

MECHANICAL INSULATION BEST PRACTICES GUIDE

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TIAC MECHANICAL INSULATION BEST PRACTICES GUIDE

PREFACE

The members of the Thermal Insulation Association of Canada, professionals in the manufacturing, fabrication, distribution and installation or removal of insulation materials, have determined that a set of standards consistent across Canada, would be of great benefit to the entire industry.

The data presently in publication across Canada varies greatly within the "design and build" community, insulation manufacturers, trade associations, contractors and individual owners or clients. To compile a set of reference materials in one document that can be maintained current, with timely updates, can only improve the economics and quality of the product supplied to the insulation customer. It will also improve the time required to estimate and the accuracy of contracts tendered by contractors.

This standard has been developed with the intent to make available a reference which can be utilized for most insulation projects in Canada. The TIAC National Standards are not meant to override Provincial and Territorial codes and regulations and other specialized insulation projects. The material selection portion of these standards are not an endorsement of any particular product nor is it the intent to suggest that products not included are not to be regarded as unacceptable alternatives.

These specifications have been prepared based on manufacturers technical information provided, however it is the specification writer's responsibility to ensure that all products comply with applicable codes, regulations and standards. The guide specification sections appearing in Section 15 have been structured to comply with specification standards published by Construction Specifications Canada (CSC), MasterFormat 2004, SectionFormat, and PageFormat.

The TIAC Mechanical insulation best practices guide is made up in different sections, focusing on specific areas of the industry. The document will be updated on a timely basis, to maintain a current reference point to assist in system design, material usage and application practice.

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SECTION 2

INSULATION MATERIALS AND PROPERTIES

2.1 DEFINITION OF INSULATION

Insulations are defined as those materials or combinations of materials which retard the flow of heat energy by performing one or more of the following functions:

1. Conserve energy by reducing heat loss or gain.
2. Control surface temperatures for personnel protection and comfort.
3. Facilitate temperature control of process.
4. Prevent vapour flow and water condensation on cold surfaces.
5. Increase operating efficiency of heating/ventilating/cooling, plumbing, steam, process and power systems found in commercial and industrial installations.
6. Prevent or reduce damage to equipment from exposure to fire or corrosive atmospheres.
7. Assist mechanical systems in meeting criteria in food and cosmetic plants.
8. Reduce emissions of pollutants to the atmosphere.

The temperature range within which the term "**thermal insulation**" will apply, is from -75°C to 815°C. All applications below -75°C are termed "**cryogenic**", and those above 815°C are termed "**refractory**".

Thermal insulation is further divided into three general application temperature ranges as follows:

A. LOW TEMPERATURE THERMAL INSULATION

1. From 15°C through 1°C - i.e. Cold or chilled water.
2. 0°C through -40°C - i.e. Refrigeration or glycol.
3. -41°C through -75°C - i.e. Refrigeration or brine.
4. -76°C through -273°C (absolute zero) - i.e. Cryogenic. (Not addressed in this manual).

B. INTERMEDIATE TEMPERATURE THERMAL INSULATION

1. 16°C through 100°C - i.e. Hot water and steam condensate.
2. 101°C through 315°C - i.e. Steam, high temperature hot water.

C. HIGH TEMPERATURE THERMAL INSULATION

1. 316°C through 815°C - i.e. Turbines, breechings, stacks, exhausts, incinerators, boilers.

2.2 GENERIC TYPES AND FORMS OF INSULATION

Insulations will be discussed in this manual according to their generic types and forms. The type indicates composition (i.e. glass, plastic) and internal structure (i.e. cellular, fibrous). The form implies overall shape or application (i.e. board, blanket, pipe covering).

2.2.1 TYPES

1. Fibrous Insulation - composed of small diameter fibers which finely divide the air space. The fibers may be perpendicular or parallel to the surface being insulated, and they may or may not be bonded together. Silica, rock wool, slag wool and alumina silica fibers are used. The most widely used insulations of this type are glass fiber and mineral wool. Glass fiber and mineral wool products usually have their fibers bonded together with organic binders that supply the limited structural integrity of the products.
2. Cellular Insulation - composed of small individual cells separated from each other. The cellular material may be glass or foamed plastic such as polystyrene (closed cell), polyisocyanurate and elastomeric.
3. Granular Insulation - composed of small nodules which may contain voids or hollow spaces. It is not considered a true cellular material since gas can be transferred between the individual spaces. This type may be produced as a loose or pourable material, or combined with a binder and fibers or undergo a chemical reaction to make a rigid insulation. Examples of these insulations are calcium silicate, expanded vermiculite, perlite, cellulose, diatomaceous earth and expanded polystyrene.

2.2.2 FORMS

Insulations are produced in a variety of forms suitable for specific functions and applications. The combined form and type of insulation determine its proper method of installation. The forms most widely used are:

1. Rigid boards, blocks, sheets, and pre-formed shapes such as pipe insulation, curved segments, lagging etc. Cellular, granular, and fibrous insulations are produced in these forms.
2. Flexible sheets and pre-formed shapes. Cellular and fibrous insulations are produced in these forms.
3. Flexible blankets. Fibrous insulations are produced in flexible blankets.
4. Cements (insulating and finishing). Produced from fibrous and granular insulations and cement, they may be of the hydraulic setting or air drying type.
5. Foams. Poured or froth foam used to fill irregular areas and voids. Spray used for flat surfaces.

2.3 PROPERTIES OF INSULATION

Not all properties are significant for all materials or applications. Therefore, many are not included in manufacturers' published literature or in the **Table of Properties** which follows this section. In some applications, however, omitted properties may assume extreme importance (i.e. when insulations must be compatible with chemically corrosive atmospheres.)

If the property is significant for an application and the measure of that property cannot be found in manufacturers' literature, effort should be made to obtain the information directly from the manufacturer, testing laboratory or insulation contractors association.

The following properties are referenced only according to their significance in meeting design criteria of specific applications. More detailed definitions of the properties themselves can be found in the **Glossary**.

2.3.1 THERMAL PROPERTIES OF INSULATION

Thermal properties are the primary consideration in choosing insulations. Refer to the following **Glossary** for definitions.

- a. **Temperature limits:** Upper and lower temperatures within which the material must retain all its properties.
- b. **Thermal conductance "C":** The time rate of steady state heat flow through a unit area of a material or construction induced by a unit temperature difference between the body surfaces.
- c. **Thermal conductivity "K":** The time rate of steady state heat flow through a unit area of a homogeneous material induced by a unit temperature gradient in a direction perpendicular to that unit area.
- d. **Emissivity "E":** The **emissivity** of a material (usually written ϵ or e) is the relative ability of its surface to emit energy by radiation. It is the ratio of energy radiated by a particular material to energy radiated by a black body at the same temperature.
- e. **Thermal resistance "R":** Resistance of a material to the flow of heat.
- f. **Thermal transmittance "U":** The overall conductance of heat flow through an "assembly".

2.3.2 MECHANICAL AND CHEMICAL PROPERTIES OF INSULATION

Properties other than thermal must be considered when choosing materials for specific applications. Among them are:

- a. **Alkalinity (pH) or acidity:** Significant when moisture is present. Also insulation must not contribute to corrosion of the system. **See [Section 3](#)**.
- b. **Appearance:** Important in exposed areas and for coding purposes.
- c. **Breaking load:** In some installations the insulation material must "bridge" over a discontinuity in its support. This factor is however most significant as a measure of resistance to abuse during handling.
- d. **Capillarity:** Must be considered when material may be in contact with liquids.
- e. **Chemical reaction:** Potential fire hazards exist in areas where flammable chemicals are present. Corrosion resistance must also be considered.
- f. **Chemical resistance:** Significant when the atmosphere is salt or chemical laden and when pipe content leaks.
- g. **Coefficient of expansion and contraction:** Enters into the design and spacing of expansion/contraction joints and/or use of multiple layer insulation applications.
- h. **Combustibility:** One of the measures of a material's contribution to a fire hazard.
- i. **Compressive strength:** Important if the insulation must support a load or withstand mechanical abuse without crushing. If, however, cushioning or filling in space is needed as in expansion/contraction joints, low compressive strength materials are specified.
- j. **Density:** A material's density may affect other properties of that material, such as compressive strength. The weight of the insulated system must be known in order to design the proper support.

- k. **Dimensional stability:** Significant when the material is exposed to temperature; expansion or shrinkage of the insulation may occur resulting in stress cracking , voids, sagging or slump.
- l. **Fire retardancy:** Flame spread and smoke developed ratings are of vital importance; referred to as "surface burning characteristics".
- m. **Resistance to ultraviolet light:** Significant if application is outdoors and high intensity indoors.
- n. **Resistance to fungal or bacterial growth:** Is important in all insulation applications.
- o. **Shrinkage:** Significant on applications involving cements and mastics.
- p. **Sound absorption coefficient:** Must be considered when sound attenuation is required, as it is in radio stations, some hospital areas where decibel reduction is required.
- q. **Sound transmission loss value:** Significant when constructing a sound barrier.
- r. **Toxicity:** Must be considered in the selection of all insulating materials.

2.4 MAJOR INSULATION MATERIALS

The following is a general inventory of the characteristics and properties of major insulation materials used in commercial and industrial installations. **See the Insulation Property Tables at the end of [Section 2](#) for a comparative review.**

2.4.1 CALCIUM SILICATE

Calcium silicate insulation is composed principally of hydrous calcium silicate which usually contains reinforcing fibers; it is available in molded and rigid forms. Service temperature range covered is 35°C to 815°C. Flexural and compressive strength is good. Calcium silicate is water absorbent. However, it can be dried out without deterioration. The material is non-combustible and used primarily on hot piping and surfaces. Jacketing is field applied.

2.4.2 MINERAL FIBER

- a. **Glass:** Available as flexible blanket, rigid board, pipe covering and other pre-molded shapes. Service temperature range is -40°C to 232°C. Fibrous glass is neutral; however, the binder may have a pH factor. The product is non-combustible and has good sound absorption qualities.
- b. **Rock and Slag:** Rock and slag fibers are bonded together with a heat resistant binder to produce mineral fiber or wool. Upper temperature limit can reach 1035°C. The same organic binder used in the production of glass fiber products is also used in the production of most mineral fiber products. Mineral fiber products are non-combustible and have excellent fire properties.

2.4.3 CELLULAR GLASS

Available in board and block form capable of being fabricated into pipe covering and various shapes. Service temperature range is -273C to 200°C and to 650°C in composite systems. Good structural strength, poor impact resistance. Material is non-combustible, non-absorptive and resistant to many chemicals.

2.4.4 EXPANDED SILICA, OR PERLITE

Insulation material composed of natural or expanded perlite ore to form a cellular structure; material has a low shrinkage coefficient and is corrosion resistant; non-combustible, it is used in high and intermediate temperature ranges. Available in pre-formed sections and blocks.

2.4.5 ELASTOMERIC FOAM

Foamed resins combined with elastomers to produce a flexible cellular material. Available in pre-formed sections or sheets, Elastomeric insulation offer water and moisture resistance. Upper temperature limit is 105°C . Product is resilient. Fire resistance should be taken in consideration.

2.4.6 FOAMED PLASTIC

Insulations produced from foaming plastic resins create predominately closed cellular rigid materials. "K" values decline after initial use as the gas trapped within the cellular structure is eventually replaced by air. Check manufacturers' data. Foamed plastics are light weight with excellent cutting characteristics. The chemical content varies with each manufacturer. Available in pre-formed shapes and boards, foamed plastics are generally used in the lower intermediate and the entire low temperature ranges. Consideration should be made for fire retardancy of the material.

2.4.7 REFRACTORY FIBER

Refractory Fiber insulations are mineral or ceramic fibers, including alumina and silica, bonded with extremely high temperature inorganic binders, or a mechanical interlocking of fibers eliminates the need for any binder. The material is manufactured in blanket or rigid form. Thermal shock resistance is high. Temperature limits reach 1750°C. The material is non-combustible.

The use and design of refractory range materials is an engineering art in its own right and is not treated fully in this manual, although some refractory products can be installed using application methods illustrated here.

2.4.8 INSULATING CEMENT

Insulating and finishing cements are a mixture of various insulating fibers and binders with water and cement, to form a soft plastic mass for application on irregular surfaces. Insulation values are moderate. Cements may be applied to high temperature surfaces. Finishing cements or one-coat cements are used in the lower intermediate range and as a finish to other insulation applications. Check each manufacturer for shrinkage and adhesion properties.

2.5 PROTECTIVE COVERINGS AND FINISHES

The efficiency and service of insulation is directly dependent upon its protection from moisture entry and mechanical and chemical damage. Choices of jacketing and finish materials are based upon the mechanical, chemical, thermal and moisture conditions of the installation, as well as cost and appearance requirements.

Protective coverings are divided into six functional types.

2.5.1 WEATHER RETARDERS

The basic function of the weather-barrier is to prevent the entry of water, ice, snow or atmospheric residue into the insulation. Sunlight and ozone can also damage certain insulations. Applications may be either jacketing of metal or plastic, or a coating of weather-barrier mastic. Jacketing must be over-lapped sufficiently to shed water. Avoid the use of plastic jacketing materials with low resistance to ultraviolet rays unless protective measures are taken.

2.5.2 VAPOUR RETARDERS

Vapour retarders are designed to retard (slow down) the passage of moisture vapour from one side of its surface to the other. Joints and overlaps must be sealed with a vapour tight adhesive or sealer

free of pin holes or cracks. Vapour retarders take three forms:

- a. Rigid jacketing - plastic fabricated jackets to the exact dimensions required and sealed vapour retarding.
- b. Membrane jacketing - laminated foils, treated or coated products and plastic films which are field or factory applied to the insulation material. (Additional sealing beyond the factory seal may be necessary depending on temperature/humidity conditions of the installation.)
- c. Mastic applications - solvent types which provide a seamless coating but require time to dry.

2.5.3 MECHANICAL ABUSE COVERINGS

Rigid jacketing provides the strongest protection against mechanical abuse from personnel, equipment, machinery, etc. The compressive strength of the insulation material should also be considered when designing for mechanical protection.

2.5.4 CORROSION AND FIRE RESISTANT COVERINGS

- a. **Corrosion protection** - can be applied to the insulation by the use of various jacket materials. The corrosive atmosphere must be determined and a compatible material selected. Mastics may be used in atmospheres that are damaging to jacket materials. (see [Section 3](#)).
- b. **Fire resistance** - can be applied to insulation systems by the use of jacketing and/or mastics. Fire resistant materials are determined by flame spread, smoke developed and combustibility. The total systems should be considered when designing for fire resistance. (see [Section 3](#)).

2.5.5 APPEARANCE COVERINGS AND FINISHES

Various coatings, finishing cements, fitting covers and jackets are chosen primarily for their appearance value in exposed areas.

2.5.6 HYGIENIC COVERINGS

Coatings and jackets must present a smooth surface which resists fungal or bacterial growth in all areas. High temperature steam or high pressure water wash down conditions require jackets with high mechanical strength and temperature ranges. (see [Section 3](#)).

2.6 PROPERTIES OF PROTECTIVE COVERINGS

The properties of jacketing and mastic materials that must be considered to meet the aforementioned functions are:

2.6.1 Chemical Compatibility

The chemical make-up of coverings must be compatible with the insulation material over which they are applied, as well as resistant to elements in the environment such as industrial chemicals, salt, air and ultraviolet or infrared light.

2.6.2 Resistance to Internal and External Movement

This property is significant if the covering must absorb or compensate for thermal expansion and contraction of the insulation it covers (i.e. shrinkage of high temperature insulation) or if the system vibration must be considered.

2.6.3 Temperature Range of the Finish or Covering

The temperature range must be compatible with the surface temperature of the insulation surface.

2.6.4 Vapour Permeability

Permeability should be considered for below ambient or dual temperature systems. The covering should significantly reduce the passage of moisture through the insulation.

2.6.5 Fire Retardancy

Flame spread and smoke developed ratings are of vital importance.

2.7 ACCESSORIES

The term "**accessories**" is applied to devices or materials serving one or more of the following functions:

1. Securement of insulation and/or jacketing
2. Reinforcement for cement or mastic applications
3. Stiffening around structures which may not support the weight of high density insulations
4. Support (pipe, vessel and insulation)
5. Sealing and caulking
6. Water flashing
7. Compensation for expansion/contraction of piping and vessels

Improper design or application in one or more of these accessories is a significant factor in the failure of insulation systems.

Securements: As most insulations are not structural materials they must be supported, secured, fastened or bonded in place. Securements must be compatible with insulation and jacketing materials. Possible choices include:

- a. Studs and pins
- b. Staples, serrated fasteners, rivets and screws
- c. Clips
- d. Wire or straps
- e. Self-adhering laps
- f. Tape*
- g. Adhesives*
- h. Mastics*

*Ambient temperature, humidity conditions and substrate surface cleanliness affects the efficiency of

tapes and adhesives and mastics on certain installations. Check the properties of temperature range and vapour permeability before choosing adhesives. And, wherever possible, use mechanical securements.

Reinforcement for cements and mastics: Mastics and cements should be reinforced to provide mechanical strength. The following materials can be used:

- a. Fiber fabrics
- b. Expanded metal lath
- c. Metal meshes
- d. Wire netting

Compatibility of materials must be considered to prevent corrosion.

Flashing: Materials which direct the flow of liquids away from the insulation may be constructed of metal, plastic or mastic.

Stiffening: Metal lath and wire netting can be applied on high temperature surfaces before heavy density insulation is applied.

Supports: Pipe supports and accessories may be supplied in part or totally by the insulation contractor. Insulation treatment at points of support are illustrated on Details. Accessories at points of support are:

- a. Heavy density insulation inserts
- b. Pipe support saddles and shoes
- c. Insulation and metal shields used to protect insulation
- d. Wood blocks or dowels; these should not be used at below ambient temperatures

Insulation support rings on vertical piping and vessels should be supplied by the piping or vessel contractor, as field welding on coded piping or vessels voids the original coding by the manufacturers. See Detail for treatment.

Sealing and caulking: A variety of sealers, caulking and tapes are available for sealing vapour and weather-barrier jackets, joints and protrusions. These products are manufactured in a large range of temperature and vapour permeability properties. Some are designed specifically for use with one type of insulation or manufacturer's products.

Expansion/Contraction compensation: Accessories used in the design of expansion/contraction joints, etc. include:

- a. Manufacturer overlapping or slip joints
- b. Bedding compounds and flexible sealers

See Details for insulation treatments.

2.8 SUMMARY - INSULATION MATERIALS AND APPLICATION WITHIN THE GENERAL TEMPERATURE RANGES

Choices of the materials available within each temperature range are based on design conditions (other than thermal) of the installation. See [Section 3](#) for more detailed design information.

2.8.1 LOW TEMPERATURE RANGE (15°C to -75°C)

The major design problems on low temperature installations are moisture penetration and operating efficiency. For below ambient applications, insulation should have low moisture absorption.

Vapour retarders are extensively used, but in practice it is difficult to achieve the perfect retarder in extreme applications. The pressure of the vapour flow from the warm outside surface to the cooler inside surface is such that, even with waterproof insulation, vapour may diffuse through the material, enter through unsealed joints or cracks, and condense, then freeze and cause damage.

Since the cost of refrigeration is higher than the cost of heating, more insulation is often justified in low temperature applications. Extra thicknesses of insulation, even beyond what would be economically dictated for cold line applications, are sometimes employed to keep the warm surface temperature above the dewpoint, thus preventing condensation from forming.

The low temperature range is further divided into application classifications.

1. Refrigeration (0°C through -75°C)

Water vapour which passes through the vapour-retarder will not only condense, but will freeze. Built up frost and ice will destroy the insulation system.

2. Cold and chilled water (15°C through 0°C)

Unless properly insulated, water vapour will condense on the metal causing corrosion and failure of the insulation assembly. The permeance of the vapour retarder should be no higher than 0.02 Perms.

The insulations generally used in this temperature range are:

- a. Cellular Glass
- b. Elastomeric Foamed Plastic
- c. Glass Fiber
- d. Mineral Fiber
- e. Phenolic (foamed)
- f. Polyethylene
- g. Polyisocyanurate
- h. Polyurethane
- i. Polystyrene

See Insulation Materials Table 1.A.

2.8.2 INTERMEDIATE TEMPERATURE RANGE (15°C TO 315°C)

This temperature range includes conditions encountered in most industrial processes and the hot water and steam systems necessary in commercial installations. Selection of material in this range is based more on its thermal values than with low temperature applications. However, other factors such as mechanical and chemical properties, availability of forms, installation time, and costs are also significant.

The materials generally used in the intermediate range are:

- a. Calcium Silicate
- b. Cellular Glass
- c. Elastomeric Foamed Plastic*
- d. Expanded Silica, or Perlite
- e. Glass Fiber
- f. Mineral Fiber
- g. Phenolic*
- h. Polystyrene*
- i. Polyurethane*

See Insulation Materials Table 1.B.

*The maximum temperature (315°C) exceeds these materials recommended maximum temperature.

2.8.3 HIGH TEMPERATURE RANGE (315°C TO 815°C)

As the refractory range of insulation is approached, fewer materials and application methods are available. High temperature materials are often a combination of other materials or similar materials manufactured using special binders. Jacketing is generally field applied. Industrial power and process piping and equipment, boilers, breechings, exhausts and incinerators fall within this application range. The materials generally used are:

- a. Calcium Silicate
- b. Cellular Glass*
- c. Cements
- d. Ceramic Fibers
- e. Glass Fibers*
- f. Mineral Fiber*
- g. Perlite*

See Insulation Materials Table 1.C.

*The maximum temperature (815°C) exceeds these materials recommended service maximum temperature.

2.9 INSULATION AND JACKET MATERIAL TABLES

These tables represent a summation of available data and information. References to test data, form, temperature range, "K" factors at certain mean temperatures, and general notes are for classification purposes only. Actual descriptions, performances, etc will vary from one manufacturer to another. Specific information on material properties should be obtained from the manufacturers' current data prior to being included in specifications. Fire hazard ratings in particular must be determined to meet local codes.

BASIC TYPES OF INSULATION

TABLE 1.A LOW TEMPERATURE

-75°C (-103°F) through 15°C (60°F)

Type	Form	Temp. Range	K-Factor* Metric/ Imperial	Mean Temp. C (F)	Notes
GLASS CELLULAR	Pipe Covering Block	-268°C to 427°C -450°F to 800°C	.048 (.33) @	4° (40°)	Good strength, water and vapour resistant, non-combustible, poor abrasion resistance.
GLASS FIBER	Pipe Covering Board Blanket	to 455°C to (850°F) to 538°C to (1000°F) to 538°C to (1000°F)	.035 (.24) @ .032 (.22) @ .030 (.21) @	4° (40°) 4° (40°) 4° (40°)	Good workability, non-combustible, water absorbent. Readily available. Vapour retarder required. Low compressive strength.
ELASTOMERIC FOAM	Pipe Sheet Roll	-40°C to 104°C -40°F to 220°F	.038 (.27) @	10° (50°)	Closed cell good workability, finish not required. Limited thickness to meet flame spread/smoke. Required UV protection.
POLYSTYRENE (Extruded)	Pipe Covering Board	-183°C to 74°C -297°F to 165°F	.035 (.24) @	4° (40°)	Lightweight, good, workability. Check manufacturers' data. Combustible. Some are treated for fire retardancy. All are closed cell except polystyrene expanded.
POLYSTYRENE (Expanded)	Pipe Covering Board	-40°C to 80°C -40°F to 175°F	.036 (.25) @	4° (40°)	
POLYURETHANE	Pipe Covering Sheet	-40°C to 107°C -40°F to 212°F	.025 (.18) @	4° (40°)	K-value may change as these materials age. Combustible. High flame spread and smoke.
POLYURETHANE	Pipe Covering Sheet Roll	-70° C to 100°C -94°C to 212°F	.036 (.25) @	10° (50°)	
POLYISOCYANURATE	Pipe Covering Sheet	-183°C to 140°C -297°F to 300°F	.025 (.18) @	4° (40°)	Lightweight, good workability. Check manufacturers' data. Some are treated for fire retardancy. K Values may change with age.

NOTE: Special attention must be given to installation and vapour seal.

*K-Factor Metric = W/m.K (Imperial = Btu.in./h.ft2. °F

TABLE 1.B I
15°C (60°F) through INTERMEDIATE TEMPERATURES
315°C (600°F)

Type	Form	Temp. Range	K-Factor* Metric/ Imperial	Mean Temp. C (F)	Notes
CALCIUM SILICATE	Pipe Covering Block Segments Type I	to 649°C (1200°F)	.065 (.45) @	93° (200°)	High compression strength, good workability, water absorbent, non-combustible. High flexural strength. Resistant to abrasion. See manufacturers' data for shrinkage factors.
GLASS CELLULAR	Pipe Covering Block Segments	to 427°C (800°F)	.050 (.35) @ .063 (.44) @	24° (75°) 93° (200°)	Good strength, water and vapour resistant, non-combustible, poor abrasion resistance. Subject to thermal shock. For applications over 204°C (400°F) see manufacturers' specifications.
GLASS FIBER	Pipe Covering Board	to 455°C (850°F) to 538°C (1000°F)	.037 (.26) @ .033 (.23) @	24° (75°) 24° (75°)	Good workability, non-combustible, water absorbent. Low compression resistance.
GLASS FIBER	Blanket	to 538°C (1000°F)	.033 (.23) @	24° (75°)	General purpose material, many facings available.
MINERAL FIBER	Pipe Covering Block Board Blanket	to 649°C (1200°F) to 1035°C (1895°F) to 649°C (1200°F) to 649°C (1200°F)	.037 (.26) @ .037 (.26) @ .037 (.26) @ .048 (.33) @	24° (75°) 24° (75°) 24° (75°) 24° (75°)	Good workability, non-combustible. Water absorbent. Low compression resistance.
PERLITE (Expanded)	Pipe Covering Board	to 649°C (1200°F)	.076 (.53) @	93° (200°)	Good workability, non-combustible. Poor abrasion resistance. Special packaging required to protect materials. Corrosion inhibitor.
ELASTOMERIC FOAM	Pipe Covering-I Sheet-II Roll	-40°C to 105°C -40°F to 220°F	.043 (.30) @	24° (75°)	Closed cell, finish not required, good workability. May require UV protection. Flame spread/smoke limited)
POLYSTYRENE (Extruded)	Pipe Covering Board	-183°C to 74°C -297°F to 165°F	.037 (.26) @	24° (75°)	Lightweight, excellent workability, combustible although some are treated for fire retardancy (check manufacturers' data sheet for properties)
POLYSTYRENE (Expanded)	Pipe Covering Board	-40°C to 80°C -40°F to 175°F	.039 (.27) @	24° (75°)	High flame spread/smoke. Check manufacturers' data sheets for values. K value may change as these materials age.
POLYURETHANE	Pipe Covering	-40°C to 105°C -40°F to 225°F	.027 (.19) @	24° (75°)	

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INSULATION MATERIALS AND PROPERTIES

POLYETHYLENE	Pipe Covering	-70°C to 100°C -94°F to 212°F	.037 (.26) @	24° (75°)	
POLYISOCYANURATE	Pipe Covering Board	-183°C to 149°C -297°F to 300°F	.027 (.19) @	24° (75°)	Lightweight, good workability. Check manufacturers' data sheets. Some are treated for fire retardancy. K values may change with age

CEMENTS – See Table 1.C

*K-Factor Metric = W/m.K (Imperial = Btu.in./h.ft². °F)

TABLE 1.C HIGH TEMPERATURE

315°C (600°F) through 815°C (1500°F)

Type	Form	Temp. Range	K-Factor* Metric/ Imperial	Mean Temp. C (F)	Notes
CALCIUM SILICATE	Pipe Covering Block Segments Type I Type II	to 649°C (1200°F) to 871°C (1600°F)	.087 (.60) @ .101 (.70) @	260° (500°) 260° (500°)	High compressive strength, good cutting characteristics, water absorbent, non-combustible. High flexural strength. Resistant to abrasion. See manufacturers' data for shrinkage factors.
CLASS CELLULAR HIGH TEMP	Pipe Covering Block Segments	to 427°C (800°F)	.103 (.72) @	260° (500°)	Good strength, water and vapour resistant, non-combustible, poor abrasion resistance. Subject to thermal shock. For application over 204°C (400°F), see manufacturers' specifications.
GLASS FIBER	Pipe Covering Board Blanket	to 455°C (850°F) to 538°C (1000°F) to 538°C (1000°F)	.083 (.58) @ .086 (.60) @ .086 (.60) @	260° (500°) 260° (500°) 260° (500°)	Good workability, water absorbent, non-combustible. Check manufacturers' data for specific properties. Low compression resistance.
MINERAL FIBER	Pipe Covering Block Board Blanket	to 649°C (1200°F) to 1035°C (1895°F) to 649°C (1200°F) to 649°C (1200°F)	.072 (.50) @ .092 (.64) @ .101 (.70) @ .101 (.70) @	260° (500°) 260° (500°) 260° (500°) 260° (500°)	Good workability, non-combustible. Low compressive resistance. Water absorbent.
PERLITE (Expanded)	Pipe Covering Block	to 649°C (1200°F)	.106 (.74) @	260° (500°)	Good workability, non-combustible, friable. Check manufacturers' data for specific properties. Poor abrasion resistance. Special packaging required to protect material. Corrosion inhibitor.
CERAMIC FIBER (Refractory Fiber)	Blanket Board	to 1260°C (2300°F) to 1260°C (2300°F)	.086 (.60) @ .080 (.56) @	260° (500°) 260° (500°)	Temperature range varies with manufacturer, style and type.
CEMENTS Hydraulic Setting Cement High Temperature Mineral Wool Finishing Cement (Mineral Fiber or Vermiculite)	Type I Type II Type III	38-649°C (100-1200°F) 38-870°C (100-1600°F) 38-980°C (100-1800°F)	.180 (1.05) @ .160 (1.12) @ .150 (1.26) @	250° (482°) 250° (482°) 250° (482°)	One coat application – insulating and finishing. Slow drying, rough texture – Pointing and insulating and filling. Used over basic insulation – Smooth finish usually 1/8" or ¼" thick application.

PROTECTIVE COVERINGS AND FINISHES

PLEASE NOTE: The following items are classified for use as weather barriers and/or vapour retarders. They also serve other purposes listed for protective coverings (i.e. mechanical abuse, corrosion, appearance, and hygienic), but each must be considered on its own merits for these aspects.

TABLE 2.A WEATHER BARRIERS*

Type	Composition	Fasteners	Notes
JACKETS:	1. Films laminated to felts or foil	Contact adhesives and/or tape	Corrosion resistant, bacteria and mildew resistant
	2. Stainless steel (various alloys – available with factory-applied moisture retarder)	Bands, screws or rivets	Excellent mechanical strength, corrosion, mildew and bacteria resistant. Excellent fire resistance.
	3. Galvanized steel (coated and with factory-applied moisture retarder)	Bands, screws or rivets	Good mechanical strength and fire resistance.
	4. Aluminum alloys (preferably with factory-applied moisture retarder)	Bands, screw or rivets	Good mechanical strength, good workability, poor fire resistance.
	5. Polyvinyl Chloride (PVC)	Mechanical fasteners, adhesive, or matching tape	May require protection from ultra-violet radiation. Resists chemicals and bacteria.
	6. High Impact Plastics (ABS)	ABS welding adhesive or mechanical fasteners	Washable surface for food processing applications.
	7. Plastic film (PVDC)	Adhesive or tape	Corrosion. Bacteria, mildew and chemical resistance. May require protection from ultra-violet radiation. Workable surface for food processing applications.
MASTICS:	1. Asphalt emulsion	Apply with reinforcing mesh	Water base, a breather mastic
	2. Asphalt cut-back	Apply with reinforcing mesh	Solvent base, also a vapour barrier
	3. Resin emulsion	Apply with reinforcing mesh	Tough, resilient film
	4. Polyvinyl acetate	Apply with reinforcing mesh	Tough, resilient film
	5. Acrylic	Apply with reinforcing mesh	Tough, resilient film

*Covering shall not be termed a weather barrier unless its joint and overlaps are adequate to prevent the entry of rainwater (See Section 2.5)

TABLE 2.B VAPOUR RETARDERS*

Type	Composition	Notes
JACKETS:	1. Foil-Scrim Laminate	Seal joints. Mechanical strength is less than metal or plastic. Easy installation.
	2. High Impact Plastics (ABS)	Seal with welding adhesive.
	3. Film Laminate	Seal with contact adhesive and/or tape.
MASTICS:	1 Asphalt cut-back	Apply with reinforcing mesh. Combustible.
	2. Resins – solvent type	Brush or spray application.
	3. Elastomeric Polymer	Apply with reinforcing mesh. Combustible.

NOTE: A perm rating of 0.05 is recommended on mechanical insulation coverings to be considered a vapour retarder.

*Covering shall not be termed a vapour retarder unless joints are sealed to prevent the entry of vapour.

SECTION 3: SYSTEMS DESIGN

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SECTION 3

INSULATION SYSTEMS DESIGN

3.1 GENERAL

An insulation system is the combination of insulations, finishes and application methods which are used to achieve specific design objectives. Among these are:

1. Energy Savings
2. Reduced Operating Costs
3. Condensation Control
4. Chemical compatibility with the metals being insulated, the atmosphere to which the system will be exposed, and the various components of the insulation system itself.
5. Protection of mechanical and insulation systems from mechanical abuse and atmospheric damage.
6. Personnel protection
7. Fire safety
8. Sound control
9. Future requirements for access to piping, fittings, etc.
10. Accommodation to limited clearances or work space
11. Reduce emissions of pollutants to the environment

While there are several choices of insulation materials which meet basic thermal and cost effective requirements of an installation, choices become more limited with each additional design objective that comes into play.

In some cases the choice of outer coverings, accessories and installation methods is more affected by design objectives than the actual insulation material used. For instance, glass fiber pipe insulation is available with a variety of factory-applied jackets designed to resist different types of mechanically and chemically abusive atmospheres.

The choices are endless and require a working knowledge of insulation material properties as well as a firm grasp of the basic function of each insulation treatment, and the design conditions under which it must operate. Section 3 is presented as a guide to the general design objectives of both commercial and industrial installations.

3.2 COMMERCIAL INSTALLATIONS

Insulation in commercial buildings such as schools, shopping centers, warehouses, hospitals, hotels and other public buildings is designed primarily to reduce energy consumption and/or prevent condensation. The types of mechanical systems commonly insulated in commercial installations vary only slightly from project to project, and involve a

relatively narrow temperature range. Typical mechanical systems include:

1. Plumbing (13°C to 80°C)
2. Ducts and housings (15°C to 43°C)
3. Steam and condensate (100°C to 185°C) *upper limit will vary with the pressure of steam
4. Outdoor air intake (seasonal outdoors temperature range)
5. Roof drains (1°C to 15°C)
6. Hot water heating (80°C to 100°C)
7. Chilled water (5°C to 13°C)
8. Engine exhaust (approximately 675°C)
9. Kitchen exhaust ducts (approximately 1100°C)
10. Refrigerant suction (-40°C to 10°C)

Care should be taken in designing commercial insulation systems to specify the thickness, material and finish necessary to accomplish the purpose of the application. Commercial buildings are designed to accommodate either human comfort or materials storage. Generally these purposes are achieved through the proper design of the heating/ventilating/cooling and plumbing systems. The purpose of the insulation system design is to enhance the efficiency of these systems, reduce energy consumption, help prevent damage from condensation, improve sound control and prevent fire.

3.2.1 DESIGN OBJECTIVES

The insulation system designer must be aware of the objectives of the installation and the amount and type of equipment planned to achieve these objectives. In some cases, as with steam heating, proper insulation planning can reduce the required capacity of the generating system. In the case of fruit and vegetable or refrigerated meat storage, temperature maintenance and condensation control objectives will supersede economic thickness design. Appearance and hygiene factors can also affect the choice of finishes in exposed areas and/or areas where food is being prepared or stored.

Condensation control on ducts, chillers, roof drains and cold piping is a basic function of insulation in commercial buildings. Design objectives here are to choose materials and application methods which will achieve the best vapour retarder seal possible, and to calculate the thickness of insulation necessary to prevent condensation.

Insulation chosen for personnel protection and/or fire protection must be able to withstand high temperatures without contributing to a possible fire hazard. Engine exhausts which can reach temperatures of 455°C to 675°C should be insulated sufficiently to reduce surface temperatures exposed to personnel or flammable materials to under 60°C. Kitchen exhaust ducts which are subjected to flammable grease accumulation fall within the same design criteria.

3.2.2 MATERIALS

The insulation materials most widely used on commercial installations are:

1. Glass and Mineral Fiber (pipe insulation, flexible blanket and board):
 - available with various jacketing materials
 - accommodates general commercial temperature range
 - meet code requirement for flame spread and smoke developed
2. Elastomeric (pipe covering and sheets):
 - no additional vapour retarder or finish usually required
 - used on plumbing piping, chilled water piping, suction piping, flexible lines and cold surfaces
 - check manufacturers data for flame and smoke developed
3. Calcium Silicate (pipe covering and block):
 - necessary for higher temperature commercial and industrial installations needing high compressive strength such as high pressure steam, diesel exhaust, kitchen exhaust and breechings
4. Urethane, Polyisocyanurate, Phenolic Foam (blocks and pipe covering):
 - necessary where a denser, less absorbent material is required
 - accommodates the general commercial temperature range
 - check code requirements for flame spread & smoke developed
5. Perlite (pipe covering and block):
 - necessary for higher temperature commercial and industrial installations needing high compressive strength such as high pressure steam, diesel exhaust, kitchen exhaust and breeching.
 - lightweight
 - moisture resistant to 315°C

A variety of weather and vapour retarder jackets and mastics is available to aid insulation materials in meeting and designing objectives such as fire safety, appearance and system abuse protection.

3.2.3 SPECIFICATIONS

Because commercial installations involve relatively limited materials and applications choices, with few variations to the mechanical systems receiving insulation treatment, there is a tendency to prepare general specifications which are often insufficient for proper installation or bidding. For example, a specification which states that "chillers or all cold surfaces of chillers will be insulated..." can be interpreted several ways especially if it hasn't been designated as to whether or not the chiller has been factory insulated.

All materials, thicknesses, finishes, securements and design objectives should be carefully communicated to the insulation contractor.

3.3 CHECK LIST - MECHANICAL SYSTEMS RECEIVING INSULATION TREATMENT

The following list is prepared for the convenience and guidance of specifiers. It may be used as a reminder to specify the treatment each individual component of general mechanical system will receive.

A. HVAC AND CHILLED WATER SYSTEM COMPONENTS

- 1. Ductwork
 - a. High Pressure Supply
 - b. Low Pressure Supply
 - c. Return Air
 - d. Mixed Air
 - e. Plenums and Housings
 - f. Variable Air Volume and Terminal Units, and Mixing Boxes
 - g. Drops to Diffusers and/or Flexible Ducts
 - h. Exhaust (from dampers to outside louvers)
- 2. Piping/Fittings/Valves, Etc.
 - a. Chilled Water Supply/Return
 - b. Refrigeration Suction
 - c. Hot Water Heating Supply/Return
 - d. Cooling Tower
 - e. Condensate Drain Lines
- 3. Equipment
 - a. Chillers
 - b. Converters/Heat Exchangers
 - c. Pumps (chilled/hot)
 - d. Expansion Tanks
 - e. Air Eliminators

B. STEAM AND CONDENSATE SYSTEMS COMPONENTS

- 1. Piping/Fittings/Valves, Etc.
 - a. Steam (High, Medium and/or Low Pressure)
 - b. Condensate (from trap to receiver tank)
 - c. Pumped Condensate (from receiver to boiler or feed water heater)
 - d. Boiler Feed Water
 - e. Cold Water Make-up
- 2. Equipment
 - a. Boilers
 - b. Generators
 - c. Converters
 - d. Pumps
 - e. Breechings/Flues
 - f. Flash Tanks
 - g. Condensate Receivers, Deaerator and Feed Water Tanks

C. DOMESTIC HOT AND COLD WATER SYSTEMS COMPONENTS

- 1. Piping/Fittings/Valves, Etc.
 - a. Cold Water
 - b. Hot Water
 - c. Hot Water Circulating
 - d. Soft Water
 - e. Soil, Waste, Vent and/or Drain Lines (condensations, sound control and fire protection).
- 2. Equipment
 - a. Hot Water Generator
 - b. Hot Water Storage Tank
 - c. Water Softeners
 - d. Cold Water Storage Tanks
 - e. Heat Recovery Storage Tanks

D. OTHER

- 1. Horizontal Suspended Roof Drain Piping and/or Roof Sumps
- 2. Kitchen Exhaust (fire hazard)
- 3. Emergency Generator Exhaust (personnel and fire protection)
- 4. Refrigeration Piping, Drains and Equipment
- 5. Sterilizer Steam (piping & equipment)

NOTE: If any of the above items are factory insulated, it should be so noted in the insulation specification.

3.4 INDUSTRIAL INSTALLATIONS

Conditions exist in industrial installations such as power plants, chemical plants, petroleum refineries, steel, pulp and paper mills, meat packing plants, food, soap, and cosmetic process plants, marine work, etc., which require that the insulation systems designer be involved in the project during the design phase. Depending upon the industrial process or function of the installation, these conditions include:

1. Stringent control of extreme temperature parameters.
2. Corrosive atmospheres resulting from the presence of process chemicals or the location of equipment and piping outdoors.
3. Increased fire hazard caused by high temperatures and the presence of volatile substances.
4. Presence of operating personnel. (personnel protection)
5. Sanitary and contamination requirements for food, meat packing, soap, cosmetic, dairy and brewery processes.
6. Additional mechanical abuse to insulations from excessive handling, foot traffic on vessel tops and lines, and the added movement of expansion, contraction and vibration.
7. Necessity for easy removal of insulation for predictable maintenance areas.
8. Critical clearance and space limitations coupled with the need for greater thickness of insulations.
9. Complex construction and installation schedules.
10. Radiation hazards in nuclear facilities.
11. Work accessibility requiring scaffolding, cranes, etc.

Pertinent data concerning the installation design objectives, the materials being processed or used, applicable government regulations or codes, operating data and temperature parameters must be determined far enough in advance of final specification preparation to insure the design of a properly functioning insulation system.

3.5 DATA REQUIRED FOR INDUSTRIAL INSULATION SYSTEM DESIGN

3.5.1 NATURE OF THE PROCESS

The possibility of spillage, leaks and accidental contamination of process chemicals and products is always present in industrial installations. Insulations should be chosen which do not react to the chemicals contained in the vessels or piping to which they are applied. Such a reaction may lower the ignition temperature of the process chemical or insulation material, contributing to fire hazard conditions.

Special care should be taken to use non-absorbent insulations in the presence of combustible or toxic liquid. Spontaneous combustion of a combustible liquid absorbed over the large surface area of insulation may occur as it oxidizes. Absorbent insulation may contribute significantly to an accidental fire by storing up the spilled or leaked combustible materials.

Stainless steel is the most appropriate of the metal jacketing materials, having high resistance to corrosives and bacterial growth as well as high mechanical strength. High cost of stainless steel usually limits its use to fire protection and corrosive environments. Aluminum may erode in wash down areas or where strong cleaning chemicals are used. The use of weather and vapour retarder coatings, reinforced with glass cloth or mesh, provides a mechanically strong and sanitary finish for equipment and other irregular surfaces. Many are also resistant to chemicals.

3.5.2 SPECIFIC TEMPERATURE PARAMETERS OF PIPING AND EQUIPMENT

In addition to the reduction of energy usage, industrial insulation systems must maintain controlled temperatures required for process materials being transported from one point in a facility to another.

Temperature control may be continuous, intermittent, cyclic or rapidly changed due to weather conditions or the necessity of steam cleaning and wash down periods.

An insulation of high thermal diffusivity, low specific heat and low density is desirable in installations which require rapid heat-up or cool-off of insulated surfaces. A process changing from hot to cold every few minutes requires an insulation that has the ability to change temperature quickly and has very low mass to retain heat.

The temperature of an insulation's outer surface must be considered where insulation is used for personnel protection or to protect the jacket or mastics or where excessive surface temperatures might cause ignition of fumes or gases. On low temperature installations, surface temperatures must be above dew point to prevent condensation and drip. The emissivity property of insulation finishes is significant in these cases. High emissivity is recommended on finishes used for personnel protection treatments.

On installations where temperatures must be maintained at specific levels, it must be decided in the design phase whether added insulation thickness or heat tracing or both would provide the most efficient service. This decision is based on data other than the conventional economic thickness considerations.

Extreme temperature surfaces in industrial process and power facilities may require the use of materials and application methods which can absorb expansion, contraction and vibration movement. Stainless steel banding or expansion bands are recommended for applications with extreme expansion movement or on large diameter surfaces. Because

most high temperature insulations shrink while the metal surface expands, methods such as double layer - staggered joint construction, the design and placement of cushioned expansion joints and/or the use of high rib lath between insulation and metal surfaces may be employed to protect the insulation seal.

Awareness of the nature of the process, its components, the relative temperatures of piping and equipment and the general location of such equipment and substances, aids the specifier in determining areas where excess heat or chemicals may create fire hazards or personnel hazards.

3.5.3 METAL SURFACES RECEIVING INSULATION TREATMENT

A selected insulation should not be chemically reactive to the metal over which it is applied. Basically, insulation installed on steel should be neutral or slightly alkaline. That installed on aluminum should be neutral or slightly acidic.

External stress corrosion, cracking of austenitic stainless steel may result from the presence of chloride ions on its surface. Insulation containing chlorides or located in a salt-laden or chloride contaminated atmosphere must not be in direct contact with unprotected stainless steel surfaces.

In the case of stainless steel jacketing, factory-applied moisture retarders on the inner surface may be sufficient protection. Virtually all stress corrosion cracking is caused by chlorides introduced from the atmosphere or from chemical fumes and not from the insulations themselves.

3.5.4 OPERATING DATA

The location of instruments and maintenance areas where personnel will be present is significant when specifying treatments for personnel protection and materials abuse protection from foot traffic, excessive handling and operational machinery. Rigid insulation materials and jacketing are recommended in these areas. High pressure wash down areas require resistance to water and detergents as well as high mechanical strength.

3.5.5 FUTURE ACCESS AND MAINTENANCE REQUIREMENTS

Leaks are most likely to occur at valves, fittings and flanges. Low temperature insulation can be protected from leaks by sealing off adjacent insulation with vapour-retarder mastics. Removable fitting covers may be specified at predictable maintenance areas, while special leak detection mechanisms may be installed at other locations. However, on hot applications a rigid inspection and replacement program is the best prevention of large scale insulation destruction due to leakage.

Turbines, which require easy access for inspection and maintenance, can be insulated with removable insulation blankets fabricated from stainless steel mesh or high temperature fabric filled with fibrous insulation. These are attached to turbine surfaces by means of metal eyelets built into the blankets around the edges.

The floor level of large tanks can be protected from spilled chemical or water from wash downs by using a nonabsorbent insulation along the bottom skirt or support, or by sealing with caulking.

3.5.6 ATMOSPHERIC CONDITIONS

The atmosphere surrounding industrial piping and equipment presents additional problems

in the selection of finishes and jacketing. Of particular concern is the presence of chemicals or humidity which act to corrode metal finishes.

Because of its excellent weather-barrier and mechanical properties, metal jacketing is widely used on industrial installations. The metals most resistant to corrosive chemicals and humidity are stainless steel and coated electro-galvanized steel. Coated aluminum can be used to combat specific conditions by selection of the exact coating required. However, the coatings are not always abrasive resistant, leaving the aluminum open to attack at fastener openings, cuts, etc.

Aluminum is weather resistant but does not always hold up in a wash down area or where strong cleaning chemicals are used. Factory-applied moisture-retarders are recommended on aluminum jacketing to prevent galvanic corrosion.

The coverings considered most resistant to corrosives and abrasive chemicals are the plastic types.

Unless protected, some PVC type coverings may break down when subjected to the effects of ozone, infra-red and ultra-violet rays. Protective paints are available for PVC coverings not manufactured for outdoor use. Weather barrier coatings offer good protection from weather as well as from the chemical attack of acids, alkali, solvents and salts, either airborne or as a result of intermittent spillage. Glass cloth and other fabric membranes are generally used as reinforcements and add mechanical strength to the installation.

Maximum protection from chemical attack on cold and dual temperature service is achieved through the use of vapour retarder coatings. They, too, are applied with reinforcing fabric.

Stainless steel jackets and bands are recommended in areas which require superior fire resistance.

Stainless steel is recommended over the use of aluminum due to the latter's lower melting point.

Some weather and vapour retarder mastics also add fire retardant properties to an insulation system.

3.5.7 CLEARANCES

Because of the complexity of process piping and the added thickness required to control heat loss or gain, clearances often become so minimal that it can be necessary to insulate piping together in groups. This is also true in marine work.

3.5.8 SCHEDULING AND MATERIALS STORAGE

Precise industrial installation schedules and good application practice often dictate that insulation be finished as soon as possible after roughing-in. The materials chosen must have the necessary strength to resist any excessive amount of handling and moving at the installations site. Materials which are moisture absorbent must also be protected from water while being stored at the site. Storage areas should be clearly indicated for the insulation contractor in project specifications, and should be noted as covered or open.

3.5.9 SPECIFICATIONS

Contract drawings should indicate the extent and general arrangements of the yard and the

process piping to receive insulation treatment. The size of piping and equipment, line origination and termination, elevations, support locations, and orientation of nozzles, fittings and valves should also be indicated and properly dimensioned.

3.5.10 QUALITY OF MATERIALS

Insulation and associated materials should be specified and ordered to meet appropriate codes and standards. Manufacturers' data sheet and test reports should be consulted in the selection process to determine conformity.

SECTION 4: PRODUCTS

4.1	PRODUCTS	1
A.	PREFORMED PIPE INSULATION	1
B.	UNDERGROUND INSULATION (GRANULAR TYPE)	2
C.	DUCT AND PLENUM INSULATION	2
D.	MINERAL FIBER DUCT LINER FOR INTERNAL APPLICATIONS	3
E.	FINISH JACKETS	3
F.	ACCESSORIES	4

SECTION 4

PRODUCTS

4.1 PRODUCTS

The following listed manufacturers' products have been accepted by TIAC as suitable for application based on technical data available from the various manufacturers. The terminology used in this products listing is consistent with that used within the Application and Finishes parts of these standards. The following manufacturer lists contain acceptable materials in regular supply in most areas (see Provincial addenda). Unless specifically noted otherwise in the project specifications, the Contractor has the option of which one of the listed manufacturers' products to use on a project for the various applications and finishes specified. The specifier should verify these specifications before using.

A. PREFORMED PIPE INSULATION

1. Mineral Fiber for Low and Medium Temperature (with or without integral jacket)
 - Knauf Insulation
 - Manson Insulation Inc.
 - Owens Corning Canada Inc.
 - Roxul Inc.
 - Johns Manville
 - Industrial Insulation Group IIG-LLC
2. Calcium Silicate for High Temperature
 - Industrial Insulation Group IIG-LLC
3. Mineral Fiber for High Temperature
 - Roxul Inc.
 - Industrial Insulation Group IIG-LLC
4. Perlite for High Temperature
 - Industrial Insulation Group IIG-LLC
 - Temperlite
 - Howred Corp.
5. Cellular Glass
 - Pittsburgh Corning Corp.

6. Flexible Foam Elastomeric
 - Armstrong World Industries
 - Halstead Corp.
7. Closed Cell Polyisocyanurate
 - ITW Insulation
8. Phenolic
 - Belform Insulation Ltd.

B. UNDERGROUND INSULATION (GRANULAR TYPE)

- Dri-Therm
- Gilsulate

C. DUCT AND PLENUM INSULATION

1. Rigid Mineral Fiber Board for Low and Medium Temperature (with or without vapour retarder)
 - Knauf Insulation
 - Manson Insulation Ltd.
 - CertainTeed Corp.
 - Owens Corning Canada Inc.
 - Roxul Inc.
 - Johns Manville
2. Flexible Mineral Fiber Blanket for Low and Medium Temperature (with or without vapour retarder)
 - Knauf Insulation
 - Manson Insulation Inc.
 - CertainTeed Corp.
 - Owens Corning Canada Inc.
 - Johns Manville
3. Calcium Silicate for High Temperature
 - Industrial Insulation Group IIG-LLC
4. Mineral Fiber for High Temperature

- Industrial Insulation Group IIG-LLC.
- Roxul Inc.
- 5. Perlite for High Temperature
 - Industrial Insulation Group IIG-LLC
 - Temperlite
 - Howred Corp.
- 6. Cellular Glass
 - Pittsburgh Corning Corp.
- 7. Flexible Elastomeric Foam
 - Armstrong World Industries
 - Halstead Corp.
- 8. Closed Cell Polyisocyanurate
 - ITW Insulation
- 9. Phenolic
 - Belform Insulations Ltd.

D. MINERAL FIBER DUCT LINER FOR INTERNAL APPLICATIONS

- Knauf Insulation
- Manson Insulation Inc.
- Owens Corning Canada Inc.
- Johns Manville
- CertainTeed Corp.

E. FINISH JACKETS

- 1. Multi-Purpose
 - Alpha and Associates
 - Claremont
 - Lamotite
 - Compac Corp.
- 2. Treated Jacket

- Alpha and Associates
 - Claremont
 - Fattal Thermocanvas
3. PVC Jacket and Fitting Covers
- Ceel-Co
 - Belform Insulation Ltd.
 - Proto Corp.
 - Sure-Fit System
 - Speedline
 - Thermo-Cover Inc.
 - Zeston
4. Aluminum and Stainless Steel Jacketing and Fitting Covers
- Aluminum materials must be furnished from aluminum with alloys conforming to ASTM B-209 designation.
 - Stainless Steel materials must be type 304 or Type 316 stainless steel conforming to ASTM A-240.
5. Vapour Retarder facing adhesive; Insulation and Fabric Coatings; FittingMastic; Fabric Adhesive; Mastic Coating
- Bakor
 - Specialty Construction Brands Inc. (Fosters/Childers)
 - Epolux
 - Nacan

F. ACCESSORIES

1. Tapes
- Avery Dennison
 - Compac Corp.
 - Ideal Tape
 - ITW Insulation
 - MACtac Canada Ltd.

- Venture Tape Corp.
- 2. Weld Pins, Studs and Clips
 - AGM
 - Continental Studwelding
 - Midwest Fastners Inc.
- 3. Insulating Cements
 - PK Insulation
 - Industrial Insulation Group IIG-LLC
- 4. Vapour Retarder Film
 - Dow Chemical Canada Inc.
- 5. Removable/Reusable Covers **Other Companies**
 - Albrico Services (1982) Ltd. **to be listed on**
 - Connelly Insulation Services
 - Crossby Dewar Insulation
 - Firwin Corporation - Guildfords Ltd.
 - Alberta Heat Saver Covers Ltd.
 - GlassCell Isofab/Sarnia Insulation Services
 - Inscan Contractors Ltd.
 - Interprovincial Insulation Inc.
 - - Knauf Fiber Glass
 - LGF Mechanical Insulations - Pro-Tec-T-Kotes
 - RRC Insulation - Sarnia Insulation Supply (1985) Ltd.
 - Scotia Insulation Sales Limited - Thermo-Cover Inc.
 - Thermal Systems

NOTE 1: The National Building Code 1995 does not permit the use of foamed plastic insulation when used for insulating an air duct. Foamed plastic insulation may be used in ceiling spaces that act as a return air plenum provided the insulation is protected from exposure to the plenum in accordance with NBC 1995, Subsection on Combustible Insulation and its Protection. The specifying authority is responsible for ensuring such protection is provided if applicable to a project, and specify accordingly in the project specifications.

NOTE 2: The National Building Code 1995 requires that in buildings of non-combustible construction, foamed plastic insulation classified as "combustible" insulation on piping located in horizontal or vertical service spaces or in rooms or spaces other than service spaces must be suitably protected from fire exposure and requires a covering with a flame spread of 25 or less in service spaces and a rating note more than that required for interior finish for the ceiling in rooms or spaces, other than service spaces. The specifying authority is responsible for ensuring such protection is provided, if applicable to a project, and specify accordingly in the project specifications. The use of foamed plastic insulation is also limited by NBC 1995 requirements for Smoke Developed Classifications. The specifier must determine such limitations for each project and specify accordingly. * Flame Spread and Smoke Developed Classification is based on 25mm thickness.

NOTE 3: The use of PVC jacket or fitting covers is limited by the 1995 National Building Code requirements for Smoke Developed Classification. The specifier must determine such limitations for each particular project and specify according.

NOTE 4: Materials shall be handled as recommended by the various manufacturers.

SECTION 5: COMMERCIAL PIPING

5.1	APPLICATION	2
A.	HOT PIPING	2
	1501-H Hot Application - Intermediate Temperature (15°C - 315°C)	2
	1501-HA Alternative Application	2
B.	COLD PIPING	3
	1501-C Cold Application - (5°C to 15°C)	3
	1501-CA Alternative Application	3
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Note: The contents of this section include the application and finishes of pipe insulation under TIAC specification code numbers 1501 and CPF. These code numbers are cross referenced in the following specification sections:

Mechanical Insulation

- Section 15250 (MasterFormat 1995)
- Section 21 07 00 – Fire-Suppression Insulation (MasterFormat 2004)
- Section 22 07 00 – Plumbing Insulation (MasterFormat 2004)
- Section 23 07 00 – HVAC Insulation (MasterFormat 2004)

Piping Insulation

- Section 15260 (MasterFormat 1995)

Section 21 07 19 – Fire-Suppression Piping Insulation (MasterFormat 2004)

Section 22 07 19 – Plumbing Piping Insulation (MasterFormat 2004)

Section 23 07 19 – HVAC Piping Insulation (MasterFormat 2004)

SECTION 5

COMMERCIAL PIPING

5.1 APPLICATION

A. HOT PIPING

Specification **Code No**

1501-H Hot Application - Intermediate Temperature (15°C - 315°C)

- Piping: Pipe covering without integral jacket shall be held in place with insulation fastening at not less than 300 mm centres. Pipe insulation with integral jacket shall be held in place by stapling the flap on 75 mm centres. Pipe insulation with integral self-sealing jacket will not require additional fastening.

- Screwed or welded fittings: Insulate fittings with sections of the pipe insulation mitered to fit tightly, or with tightly placed flexible insulation covered with reinforcing membrane stapled in place. Alternately insulate fittings with tightly placed flexible insulation and apply PVC fitting covers.

- Valves, Strainers: Insulate valve bodies and strainers with fitted pipe insulation segments, or mitered blocks all to thickness of the adjacent pipe insulation. Drains, blowoff plugs and caps shall be left uncovered. Alternately insulate with tightly placed flexible insulation and apply PVC fitting covers. (**See Note 1**).

- Flanged and grooved fittings: Insulate with oversized pipe covering or mitered blocks to the thickness of the adjacent pipe covering (**See Note 2**). Alternately insulate with tightly placed flexible insulation and apply PVC fitting covers. (**See Note 1**)

- Insulation Termination Points: Terminate insulation 75mm from fittings to provide working clearance and bevel insulation at 45° angle.

1501-HA Alternative Application

- For certain areas where insulation application as described above is impractical, flexible foamed elastomeric of adequate thickness may be used and applied in accordance with the manufacturer's directions (**See Note 2**).

Note 1: The use of this code number does not include insulation application on valve bodies, strainers or flanges. The specifying authority must specify in the project specifications if valve bodies, strainers or flanges are to be insulated. Refer to specification format, Page SF-4, under "Application".

Note 2: The National Building Code 1995 requires that in buildings of non-combustible construction, foamed plastic insulation on piping located in vertical service spaces or in rooms or spaces other than service spaces must be suitably protected from fire exposure. The specifying authority is responsible for ensuring such protection is provided, if applicable to a project, and specify accordingly in the project specifications. The use of foamed plastic insulation is also limited by NBC 1995 requirements for Smoke Developed Classification. The specifier must determine such limitations for each project and specify accordingly. Also note the temperature limitation of these products.

B. COLD PIPING

Specification
Code No.

1501-C Cold Application - (5°C to 15°C)

- Piping: Apply pipe insulation with integral vapor retarder jacket to piping and hold in place by securing the jacket flap. Seal all flaps and butt strips with vapor retarder adhesive or alternately secure with staples on 75 mm centers and cover with vapor retarder tape. Pipe insulation with integral self-sealing vapor retarder jacket will not require additional fastening.
- Screwed or welded fittings: Insulate fittings with section of the pipe insulation mitered to fit tightly. All seams shall be sealed using vapor retarder tape.
- Valves, Strainers: Insulate valve bodies, bonnets and strainers with fitted pipe insulation or mitered blocks all to thickness of adjacent pipe insulation, then seal all seams of vapor retarder with vapor retarder tape.
- Flanged and grooved fittings: Insulate with oversized pipe insulation or mitered blocks to the thickness of the adjacent pipe insulation, then seal all seams of vapor retarder jacket with vapor retarder tape.

1501-CA Alternative Application

- Flexible foamed elastomeric or closed cell insulation may be used in accordance with the manufacturer's instructions. **(See Note 2 on page CP-2).**

C. UNDERGROUND INSULATION

Specification
Code No.

1501-U Buried Underground Application

- Buried underground insulation employs specific systems based on the particular characteristics of the insulation materials to be used.
- Install the underground insulation in accordance with the manufacturer's

recommendations and specifications.

(Type to be specified from materials listed under Products Group B, Page 2).

5.2 FINISHES

- 1 INSULATION ON CONCEALED PIPING WILL BE LEFT AS FACTORY FINISHED WITH NO FURTHER FINISH REQUIRED.
- 2 THE FOLLOWING FINISHES APPLY TO EXPOSED PIPING ONLY:

Specification
Code No.
CPF/1 Indoor

- The factory applied integral all service jacket shall be neatly applied to receive the fabric jacket. Apply a jacket with a fire resistive lagging coating. Apply a finishing coat of fire resistive lagging coating

CPF/2 Indoor (THIS FINISH SHOULD ONLY BE USED IN CONCEALED AREAS UNLESS OTHERWISE SPECIFIED)

- Leave insulation as is, with no additional finish.

CPF/3 Indoor/Outdoor (Metal Jacket)

- Over the pipe insulation apply metal jacketing with a 60mm overlap at 3 o'clock using necessary fastenings on approximately 150mm centers.
- Over insulated fittings, (valve bodies, valve bonnets, strainers and flanges if specified) apply metal jacket or preformed metal fitting covers to provide a complete jacket system. Secure with necessary fastenings.

CPF/4 Indoor/Outdoor (PVC Jacket)

- Over the pipe insulation apply PVC jacketing using necessary fastenings on approximately 300mm centers, or bond using an adhesive recommended by the manufacturer to provide continuous seal. Overlap each section a minimum 3 inches.. Cover longitudinal and circumferential joints with finishing tape neatly applied.
- Over insulated fittings, valve bodies, valve bonnets, strainers and flanges if specified) apply PVC jacket or preformed PVC fitting covers to provide a complete jacket system. Secure with appropriate fastenings and jacket finishing tape. **(See**

Note 1) CPF/5

Outdoor

- Over the insulated surfaces apply a coat (minimum 1 litre per 1.5 m) of weather coating. 2 While still wet, embed a layer of reinforcing membrane and finish with a final coat (minimum 1 liter per 1.5 m) of weather coating. 2

NOTE 1: PVC Jacket and Fittings exposed to outdoor use or fluorescent lighting shall be ultra-violet ray resistant.

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C. OVAL DUCTS

6

Note: The contents of the Section include the application and finishes of duct and plenum insulation under Specification Code Numbers CER, CEF, CIR, CIF, CIU, CRF and CRD. These code numbers are cross referenced in TIAC specification sections 15250 (23 07 00) - Mechanical Insulation and 15270 (23 07 13) - Ductwork Insulation.

SECTION 6

COMMERCIAL DUCTWORK AND PLENUM

6.1 APPLICATION

A. RIGID INSULATION EXTERNAL APPLICATION

**Specification
Code No.**

CER/1 Hot Duct and Plenum (20° to 65°C)

- Preparation: Fix mechanical fasteners to both horizontal and vertical surfaces at approximately 300 mm centers, each direction.
- Application: Cut insulation without integral vapor retarder to required size and apply to exterior of duct and/or plenum, with horizontal surfaces overlapping vertical surfaces and edges tightly butted together. Secure insulation by impaling on mechanical fasteners. (See Note 1)

CER/2 Cold or Dual Temp Duct and Plenum (Sub-ambient to 65°C)

- Preparation: Fix mechanical fasteners to both horizontal and vertical surfaces at approximately 300 mm on centers, each direction.
- Application: Cut insulation with integral vapor retarder to required size and apply to exterior of duct and/or plenum with vapor retarder to the warm side with horizontal surfaces overlapping vertical surfaces. Butt edges together tightly. Secure insulation by impaling on mechanical fasteners. Where mechanical fasteners penetrate vapor retarder, and at all corners and joints, apply self adhesive vapor retarder tape or vapor retarder strips adhered with vapor retarder adhesive. Where raised seams are encountered, add a strip of insulation above seam termination on each side of the seam, secure to the seams an overlapping strip of insulating material of equal thickness to the one required with integral vapor retarder to provide a continuous vapor retarder and seal all joints and edges with self adhesive vapor retarder tape.. (See Note 1)

CER/3 Outside Air Duct and Plenum - (-40°C to Ambient)

- As CER/2 above but firstly apply a layer of rigid insulation without vapor retarder before applying layer of rigid insulation with vapor retarder. All joints shall be staggered.

Note 1: For external applications of rigid insulation (CER/1 and CER/2) where the use of mechanical fasteners is unsuitable due to space limitations, wire fastenings, insulation adhesive or other suitable method of attachment may be substituted.

Note 2: Except where specifically called for in the Insulation section of the project specifications, where an interior duct liner is used, external insulation shall not be applied.

B. FLEXIBLE INSULATION EXTERNAL APPLICATION

Specification Code .:

CEF/1 Hot Duct and Plenum - (20°C to 65°C)

- Preparation: On round ducts and on rectangular ducts 740mm or less in width, no preparation is necessary. On rectangular ducts 600mm or more in width, apply to bottom surface, either mechanical fasteners at approximately 300 mm centres, or insulation adhesive applied in strips 100mm wide on approximately 300 mm centres.

- Application: Cut insulation without integral vapour retarder to required size allowing for 50 mm overlap at each joint and apply to exterior of duct. Secure insulation with either twine or wire fastening on approximately 300 mm centres, or by stapling laps; or by 100% insulation adhesive coverage.

CEF/2 Cold or Dual Temp Duct and Plenum – (sub-ambient 65°C)

- Preparation: On rectangular ducts 600 mm or more in width, apply to bottom surface, either mechanical fasteners at approximately 300 mm centers or insulation adhesive in strips 100 mm wide on approximately 300 mm centers.

- Application: Cut insulation with integral vapor retarder to required size and apply to exterior of duct with vapor retarder to the outside. Where mechanical fasteners or staples penetrate the vapor retarder and at all joints apply vapor retarder tape or vapor retarder strips adhered with vapor retarder adhesive. All joints shall be overlapped a minimum of 50 mm and stapled on approximately 100 mm centers. Secure insulation with wire fastening on approximately 300 mm centers. (See Notes 1 and 3)

Note 1: Except where specifically called for in the Insulation section of the project specifications, where an interior duct liner is used, external insulation shall not be applied.

Note 2: All Outside Air Ducts shall be insulated as specified under CER/3, Page CD-1.

C. LINER INTERNAL APPLICATION

Specification Code No.

CIR/1 Rigid Duct Liner

- Preparation: Fix mechanical fasteners to both horizontal and vertical surfaces at approximately 300 mm centers each direction.

- Application: Cut insulation material to required size and apply to interior of duct and/or plenum with horizontal surfaces overlapping vertical surfaces and with edges tightly butted together. Insulation shall be applied to the ductwork with a minimum 90% coverage of adhesive and mechanical fasteners. Where mechanical fasteners penetrate factory finish and at all joints, apply a heavy layer of seal coating. On high velocity duct systems 20.32 m/s to 30.48 m/s apply reinforcing membrane over the entire insulation joint surface. Seal off leading edge of insulation to duct surface with reinforced seal coating.

CIF/1 Flexible Duct Liner

- Preparation: Fix mechanical fasteners to both horizontal and vertical surfaces at approximately 300 mm centers each way.

- Application: Cut insulation material to required size and apply to interior of duct, edges tightly butted together. Insulation shall be applied to the ductwork with a minimum 90% coverage of adhesive and mechanical fasteners. Where mechanical fasteners penetrate factory finish and at all joints, apply a heavy layer of seal coating. On duct systems having a 10.16 m/s to 20.32 m/s velocity, reinforce the joints with seal coating and reinforcing membrane. Seal off leading edge of insulation to duct surface with reinforced seal coating.

Note 1: Except where specifically called for in the Insulation section of the project specifications, where an interior duct liner is used, external insulation shall not be applied.

Note 2: Internal insulation shall not be applied to duct work that is below ambient temperature.

D. UNDERGROUND INSULATION

Specification

Code No.

CUI/1 Buried Underground Insulation

- Patented encasement type based on the particular characteristics of the insulation materials shall be used.

- Install the underground insulation in accordance with the manufacturer's recommendations and specifications.

6.2 FINISHES

A. RECTANGULAR DUCTS

INSULATION ON CONCEALED DUCTWORK WILL BE LEFT AS FACTORY FINISHED WITH NO FURTHER FINISH REQUIRED.

The following finishes apply to exposed ductwork and plenums only.

Specification

Code No.

CRF/1 Indoor

- Use over rigid insulation with an integral vapor retarder. Apply continuous metal corner bead to all corners. Adhere vapor retarder tape over all joints and breaks in vapor retarder, and at all corners.

- Secure canvas jacket over insulation using fire resistive lagging coating and adhesive, and finish with one (1) coat of fire resistive lagging coating adhesive..

CRF/2 Indoor

- Use over rigid insulation with an integral vapor retarder. Apply continuous metal corner bead to all corners. Adhere vapor retarder tape over all joints and breaks in vapor retarder, and at all corners.

CRF/3 Outdoor

- Adhere vapour retarder tape over all joints and breaks in vapor retarder and at all corners on cold or dual temp ductwork.

- Apply over the insulation surface a stucco embossed aluminum jacket secured with pop rivets or stainless steel self tapping screws. All joints sealed or flashed to prevent water infiltration.

CRF/4 Outdoor

- Apply to the insulation surface a coat (minimum 1 litre per 1.5 m) of weather coating. While still wet, embed a layer of reinforcing membrane and finish with a final coat (minimum 1 litre per 1.5 m) of weather coating. (Insulation having factory applied vapour retarder is not 2 required with this finish).

CRF/5 Outdoor

- Install a modified bitumen membrane in accordance to manufacturer's instructions.

B. ROUND DUCTS

INSULATION ON CONCEALED DUCT WORK WILL BE LEFT AS FACTORY FINISHED WITH NO FURTHER FINISH REQUIRED.

The following finishes apply to exposed duct work only.

Specification
Code No.

CRD/1 Indoor

- Use with flexible insulation or pipe and tank wrap with integral vapor retarder. At all joints and breaks, apply self-adhesive vapor retarder tape.
- Apply canvas jacket over insulation using fire resistive lagging coating and finish with one (1) coat of fire resistive lagging coating.

CRD/2 Indoor

- Use flexible insulation with integral vapour retarder.
- At all joints and breaks, apply vapour retarder tape.

CRD/3 Outdoor

- Adhere vapor retarder tape over all joints and breaks in vapor retarder on cold or dual temp ductwork.
- Apply over the insulation surface a stucco embossed aluminum jacket secured with pop rivets or stainless steel self-tapping screws. All joints sealed or flashed to prevent water infiltration.

CRD/4 Outdoor

- Install an aluminized modified bitumen membrane in accordance to manufacturer's instructions.

CRD/5 Outdoor

- Apply to the insulation surface a coat (minimum 1 litre per 1.5 m) of weather coating. While still wet, embed a layer of reinforcing membrane and finish with a final coat (minimum 1 litre per 1.5 m) of weather coating. (Insulation having factory applied vapour retarder is not required with this finish).

C. OVAL DUCTS

Please refer to the specifications for RECTANGULAR DUCTS in Section 6.2.A

SECTION 7 : COMMERCIAL EQUIPMENT

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	CEF/1 Indoor/Outdoor	1
	CEF/2 Indoor	2
	CEF/3 Outdoor	2
B.	COLD TANKS AND EQUIPMENT	2

Note: The contents of this Section include the application and finishes of equipment insulation under Specification Code Numbers 1503 and CEF. These code numbers are cross referenced in TIAC specification sections 15250 (23 07 00) Mechanical Insulation and 15280 (23 07 16) Equipment Insulation.

SECTION 7

COMMERCIAL EQUIPMENT

7.1 APPLICATION

A. HOT TANKS, BREECHINGS AND EQUIPMENT

**Specification
Code No.**

1503-H

- Apply insulation block, board segments or pipe and tank insulation and secure firmly with mechanical fastenings, wire or banding. Insulation shall be fitted neatly to all contours without voids.

B. COLD TANKS AND EQUIPMENT

1503-C

- For this application use either insulation with an integral vapor retarder or field apply a vapor retarder treatment. Apply insulation block board segments or pipe and tank insulation and secure firmly with mechanical fasteners, wire or banding. All openings, joints and seams shall be sealed with self adhesive vapor retardant tape. Insulation shall be fitted neatly to all contours without voids.

Note 1: If chillers are not factory insulated, they shall be insulated in accordance to the manufacturer's specifications.

7.2 FINISHES

A. HOT TANKS, BREECHINGS AND EQUIPMENT

**Specification
Code No.**

CEF/1 Indoor/Outdoor

- Over the insulation, apply aluminum jacket secured with stainless steel self-tapping screws or pop rivets with all joints caulked or flashed to prevent water infiltration..

CEF/2 Indoor

- Secure canvas using fire resistive lagging coating and finish with one (1) coat of fire resistive lagging coating.. Alternatively, finish with a layer of PVC jacket with all joints and seams sealed.

CEF/3 Outdoor

- Apply a coat of weather coating to manufacturer's recommendations. While still wet, embed a layer of reinforcing membrane and finish with a coat of weather coating.

Note 1: Irregular areas or small heads to be finished with or weather coating to suit application and shell finish.

B. COLD TANKS AND EQUIPMENT

Please refer to the specifications for HOT TANKS in Section 7.2.A

SECTION 8: SPECIFICATION CONCEPTS AND EXAMPLES - COMMERCIAL INSULATION

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SECTION 8

SPECIFICATION CONCEPTS AND EXAMPLES

OVERVIEW: SPECIFICATIONS

This section reviews the standards related to specifications, and provides examples of how to use this TIAC Mechanical insulation best practices guide in specifications.

MasterFormat 2004

Mechanical insulation specifications are organized according to the MasterFormat numbering standard (master list of section titles and numbers), jointly published by Construction Specifications Canada (CSC – in Canada) and Construction Specifications Institute (CSI – in the USA).

MasterFormat 2004 is the newest edition, and was radically changed to accommodate a variety of needs. Six-digit numbers are introduced (from the former 5-digit standard), and many new Divisions were added. Mechanical sections were expanded from the old Division 15 - Mechanical into new Divisions 21 - Fire Suppression, 22 - Plumbing, and 23 - Heating, Ventilating and Air Conditioning. Within these Divisions, insulation was given a major heading, and types of insulation given sub-headings.

MasterFormat 2004 Insulation Classes:

- 21 07 00 - Fire Suppression Insulation
 - 21 07 16 - Fire Suppression Equipment Insulation
 - 21 07 19 - Fire Suppression Piping Insulation
- 22 07 00 - Plumbing Insulation
 - 21 07 16 - Plumbing Equipment Insulation
 - 21 07 19 - Plumbing Piping Insulation
- 23 07 00 - HVAC Insulation
 - 21 07 13 - Duct Insulation
 - 21 07 16 - HVAC Equipment Insulation
 - 21 07 19 - HVAC Piping Insulation

When writing a specification for insulation, specifiers have three alternatives:

- Write detailed insulation sections in each Division, one for each type in each application (the 13, 16, and 19 level).
- Write a single specification section at the "00" level, which contains text that applies to all applications within that Division.

- Write a single insulation section for all types and all applications. If this method is chosen, the specifier must choose a number from Division 21, 22, or 23. This section may then be referenced from other Divisions.

In all cases, it is the specifier's responsibility to ensure that appropriate references to the insulation section(s) are contained in other sections.

OmniClass

OmniClass is a classification system for all kinds and varieties of design and construction information. MasterFormat can be used within OmniClass, as Table 22 - Work Results. Where MasterFormat is used to classify "work result" specification sections, OmniClass is used to classify information for all other uses, such as the management of product libraries, cost estimating, human resources, scheduling, project management, etc.

A summary of OmniClass tables is provided, along with a short description of its application to the insulation industry. Complete descriptions of the contents of these tables can be found in the OmniClass 2004 standard.

- Table 11 - Construction Entities by Function
- Table 12 - Construction Entities by Form
- Table 13 - Spaces by Function
- Table 14 - Spaces by Form

- Table 21 - Elements (Including Designed Elements): Insulation is represented here in a generic context as a medium for containing heat transfer.
- Table 22 - Work Results: Insulation is represented here in "work result" specification sections, organized to MasterFormat 2004 numbering.
- Table 23 - Products: Insulation is represented here as single manufactured products, some of which may have multiple uses.

- Table 31 - Phases
- Table 32 - Services: This table provides a place for the services (labour) required to install insulation for mechanical ducts and piping.
- Table 33 - Disciplines: Mechanical contractors will have a place in this table, or more specifically, insulation contractors as a sub-type of mechanical.
- Table 34 - Organizational Roles
- Table 35 - Process Aids
- Table 41 - Information

- Table 42 - Materials: This table includes generic material types, which may be referenced by other tables. For the insulation industry, "mineral fibre " is an example of an "insulating" material. Materials are normally used in the construction of items found in the "Products" table (such as insulation).
- Table 49 - Properties: Properties are ways to quantify items in any of the other tables. For example, "thermal resistivity" and "thickness" are both properties of insulation.

SPECIFYING WITH TIAC MECHANICAL INSULATION BEST PRACTICES GUIDE

The use of the TIAC Mechanical insulation best practices guide specification code numbers implies acceptance of the best practices covered by such numbers in the guide and any required additions, deletions or modifications to these Mechanical insulation best practices must be clearly stated in the project specification by the specifier.

Where required to state the insulation type in the specification, only the material code number and generic term heading as listed in the Mechanical insulation best practices guide Manual need be stated. The Contractor will have the option to use any one of the approved products listed in the TIAC Mechanical insulation best practices guide under a particular insulation heading. If the specifier wishes to use one particular product from those listed in the Mechanical insulation best practices guide, then the product name must be stated in lieu of the generic insulation type.

It is recommended that the suggested examples be used with the generic insulation type only being stated, as all manufacturers products listed have been accepted by TIAC as suitable for the intended application, within the limits established in the Mechanical insulation best practices guide. This option applies also to all other listed products in the Mechanical insulation best practices guide and unless noted otherwise in the project specification, any one of the listed products for the intended application or finish may be used by the Contractor.

SPECIFICATION EXAMPLES

The following specification examples are divided into three types to correspond to the three types of these Mechanical insulation best practices guide, i.e. Piping, Ductwork and Plenum, and Equipment.

It is recommended that the three types of specifications be incorporated into the project specifications as recommended in this manual. If required, each type may be incorporated individually into the applicable section of the project specifications, i.e. Plumbing, or Heating, Ventilating and Air Conditioning (HVAC), or Equipment. However, the Quality Assurance clause must be included with each type if used within separate sections of the project specifications. Examples of complete master specification sections have been included in [Section 15](#) of this manual.

It should be noted that only representative examples have been included under the headings in each of the three types of specification examples. All additional items required to be insulated in a particular project, together with the necessary insulation thicknesses, must be included under the appropriate heading by the specifier.

8.1 QUALITY ASSURANCE - STANDARD SPECIFICATIONS.

- 1 The Thermal Insulation Association of Canada (TIAC) Mechanical Insulation best practices guide, together with authorized additions and amendments, shall be used as a reference standard and shall form part of this project specification.
- 2 The Contractor responsible for mechanical insulation installation work shall keep a copy of the above Mechanical insulation best practices guide available for reference.
- 3 Specification code numbers quoted shall be taken to refer to that particular specification in the TIAC guide, with exceptions only as specified herein.
- 4 Where modifications to the TIAC Mechanical insulation best practices guide are included in the project specification, then such modifications shall govern in case of conflict.

8.2 INSULATION - PIPING

Provide and apply piping insulation in accordance with TIAC Mechanical insulation best practices guide Specification 1501, Piping, as hereinafter specified and/or modified.

1 Scope - Hot Piping

- Hot Water Heating: A.1 - Mineral Fibre (low and medium temperature), 25mm thick. **(EXAMPLE ONLY)**
- Domestic Hot Water, Including Recirculation: [] (No. and type), [] mm thick.
- Steam Piping: [] (No. and type), [] mm thick.
- Condensate Piping: [] (No. and type), [] mm thick.
- []:[] (No. and type), [] mm thick

Spec. Note: State insulation type required for each scope item, from Group A on Page 1 and 2 of Section 4 - Products. Insert insulation thickness required for each scope item. Add other scope items as required. If closed cell insulation is selected for any of the above scope items then, because of different k factors, state also the specific trade name of the product required.

2 Scope - Cold Piping

- Primary Chilled Water Piping: - Mineral Fibre (low and medium temperature), 25mm thick. **(EXAMPLE ONLY)**
- Secondary Chilled Water Piping: [] (No. and type), [] mm thick
- Domestic Cold Water Piping: [] (No. and type), [] mm thick.
- Interior Rainwater Leaders: [] (No. and type), [] mm thick
- []:[] (No. and type), [] mm thick.

Spec. Note: State insulation number and type required for each scope item, from Group A on Page 1 and 2 of Section 4 - Products. Insert insulation thickness required for each scope item. Add other scope items as required. If closed cell insulation is selected for any of the above scope items then, because of different k factors, state also the specific trade name of the product required.

For induction unit run-outs use TIAC Specification 1501-CA with flexible foamed elastomeric insulation, _____ mm thick.

Spec Note: Insert thickness required.

3 Scope - Underground Piping Insulation

Underground piping insulation to be [_____]. Install in accordance with manufacturer's directions.

Spec. Note: State exact product trade name required, from Group B, Page 2 of Section 4 - Products.

4 Application - Hot Piping

Apply insulation to hot piping in accordance with TIAC Specification 1501-H (1501-HA).

Spec Note: Delete 1501-HA if not applicable.

Include insulation on valve bodies, strainers and flanges in accordance with TIAC Specification 1501-H.

Spec. Note: Include in project specification only if required.

5 Application - Cold Piping

Apply insulation to cold piping in accordance with TIAC Specification 1501-C (1501-CA)

Spec. Note: Delete 1501-CA if not applicable.

Include insulation on valve bodies, valve bonnets, strainers and flanges in accordance with TIAC Specification 1501-C.

Spec. Note: Include in project specification only if required.

6 Finishes

- Concealed Piping: No further finish required.

- Exposed Piping: Apply finishes as follows:

Hot Water Heating: ONLY)	TIAC CPF/1 Indoor (EXAMPLE
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Domestic Hot Water:	[_____] finish
---------------------	----------------

Steam Piping:	[_____] finish
---------------	----------------

Condensate Piping:	[] finish
[]:	[] finish
Primary Chilled Water: ONLY)	TIAC CPF/1 Indoor (EXAMPLE
Secondary Chilled Water:	[] finish
Domestic Cold Water:	[] finish
Interior Rainwater:	[] finish
[]:	[] finish

Spec Note: Select finish from TIAC CPF/1 to CPF/5 as listed on Page CP-5 and CP-6. Include finish for each scope item as required. Add other scope items as required.

8.3 INSULATION - DUCTWORK AND PLENUM

Provide and apply insulation to ductwork and plenums in accordance with TIAC Mechanical insulation best practices guide Specification 1502, Ductwork and Plenum, as hereinafter specified and/or modified.

1 Scope - Externally Applied

- Outside Air Ductwork (Intake to Mixing Plenum): [] mm thick, - rigid insulation (with vapour retarder)
- Sheet Metal Air Conditioning Supply Air Ductwork: [] mm thick, [] mm thick, rigid insulation (with vapour retarder) where exposed. [] mm thick, - flexible insulation (with vapour retarder) where concealed.
- []

Spec Note: Insert required thickness. Add other scope items as required.

2 Scope - Internally Applied

- Rigid Duct Liner: Mixed air plenum [] mm thick.
- Rigid Duct Liner: Filter/Coil plenum [] mm thick
- Rigid Duct Liner: Fan plenum [] mm thick.
- []

Spec. Note: Insert required thickness for each scope item. Add other scope items as required.

Acoustic lining, where indicated or denoted as such on the drawings, use xx mm thick flexible duct liner.

Spec Note: Delete if not applicable. Insert thickness required.

3 Application - Rigid External (Duct and Plenum)

- Hot: Apply insulation in accordance with TIAC Specification CER/1.
- Cold: Apply insulation in accordance with TIAC Specification CER/2.

Spec Note: Delete item not applicable.

4 Application - flexible external (Duct and Plenum)

- Hot: Apply insulation in accordance with TIAC Specification CEF/1.
- Cold: Apply insulation in accordance with TIAC Specification CEF/2.

Spec Note: Delete item not applicable.

5 Application - Liner Internal (Duct)

- Rigid: Apply insulation in accordance with TIAC Specification CIR/1.
- Flexible: Apply insulation in accordance with TIAC Specification CIF/1.

Spec Note: Delete items not applicable.

6 Finishes - Rectangular Ducts

- Concealed Ducts: No further finish required.
- Exposed Ducts: Apply TIAC CRF/1 - Indoor (CRF/2 - Indoor) (CRF/3 - Outdoor) (CRF/4 - Outdoor)

Spec Note: Select finish required. Delete finishes not applicable. Include finish for additional scope items as required.

7 Finishes - Round Ducts

- Concealed Ducts: No further finish required.
- Exposed Ducts: Apply TIAC CRD/1 - Indoor (CRD/2 - Indoor) (CRD/3 - Indoor) (CRD/4 - Outdoor) (CRD/5 - Outdoor).

Spec. Note: Select finish required. Delete finishes not applicable. Include finish for additional scope items as required.

8.4 INSULATION - EQUIPMENT

Provide and apply insulation to equipment in accordance with TIAC Mechanical insulation best practices guide Specification 1503, Equipment, as hereinafter specified and/or modified.

1 Scope - Hot Tanks and Equipment

- Breeching: - Calcium Silicate (high temperature), 50 mm thick, (**EXAMPLE ONLY**)
- Heating Converters: [] (No. and type), [] mm thick.
- Domestic Hot Water Storage Tanks: [] (No. and type), [] mm thick.
- Condensate Receivers: [] (No. and type), [] mm thick.
- : (No. and type), mm thick.

Spec Note: State insulation type required for each scope item, from Group A or B, Page 1 of Section 4 - Products. Insert insulation thickness required for each scope item. Add other scope items as required. If closed cell insulation is selected for any of the above scope items then, because of different k factors, state also the specific trade name of the product required.

2 Scope - Cold Tanks and Equipment

- Chilled Water Expansion Tanks: - Flexible Foamed Elastomeric, 25mm thick. (**EXAMPLE ONLY**)
- Chilled Water Pumps: [] (No. and type), [] mm thick.
- Absorption Chillers: [] (No. and type), [] mm thick.
- []: [] (No. and type), [] mm thick.

Spec Note: State insulation number and type required for each scope item, from Group A on Page 1 of Section 4 - Products. Insert insulation thickness required for each scope item. Add other scope items as required. If closed cell insulation is selected for any of the above scope items then, because of different k factors, state also the specific trade name of the product required.

3 Application - Tanks, Breechings and Equipment

- Hot: Apply insulation in accordance with TIAC Specification 1503-H.
- Cold: Apply insulation in accordance with TIAC Specification 1503-C.

Spec. Note: Delete item not applicable.

Chillers shall be insulated in accordance with manufacturer's directions.

Spec Note: Delete if not applicable.

4 Finishes

- | | |
|---------------------|----------------------------------|
| Breeching: | TIAC CEF/1 Indoor (EXAMPLE ONLY) |
| Heating Converters: | [] finish |
| Domestic Hot Water: | [] finish |

Storage Tanks

[] finish

[]:

[] finish

Spec Note: Select finish from TIAC CEF/1 to CEF/3 as listed on Page CE-2. Include finish for each scope item as required. Add other scope items as required.

**SECTION 9: FIRESTOPPING, SMOKE SEALS AND AIR
BARRIERS**

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SECTION 9

FIRESTOPPING, SMOKE SEALS AND AIR BARRIERS

OVERVIEW: FIRESTOPPING AND SMOKE SEALS

It is critical that the compartmentalization of a structure -- created by the use of fire rated floor, wall and ceiling assemblies -- be maintained in order to reduce the severity of a fire and the passage of developing smoke and gases to ensure safety to both life and property.

When penetrations are created for building services, within a fire rated floor, wall or roof assembly it becomes critical to seal these penetrations to a rating equivalent to the fire resistance rating of the assembly. This design approach will assist in confining a fire to its origin, thereby giving the building's suppression system of firefighters a better chance to control it before the entire structure becomes involved.

The Standards Council of Canada has adopted criteria for minimum test procedures and performance standards resulting in acceptable test methods and standards in Canada. The acceptable test method in Canada is CAN/ULC-S101-04 ("Standard Methods of Fire Endurance Tests of Building Construction and Materials"). The acceptable test standard in Canada is ULC-S115-1995(R2001) "Fire Tests of Firestop Systems". Both have been included into the National Building Code. Only testing agencies with Standards Council of Canada (SCC) accreditation are considered acceptable testing laboratories.

In Canada, building codes address this issue. National Building Code of Canada (NBC) - Building Services in Fire Separations and Fire Rated Assemblies - Fire Stopping of Service Penetrations.

These subsections specify requirements for the use of "tested" fire stop materials for sealing building services which penetrate a fire separation or an assembly required to have a fire resistance rating.

Service penetration assemblies are assigned a fire rating when tested in accordance with the Fire Tests of Firestop Systems, ULC-S115. These firestop assemblies are intended for use in openings in fire resistive wall and/or floor assemblies which are evaluated in accordance with CAN/ULC-S101.

Under ULC-S115, ratings may be established for each firestop assembly (F, FT, FH and FTH). An "F" rating is based upon flame occurrence on the unexposed surface. An "FT" rating is based upon temperature rise criteria as well as flame occurrence on the unexposed surface. When a test sample is also subjected to a hose stream test, "FH" and "FTH" ratings may be established. An "FH" rating is based upon flame occurrence on the unexposed surface and acceptable performance during the hose stream test. An "FTH" rating is based upon a temperature rise criterion, flame occurrence on the unexposed surface and acceptable performance during the hose stream test. The rating of a firestop system applies to its use in the specific assembly of materials, penetrations, annular spaces and floor or walls in which it was tested.

Under building code requirements where piping or ductwork penetrates a fire rated wall or floor assembly, the joint between the fire assembly construction and piping or ducts must be sealed with a fire tested and rated firestopping and smoke seal materials to prevent the passage of smoke and flame through such joints. Such firestopping materials shall consist of material that will remain in place and prevent the passage of flame and smoke when subjected to the standard fire exposure in CAN/ULC-S101, for a period of time equal to the

protection rating required for the grade of fire separation.

Under ULC-S115 this is classified as an "F" rating.

The ULC-S115 definition of temperature rise ("T" rating) for firestopping materials can be briefly defined as "the unexposed surfaces of firestop materials or penetrating items shall not have a measured temperature rise greater than 180°C for the duration of the hourly time/temperature rating." Firestopping materials conforming to both flame rating ("F" rating) and temperature rating ("FT" rating) under ULC-S115 are classified as having an "FT" rating.

A firestopping system should not only conform to the relevant flame rating, but equally important it should have a hose stream test rating ("H" rating) to prevent passage of gases or water. In some instances a temperature rise ("T" rating) may be required to prevent the ignition of highly combustible materials which may be stored within close proximity to the unexposed side of the firestopping.

In order to provide a specifier with accurate and concise specifications which conform to building code requirements, a suggested single source specification for firestopping and smoke seals has been developed for TIAC for incorporation by a specifying authority in the project specifications.

It is recommended that this single source specification be incorporated in the project specifications under a separate section under Section [07840] [07 84 00] (Refer to Section 15 of this manual for a master specification)

OVERVIEW: AIR BARRIERS

An air barrier is required by the building code as a requirement to contain an interior controlled environment. Refer to an "Air Barrier" definition in the Glossary in Section 17. Air barriers are different than vapour retarders in that an air barrier is to stop air infiltration or exfiltration whereas a vapour retarder is to slow down or arrest moisture movement through building enclosure materials. At any location in the building's enclosure, an air barrier seal is subjected to a variety of pressures and suction. The point at which these imposed loads on an air barrier are at their highest level, is usually at the upper-most part of the enclosure during the winter and at the lower-most part in the summer. Most vapour retarder materials will not contain those pressures – therefore an air barrier seal is required.

There are occasions where piping, conduit or ducting penetrates the contained building envelope. Those components are usually insulated and wrapped or covered, up to the point of a penetration. At that juncture, the component must be air sealed in conjunction with the building's air barrier seal. The objective is to eliminate air leakage in either direction.

Air barrier criteria and requirements are usually specified in a specification section located in MasterFormat Division 08. If a fire stop is required to seal a roof assembly penetration (perhaps a rated roof assembly) by pipe, conduit, or a duct, then a specifier will usually specify a firestopping seal material that will also function as an air barrier seal. That material or product may appear in a Division 07 section (within an Air Barrier section) or in a Division 08 (Sealant) section.

9.1 MATERIALS

The following list contains manufacturer's firestopping and smoke seal materials in regular supply which have been fire tested and rated as required by the building code.

These materials are listed for information only and their suitability for the intended application and the acceptability by local authorities having jurisdiction should be confirmed by a specifying authority. In addition, the prices for such firestopping materials vary by manufacturer and such prices should be checked with the manufacturer or the distributor by a specifier.

All firestopping materials proposed to be used must conform to ULC-S115 and CAN/ULC-S101. The acceptability of ULI (USA) or by ULC by local authorities having jurisdiction, should be confirmed by the Contractor to ensure that the test procedures were performed to ULC-S115 and CAN/ULC-S101.

Dow Corning Corporation

Tremco Ltd.

Firestop Systems Inc.

General Electric Canada Inc.

The materials used in firestop assemblies must be the exact material tested and listed by the certifying agency and bear that agency's certification mark (i.e. Warnock Hersey or ULC).

Air barrier materials cover a very wide range and selection. Usually the density of the material determines its acceptability as an air seal (non-porous) – such as cast-in-place concrete, cementitious mortars, sheet metal, sheet glass, gypsum board, certain sealants, and yes, a few firestopping materials. Certain thick and viscous materials can function as both a firestopping and an air barrier material – providing this material will not flow under prevailing pressure/suction conditions.

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SECTION 10

INDUSTRIAL PIPING

10.1 APPLICATION

A. HOT PIPING

Specification
Code No.

1601-H Hot Application

- Piping: Single layer pipe covering without integral jacket shall be held in place with wire for pipe 300 mm diameter or less and banding and wing seals on larger pipe. Double layer staggered joint pipe covering without integral jacket shall have the first layer held in place with wire and the outer layer held in place with banding and wing seals.

-Fittings: Insulate fittings 75mm diameter and less with insulating cement or flexible insulation secured in place with 1.62 mm stainless steel wire and finished with insulating cement to thickness of adjacent pipe covering. Insulate fittings over 75 mm diameter with sections of pipe covering mitred to fit tightly with each mitred section secured in place with a minimum of one loop of 1.62 mm stainless steel wire. All voids and cracks to be filled with insulating cement.

-Valves, Flanges: Insulate valve bodies and flanges with fitted oversized pipe covering, or mitred blocks to thickness of adjacent pipe covering. Expansion joints, steam trap assemblies, unions, slag pocket drain piping & valves, safety relief valves and orifice flanges shall be left uncovered. **(See Note 1)**.

- Insulation Termination Points: Insulation shall be terminated 75 mm from fittings to provide working clearance, and bevel insulation at a 45 degree angle.

Note 1: The use of this code number does not include insulation application on valves and flanges. The specifying authority must specify in the project specification, if valves and flanges are to be insulated.

B. ANTI SWEAT PIPING

Specification
Code No.

1601-A Anti Sweat Application

- Piping: Apply pipe covering with integral vapour retarder jacket to piping and hold in place by securing the jacket flap with staples on 75 mm centres. Pipe covering with integral self-sealing jacket will not require additional fastening. Seal all flaps and butt strips with vapour retarder adhesive or alternatively secure with staples and cover with a heavy brush coat of retarder coating.

- Fittings: Insulate fittings 75 mm diameter and less with flexible insulation secured in place with 1.62 mm stainless steel wire and finish with reinforcing membrane embedded in a heavy brush coat of retarder coating. Insulate fittings

over 75 mm diameter with sections of pipe covering mitred to fit tightly with each mitred section secured in place with a minimum of one loop of 1.62 mm stainless steel wire. All voids and cracks to be filled with insulating cement, then cover the entire fitting with reinforcing membrane embedded in a heavy brush coat of retarder coating.

- Valves, Flanges: Insulate valve bodies and flanges with fitted over sized pipe covering, or mitred blocks to thickness of adjacent pipe covering, then apply reinforcing membrane embedded in retarder coating. Alternatively, insulate with tightly placed flexible insulation covered with reinforcing membrane, stapled in place and covered with a retarder coating. Drains, blow-off plugs and caps shall be left uncovered. **(See Note 1)**.

Note 1: The use of this code number does not include insulation application on valve bodies, valve bonnets, strainers or flanges. However, it is recommended that valve bodies, valve bonnets, strainers and flanges be insulated. A specifier must include in the project specifications if valve bodies, valve bonnets, strainers or flanges are to be insulated.

C. COLD PIPING

Specification Code No.

1601-C Cold Piping Application (Closed Cell Material)

- Piping: Apply single layer pipe covering to piping (cellular glass insulation to firstly have been prepared with a layer of bore coating in areas of vibration) with all joints coated with a layer of manufacturers approved retarder coating and held in place with 12 mm wide reinforced filament tape at approximately 150 mm centres for piping under 100 mm or secured with banding and wing seals located on 225 mm centres for piping over 100 mm size. Over the insulation apply a vapour retarder jacket recommended by the insulation manufacturer or apply a heavy brush layer of vapour retarder coating at the rate of 1.2 L/square metre, embed a layer of reinforcing membrane and then apply another heavy brush layer of vapour retarder coating at the rate of 1.0 L/square metre. Multiple layer staggered joint pipe covering shall have the first layers (cellular glass insulation to firstly have been prepared with a layer of bore coating in areas of vibrations) with all joints coated with a layer of manufacturers approved retarder coating and inner layers for piping 200 mm and under held in place with 12 mm wide reinforced filament tape tightly spiral wrapped at approximately 75 mm centres or banded with 0.40 mm thick by 12 mm wide stainless steel banding and wing seals located on 300 m centres for piping over 200 mm. The outer layer shall be secured with 0.40 mm by 12 mm wide stainless steel banding and wing seals. Over the insulation apply a vapour retarder jacket as recommended by the manufacturer or apply a heavy brush layer of vapour retarder coating at the rate of 1.2 L/square metre, embed a layer of reinforcing membrane and then apply another heavy brush layer of vapour retarder coating at the rate of 1.0 L/square metre.

- Fittings: Insulate fittings with sections of pipe covering mitred to fit tightly or pre-moulded fitting covers, with each mitred section or cover secured in place with a minimum of one loop of 12 mm wide reinforced filament tape and all joints shall be sealed with a heavy brush coat of manufacturers approved vapour retarder. Over the insulation apply a heavy brush layer of vapour retarder coating at the rate of 1.2 L/square metre, embed a layer of reinforcing membrane and then

apply another heavy brush layer of vapour retarder coating at the rate of 1.0 L/square metre.

- Valves, Flanges: Insulate valve bodies, valve bonnets, and flanges with fitted over sized pipe covering or mitred blocks to thickness of adjacent pipe covering with all joints sealed with a heavy brush coat of manufacturers approved vapour retarder. Over the insulation apply a heavy brush layer of vapour retarder coating at the rate of 1.2 L/square meter, embed a layer of reinforcing membrane and then apply another heavy brush layer of vapour retarder coating at the rate of 1.0 L/square metre.

Note: On straight runs of pipe over 15 m and every 15 m, an expansion joint of flexible insulation 50 mm wide to the thickness of the pipe covering shall be installed and finished with the same vapour retarder coating as the piping.

10.2 FINISHES

Application Code No.

IPF-1 Piping:

Over the insulation apply metal jacket with 50 mm circumferential and 50 mm longitudinal laps placed against the weather and shall be secured with banding with wing seals or screws. Vertical or inclined lines shall have S-clips installed every 10 m to prevent slipping.

Elbows: Shall be finished with pre-formed covers or field fabricated gore type fitting covers made in a first quality workmanship manner and secured with stainless steel sheet metal screws.

Fittings, Valves, Flanges: Shall be finished with field fabricated fitting covers and secured with stainless steel screws and/or stainless steel banding and wing seal

Note 1: The specifying authority must specify in the project specifications if removable valve or flange covers are required.

10.3 PIPING FORMAT

A. PIPE INSULATION

- Mineral Fibre - Low & Medium Temperature
- Mineral Fibre - Low & Material Temperature
- Calcium Silicate - High Temperature
- Mineral Fibre - High Temperature
- Mineral Fibre - High Temperature
- Polyisocyanurate
- Cellular Glass

Perlite

B. PIPE INSULATION

The following systems shall be insulated:

System Material Thickness

- 1.
- 2.
- 3.
- 4.

C. INSULATION ATTACHMENT

Material Size Spacing

- Galvanized Wire 18 Gauge 150 mm on centre
- Stainless Steel Wire 16 gauge 225 mm on centre
- Aluminum Band 14 gauge 300 mm on centre
- Stainless Steel Band 12mm x .38 mm
- Filament Tape 12 mm x .50 mm
- Wing Seals
- Closed Seals

D. INSULATION FINISHES

Material Thickness Material Form

- Aluminum Plain 0.250 mm Smooth
- Acrylic 0.400 mm Stucco Embossed
- Stainless Steel 0.500 mm Corrugated
- Type 316 Type 304
- Glass fabric and mastic

E. INSULATION FINISH ATTACHMENT

Material Size Spacing

- Stainless Steel Screws 12 mm x #8 150 mm on centre
- Stainless Steel Bands 12 mm x 0.38 mm 225 mm on centre

Wing Seals 12 mm x 0.50mm 300 mm on centre

Closed Seals

F. GENERAL

Removable Valve Covers

Removable Flange Covers

Valves and Strainers

Valve Bonnets

Flanges

10.4 GENERAL

1. The application of insulation shall not begin prior to testing. Should it become necessary to commence work prior to such testing, written permission shall be given by the project manager, engineer or superintendent.
2. If direction is given to commence work prior to the testing, all welds, threads, unions, fittings and flanged joints shall be left uncovered until such tests are completed.
3. All instrument assemblies requiring insulation and attached to insulated piping shall be insulated for the operating temperature of the piping to which it is attached using the insulation thicknesses required in the specification if the work is listed in the project specification.
4. There shall be sufficient clearance between insulation surfaces and any obstruction such as stairs, platforms, railings or other piping to allow for the insulation and for normal operational movements.
5. Piping insulated for personnel protection shall be determined on site by the owners representative and paid for on a unit price basis, work order or other arranged method.
6. Insulation shall be protected as best possible from the weather prior to and during application.
7. Insulation shall be applied with all joints fitted to eliminate voids. All voids or open cracks shall be filled in an acceptable manner.
8. Hot piping over 300 C insulated for heat conservation or when insulation thickness is greater than 75 mm thick, the insulation shall be applied using double layer construction with all joints staggered.
9. Cold piping insulation greater than 75 mm thick shall be applied using double layer construction with all joints staggered.
10. Tracer leads, drains and loops that are to be insulated shall be paid for on a unit price basis, work order or other arranged method.

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SECTION 11

INDUSTRIAL EQUIPMENT

11.1 APPLICATION

A. HOT EQUIPMENT

Specification
Code No.

1701-H - Apply insulation to sidewalls, breechings, etc. in block form applied to equipment with wire, stud, or strap fastening. The insulation shall be fabricated using bevelled lags or curved pre-formed segments and shall be installed in such a manner as to closely fit the equipment contours without voids. Equipment operating below 300 C shall have single layer construction and equipment operating at 300 C or greater or when insulation thickness is greater than 75 mm it shall be insulated in double layer construction with all joints staggered.

1702-H - Apply insulation to heads, transitions, tapers, etc. in block form applied to equipment with wire, stud, or strap attached to float rings or anchor rings. The spacing of wire, stud or strap at rings shall not exceed 300 mm on centres. The insulation shall be cut to fit snugly with all joints butted together and bevelled to prevent "V" shaped voids between pieces. Equipment operating below 300 C shall have single layer construction and equipment operating at 300 C or greater or when insulation thickness is greater than 75 mm it shall be insulated in double layer construction with all joints staggered.

B. COLD EQUIPMENT

Specification
Code No.

1703-C - Apply insulation to sidewalls in block form to equipment with wire or strap fastenings. The insulation shall be fabricated using bevelled lags or curved preformed segments and shall be installed in such a manner as to closely fit the equipment contours without voids. Equipment operating below +2 C shall have single layer construction and equipment operating below -20 C or when insulation thickness is greater than 50 mm, it shall be insulated in double layer construction with all joints staggered. The entire surface shall be given a coating of vapour retarder coating at the rate of coverage as recommended by the manufacturer, embed a layer of reinforcing membrane and then apply a second coat of vapour retarder coating at the rate of coverage as recommended by the manufacturer.

Equipment operating below -30 C shall have all support saddles, skirts, etc. insulated for a distance of four (4) times the insulation thickness from the equipment.

1704-C - Apply insulation to heads, transitions, tapers, etc. in block form applied to equipment with wire, stud or strap attached to float rings or anchor rings. The spacing of wire or strap at rings shall not exceed 300 mm on centres. The insulation shall be cut to fit snugly with all joints butted together and bevelled to prevent "V" shaped voids between pieces. Equipment operating below +2 C shall have single layer construction and equipment operating below -20 C or when insulation thickness is greater than 50mm, it shall be insulated in double layer construction with all joints staggered. The entire surface shall be given a coat of vapour retarder coating at the

rate of coverage as recommended by the manufacturer, embed a layer of reinforcing membrane and then apply a second coat of vapour retarder coating at the rate of coverage as recommended by the manufacturer.

NOTE: Insulated tanks or vessels that are set on a concrete slab, the first 300mm of insulation shall be closed cell imbedded in mastic.

11.2 FINISHES

Application Code No.

IEF-1 Where corrugated metal is specified in the equipment finish format, all vertical seams shall be lapped a minimum of 75 mm and shall be secured with specified bands. All horizontal seams shall be lapped a minimum of 50 mm. Two "S" clips per sheet to be installed to support sheets on the circumferential laps. (Do not install "S" clips at corners of sheets where they overlap.) Equipment over 2 m in diameter shall have an expansion spring in each securing band for equipment operating at over 200 C and two expansion springs spaced at 180 degrees apart if operating at over 400 C. All metal shall be cut to fit snugly around nozzles, man-ways, platform supports, etc. and shall be flashed with an approved sealing compound.

IEF-2 Where smooth metal is specified in the equipment finish format for horizontal vessels, and equipment heads the metal shall be lapped a minimum of 75 mm on all joints for horizontal equipment and secured with specified bands. Orange peel sections shall be applied to heads with overlaps placed to shed water and shall be secured with sheet metal screws or pop rivets 100 mm on centres. The orange peel sections shall overlap shell jacket approximately 100 mm. Metal jackets are not required on bottom heads of vertical vessels inside skirts.

IEF-3 Irregular surfaced equipment such as pumps and compressors shall be finished with insulating cement embedded on a layer of reinforcing mesh followed by a second layer of insulating cement trowelled smooth. Over the cement apply a brush coat of mastic weather coating at the rate of 1.2 L/square metre, embed a layer of reinforcing membrane and then apply another brush coat of mastic weather coat at the rate of 1.0 L/square metre.

11.3 EQUIPMENT FORMAT

A. EQUIPMENT INSULATION

- Mineral Fibre - Low and Medium Temperature
- Mineral Fibre - Low and Medium Temperature
- Calcium Silicate - High Temperature
- Mineral Fibre - High Temperature
- Mineral Fibre - High Temperature
- Polyisocyanurate
- Cellular Glass

Perlite

B. EQUIPMENT INSULATION

The following equipment shall be insulated.

<u>Equipment</u>	<u>Material</u>	<u>Thickness</u>
1.		
2.		
3.		

C. INSULATION ATTACHMENT

<u>Material</u>	<u>Size</u>	<u>Spacing</u>
<input type="checkbox"/> Galvanized Wire	<input type="checkbox"/> 18 gauge	<input type="checkbox"/> 300 mm on centre
<input type="checkbox"/> Stainless Steel Wire	<input type="checkbox"/> 16 gauge	<input type="checkbox"/> 450 mm on centre
<input type="checkbox"/> Stainless Steel Band	<input type="checkbox"/> 14 gauge	<input type="checkbox"/> 600 mm on centre
<input type="checkbox"/> Wing Seals	<input type="checkbox"/> 12 mm x 0.38 mm	
<input type="checkbox"/> Closed Seals	<input type="checkbox"/> 18 mm x 0.50 mm	

D. INSULATION FINISH

Material Thickness Form

<input type="checkbox"/> Aluminum	<input type="checkbox"/> 0.250 mm	<input type="checkbox"/> Smooth
<input type="checkbox"/> Plain	<input type="checkbox"/> 0.400 mm	<input type="checkbox"/> Corrugated
<input type="checkbox"/> Acrylic	<input type="checkbox"/> 0.500 mm	<input type="checkbox"/> Stucco Embossed
	<input type="checkbox"/> 0.600 mm	
<input type="checkbox"/> Stainless Steel		
<input type="checkbox"/> Type 304		
<input type="checkbox"/> Type 316		
<input type="checkbox"/> Glass fabric and Mastic		

E. INSULATION FINISH ATTACHMENT

Material Size Spacing

<input type="checkbox"/> Stainless Steel Screws	<input type="checkbox"/> 12mm x #8	<input type="checkbox"/> 300mm centres
-------------------------------------------------	------------------------------------	----------------------------------------

- | | | |
|------------------------------------------------|-----------------------------------------|-----------------------------------------|
| <input type="checkbox"/> Stainless Steel Bands | <input type="checkbox"/> 12 mm x 0.38mm | <input type="checkbox"/> 450 mm centres |
| <input type="checkbox"/> Wing Seals | <input type="checkbox"/> 19 mm x 0.50mm | <input type="checkbox"/> 600 mm centres |
| <input type="checkbox"/> Closed Seals | | |

SECTION 12: DENIS FORMULA - REV #4 - METRIC

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SECTION 12

DENIS FORMULA - REVISION #4 - METRIC

12.1 OVERVIEW: DENIS FORMULA

James S. Denis, President of MHG International Inc. based in Calgary, Alberta, first introduced the proposed "Standard Method of Measurement", May 1980 to a World Insulation and Acoustic Congress (W.I.A.C.O.) held in Paris, France.

Later in 1980, the 'Denis Formula' was introduced to major clients in the petro-chemical industry. It quickly gained approval and acceptance as 'fair' to both client and contractor. It is now widely used on industrial projects. Quite apart from the obvious benefit of having one standard method of measurement for the industry, the formula, with ever increasing acceptance and usage, brings economic benefits to the owner.

By identifying and defining the 'labour' intensive portions of the work, with factors to compensate for same, the formula has the balancing effect of reducing 'unit prices'. The prices more properly are based on the straight work where previously they had built-in difficulty factors at time of tendering.

Use of the standard method of measurement (Denis Formula) has eliminated most of the guesswork.

The end result is beneficial to both the owner/client and the insulation contractor. By use of the formula the parties simplify the process of determining the final quantities and value of the work with strict control over the method.

12.2 STANDARD METHOD OF MEASUREMENT FOR INSTALLED INDUSTRIAL INSULATION

These standards are to be used for the express purpose of measuring the quantities of insulation required for a mechanical system. They can be used for tendering, evaluation of bids, and for finalizing accounts.

SCOPE

1. Insulation of mechanical systems including, but not limited to, vessels, equipment, exchangers, pumps, tanks, ducts or flues and pipe work.
2. All measurements shall be taken on the external surface of the insulation system.
3. There shall be no deductions for surfaces not insulated within the specified insulation area. Exceptions to this rule may be negotiated where termination of insulation does not require a finish or weatherproofing and/or where the uninsulated portion is more than 5% of the total.
4. Irregular shapes, fittings on piping systems, valves, etc., shall be counted separately. The conversion tables of the formula are designed to include for general requirements. Conversion factors for unusual items, e.g. seismological anchor or hangers, shall be negotiated by the parties prior to commencing the work.

5. All obstructions and penetrations of the insulation system shall be measured separately.
6. All effected areas and pipe lengths shall be multiplied by the complete applicable unit prices.

DEFINITIONS

Types of insulation: hot, anti-condensation, cryogenic, acoustic, fireproofing.

General description of items to be insulated:

(a) Vessels

Towers, columns, drums, containers, receivers, exchangers, storage tanks, etc.

(b) Equipment

Equipment which has an irregular outer surface, e.g. transitions, stiffeners, heads, roof ends, turbines, pumps, compressors, air or gas handling fans, etc.

(c) Flat Surfaces

Boiler walls, precipitators, hoppers, ducts & flues, storage bins, etc.

(d) Piping

Straight pipes, bends, elbows, accessories, fittings, valves, flanges, strainers, termination points, bevels, etc.

(e) Instruments

Measuring and controlling devices for process requirements.

(f) Height allowances

Standards, see page DF-6.

PRINCIPALS OF MEASURING EQUIPMENT

Shell - Cylindrical

The outside diameter of the vessel plus two times the insulation thickness multiplied by 3.14 and by the length, tangent line to tangent line, as illustrated in diagram. Transition sections (changes in diameter) shall be measured using the larger diameter, times the length. There shall be no deductions for manholes and any other interruption or projection, whether insulated or not.

Irregular Surfaces

Any irregular shape shall be measured on the outside of the insulation surface, using the largest diameter. The surface area for irregular surfaces to be multiplied by a correction factor of 1.75 to obtain the equivalent area of flat surface. For small pumps, turbines, etc. the minimum equivalent area of measurement shall be 1 sq. meter.

Heads, Roofs, Ends

Flat: The surface area with diameter outside of the vessel insulation.

Spherical: The surface area of the hemisphere with diameter outside of the vessel insulation.

Dished: The surface area of a flat circle with a diameter outside of the vessel insulation, multiplied by a correction factor of 1.37.

Cones: The geometrical surface area of the cone, measured outside the insulation thickness.

ADDITIONAL MEASUREMENTS

On "Unit Price" contracts, all insulated nozzles and man-ways connecting to a vessel will be measured as pipe run to the vessel wall plus flange. In addition, all nozzles, man-ways, brackets, platform supports, obstructions, and penetrations, shall have their perimeter measured as irregular surface. All penetrations shall be a minimum 0.1 sq. meter per each.

On "Lump Sum" contracts, where like obstructions, penetrations, nozzles, brackets, supports, stiffener rings, etc. have not been shown in detail on bid drawings, they shall be measured, as above, as extra work to the contract.

PRINCIPALS OF MEASURING

PIPING

Pipe shall be measured from center line to center line through all fittings, in accordance with Diagram 'A', Page 10. All fittings will be counted and classified for multiplication by the appropriate factor listed in the "Fitting Factor Tables" Pages 5 to 8. Fittings connecting two or more different sizes of pipe shall be counted as the largest size involved.

Bent Pipe:

Shall be measured on the outside radius of the bend(s),

Traced Piping:

Insulation sized to accommodate tracer(s) shall be measured at the actual size of insulation used.

Tracer loops shall be measured separately.

12.3 CONVERSION TABLES FOR FITTINGS TO BE ADDED TO LINE TOTAL MEASURED THROUGH ALL FITTINGS

45 Elbows

12.5 mm to 65 mm pipe	0.47	lin. meters of same size & thickness
75 mm to 125 mm pipe	0.62	"
150 mm to 200 mm pipe	0.78	"

225 mm to 300 mm pipe	0.93	"
350 mm to 600 mm pipe	1.24	"
625 mm to 750 mm pipe	1.55	"

90 Elbows

12.5 mm to 65 mm pipe	0.62	lin. meters of same size & thickness
75 mm to 125 mm pipe	0.93	"
150 mm to 200 mm pipe	1.24	"
225 mm to 300 mm pipe	1.55	"
350 mm to 600 mm pipe	1.86	"
625 mm to 750 mm pipe	2.17	"

When stainless steel or FRP jacketing is specified, factors for elbows (with stainless steel or FRP covers), multiply the above tables by 2.5

Bent Pipe multiply length by factor of 3 of same size and thickness

Tracer Loops 0.93 lin. meters minimum, per loop at tracer

(Wrapped Insulation) size by 25 mm (nominal) thickness

Flanges (Pair)

- Hot	0.93	lin. meters of same size and thickness
- Cryogenic	2.17	"
- Anti-condensation	1.24	"

Valve Body (screwed)

12.5 mm to 75 mm	0.62	lin. meters of same size & thickness
100 mm to 200 mm	0.93	"
250 mm and over	1.24	"

Valve Body (welded)

12.5 mm to 75 mm	0.93	lin. meters of same size & thickness
100 mm to 200 mm	1.24	"
225 mm to 300 mm	1.55	"
350 mm to 450 mm	1.86	"

500 mm to 600 mm	2.48	"
650 mm to 750 mm	3.10	"
800 mm and over		measured as equipment

Valve Body (flanged)

12.5 mm to 75 mm	0.62	lin. meters of same size & thickness (+ flanges)
100 mm to 200 mm	0.93	"
225 mm to 300 mm	1.24	"
350 mm to 450 mm	1.55	"
500 mm to 600 mm	1.86	"
650 mm to 750 mm	2.48	"
800 mm and over	3.10	"

Valve Body (with bonnet) Use appropriate factors as above.

12.5 mm to 125 mm	And	0.62	lin. meters to factor (+ bonnet flange)
150 mm to 300 mm	"	0.93	"
350 mm to 500 mm	"	1.24	"
550 mm to 750 mm	"	1.55	"
800 mm to 900 mm	"	1.86	"

Tees .62 lin. meters of same size and thickness

Branch Fittings 0.62 lin. meters of same size and thickness

Reducers, Caps and Termination Points 0.47 lin. meters of same size and thickness

***Hangers (hot)** 0.31 lin. meters of same size and thickness

*Including shoe supports and brackets. Excludes guides and anchors.

Hangers(cryogenic/anti-condensation)

0.31 lin. meters of same size and thickness

Removable Covers multiply fitting factors by 2.5, or a price per cover established by tender.

Screwed / FRP Fittings:

Specified flexible insulation, multiply all factors by 2. Specified preformed or rigid insulation multiply all factors by 3.

Vitaulic Fittings:

These fittings require special consideration because of size and complexity. Therefore the conversion table factors are to be multiplied as follows:

45 Elbows Multiply factors 3 times

90 Elbows Multiply factors 3 times

Tees, Fittings:

12.5 mm to 125 mm Multiply factors 3 times

150 mm to 300 mm Multiply factors 5 times

350 mm and over Multiply factors 7 times

Penetrations:

Items which interfere with the insulation system, e.g., conduits, handrails, ancillary hangers, uninsulated pipe or tubing, etc.

Each cut out 0.62 lin. meters of same size and thickness

When penetrations occur at fittings:

Each cut out 0.93 lin. meters of same size and thickness

Obstructions

Where insulation thickness has to be shaved or cut for walls, sleeves, equipment or other interferences:

Multiply the length of interference by factor of 2

HEIGHT ALLOWANCES

Height Factor Above Grade*

- Factor to increase unit price for over 9.2 m height by 10%
- Factor to increase unit price for over 12.2 m height by 20%
- Factor to increase unit price for over 15.3 m height by 30%
- Factor to increase unit price for over 18.3 m height by 40%
- Factor to increase unit price for over 21.4 m height by 50%
- Factor to increase unit price for up to 24.4 m height by 60%
- Factor to increase unit price for over 27.5 m height by 70%
- plus 3% per additional meter of height

*Grade does not include working platforms

HOT WORK: (When insulation applied to line in service above 65°C operating temperature)

12.5 mm to 65 mm pipe	increase labour component by	25%
75 mm to 125 mm pipe	"	35%
150 mm to 200 mm pipe	"	45%
225 mm to 350 mm pipe	"	60%
375 mm to 500 mm pipe	"	75%
over 500 mm pipe	"	100%

If labour component has not been identified apply only 50% of the above to the unit prices. These percentages are to compensate for loss of productivity, however safe working conditions shall take precedent.

Imperial Measurement (Conversion)

For equivalent fitting factors multiply computations by 3.28

12.4 EXAMPLE OF PIPING MEASUREMENTS

Pipe Size	25 mm	750 mm
Spec	Hot	Hot
Length of Pipe	32.9 M	92.1 M
Bent Pipe	-	-
45 Elbow	-	4
90 Elbow	16	3
Flanges (Pair)	-	-
Valves (Weld)	-	1
Valves (Flanged)	-	-
Valves (Bonnet)	-	-
Tees	6	7
Reducers or Caps	3	1
Hangers	-	12
Screwed Fittings	13	-
Equivalent Meters	60.04	116.44

SECTION 12: DENIS FORMULA - REV #4 - IMPERIAL

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SECTION 12

DENIS FORMULA - REVISION #4 - IMPERIAL

12.1 OVERVIEW: DENIS FORMULA

James S. Denis, President of MHG International Inc. based in Calgary, Alberta, first introduced the proposed "Standard Method of Measurement", May 1980 to a World Insulation and Acoustic Congress (W.I.A.C.O.) held in Paris, France.

Later in 1980, the 'Denis Formula' was introduced to major clients in the petro-chemical industry. It quickly gained approval and acceptance as 'fair' to both client and contractor. It is now widely used on industrial projects. Quite apart from the obvious benefit of having one standard method of measurement for the industry, the formula, with ever increasing acceptance and usage, brings economic benefits to the owner.

By identifying and defining the 'labour' intensive portions of the work, with factors to compensate for same, the formula has the balancing effect of reducing 'unit prices'. The prices more properly are based on the straight work where previously they had built-in difficulty factors at time of tendering.

Use of the standard method of measurement (Denis Formula) has eliminated most of the guesswork.

The end result is beneficial to both the owner/client and the insulation contractor. By use of the formula the parties simplify the process of determining the final quantities and value of the work with strict control over the method.

12.2 STANDARD METHOD OF MEASUREMENT FOR INSTALLED INDUSTRIAL

INSULATION

These standards are to be used for the express purpose of measuring the quantities of insulation required for a mechanical system. They can be used for tendering, evaluation of bids, and for finalizing accounts.

SCOPE

1. Insulation of mechanical systems including, but not limited to, vessels, equipment, exchangers, pumps, tanks, ducts or flues and pipework.
2. All measurements shall be taken on the external surface of the insulation system.
3. There shall be no deductions for surfaces not insulated within the specified insulation area. Exceptions to this rule may be negotiated where termination of insulation does not require a finish or weatherproofing and/or where the uninsulated portion is more than 5% of the total.
4. Irregular shapes, fittings on piping systems, valves, etc., shall be counted separately. The conversion tables of the formula are designed to include for general requirements. Conversion factors for unusual items, e.g. seismological anchor or hangers, shall be negotiated by the parties prior to commencing the work.

5. All obstructions and penetrations of the insulation system shall be measured separately.
6. All effected areas and pipe lengths shall be multiplied by the complete applicable unit process.

DEFINITIONS

Types of insulation: hot, anti-condensation, cryogenic, acoustic, fireproofing.

General description of items to be insulated:

(a) Vessels

Towers, columns, drums, containers, receivers, exchangers, storage tanks, etc.

(b) Equipment

Equipment which has an irregular outer surface, e.g. transitions, stiffeners, heads, roof ends, turbines, pumps, compressors, air or gas handling fans, etc.

(c) Flat Surfaces

Boiler walls, precipitators, hoppers, ducts & flues, storage bins, etc.

(d) Piping

Straight pipes, bends, elbows, accessories, fittings, valves, flanges, strainers, termination points, bevels, etc.

(e) Instruments

Measuring and controlling devices for process requirements.

(f) Height allowances

Standards, see page DF-14.

PRINCIPALS OF MEASURING EQUIPMENT

Shell - Cylindrical

The outside diameter of the vessel plus two times the insulation thickness multiplied by 3.14 and by the length tangent line to tangent line as illustrated in diagram. Transition sections (changes in diameter) shall be measured using the larger diameter, times the length. There shall be no deductions for manholes and any other interruption or projection, whether insulated or not.

Irregular Surfaces

Any irregular shape shall be measured on the outside of the insulation surface, using the largest diameter. The surface area for irregular surfaces to be multiplied by a correction factor of 1.75 to obtain the equivalent area of flat surface. For small pumps, turbines, etc. the minimum equivalent area of measurement shall be 10 sq. feet..

Heads, Roofs, Ends

Flat: The surface area with diameter outside of the vessel insulation.

Spherical: The surface area of the hemisphere with diameter outside of the vessel insulation.

Dished: The surface area of a flat circle with a diameter outside of the vessel insulation, multiplied by a correction factor of 1.37.

Cones: The geometrical surface area of the cone, measured outside the insulation thickness.

ADDITIONAL MEASUREMENTS

On "Unit Price" contracts, all insulated nozzles and man-ways connecting to a vessel will be measured as pipe run to the vessel wall plus flange. In addition, all nozzles, man-ways, brackets, platform supports, obstructions, and penetrations, shall have their perimeter measured as irregular surface. All penetrations shall be a minimum 1 sq. foot per each.

On "Lump Sum" contracts, where like obstructions, penetrations, nozzles, brackets, supports, stiffener rings, etc. have not been shown in detail on bid drawings, they shall be measured, as above, as extra work to the contract.

PRINCIPALS OF MEASURING

PIPING

Pipe shall be measured from center line to center line through all fittings, in accordance with Diagram 'A', Page 10. All fittings will be counted and classified for multiplication by the appropriate factor listed in the "Fitting Factor Tables" Pages 5 to 8. Fittings connecting two or more different sizes of pipe shall be counted as the largest size involved.

Bent Pipe:

Shall be measured on the outside radius of the bend(s),

Traced Piping:

Insulation sized to accommodate tracer(s) shall be measured at the actual size of insulation used.

Tracer loops shall be measured separately.

12.3 CONVERSION TABLES FOR FITTINGS TO BE ADDED TO LINE TOTAL

MEASURED THROUGH ALL FITTINGS

45 Elbows

½" to 2 ½" pipe	1.5	lin. feet of same size and thickness
3" to 5" pipe	2.	"
6" to 8" pipe	2.5	"

9" to 12" pipe	3.	"
14" to 24" pipe	4.	"
25" to 30" pipe	5.	"

90 Elbows

½" to 2 ½" pipe	2.	lin. feet of same size and thickness
3" to 5" pipe	3.	"
6" to 8" pipe	4.	"
9" to 12" pipe	5.	"
14" to 24" pipe	6.	"
25" to 30" pipe	7.	"

When stainless or FRP steel jacketing is specified, factors for elbows (with stainless steel or FRP covers), multiply the above tables by 2.5

Bent Pipe 3 lin. feet of same size and thickness

Tracer Loops 3 lin. feet minimum, per loop at tracer

(Wrapped Insulation) size by 1" (nominal) thickness

Flanges (Pair)

- Hot	3.	lin. feet of same size and thickness
- Cryogenic	7.	"
- Anti-condensation	4.	"

Valve Body (screwed)

½" to 3"	2.	lin. feet of same size & thickness
4" to 8"	3.	"
10" and over	4.	"

Valve Body (welded)

½" to 3"	3.	lin. feet of same size & thickness
4" to 8"	4.	"
9" to 12"	5.	"
14" to 18"	6.	"

20" to 24"	8.	"
26" to 30"	10.	"
32" and over		measured as equipment

Valve Body (flanged)

½" to 3"	2.	lin. feet of same size & thickness (plus flanges)
4" to 8"	3.	" "
9" to 12"	4.	" "
14" to 18"	5.	" "
20" to 24"	6.	" "
26" to 30"	8.	" "
32" to 36"and over	10.	" "

Valve Body (with bonnet) Use appropriate factors as above.

½" to 5"	Add	2.	lin. feet to factors (plus bonnet flange)
6" to 12"	"	3.	" "
14" to 20"	"	4.	" "
22" to 30"	"	5.	" "
32" to 36"	"	6.	" "

Tees 2. lin. feet of same size and thickness

Branch Fittings 2. lin. feet of same size and thickness

Reducers, Caps and Termination Points 1.5 lin. feet of same size and thickness

***Hangers (hot)** 1 lin. feet of same size and thickness

*Including shoe supports and brackets. Excludes guides and anchors.

Hangers(cryogenic/anti-condensation)

2. lin. feet of same size and thickness

Removable Covers multiply fitting factors by 2.5, or a price per cover established by tender.

Screwed / FRP Fittings:

Specified flexible insulation, multiply all factors by 2. Specified preformed or rigid insulation – 3 linear feet per fitting.

Vitaulic Fittings:

These fittings require special consideration because of size and complexity. Therefore the conversion table factors are to be multiplied as follows:

45 Elbows Multiply factors 3 times

90 Elbows Multiply factors 3 times

Tees, Fittings:

½" to 5" Multiply factors 3 times

6" to 12" Multiply factors 5 times

14" and over Multiply factors 7 times

Penetrations:

Items which interfere with the insulation system, e.g., conduits, handrails, ancillary hangers, uninsulated pipe or tubing, etc.

Each cut out 2. lin. feet of same size and thickness

When penetrations occur at fittings:

Each cut out 3. lin. feet of same size and thickness

Obstructions

Where insulation thickness has to be shaved or cut for walls, sleeves, equipment or other interferences:

Multiply the length of interference by factor of 2

HEIGHT ALLOWANCES

Height Factor Above Grade*

- Factor to increase unit price for over 30'0" height by 10%
- Factor to increase unit price for over 40'0" height by 20%
- Factor to increase unit price for over 50'0" height by 30%
- Factor to increase unit price for over 60'0" height by 40%
- Factor to increase unit price for over 70'0" height by 50%
- Factor to increase unit price for up to 80'0" height by 60%
- Factor to increase unit price for over 90'0" height by 70% plus 1% per additional foot of height

*Grade does not include working platforms

HOT WORK: (When insulation applied to line in service above 150°F/65°C operating temperature)

½" to 2 ½" pipe	increase labour component by	25%
3" to 5" pipe	"	35%
6" to 8" pipe	"	45%
9" to 12" pipe	"	60%
14" to 24" pipe	"	75%
25" to 30" pipe	"	100%

If labour component has not been identified apply only 50% of the above to the unit prices. These percentages are to compensate for loss of productivity, however safe working conditions shall take precedent.

Metric Measurement (Conversion)

For equivalent fitting factors multiply computations by .31

12.4 EXAMPLE OF PIPING MEASUREMENTS

Pipe Size	1"	3"	8"	30"
Spec	Hot	Cryog	Hot	Hot
Length of Pipe	108'	78'	200'	302'
Bent Pipe	-	-	26'	-
45 Elbow	-	2	-	4
90 Elbow	16	8	7	3
Flanges (Pair)	-	3	11	-
Valves (Weld)	-	-	-	1
Valves (Flanged)	-	1	2	-
Valves (Bonnet)	-	-	1	-
Tees	6	-	3	7
Reducers or Caps	3	-	1	1
Hangers	-	3	7	12
Screwed Fittings	13	1	-	-
Equivalent Footage	195.5	138.0	365.5	380.5

SECTION 13 : INSTALLATION DETAILS

- FIGURE 1 PRE-FORMED PIPE INSULATION MULTIPLE LAYER CONSTRUCTION
- FIGURE 2 FLEXIBLE CLOSED CELL PIPE COVERING
- FIGURE 3 FIELD AND FACTORY APPLIED NON-METAL JACKETING
- FIGURE 4 FIELD APPLIED METAL JACKET
- FIGURE 5 STANDARD AND SPLIT RING HANGERS
- FIGURE 6 CLEVIS HANGER HIGH DENSITY INSERTS
- FIGURE 7 PIPE SHOE ON ROLLER SUPPORT
- FIGURE 8 TRACED PIPING
- FIGURE 9 INSULATION SUPPORT RINGS / EXPANSIONCONTRACTION JOINTS
- FIGURE 10 PRE-FORMED ELBOW INSULATION
- FIGURE 11 MITRED INSULATION ELBOW OVER-SIZED APPLICATION
- FIGURE 12 PVC / GLASS FIBRE ELBOW INSULATION SYSTEM
- FIGURE 13 FIELD OR FACTORY FABRICATED VALVE INSULATION
- FIGURE 14 PVC / GLASS FIBRE VALVE INSULATION
- FIGURE 15 IN-LINE FLANGE INSULATION BUILT-UP AND BEVELED
- FIGURE 16 PVC / GLASS FIBRE COUPLING OR IN-LINE FLANGE INSULATION SYSTEM
- FIGURE 17 FLEXIBLE DUCT INSULATION ON RECTANGULAR DUCTS INDOORS
- FIGURE 18 RIGID DUCT INSULATION ON RECTANGULAR EXPOSED DUCTS OUTDOORS
- FIGURE 19 HIGH TEMPERATURE BLOCK OR BOARD INSULATION
- FIGURE 20 VESSEL BOTTOM HEAD, LEG, SKIRT INSULATION AND SECUREMENT
- FIGURE 21 PIPE AND TUBE EXCHANGERS - ENCASED
- FIGURE 22 LARGE DIAMETER VERTICAL VESSELS BLOCK AND BLANKET INSULATION
- FIGURE 23 LARGE DIAMETER HORIZONTAL VESSELS INSULATION SUPPORT AND SECUREMENT
- FIGURE 24 FLEXIBLE CLOSED CELL SHEETS

FIGURE 25	EXTREME TEMPERATURE VESSELS BLOCK INSULATION
FIGURE 26	SMALL DIAMETER VESSELS / EXHAUST PIPE COVERING
FIGURE 27	FIELD APPLIED LINING
FIGURE 28	CURVED SURFACES RIGID BOARD INSULATION
FIGURE 29	NOZZLES AND INSULATION MANWAYS
FIGURE 30	BLOCKS AND PRE-FORMED PIPE INSULATION AROUND BREECHINGS AND EXHAUST DUCTS
FIGURE 31	HEAD INSULATION, SECUREMENT AND COVER FABRICATION
FIGURE 32	PIPING
FIGURE 33	FITTINGS
FIGURE 34	FLEXIBLE INSULATION BLANKETS
FIGURE 35	REMOVABLE AND REUSABLE INSULATION
FIGURE 36	REMOVABLE INSULATED METAL EQUIPMENT COVERS
FIGURE 37	REMOVABLE AND REUSABLE INSULATION
FIGURE 38	ELASTOMETRIC REMOVABLE COVERS
FIGURE 39	TYPICAL FIRE STOP COMPONENTS FOR FLOOR EXPANSION JOINT
FIGURE 40	TYPICAL FIRE STOP COMPONENTS FOR FLOOR EXPLANSION JOINT
FIGURE 41	TYPICAL FIRE STOP FOR WALL PENETRATIONS
FIGURE 42	TYPICAL FIRE STOP FOR WALL PENETRATIONS
FIGURE 43	TYPICAL FIRE STOP FOR WALL PENETRATIONS
FIGURE 44	TYPICAL FIRE STOP FOR WALL PENETRATIONS
FIGURE 45	TYPICAL FIRE STOP FOR WALL PENETRATIONS
FIGURE 46	TYPICAL FIRE STOP FOR DEFLECTION OF METAL STUD WALLS
FIGURE 47	TYPICAL FIRE STOP COMPONENTS FOR THE TOP OF THE MASONRY WALL

SECTION 14: GLOSSARY AND DEFINITIONS

The following definitions sometimes are not as strict as those which would be applied by a physicist, but are phrased in the terms familiar to and commonly used by engineers and the people of the construction industry. Users of this Glossary should note that, in many cases, words are used in the connotations familiar to the industry, and the definitions are restricted to this limited usage.

ABSORPTION	That property of a material which enables it to retain liquids (in either liquid or vapour form) upon its surfaces, both internal and external.
AFTERGLOW	The incandescence in a material after removal of an external flame or fire, or after an integral flaming has been extinguished.
AIR BARRIER	A continuous network of materials and joints providing air tightness, with adequate strength and stiffness to not deflect excessively under air pressure differences, to which it will be subjected in service. It can be comprised of a single material or a combination of materials to achieve the required performance requirements.
ALLIGATORING	A term describing the action of a coating or mastic when it cracks into large segments. When the action is fine and incomplete it is usually referred to as "checking".
AMBIENT TEMPERATURE	The temperature of the medium, usually air, surrounding the object under consideration.
ASBESTOS	A group of fibrous minerals which occur as small veins in the massive body of natural hydrous silicates of serpentine of amphibole, and have heat-, fire-, and solvent-resistant properties. Used as a reinforcement in the manufacture of mastics.
ASPHALT EMULSION	A colloidal dispersion of petroleum asphalt in water. The emulsifying agent may be a colloidal clay or a chemical soap.
BATT	A piece of insulation of the flexible type, cut into easily handled sizes, square or rectangular in shape, usually 600 mm or 1200 mm long and usually with a vapour retarder on one side, and with, or without, a container sheet on the other side.
BEDDING COMPOUND	A plastic material, composed of various ingredients, spread on the substrate and used as a medium in which to embed the insulation layer. The compound acts as a cushion, anti-abrasive, and adhesive.
BLANKET	Insulation, of the flexible type, formed into sheets or rolls, usually with a vapour retarder on one side and with or without a container sheet on the other side.

BLEEDING	The diffusion of colouring matter through a coating from the substrate. (Such as bleeding of asphalt mastic through a topcoat of paint.)
BLOCK	Rigid or semi-rigid insulation formed into sections, rectangular both in plan and cross section, usually 900 mm to 1200 mm long, 150 mm to 600 mm wide, and 25 mm to 150 mm thick.
BOND STRENGTH	The unit load applied in tension, compression, peel, impact, cleavage, or shear required to break an adhesive assembly with failure occurring in or near the plane of the bond.
BRITISH THERMAL UNIT (BTU)	Originally the amount of heat necessary to raise one pound of water one degree Fahrenheit at standard atmospheric pressure. Now, by international agreement has been established as 778.26 ft lbs.
CANVAS	A light, plain weave, coarse, cotton cloth with hard twisted yarns, usually not more than 271 g/sq m (8 oz. per square yard).
CAPILLIARITY	That property of a material which will enable it to suck a liquid up into or through itself, with the driving force of the liquid being its surface tension.
CAULKING COMPOUND	A soft, plastic material, consisting of pigment and vehicle, used for sealing joints in buildings, and other structures, where normal structural movement may occur.
CENTIGRADE	The temperature measuring scale in which the ice point of water is taken at 0° and the steam point at 100°. The absolute zero on this scale is -273.2°.
CHEMICALLY FOAMED PLASTIC	A cellular plastic produced by gases generated from chemical interaction of constituents.
CHLORINATED SOLVENT	An organic chemical liquid characterized by a high chlorine content and used in coating products to impart non-flammability.
CLOSED-CELL FOAMED PLASTIC	A cellular plastic in which there is a predominance of non-interconnecting cell.
COATING	A liquid, or semi-liquid, protective finish capable to application to thermal thickness, less than 30 mils (0.030 inches).
COEFFICIENT OF EXPANSION (CONTRACTION)	The increase (decrease) in length of a material, one unit long, due to the increase (decrease) of its temperature one degree. In the British System the unit is usually one foot, and the temperature Fahrenheit.
COMBUSTIBLE	Capable of uniting with air or oxygen in a reaction initiated by heating, accompanied by the subsequent evolution of heat and light. Capable of burning.

COMBUSTIBILITY	That property of a material which measures its tendency to burn. Combustibility is measured in accordance to CAN4-S114 and is a measurement of the non-combustibility of a material. Combustibility should not be confused with the arbitrary terms of "Flame Spread Index" and "Smoke Density Index" according to CAN/ULC-S102-2003, as they are separate material properties and measured differently.
COMPACTION OR SETTLING	The property of the blankets, or batts, which measures their change in density and thickness resulting from loading, or vibration, with a resultant change of thermal efficiency.
CONDENSATION	The act of water vapour turning into liquid water upon contact with a surface at a lower temperature than the dew point of the vapour.
CONCEALED SPACES	Spaces not generally visible after the project is completed such as furred spaces, pipe spaces, pipe and duct shafts, spaces above ceilings, unfinished spaces, crawl spaces, attics and tunnels.
CONDUCTION	The transfer of energy within a body, or between two bodies in physical contact, from a higher temperature region to a lower temperature region by tangible contact.
COVERAGE-WET	The property of a material which measures the amount of material necessary to cover a given area to obtain a specific dried or cured thickness.
CREEP	The dimensional change with time of a material under load apart from, and following, the initial instantaneous elastic or rapid deformation.
CRYOGENIC	Pertaining to the extremely low temperatures, such as the liquefaction points of gaseous elements, usually below -75°C on down to absolute zero.
CURING AGENT	An additive incorporated in a coating or adhesive resulting in increased chemical activity between the components, with an increase or decrease in the rate of cure.
CURVED SEGMENTAL BLOCK	A piece of rigid insulation, rectangular in plan, and the sector of a tube, in cross section, molded or cut from block of the proper thickness
DEWPOINT	The temperature at which the quantity of water vapour in a material would cause saturation, with resultant condensation of the vapour into liquid water by any further reduction of temperature.
DRYING TIME (ADHESIVES)	Time elapsed since bonding at the optimum time when no further increase in bond strength is realized
DRYING TIME FINISHES	Time elapsed after which no further significant changes take place in appearance or performance properties, due to drying.

EFFLORESCENCE (BLOOM)	A white powdery substance occurring on the surface of coated insulation (products, caused by the migration of soluble salts from the insulation, followed by precipitation and carbonation.
EMULSION	Strictly stated, a colloidal suspension of one liquid in another.
EXPLOSIVE LIMITS	In the case of solvent vapours which form flammable mixtures with air or oxygen, there is a minimum concentration of vapour in air or oxygen below which propagation of flame does not occur on contact with a source of ignition. There is also a maximum proportion of vapour or gas in air, above which propagation of flame does not occur. These boundary-line mixtures of vapour with air, which if ignited, will just propagate flame, are known as the "lower and upper flammable" usually expressed in terms of percentage by volume of vapour in air.
EXPLOSIVE RANGE	The range of combustible vapour and air mixtures between the upper and lower flammable limits is known as the "flammable range", sometimes referred to as the "explosive range".
FACING	A thin layer on the surface of an insulating product, variously acting as either a vapour retarder, weather-barrier, protector from damage, or a decorative coating.
FAHRENHEIT	The temperature scale of the British System of units in which the ice point of water is assigned the value of 32°, and the steam point the value of 212°, with 180 even divisions between, and corresponding divisions above and below. Absolute zero on this scale is - 459.6°.
FILLER	A relative inert material added to a mastic or coating to modify its strength, permanence, working properties, or other qualities.
FILLET	That portion of an adhesive, mastic coating, or sealant which fills the corner, or angle, where two adherents or surfaces are joined.
FILM	An optional term for sheeting having nominal thickness not greater than 0.25mm (0.010").
FINISHING CEMENT	A mixture of asbestos fibers and bonding clays, water-mixed to a plastic mass on the job, and used on the surface of insulations to provide a medium-hard to hard, even finish.
FIRE POINT TEMPERATURE	The lowest temperature of a material at which it gives off vapour, which, when combined with air near its surface, forms an ignitable mixture at a rate sufficient to support combustion continuously after the external ignition source is removed.
FIRE RESISTANCE	That property of a material which enables it to resist a decomposition or deterioration when exposed to a fire.
FIRE RETARDANCE	That property of a material which delays the spread of fire, either through or over itself.

FISH-MOUTH	A transverse gap between layers of sheet materials caused by warping or bunching of one or both layers.
FLAME SPREAD	The rate, expressed in distance-time, at which a material will propagate flame on its surface. As this is a difficult property to measure in time and distance, the measure is now by flame spread index to enable the comparison of materials by test methods. (CAN/ULC-S102-2003).
FLAMMABLE	That property of a material which permits it to oxidize rapidly and release heat of combustion when exposed to flame or fire, and allows continuous burning after the external ignition source is removed.
FLASH POINT	The lowest temperature of a material at which it gives off vapour, which, when combined with air near its surface, forms an ignitable mixture. Various apparatus is used depending on the type of material to be tested, such as Tagliabue Open or Closed Cup, Cleveland Open or Closed Cup or Pennsky-Martens Closed Tester.
FLEXIBILITY	That property of a material which allows it to be bent (flexed) without loss of strength.
FREEZE-THAW RESISTANCE	The property of a material which permits it to be alternately frozen and thawed - through many cycles - without damage from rupture or cracking.
FUEL CONTRIBUTED	Flammable by-products of fire generated by, and emitted from, a burning object. (Fuel-Contributed.)
GALVANIC CORROSION	Pitting or eating away of one of the metals when two metals of different electric potential are in direct contact, or electrically connected by an electrolyte.
HEAT TRANSFER CEMENT	A soft, plastic material, which under use quickly solidifies to a rock-like hardness, having a high coefficient of heat transfer, which is used to bond tubes, or other heat-conveying devices, to the pipe or equipment to which it is desired to transfer the heat.
HOLIDAY	In a coating application a place not covered by coating compound.
HYGROSCOPICITY	That property of a material which enables it to readily absorb and retain water in either its liquid or vapour state.
INSULATING MASTIC	A premixed soft, plastic material of various consistencies, applied by spray, trowel, brush or palm, which possesses some insulating value in addition to its other vapour retarder or weather-barrier characteristics.
INSULATING CEMENT	A mixture of various fibers and binders, to be mixed with water to form a soft, plastic mass, and used to insulate small irregular surfaces and fill the cracks and crevices between the units insulating larger surfaces.

INSULATION COVER	The cover for a flange, pipe fitting, or valve, composed of the specified thickness insulating material, and preformed into its proper shape before application.
INTUMESCENCE	The process of swelling or expanding on fire exposure to form a cellular charred layer which insulates and retards flaming.
INSULATION SYSTEM	An application of insulation to piping, ductwork or equipment that may include the use of adhesives, mechanical fastenings, coatings, reinforcing fabrics, sealants and metal covering.
INSULATION COATING	A material, or materials, used over insulation or over the weather coating to provide the desired colour or texture for decorative purposes.
JACKET	A covering placed around an insulation to protect it from mechanical damage, and, insofar as it is intrinsically able, from weather, water, ultra violet light, etc.
LAG	A long, narrow piece of rigid insulation, rectangular in plan, trapezoidal in cross section, molded, or cut from block of the proper thickness.
LAGGING	An insulation layer, on a cylindrical surface, composed of lags.
MASTERFORMAT	A standard listing of specification section numbers and titles, used for organizing construction documents in a specification. MasterFormat 2004 is published by Construction Specifications Canada (CSC) and Construction Specifications Institute (CSI-USA).
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 0.76mm (30 mil).
MINERAL FIBER	A durable fibrous material processed from rock, slag or glass.
MUD CRACKING	A form of alligatoring, or stress cracking, which may occur during drying in thick applications of water-base mastics or coatings, usually caused by shrinkage from excessive volatile content.
NOISE REDUCTION COEFFICIENT (N.R.C.)	Is an arithmetic average representation of sound absorption coefficients of frequencies from 250 to 2000 Hertz. Refer also to "Sound Absorption Coefficient".
NON-COMBUSTIBLE	A material which will not contribute fuel or heat to a fire to which it is exposed (CAN4-S114-1980(R1997))
NONFLAMMABLE	That property of a material which prevents it from oxidizing rapidly and releasing heat of combustion when exposed to fire or flame.
OPEN-CELL FOAMED PLASTIC	A cellular plastic in which there is a predominance of inter-connected cells.

OPEN TIME MAXIMUM (ADHESIVES)	That open time which corresponds to 90 percent of the optimum strength after the maximum value has been reached.
OPEN TIME MINIMUM (ADHESIVES)	That open time which corresponds to 90 percent of the optimum strength prior to reaching the maximum value.
OPEN TIME OPTIMUM (ADHESIVES)	That open time which gives the optimum strength at a bond age of 24 hours.
ORANGE-PEEL	Uneven surface of a spray-applied coating, somewhat resembling an orange peel.
PENETRATION	The consistency of a mastic material, expressed as the distance that a standard cone vertically penetrates a sample of the material under known conditions of loading, time, and temperature. The units of penetration indicate hundredths of a centimeter.
PERM	The accepted unit of Water Vapour Permeance. Is expressed as 1 grain per square foot, hour, inch of mercury.
PERM-INCH	The accepted unit of Water Vapour Permeability. Is expressed as 1 grain per square foot, hour, inch of mercury, inch of thickness.
PINHOLE	Very small hole through a mastic or coating.
PIT	Small regular or irregular crater in the surface of a plastic, usually with its width approximately of the same order of magnitude as its depth.
POLYSTYRENE	A resin made by polymerization of styrene as the sole monomer.
POT LIFE	The period of time during which an adhesive or coating, after mixing with catalyst, solvent, or other compounding ingredients, remains suitable for use.
PUNKING	The incandescent, or glow, which lingers in some material after any flame, or other evidence of fire, has departed.
PRIMER	The first application of a coating system used to seal or condition the surface for the proper bonding of subsequent layers or coats.
RADIATION	The transfer of energy from a higher temperature body, through space, to another body, or bodies, some distance away at a lower temperature, without raising the temperature of the medium through which the energy passes.
REFLECTANCE	The ratio of the radiant energy reflected by a body to that incident upon it.
REINFORCING MEMBRANE	A loosely woven cloth or fabric of glass or resilient fibres, placed approximately in the centre of the vapour- retarder or weather-barrier to act as reinforcing to the mastic of the barrier.

REINFORCING MESH	Generic term for poultry netting, chicken wire, etc., usually made from galvanized wire woven in 25 mm mesh size. Also available in galvanized and rustless metal alloys.
RELATIVE HUMIDITY	The ratio of the actual pressure of existing water vapour to the maximum possible (saturation) pressure of water vapour in the atmosphere at the same temperature, expressed as a percentage. (See dew point.)
RESILIENT	Capable of recoiling from pressure or shock unchanged or undamaged.
SAG	Excessive flow in material after application to a surface, resulting in "curtaining" or running.
SELF-IGNITION TEMPERATURE (AUTOGENOUS IGNITION)	The lowest temperature of a material which will cause it to ignite without other ignition source.
SELF-EXTINGUISHING	That property of a material which enables it to stop its own ignition after external ignition sources are removed.
SEALER	A substance, composed of various materials, used to retard the passage of water vapour or liquid water into the joint formed by the mating surface of jackets and vapour retarder over insulation. A good sealer will possess relatively little shrinkage. There are several types of sealers, such as non-setting, setting, and heat resisting.
TEMPERATURE LIMITS	The limiting temperatures at a coated surface, within which limits the applied coating will have satisfactory service performance.
SET	To convert into a fixed or hardened state by chemical or physical action.
SHRINKAGE - WET TO DRY	The property of a material which measures the difference in volumetric and linear change which occurs in the drying of insulating cements and mastics.
SIZING	Any of various glutinous materials, used to fill the pores in the surface of a paper, fiber, or cloth.
SKINNING	The formation of a relatively dense film on the surface of a mastic or coating material while stored in containers.
SMOKE DENSITY	The Smoke Density Factor is the amount of smoke given off by the (SMOKE-burning material compared to the amount of smoke given off by DEVELOPED) the burning of a standard material (CAN/ULC-S102-2003.)
SMOKE TOXICITY	The degree of hazard to health of the smoke.
SOFTENING POINT	That temperature at which a material will change its property from firm or rigid to soft or malleable.

SOLIDS CONTENT	<p>The percentage of the non-volatile matter.</p> <p>NOTE: The determined value of non-volatile matter in any adhesive, coating, or sealant will vary somewhat, according to the analytical procedure used. A standard test method must be used to obtain consistent results.</p>
SOLVENT	<p>Any substance, usually a liquid, which dissolves other substances. Normally a liquid organic compound used to make a coating work more freely.</p>
SOUND ABSORPTION COEFFICIENT	<p>Is the decimal fraction representing the absorbed portion of an incident sound wave, when tested in accordance with ASTM C423, #6 mounting (Metal Duct). Refer also to "Noise Reduction Coefficient".</p>
SUBSTRATE	<p>A material upon the surface of which an adhesive or coating is spread.</p>
SURFACE WETTING	<p>The property of a material applied to a substrate which enables it to thoroughly wet the substrate to produce a good bond.</p>
TACK	<p>The property of an adhesive that enables it to form a bond of measurable strength immediately after adhesive and adherent are brought into contact under low pressure.</p>
TAR	<p>Brown or black bituminous material, liquid or semi-solid in consistency, in which the predominating constituents are bitumens obtained as condensates in the destructive distillation of coal, petroleum, oil-shale, wood, or other organic materials, and which yields substantial quantities of pitch when distilled.</p>
TEMPERATURE LIMITS	<p>The upper and lower temperatures at which a material will experience no essential change in its properties.</p>
THERMAL CONDUCTANCE	<p>Thermal conductance (expressed as C) is the amount of heat expressed in BTU transmitted in one hour through one square foot and is applied to specific materials as used, which may be either homogeneous or heterogeneous, for the thickness or type under consideration, for a difference in temperature of one degree F. between the two surfaces of the material.</p> <p>Overall coefficient of heat transmission (expressed as U) is the amount of heat expressed in BTU transmitted in one hour per square foot of wall, floor, roof or ceiling for a difference in temperature of one degree F. between the air on the inside and outside of the wall, floor, roof or ceiling.</p>

Film or surface conductance (expressed as f) is the amount of heat expressed in BTU transmitted from a surface to the air surrounding it or vice versa, in one hour per square foot of the surface for a difference of one degree Fahrenheit. To differentiate between inside and outside surfaces, f_i is used to designate the inside film and f_o for outside film. f_i for ordinary building materials and for still air is about 0.68 and f_o for ordinary building materials and a wind of 15 miles per hour is about 0.17.

Thermal Conductance of an air space (expressed as a) is the amount of heat expressed in BTU transmitted in one hour through an area of one square foot of an air space for a temperature difference of one degree Fahrenheit. "a" for an air space of 19 mm or larger and bounded by ordinary surfaces (not reflective), the average is 1.1

THERMAL CONDUCTIVITY

Thermal Conductivity (expressed as k) is the amount of heat expressed in BTU transmitted in one hour through one square foot of a homogeneous material 25 mm thick for a difference in temperature of one degree Fahrenheit between the two surfaces of the materials.

Note: the value of k will vary with the mean temperature. The value of k will vary with the density of the material when the mean temperature is constant. Therefore, the density and mean temperature are usually given when expressing the k factor for any insulating material.

THERMAL INSULATION

Material having air-filled or gas-filled pockets, void spaces, or heat-reflective surfaces, which, when properly applied, will retard the transfer of heat with reasonable effectiveness under ordinary conditions.

THERMAL RESISTANCE

That property of a material which enables it to withstand the passage of heat through it, due to a temperature difference between its two opposite surfaces. Resistance (expressed as R) is numerically equal to the reciprocal of the conductance.

$$R = 1 / C \quad R = 1 / f \quad R = 1 / a \quad R = 1 / u \quad i \quad 0$$

To obtain the resistance when k is given $R = x / k$ when x is the thickness of the insulation

The overall resistance of a wall, floor or roof is the sum of the resistances of each part.

THERMAL SHOCK RESISTANCE

That property of a material which enables it to retain its shape and not distort, crack, or shatter, due to a sudden change in its temperature.

THERMOPLASTIC

Capable of being repeatedly softened by increase of temperature.

Note: Thermoplastic applies to those materials whose change upon heating is substantially physical.

THERMOSET	A plastic or coating which, when cured by application of heat or chemical means, changes into a substantially infusible and insoluble product.
THIXOTROPY	The property of decreasing in consistency upon being sheared or worked, followed by a gradual recovery of consistency when the shearing stress is removed.
TOXICITY	The degree of hazard to health.
VAPOUR RETARDER	A material or materials, which when installed on the high vapour pressure side of a retarder material, retards the passage of moisture vapour to the lower vapour pressure side.
VAPOUR DENSITY	The relative density of a vapour or gas (with no air present) as compared with air. A figure less than 1 indicates that a vapour is lighter than air, and a figure greater than 1 that a vapour is heavier than air.
VAPOUR MIGRATION	That property of a material which measures the rate at which water vapour will penetrate it, due to vapour pressure differences (PERMEABILITY) between its surfaces.
VAPOUR PRESSURE	The gas pressure exerted by the water vapour present in the air.
VEHICLE	The liquid portion of a mastic or coating. Anything that is dissolved in the liquid portion is part of the vehicle.
VISCOSITY	<p>The property of resistance to flow exhibited within the body of a material.</p> <p>Note: This property can be expressed in terms of the relationship between applied shearing stress and resulting rate of strain in shear. Viscosity is usually taken to mean "Newtonian Viscosity", in which case the ratio of shearing stress to the rate of shearing strain is constant. In non-Newtonian behaviour, which is the usual case with adhesives, coatings, and sealants, the ratio varies with the shearing stress. Such ratios are often called the "apparent viscosity's" as the corresponding shearing stresses.</p>
WATER ABSORPTION	The increase in weight of a test specimen, expressed as a percentage of its dry weight after immersion in water for a specified time.
VAPOUR	Water in a gaseous state.
WATER VAPOUR PERMEABILITY	The water vapour permeability of a homogeneous material is a property of the substance. This property may vary with conditions of exposure. The average permeability of a specimen is the product of its permeance and thickness. An accepted unit of permeability is a perm inch, or 1 grain per square foot, hour, inch of mercury per inch of thickness. The test conditions must be stated.

**WATER VAPOUR
TRANSMISSION
(WVT)**

The rate of water vapour transmission of a body between two specified parallel surfaces is the time rate of water vapour flow normal to the surfaces under steady condition through unit area, under the conditions of test. An accepted unit of WVT is 1 grain per square foot, hour (with the test conditions stated).

**WEATHER-
COATING**

A material or materials, which, when installed on the outer surface of thermal insulation, protects the insulation from the ravages of weather, such as rain, snow, sleet, wind, solar radiation, and atmospheric contamination.

SECTION 15: MASTER SPECIFICATIONS

OVERVIEW: MASTER SPECIFICATIONS

Five separate specification sections, prepared to CSC formats (MasterFormat, SectionFormat and PageFormat), are included in this section. Section numbers are designated in 5-digits (MasterFormat 1995) and 6-digits (MasterFormat 2004). They consist of

- Section [15250] [23 07 00] - [HVAC] Mechanical Insulation,
- Section [15260] [23 07 19] - [HVAC] Piping Insulation,
- Section [15280] [23 07 16] - [HVAC] Equipment Insulation,
- Section [15290] [23 07 13] - Ductwork Insulation.
- Section [07840] [07 84 00] - Firestopping and Smoke Seals

Note that these specifications have been numbered in Division 23 - HVAC (per MasterFormat 2004). Sections for plumbing (Division 22) and Fire Suppression (Division 21) piping and equipment should be renumbered accordingly.

It is recommended that these specifications be selected and incorporated in project specifications to complement system design.

A variety of specification sections allow combined system selection under Section [15250] [23 07 00] while Sections [15260] [23 07 00], [15280] [23 07 16] and [15290] [23 07 13] make it possible to select separate specifications for piping, equipment and ductwork.

Section [07840] [07 84 00] is intended to include mechanical and non-mechanical firestopping. Coordination should be done with any mechanical equipment which may be provided with integral firestop equipment (fire-rated diffusers, for example).

TIAC insulating system code numbers are cross-referenced with mechanical system names. Use of these code numbers implies acceptance of the related insulating system standards. Any required addition, deletion or modification of these insulation standards must be clearly defined by the Specifier.

Where required to state the insulation type, only the material code number and generic term heading as listed in the guide need be stated. The Contractor will have the option to select any of the approved products listed in the TIAC Mechanical insulation best practices guide under a particular insulation heading.