INTERPLANT STANDARD - STEEL INDUSTRY		
IPSS	**SPECIFICATION FOR VACUUM INSULATED (SUPER INSULATION) CRYOGENIC PIPES**	**IPSS:1-06-047-09**
	NO CORRESPONDING INDIAN STANDARDS EXISTS	

0.1 FOREWORD

This Inter Plant Standard prepared by the Standards Committee on Pipes, Fittings, Valves and Piping Layout, IPSS 1:6 with the active participation of the representatives of all the steel plants and associated organization in the field was adopted in February 2009.

0.2 Inter Plant Steel Standards primarily aim at achieving rationalization and unification of parts and sub-assemblies used in steel plant equipment and accessories, and provide guidance in indenting stores or equipment for existing or new installations by individual steel plants. It is not desirable to make deviations in technical requirements.

1. SCOPE

1.1 This specification covers the minimum technical requirements for design, manufacture and supply of **Super Insulated (SI)** piping used in Air Separation Units / Tonnage Oxygen Plants for handling and transfer of cryogenic liquids like liquid oxygen, liquid nitrogen, liquid argon or mixture of these liquids and its vapours at cryogenic temperatures which is generally below (-) 150°C.

1.1.1 **Super Insulation (SI)**: The class of insulation achieved by application of multiple layers of super insulating material in very high vacuum is termed as 'Super Insulation'. This type of insulation is generally used in cryogenic application.

1.2 PHYSICAL CONFIGURATION

1.2.1 Typical configuration of Super Insulation is shown in **Fig-1**. Inner pipe is wrapped with multiple layers of super insulation material which consists of highly reflective radiation barrier interspaced with low conductivity thermal

spacers. These are generally made up of aluminum foil and glass paper respectively. This super insulating layer greatly reduces the heat ingress by conduction and radiation.

1.2.2 Super Insulated (SI) pipes are double walled stainless steel pipes. Inner pipe is wrapped with multiple layers of super insulating material. The annular space between inner and outer pipe is kept under very high vacuum (usually limited to 4 Pascal). Sometimes it is also referred as 'Vacuum Insulated Pipe' or 'Vacuum Jacketed Pipe'. Joint between two super insulated pipe sections is insulated by expanded Perlite, Poly Urethane Foam (PUF) or any Super Insulation material. A Super Insulated pipe section along with its various components and perlite insulated joint on the right side is shown in **Figure-1**.

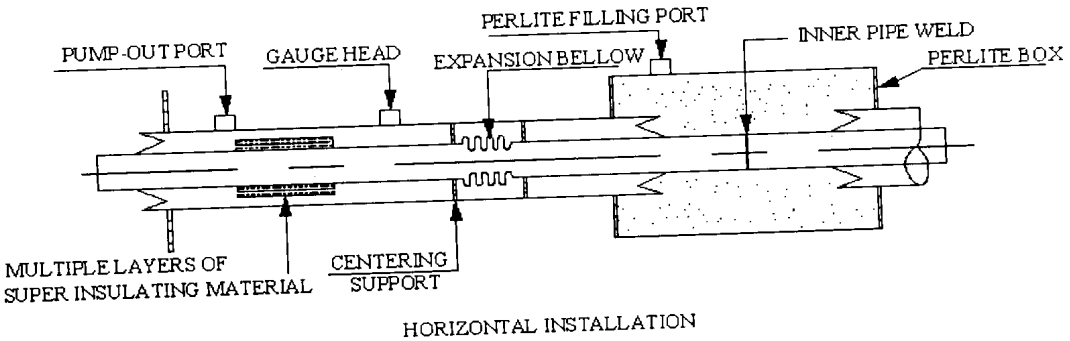

Figure-1 - Super Insulated Pipe

1.2.3 Super Insulation Piping consists of following parts:

1.2.3.1 **Inner Pipe**: It is a stainless steel pipe carrying the fluid at required pressure and temperature.

1.2.3.2 **Outer Pipe**: It is a metallic jacket over the inner pipe. Port for Suction pump and vacuum gauge connector are welded on outer pipe.

1.2.3.3 **Bellow Compensator**: One or two bellow compensators depending on length of the pipe section is welded usually to inner pipe to take care of expansion / contraction due to enormous differential temperature between inner pipe and outer pipe. Outer pipe generally have ambient temperature, whereas inner pipe have temperature of carrying fluids at cryogenic temperature about (-) 190°C. It has to compensate during the other extreme

condition also when inner pipe is subjected to around (+) 80°C during deriming.

1.2.3.4 **Suction Pump Port**: It is a provision on outer pipe for connecting vacuum pump for vacuuming the annular space. It consists of vacuum plug with necessary sealing.

1.2.3.5 **Gauge Head**: It is a non-contact type gauge head suitable for connecting high sensitivity vacuum gauge.

1.2.3.6 **Centering Support**: This support is needed to keep inner and outer pipes nearly concentric over the length. Usually it is star shaped to minimize the conduction of heat through it from outer pipe to inner pipe. Number of support depends on the length of pipe section.

1.2.3.7 **SI Pipe Field Joint**: It is a connecting point for two SI pipe sections. It can be either perlite insulated, PUF insulated or super insulated. Perlite insulated joint is also called 'perlite box'.

2. DESIGN REQUIREMENTS

2.1 The working pressure and temperature shall be as required by the Purchaser.

2.2 SI pipe sections shall be subjected to a minimum of (–) 196° C during handling of cryogenic liquid and up to (+) 80 °C during deriming of the inner pipe.

2.3 The vacuum level shall be less than 4 Pa (30 microns Hg) on absolute basis.

2.4 Inner pipe shall be provided with centering supports at every suitable interval to maintain the relative position of inner pipe with respect to outer pipe.

2.5 The pipe sections shall be self compensated type with provision of suitable bellow compensators as per Expansion Joint Manufacturers Association (EJMA) standard, preferably in inner pipe, designed for extreme conditions of temperature and pressure.

2.6 The pipe section shall withstand the thermal shock during charging of cryogenic fluid from warm condition.

2.7 The super insulation shall be designed for very low heat in-leak rate. For SI pipe of 1" inner pipe size, heat in-leak rate shall be limited to 1.0 W/m.

2.8 Vacuum jacket shall be subjected to helium leak detection test by mass spectroscopy. Maximum allowable leak rate shall be 10-8 std cc/s.

3. OTHER TECHNICAL REQUIREMENTS

3.1 Shape and the dimensions of the pipe sections shall be as per the requirements of the Purchaser.

3.2 Unless specifically required by the Purchaser, maximum length of the SI pipe section shall be limited to 8000 mm, and length of the bends and Tee's shall be 500 mm. Length of box for making field joint is usually kept 300 to 450 mm. Plate for ring flange shall be 10 mm thick and is welded on outer pipe about 75-125 mm from its edge before vacuuming of annular space.

3.3 All welding work shall be of good quality Tungsten Inert Gas (TIG) welding. Manufacturer is required to furnish Welding Procedure Specification (WPS) if desired by the Purchaser.

3.4 All the components of the pipe section irrespective of the service shall be suitably degreased for oxygen service.

3.5 Joint between two SI pipes shall be either perlite insulated, PUF insulated or super insulated. Outer pipe sections for making the field joint (usually 300 to 450 mm long) shall be supplied loose for site welding.

3.6 Super insulated field joints shall have vacuum pulling port similar to the main pipe. Perlite filled joints shall have filling port and draining port with plugs similar to vacuum pulling port.

4. MATERIAL REQUIREMENTS

4.1 Materials of construction of SI pipe shall be as indicated in **Table -1**.

Table-1
Material of construction

Description	Material	Standard
Inner pipe	Stainless Steel, seamless	SA312 TP304 L
Outer pipe	Stainless Steel, seamless	SA312 TP304
Pipe fittings	Stainless Steel	SA403 WP 304 / SA182 304
Super insulating layer	Aluminum foil and insulation sheet	Manufacturer's standard

Vacuum pulling port and perlite filling/draining port	Plug : Stainless steel Socket : Stainless steel Sealing: PTFE /Viton 'O' ring	SA 312 TP304 SA 312 TP304 Flange: ISO NW 25
Bellows	Stainless Steel	SS316Ti, SS321 As per EJMA Standard
Pipe for field joint	Stainless steel	SA312 TP304
Ring flange	Stainless steel	SA240 TP304

4.2 Piping schedule and bellow material shall be selected based on working pressure and temperature of fluid to be handled as specified by the Purchaser and ASTM standards.

4.3 Size of inner pipe (also referred as the size of SI pipe) is decided by the required flow rate of the fluid or as specified by the Purchaser. Outer pipe size and pipe size required for the boxes for the field joints are generally selected as indicated in **Table-2** or as specified by the Purchaser.

Table-2
Relative pipe sizes used in Super Insulated Pipe

Inner Pipe Size	Outer Pipe Size	Pipe Size For Perlite Insulated Field Joint	Pipe Size For Vacuum Insulated Field Joint
15 NB	50/65 NB	150 NB	100 NB
20 NB	50/65 NB	150/200 NB	100 NB
25 NB	65/80 NB	150/200 NB	100 NB
40 NB	80/100 NB	200 NB	150 NB
50 NB	100 NB	200 NB	150 NB
65 NB	125/150 NB	200/250 NB	200 NB
80 NB	125/150 NB	250 NB	200 NB
100 NB	200 NB	250/300 NB	200 NB

5. TOLERANCES

5.1 Overall length of SI pipe section : +25 to +50 mm
(Overall length is equal to inner pipe length. Positive tolerance is required for adjustment at site while installation. Excess length is to be cut)

5.2 Length of outer pipe : +/- 3 mm

5.3 Length of box for field joint : +/- 3 mm

5.4 Distance of ring flange for joint from outer pipe edge : +/- 3 mm

5.5 Orientation of bend / Tee : +/- 2 deg

6. PACKING AND DISPATCH

6.1 Each pipe section shall be placed in a rigid wooden box and shall be clamped at sufficient places in the box so as to ensure no any lateral movement or damage during transportation. The wooden boxes shall be properly closed with 'side-up' marking. Instructions for preservation and safe handling are needed to be displayed to avoid damages.

6.2 Weak and sensitive parts like vacuum plug and vacuum gauge head which are prone to get damaged by jerk or shock shall be carefully protected.

6.3 Up to 3 or 4 pipe sections can be placed in single box depending on shapes and sizes. Special care is required for sections having 'Tee' and bends while packing multiple sections.

6.4 Manufacturer's name, year of manufacture and serial number etc shall be marked on each SI pipe section.

7. DRAWINGS

7.1 Manufacturer shall prepare the drawings showing dimensions and Bill Of Materials (BOM) for each section for approval of the Purchaser. The drawings shall also indicate the dimensional details and orientation of vacuum gauge head and vacuum pulling port and details of the clamps, O-rings, centering support etc.

8. TESTING

8.1 Following test certificates shall be submitted for bought out items

i) Material Test Certificate-both physical & chemical analysis
ii) Hydrostatic Test Report

8.2 Following tests are to be carried out by the manufacturer and reports to be submitted:

i) Vacuum stabilization/ retention test.
ii) Dye Penetration test for all weld joints.
iii) Radiography test for butt weld joints.
iv) Helium leak detection test.
v) Inner pipe pneumatic test report.
vi) Cold shock test.

vii) Final dimensions check

viii) UV lamp test for oxygen service cleaning.

9. QUALITY ASSURANCE PLAN (QAP)

9.1 The manufacturer shall have a well defined quality assurance plan indicating the vital test parameters, stages of inspection and inspection agencies which shall be agreed / approved by the Purchaser.

10. GUARANTEE

10.1 Manufacturer shall stand guarantee for the satisfactory performance of the super insulated pipe for minimum period of 12 months from the date of installation.

11. ORDERING INFORMATION

Following information / data are to be mentioned while ordering:

i) Overall dimensional drawing of the SI pipe section indicating length, size and shape of inner pipe, junction boxes, location and orientation of fittings etc.

ii) Fluid to be handled

iii) Pressure and temperature of the fluid

iv) Duty cycle

v) Deriming temperature

vi) Material specifications

vii) Tests, test standards and inspections

viii) Type of field joint

ix) Details of ambient conditions