MATERIAL AND EQUIPMENT STANDARD

FOR

THERMAL INSULATION

ORIGINAL EDITION

DEC. 1997

This standard specification is reviewed and updated by the relevant technical committee on Feb. 2003. The approved modifications are included in the present issue of IPS.

0. INTRODUCTION

This Standard consists of nine parts as follows:

Part I:	Mineral Fiber Preformed Pipe Thermal Insulation.
Part II:	Mineral Fiber Block and Board Thermal Insulation.
Part III:	Mineral Fiber Blanket and Blanket Type Pipe Thermal Insulation.
Part IV:	Calcium Silicate Preformed Block and Pipe Thermal Insulation.
Part V:	Cellular Glass/Foam Glass Thermal Insulation.
Part VI:	Cork board and Cork pipe Thermal Insulation.
Part VII:	Spray-Applied Rigid Cellular Polyurethane (PUR) and Polyisocyanurate (PIR) Thermal Insulation.
Part VIII:	Preformed Rigid-Cellular Polyurethane (PUR) and Polyisocyanurate (PIR) Thermal Insulation.
Part IX:	Miscellaneous Materials to be Used with Thermal Insulation.

Parts I through V are categorized as Hot Thermal Insulation whereas Parts VI, VII and VIII are classified as Cold Thermal Insulation.

Note:

Cellular glass/foam glass hot thermal insulation may also be used as cold thermal insulation detail of which has been given in volume one.

PART I

MINERAL FIBER PREFORMED PIPE

THERMAL INSULATION

CONTENTS : PAGE No.

1. SCOPE

1.1 This Standard specification covers the minimum requirements for composition, sizes, dimensions, physical properties, inspection, packaging and marking of mineral wool preformed pipe insulation for use on pipe surfaces up to 600°C. If insulation is to be used at higher temperature the actual temperature limits shall be as agreed upon between the manufacturer and the Company.

1.2 For satisfactory performance, properly installed protective vapor barriers shall be used in low-temperature applications to prevent movement of moisture through or around the insulation towards the colder surface.

Note:

This standard specification is reviewed and updated by the relevant technical committee on Feb. 2003. The approved modifications by T.C. were sent to IPS users as amendment No. 1 by circular No. 191 on Feb. 2003. These modifications are included in the present issue of IPS.

2. REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

ASTM (AMERICAN SOCIETY FOR TESTING AND MATERIALS)

C 585	"Practice for Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System)"
C 390	"Criteria for Sampling and Acceptance of Preformed Thermal Insulation Lots"
C 356	"Test Method for Linear Shrinkage of Preformed High Temperature Thermal Insulation Subjected to Soaking Heat"
C 335	"Test Method for Steady State Heat Transfer Properties of Horizontal Pipe Insulation"
C 547	
C 871	"Test Methods for Chemical Analysis of Thermal Insulation Materials for Leachable Chloride, Fluoride, Silicate, and Sodium Ions"
C 692	"Test Methods for Evaluating the Influence of Thermal Insulation Wicking-Type on the External Stress Corrosion Cracking Tendency of Austenitic Stainless Steel"
C1104	

3. DEFINITIONS AND TERMINOLOGY

Jacket

A form of facing applied over insulation. It may be integral with the insulation, or field applied using sheet materials.

Mineral fiber

Insulation composed principally of fibers manufactured from rock, slag, or glass with or without binders.

Pipe insulation

Insulation in a form suitable for application to cylindrical surfaces.

Rock wool

Mineral fiber produced from naturally occurring igneous rock.

Slag wool

Mineral fiber produced from steel mill slag.

Soaking heat

A test condition in which the specimen is completely immersed in an atmosphere maintained at a controlled temperature.

Water-vapor-permeability

The time rate of water-vapor transmission through unit area of flat material of unit thickness induced by unit vapor pressure difference between two specific surfaces, under specified temperature and humidity condition.

4. UNITS

This Standard is based on International System of Units (SI), except where otherwise specified.

5. MATERIALS AND MANUFACTURE

5.1 Composition

The mineral fiber preformed thermal insulation for pipes shall be manufactured from mineral fiber substances such as rock or slag from a molten state into fibrous form and shall be made rigid with organic binder. The binder shall be phenolic or manufacturer Standard.

5.2 Jacket (facing)

The pipe insulation may be jacketed or plain as will be specified by the purchaser, if jacketed, the type of jacket to be aluminum foil or kraft paper as is specified by the Purchaser.

6. GENERAL PROPERTIES

The mineral fiber preformed pipe insulation shall have the general properties as follows:

6.1 Insulation shall have suitable resistance to sunlight in order to minimize shrinkage below the limit specified in Clause 8.1 and have as low water vapor permeability as possible.

6.2 It shall be non-combustible and shall be resistant to vermins and fungus, be free from objectionable odors, and shall not react with process chemicals present.

6.3 The insulation shall be asbestos free and shall have not health hazard in case of contact or during labor working.

6.4 The insulation shall have only traces of corrosive materials; e.g. water-soluble chlorides which attack stainless steels or alkalinity which attacks aluminum jacketing.

7. CHEMICAL COMPOSITION

7.1 Chemical composition for major constituent of mineral fiber preformed pipe insulating materials shall be as following when tested by spectrometric methods:

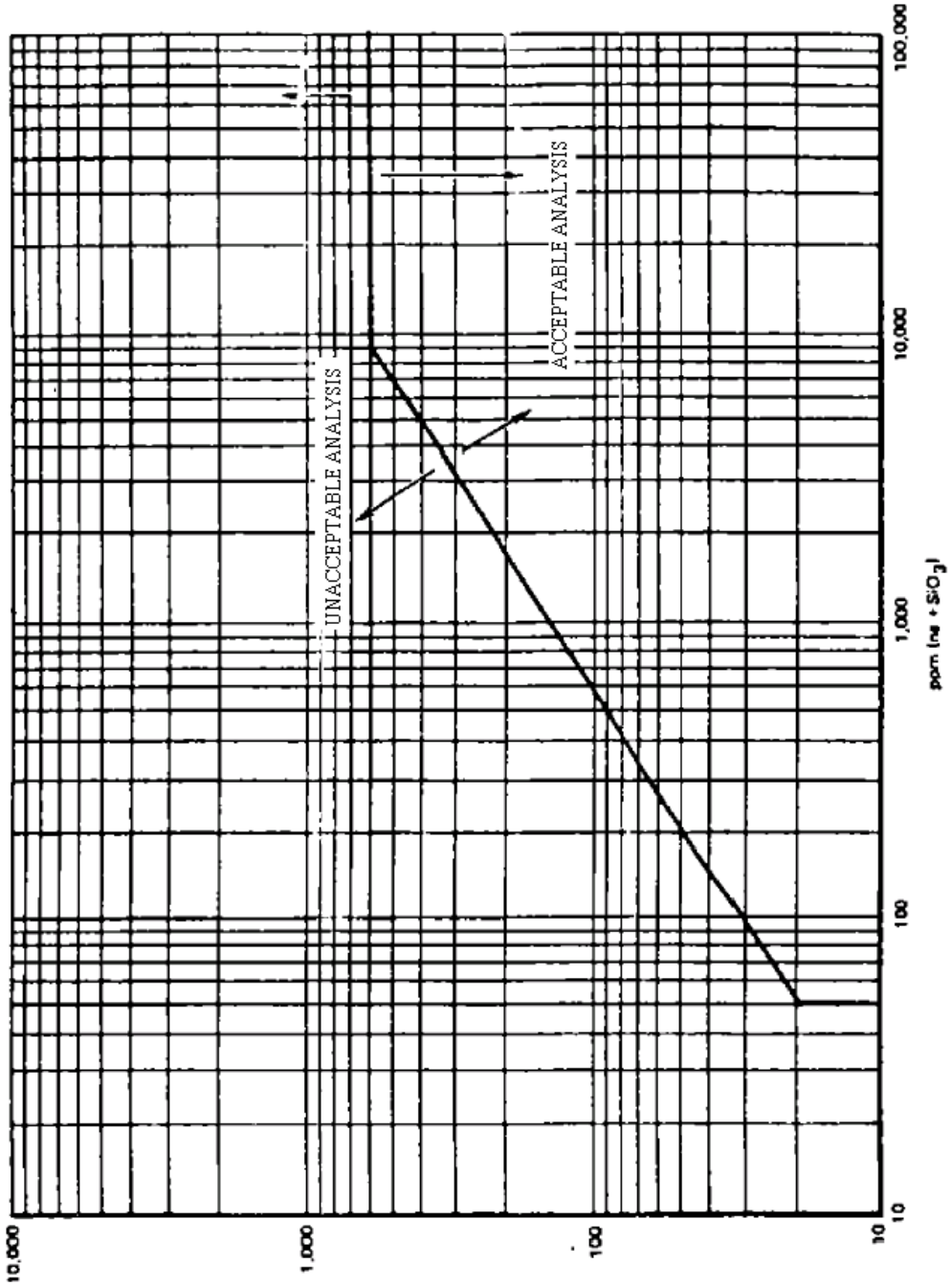
SiO_2	= 30 - 45	weight %
Al_2O_3	= 8 - 15	weight %
TiO_2	= 2 - 4	weight %
Fe_2O_3	= 2.5 max.	weight %
CaO	= 30 - 35	weight %
MgO	= 6 - 12	weight %
Na_2O	= 0 - 1	weight %
K_2O	= 0 – 1	weight %
P_2O_5	= 0 - 1	weight %

Water soluble chloride: Approximately 6 mg/kg when tested in accordance with ASTM C871.

7.2 If water-soluble chloride content of the insulation material exceeds the amount specified in the chemical composition above, sufficient amounts of sodium silicate (Na_2SiO_3) inhibitor shall be added to the insulation material. Acceptable proportion of sodium plus silicate ions to the chlorides ions as found by leaching from the insulation when tested in accordance with ASTM Test Method C871 shall be in accordance with Fig. 1.1.

With reference to Fig. 1.1 the minimum allowable value of sodium plus silicate will be 50 ppm when tested in accordance with ASTM Test Method C692, providing leachable (water soluble) chloride be higher than 10 mg per kg of insulation material.

7.3 The pH of leach water shall be measured, in accordance with ASTM Test Methods C871, and shall be greater than 7.0 but not greater than 11.7 at 25°C.



Cl ppm

ACCEPTABILITY OF INSULATION MATERIAL ON THE BASIS OF THE PLOT POINTS OF THE Cl AND THE ($Na+SiO_3$) ANALYSIS

Fig. 1.1

8. PHYSICAL PROPERTIES

The physical properties of mineral fiber preformed pipe insulation shall be as follows:

8.1 Linear Shrinkage

Linear shrinkage for length shall be maximum 2% after soaking heat and tested in accordance with ASTM Test Method C356 at manufacturer's temperature limit.

8.2 Density

The minimum density shall be agreed between purchaser and manufacturer. As a reference the value 48 Kg/m^3 for the temperature up to 450°C and 96 Kg/m^3 for the temperature up to 650°C should be used in accordance with ASTM test method C302.

8.3 Thermal Conductivity

Maximum thermal conductivity value shall be 0.065 W/mK at 200°C and 0.073 w/mK up to 450°C in accordance with ASTM Test Method C335.

8.4 Water Vapor Sorption

Water vapor sorption shall be minimum 5% by weight in accordance with ASTM test method C1104.

9. SHAPES, SIZES AND DIMENSIONS

9.1 The mineral fiber preformed pipe insulation shall be supplied as hollow cylinders, split lengthwise on one or both sides of the cylindrical axis (depending on Company request) and shall be furnished in sections or segments in a length of 1 meter unless otherwise agreed between company and manufacturer.

9.2 The minimum and maximum thickness shall be specified by the Company but in no case shall be less than 13 mm.

9.3 Thicknesses greater than 150 mm may be furnished in multiple layers.

9.4 Dimensional standard of inner and outer diameter of insulation for nominal pipe size shall be in accordance with ASTM C585.

10. DIMENSIONAL TOLERANCES

10.1 The average measured length and thickness of any individual section or segment shall not differ from the specified dimensions by more than the following:

DIMENSION	TOLERANCE
Length	±3mm
Thickness	±3% (see 9.2 for minimum thickness)

10.2 When installed on the pipe of the specified size, sections shall fit snugly and shall have tight longitudinal and circumferential joints.

11. WORKMANSHIP

The insulation shall not have visible defects that will adversely affect its installation or service quality.

12. SAMPLING

The insulation shall be sampled for the purpose of tests in accordance with criteria ASTM C390.

13. INSPECTION AND REJECTION

13.1 Inspection

13.1.1 The manufacturer and/or supplier shall be responsible for carrying out the tests and inspections required by this Standard specification, using his own or other reliable facilities, and he shall maintain complete records of all such tests and inspections. Such records shall be available for review by the Purchaser. The manufacturer and/or supplier shall furnish to the Purchaser a certificate of inspection stating that each lot has been sampled, tested, and inspected in accordance with this Standard specification and has been found to meet the requirements specified.

13.1.2 The supplier shall afford the Purchaser's inspector all reasonable facilities necessary to satisfy that the material is being produced and furnished in accordance with this Standard specification. Such inspections in no way relieve the manufacturer and/or supplier of his responsibilities under the term of this Standard specification.

13.1.3 The Purchaser reserves the right to perform any inspections set forth in this Standard specification where such inspections are deemed necessary to assure that supplies and services comform to the prescribed requirements.

13.1.4 The Purchaser's inspector shall have access to the material subject to inspection for the purpose of witnessing the selection of the samples. The preparation of the test pieces, and the performance of the test(s). For such tests, the inspector shall have the right to indicate the pieces from which the samples will be taken in accordance with the provisions of this Standard specification.

13.2 Rejection

13.2.1 If the inspection of the sample shows failure to conform to the requirements of this Standard specification, a second sample from the same lot shall be tested and the results of this retest averaged with the result of the original test.

13.2.2 Upon retest as described in 13.2.1 failure to conform to this Standard specification shall constitute grounds for rejection.

13.2.3 In case of rejection, the manufacturer or supplier shall have the right to reinspect the rejected lot and resubmit the lot for inspection after removal of that portion of the lot not conforming to the specified requirement.

14. PACKAGING AND MARKING

14.1 Packaging

14.1.1 Unless otherwise specified by the Purchaser, the mineral fiber preformed pipe insulation shall be packaged in manufacturer's standard commercial container approved by the Purchaser and considering the following:

14.1.2 Overseas consignments shall be packed in double-corrugated cartons incorporating weather proof paper because of greater handling involved and possibly of exposure to wet conditions. If the size of sections exceeds the practical size for cartons, wooden or strong mesh crates may be used.

14.1.3 Mineral fiber preformed pipe insulations materials shall not be unpacked at site until is required for use.

14.1.4 Stacking of packed mineral fiber preformed pipe insulation during transportation shall be in accordance with the manufacturer's recommendation.

14.2 Marking

14.2.1 Unless otherwise agreed between purchaser and manufacturer and/or supplier, containers shall be marked as follows:

- purchase order No.;
- name and type of material;
- thickness of insulation and pipe size in case of pipe insulation;
- quantity of material in the container;
- date of manufacturing;
- supplier's name;
- origin of manufacturing;
- destination.

15. STORAGE

15.1 The insulation shall be stored in a dry atmosphere under cover and inspected at interval not exceeding three months.

15.2 Cartons shall be stored end up and be stacked no more than three high.

APPENDICES

APPENDIX A

ORDERING INFORMATION

The following information shall be supplied with purchase order:

a) The number and date of this IPS Standard,

b) the dimension of the sections required,

c) the finish required,

d) the maximum service temperature to which the product will be subjected,

e) a note of any adverse condition in the environment of insulation or special requirements,

f) density.

PART II

MINERAL FIBER BLOCK AND BOARD

THERMAL INSULATION

CONTENTS : PAGE No.

1. SCOPE

1.1 This Standard specification covers the minimum requirements for chemical composition, dimensions, physical properties, inspection, packaging and marking of rigid and semi-rigid mineral fiber block and board thermal insulation for use on surfaces up to 540°C. If the insulation is to be used at higher temperatures the actual temperature limits shall be as agreed upon between the manufacturer and Company.

1.2 For satisfactory performance, properly installed protective vapor barriers must be used in low temperature application to prevent movement of moisture through or around the insulation towards the colder surface.

2. REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

ASTM (AMERICAN SOCIETY FOR TESTING AND MATERIALS)

C 177	"Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus"
C 356	"Test Method for Linear Shrinkage of Preformed High Temperature Thermal Insulation Subjected to Soaking Heat"
C 390	"Criteria for Sampling and Acceptance of Preformed Thermal Insulation Lots"
C 411	"Hot-Surface Performance of High Temperature Thermal Insulation"
C 553	"Test Method for Mineral Fiber Blanket and Felt Insulation"
C 692	"Test Method for Evaluating the Influence of Wicking-Type Thermal Insulations on the External Stress Corrosion Crackin Tendency of Austenitic Stainless Steel"
C 871	"Test Methods for Chemical Analysis of Thermal Insulation Material for Leachable Chloride, Fluoride, Silicate, and sodium Ions"

BSI (BRITISH STANDARD INSTITUTION)

BS 3958: Part 5	"Thermal Insulating Materials Part 5: Specification for Bonded man-made Mineral Fiber Slabs"
BS 2972	"Methods of Test for Inorganic Thermal Insulating Materials"

3. DEFINITIONS AND TERMINOLOGY

Block Insulation

Semi-rigid insulation formed into sections, rectangular both in plan and cross section, usually 90-

120 cm long, 15-60 cm wide and 2.5-15 cm thick.

Board

Rigid or semi-rigid insulation formed into sections, rectangular both in plan and cross section, usually more than 120 cm long, 60-75 cm wide and up to 10 cm thick.

Mineral fiber (Mineral wool)

Insulation composed principally of fibers manufactured from rock, slag, or glass with or without binders.

Rock wool

Mineral fiber produced from naturally occurring igneous rock.

Slab

See definition for block.

Slag wool

Mineral fiber produced from steel mill slag.

Soaking heat

A test condition in which the specimen is completely immersed in an atmosphere maintained at a controlled temperature.

Vapor barrier

A vapor check with water vapor permeance not exceeding 0.067 g/(s MN), when tested in accordance with BS 2972.

4. UNITS

This Standard is based on International System of Units (SI), except were otherwise specified.

5. MATERIAL AND MANUFACTURE

The mineral fiber preformed block and board thermal insulation shall be manufactured from mineral substances such as rock or slag processed from a molten state into fibrous form. The boards shall not contain non-fibrous pieces of these materials that have any dimensions exceeding 10 mm. Mineral fiber preformed block and board insulation shall be rigid or semi-rigid material composed of mineral fibers with or without binder.

6. GENERAL PROPERTIES

The mineral fiber preformed block and board thermal insulation shall have general properties as follows:

6.1 Insulation shall have suitable resistance to sunlight in order to minimize shrinkage bellow the limit specified in 8.1 and have as low water permeability as specified in 8.5.

6.2 It shall be non-combustible and shall be resistant to vermins and fungus, be free from

objectionable odors, and shall not react with process chemicals present.

6.3 The insulation shall be asbestos free and shall have not health hazard in case of contact or during labor working.

6.4 The insulation shall have only traces of corrosive materials; i.e. water soluble chloride, which attacks stainless steels or alkalinity which attacks aluminum jacketing.

7. CHEMICAL COMPOSITION

7.1 Optimum chemical composition for major constituent of mineral fiber preformed block and board thermal insulation shall be as follows, when tested by spectrometric methods.

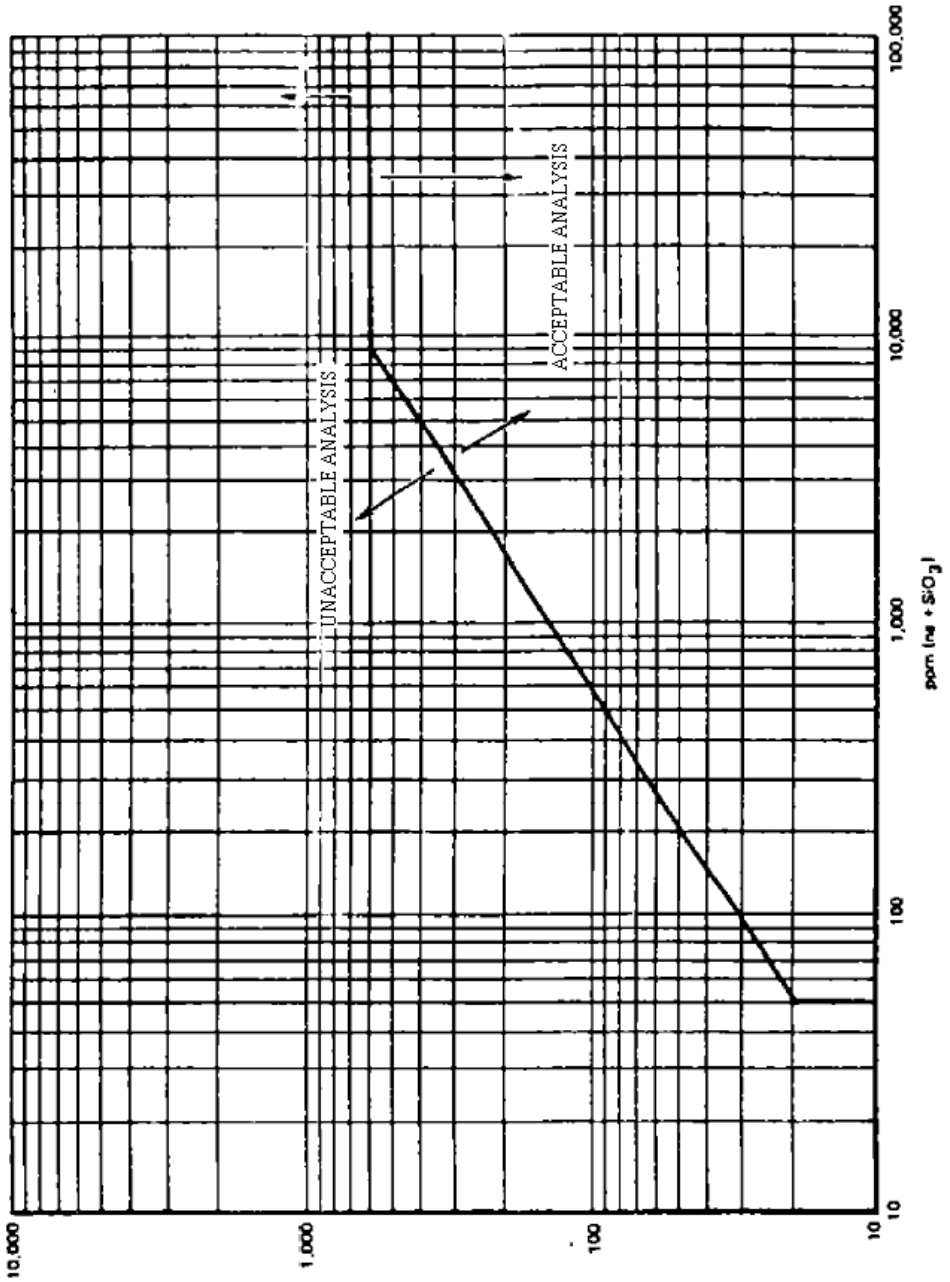
SiO_2	= 30 - 45	weight %
Al_2O_3	= 8 - 15	weight %
TiO_2	= 2 - 4	weight %
Fe_2O_3	= 2.5 max.	weight %
CaO	= 30 - 35	weight %
MgO	= 6 - 12	weight %
Na_2O	= 0 - 1	weight %
K_2O	= 0 - 1	weight %
P_2O_5	= 0 - 1	weight %

Water soluble chloride: Approximately 6 mg/kg when tested in accordance with ASTM C-871.

7.2 If water-soluble chloride content of the insulation material exceeds the amount specified in the chemical composition above, sufficient amount of sodium silicate (Na_2SiO_3) inhibitor shall be added to the insulation material. Acceptable proportion of sodium plus silicate ions to the chloride ions as found by leaching from the insulation when tested in accordance with ASTM Test Method C 871 shall be in accordance with Fig. 2.1.

With reference to Fig. 2.1 the minimum allowable value of sodium plus silicate will be 50 ppm when tested in accordance with ASTM Test Method C-692, providing leachable (water soluble) chloride be higher than 10 mg per kg of insulation material.

7.3 The pH of leach water shall be measured, in accordance with ASTM Test Methods C871, and shall be greater than 7.0 but not greater than 11.7 at 25°C .



ACCEPTABILITY OF INSULATION MATERIAL ON THE BASIS OF THE PLOT POINTS OF THE Cl AND THE ($Na+SiO_3$) ANALYSIS

Fig. 2.1

8. PHYSICAL PROPERTIES

The physical properties of mineral fiber preformed block and board insulation shall be as follows:

8.1 Linear Shrinkage

Linear shrinkage for length shall be maximum 2% after soaking heat and tested in accordance with ASTM Test Method C-356 at manufacturer's temperature limit.

8.2 Thermal Conductivity

Maximum thermal conductivity value shall be 0.065 w/mk at 200°C when tested in accordance with ASTM Test Method C 177.

8.3 Temperature of Use

When tested in accordance with ASTM Test Method C411 at the intended use temperature, insulation for use above ambient shall show no physical changes that adversely affect its service qualities.

8.4 Bulk Density

Density of the block and board mineral fiber thermal insulation shall be 300 kg/m³ maximum and variation from the specified density shall not exceed ±15%.

8.5 Moisture Absorption (water vapor)

When tested in accordance with ASTM C553 insulation for use below ambient temperature shall gain no more than 1% volume.

8.6 Recovery after Compression

When tested in accordance with BS 3958: Part 5 the recovery after compression shall be not less than 95% of the original thickness.

9. SIZE OF BOARD AND SLAB

9.1 The length and width of Board and slab shall be as per manufacturer's standard dimension unless otherwise agreed between Company and manufacturer.

9.2 The thickness of board and slab shall be specified by the Purchaser (see Appendix A "ordering information"). However the thickness shall be within the range of 25 to 100 mm in 13 mm increments.

10. DIMENSIONAL TOLERANCES

The average measured length, width, and thickness of the board and slab thermal insulation shall not differ from the dimension specified by more than the following:

DIMENSION	TOLERANCE IN mm
Length	±١٢
Width	±6
Thickness	+6
	-3

11. WORKMANSHIP

The insulation shall not have visible defects that will adversely affect its service qualities.

12. SAMPLING

The insulation shall be sampled for the purpose of tests in accordance with Test Method ASTM C390.

13. INSPECTION AND REJECTION

13.1 Inspection

13.1.1 The manufacturer and/or supplier shall be responsible for carrying out all the tests and inspections required by this Standard specification, using his own or other reliable facilities, and he shall maintain complete records of all such tests and inspections. Such records shall be available for review by the Purchaser. The manufacturer and/or supplier shall furnish to the Purchaser a certificate of inspection stating that each lot has been sampled, tested, and inspected in accordance with this Standard specification and has been found to meet the requirements specified.

13.1.2 The supplier shall afford the Purchaser's inspector all reasonable facilities necessary to satisfy that the material is being produced and furnished in accordance with this Standard specification. Such inspections in no way relieve the manufacturer and/or supplier of his responsibilities under the term of this Standard specification.

13.1.3 The Purchaser reserves the right to perform any inspections set forth in this Standard specification where such inspections are deemed necessary to assure that supplies and services comform to the prescribed requirements.

13.1.4 The Purchaser's inspector shall have access to the material subject to inspection for the purpose of witnessing the selection of the samples. The preparation of the test pieces, and the performance of the test(s). For such tests, the inspector shall have the right to indicate the pieces from which the samples will be taken in accordance with the provisions of this Standard specification.

13.2 Rejection

13.2.1 If the inspection of the sample shows failure to conform to the requirements of this Standard specification, a second sample from the same lot shall be tested and the results of this retest averaged with the result of the original test.

13.2.2 Upon retest as described in 13.2.1 failure to conform to this Standard specification shall constitute grounds for rejection.

13.2.3 In case of rejection, the manufacturer or supplier shall have the right to reinspect the rejected lot and resubmit the lot for inspection after removal of that portion of the lot not conforming to the specified requirement.

14. PACKAGING AND MARKING

14.1 Packaging

14.1.1 Unless otherwise specified by the Purchaser, the mineral fiber block and board thermal insulation shall be packaged in manufacturer's standard commercial container approved by the Purchaser and considering the following:

14.1.2 Overseas consignments shall be packed in double-corrugated cartons incorporating weather proof paper because of greater handling involved and possibly of exposure to wet conditions. If the size of sections exceeds the practical size for cartons, wooden or strong mesh crates may be used.

14.1.3 Mineral fiber block and board insulations materials shall not be unpacked at site until is required for use.

14.1.4 Stacking of packed mineral fiber block and board insulation during transportation shall be in accordance with the manufacturer's recommendation.

14.2 Marking

14.2.1 Unless otherwise agreed between purchaser and manufacturer and/or supplier, containers shall be marked as follows:

- purchase order No.;
- name and type of material;
- sizes of thermal insulation;
- quantity of material in the container;
- date of manufacturing;
- supplier's name;
- origin of manufacturing;
- destination.

15. STORAGE

15.1 The insulation shall be stored in a dry atmosphere under cover and inspected at interval not exceeding three months.

15.2 Cartons shall be stored end up and be stacked no more than three high.

APPENDICES

APPENDIX A

ORDERING INFORMATION

The following information shall be supplied with the order:

a) The number and date of this IPS Standard,

b) the dimension of thermal insulation required,

c) the maximum temperature to which the insulation will be subjected,

d) the density of thermal insulation,

e) a note of any other special requirements or properties that the material shall have in addition to this Standard.

PART III

MINERAL FIBER BLANKET

AND

BLANKET TYPE PIPE

THERMAL INSULATION

CONTENTS : PAGE No.

1. SCOPE

1.1 This Standard specification covers minimum requirements for chemical composition, physical properties dimension inspection, packaging and marking of mineral blanket and blanket type pipe insulation for use on heated surfaces operating at temperatures up to and including 650°C. For specific applications the actual temperature limit shall be agreed upon between the manufacturer and the Purchaser. The insulation shall be faced on one or both sides with a flexible metal mesh.

2. REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

ASTM (AMERICAN SOCIETY FOR TESTING AND MATERIALS)

C 177-97	"Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus"
C-390-89	"Criteria for Sampling and Acceptance of Preformed Thermal Insulation Lots"
C 592-95	
C-692-97	"Evaluating the Influence of Wicking-Type Thermal Insulations on the Stress Corrosion Cracking Tendency of Austenitic Stainless Steel"
C-871-95	"Test Method for Chemical Analysis of Thermal Insulation Material for Leachable Chloride, Fluoride, Silicate and Sodium Ions"

BSI (BRITISH STANDARD INSTITUTION)

BS 2972-89	"Methods of Test for Inorganic Thermal Insulating Materials"

3. DEFINITIONS AND TERMINOLOGY

Blanket insulation

Insulation of the flexible type, formed into sheets or rolls, usually with a vapor-barrier or facing on one or both sides.

Blanket insulation, metal mesh

Blanket insulation covered by flexible metal-mesh facings attached on one or both sides.

Expanded metal

Metal network made by suitably stamping or cutting sheet metal and stretching it to form open diamond-shaped meshes.

Facing

A protective or decorative (or both) surface applied as the outer most layers of an insulation system.

Metal-mesh covered mineral fiber blanket thermal insulation and mineral fiber blanket type pipe insulation

Mineral fiber blanket thermal insulation covered by metal mesh facings on one or both sides, held together by heat resistant ties extending through from one face to the other.

Mineral fiber (Mineral wool)

Insulation composed principally of fibers manufactured from rock, slag, or glass with or without binder.

Rock wool

Mineral fiber produced from naturally occurring igneous rock.

Slag wool

Mineral fiber produced from steel mill slag.

4. UNITS

This Standard is based on International System of Units (SI), except where otherwise specified.

5. MATERIAL AND MANUFACTURE

5.1 Composition

The mineral fiber blanket and blanket type pipe thermal insulation shall be manufactured from mineral substances such as rock or slag processed from a molten state into fibrous form. The blanket shall not contain non-fibrous pieces of these materials that have any dimensions exceeding 10 mm.

5.2 Facing

5.2.1 The blanket shall be faced on one or both sides with woven wire mesh or expanded metal, and held together by wire or twine extending from one face to the other, spaced not more than 120 mm apart. The ties shall not become detached from the facing when pressure is applied over the surface of the blanket. When both sides are to be faced, units may have the same or different types on the two sides.

5.2.2 Standard types of metal-mesh used as facings are as follows:

5.2.2.1 Woven wire mesh, mild steel No. 20 to 22 gauges (approximately 0.33 to 0.73mm) having hexagonal-shaped opening, galvanized after weaving.

5.2.2.2 Expanded metal lath, (copper bearing not galvanized mild steel) having diamond-shaped openings; 6-10 mm short way of mesh (SWM), 0.45 mm thick strand, 1.22 kg/m² mass.

5.2.2.3 Other types or compositions of facings may be specified.

6. GENERAL PROPERTIES

The mineral fiber blanket thermal insulation shall have general properties as follows:

6.1 Insulation shall have suitable resistance to sunlight and have as low water permeability as specified in 8.4.

6.2 It shall be non-combustible and shall be resistant to vermins and fungus, be free from objectionable odors, and shall not react with process chemicals present.

6.3 The insulation shall be asbestos free and shall have not health hazard in case of contact or during labor working.

6.4 The insulation shall have only traces of corrosive materials; i.e. water soluble chloride which attacks stainless steels or alkalinity which attacks aluminum jacketing.

7. CHEMICAL COMPOSITION

7.1 Chemical composition for major constituent of mineral fiber blanket thermal insulation may be as follows:

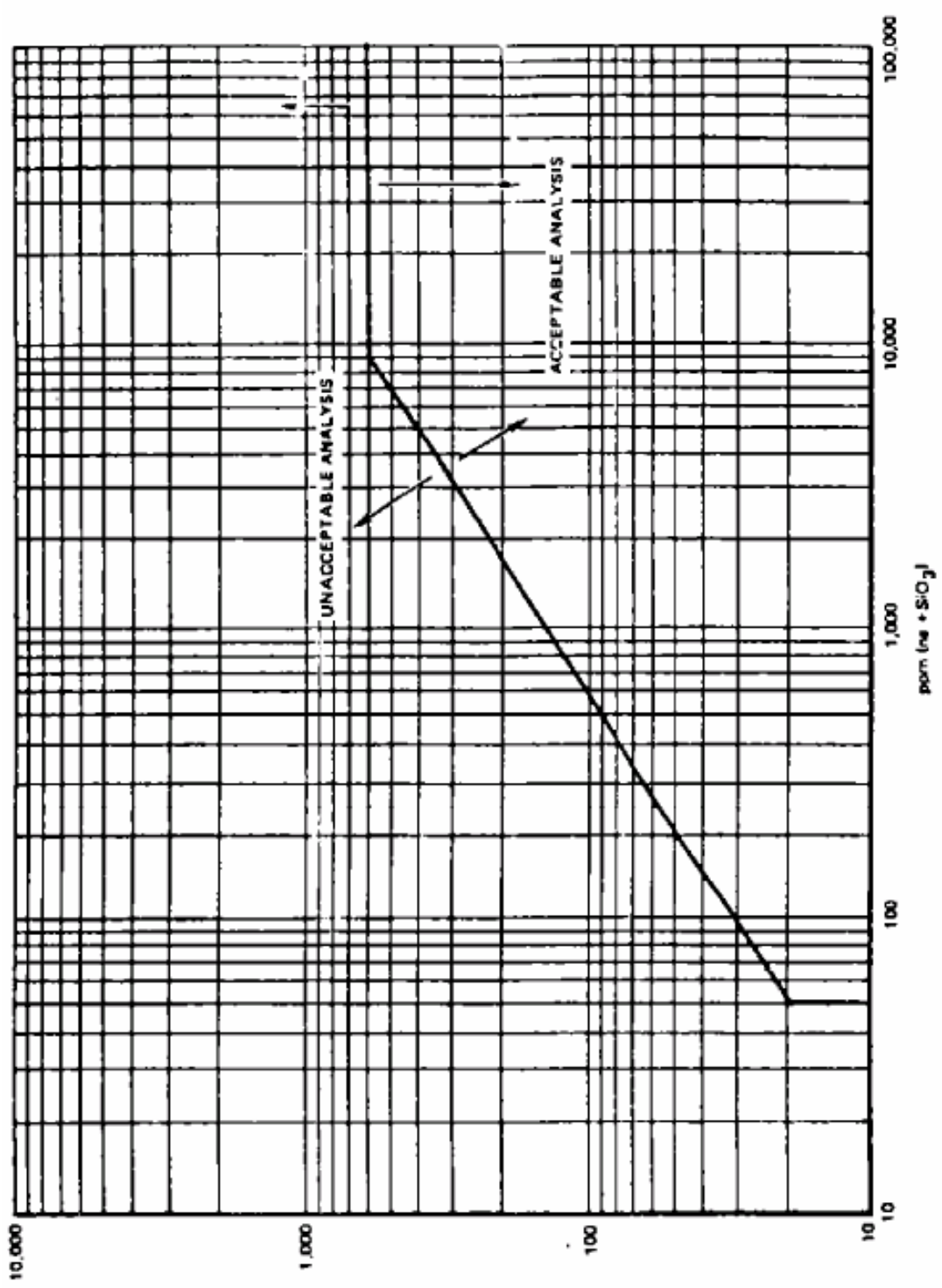
SiO_2	= 30 - 45	weight %
Al_2O_3	= 8 - 15	weight %
TiO_2	= 2 - 4	weight %
Fe_2O_3	= 2.5 max.	weight %
CaO	= 30 - 35	weight %
MgO	= 6 - 12	weight %
Na_2O	= 0 - 1	weight %
K_2O	= 0 - 1	weight %
P_2O_5	= 0 - 1	weight %

Water soluble chloride: Approximately 6 mg/kg when tested in accordance with ASTM C-871.

7.2 If water soluble chloride content of the insulation material exceeds the amount specified in the chemical composition above, sufficient amount of sodium silicate (Na_2SiO_3) inhibitor shall be added to the insulation material. Acceptable proportion of sodium plus silicate ions to the chloride ions as found by leaching from the insulation when tested in accordance with ASTM Test Method C 871 shall be in accordance with Fig. 3.1.

With reference to Fig. 3.1 the minimum allowable value of sodium plus silicate will be 50 ppm when tested in accordance with ASTM Test Method C-692, providing leach able (water soluble) chloride be higher than 10 mg per kg of insulation material.

7.3 The pH of leach water shall be measured, in accordance with ASTM Test Methods C871, and shall be greater than 7.0 but not greater than 11.7 at 25°C.



ACCEPTABILITY OF INSULATION MATERIAL ON THE BASIS OF THE PLOT POINTS OF THE Cl AND THE ($Na+SiO_3$) ANALYSIS

Fig. 3.1

8. PHYSICAL PROPERTIES

The physical properties of mineral fiber blanket and blanket type pipe insulation shall be as follows:

8.1 Thermal Conductivity

Maximum thermal conductivity shall be 0.065 w/mk at 200°C when tested in accordance with ASTM Test Method C 177.

8.2 Density

The density of thermal insulation shall be as agreed between manufacturer and purchaser.

8.3 Handle ability

Each piece of metal mesh covered insulation shall be sufficiently coherent to permit transportation and installation as a unit.

8.4 Moisture Content

The moisture content of the materials shall not exceed 5% by mass when conditioned at high humidity in accordance with BS 2972.

8.5 Compressibility and Resilience

When tested by the method described in Appendix B the thickness of the specimen whilst under pressure shall be not greater than the nominal thickness plus 3 mm. After removal of the pressure, the thickness shall be not less than the nominal thickness minus 3 mm.

Note:

The objects of this test are to ensure that a mattress supplied at greater than nominal thickness is sufficiently compressible to be fitted at its nominal thickness and that a mattress is sufficiently resilient to recover its nominal thickness after being subjected to compression.

8.6 Limiting Temperature and Thickness

8.6.1 The manufacturer shall state the maximum limiting temperature and limiting thickness at that temperature.

8.6.2 When a sample is heated in accordance with BS 2972 at the stated maximum limiting temperature of use, the material shall maintain its general form and not suffer visible deterioration of the fibrous structure.

8.7 Liner Shrinkage

Liner shrinkage for length shall be maximum 4% at maximum used temperature.

Note:

The color changes are not relevant.

9. DIMENSIONS

Standard sizes of metal-mesh blanket insulation may be as specified herein below or as agreed between the manufacturer and Purchaser:

Length: 1.25 and 2.5 m

Width: 0.6 m

Thickness: 25 to 150 mm in 13 mm increments

Note:

Thicknesses over 75 mm may be composed of two or more blankets plied together.

10. DIMENSIONAL TOLERANCES

The average measured length, width, and thickness shall differ from the manufacturer's standard dimensions by not more than the following:

11. WORKMANSHIP

The insulation shall not have visible defects that will adversely affect the service quality.

12. SAMPLING

The insulation shall be sampled for the purpose of tests in accordance with ASTM C390 or BS 2972 as specified in the relevant test.

13. INSPECTION AND REJECTION

13.1 Inspection

13.1.1 The manufacturer and/or supplier shall be responsible for carrying out all the tests and inspections required by this Standard specification, using his own or other reliable facilities, and he shall maintain complete records of all such tests and inspections. Such records shall be available for review by the Purchaser. The manufacturer and/or supplier shall furnish to the Purchaser a certificate of inspection stating that each lot has been sampled, tested, and inspected in accordance with this Standard specification and has been found to meet the requirements specified.

13.1.2 The supplier shall afford the Purchaser's inspector all reasonable facilities necessary to satisfy that the material is being produced and furnished in accordance with this Standard specification. Such inspections in no way relieve the manufacturer and/or supplier of his responsibilities under the term of this Standard specification.

13.1.3 The Purchaser reserves the right to perform any inspections set forth in this Standard specification where such inspections are deemed necessary to assure that supplies and services conform to the prescribed requirements.

13.1.4 The Purchaser's inspector shall have access to the material subject to inspection for the purpose of witnessing the selection of the samples. The preparation of the test pieces, and the performance of the test(s). For such tests, the inspector shall have the right to indicate the pieces from which the samples will be taken in accordance with the provisions of this Standard specification.

13.2 Rejection

13.2.1 If the inspection of the sample shows failure to conform to the requirements of this Standard specification, a second sample from the same lot shall be tested and the results of this retest averaged with the result of the original test.

13.2.2 Upon retest as described in 13.2.1 failure to conform to this Standard specification shall constitute grounds for rejection.

13.2.3 In case of rejection, the manufacturer or supplier shall have the right to reinspect the rejected lot and resubmit the lot for inspection after removal of that portion of the lot not conforming to the specified requirement.

14. PACKAGING AND MARKING

14.1 Packaging

14.1.1 Unless otherwise specified by the Purchaser, the mineral fiber blanket and blanket type pipe thermal insulation shall be packaged in manufacturer's standard commercial container approved by the Purchaser and considering the following:

14.1.2 Overseas consignments shall be packed in double-corrugated cartons incorporating weather proof paper because of greater handling involved and possibly of exposure to wet conditions. If the size of sections exceeds the practical size for cartons, wooden or strong mesh crates may be used.

14.1.3 Mineral fiber blanket insulations materials shall not be unpacked at site until is required for use.

14.1.4 Stacking of packed mineral fiber blanket insulation during transportation shall be in accordance with the manufacturer's recommendation.

14.2 Marking

14.2.1 Unless otherwise agreed between the Purchaser and manufacturer and/or supplier, containers shall be marked as follows:

- purchase order No.;
- name and type of material;
- dimension of thermal insulation;
- quantity of material in the container;
- date of manufacturing;
- supplier's name;
- origin of manufacturing;
- destination.

15. STORAGE

15.1 The insulation shall be stored in a dry atmosphere under cover and inspected at interval not exceeding three months.

15.2 Cartons shall be stored end up and be stacked no more than three high.

APPENDICES

APPENDIX A

ORDERING INFORMATION

The following information shall be supplied with the order:

a) The number and date of this IPS Standard,

b) the dimension of thermal insulation required,

c) the maximum temperature to which the insulation will be subjected,

d) the density of thermal insulation,

e) the type of metal facing, e.g. woven wire mesh or expanded metal, or a special type of metal facing;

f) whether the material is required to be faced on two sides or on one side only;

g) the type of tie required;

h) a note of any other special requirements or properties that the material shall have in addition to this Standard.

APPENDIX B

METHOD OF TEST FOR COMPRESSIBILITY AND RESILIENCE

B.1 Specimens

Cut five specimens, each 200 mm × 200 mm, from the mattress sample.

B.2 Procedure

Remove all facings and ties from a specimen and place the specimen on a flat horizontal surface. Place on it a flat, stiff platen of dimensions 300 mm × 300 mm and a mass of 0.5 ±0.05 kg. Apply a 10 kg load (equal to 2.6 kPa) centrally to the platen and, after 5 min., determine the thickness of the specimen by measurements at the four corners of the platen. Remove the load and the platen, allow the specimen to expand freely for 5 min, replace the platen and measure the final thickness at the four corners of the platen with a steel rule.

PART IV

CALCIUM SILICATE PREFORMED BLOCK

AND

PIPE

THERMAL INSULATION

CONTENTS : PAGE No.

1. SCOPE

This Standard Specification covers the minimum requirements for composition, dimensions, physical properties dimensions, inspection, packaging and marking of calcium silicate preformed block and pipe sections thermal insulation for use on surfaces with temperature limit up to 920°C. For specific applications, the actual temperature limit shall be agreed upon between manufacturer and the Purchaser.

2. REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

ASTM (AMERICAN SOCIETY FOR TESTING AND MATERIALS)

C 165-95	"Test Method for Measuring Compressive Properties of Thermal Insulations"
C 177-97	"Test Method for Steady State Heat Flux Measurement and Thermal Transmission Properties by Means of the Guarded Hot Plate Apparatus"
C 203-99	"Test Methods for Breaking Load and Flexural Properties of Block-Type Thermal Insulation"
C 302-98	"Test Method for Density and Dimension of Preformed Pipe Covering-Type Thermal Insulation"
C 303	"Test Method for Density of Preformed Block-Type Thermal Insulation"
C 335-95	"Test Method for Steady State Heat Transfer Properties of Horizontal Pipe Insulation"
C 356-87	"Test Method for Linear Shrinkage of Preformed High-Temperature Thermal Insulation Subjected to Soaking Heat"
C 390-79	"Criteria for Sampling and Acceptance of Preformed Thermal Insulation Lots"
C 411-97	"Test Method for Hot-Surface Performance of High Temperature Thermal Insulation"
C 421-95	"Test Method for Tumbling Friability of Block-Type Thermal Insulation"
C 466-97	"Test Method for Breaking Load Modulus of Rupture of Preformed Insulation"
C 533-95	
E-84-99	"Test Method for Surface Burning Characteristics of Building Materials"

3. DEFINITIONS AND TERMINOLOGY

Asbestos

The generic name for those silicate minerals that cleave naturally into fibers, the three important form, being chrysotile (white asbestos), crocidolite (blue asbestos), and amosite.

Block insulation (slab)

Rigid insulation preformed into sections, rectangular both in plan and cross section.

Calcium silicate

Hydrated calcium silicate with added reinforcing fiber.

Pipe insulation

Insulation in a form suitable for application to cylindrical surfaces.

Soaking heat

A test condition in which the specimen is completely immersed in an atmosphere maintained at a controlled temperature.

4. UNITS

This Standard is based on International System of Units (SI), except where otherwise specified.

5. GENERAL PROPERTIES

5.1 The insulation shall have suitable resistance to sunlight in order to minimize shrinkage.

5.2 It shall be non-combustible and shall be resistance to vermins and fungus, be free from objectionable odors, and shall not react with process chemical present.

5.3 The insulation shall be asbestos free and shall have not health hazard in case of contact or during labor working.

5.4 The insulation shall have only traces of corrosive materials, e.g. water-soluble chlorides which attack stainless steels or alkalinity which attacks aluminum jacketing.

6. COMPOSITION

Calcium silicate thermal insulation shall be composed predominately of reacted hydrous calcium silicate and usually incorporates a fibrous reinforcement. Asbestos shall not be used as a component in the manufacture of the material.

7. PHYSICAL PROPERTIES

7.1 Thermal Conductivity

The thermal conductivity shall not exceed 0.079 W/mk for type I and 0.039 w/mk for type II at 204°C when tested in accordance with following ASTM test methods:

7.1.1 Block insulation

Test Method C177 or C518 using 38 ±13 mm thick specimen. Curved block shall be trimmed to provide plane parallel surfaces.

7.1.2 Pipe insulation

Test Method C335 using 38 ±13 mm thick specimen of pipe insulation as supplied for fit to 76 mm nominal steel pipe.

7.2 Bulk Density

The maximum bulk density of the dry material shall be 240 kg/m³ for type I and 352 Kg/m for type II when tested in accordance with ASTM Methods C303 for block insulation and C302 for pipe insulation.

7.3 Flexural Strength

The flexural strength shall not be less than 250 kN/m² when tested in accordance with ASTM Test Methods C203 for block insulation and C446 for pipe insulation.

7.4 Compressive Strength

The reduction in thickness shall not exceed 5% under compressive load of 500 kN/m² when tested in accordance with ASTM Recommended Practice C165.

7.5 Weight Loss by Tumbling

Maximum loss in weight when tested in accordance with ASTM Test Method C421 shall be as following:

Duration	Weight loss%
After first 10 min After second 10 min	20 40

7.6 Linear Shrinkage

Linear shrinkage after heat soaking shall be maximum 2% when tested according to ASTM Test Method C356 at the insulation temperature limit specified in 1 or manufacturer temperature limit whichever is higher.

7.7 Hot Surface Performance

7.7.1 Hot surface performance shall be tested in accordance with ASTM Test Method C411. The temperature shall be as specified in 1 or manufacturer temperature limit.

7.7.2 Warpage

Maximum warpage shall be 6 mm.

7.7.3 Cracking

No cracks shall completely penetrate through the insulation thickness, but minor surface cracks on hot face are acceptable.

7.8 Surface Burning Characteristic

Test Method shall be ASTM E84 and maximum flame spread index and smoke density index for calcium silicate block and pipe thermal insulation shall be zero.

8. STANDARD SHAPE, SIZE AND DIMENSION

8.1 Calcium silicate preformed thermal insulation shall be supplied in the form of flat block, curved block, grooved block and pipe section with the following dimensions:

Note:

Note all the suppliers provide the full range of standard shapes and sizes listed in 8.2 to 8.5. Conversely other shapes and sizes may be available. Supplier shall be consulted for details of the range offered.

8.2 Flat Block

Flat block shall be furnished in a length of 450 to 1000 mm, a width of 150 to 1000 mm and in thicknesses from 25 to 150 mm in 13 mm increments. The thicknesses greater than 75 mm may be furnished in 2 or more layers when specified by Purchaser.

8.3 Curved Block

Curved block shall be furnished in a length of 1000 mm, a width of approximately 150 mm or 300 mm, a thickness of 38 to 100 mm in 13 mm increments, and curved to inside radii of over 419 mm. Individual dimensions shall conform to those specified by the manufacturer.

8.4 Grooved Block

Grooved block shall be furnished in a length of 1000 mm, a width of 305 mm or 458 mm and in thickness from 25 to 150 mm in 13 mm increments. Size and spacing of grooves shall be as specified by manufacturer. Long edges of grooved block may be furnished beveled as specified by the manufacturer.

8.5 Pipe Section

Calcium silicate pipe insulation shall be supplied either as hollow cylindrical shapes split in half lengthwise (in a plane including the cylindrical axis) or as a curved segments. The pipe insulation shall be furnished in sections or segments in a length of 1000 mm to fit standard size of pipe and tubing, and in nominal thickness of from 25 to 150 mm), in 13 mm increments. Thicknesses greater than 75 mm may be furnished in two or more layers, as specified by the Purchaser. Individual dimensions shall conform to those specified by the manufacturer.

9. DIMENSIONAL TOLERANCES

9.1 General

The average measured length, width and thickness shall not differ from the manufacturer's standard dimensions by more than the following:

	BLOCK	PIPE
Length	±٣ mm	±٣ mm
Width	±3 mm	---
Thickness	±3 mm	±3 mm

9.2 Pipe Insulation

The following additional dimensional tolerances apply only to calcium silicate pipe insulation supplied as half sections.

9.2.1 Fit and closure

When fitted to the appropriate size pipe by banding on 230 mm centers, the longitudinal seams on both sides of the pipe insulation shall close to within 1.6 mm along the entire length of the section.

9.2.2 Concentricity

The inner bore of the pipe insulation shall be concentric with the outer cylindrical surface. The deviation from concentricity shall not exceed 3 mm or 5% of the wall thickness, whichever is greater.

9.2.3 Half section balance

The plane formed by the slit between the half sections shall include the cylindrical axis. Deviation of the slit plane from the cylindrical axis over 914 mm length shall not exceed 3 mm.

9.3 Grooved Block

The following additional requirements apply only to calcium silicate block insulation containing grooves and intended for installation over curved surfaces 508 mm in diameter or larger.

9.3.1 Fit and closure

When fitted to the curved surface, the grooves shall close to 3 mm or less through the depth of the groove. The exposed surface crack shall not open more than 3 mm. The insulation will pivot at the ungrooved area at the bottom of the groove with the groove closing and the exposed ungrooved surface cracking. The deeper the groove is in the insulation, the smaller the crack on the exposed surface will be.

10. WORKMANSHIP

Since some requirements for this material are not easily defined by a numerical value, the insulation shall not have visible defects that will adversely affect its service qualities.

11. SAMPLING

The insulation shall be sampled in accordance with ASTM C390. Specific provision for sampling

shall be agreed upon between the Purchaser and the supplier as part of the purchase contract.

12. INSPECTION AND REJECTION

12.1 Inspection

12.1.1 The manufacturer and/or supplier shall be responsible for carrying out all the tests and inspections required by this Standard specification, using his own or other reliable facilities, and he shall maintain complete records of all such tests and inspections. Such records shall be available for review by the Purchaser. The manufacturer and/or supplier shall furnish to the Purchaser a certificate of inspection stating that each lot has been sampled, tested, and inspected in accordance with this Standard specification and has been found to meet the requirements specified.

12.1.2 The supplier shall afford the Purchaser's inspector all reasonable facilities necessary to satisfy that the material is being produced and furnished in accordance with this Standard specification. Such inspections in no way relieve the manufacturer and/or supplier of his responsibilities under the term of this Standard specification.

12.1.3 The Purchaser reserves the right to perform any inspections set forth in this Standard specification where such inspections are deemed necessary to assure that supplies and services comform to the prescribed requirements.

12.1.4 The Purchaser's inspector shall have access to the material subject to inspection for the purpose of witnessing the selection of the samples. The preparation of the test pieces, and the performance of the test(s). For such tests, the inspector shall have the right to indicate the pieces from which the samples will be taken in accordance with the provisions of this Standard specification.

12.2 Rejection

12.2.1 If the inspection of the sample shows failure to conform to the requirements of this Standard specification, a second sample from the same lot shall be tested and the results of this retest averaged with the result of the original test.

12.2.2 Upon retest as described in 12.2.1 failure to conform to this Standard specification shall constitute grounds for rejection.

12.2.3 In case of rejection, the manufacturer or supplier shall have the right to reinspect the rejected lot and resubmit the lot for inspection after removal of that portion of the lot not conforming to the specified requirement.

13. PACKAGING AND MARKING

13.1 Packaging

13.1.1 Unless otherwise specified by the Purchaser, the calcium silicate preformed block and pipe thermal insulation shall be packaged in manufacturer's standard commercial container approved by the Purchaser and considering the following:

13.1.2 Overseas consignments shall be packed in double-corrugated cartons incorporating weather proof paper because of greater handling involved and possibly of exposure to wet conditions. If the size of sections exceeds the practical size for cartons, wooden or strong mesh crates may be used.

13.1.3 The insulation materials shall not be unpacked at site until is required for use.

13.1.4 Stacking of packed calcium silicate insulation during transportation shall be in accordance with the manufacturer's recommendation.

13.2 Marking

13.2.1 Unless otherwise agreed between purchaser and manufacturer and/or supplier, containers shall be marked as follows:

- purchase order No.;
- name and type of material;
- sizes of thermal insulation;
- quantity of material in the container;
- date of manufacturing;
- supplier's name;
- origin of manufacturing;
- destination.

14. STORAGE

14.1 The insulation shall be stored in a dry atmosphere under cover and inspected at interval not exceeding three months.

14.2 Cartons shall be stored end up and be stacked no more than three high.

APPENDICES

APPENDIX A

ORDERING INFORMATION

The following information shall be supplied with the order:

a) The number and date of this IPS Standard,

b) the dimension of thermal insulation required,

c) the maximum temperature to which the insulation will be required and the class of insulation,

d) a note of any other special requirements or properties that the material shall have in addition to this Standard,

e) bulk density.

PART V

CELLULAR GLASS / FOAM GLASS

THERMAL INSULATION

CONTENTS : PAGE No.

1. SCOPE

This Standard specification covers the minimum requirements for composition, physical properties, dimensions, inspection, packaging and marking of cellular glass thermal insulation intended for use on surfaces operating at temperature between -268 and 427°C.

2. REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

ASTM (AMERICAN SOCIETY FOR TESTING AND MATERIALS)

C-165-95	"Method for Measuring Compressive Properties of Thermal Insulations"
C-177-97	"Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of Guarded Hot Plate Apparatus"
C-203-99	"Test Method for Breaking Load and Flexural Properties of Block-Type Thermal Insulation"
C-303-98	"Test Method for Density of Preformed Block-Type Thermal Insulation"
C-390-79(1995)	"Criteria for Sampling and Acceptance of Preformed Thermal Insulation Lots"
C-411-87	"Test Method for Hot-Surface Performance of High Temperature Thermal Insulation"
C-534	
C-585-95	"Practice for Inner and Outer Diameter of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS Systems)
C-623-92-(1995)	"Test Method for Young's Modulus, Shear Modulus, and Poisson's Ratio for Glass and Glass- Ceramics by Resonance"
E-96-95	"Test Method for Water Vapor Transmission of Materials"

BSI (BRITISH STANDARD INSTITUTION)

BS 476	"Fire Test on Building Materials and Structures"

3. DEFINITIONS AND TERMINOLOGY

Block (slab) insulation

Semi rigid insulation formed into sections rectangular both in plan and cross section, usually 90-120 cm long, 15-60 cm wide and 2.5-15 cm thick.

Board insulation

Semi rigid insulation formed into sections rectangular both in plan and cross section, usually more than 120 cm long, 60-75 cm wide and up to 10 cm thick.

Cellular glass (foam glass) insulation

A lightweight expanded glass insulation with small cells, preferably non-intercommunicating produced by a foaming process.

Jacket

A form of facing applied over insulation. It may be integral with the insulation, or field applied using sheet material.

Water vapor transmission rate

The steady water vapor flow in unit time through unit area of a body, normal to specific parallel surfaces, under specific conditions of temperature and humidity at each surface.

4. UNITS

This Standard is based on International System of Units (SI), except where otherwise specified.

5. CLASSIFICATION

5.1 The cellular glass insulation may be furnished in the following types and classes as required by the Company (see Clause 8 of this Part of the Standard):

5.1.1 Type I: Flat Block.

5.1.2 Type II: Pipe and Tubing Insulation.

5.1.2.1 Class 1: Regular (uncovered).

5.1.2.2 Class 2: Jacketed.

5.1.3 Type III: Special Shapes.

5.1.4 Type IV: Board.

6. MATERIAL AND MANUFACTURE

6.1 The material shall consist of a glass composition that has been foamed or cellulated under molten conditions, annealed, and set to form a rigid incombustible material with hermetically sealed cells. The material shall be trimmed into blocks of standard dimensions or commercial sizes.

6.2 The pipe insulation, board and special shapes such as curved sidewall segments and head segments, shall be fabricated from standard blocks.

7. PHYSICAL PROPERTIES

7.1 The physical properties of cellular glass insulation shall be as following. Since all cellular glass is produced initially in block form and is only cut to form pipe, curved, or segmental insulation without additional treatment, the physical testing of cellular glass shall be made on block and dry specimens.

7.2 Density

The density of insulation when meets the other physical properties can be between 112 to 152

kg/m³ when tested in accordance with ASTM Test Method C 303.

7.3 Thermal Conductivity

Thermal conductivity of cellular glass thermal insulation shall not be greater than the following when tested in accordance with ASTM Test Method C 177:

MEAN TEMPERATURE °C	THERMAL CONDUCTIVITY W/mk
+٢٠	٠,٠٤٥
0	0.042
-20	0.038

7.4 Compressive Strength

Compressive strength shall not be less than 490 kPa when tested in accordance with ASTM Test Method C 165.

7.5 Water Vapor Transmission

Water vapor transmission of cellular glass thermal insulation shall be zero according to ASTM Test Method E96.

7.6 Flexural Strength

Minimum flexural strength of insulation shall be 414 kPa when tested in accordance with ASTM Test Method C 203.

7.7 Hot Surface Performance

Hot surface performance of insulation when tested in accordance with ASTM Test Method C411 at maximum test temperature of 427°C and maximum rate of heating at 111°C/hr. shall indicate maximum warpage of 3 mm and no open cracks completely penetrate through the insulation thickness.

7.8 Fire Resistive Property

The insulation as per BS 476 shall be non-combustible.

7.9 Modulus of Elasticity

Modulus of elasticity of insulation when tested in accordance with ASTM Test Method C623 shall not be less than 980 MPa.

8. STANDARD SIZES AND DIMENSIONS

8.1 Blocks shall be rectangular sections and shall be true to form and dimension, the corner square and the sides and edges parallel. The typical sizes and thicknesses are shown in the following table. The required sizes and thicknesses shall be as specified by the Company:

LENGTH mm	WIDTH mm	THICKNESS mm
٤٥٧	٣٠٥	٣٨,١
		44.5
		50.8
		63.5
		76.2
		102
		127
610	457	50.8
		63.5
		76.2
		102
		127

8.2 Type II: Pipe and Tubing Insulation

8.2.1 Cellular glass pipe and tubing insulation shall be fabricated in either 457 mm or 610 mm nominal length and/or as will be specified by the Company.

8.2.2 Cellular glass pipe insulation for 152 mm (NPS 6) and smaller pipe shall be fabricated made to a minimum thickness of 25 mm. Pipe insulation for larger than 152 mm (NPS 6) shall be made to a minimum 38 mm thickness. Sizes shall conform to ASTM Practices C 585.

8.2.3 Cellular glass pipe insulation for pipe sizes up to 250 mm (NPS 10) shall be supplied in half sections. For pipe sizes with diameter exceeding 250 mm (NPS 10) and for equipment up to 7000 mm diameter, cellular glass insulation shall be supplied in radiused and beveled segments having a width on the outside radius of between 140 and 160 mm for diameters up to 1000 mm, and a width on the outside radius between 210 and 435 mm for diameter from 1000 mm up to 7000 mm.

8.2.4 For equipment in excess of 7000 mm diameter, cellular glass insulation shall be supplied in flat block of minimum 300 mm wide.

8.2.5 For equipment heads and spherical tanks special factory radiused and beveled segments to suit the curvature of heads/tanks requiring not more than one field cut for proper closure shall be used.

8.2.6 All circumferential and longitudinal joints in pipe sections, radiused and beveled segments and slabs shall be of the butt type.

8.3 Type III: Special Shapes
Dimensions of special shapes shall be specified by the Company.

8.4 Type IV: Board
Dimensions of board shall be 610 mm wide by 1219 mm long by 38 mm or 51 mm thick as standard available sizes and/or as specified by the Company.

9. DIMENSIONAL TOLERANCES

9.1 The average measured length, width and thickness for Types I, II and IV shall not differ from the supplied dimensions by more than the tolerances listed below:

DIMENSION mm	BLOCK	PIPE	BOARD
Length	±١,٦	±٣,٢	±٣,٢
Width	±1.6	-	±1.6
Thickness	±1.6	±3.2	±1.6

9.2 Manufacturing tolerances for the bore diameter and wall thickness of cellular glass pipe

insulation are as given in ASTM Practice C 585.

9.3 The following additional tolerances apply only to cellular glass pipe and tubing insulation applied in half section.

9.3.1 Fit end closure

When fitted to appropriate size pipe by banding on 230 mm centers, the longitudinal joints on both sides of the pipe insulation shall close to within 1.6 mm along the entire length of the section.

9.3.2 Concentricity

The inner bore of the pipe insulation shall be concentric with the outer cylindrical surface. Deviation from concentricity shall not exceed 3.2 mm or 5% of the wall thickness, whichever is greater.

9.3.3 Half section balance

The plane formed by the slit between half sections shall include the cylindrical axis. Deviation of the split plane from the cylindrical axis over 610 mm length shall not exceed 3.2 mm.

9.4 Dimensional tolerances for Type III shall be decided upon between the manufacturer and the Company.

10. WORKMANSHIP

Since some requirements for this material are not easily specified by numerical value, the insulation shall have no visible defects that will adversely affect its service qualities.

11. SAMPLING

The insulation shall be sampled for the purpose of testing in accordance with ASTM Criteria C390.

12. INSPECTION AND REJECTION

12.1 Inspection

12.1.1 The manufacturer and/or supplier shall be responsible for carrying out all the tests and inspections required by this Standard specification, using his own or other reliable facilities, and he shall maintain complete records of all such tests and inspections. Such records shall be available for review by the Purchaser. The manufacturer and/or supplier shall furnish to the Purchaser a certificate of inspection stating that each lot has been sampled, tested, and inspected in accordance with this Standard specification and has been found to meet the requirements specified.

12.1.2 The supplier shall afford the Purchaser's inspector all reasonable facilities necessary to satisfy that the material is being produced and furnished in accordance with this Standard specification. Such inspections in no way relieve the manufacturer and/or supplier of his responsibilities under the term of this Standard specification.

12.1.3 The Purchaser reserves the right to perform any inspections set forth in this Standard specification where such inspections are deemed necessary to assure that supplies and services conform to the prescribed requirements.

12.1.4 The Purchaser's inspector shall have access to the material subject to inspection for the purpose of witnessing the selection of the samples.

The preparation of the test pieces, and the performance of the test(s). For such tests, the inspector shall have the right to indicate the pieces from which the samples will be taken in accordance with

the provisions of this Standard specification.

12.2 Rejection

12.2.1 If the inspection of the sample shows failure to conform to the requirements of this Standard specification, a second sample from the same lot shall be tested and the results of this retest averaged with the result of the original test.

12.2.2 Upon retest as described in 12.2.1 failure to conform to this Standard specification shall constitute grounds for rejection.

12.2.3 In case of rejection, the manufacturer or supplier shall have the right to reinspect the rejected lot and resubmit the lot for inspection after removal of that portion of the lot not conforming to the specified requirement.

13. PACKAGING AND MARKING

13.1 Packaging

13.1.1 Unless otherwise specified by the Purchaser, the cellular glass thermal insulation shall be packaged in manufacturer's standard commercial container approved by the Purchaser and considering the following:

13.1.1.1 Overseas consignments shall be packed in double-corrugated cartons because of greater handling involved. If the size of sections exceeds the practical size for cartons, wooden or strong mesh crates may be used.

13.1.1.2 The insulation materials shall not be unpacked at site until is required for use.

13.1.1.3 Stacking of packed cellular glass insulation during transportation shall be in accordance with the manufacturer's recommendation.

13.2 Marking

Unless otherwise agreed between purchaser and manufacturer and/or supplier, containers shall be marked as follows:

- purchase order No.;
- name and type of material;
- class of material (if required);
- sizes of thermal insulation;
- shape of insulation in case of special shapes;
- quantity of material in the container;
- date of manufacturing;
- supplier's name;
- origin of manufacturing.

14. STORAGE

14.1 The insulation shall be stored in a dry atmosphere under cover and inspected at interval not exceeding three months.

14.2 Cartons shall be stored end up and be stacked no more than three high.

APPENDIX A TO PARTS RELATED TO HOT THERMAL INSULATION

1. GLASS-FIBER THERMAL INSULATION

The glass-fiber thermal insulation shall have the properties of mineral fiber thermal insulation as specified in Part I to Part III with the amendments as following:

FORM OF INSULATION	TEMPERATURE LIMIT °C	DENSITY max. kg/m³	REFERENCE TO
Blanket	٥٠٠	١٢٨	Part 3
Pipe section	٤٥٠	١٩٢	Part 1
Board/slab	٤٥٠	١٩٢	Part 2

2. CERAMIC FIBER BLANKET THERMAL INSULATION

The ceramic fiber thermal insulation shall be refractory oxides consisting primarily of alumina and silica, with small amounts of impurities permitted, processed from a molten state into fibrous form without binder.

The insulation material shall be in accordance with ASTM C-892, Grade 6, with the following amendments:

The insulation shall be suitable for use up to 1150°C.

The minimum density shall be 96 kg/m³ with a thermal conductivity of maximum 0.09 W/mK at 450°C.

ASTM C-892-High Temperature Fiber Blanket Thermal Insulation.

PART VI

CORK BOARD AND CORK PIPE

THERMAL INSULATION

CONTENTS : PAGE No.

1. SCOPE

This Standard specification covers the minimum requirements for material, physical properties, dimensions, tolerances and inspection of baked cork thermal insulation in the form of board and pipe for use on surfaces operating at temperatures below approximately 80°C. For specific applications, the temperature limit shall be agreed between the manufacturer and the Purchaser.

2. REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

ASTM (AMERICAN SOCIETY FOR TESTING AND MATERIALS)

C-177-97	"Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot Plate Apparatus"
C-203-99	"Test Methods for Breaking Load and Flexural Properties of Block-Type Thermal Insulation"
C-302-95	"Test Method for Density of Preformed Pipe-Covering-Type Thermal Insulation"
C-303-89	"Test Method for Density of Preformed Block-Type Thermal Insulation"
C-335-95	"Test Method for Steady-State Heat Transfer Properties of Horizontal Pipe Insulation"
C-390-79(1995)	"Criteria for Sampling and Acceptance of Preformed Thermal Insulation Lots"
C-518-98	"Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus"
C-647-95	"Guide for Properties and Tests of Mastics and Coating Finishes for Thermal Insulation"
C-755-97	"Practice for Selection of Vapor Retarders for Thermal Insulation"

3. DEFINITIONS AND TERMINOLOGY

Cork

The elastic, tough outer tissue of the cork oak that is used specially for stoppers and insulation.

Mastic

A relatively thick consistency protective finish capable of application to thermal insulation or other surfaces, usually by spray or trowel, in thick coats, greater than 1 mm.

4. UNITS

This Standard is based on International System of Units (SI), except where otherwise specified.

5. MATERIALS AND MANUFACTURE

Composition

Cork board and cork pipe insulation shall be composed of compressed and baked granulated cork, without added binder.

Cork board

cork board shall be reasonably smooth without undue voids. The edges shall be firm, the corners square, and the sides and ends parallel. When specified, one side of the board shall be sanded to a smooth finish.

Cork pipe insulation

Cork pipe insulation is supplied in various thicknesses, grouped into four classes according to the operating temperature of the pipe on which it is to be applied.

CLASS	PIPE TEMPERATURE RANGE
Light-duty thickness	above 2°C
Medium-duty thickness	2 to -18°C
Heavy-duty thickness	-18 to -32°C
Special thickness	below -32°C

Note:

The wall thicknesses of cork pipe insulation are selected not only to reduce heat gain or loss but also to prevent condensation on the outer surface of the insulation under particular conditions of ambient temperature and humidity. Detailed information as to the thickness, heat gain, and condensation prevention is available from the manufacturer, or may be calculated.

Cork pipe insulation shall be supplied either as hollow cylindrical shapes split in half lengthwise or as beveled lagging.

Cork pipe insulation is usually factory finished on the outside with an asphalt mastic coating. When stipulated by the Purchaser, it shall be supplied without the coatings. For further information see Guide C 647 and Practice C 755.

The Purchaser shall specify class and shape of insulation as required by the job.

6. PHYSICAL PROPERTIES

The insulation shall have the minimum physical properties as follows:

6.1 The average thermal conductivity at mean temperature of 297 K shall be maximum 0.042W/mK for cork board when tested in accordance with ASTM Test Method C 177 and Test Method C 518 and 0.048W/mK for cork pipe when tested in accordance with ASTM Test Method C 335 respectively.

6.2 Density of cork board insulation shall be 96-128 kg/m³ when tested in accordance with ASTM Test Method C 303 and of cork pipe insulation shall be 112 to 224 kg/m³ when tested in accordance with ASTM Test Method C 302 respectively.

6.3 Flexural strength avg. shall be minimum 103 kPa for cork-board insulation when tested in accordance with ASTM Test Method C 203 with the following modification: The preferred specimen size shall be 305 mm long by 76 mm wide and 51 mm thick, and the test conditions shall conform to Note 2. For thicknesses less than 51 mm the span shall be 5 times the thickness. Use a testing speed of 152 ±25 mm/min.

6.4 Deflection avg. shall be minimum 6.4 mm and shall be determined at the same time as the flexural strength test is made. Measure total deflection at midspan when the specimen reaches the maximum load.

Note:

Tests for density, flexural strength, and deflection shall normally be made under prevailing atmospheric conditions. In the case of dispute, tests shall then be run on test specimens conditioned until weight equilibrium is obtained at 23 ±1°C and 50 ±2% relative humidity.

7. STANDARD SIZES AND DIMENSIONS

7.1 Cork Board

Standard sizes of cork board are shown in Table 1. Other sizes shall be available on request.

7.2 Cork Pipe Insulation

Cork pipe insulation shall be made to fit nominal pipe sizes from 6.4 to 915 mm inclusive and tubing sizes from 6.4 to 152 mm inclusive. All sizes shall be furnished in sections 915 mm long. Each section shall be true to shape and roundness and shall be a neat fit on an average pipe or tube of the size for which the section was designed. The edges and ends shall be square.

The Purchaser shall specify the site and dimensions of the insulation.

TABLE 1 - STANDARD SIZES OF CORK BOARD

WIDTH (mm)	LENGTH (mm)	THICKNESS (mm)
٣٠٥	٩١٥	٢٥, ٣٨, ٥١, ٧٦, ١٠٢
610	915	51, 76, 102
915	915	51, 76, 102

8. DIMENSIONAL TOLERANCES

8.1 Cork Board

Tolerances for length, width and thickness of cork board shall be as follows:

Width (mm)	±1.6
Length (mm)	±3.2
Thickness	+0, -1.6

When one side of the board is sanded, the thickness tolerance shall be +0, -3.2 mm.

8.2 Cork Pipe Insulation

The tolerance for length and thickness of cork pipe insulation shall be as follows:

Length	(mm)	915 ±2.4
Thickness	(mm)	±1.6

9. WORKMANSHIP

9.1 The insulation shall not have visible defects that will adversely affect its performance in service.

9.2 For cork insulation the moisture-proof coating, when finished, shall be continuous and free of holes.

10. SAMPLING

10.1 The insulation shall be sampled for the purpose of the tests in accordance with ASTM Criteria C 390.

11. INSPECTION AND REJECTION

11.1 Inspection

11.1.1 The manufacturer and/or supplier shall be responsible for carrying out all the tests and inspections required by this Standard specification, using his own or other reliable facilities, and he shall maintain complete records of all such tests and inspections. Such records shall be available for review by the Purchaser. The manufacturer and/or supplier shall furnish to the Purchaser a certificate of inspection stating that each lot has been sampled, tested, and inspected in accordance with this Standard specification and has been found to meet the requirements specified.

11.1.2 The supplier shall afford the Purchaser's inspector all reasonable facilities necessary to satisfy that the material is being produced and furnished in accordance with this Standard specification. Such inspections in no way relieve the manufacturer and/or supplier of his responsibilities under the term of this Standard specification.

11.1.3 The Purchaser reserves the right to perform any inspections set forth in this Standard specification where such inspections are deemed necessary to assure that supplies and services comform to the prescribed requirements.

11.1.4 The Purchaser's inspector shall have access to the material subject to inspection for the purpose of witnessing the selection of the samples, the preparation of the test pieces, and the performance of the test(s). For such tests, the inspector shall have the right to indicate the pieces from which the samples will be taken in accordance with the provisions of this Standard specification.

11.2 Rejection

11.2.1 If the inspection of the sample shows failure to conform to the requirements of this Standard specification, a second sample from the same lot shall be tested and the results of this retest averaged with the result of the original test.

11.2.2 Upon retest as described in 11.2.1, failure to conform to this Standard specification shall constitute grounds for rejection.

11.2.3 In case of rejection, the manufacturer or supplier shall have the right to reinspect the rejected lot and resubmit the lot for inspection after removal of that portion of the lot not conforming to the specified requirement.

12. PACKAGING AND MARKING

12.1 Packaging

12.1.1 Unless otherwise specified or agreed upon between manufacturer and purchaser, cork board and cork pipe insulation shall be packaged in manufacturer's standard commercial container.

12.1.2 Overseas consignments shall be packed in double-corrugated cartons incorporating weather proof paper because of greater handling involved and possibly of exposure to wet condition. If the size of sections exceeds the practical size for cartons, wooden or strong mesh crates may be used.

12.1.3 Cork board and cork pipe insulation shall not be unpacked at site until is required for use.

12.1.4 Stacking of insulation during transportation shall be in accordance with the manufacturer's recommendation.

12.2 Marking

12.2.1 Unless otherwise agreed between Purchaser and manufacturer and/or supplier, containers shall be marked as follows:

- name and type of material;
- size of insulation;
- quantity of insulation in the container;
- date of manufacturing;
- name of manufacturer;
- origin of manufacturing;
- destination.

13. STORAGE

The insulation shall be stored in accordance with the manufacturer's recommendation which will be common with this type of materials.

APPENDICES

APPENDIX A

ORDERING INFORMATION

The following information shall be supplied with the order.

a) Class of pipe insulation,

b) mastic coating if required,

c) dimensions,

d) quantity of insulation,

e) special packaging or marking if required,

f) special requirements for inspection or testing or both.

PART VII

SPRAY-APPLIED RIGID-CELLULAR

POLYURETHANE (PUR) AND POLYISOCYANURATE (PIR)

THERMAL INSULATION

CONTENTS : PAGE No.

1. SCOPE

This Standard specification covers the minimum requirements for types, composition, physical properties, inspection, packaging and marking of spray applied rigid cellular polyurethane and polyisocyanurate intended for use as thermal insulation for service temperature between -100°C to +85°C or as agreed between the manufacturer and the Purchaser.

2. REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

ASTM (AMERICAN SOCIETY FOR TESTING AND MATERIALS)

C-165-95	"Test Method for Measuring Compressive Properties of Thermal Insulation"
C-177-97	"Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot Plate Apparatus"
C-518-95	"Test Method for Steady State and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus"
C-1029-96	
D-696-98	"Test Method for Coefficient of Linear Thermal Expansion of Plastics"
D-1621-94	"Test Method for Compressive Properties of Rigid Cellular Plastics"
D-1622	"Test Method for Apparent Density of Rigid Cellular Plastic"
D-1623-78	"Test Method for Tensile and Tensile Adhesion Properties of Rigid Cellular Plastics"
D-2126-94	"Test Method for Response of Rigid Cellular Plastics to Thermal and Humid Aging"
D-2842-97	"Test Method for Water Absorption of Rigid Cellular Plastics"
D-2856-94	"Test Method for Open Cell Content of Rigid Cellular Plastics by the Air Pycnometer"
E-84-99	"Test Method for Surface Burning Characteristics of Building Materials"
E-96-95	"Test Methods for Water Vapor Transmission of Materials"

3. DEFINITIONS AND TERMINOLOGY

3.1 Relative Humidity

The ratio of mol fraction of water vapor present in the air to the mol fraction of water vapor present in saturated air at the same temperature and barometric pressure. Approximately it equals the ratio of the partial pressure or density of the water vapor in the air to the saturation pressure or density, respectively, at the same temperature.

3.2 Water Vapor Permeability

The time rate of water vapor transmission through unit area of flat material of unit thickness induced by unit vapor pressure difference between two specific surfaces, under specified temperature and humidity condition.

3.3 Water Vapor Permeance

The time rate of water vapor transmission through unit area of flat material or construction induced by unit vapor pressure difference between two specific surfaces, under specified temperature and humidity condition.

3.4 Water Vapor Retarder (Barrier)

A material or system that adequately impedes the transmission of water vapor under specified condition.

4. UNITS

This Standard is based on International System of Units (SI), except where otherwise specified.

5. DESIGNATION

5.1 For the purpose of this Standard, the materials are divided into four types as follows:

Type 1: Polyurethane foams (PUR) suitable for general use.

Type 2: Polyurethane foams suitable for use where there is a requirement for greater resistance to compressive forces.

Type 3: Polyisocyanurate foams (PIR) suitable for general use.

Type 4: Polyisocyanurate foams suitable for use where there is a requirement for greater resistance to compressive forces.

5.2 The designation shall consist of a three component code comprising the following items, in the order presented:

a) The number of this IPS Standard i.e., IPS-M-TP-710 Part VII,

b) foam type,

c) thermal conductivity selected in accordance with Table 1.

5.3 An example of the designation required for a Type 4 foam with a thermal conductivity of 0.02 W/mK is as follows:

Standard:	IPS-M-TP-710 Part VII.
Foam Type:	Type 4.
Thermal Conductivity:	0.020 W/(m.K).

TABLE 1 - THERMAL CONDUCTIVITY OF THE FOAM

THERMAL CONDUCTIVITY W/(m.K)
۰,۰۱۵
0.016
0.017
0.018
0.019
0.020
0.021
0.022
0.023
0.024
0.025
0.026
0.027
0.028
0.029
0.030
0.031
0.032

Note:

These values are 30 day values for quality control purposes. For corresponding long-term design values the manufacturer's advice should be sought .

6. COMPOSITION

6.1 The material shall be of rigid polyurethane or polyisocyanurate foam as will be specified by the Purchaser.

Note:

No requirement for odor is included as its assessment is largely subjective. However it is recommended that the material should be free from objectionable odor.

7. MANUFACTURE

7.1 Spray-applied rigid-cellular polyurethane thermal insulation is produced by the catalyzed chemical reaction of polyisocyanates with polyhydroxyl compounds, with the addition of other compounds such as stabilizers and blowing agents.

7.2 Spray-applied rigid-cellular polyisocyanurate thermal insulation is produced by the catalyzed polymerization of polyisocyanates usually in the presence of polyhydroxyl compounds, with the addition of other compounds such as stabilizers and blowing agents.

7.3 The materials shall be capable of being mixed and applied using commercial polyurethane spray equipment.

7.4 In most cases the thermal insulation is formed directly on the surface to be insulated.

7.5 The foam injection process shall be compatible with the atmospheric site conditions and a minimum temperature of 15°C shall be maintained for foam components.

8. PHYSICAL PROPERTIES

The products are to be delivered on site in two components ready for use with the following foam properties.

8.1 The insulation shall be self-extinguishing.

8.2 Density after molding shall be 45 ± / 5% kg/m³ in accordance with ASTM D 1622.

8.3 The free rise density shall be 28 (±2) kg/m³, to ensure good compaction of the foam and good homogeneity due to high compression rate.

8.4 Thermal conductivity at 20°C mean temperature per ASTM C 177 measured on 25 mm thick foam, cut on both sides and aged at 21°C for 180 days shall be no greater than 0.023 W/mK. The thermal conductivity for freshly blown foam shall be no greater than 0.020 W/mK.

8.5 Minimum percentage of closed cells shall be 90% when tested in accordance with ASTM D 2856.

8.6 The leachable halides contents shall not exceed 30 ppm.

8.7 Maximum water vapor permeability shall be 4.4 ng/pa.s.m for Types 1 and 3 and 3.6 ng/pa.s.m for Types 2 and 4 when tested in accordance with ASTM E-96 at 24°C.

8.8 Maximum water absorption shall be 3% volume when tested in accordance with ASTM D 2842.

8.9 Linear coefficient of thermal contraction shall be (50-100) × 10-6 m/m°C according to ASTM D 696.

8.10 Response to thermal and humid aging shall be maximum 12% volume change for Types 1 and 3 and maximum 6% volume change for Types 2 and 4 when tested in accordance with ASTM test method D 2126. Expose 305 by 25 mm specimens to 70 ±2°C and 97 ±3% relative humidity for 168 ±2h. Measure after 24 ±½h and 168 ±2h.

8.11 Surface burning characteristics shall be determined in accordance with ASTM Test Method E-84 at the end use thickness and the results be reported.

8.12 Tensile strength shall be:

at room temperature	= 500 - 700 kPa
at -19 6°C	= 600 - 800 kPa

When tested in accordance with ASTM D 1623.

8.13 Tensile modulus shall be:

at room temperature	= average 14 MPa
at -196°C	= average 28.5 MPa

When tested in accordance with ASTM D 1623.

8.14 Compressive strength shall be at least 100 kPa for Types 1 and 3 and 210 kPa for Types 2 and 4 at 10% deformation and at 20°C when tested in accordance with ASTM D 1621. Different compressive strength may be manufactured when agreed between manufacturer and purchaser.

8.15 The above thermal and structural properties shall be supplemented by the following data:

8.15.1 Test reports on compressive, tensile and shear strength and moduli at 21°C and also at -165°C. (ASTM C 165).

8.15.2 Thermal conductivity versus temperature curve of the foam from -165°C to 65°C with adequate definition as per ASTM C 177 or C 518 measured on sample cut from freshly blown foam, after initial cure, parallel to foam rise. Minimum of six data points are required.

8.15.3 Thermal conductivity versus time curve of foam aged for 180 days at 21°C and 50% RH measured by ASTM C 518 at 24°C parallel to foam rise. Adequate points are required to define curve.

8.15.4 Thermal conductivity versus temperature curve of foam aged for 180 days from -40°C to 65°C measured by ASTM C 518 parallel to foam rise. Minimum of six data points are required.

8.15.5 Contraction/expansion coefficients versus temperature curves from -165°C to 21°C.

9. PUR MATERIALS FOR PIPE SUPPORTS

9.1 For pipe sizes 150 mm and under foam shall be 160 kg/m³ high density molded polyurethane with a minimum ultimate compressive strength of 2 MPa at 20°C and a design stress of 735 kPa.

9.2 For pipe sizes 200 mm through 600 mm foam shall be 224 kg/m³ high density molded polyurethane with a minimum ultimate compressive strength of 4 MPa at 20°C and a design stress of 1.15 MPa.

9.3 For pipe sizes 600 mm and larger foam shall be 320 kg/m³ high density molded polyurethane with a minimum ultimate compressive strength of 7 MPa at 20°C and a design stress of 1.8 MPa.

9.4 Thermal conductivity: When tested at cryogenic temperature of -160°C, the maximum apparent thermal conductivity shall be as follows:

160 kg/m³	0.022 W/m.K
224 kg/m³	0.025 W/m.K
320 kg/m³	0.035 W/m.K

The above values shall be substantiated by the vendor by independent laboratory test reports.

10. PREFORMED SPACERS

Preformed spacers shall be of PUR/PIR with the following minimum properties:

10.1 The spacers shall consist of fully monolithic molded (180°) half pipe sections with a minimum density of 50 kg/m³, designed to form compartments for the in-situ molding operation.

10.2 The foam shall be self extinguishing.

10.3 Minimum percentage of closed cells 90% per ASTM D 2856.

10.4 Compressive strength, shall be minimum 240 kPa.

10.5 Thermal conductivity at 20°C mean temperature per ASTM C 177, measured on 25 mm thick foam cut on both sides and aged at 21°C for 180 days shall be no greater than 0.025 W/m.K.

10.6 The leachable halides content shall not exceed 90 ppm.

11. SAMPLING

11.1 Lot

For purpose of sampling, the lot shall consist of all the polyurethane liquid components purchased at one time.

11.2 Unit Sample

The unit sample shall consist of approximately 23 kg of each of the two liquid components as required to prepare the foam test specimens specified in Section 12. Samples may be drawn from representative bulk storage or from one or more shipping containers.

11.3 Sampling for qualification tests shall be in accordance with statistically sound practice. Qualification tests will be conducted on the physical properties specified in Section 8.

11.4 Sampling for inspection test, shall be for properties agreed between the manufacturer and the Purchaser.

12. TEST SPECIMEN PREPARATION

12.1 Finished foam insulation test panel shall be made by spray application consistent with the manufacturer's recommendation including: temperature of the liquid components, ambient temperature, temperature and type of the substrate, type and operation of spray equipment, and thickness of foam per pass. Unless otherwise specified and reported, the ambient and substrate temperature shall be 24 ±3°C. The relative humidity must not exceed 80%. The test panels shall be of a sufficient quantity and size to satisfy test requirements.

Note:

About 15m² of finished foam should be sufficient. Specific panel sizes and thickness should be selected based on the requirement of the individual tests.

12.2 The test panels shall be allowed to cure for at least 72 h at 23 ±1°C and 50 ±5% relative humidity prior to cutting or testing for physical properties.

12.3 Core specimens, when required, shall be obtained by removing both the external skin and the boundary skin found at the substrate/foam interface. A trim cut on each face to a depth of 3 to 6 mm is generally sufficient. Core specimens may obtain one or more internal skins at spray pass boundaries.

13. INSPECTION AND REJECTION

13.1 Inspection

13.1.1 The manufacturer and/or supplier shall be responsible for carrying out all tests and inspections required by this Standard specification, using his own or other reliable facilities, and shall maintain complete records of all such tests and inspections. Such records shall be available for review by the Purchaser. The manufacturer and/or supplier shall furnish to the Purchaser a certificate of inspection stating that each lot has been sampled, tested, and inspected in accordance with this Standard specification and has been found to meet the requirements specified.

13.1.2 The supplier shall afford the Purchaser's inspector all reasonable facilities necessary to satisfy that the material is being produced and furnished in accordance with this Standard specification. Such inspection in no way relieves the manufacturer and/or supplier of his responsibilities under the term of this Standard specification.

13.1.3 The Purchaser reserves the right to perform any inspections set forth in this Standard specification, where such inspection are deemed necessary to assure that the supplies and services conform to the prescribed requirements.

13.1.4 The Purchaser's inspector shall have access to the material subject to inspection for the purpose of witnessing the selection of the samples, the preparation of the test pieces, and the performance of test(s). For such tests, the inspector shall have the right to indicate the pieces from which the samples will be taken in accordance with the provision of this Standard specification.

13.2 Rejection

13.2.1 If the inspection of the sample shows failure to conform to the requirements of this Standard specification, a second sample from the same lot shall be tested and the result of this retest averaged with the result of the original test.

13.2.2 Upon retest as described in 13.2.1 failure to conform to this Standard specification shall constitute grounds for rejection.

13.2.3 In case of rejection, the manufacturer or supplier have the right to reinspect the rejected lot and resubmit the lot for inspection after removal of that portion of the lot not conforming to the specified requirement.

14. CERTIFICATION

14.1 When specified in the purchase order or contract, a manufacturer's certification shall be furnished to the Purchaser that the material was manufactured, sampled, tested, and inspected in accordance with this Standard specification and has been found to meet the requirements. When specified in the purchase order or contract, a report of the test results shall be furnished.

14.2 Upon the request of the Purchaser in the contract or order, the certification of an independent third party indicating conformance to the requirements of this Standard specification may be considered.

15. PACKAGING AND MARKING

15.1 Packaging

15.1.1 Unless otherwise specified or agreed upon between the manufacturer and the Purchaser,

the liquid components shall be packaged in the manufacturer's standard commercial containers.

15.1.2 Each container shall be blanketed with dry air and nitrogen and sealed.

15.2 Marking

15.2.1 Each container shall be marked with the following information:

- Polyisocyanate (A Component) or resin (B Component).
- Name of the manufacturer.
- Manufacturer's product designation.
- Manufacturer's lot number or the date of production, or both.
- Net weight of the contents and gross weight of the container and contents.
- Instruction for safe handling and recommended storage temperatures.
- Mixing instruction.
- Listing agency label if available.
- Destination.

16. STORAGE

16.1 The storage of the liquid components shall be in accordance with the manufacturer's recommendation which will be common with this type of materials.

17. HEALTH AND SAFETY PRECAUTION

17.1 The manufacturer shall provide the Purchaser information regarding any hazards and recommended protective measures to be employed in the safe installation and use of the material.

APPENDICES

APPENDIX A

ORDERING INFORMATION

The following information shall be supplied with the order:

a) Designation of this Standard.

b) Type of material.

c) Thermal conductivity or thickness required.

d) Sampling, if different.

e) Certificate of compliance.

f) If packaging is other than specified.

g) If marking is other than specified.

PART VIII

PREFORMED RIGID-CELLULAR

POLYURETHANE (PUR) AND POLYISOCYANURATE (PIR)

THERMAL INSULATION

CONTENTS : PAGE No.

1. SCOPE

1.1 This Standard specification covers minimum requirements for types, composition, physical properties, dimensions, tolerance, inspection, packaging and marking of preformed rigid-cellular polyurethane and polyisocyanurate material intended for use as thermal insulation for pipe-work and equipment for service temperature between -100 and +140°C.

1.2 It applies to slab cut and molded pipe sections and radiused and beveled lags.

1.3 For specific application, the actual temperature limits shall be agreed upon by the manufacturer and purchaser.

1.4 The application of a suitable vapor retardant material may be required in conjunction with the application of this insulant where the service temperatures are to be generally below ambient.

2. REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

ASTM (AMERICAN SOCIETY FOR TESTING AND MATERIALS)

C-16595	"Test Method of Measuring Compressive Properties of Thermal Insulation"
C-177-97	"Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Meas of the Guarded Hot Plate Apparatus"
C-390-79	"Criteria for Sampling and Acceptance of Preformed Thermal Insulation Lots"
C-518-98	"Test Method for Steady State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus"
C-550-95	"Practice for Measuring Truness and Squareness of Rigid Block Thermal Insulation"
D-1621-94	"Test Method for Compressive Properties of Rigid Cellular Plastics"
D-1622-93	"Test Method for Apparent Density of Rigid Cellular Plastics"
D-3014-94	"Test Method for Flame Height, Time of Burning and Loss of Weight of Rigid Cellular Plastics in a Vertical Position"
D-2856-94	"Test Method for Open Cell Content of Rigid Cellular Plastics by the Air Pycnometer"
E-96-95	"Test Method for Water Vapor Transmission of Materials"

BSI (BRITISH STANDARDS INSTITUTE)

BS-4370(1988)	"Method of Test for Rigid Cellular Materials"

ISO (INTERNATIONAL STANDARD ORGANIZATION)

ISO 4375-2000	"Laboratory Method of Test for Assessment of the Horizontal Burning Characteristics of Specimens no Larger that 150 mm × 50

mm × 13 mm (Nominal) of Cellular Plastics and Cellular Rubber Materials When Subjected to a Small Flames"

3. DEFINITIONS AND TERMINOLOGY

Lag

Preformed rigid insulation for longitudinal application to cylinders larger than those for which pipe sections are available.

There are three type as follows:

Beveled lags

Lags similar to plain lags, but with one or more edges beveled.

Plain lags

Lags having rectangular cross sections, for use on cylinders of such diameter that this shape conforms sufficiently closely to the surface.

Radiused and beveled lags

Beveled lags with faces curved to fit the surface of the cylinder (sometimes know as curved and beveled lags).

Pipe sections

Sections of insulating materials in cylindrical form, suitable for application to pipes.

Relative humidity

The ratio of mol fraction of water vapor present in the air to the mol fraction of water vapor present in saturated air at the same temperature and barometric pressure. Approximately it equals the ratio of the partial pressure or density of the water vapor in the air to the saturation pressure or density, respectively, at the same temperature.

Slab

Rigid or semi-rigid insulation formed into sections, rectangular both in plan and cross section, usually 90-120 cm long, 15-60 cm wide and 2.5-15 cm thick.

Vapor permeance

The time rate of water vapor transmission through unit area of flat material or construction induced by unit vapor pressure difference between two specific surfaces under specified temperature and humidity condition.

Vapor retardant

A material or system that adequately impedes the transmission of water vapor under specified condition.

4. UNITS

This Standard is based on International System of Units (SI), except where otherwise specified.

5. DESIGNATION

5.1 For the purpose of this Standard, the materials are divided into four types as follows:

Type 1: Polyurethane foams suitable for general use.

Type 2: Polyurethane foams suitable for use where there is a requirement for greater resistance to compressive forces.

Type 3: Polyisocyanurate foams suitable for general use.

Type 4: Polyisocyamerate foams suitable for use where there is a requirement for greater resistance to compressive forces.

5.2 The designation shall consist of a three component code comprising the following items, in the order presented.

a) The number of this IPS Standard i.e. IPS-M-TP-710 Part VIII,

b) foam type,

c) thermal conductivity selected in accordance with Table 1.

5.3 An example of the designation required for a Type 2 foam with a thermal conductivity of 0.02 W/mK is as follows:

Standard:	IPS-M-TP-710 Part VIII
Foam type:	Type 2
Thermal Conductivity:	0.02 W/mk.

TABLE 1 - THERMAL CONDUCTIVITY OF THE FOAM

THERMAL CONDUCTIVITY W/(m.K)
٠,٠١٥
0.016
0.017
0.018
0.019
0.020
0.021
0.022
0.023
0.024
0.025
0.026
0.027
0.028
0.029
0.030
0.031
0.032

Note:

These values are 30 day values for quality control purposes. For corresponding long-term design values the manufacturer's advice should be sought.

6. COMPOSITION

6.1 The material shall consist of rigid polyurethane or rigid polyisocyanurate foam with closed cell structure.

6.2 The material shall be suitably formulated to ensure that, when tested by method described in BS 4375: 1974, a test specimen of 150 mm × 50 mm × 13 mm exposed to as small flame shall show an extent burnt of less than 125 mm for rigid polyurethane foam and less than 25 mm for rigid polyisocyanurate.

Note:

Materials indicated by PUR are substantially composed of polyurethane linkage and those indicated by PIR are substantially composed of polyisocyanurate linkage.

7. MANUFACTURE (PUR)

7.1 Preformed rigid cellular polyurethane thermal insulation is produced by the chemical reaction of polyisocyanates with polyhydroxyl compounds usually in the presence of catalysts, cell stabilizers, and blowing agents.

7.2 Preformed rigid cellular polyisocyanurate (PIR) thermal insulation is produced by the polymerization of polymeric polyisocyanates, usually in the presence of polyhydroxyl compounds with the addition of catalysts, cell stabilizers, and blowing agents.

8. PHYSICAL PROPERTIES

Preformed PUR/PIR shall have the following minimum properties.

8.1 Thermal conductivity at 20°C mean temperature per ASTM C 177 measured on 25 mm thick foam, cut on both sides and aged at 21°C for 180 days shall be no greater than 0.023 W/mK. The thermal conductivity for freshly blown foam shall be no greater than 0.020 W/mK.

8.2 Minimum percentage of closed cells shall be 90% when tested in accordance with ASTM D-2856.

8.3 Maximum water vapor permeance at 38°C and 100% relative humidity shall be 4.38×10^{-3} µg/NS when tested in accordance with ASTM E-96.

8.4 Linear coefficient of thermal expansion/contraction shall be 70×10^{-6} m/m per °C when tested in accordance with BS 4370.

8.5 The insulation shall be self extinguishing and have 90% retention of weight in accordance with ASTM D 3014.

8.6 Maximum leachable halides content shall be 90 ppm.

8.7 Structural Properties

The density and the chemical formulation of foam shall be selected in such away that the following relation is satisfied:

$$\frac{\sigma(1-\phi)}{E\alpha(T_2-T_1)} \geq 1.5$$

Where:

σ = Tensile strength of the foam at -165°C (minimum value of all directions in kPa).

E = Tensile modulus of the foam at -165°C (maximum value of all directions in kPa).

α = Average linear contraction coefficient of the foam from -165°C up to +21°C (maximum value of all directions).

T_2-T_1 = 180°C; temperature difference between cold surface and surroundings.

ϕ = 0.4; poisson's ratio at -165°C estimated value. Other values may be used if substantiated by experimental data.

The formula above is a safety factor, expressing the ratio of the tensile strength of material and the tensile stress induced in the material under cryogenic

8.8 The density shall be minimum 45 kg/m³ when tested in accordance with ASTM D 1622.

8.9 Compressive strength shall be at least 100 kPa for Types 1 and 3 and 210 kPa for Types 2 and 4 at 10% deformation and at 20°C when tested in accordance with ASTM D 1621. Different compressive strength shall be manufactured if agreed between manufacturer and Purchaser.

8.10 The above thermal and structural properties shall be supplemented by the following data:

8.10.1 Test reports on compressive, tensile and shear strength and moduli at 21°C and also at -165°C. (ASTM C 165).

8.10.2 Thermal conductivity versus temperature curve of the foam from -165°C to 65°C with adequate definition as per ASTM C 177 or C 518 measured on sample cut from freshly blown foam, after initial cure, parallel to foam rise. Minimum of six data points are required.

8.10.3 Thermal conductivity versus time curve of foam aged for 180 days at 21°C and 50% RH measured by ASTM C 518 at 24°C parallel to foam rise. Adequate points are required to define curve.

8.10.4 Thermal conductivity versus temperature curve of foam aged for 180 days from -40°C to 65°C measured by ASTM C 518 parallel to foam rise. Minimum of six data points are required.

8.10.5 Contraction/expansion coefficients versus temperature curves from -165°C to 21°C.

9. SHAPES AND SIZES

9.1 Where supplied in two halves, pipe sections shall be oversized to accommodate contractions in accordance with Table 2.

9.1.1 The longitudinally mating faces shall be flat and in the same plane, so that when the two pieces are put together no gap exists between the mating surfaces.

Note:

It is common practice for the mating faces whilst still being flat in the length wise direction to have a variable profile in the radial direction. This is acceptable provided that the mating surfaces so created still fit snugly together. In many case this practice enhance the 'snugness' of the fit.

9.1.2 The ends shall be flat and normal to the longitudinal axis of the section.

9.2 For all sizes up to and including 508 mm diameter the PUR/PIR shall be applied in tow half sections.

9.3 For sizes over 508 mm and equipment between 500 mm and 3600 mm diameters, the PUR/PIR shall be supplied in radiuses and beveled segments having a width on the outside radius of minimum 450 mm.

9.4 For equipment in excess of 3600 mm diameter, the PUR/PIR may be supplied in flat beveled

blocks of maximum 300 mm wide.

9.5 For equipment heads, the PUR/PIR shall be supplied preferably all in radiused and beveled head segments for diameters between 900 mm and 3600 mm.

For equipment heads up to 900 mm these shall be supplied in one piece blocks.

For equipment heads over 3600 mm flat and beveled blocks shall be used.

9.6 The mating beveled edges shall be flat, so that when they are put together to form a cylinder no gaps exist between abutting lags.

9.7 The ends shall be flat and normal to the longitudinal axis of the lag.

Note:

No valves are specified for their width on the outer and inner faces.

9.8 Molded Components

All molded items shall be free from grease or other molding release agent that will adversely reduce the adhesion of insulation, mastic and adhesives.

9.9 Color Identification

PIR foam shall be supplied colored pink. PUR foam shall be supplied in any other color or without added color as required.

TABLE 2 - CONTRACTION GAP BETWEEN PIPE/EQUIPMENT SURFACE AND INNER LAYER OF PUF

OPERATING TEMPERATURE, °C	MINIMUM GAP IN mm			
	Operating Temperature Pipe/Equipment O.D. Range in mm			
	D < 219	219 < D < 406	406 < D < 610	610 < D < 800
-196 < T < -75	2.0	4.0	6.0	7.0
-75 < T < -40	1.0	2.0	3.0	4.0

Note:

Diameter of preformed PUR sections shall be the contraction gap plus the O.D. of pipe/equipment. The maximum contraction gap shall not exceed 1.25 times the minimum gap.

10. DIMENSIONAL TOLERANCES

10.1 The dimensions of product supplied shall not deviate from those specified by more than the appropriate tolerances given in either Table 3 or Table 4. For the slab the permissible thickness deviations shall be ±1.5 mm.

TABLE 3 - DIMENSIONAL TOLERANCES FOR PIPE SECTIONS AND LAGS

Dimensions in millimeters

DIMENSIONS	PERMISSIBLE DEVIATIONS	
	Molded Pipe Sections	Cut Pipe Sections and Lags
Lengths	±۳	±۳
Bores less than 150	+۱,٥ -0	+۱,٥ -0
Bores 150 and above	+۳ -0	+۱,٥ -0
Outside diameters less than 150	+۱,٥ -0	+۱,٥ -0
Outside diameters 150 and Above	+۳ -0	+۱,٥ -0

Note:

For single-layer components or the first layer of a multi-layer component the tolerance on the bore is given on the quoted pipe outside diameter. For the second or subsequent layer(s) of multi-layer components it is given on the outside diameter of the mating inner layer.

TABLE 4 - DIMENSIONAL TOLERANCES FOR SLABS

LENGTHS OR WIDTHS	PERMISSIBLE DEVIATIONS OF LENGTHS OR WIDTHS	MAXIMUM DIFFERENCES IN THE LENGTH OF THE DIAGONALS OF RECTANGULAR SLABS
Up to and including 100	±۱	۳
Over 100 up to and including 1000	±۱,٥	٥
Over 1000 up to and including 2000	±۲,٥	۷

10.2 Other slab parameters shall be as follows:

10.2.1 Squareness

This thermal insulation boards shall not be out of square by more than 1.5 mm/30 cm of width or length.

10.2.2 Straightness

Unless otherwise specified, the slab shall be furnished with straight edges that shall not deviate by more than 0.8 mm/30 cm.

10.2.3 Flatness

The slabs shall not depart from absolute flatness by more than 1.5 mm/30 cm of width or length.

10.2.4 The truness, squreness, and flatness shall be determined in accordance with ASTM practice C 550, except that a straight edge of length longer than the dimension being determined shall be used.

11. WORKMANSHIP

11.1 This insulation shall not have visible defects that will adversely affect the service properties. Material shall have a uniform fine cellular structure.

12. SAMPLING

12.1 Sampling for qualification test, shall be in accordance, with criteria C 390. Conduct the qualification tests in accordance with the physical properties in 8.

13. SPECIMEN PREPARATION

13.1 A period of at least 72 h must elapse from the time of manufacture of the rigid cellular PUR or PIR until the cutting of any test specimen.

13.2 Unless otherwise specified, the test specimen shall be conditioned at 23 ±2°C and 50 ±5% relative humidity for at least 12 h prior to testing.

14. INSPECTION AND REJECTION

14.1 Inspection

14.1.1 The manufacturer and/or supplier shall be responsible for carrying out all the tests and inspections required by this Standard specification, using his own or other reliable facilities, and shall maintain complete records of all such tests and inspections. Such records shall be available for review by the Purchaser. The manufacturer and/or supplier shall furnish to the Purchaser a certificate of inspection stating that each lot has been sampled, tested and inspected in accordance with this Standard specification and has been found to meet the requirements specified.

14.1.2 The supplier shall afford the Purchaser; inspector all reasonable facilities necessary to satisfy that the material is being produced and furnished in accordance with this Standard specification. Such inspection in no way relieves the manufacturer and/or supplier of his responsibilities under the term of this Standard specification.

14.1.3 The Purchaser reserves the right to perform any inspections set forth in this Standard specification, where such inspections are deemed necessary to assure that supplies and services conform to the prescribed requirements.

14.1.4 The Purchaser's inspector shall have access to the material subject to inspection for the purpose of witnessing the selection of the samples, the preparation of the test pieces, and the performance of test(s). For such tests, the inspector shall have the right to indicate the pieces from which the samples will be taken in accordance with the provisions of this Standard specification.

14.2 Rejection

14.2.1 If the inspection of the sample shows failure to conform to the requirement of this Standard specification, a second sample from the same lot shall be tested and the results of this retest averaged with the result of the original test.

14.2.2 Upon retest as described in 14.2.1 failure to conform to this Standard specification shall constitute grounds for rejection.

14.2.3 In case of rejection, the manufacturer or supplier shall have the right to reinspect the rejected lot and resubmit the lot for inspection after removal of that portion of the lot not conforming to the specified requirement.

15. PACKAGING AND MARKING

15.1 Packaging

15.1.1 Unless otherwise specified by the Purchaser, the preformed rigid cellular polyurethane and polyisocyanurate foam thermal insulation shall be packaged in manufacturer's standard commercial container approved by the Purchaser and considering the following:

15.1.2 Overseas consignments shall be packed in double-corrugated cartons incorporating weather proof paper because of greater handling involved and possibly of exposure to wet conditions. If the size of sections exceeds the practical size for cartons, wooden or strong mesh crates may be used.

15.1.3 PUR/PIR insulation materials shall not be unpacked at site until is required for use.

15.1.4 Stacking of packed PUR/PIR preformed insulation during transportation shall be in accordance with the manufacturer's recommendation.

15.2 Marking

15.2.1 Unless otherwise agreed between purchaser and manufacturer and/or supplier, containers shall be marked as follows:

- Name and type of material
- Manufacturer's description and/or product reference.
- Dimension of insulation in the container.
- Quantity of material in the container.
- Date of manufacturing.
- Manufacturer's name or trade mark or both.
- Origin of manufacturing.
- Destination.

16. STORAGE

16.1 The storage of PUR/PIR thermal insulation shall be in accordance with the manufacturer recommendation which will be common with this type of materials.

17. HEALTH AND SAFETY HAZARDS

17.1 The installation and use of thermal insulating materials may expose individuals to health and safety hazards. The manufacturer shall provide the buyer appropriate information regarding any hazards, known to him associated with the designated end use of this product, and shall recommend the protective measures to be employed in the safe installation and use.

APPENDICES

APPENDIX A

ORDERING INFORMATION

The following information shall be supplied with the order:

a) Designation of this Standard.

b) Product name and type.

c) Dimensions.

d) Quantity of material.

e) Special packaging or marking, if required.

f) Special requirements for inspection or testing or both.

PART IX

MISCELLANEOUS MATERIALS TO BE USED

WITH

THERMAL INSULATION

CONTENTS : PAGE No.

1. SCOPE

This Standard specification covers minimum requirements for the properties of filler insulation, vapor barriers, joint sealants, adhesive materials, metallic jacketing and accessory materials. Unless otherwise specified the test methods used shall be approved by the Purchaser.

2. REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

ASTM (AMERICAN SOCIETY FOR TESTING AND MATERIALS)

A-167-98	"Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate-Sheet and Strip"
A-463-97 A	"Specification for Steel Sheet, Aluminum Coated by Hot Deep Process"
A-924-97 A	"Specification for General Requirements for Steel Sheet, Metallic-Coated or Zinc Iron Alloy Coated (Galvanized)"
A-523-98	"Specification for Steel Sheet, Zinc-Coated (Galvanized) by Hot-Dip Process"
B-209-M 95	"Specification for Aluminum and Aluminum Alloy Sheet and Plate"
C-449-95	"Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement"
C-795-92	"Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel"
D-412-98 A	"Test Method for Rubber Properties in Tension"
D-3039-95 A	"Test Method for Tensile Properties of Polymer Matrix Composite Material"
E-84-99	"Test Method for Surface Burning Characteristics of Building Materials"
E-96-95	"Test Method for Water Vapor Transmission of Materials"

BSI (BRITISH STANDARDS INSTITUTE)

BS 476-1971	"Fire Test on Building Materials and Structures"
BS 2972-1991	"Methods of Test for Inorganic Thermal Insulating Materials"

IPS (IRANIAN PETROLEUM STANDARDS)

IPS-E-TP-100 "Paints"

3. DEFINITIONS AND TERMINOLOGY

Expanded metal

Metal network made by suitably stamping or cutting sheet metal and stretching it to form open

diamond-shaped meshes.

Glass cloth

Fabric woven from continuous filament or staple glass fiber.

Mastic

A material of relative viscous consistency that dries or cures to form a protective finish, suitable for application to thermal insulation in thickness greater than 0.76 mm per coat.

Metal jacketing (Cleaning)

Sheet metal fitted as a protective finish over insulation.

Vapor barrier

A vapor check with water vapor permeance not exceeding 0.067 g/s MNl, when tested in accordance with BS 2972.

4. UNITS

This Standard is based on International System of Units (SI), except where otherwise specified.

5. FILLER INSULATION

5.1 Medium Density Rock Wool/Glass Wool Board

Medium density rock wool/glass wool board stock for contraction joints:

a) Density 32 kg/m³ (±10%).

b) Thermal conductivity at 25°C mean temperature: 0.035 W/m.K or less.

c) The material shall be free from delamination or fiber fallout when tested to BS 2972.

5.2 Low Density Rock Wool/Glass Wool Blankets

Low Density rock wool/glass wool blankets for packing voids between piping/equipment and insulation:

a) Density: 24 kg/m³ (±10%).

b) Thermal conductivity at 25°C mean temperature: 0.034 W/m.K or less.

c) The material shall be free from delamination and fiber fallout when tested to BS 2972.

6. VAPOR BARRIERS

6.1 Primary Metal Vapor Barrier

The vapor barrier shall be of a corrugated aluminum sheet, Alloy 3003 or 5005 in accordance with ASTM B 209. Corrugation to be 5 mm. Material to have a factory applied moisture barrier of a laminate of chemically inert polyethylene and a layer of Kraft paper (without adhesives), to ensure the highest adhesion with the foam. Thickness of the vapor barrier to be at least 0.2 mm minimum.

6.2 Primary Vapor Barrier Mastic

The vapor barrier mastic shall be a heavy duty highly durable flexible elastomeric polymer "Hypalon" based-fireretardant coating with exceptional dry film strength and good puncture

resistance and shall have the following minimum properties:

PROPERTY	UNIT	VALUE
Temperature resistance	°C	-40 to +120
Water vapor transmission ASTM E 96 at 0.75 mm dry film thickness	perms*	0.02
Average non-volatile	vol. %	30
Fire resistance:		
ASTM E-84/76A flame spread		20
Smoke developed		5
Fuel Contribution		10
Spread of flame (BS 476)	Class 1	
Specific gravity	kg/l	1.1 - 1.3
Consistency	Thixotropic soft paste	
Minimum applied thickness (dry film)	mm	1.2
Minimum HYPALON content		
Minimum coats	%	15

6.3 Secondary Foil Vapor Barrier

The vapor barrier shall be a three-layer lamination of polyester film/aluminum foil/polyester film, with the following minimum properties:

PHYSICAL PROPERTIES		UNIT	VALVE
Polyester layer		µm	≥ 12
Aluminum foil		µm	≥25
Elongation:	LD	%	≥50
	TD	%	≥50
Tensile strength:	LD	kg/15 × 100 mm²	≥8
	TD	kg/15 × 100 mm²	≥10

CHEMICAL PROPERTIES		
Humidity absorption	%	0.3 max.
Water vapor transmission	perms*	< 0.001

THERMAL PROPERTIES		
Temperature resistance	°C	-60/+150

* Perms = permeance = WVT/Δp (ASTM E96)

WVT = rate of water vapor transmission, g/hm²

Δp = vapor pressure difference, mm Hg

6.4 Vapor Stop Coating/Adhesive

This shall be a two-part elastomeric material suitable for use in cryogenic conditions with the following minimum properties:

PROPERTY	UNIT	VALUE
Specific gravity	kg/l	1.1 - 1.2
Non-volatile content	vol. %	55 - 60
Tensile strength (ASTM D-412)	kg/cm²	> 8
Two-component minimum thickness (dry film)	mm	1.2

Service temperature	°C	-196to +120
Halides	ppm	≤ 10

6.5 Glass Fiber Reinforced Epoxy (GRE) Vapor Stop

The epoxy resin used shall be Epikote 816 with an aromatic/cycle-aliphatic amine type curing agent. The fabric glass fiber reinforcement shall be of low alkali fibrous glass which is compatible with the epoxy resin. Minimum weight of glass fiber reinforcement shall be approximately 220 g/m².

The epoxy resin and glass fiber shall be capable of producing a reinforced vapor stop over the surface of the PUR insulation, self-extinguishing type and shall withstand ambient/sub-ambient conditions and ultra-violet light exposure. The GRE vapor stop shall have the following minimum properties:

- Tensile Strength (ASTM D3039):
  - Longitudinal 15.7 MPa
  - Circumferential 78.5 MPa
- Maximum water vapor transmission 0.03 perms*
- Minimum dry film thickness 5.5 mm:
  - Comprising of 5.0 mm reinforced and 0.5 mm unreinforced outer layer.

7. JOINT SEALANT/ADHESIVE MATERIALS

7.1 The joint sealant used to seal all cellular glass insulation for dual temperatures and those parts in the insulation system that shall be readily removable shall have the following minimum properties:

PHYSICAL PROPERTIES	UNIT	VALVE
Consistency		Soft paste
Color		Gray or white
Average non-volatile content	vol.%	98
Flammability (dry) Low flame		
Service temperature (Material shall remain soft and tough in service and shall not crack or shrink with thermal cycling)	°C	-70 to +150
Water vapor transmission (at 3 mm dry-film thickness)	perms*	≤ 0.03

* perms = permeance = WVT/ Δ p (ASTM E96)

WVT = rate of water vapor transmission, g/hm²

Δ p = vapor pressure difference, mm Hg

7.2 The joint sealant/adhesive used to seal all PUR/PIR inner/intermediate layers shall be as described in 3.3.4.

7.3 The fabrication adhesive used for bonding together pieces of prefabricated PUR/PIR and cellular glass insulation for removable fittings/flange covers and valves, shall be a fire resistive two-part component material with the following minimum properties:

PROPERTY	UNIT	VALUE
Color		Gray
Consistency		Soft paste
Specific gravity kg/l		1.3 - 1.8
Flammability: wet		Non-flammable
dry		Fire resistive
Service temperature	°C	-70 to +90

7.4 The adhesive used to bond insulation and/or supports to piping/equipment in cold insulation

shall be a virtually 100% solids free, three component cryogenic adhesive, enabling bonding between non-porous surfaces without problems of evaporation and having the following minimum properties:

PROPERTY	UNIT	VALUE
Color		Black
Consistency		Thixotropic
Specific gravity	kg/l	1.8
Service temperature range	°C	-196 to +121

7.5 The anti-abrasive coating to be applied as a bore coating to all cellular glass in insulation, applied to aluminum piping and/or piping under vibrational influences shall be an oil modified urethane compound designed for the specified purpose and having the following minimum properties:

PROPERTY	UNIT	VALUE
Color		Gray/off-white
Consistency		Brushing
Specific gravity	kg/l	1.8
Average non-volatile content	vol.%	50
Flammability: wet		Non-flammable
dry		Fire resistive
Service temperature	°C	-196 to +121

For service temperatures above 121°C a High Temperature Anti-Abrasive coating shall be used.

7.6 The metal sealant suitable for gun extrusion to a minimum of 4 mm at all overlaps in the metallic jacketing, shall be a tough flexible elastomer based material, comprising polymeric vapor sealant of butyl rubber with permanent flexibility, good adhesion and having the following minimum properties:

PROPERTY	UNIT	VALUE
Color		Light Gray
Consistency		Soft paste
Specific gravity	kg/l	1.55
Average non-volatile content	% wt.	65 - 70
Flammability: wet		Non-flammable
dry	BS 476, Part 7	Class 1
Service temperature range	°C	-70 to +120

8. METALLIC JACKETING

8.1 General

Galvanized sheeting shall not be used over insulation on or near (austenitic) stainless steel and/or nickel alloy piping and equipment. Galvanized sheeting is vulnerable to corrosion in coastal and arid areas.

In areas with potential fire hazard, aluminized steel or stainless steel sheeting shall be used.

8.2 Jacketing Material

Metallic jacketing materials shall be one of the following:

8.2.1 Aluminized steel

The material shall be Aluminized steel Type 2, coating designation T_2-100 in accordance with ASTM A463.

8.2.2 Aluminum sheet

The material shall be of a quality meeting ASTM B-209M requirements and shall be half hard, Alloy 1060, Temper H14, with a factory applied polykraft moisture retarder permanently bonded to inner side.

8.2.3 Stainless steel sheet

The material shall be of a quality meeting the requirements of ASTM A 167 Type 304L or 316L.

8.2.4 Galvanized steel sheet

The material shall be in accordance with ASTM A653 and ASTM A924; hot dip galvanized to ASTM A 525 coating designation G 90.

8.2.5 Coated steel

The material shall be mild carbon steel with protective coating finish in accordance with IPS-E-TP-100.

8.3 Thickness of Sheets

The thickness of the sheets shall be as follows:

OUTSIDE DIAMETER OF INSULATION (mm)	THICKNESS IN mm					
	ALUMINUM		ALUMINIZED OR GALVANIZED STEEL		STAINLESS STEEL	
	Flat	Corrugated	Flat	Corrugated	Flat	Corrugated
Up to 150	٠,٨	٠,٦ (٥ mm Corrugations)	٠,٦	٠,٤ (٥ mm Corrugations)	٠,٦	٠,٤ (٥ mm Corrugations)
١٥٠ to 450	٠,٩	٠,٧ (٥ mm Corrugations)	٠,٨	٠,٦ (٥ mm Corrugations)	٠,٨	٠,٦ (٥ mm Corrugations)
Over 450	١,٢	١,٠ (٥ mm Corrugations)	٠,٨ - 1.0	٠,٦ (٥ mm Corrugations)	٠,٨	٠,٦ (٥ mm Corrugations)

Removable covers for flanges, valves, etc. shall be made of 1.0 mm sheets, independent of the type of material.

9. ACCESSORY MATERIALS

9.1 The metallic fastening materials shall be as following:

Stainless steel Type 302 or 304	in accordance with ASTM A167.
Galvanize mild steel	in accordance with ASTM A 653 and ASTM A924
Aluminum	in accordance with ASTM B 209 m Ally 1060 H14

9.2 Bands shall be 10 mm to 20 mm wide with a minimum thickness of 0.5 mm. The material shall be Type 304 stainless steel, galvanized mild steel or aluminum as appropriate.

9.3 Expander type bands shall be of a stainless steel type, and capable of remaining in tension during heating and cooling cycles experienced in normal operation.

9.4 Breather springs for bands shall be of a stainless steel type and capable of remaining under tension during the heating and cooling cycles experienced in normal operation.

9.5 Seals for banding shall be of the wing-type construction, type 302 or 304 stainless sheet.

9.6 Quick-release toggle fasteners for securement of removable boxes shall be of Type 304 or 302 stainless steel spring shackle lock type and shall be sized commensurate with the weight of the box concerned. They shall be spot-welded to the stainless steel bands which are to be incorporated in the box design.

9.7 Rivets where permitted in place of screws for metal fabrication shall be expanding hard aluminum blind rivet poptype 4 mm diameter or stainless steel pop, blind eye type and of the following sizes: pipework and equipment up to 1000 mm shall be 3.2 mm diameter Pipework and equipment over 1000 mm shall be 4.8 mm diameter.

9.8 Screws required for metal jacket fabrication shall be slotted pan head self-tapping Type A No. 8

× 12 mm long in accordance with BS 4171, complete with chloroprene rubber washers under the head. The material may be hard aluminum alloy for aluminum jackets and Type 302 or 304 stainless steel for steel jackets.

9.9 "S" and "J" clips shall be formed from 20 mm wide 0.5 mm thick banding Type 302 or 304 stainless steel.

9.10 The reinforcing membrane for embedding between the coats of the vapor barrier mastic in preformed PUR/PIR insulation or cellular glass shall be a high strength resilient synthetic fabric, having minimum 20 × 10 threads per 25 mm and a weight of 33 g/m², or an open weave glass cloth, with a weave lock finish and having minimum 18 × 12 threads per 25 mm.

9.11 The tape used to secure the inner layers of PUR/PIR to the pipework shall be a pressure sensitive glass fiber reinforced tape of minimum 19 mm wide.

9.12 The vapor barrier cover for contraction joints in the outer layer of insulation shall be a corrugated butyl rubber sheet with 1.2 mm minimum thickness.

9.13 The adhesive for the secondary foil vapor barrier shall be an adhesive suitable for adhering the polyester and stay flexible within the service temperature range from -60°C up to ambient.

9.14 The glued overlaps of the secondary foil vapor barrier shall be sealed off with a 50 mm wide adhesive tape of similar material (adhesive on one face) capable of sealing the foil within the temperature range from -60°C up to ambient.

9.15 The tape to seal all longitudinal/circumferential joints of primary metal vapor barrier shall be a composite type aluminum foil, reinforced and with a self-bonding layer made of butyl rubber on the back face. Minimum width of 75 mm to allow for sufficient cover of the joints.

9.16 Expanded metal as reinforcement shall have 6 mm to 10 mm mesh, bitumen coated or galvanized mild steel or Type 302 or 304 stainless steel.

9.17 Wire mesh poultry netting shall have 25 mm hexagon openings of 0.9 mm minimum diameter wire, carbon steel galvanized after weaving.

9.18 Wire to secure insulation shall be 1.5 mm (16 gauge) diameter soft annealed galvanized mild steel wire for hot insulation system and stainless steel Type 302 or 304 for cold insulation system.

9.19 Support Rings

Support rings for metal sheeting shall be made of:

- 1.5 × 25 mm carbon steel strip for an outside diameter of insulation up to 125 mm.
- 3 × 25 mm carbon steel strip for an outside diameter of insulation above 125 mm up to 760 mm.
- 5 × 30 mm carbon steel strip for an outside diameter of insulation above 760 mm.

9.20 Mineral fiber hydraulic-setting thermal insulating and finishing cement shall be asbestos free and shall be in accordance with ASTM C 449. When cement is to be used in contact with austenitic stainless steel, the product shall conform to the requirement of ASTM C 795.

9.21 Glass fiber cloth, 4 × 4 strand/cm open mesh shall be used as reinforcement or bonding agent for coating and mastic.

10. INSPECTION AND REJECTION

10.1 Inspection

10.1.1 The manufacturer and/or supplier shall be responsible for carrying out all the tests and inspections required by this Standard specification, using his own or other reliable facilities, and he shall maintain complete records of all such tests and inspections. Such records shall be available for review by the Purchaser. The manufacturer and/or supplier shall furnish to the Purchaser a certificate of inspection stating that each lot has been sampled, tested, and inspected in accordance with this Standard specification and has been found to meet the requirements specified.

10.1.2 The supplier shall afford the Purchaser's inspector all reasonable facilities necessary to satisfy that the material is being produced and furnished in accordance with this Standard specification. Such inspections in no way relieve the manufacturer and/or supplier of his responsibilities under the term of this Standard specification.

10.1.3 The Purchaser reserves the right to perform any inspections set forth in this Standard

specification where such inspections are deemed necessary to assure that supplies and services conform to the prescribed requirements.

10.1.4 The Purchaser's inspector shall have access to the material subject to inspection for the purpose of witnessing the selection of the samples the preparation of the test pieces, and the performance of the test(s). For such tests, the inspector shall have the right to indicate the pieces from which the samples will be taken in accordance with the provisions of this Standard specification.

10.2 Rejection

10.2.1 If the inspection of the sample shows failure to conform to the requirements of this Standard specification, a second sample from the same lot shall be tested and the results of this retest averaged with the result of the original test.

10.2.2 Upon retest as described in 10.2.1 failure to conform to this Standard specification shall constitute grounds for rejection.

10.2.3 In case of rejection, the manufacturer or supplier shall have the right to reinspect the rejected lot and resubmit the lot for inspection after removal of that portion of the lot not conforming to the specified requirement.

11. PACKAGING AND MARKING

Unless otherwise agreed and specified between the manufacturer and the Purchaser the materials shall be packaged and marked according to manufacturer's standard.

APPENDICES

APPENDIX A
ORDERING INFORMATION

The following information shall be supplied with the order:

a) the number and date of this IPS Standard;

b) the quantity of material required;

c) type of material

d) a note of any other special requirements or properties that material shall have in addition to this Standard.