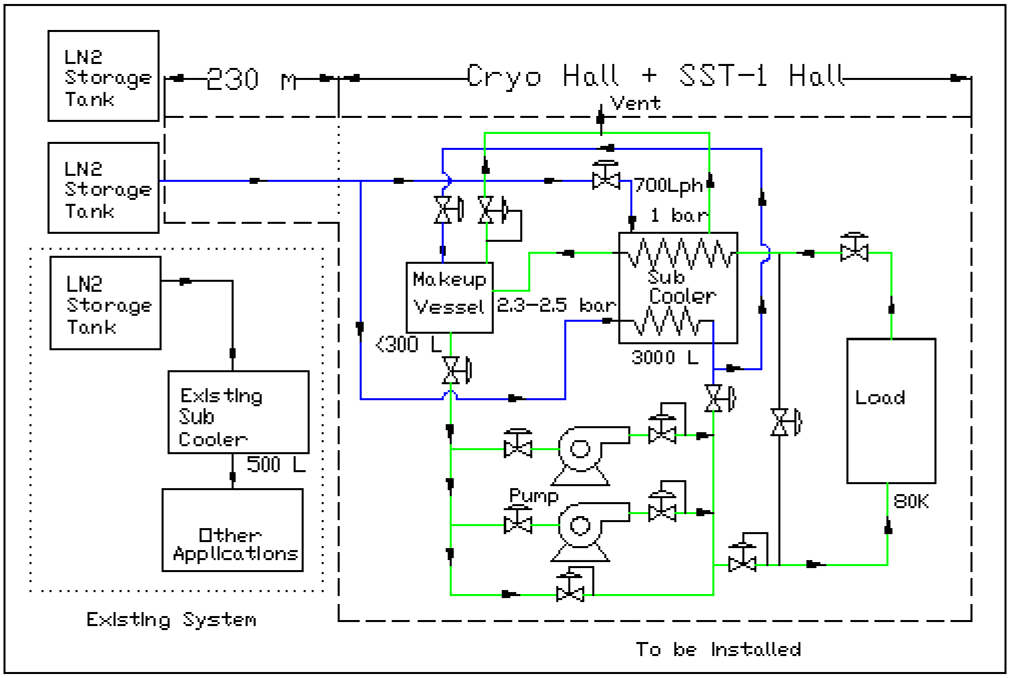

Figure 1: Process flow diagram (PFD) of Cool down mode, the 'blue' line indicates the continuous filling up of LN_2 in the LN_2 sub-cooler Dewar and make up vessel while the 'green' line indicates the path of cool-down from the existing LN_2 storage system

Steady state operation mode at 80 K in closed loop:

After cool-down mode of operation, the 80 K thermal shields system along with the all components of 80 K booster system reach up to 85 K, the booster system will be authorized to start the forced-flow cooling then actually the steady state operation mode will start. This mode will be in the closed loop. Refer Figure 2, which describes the Process Flow Diagram (PFD) of Steady state mode of the 80 K Booster system.

After reaching to steady state operation, the basic job of the 80 K booster system is to circulate the rated mass flow rate of single phase LN_2 at 7 bar (a) / 80 K in closed loop. During this phase of operation, there will be losses (Make up, Natural Evaporation Rate (NER), Dumped heat load from Thermal shields as application load) will be supplemented from the Existing storage tanks. The steady state heat load of 20 kW at 80 K will be dumped to sub-cooler LN_2 vessel in terms of Latent heat of vaporization from 20 kW, which will also act as a phase separator. One has to ensure the clear liquid phase of LN_2 at the suction of the pumps otherwise its bearing can get damaged. For this purpose, the make up vessel shall be always kept at 2.3 – 2.5 bar. This condition also fixes the suction pressure conditions for the booster pumps. The discharge pressure of 7 bar (a) is fixed in order to get the sufficient temperature margin for avoiding two-phase flow within the application load. There are two cold process booster pumps envisaged in order to operate the system in more reliable and redundant way. Here, in Figure 2, the steady state operation of 80 K thermal shields system is discussed along with the booster system. The 'red' line indicates the steady state closed loop operation of 80 K booster system.

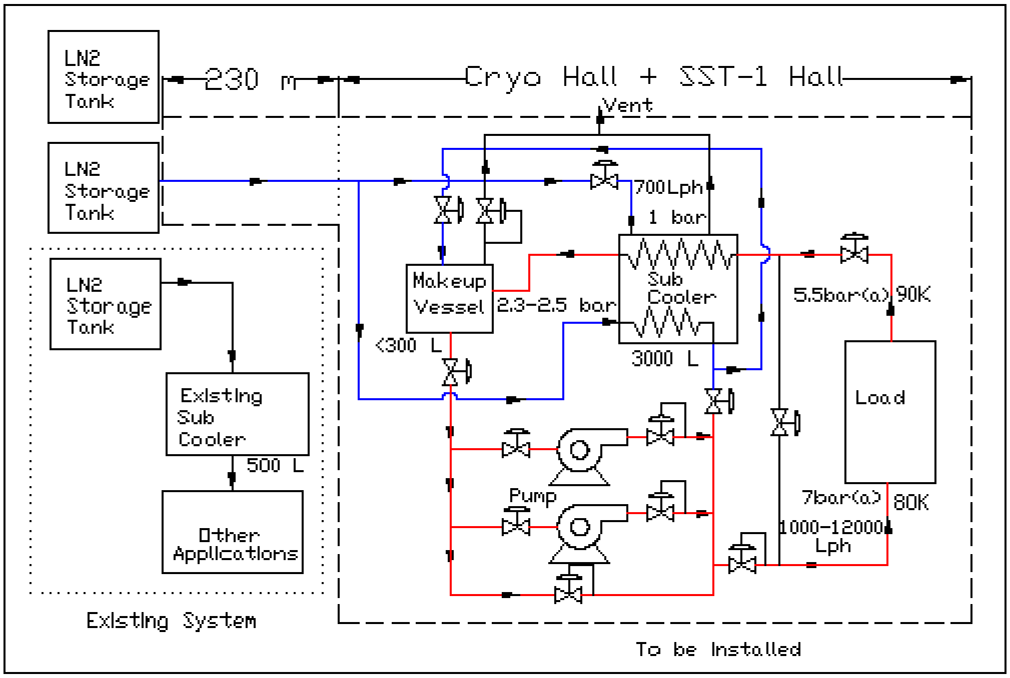

Figure 2: Process flow diagram (PFD) of Steady state mode, the 'blue' line indicates the continuous filling up of LN_2 in the LN_2 sub-cooler Dewar and make up vessel while the 'red' line indicates the steady state closed loop operation of 80 K booster system.

2. Overview of Existing LN_2 storage and distribution system at IPR

IPR has already installed and commissioned LN_2 storage and distribution system which consists of 3 numbers of 35 m^3 (each) LN_2 storage tanks in horizontal configuration in 2002. The maximum operating pressure of these tanks is 3.0 bar (g) and design pressure is about 4.0 bar (g). Each tank is capable to deliver 1000 l/h LN_2 flow rate. It has 230 m long, 40 NB size, vacuum and MLI insulted cryo line as discharge line running between the tank area and application at Cryo hall. In the Cryo Hall, there is one already existing Sub-cooler Dewar (<300 L, 1.5 bar) in order to stabilize the coolant temperature to 80 K. This sub-cooler Dewar caters the required LN_2 coolant to different sub-systems of SST-1 machine as mentioned below,

(i) SST-1 LHe Plant (Purifier & Heat Exchangers)

(ii) Current leads Assembly chamber and Current feeders system

(iii) Integrated flow Distribution System

(iv) NBI

(v) Other Misc. Requirements

Figure 3 describes the photographs of LN_2 storage and distribution system.

Figure 3 Photographs of LN_2 Storage system along with Sub-cooler Dewar at Cryo Hall

The approximate distance between the storage tanks area and application at Cryo hall is about 230 m. The inter connecting cryo pipes within the proposed system may be approx. 40 m based on the experience only but it will be finalized during execution by the vendor. Looking at full-fledged SST-1 LN_2 requirements, it is better to have separate dedicated cryo line for the 80 K Booster system in order to fill the Make up as well as sub-cooler LN_2 vessel.

3. Proposed placement of 80 K Booster system at IPR site

We need to install and commission the 80 K booster system at IPR site. It consists of different components viz. Sub-cooler LN_2 Vessel, Make up Vessel, Additional separate LN_2 cryo line for supply and installation of Cryo valves for LN_2 services. From our preliminary studies, it is clear that we need Sub-cooler vessel of 3 m^3 at 2.3 – 2.5 bar (a) / 80 K, < 0.3 m^3 of Make up Vessel, Additional Cryo line and cryo valves required to complete the scope of the 80 K booster system. At present we have certain limitations of available space within Cryo hall as well as SST-1 machine hall. Installation of this equipment may require CCOE approval as per their guidelines. Looking at these aspects, we request to vendor that final location of the placement of these components shall be mutually agreed by IPR and Vendor after studying the possibilities and appropriateness of the

Installation of these components. Refer the 2-D drawing of Cryo hall and placement of different sub systems already existing at present.

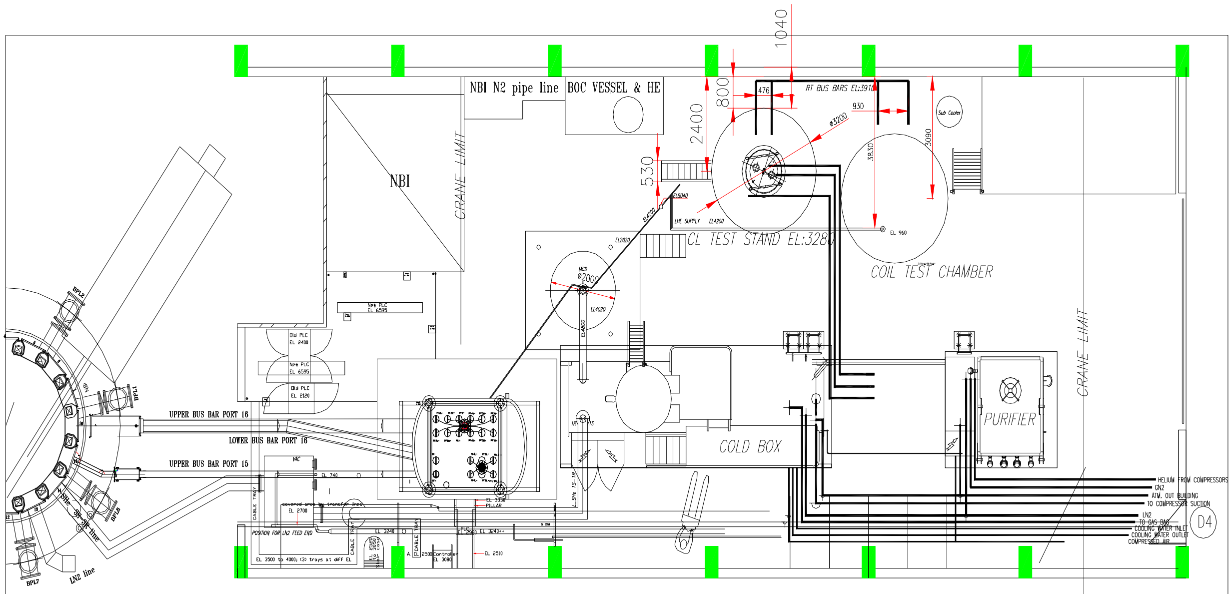

Figure 4 a 2-D drawing of Cryo hall along with installed sub-systems at IPR

4. Scope of Work and Supply

Overall scope of the work contains design, analysis, fabrication, testing, supply, assembly, integration and commissioning of integrated assembly with LOAD (as shown in Fig.1). The scope of supply includes delivery of LN_2 Booster pumps, cryo line, sub-cooler Dewar, make-up vessel, Electro-pneumatically operated cryogenic valves, instrumentation and their accessories. The scope of work also includes the design layout, mounting structure and supports required for integration, commissioning and testing of proposed system.

4.1 Scope of Work:

Entire scope consists of the following work tasks: -

[a] Generating details PFD and P&ID from the reference PFD given in the tender document. Final P&ID (Piping & Instrumentation Diagram) with all the detailed instrumentation, controls, valves, pumps etc. to be submitted based on the given PFD. P&ID must contain all the safety aspects for the components as well as power failure mode.

[b] Approval of (a) from IPR on the above

[c] Generating detailed engineering design from the approved P&ID as well as specification of components, preparation of QAP. Design & Engineering includes:

[i] Thermo hydraulic and process calculations on the proposed system. Each and every component has to be designed properly and to be documented as per the system functional requirements.

[ii] Flow distribution in the system and pressure drops.
[Detailed design and analysis of optimizing the system shall be submitted for approval]

[iii] Thermal stress & deflection analysis of the integrated assembly [During cool-down and steady state operations]

[iv] Design and analysis of Mounting structure and supports for all the components of system

[v] Detailed engineering analysis using some standard software for circuits

[vi] Flexibility analysis of all the piping layouts. (If vendor feels to put some flexible hoses for flexibility then he has to justify it and the procurement will be under the scope of vendor)

[vii] Submission of Final Assembly sequence [Drawings and documentations]

[viii] Submission of detailed QA plan to be followed during fabrication, assembly and testing.

[ix] All the instrumentation required in terms of pressure, flow and temperature measurements is under vendor's scope.

[x] All the components used in proposed system should be from the standard well known make and manufacturers only and vendor should take the prior approval for the same before Procurement.

[d] Approval of (c) from IPR

[e] Generating engineering and manufacturing drawings from the approved detailed design and specifications

[f] Approval of (e) from IPR

[g] Procurement of materials and components as per approvals

[h] Intermediate testing of materials and components as per QAP

[i] Manufacturing as per approved manufacturing drawings

[j] Factory testing of sub-assemblies as per QAP

[k] Packing, forwarding and Supply of system at IPR Stores

[l] Complete assembly of the system at IPR site

[m] Submission of Final documentation including all above [Including Soft copies of Documentations and Database]

[n] Details, which are not clearly covered above but specified in this document

[o] If vendor is involving some sub-contractor for any purpose then it should be brought to the notice of IPR and has to take the approval for the same.

[p] The vendor should provide the break up cost of the budget mentioning all components.

[q] The vendor has to provide the complete scheme of cooled down (From 300 K to 80 K) with all the parameters trends / Graphs for the parameters to be controlled i.e. Mass flow rate, Pressure drop variation etc.

[r] The vendor should provide the normal operation scheme i.e. at 80 K steady state operation with controls to maintain the inlet temperature.

[s] The minimum modification in existing cryo lines, valves at the LN_2 storage tanks area required for execution and realization of the 80 K Booster system shall be within the scope of Vendors.

[t] Installation

[u] Commissioning

[v] Final acceptance test at IPR

NOTE:- 1. If Vendor feels any modification in the proposed system then it should be brought to the notice of IPR representative and should take approval from IPR. The proposed system modifications without informing to IPR will not be acceptable.

2. Before quoting for the entire system, the vendor is advised to visit the site to check the space constrains. It is better for vendors to come with some preliminary calculations to have idea about the size of their equipments to be installed.

3. If Vendor wants to put some other equipment except mentioned in the document or shown in Fig. 1. Then vendor has to give the detailed justification about its essentiality. It should be brought to the Notice of IPR representative and should take approval from IPR. The proposed system modifications without informing to IPR will not be acceptable.

4.2 Scope of Supply:

- LN_2 Booster Pumps (2 nos.) [Cold process pumps]
- Sub-cooer Vessel with Heat Exchanger (1 nos./ 02 nos. as per process requirements)
- Cryogenic Valves (On-off, Control, Safety etc.), temperature sensors, pressure sensors, flow meter, flexible hoses etc. (depending upon the P&ID) (As per requirements)
- LN_2 Lines (for connecting the system and within the system) (As per placements of equipments)
- Instrumentation and Control System (for operation, monitoring and controlling automatically)
- Cabling, wiring and interfacing the instrumentation with the existing PLC system

5. Technical specifications of 80 K Booster system

5.1 General specifications and operation conditions

Functional requirements:

1. Phase of the cryogen during the operation in loop : Single Phase (Liquid) only
2. LN_2 flow path during the 80 K operation : Closed Loop
3. Temperature at the inlet of Thermal Shield (Load) : $\leq$ 80 K
4. Pressure at the inlet of Load : 7 bar(a)
5. Mass flow Rate through the Load : 1000 lph-12000 lph (Variable)

Other essential requirements:

6. Temperature at the outlet of Thermal Shield (Load) : 90 K
7. Pressure at the outlet of Load : 5.5 bar (a)
8. Temperature at the inlet of Sub-cooler Vessel : 90 K
9. Temperature at the outlet of Sub-cooler Vessel : 78 K
10. Pressure at the inlet of Pump : 2.5-3.0 bar (a); Variable
11. Pressure at the outlet of Pump : 7 bar (Fixed)
12. Heat Load Dumped in sub-cooler Vessel : 20 kW
13. Duty cycle of Boosting system : Continuous min. 3 months
14. Closed loop evacuation & purging ports : To remove moisture

<u>Components with their technical specifications of the LN_2 Boosting System (Minimum No.):</u>

1. LN_2 Booster Pumps (2 nos.) [Cold process pumps]
2. Sub-cooer Vessel with Heat Exchanger (1 nos./ 02 nos. as per process requirements)
3. Cryogenic Valves (On-off, Control, Safety etc.), temperature sensors, pressure sensors, flow meter, flexible hoses etc. (depending upon the P&ID) (As per requirements)
4. LN_2 Lines (for connecting the system and within the system) (As per placements of equipments)
5. Instrumentation and Control System (for operation, monitoring and controlling automatically)
6. Cabling, wiring and interfacing the instrumentation with the existing PLC system

NOTE: The load in the basic Liquid Nitrogen Boosting System is not the part of vendor's scope. It will be available at IPR Site during the erection of system.

5.2 Technical details of components

5.2.1 Booster pumps for LN_2 services (cold process pumps)

Required Quantity: 02 numbers

Technical Specifications:

(i) No. of pumps: Two (One will be in operation while other one will be in standby). The standby pump should be ready all time for start. In case of any failure of one pump, another pump should be started automatically as a part of redundancy.

(ii) Suction pressure: 2.3 – 2.5 bar (a), discharge pressure: 7 bar (a), flow rate: 10,000 l/h, and working fluid: LN_2 (single phase)

(iii) Flow rate: As specified in operating conditions. The flow will be primarily controlled by the temperature output from the Load. Then it can be secondary controlled by mass flow meter. This may be achieved by VFD (Variable Frequency Drive) control.

(iv) Efficiency of the pump: Isentropic efficiency should be more than 30% for optimum design flow rate.

(v) Leak rate: Leakage of nitrogen to the ambient from the pumping system should be less than 1 Nm^3 (reference temperature is $0\,^0$C and pressure is 1 atmosphere) gas per hour.

(vi) Mounting System: The mounting system should be designed in such a way that vibration should not transferred to the load at any cost. Hence it is proposed that the suction and discharge pipes from the pump should have a bellow of length 50 cm covered with good insulation (heat load should be less than 5 watt for this line) to absorb the vibrations of the pump.

(vii) Repair / Replacement: The complete assembly of pump should be mounted on a skid (each pump on separate skid) with appropriate vibration absorbing elements. Its noise level should be less than 60 dB. Provision should be made such that, when one pump is out of order, it can be easily removed out of the skid for repair/replacement.

(viii) Vendor has to provide the detailed view of all the parts used within the pump with their material. The drawing should show all the part names in assembled view.

(ix) Vendor should provide the Pump characteristic for flow rate versus pressure head, Pump characteristic showing isentropic efficiency vs. flow rate of the pump.

(x) Vendor has to provide the calibration curves if required.

(xi) Vendor should provide the information for the external heat load absorbed into the pumping system during operation.

(xii) Vendor should provide the operation manual with detailed trouble shooting description. Vendor should provide the hands on training for troubleshooting.

(xiii) Vendor has to provide the detailed data on seals. They have to mention the life of the seals. It is the mostly failure part in pumps.

(xiv) Guarantee/ warrantee certificate for one year starting from the final acceptance at IPR.

(xv) Necessary spare parts with list of it and price.

(xvi) Available electrical power at IPR for the motor: 440 V (± 10%)/50 Hz/3 Phase.

(xvii) The vendor should provide electrical grounding of the pumping system.

(xviii) Electrical control box equipped with main breaker, fuses, and push button for on/off, light signals should be provided by the vendor. Automatic switching over from one pump to another pump in fault conditions should be included. The vendor should provide the necessary instruments required with the pumping system for this automatic control.

(xix) Complete system should be equipped with appropriate cryogenic and electrical safety and alarm provisions.

5.2.2 Sub-cooler LN_2 Vessel (Along with Heat exchangers)

Required Quantity: 01 numbers

Technical Specifications:

(i) The sub-cooler vessel should work as Sub-Cooler i.e. Heat exchanger and Storage tank etc. This will be open to atmosphere through vent, which means that its operating pressure will be 1.0 bar and the vessel should be LN_2 cryogenic compatible from the materials and helium leaktigntness point of view.

(ii) The original NER (Net Evaporating Rate) of such Sub-cooler vessel should be less than 1% per day. It requires improved design with appropriate thermal insulation, surface finish and vacuum conditions.

(iii) The 2 nos. of heat exchangers will be provided within the Sub-cooler vessel; One is for initial cool down and other for dumping the heat load. This Second heat exchanger will be in the closed loop and should be able to dump the heat load of 20 kW received from the LOAD and should discharge the LN_2 of 78 K.

(iv) Pressure drop in the 1st heat exchanger used for cool down should be minimum. Pressure drop in the 2nd heat exchanger should be such that it can provide the required pressure in the buffer vessel.

(v) The heat exchanger should be maintenance/defect free. Because once the plant is in operation, we cannot repair it.

(vi) The sub-cooler vessel will be mounted with proper support structure.

(vii) The capacity of the sub-cooler vessel should be enough so that it can provide the back up of at least one hour during any eventuality of LN_2 filling system.

(viii) The level of LN_2 has to be maintained continuously so that it should not affect the performance of the heat exchanger. The operation should be automated completely.

(ix) The LN_2 sub-cooler vessel shall be mounted with appropriate safety device in case of over pressure rise during the abnormal situations.

5.2.3 Buffer / Make up LN_2 Vessel

Required Quantity: 01 numbers

Technical Specifications:

(i) The Buffer / Make up vessel should work as Storage tank to cater the circulation loss and as phase separator. This will be Pressurized Vessel to maintain the pressure from 2.3 bar (a) to 2.5 bar (a). The buffer vessel should be filled with the existing system hence the required pressure is lower than the operating pressure of the existing tanks. It should be LN_2 compatible.

(ii) The Buffer vessel will be mounted with proper support structure in such a position so that it can provide the necessary NPSH (Net Positive Suction Head) to avoid any cavitations in the pump for its starting and during the steady state operation.

(iii) The Make up vessel shall be mounted with appropriate safety device in case of over pressure rise during the abnormal situations.

5.2.4 Cryogenic Valves for LN_2 services (ON-OFF, Control, Safety)

Required Quantity: As per the P& ID

Technical Specifications:

(i) All the required components should be cryo-compatible for 80 K and Electro pneumatically operated.

(ii) Required accessories should be provided as spares (min. 10%) depending upon the life of consumable used.

(iii) The components should be used from well-know manufactures of that field (i.e. Velan, Weka, Samson control or equivalent) and the information should be provided to IPR for the approval of purchase. The vendor should give all these details in their offer.

(iv) All the specifications of all the components should be documented properly. So that in future if any component has to be replaced as per its lifetime.

(v) The offer should describe the cost break-up of each component separately.

5.2.5 Cryo line for LN_2 services (VJ + Superinsulation line)

Required Length: As per the P&ID

Technical Specifications:

(i) Wherever possible, the Vacuum Jacketed lines should be used. The P& Id should be indicated all the different types of lines used in the system. Vendor has to mention the leak rate and the life of vacuum imposed.

(ii) The LN_2 lines should be designed in such a way that the heat load should be minimum and we can obtain the required operating parameters without any compromise.

(iii) The LN_2 lines joining from Sub-cooler vessel to Buffer Vessel should give the pressure drop so that the pressure should be maintained in the Buffer Vessel.

(iv) The vendor will calculate the length after visiting the site. But the tentative length will be approximately 40 m as per the previous experience. Vendor is responsible to install the required length without any extra cost.

(v) The offer should indicate clearly about the insulation, if they intend to apply on the lines of the system.

5.2.6 Instrumentation and Controls requirements

Required Quantity: As per the P&ID

Technical Specifications:

The Booster System is required to be operated in fully automated mode. For this, vendor has to define the process control logic and select suitable instrumentation and control system with appropriate P & ID.

A. Instrumentation

i. As per process diagram, vender has to discuss and approve the instrumentation with IPR's engineer.

ii. Only standard cryogenic compatible instrumentation will be accepted.

IPR prefers following makes for, as Flow measurement (Orifice/Venturi): Emersion make, DPT: Emersion make, Pressure Transmitter: Keller make, Temperature: PT102, Lakeshore make.

iii. Vendor has to provide sensor and transmitter for all instruments.

iv. Safety valves, local monitoring gauge must be provided at critical locations in the process.

v. Selection of range and accuracy of each instrument will be discussed with IPR's Engineer for approval.

B. Installation and Commissioning of instrumentation

i. Vendor should do installation and commissioning of required instrumentation.

ii. Vendor should carry out Cable laying as well as wiring from instruments to PLC terminal box.

iii. Vendor will do tagging and documentation of cabling.

C. Programmable Logic Controller (PLC) and SCADA based Control System.

i. IPR will provide the complete hardware for PLC system with processor, input/output modules, power supply etc in closed panel. The detail description of IPR's PLC system is as follow:
    - Telemecanique make PLC.
    - CPU model: P57 5634 M.
    - Analog input module: TSX- AEY1600. Total available input channel: 352.
        - Input Range: +/-10V, 0-10V,0-5V, 1-5V, 0-20mA, 4-20mA.
    - Analog output module: TSX-ASY 800. Total available output channel: 32
        - Output Range: +/-10V, 4-20mA, and 0-20mA.
    - Digital input module: TSX DEY 16D2. Total available input channel: 16
        - Input: 24Vdc sink type input
    - Digital output module: TSX DSY 16T2. Total available input channel: 64
        - Output: 230V, 5A contact rating

ii. Wonderware make Intouch version 9.2 SCADA system with 3000 tags available.

iii. Vendor will do all programming for PLC and SCADA. Defining control logic, PID loops, failure analysis and correction in PLC for fully automated control system. SCADA will include MIMIC page, trend page, alarm/warning page, manual and automated operation of each valve. MIMIC pages will be designed according to the requirement of process and should include overall control for entire system.

iv. After successful automation of process, vendor will provide detail documentation of each and every channel of PLC.

v. All the process tuning parameters should be tuned automatically to get the system performance.

vi. All tuning parameters and process parameters should be visible through SCADA and should have provision to change them based on privileges defined by IPR.

(vi) Codes and Standards to be used

Following Codes and Standards need to be used and followed in different phases of execution of this project. The compliance towards each task using appropriate codes and standards are listed below.

Sr. No	Task	Recommended Codes and Standards
1	Design Phase	ASME VIII-div-I, ASME B31.3,
2	Standards of Pipes and Fittings	ASME B16 series

3	Material Test	ASTM
4	Cryogenic valves	ANSI -American National Standards Institute B16.34: “Valves - Flanged, Threaded, and Welding End” B16.10: “Face-to-Face and End-to-End Dimensions of Valves”
5	Cryogenic Flexible Hoses	EN 12434:2000 CV - Cryogenic flexible hoses ISO/WD 21012, NF E86-511

Standard software tools for analysis like ANSYS, Fluent / CFD, CEASER should be used during design phase. If vendor wants to use any other tool then he should take approval for the same.

(vii) Acceptance Criteria

7.1 Tests to be conducted at Vendor’s site

IPR representative will observe and inspect the following tests will be carried out at vendor’s site

(i) Inspection of complete system in different stages of fabrication and procurement. The stages will be agreed mutually with IPR.

(ii) Physical Inspection of LN_2 Booster Pump

(iii) Checking its operation by running the pump using LN_2 under VFD operation

(iv) The overall isentropic efficiency of the pump will be measured by measuring the temperatures of liquid nitrogen at suction and discharge side of the pump.

(v) Leak test of LN_2 pump under the running conditions at LN_2 temperatures and Sub-cooler vessel.

(vi) Verification of all the relevant Test certificates (i.e. material, hydraulic performance etc.)

(vii) Performance test on Sub-cooler Vessel and make up Vessel (Pressure, Leak test, NER)

(viii) Leak test, physical verifications and electro-pneumatic Position test on Cryo valves

7.2 Tests to be done at IPR site:

The following acceptance tests will be carried out at IPR site:

(i) Flow rate versus pressure head performance test of the pump will be done after installation of pump at the IPR site.

(ii) Leak rate during running condition will be tested by measuring the loss of the operating pressure from a closed loop circuit. For this the flow from the pump will be circulated through the by pass line while supply LN2 from the storage tank and to the application side will be isolated.

(iii) During cool-down and warm up cycle's thermo-structural stability, uniformity and flexibility of the whole integrated system will be ensured.

(iv) Radiography or DP shall test all the in-situ joints as per the suitability for individual joints.

(v) Vacuum and Helium Leak test at Room Temperature of entire assembly will be done by vendor and All individual leaks shall be less than 1 X 10-9 mbar – l /s.

(vi) At least five thermal cycles will be given in the integrated system and then Helium leak test will be done. An integrated leak of integrated system should be less than 1 x 10-6 mbar-l/s at service operating conditions. All individual leaks shall be less than 1 X 10-9 mbar – l /s

(vii) Pressure drop measurement across the module inlet and outlet will be carried out through the bypass line (without LOAD) and with LOAD at different flow rates.

(viii) Establishment of instrumentation and control, flow parameters and their variations. All the input and output should be displayed in the local panel and the signals should be taken in the existing SCADA system in IPR for its operation and control. If any problem occurs then Vendor has to solve the problem with IPR.

(ix) The entire LN2 circuit, it will be subjected to pneumatic pressure test at 1.25 times the design pressure (As per ASME).

(x) After pneumatic test is carried out further He leak tightness test will be done for the entire circuit. Pressure will be retained for the duration of one hour during pneumatic test.

(xi) The entire LN2 circuit is tested with LN2 at designed inlet and outlet flow parameters; to check the integrated performance of the circuit, for achieving the desired temperature and pressure distribution as mentioned in earlier sections of this document, flow parameters within the circuit.

(xii) If the desired parameters achieved during testing are not satisfactory and are different from design / required parameters, necessary adjustments/modifications shall be done by the vendor without any extra cost.

(xiii) Once the rated performance of the entire assembly is achieved with load, the LN2 boosting system shall be treated as accepted by IPR.

7.3 Integrated test for final Acceptance

As a part of final acceptance test at IPR, the vendor has to carry successful installation and commissioning of the 80 K booster system at IPR as per defined scope. Once this task is completed, the integrated performance test will be conducted at IPR on actual load conditions. The vendor is finally responsible to achieve the performance of the 80 K booster system as described in the scope and IPR specifications.

8. Details of Facilities and Utilities provided by IPR during Execution of work

[a] During assembly and Integration:

1. Pressurized air for electro-pneumatic valves at 6 bars (g).
2. LN2 fluid consumables for all test trials conducted at IPR.
3. He gas for leak testing.
4. Argon gas for welding purpose.
5. Water and electricity.
6. 10-ton overhead crane for material handling that is available in IPR.

[b] Facilities: (At IPR Site)

1. Storage area for storing the supplied hardware materials, tools and tackles to be deployed during site work.
2. Free working area and free access to site.

1. Delivery Time Schedule

IPR prefers that the complete task involves two parallel category of activities can be planned as mentioned in the following Table.

Category: I Design and Fabrication Activities

Sr. No.	Activities	Time Schedule
1	Design of system with components viz. Make up vessel, Sub-cooler Vessel, Cryo line etc.	4 weeks
2.	Fabrication and Testing at Vendor site	8 weeks
3.	Delivery at IPR site	4 weeks
4.	Installation and Commission at IPR site	10 weeks

Category: II Procurement Activities

Sr. No.	Activities	Time Schedule
1	Procurement of Cryogenic Valves	12 weeks
2.	Procurement of Cold Process Pumps	12 weeks
3.	Procurement of Misc Instrumentation	12 weeks
4.	Testing of procured items at Vendor site	4 Weeks
4.	Delivery at IPR site	4 weeks
5.	Installation and Commission at IPR site	10 weeks

Total Time Schedule shall be within 30 - 32 weeks

Note: Here the activities mentioned in the Category - II and I could go in parallel.

The vendor is requested to strictly follow this Time Schedule.

10. Eligibility Criteria for the Vendors

[1] The party should have carried out the cryogenic system related jobs in past, especially dealing with LN2 system.

[2] The vendor should have the experience of manufacturing cryo-transfer lines, cryo-heat exchangers (sub-cooler) etc.

[3] The vendor should have technological know-how and background for cryogenic system process design.

[4] The vendor should submit the details of similar turnkey projects carried out in past.

[5] The vendors should have design, manufacturing infrastructure and test facility to conduct the cryogenic test at vendor / its associate's site.

[6] The vendor should have knowledge of handling cryo valves, instrumentation and controls and making out process flow diagram and process calculations.

[7] Submit proof for the above along with final tender.