

# Mechanical Insulation Guide and Specifications for British Columbia



**DRAFT**

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# 1.0 Introduction

## 1.1 Overall Objectives

The overall objective of this guide is to support the implementation of mechanical insulation best practices on heating and cooling systems in BC, by providing a resource to a wide range of stakeholders from building and facility owners to mechanical insulation installers – helping to work towards an ultimate goal of having every section of pipe and duct in the Province of BC insulated correctly.

This Guide will help stakeholders to:

- Make timely and effective decisions about mechanical insulation needs in new buildings and what upgrades may be required to improve mechanical insulation in existing buildings,
- Understand the importance and business case for mechanical insulation, and
- Understand the key elements required to achieve successful implementation of mechanical insulation in projects.

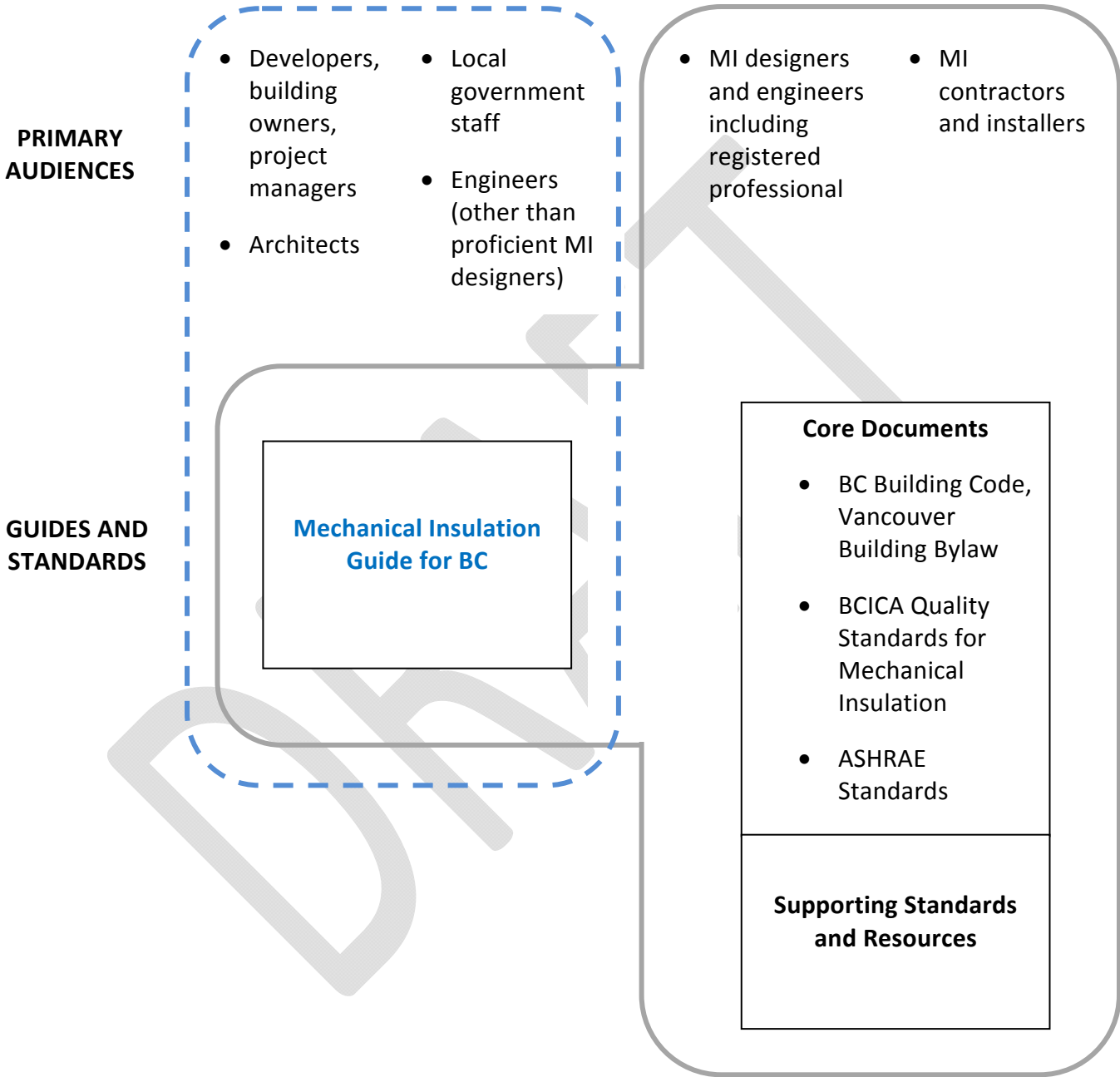
Mechanical insulation best practices are important to achieving Triple Bottom Line objectives:

- Social, health and safety objectives:
  - Providing protection of people who may come in contact with pipes, ducts or equipment, and
  - Reducing potential health risks such as mold caused by condensation.
- Economic objectives:
  - Providing protection for pipes, ducts and equipment to prevent damage and extend service life, and
  - Reducing energy spending over the lifetime of buildings and improving returns on investment.
- Environmental objectives:
  - Reducing energy consumption and associated greenhouse gas emissions through reducing unintended heat transfer.

## 1.2 Target Audience and Role of this Guide

This guide is intended to complement, rather than duplicate, existing standards, codes and guides. It is aimed at a broader audience than most existing detailed standards, as shown in the following figure. While any of the audience groups shown may benefit from any of the guides and standards shown, this guide serves audiences on the left side, in addition to supporting those on the right side.

Figure 1.2.1- Role and Audience of this Guide



## **1.3 Application**

### **.1 Systems**

- Primarily pipes and ducts; however, can also include equipment such as vessels, boilers and heat exchangers.
- Can include entire HVAC systems, not just mechanical rooms.

### **.2 Buildings**

- Applicable to all buildings and facilities with heating or cooling equipment, but most applicable to larger, more complex residential, commercial and institutional buildings (generally “Part 3” buildings).
- Both new and existing buildings.

### **.3 Geographic Areas**

- Applicable to jurisdictions within BC.

## **1.4 Background**

A timely opportunity exists in British Columbia to reverse a trend of deteriorating building practice, save millions of dollars per year in energy costs and contribute to provincial climate change goals - the opportunity is the typically unseen insulation on pipes and ducts of heating and cooling systems, known as mechanical insulation (MI)<sup>1</sup>. Non compliance with standards, plus poor practice, has resulted in wasted money and energy and avoidable greenhouse gas (GHG) emissions. Based on an economic analysis of simple case studies that looked at installed costs, maintenance and energy saved, it was found that the costs of fitting mechanical insulation on hot water pipes, for instance, can be recovered quickly – usually within two to five years. In addition, case studies indicate that energy savings associated with pipe insulation can account for a significant proportion of overall building energy consumption. This suggests that without proper mechanical insulation, buildings are consuming more energy, and producing more greenhouse gas emissions than necessary. Yet, mechanical insulation is relatively inexpensive to install. Generally, the installed costs are less than 1% of the total construction cost.

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<sup>1</sup> Pipes Need Jackets Too: Conserving Energy, Saving Money and Reducing Greenhouse Gas Emissions in BC Buildings through Mechanical Insulation Practice and Standards. HB Lanarc, January 2011.

## **1.5 Summary of Performance Objectives**

This section provides a brief overview of the key performance areas that are relevant to mechanical insulation (not specific to system type), and the types of tradeoffs that are encountered.

### **.1 Health, Safety and Noise**

Most of these objectives are addressed in the BC Building Code (see the BC Building Code Summary section later):

- Safety, fire and smoke
- Prevention of mould and mildew due to condensation that could have adverse health impacts
- Durability and corrosion protection
- Noise

### **.2 Reducing Energy Consumption and Energy Cost**

In addition to meeting Code and any other minimum requirements, an important decision for designers and ultimately building owners or tenants is the thermal performance (i.e., minimizing unintended heat transfer) of mechanical insulation. This performance affects energy consumption, associated greenhouse gas emissions, and ultimately the long-term operating costs of a building or facility.

There are two suggested approaches to determining insulation thickness and thermal performance:

- A prescriptive approach, using the insulation values recommended in the standards referenced in the specifications.
- A performance-based approach, that meets prescriptive requirements as a minimum but considers economic performance. This approach gives designers the option to better optimize their design choices to balance capital and operating costs, and to consider long term/life cycle economic performance. Refer to the Economic Performance Analysis subsection, later in this section, for guidance.

### **.3 Increasing Equipment Service Life and Decreasing Maintenance Costs**

Mechanical insulation best practices can not only increase pipe, duct and equipment service life, but reduce maintenance issues and costs, and help prevent damage to building components. These objectives can be met through:

- Preventing condensation that can damage pipes, equipment and building components.
- Reducing mechanical equipment cycling and helping to maintain the design operating conditions of equipment.



## ***1.6 Summary of Key Codes and Standards***

The information in this guide does not replace or change codes such as the BC Building Code, national codes or municipal codes and other regulations. Rather, this guide is designed to complement existing codes and minimum requirements. The summaries below provide a commentary on BC Building Code issues and other standards and are intended to assist practitioners understand the purpose and role of each. Practitioners are still responsible to identify, understand and implement all applicable codes and regulations within their particular jurisdiction.

The first three codes and standards listed in this section represent the “core” standards that address mechanical insulation requirements and practices for most types of projects in BC that are the focus of this guide. Note, however, that additional codes and standards may apply to any given project, and these may or may not be listed.

### **.1 BC Building Code**

The Building Code requires that designers and builders conform to the principles of good engineering practice. This extends to optimizing energy efficiency and cost considerations. However, the main focus of the Code is on life safety issues and on issues relating to preserving the condition of buildings. The BC Building Code (2006) references other standards (including the ASHRAE Handbooks and Standards, and other sources)<sup>2</sup> and provides some direct guidance for designers of mechanical insulation systems. These other standards provide detailed information about materials choices, insulation thicknesses as well as installation practices.

Designers and installers should keep in the mind the overall objectives of the BC Building Code<sup>3</sup>. Briefly, these include the following:

- Limit the probability that a person will be exposed to an unacceptable risk of injury. This applies to both temperature related issues and to physical protection of individuals from hard surfaces for mechanical insulating systems.
- Limit the probability that a person will be exposed to an unacceptable risk of injury due to fire. This applies to the flame spread ratings and smoke developed classifications for insulating materials.
- Limit the probability of deterioration of the building elements. This includes corrosion to pipes and ducts, and damage to insulating materials due to temperature, moisture, mildew, etc.
- Limit the probability of exposure to hazardous substances (such as asbestos).
- Limit the probability of exposure to an unacceptable risk of illness due to noise or vibration.

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<sup>2</sup> BC Building Code. 2006. Province of British Columbia. Section 6.2, 6.2.1.1. pg 235.

<sup>3</sup> Ibid. Section. 2.2. pg 19.

The Code requires that insulation materials for air ducts<sup>4</sup> be of either non-combustible construction or have a limited flame spread rating and smoke developed classification. The Code expressly forbids the use of foamed plastic insulation on and in interior and exterior air ducts. And, the Code does not allow combustible duct coverings to pass through rated fire separations.

The same basic requirements apply to insulation and coverings on pipes<sup>5</sup>. The flame spread ratings and smoke developed classifications are actually higher for pipes than for ducts in some piping applications.

Designers and installers need to be aware of the classification of the building and the physical location of the pipe or duct in making their selection for insulating materials. The building construction (i.e., combustible vs. non-combustible) and duct or pipe location (i.e., concealed or non-concealed) does demand different insulating materials.

The Building Code also identifies life safety issues in its requirements for piping systems<sup>6</sup>. There are no equivalent statements for ducted systems, but the general Code requirement is to not expose a person to unacceptable risk of injury<sup>7</sup>.

Finally, the Building Code gives a limited amount of direct guidance for designers in their selection of materials. The Code requires that insulation and coverings will withstand deterioration from a variety of mechanisms that would occur through normal use<sup>8</sup>.

The key reminders for designers and installers include:

- Have a clear understanding of Code requirements and their application including classification of the building structure. It is good engineering practice for designers to include a Code summary on their contract documents.
- Review the location of insulating systems to understand how the Code requirements may apply. This would include flame spread ratings and smoke developed classifications as well issues such as moisture, mildew, etc.
- Provide adequate clearance for proper insulation thickness.

Other Codes and Standards are outlined in the following sections. This is an illustrative, not exhaustive sample.

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<sup>4</sup> Ibid. Section 3.6.5.4 pg 140.

<sup>5</sup> Ibid. Section 3.6.5.5. pg 141.

<sup>6</sup> Ibid. Section 6.2.9.2. pg 239.

<sup>7</sup> Ibid. Section 2.2.1.1. pg 19.

<sup>8</sup> Ibid. Section 6.2.9.2. pg 239.

## **.2 American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standards**

As of September 2008, ASHRAE 90.1 (2004) is referenced by the BC Building Code for residential buildings of 5+ stories, or non-residential buildings of 4+ stories or greater than 600 square metres in area. Note that the City of Vancouver has its own Building Bylaw that includes energy performance requirements and also references ASHRAE 90.1. ASHRAE 90.1 versions referenced in both the BC and Vancouver codes are expected to change as new codes and bylaws are issued.

ASHRAE Standard 90.1 specifies thicknesses for mechanical insulation on pipes and ducts, and specifies thermal conductivity ranges for different piping and duct applications<sup>9</sup>.

The reader is referred to the ASHRAE website, Standards and Handbooks for more comprehensive information on recommended insulation practices.

ASHRAE 90.1 provides some cursory guidance on design objectives, noting that mechanical insulation should be protected from the elements and cites means of doing so<sup>10</sup>. However, this instruction alone is not sufficient to ensure energy efficiency, or other objectives such as durability. ASHRAE 90.1 also specifies that “[Mechanical] Insulation ... shall be installed in accordance with industry-accepted standards”<sup>11</sup>. It refers readers to Appendix E in the Midwest Insulation Contractors Association’s *Commercial and Industrial Insulation Standards Manual*.

A new standard, ASHRAE 189.1-2010, includes minimum insulation thickness for mechanical insulation on pipes and ducts. This standard defines the minimum requirements for high-performance green buildings.

## **.3 BC Insulation Contractors Association, “Quality Standards for Mechanical Insulation (Commercial and Institutional Buildings)”**

This document developed for practitioners in British Columbia provides material quality standards and workmanship requisite to the design, specifying and installation of systems for mechanical insulation, fire stopping and smoke seals, and asbestos removal. It is widely used across the province.

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<sup>9</sup> ANSI/ASHRAE/IESNA Standard 90.1-2007. Tables 6.8.2 Duct Insulation Tables and Table 6.8.3 Minimum Pipe Insulation Thickness.

<sup>10</sup> ANSI/ASHRAE/IESNA Standard 90.1-2007. Section 6.4.4 HVAC System Construction and Insulation.

<sup>11</sup> Ibid.

#### **.4 Other Supporting Standards, Guides and Resources**

**.1 *Thermal Insulation Association of Canada (TIAC) “Mechanical Insulation Best Practices Guide” ([www.tiac.ca](http://www.tiac.ca))***

This guide provides detailed design information, including installation details, for industrial and commercial systems requiring mechanical insulation. TIAC is the national industry association for contractors, distributors and manufacturers of commercial, industrial and institutional thermal insulation, asbestos abatement and fire stopping.

**.2 *Whole Building Design Guide (WBDG) “Mechanical Insulation Design Guide” ([www.wbdg.org/design/midg.php](http://www.wbdg.org/design/midg.php))***

The USA-based WBDG is a web-based portal providing government and industry practitioners with one-stop access to up-to-date information on a wide range of building-related guidance, criteria and technology from a 'whole buildings' perspective. The Mechanical Insulation Design Guide is design focused, and includes design objectives, data and guidance on writing specifications, and economic performance analysis.

**.3 *North American Insulation Manufacturers Association (NAIMA) ([www.naimacanada.ca](http://www.naimacanada.ca))***

NAIMA is the association for North American manufacturers of fibre glass, rock wool, and slag wool insulation products, and provides various resources on materials, installation practices, thermal performance, economic evaluations, and health and safety issues.

**.4 *Sheet Metal and Air Conditioning Contractors’ National Association (SMACNA) “Fibrous Glass Duct Construction Standards” ([www.smacna.org](http://www.smacna.org))***

The Sheet Metal and Air Conditioning Contractors’ National Association provides a standard for the installation of fibreglass duct insulation.

**.5 *Process Industry Practices ([www.pip.org](http://www.pip.org))***

The Process Industry Practices organization provides detailed information on the use and installation of mechanical insulation for process piping applications. The guidelines or specifications can be purchased from their web site. For these specific applications, we encourage the reader to familiarize themselves with this material.

## 1.7 Common Mechanical Insulation Problems

This section provides an overview of poor mechanical engineering practices that are commonly encountered in the field, as identified in the mechanical insulation White Paper<sup>12</sup>.

The following table summarizes common deficiencies identified, and the types of impacts that these deficiencies can result in.

**Table 1.7.1 - Common Mechanical Insulation Problems**

Deficiency	Effects or Impacts
No insulation (either not installed, or removed by maintenance contractors)	Excessive heat transfer
	Pipe or duct deterioration due to corrosion
	Risk of injury, e.g. from burns or sharp corners
	Condensation may damage building structures
	Energy efficient systems may not perform as specified
Improper installation	Same as above
No mechanical protection for insulation	Insulation removed by pests or damaged by exposure to the environment
	Vandalism damage to insulation
Improper selection of materials for insulation	Damage to insulation due to heat, corrosion or physical abrasion
	Excessive heat transfer and potential damage to the insulation
	Energy efficient systems may not perform as specified

The reasons for poor practice in the industry (identified during interviews) are numerous, and include:

- Outdated or incomplete engineering specifications, or lack of knowledge of best practices by engineers, especially for newer, high performance and low-temperature systems.
- Problems due to unqualified installers and inadequate training.
- Lowest cost tendering and “value engineering,” reducing costs below what is necessary for best practices, particularly when the developer is not the eventual owner or operator.

<sup>12</sup> Pipes Need Jackets Too: Conserving Energy, Saving Money and Reducing Greenhouse Gas Emissions in BC Buildings through Mechanical Insulation Practice and Standards. HB Lanarc, January 2011.

- A perception among some developers and engineers that mechanical insulation is not a critical building component. This may be due in part to lack of educational focus on this issue.
- Poor quality, lower cost insulation materials on the market.
- Challenges related to engineering field review, including assessing whether installations meet code and design specifications.
- A fragmented design and construction process where engineers and installers do not typically work closely together.
- Tight construction timelines and focus on drywall completion, which can prevent inspection of some systems.

Refer to Appendix A for example photographs of mechanical insulation problems.

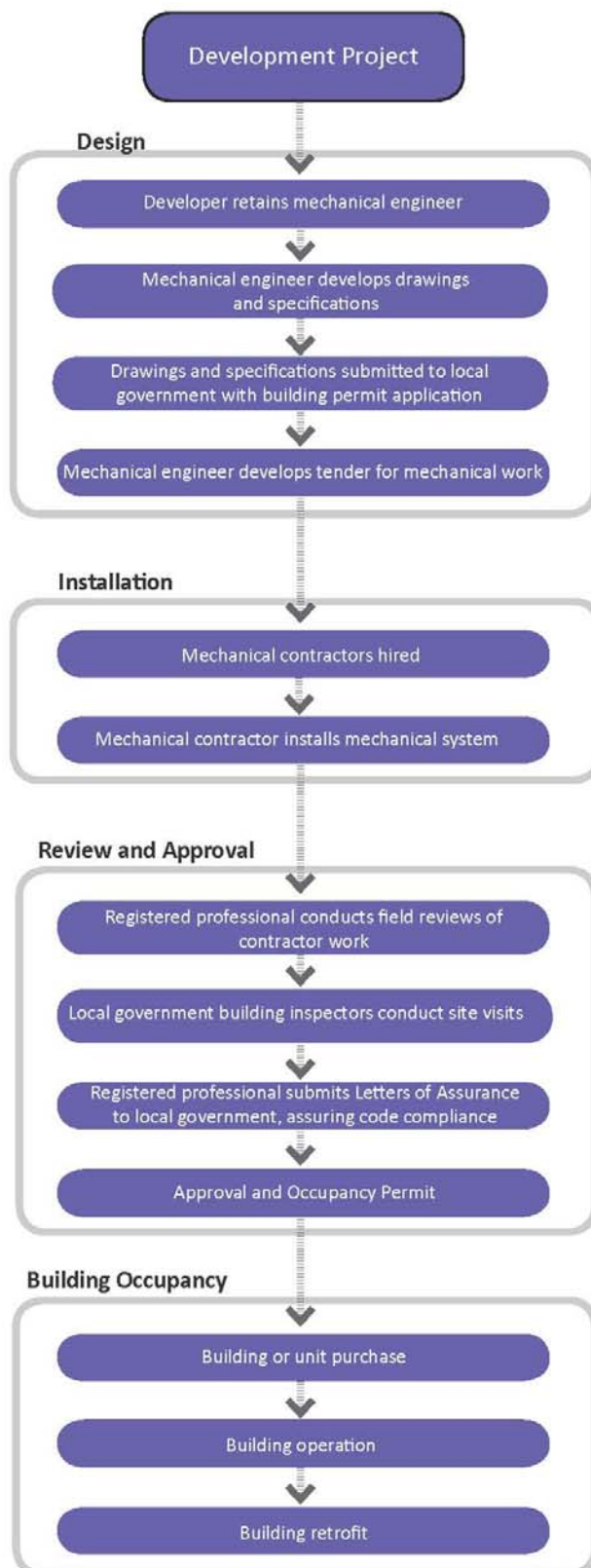
## ***1.8 Avoiding Problems through Best Practices and Processes***

Avoidance of the problems outlined above and achieving desired project objectives requires good practice to be implemented throughout the mechanical insulation process; it also requires participation of a range of project stakeholders.

### **.1 Example Project Process**

The following flow chart illustrates a typical process followed during a development project, as it pertains to mechanical insulation.

Figure 1.8.1 - Example Process for a Development Project.



## .2 Mechanical Insulation Roles and Responsibilities

Following are typical roles and responsibilities needed to achieve successful projects with respect to mechanical insulation objectives. These roles and responsibilities will vary somewhat by project and jurisdiction, and are not intended to replace roles and responsibilities that are required through regulation; rather they are intended to highlight the elements generally needed for good mechanical insulation practice throughout all phases of a project.

**Table 1.8.2 - Mechanical Insulation Roles and Responsibilities**

Project Participant	Key Role	Best Practice Elements
Building Developer, Owner, Project Manager	Hiring, business case review, overall decision making	<p>Understands the importance and value of mechanical insulation to their project.</p> <p>Hires engineers and contractors familiar with, and qualified in, mechanical insulation.</p>
Mechanical Engineer	Design and review	<p>Understands design objectives, code requirements and applicable standards.</p> <p>Helps developer/owner/project manager understand the business case for mechanical insulation.</p> <p>Develops or adapts up to date mechanical insulation specifications that are appropriate for each project.</p> <p>Conducts informed and timely field reviews to ensure the specification is fulfilled and best practices are implemented, and design objectives are not compromised by “value engineering.”</p> <p>Ensures inspections have been completed by a qualified party – e.g., 3<sup>rd</sup> party inspector or registered professional.</p>



Project Participant	Key Role	Best Practice Elements
Mechanical Contractor	Subcontracting or installation	<p>If subcontracting: subcontract to qualified mechanical insulation contractors.</p> <p>Familiar with Code objectives and material characteristics.</p> <p>Awareness of performance characteristics of the mechanical systems and implications of “value engineering” or incomplete insulation.</p> <p>Ensure insulation is installed only when the building is ready and dry.</p> <p>If installing: qualified in mechanical insulation installation best practices.</p>
Mechanical Insulation Contractor, Tradesperson	Subcontracting or installation	<p>If subcontracting: subcontract to qualified mechanical insulation installers.</p> <p>If installing: qualified in mechanical insulation installation best practices.</p>
3 <sup>rd</sup> Party Inspector	Inspection	<p>Conducts informed and timely inspections to ensure best practices are implemented.</p> <p>Qualified in mechanical insulation best practices and quality assurance.</p>
Local government building inspector	Inspection	<p>Qualified in mechanical insulation best practices and quality assurance and conducts informed and timely inspections to ensure best practices are implemented.</p> <p>OR</p> <p>Ensures inspections have been completed by a qualified party – e.g., 3<sup>rd</sup> party inspector or registered professional.</p>

Refer to the following section for recommendations on qualifications.

## ***1.9 Qualifications for Practitioners***

Consistent with the Roles and Responsibilities table above, recommended qualifications include:

- Mechanical engineer:
  - Registered Professional Engineer in BC with specific mechanical insulation knowledge and experience.
- Mechanical insulation contractors, installers and tradespersons – options include:
  - Accreditation as a Heat and Frost Insulator (Red Seal program).
  - Membership in BC Insulation Contractors Association.
- Inspector:
  - Certificate for mechanical insulation inspection from a recognized Quality Assurance program.

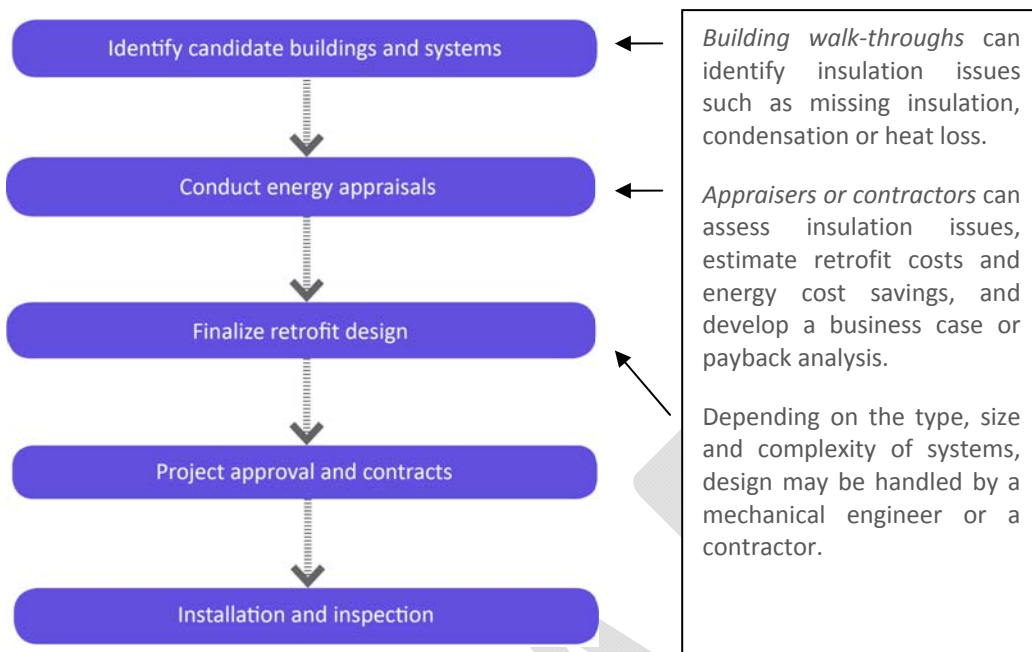
## ***1.10 Existing Buildings, Maintenance and Retrofits***

Retrofitting mechanical insulation in existing buildings is also a critical issue for practitioners and building owners/operators to be aware of. Most common is a failure to properly replace the insulation after removal when servicing/ replacing a pipe or valve.

Many existing buildings also have insufficient insulation installed, or other insulation deficiencies. This creates opportunities for a positive return on investment through retrofitting, while addressing other objectives such as protecting building components.

The following figure provides an example of a mechanical insulation retrofit process that includes assessment of energy savings.

Figure 1.11.1 - Example Retrofit Project Process



Three key elements for a successful mechanical insulation retrofit project include:

- Hiring mechanical contractors and insulation installers qualified in mechanical insulation
- Assessing the retrofit business case and recognizing the longer term risks of failing to maintain original mechanical insulation or correct deficiencies
- Timely and informed inspection and sign-off of the completed work.

## 2.0 Design, Materials and Quality Guidelines

This section provides guidance on the elements necessary to maximize mechanical insulation performance, with a focus on material selection, quality, and durability. The focus of this section is on commercial and institutional buildings and systems. Section 2.6 provides a high level overview of Industrial systems and refers to additional resources.

### 2.1 Performance Specifications

Specifications provide the basis for design and installation of mechanical insulation.

The construction industry commonly uses a MasterFormat specification that is modified for each project with up-to-date products and conditions. A limitation with this approach lies in the fact that detailed project information contained within the MasterFormat specification is not readily accessible or sometimes even available early on in the project design phase. With no project information available during the primary project description phase, the detailed MasterFormat specification that is produced may need considerable editing to accurately capture the goals of the project.

If a project is delivered by construction management (CM), or by an owner-builder, a big part of the CM's or the owner-builder's mandate is to look for equivalents that are less expensive, easier, or faster to construct—also known as value engineering. The precision of the MasterFormat specification may limit the creativity that the CM or owner-builder can bring to the value engineering process, leading to less than optimal results. Further, any changes have to undergo careful review by the specification writer and the designers to ensure that the performance requirements are met.

An alternative is to organize performance specifications by UniFormat instead of MasterFormat. The ASTM E1557 2010, Uniformat II standard is another way of looking at the project and its definitions. The Uniformat system is a top down project definition system *that can work in conjunction with the MasterFormat specification system*. The Uniformat system defines assemblies through performance and other user defined variables, starting at a concept level then progressively refines the project deliverables. Specific products are only an end result.

With UniFormat specifications almost all selections of proprietary materials and equipment can be left to the constructor, who selects them on the basis of detailed descriptions of performance attribute requirements.

This method provides more flexibility in meeting performance objectives and may result in cost savings to the owner. The method is ideal for projects where design goals can be easily described in written form.

The UniFormat II document structure can also be used for Preliminary Project Descriptions. Both performance specifications and Preliminary Project Descriptions share a similar approach, they differ

in purpose and level of detail. Preliminary Project Descriptions are not suitable as contract documents because descriptions of elements and their components are brief and intended only for conveying preliminary information to evaluate the practicality of the design. Performance specifications must have sufficient detail to be suitable for use as contract documents, including actual cost of the work.

The basic underlying ideas behind the concept of the Preliminary Project Description are:

- Written descriptions of the Schematic Design should be organized around systems and assemblies that correlate to prevailing industry methods of cost estimating for this phase.
- Written descriptions should allow design professionals to provide sufficient information for cost estimating without the necessity of making final design decisions.
- Written descriptions should document qualitative requirements for the project appropriate to the level of decision-making and detail in the design.
- Using an industry-standard organizational format provides a checklist to help design teams make sure all appropriate subjects are included.

Further, as the industry moves into using Building Information Modelling<sup>14</sup> (BIM) for producing construction documentation, designers should correlate the organization of information into functional elements in the Preliminary Project Description, which should correspond to the model objects in BIM or conventional CAD software. The major developers of BIM software use UniFormat as the organizing format for objects in the electronic model. By aligning the descriptions with objects in the electronic model, designers can achieve a unified presentation of the design not possible with un-structured narratives.

For purposes of this study, we have provided a simple UniFormat model project description as an example. Note that most elements will have multiple components. In these cases, it is necessary to describe requisites for the entire assembly as well as for the constituent parts.

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<sup>14</sup> Building information modeling (BIM) involves the generation and management of digital models of physical and functional characteristics of a facility, including visualization, coordination of construction documents, and other information.

**Table 2.1.1 - Example<sup>15</sup> Preliminary Project Description Using Unifomat**

<b>D20 Plumbing</b>	<p><u>Sustainability and Energy Performance:</u> At minimum, meet ASHRAE 90.1 2007 requirements for mechanical insulation.</p> <p>Whole building to achieve LEED 2009 NC Gold certification with 2 “optimize energy” points – equivalent to 14% improvement over ASHRAE 90.1 2007. MI may be optimized to help meet economic and whole building LEED energy objectives.</p> <p><u>Aesthetic Requirements:</u> Match appearance of existing building.</p>
D2010 Domestic Water Distribution	<p><u>Service life:</u> Greater than 25 years.</p>
D2010.40 Domestic Water Piping	<p><u>Materials:</u> Copper on main vertical runs and where pipe diameter greater than 1 inch and PEX piping used within suites. No reduction in insulation for claimed R- Value.</p> <p><u>Supports:</u> As required by Plumbing Code.</p> <p><u>Labeling:</u> All valves and pipe to have tags and labels indicating on/off positions and direction of flow within equipment rooms.</p> <p><u>Data Acquisition:</u> Provide water meters on hot and cold water lines and thermostats on tanks, supply and return piping.</p>

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<sup>15</sup> Content is provided as an example, and is not intended as actual design information

Insulation and Vapour Retarder	<p><u>Application:</u> Insulate all copper, pex and other pipe, valves and fittings</p> <p><u>Labeling:</u> to match standard for Domestic Water Piping</p> <p><u>Thermal performance:</u> to meet minimum pipe insulation thickness requirements or exceed ASHRAE 189.1 requirements.</p> <p><u>Vapour Retarder:</u> Required on cold water piping.</p> <p><u>Mechanical Protection:</u> Outside of building envelope and in certain areas of parking garage.</p> <p><u>Service Life and Durability:</u> Insulation systems should remain in service for the life of the piping system and the appearance should remain as new throughout the life of the system.</p> <p><u>Installation Requirements:</u> All valves and fittings to be insulated.</p> <p><u>Fire Rating:</u> 25</p> <p><u>Smoke Developed Rating:</u> 50</p>
<b>D30 Heating, Ventilation and Air Conditioning</b>	<p><u>Thermal Performance Requirements:</u> At minimum, meet ASHRAE 90.1 2007 requirements for mechanical insulation.</p> <p><u>Sustainability Requirements:</u> Whole building to achieve LEED 2009 NC Gold certification with 2 “optimize energy” points – equivalent to 14% improvement over ASHRAE 90.1 2007. MI may be optimized to help meet economic and LEED objectives.</p> <p><u>Sustainability Requirements:</u> Meet or exceed ASHRAE 189.1.</p> <p><u>Aesthetic Requirements:</u> Match appearance of existing building</p>
D3030 Cooling Systems	<p><u>Service Life:</u> Greater than 40 years</p>
D3030.30 Evaporative Air Cooling	<p><u>Materials:</u> Galvanized steel and aluminum.</p> <p><u>Supports:</u> As required by SMACNA.</p> <p><u>Labeling:</u> All ducts to have tags and labels for service and direction of flow within equipment rooms.</p> <p><u>Data Acquisition:</u> Provide water meters on hot and cold water lines and thermostats on tanks, supply and return piping.</p>

Insulation and Vapour Retarder	<p><u>Application:</u> Insulate all heating and cooling supply air ducts.</p> <p><u>Labeling:</u> To match standard for Supply Air.</p> <p><u>Thermal Performance:</u> U value to meet or exceed ASHRAE 189.1 requirements.</p> <p><u>Vapour Retarder:</u> Required on cold air supply duct work.</p> <p><u>Mechanical Protection:</u> Outside of building envelope and in certain areas of parking garage.</p> <p><u>Service Life and Durability:</u> Insulation systems should remain in service for the life of the duct system and the appearance should remain as new throughout the life of the system.</p> <p><u>Fire Rating:</u> 25</p> <p><u>Smoke Developed Rating:</u> 50</p>
D3050 Facility HVAC Distribution System	<p><u>Service Life:</u> Greater than 40 years.</p>
D3050.10 Hydronic Distribution	<p><u>Materials:</u> Seamless, ERW, Sch 40, Copper.</p> <p><u>Supports:</u> As required by Building Code.</p> <p><u>Labeling:</u> All piping to have valve tags and labels for direction of flow within equipment rooms.</p> <p><u>Data Acquisition:</u> Provide pressure gauges on pumps.</p>
Insulation and Vapour Retarder	<p><u>Application:</u> Insulate all heating and cooling supply piping.</p> <p><u>Labeling:</u> To match standard for Hydronic Distribution.</p> <p><u>Thermal Performance:</u> U value to meet or exceed ASHRAE 189.1 requirements.</p> <p><u>Vapour Retarder:</u> Required on chill water supply piping.</p> <p><u>Mechanical Protection:</u> Outside of building envelope and in certain areas of parking garage.</p> <p><u>Service Life and Durability:</u> Insulation systems should remain in service for the life of the duct system and the appearance should remain as new throughout the life of the system.</p> <p><u>Fire Rating:</u> 25</p> <p><u>Smoke Developed Rating:</u> 50</p>



D3050.50 HVAC Air Distribution	<p><u>Materials:</u> Galvanized steel and aluminum.</p> <p><u>Supports:</u> As required by SMACNA.</p> <p><u>Labeling:</u> All ducts to have tags and labels for service and direction of flow within equipment rooms.</p> <p><u>Data Acquisition:</u> Provide pressure gauges across all filters.</p>
Insulation and Vapour Retarder	<p><u>Application:</u> Insulate all heating and cooling supply air ducts.</p> <p><u>Labeling:</u> To match standard for Supply Air.</p> <p><u>Thermal Performance:</u> U value to meet or exceed ASHRAE 189.1 requirements.</p> <p><u>Vapour Retarder:</u> Required on cold air supply duct work.</p> <p><u>Mechanical Protection:</u> Outside of building envelope and in certain areas of parking garage.</p> <p><u>Service Life and Durability:</u> Insulation systems should remain in service for the life of the duct system and the appearance should remain as new throughout the life of the system.</p> <p><u>Fire Rating:</u> 25</p> <p><u>Smoke Developed Rating:</u> 50</p>

In Section 3 of this Guide, detailed reference specifications are provided using MasterFormat, and a numbering matrix for MasterFormat and UniFormat is provided. Either or both formats may be used for a given project, depending on project needs.

## ***2.2 Design Considerations & Objectives***

### **.1 Economic Performance Analysis**

Construction costs and capital cost reduction are common drivers of mechanical insulation practices. However, it is important to note that this approach does not consider the operations and maintenance costs. Economic performance should include both capital, operating and maintenance costs over the life of the equipment.

Overall economic performance will be determined primarily by:

- Capital costs of insulation materials and labour
- Energy consumption costs, which are related to thermal performance of the insulation
- System maintenance costs, which are related to the mechanical insulation materials and installation
- Costs associated with space requirements of mechanical insulation.

The greatest energy benefits from mechanical insulation are found in systems that have the highest rates of heat transfer; this occurs where temperature difference is the greatest. The following table shows typical levels of heat loss based on system type, insulation thickness, and surface temperature, assuming a constant ambient temperature.

**Table 2.2.1 - Example Heat Transfer Rates<sup>16</sup>**

System	Surface Temp (°C)	Insulation Thickness (mm)	Heat Transfer Rate	Energy Losses (kWh/yr)	Example Lost Energy Cost <sup>17</sup> (\$/yr)
Duct System— heating	49	0	249 W/m <sup>2</sup>	2,181	\$180
		25	31 W/m <sup>2</sup>	272	\$22
		50	17 W/m <sup>2</sup>	149	\$12
Duct System— cooling	10	0	102 W/m <sup>2</sup>	894	\$74
		25	15 W/m <sup>2</sup>	131	\$11
		50	8 W/m <sup>2</sup>	70	\$6
Piping System— heating (40 mm NPS)	82.2	0	119 W/m	1,042	\$86
		25	18 W/m	158	\$13
		50	11 W/m	96	\$8
Piping System— chilled water (40 mm NPS)	4.4	0	25 W/m	219	\$18
		25	5 W/m	44	\$4
		50	3 W/m	26	\$2
Piping System— condenser water (100 mm NPS)	29.4	0	21 W/m	184	\$15
		25	4 W/m	35	\$3
		50	2 W/m	18	\$1

**Notes:**

- All cases above (where insulation thickness is greater than 0) assume jacketed mineral fibre insulation.

<sup>16</sup> Note heat transfer units shown are different for ducts and pipes (per unit area vs. unit length respectively); similarly, energy losses and energy costs are referenced to the same units – i.e., per m<sup>2</sup> or per m.

<sup>17</sup> Energy costs are estimated assuming electrical power at approx. \$0.08/kWh, the same across all cases for simplicity. The values shown are for comparative purposes, and will change over time as energy prices change.

## .2 Key Design Objectives

In addition to minimum Code and regulatory requirements (e.g., fire, smoke & safety), insulation in commercial and institutional buildings such as schools, shopping centers, warehouses, hospitals, hotels and other public buildings is designed primarily to reduce energy consumption and/or prevent condensation. Appearance is another objective that is typically most important in mechanical rooms. The types of mechanical systems commonly insulated in commercial buildings vary only slightly from project to project, and involve a relatively narrow temperature range. The following table provides guidance on the primary mechanical insulation design objectives that apply to a range of system types\*.

**Table 2.2.2 - Key Design Objectives by System Type and Temperature Range**

System	Temperature Range	Typical Design Objectives					
		Personnel Protection*	Fire*	Vapour Retarder	Thermal	Noise	Appearance
Plumbing	13°C to 80°C	X		X	X		X
Ducts and housings	15°C to 43°C			X	X	X	X
Steam and condensate	100°C to 185°C	X			X		X
Outdoor air intake	seasonal outdoor temp range			X	X	X	X
Roof drains	1°C to 15°C			X			
Hot water heating	80°C to 100°C	X			X		X
Chilled water	5°C to 13°C			X	X		X
Engine exhaust	approximately 675°C	X	X			X	X
Kitchen exhaust ducts	approximately 1100°C	X	X			X	X
Refrigerant suction	-40°C to 10°C	X		X	X		X

\*All fire, smoke and safety objectives for any system types must conform to the BC Building Code and any other applicable regulations and standards; the above table does not supersede requirements of the BC Building Code or other regulations.

**.3 Green Building Rating Frameworks**

There are opportunities to support achievement of green building rating system points and meet minimum requirements through increased mechanical insulation thickness and material selection. This includes:

1. Improving thermal performance can help meet energy performance objectives within green building rating systems. For example, “Optimize Energy Performance” credits within LEED® (Leadership in Energy and Environmental Design) Canada - NC 1.0, or NC/CS 2009. Note that there are different pathways to validate energy performance within LEED; for example, if a whole building energy modelling path is chosen, the modelling method would need to recognize the energy gains provided by mechanical insulation, in order to benefit the LEED performance.
2. Materials chosen for mechanical insulation may need to meet specific requirements. For example, the Living Building Challenge<sup>18</sup> includes a “Red List” of prohibited materials and chemicals<sup>19</sup>, which will restrict the acceptable mechanical insulation materials. In this case, suppliers and manufacturers product specifications will need to be consulted to confirm compliance.

**.4 Applicable Systems and Components**

The following table provides a list of system elements that should be considered for mechanical insulation in a commercial or institutional project, organized by system type (across columns), to help practitioners in identifying all elements that may require mechanical insulation.

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<sup>18</sup> The Living Building Challenge is currently a program under the International Living Future Institute, and has been endorsed by the Canada and US Green Building Councils.

<sup>19</sup> The framework allows for some temporary exceptions.

**Table 2.2.3 - Mechanical Insulation Commercial and Institutional System Components Check List**

Plumbing	Ducts and housings	Steam and condensate	Hot water heating	Chilled water	Engine exhaust	Kitchen exhaust ducts	Refrigerant suction
Cold Water	High Pressure Supply	Steam (High, Medium and/or Low Pressure)	Hot Water Heating Supply/Return	Chilled Water Supply/Return	Generators	Kitchen Exhaust	Refrigeration Piping, Drains and Equipment
Hot Water	Low Pressure Supply	Condensate (from trap to receiver tank)	Pumps (chilled/hot)	Refrigeration Suction	Breechings/Flues		
Hot Water Circulating	Return Air	Pumped Condensate (from receiver to boiler or feed water heater)	Expansion Tanks	Cooling Tower			
Soil, Waste, Vent and/or Drain Lines	Mixed Air	Boiler Feed Water	Air Eliminators	Condensate Drain Lines			
Cold Water Storage Tanks	Plenums and Housings	Cold Water Make-up	Boilers	Chillers			
Horizontal Suspended Roof Drain Piping and/or Roof Sumps	VAV and Terminal Units, and Mixing Boxes	Flash Tanks		Converters/Heat Exchangers			
	Drops to Diffusers and/or Flexible Ducts	Condensate Receivers, Deaerator and Feed Water Tanks					
	Exhaust (from dampers to outside louvers)						

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

## **.5 Analysis Tools**

Software analytical tools can help designers to determine the appropriate amount of insulation in order to optimize thermal performance and cost.

### **.1 *3E Plus® Insulation Thickness Computer Program* ([www.pipeinsulation.org](http://www.pipeinsulation.org))**

The 3E Plus® Insulation Thickness Computer Program is an industrial energy management tool developed by the North American Insulation Manufacturers Association (NAIMA) to simplify the task of determining how much insulation is necessary to use less energy, reduce plant emissions and improve system process efficiency. The 3E Plus program can:

- Calculate the thermal performance of both insulated and uninsulated piping, ducts and equipment
- Translate BTU losses into actual dollars
- Calculate greenhouse gas emission and reductions

### **.2 *Whole Building Design Guide* ([www.wbdg.org/design/midg.php](http://www.wbdg.org/design/midg.php))**

The online Mechanical Insulation Design Guide, part of the WBDG, provides several tools related to economic and financial performance.

These two tools provide a simple to use calculation of energy savings and payback for different design options:

- Energy Calculator for Equipment (Vertical Flat Surfaces)
- Energy Calculator for Horizontal Piping

This tool provides project cash flows, return on investment, and NPV, from energy savings and other inputs:

- Mechanical Insulation Financial Calculator

The WBDG also provides a “time to freezing” calculator, which estimates the time for a long, water-filled pipe or tube (with no flow) to reach the freezing temperature.

## 2.3 Materials Selection

This section provides guidance on selection of mechanical insulation materials, based on factors including temperature ranges, material characteristics, and system type.

### .1 Insulation Selection

In addition to thermal performance, other considerations are important in selection of insulation material. The following table discusses these considerations for each operating temperature range.

**Table 2.3.1 - Material Selection Considerations by Temperature Range**

Temp Range	Selection Considerations
<p>Low (15° to -75°C)</p>	<p>The major design problems on low temperature installations are moisture penetration and operating efficiency. For applications below 0°C, the insulation material should have low water adsorption.</p> <p>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.</p> <p>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.</p> <p>The low temperature range is further divided into application classifications.</p> <ol style="list-style-type: none"> <li>1. Refrigeration (0°C through -75°C) <p>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.</p> </li> <li>2. Cold and chilled water (15°C through 0°C) <p>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.</p> </li> </ol>



Medium (15° 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.
High (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.

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 that 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.

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.

All insulation, jacket, adhesives, mastics, sealers, etc., utilized in the fabrication of these systems shall meet NFPA for fire resistant ratings (maximum of 25 flame spread and 50 smoke developed ratings) and shall be approved by the insulation manufacturer for guaranteed performances when incorporated into their insulation system, unless a specific product is specified for a specific application and is stated as an exception to this requirement.

Care should be taken in designing insulation systems to specify the thickness, material and finish. All materials, thicknesses, finishes, securements and design objectives should be carefully communicated to the insulation contractor.

## .2 General Materials Selection Tables

The following two tables provide general guidance on appropriate materials choices based on system temperature and system type respectively. Note that in some cases there may be exceptions to the temperature ranges shown; consult manufacturer's product specifications.

For more detailed information on insulation materials descriptions, characteristics and physical properties, refer to Appendix B, Materials Reference Tables.

**Table 2.3.2 - Mechanical Insulation Temperature Selection Table**

	<b>Low (-75°C to 15°C)</b>	<b>Medium (15°C to 315°C)</b>	<b>High (315°C to 815°C)</b>
Polyethylene	X		
Polyisocyanurate	X		
Elastomeric and Foamed Plastic	X	X*	
Fibre Glass	X	X*	X*†
Cellular Glass	X	X	X*
Perlite or Expanded Silica	X	X	X*
Mineral Fibre	X	X	X
Calcium Silicate		X	X
Refractory Fibre			X

\* Indicates temperature range exceeds rating for insulation; in this case the material would be suitable only at the lower end of the temperature range.

†There are some fibre glass products available that can service the lower end of this range.

**Table 2.3.3 - Material Recommendations by System Type for Commercial & Institutional Systems**

System	Poly-ethylene	Polyiso-cyanurate	Elasto-meric & foamed plastic	Fibre-glass	Cellular Glass	Perlite or Expanded Silica	Mineral Fibre	Calcium Silicate	Refract-ory Fibre
Plumbing	X	X	X	X	X		X		
Ducts and housings		X	X	X	X	X	X		
Steam and condensate				X	X	X	X	X	X
Outdoor air intake	X	X	X	X	X	X	X		
Roof drains	X		X	X			X		
Hot water heating		X	X	X		X	X		
Chilled water	X	X	X	X	X	X	X		
Engine exhaust						X	X	X	X
Kitchen exhaust ducts						X			X
Refrigerant suction	X	X		X	X	X	X	X	

### .3 Protective Covering Selection

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.

**Table 2.3.4 - Mechanical Insulation Covering Types and Descriptions**

Protective Coverings	
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 materials. 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.

Protective Coverings	
VAPOUR RETARDERS	<p>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:</p> <ol style="list-style-type: none"> <li>1. Rigid jacketing - plastic fabricated jackets<sup>20</sup> to the exact dimensions required and sealed vapour retarding.</li> <li>2. 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.)</li> <li>3. Mastic applications - solvent types which provide a seamless coating but require time to dry.</li> </ol>
MECHANICAL ABUSE COVERINGS	<p>The jacket stiffness and compressibility of the insulation need to be considered together, in order to avoid damage or deteriorating appearance that can potentially arise – e.g., a denting of a jacket on a compressible insulation material.</p>
CORROSION AND FIRE RESISTANT COVERINGS	<p>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).</p> <p>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.</p>
APPEARANCE COVERINGS AND FINISHES	<p>Various coatings, finishing cements, fitting covers and jackets are chosen primarily for their appearance value in exposed areas.</p>

<sup>20</sup> Note that PVC jacketing would not be suitable for “Living Building” certification, as it would fall on the “Red List”; other jacketing and insulation materials may also fall on this list (see section 2.2.3).

Protective Coverings	
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.

Specific materials have not been recommended for protective covering; commonly, the insulation and jacket must work together as a system to achieve the design goals. Manufacturers of these systems are best qualified to make recommendations, in consideration of the conditions.

## ***2.4 Building Envelope, Air Barrier and Fire Stopping***

Mechanical insulation interacts with building components such as walls, partitions and roofs, and these boundaries need to be considered in design and installation of the mechanical insulation system.

An air barrier is required by the building code to maintain a controlled interior environment. Air barriers are different than vapour barriers in that an air barrier is to stop air infiltration or exfiltration, whereas vapour barriers slow down or arrest moisture movement by vapour diffusion through building enclosure materials. At any location in the building's enclosure, an air barrier seal is subjected to a range of air pressure differences in both directions. The highest design loads are usually due to wind pressure during storms; these are high enough to cause many sheet materials to vibrate and tear off their fastenings. An air barrier must withstand much higher physical forces than a vapour barrier.

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. Further fire stopping may be required to meet to the Building Code requirements for the ratings of the wall assemblies. Fire stopping materials may function as air barrier materials; however this should be verified with the manufacturer. All firestopping materials proposed to be used must conform to ULC-S115 and CAN/ULC- S101. The suitability of the material should be confirmed with the Authority Having Jurisdiction by the contractor prior to its application.

## 2.5 Installation Review Guidelines and Checklist

For field review of mechanical insulation installation, the following table lists the key inspection categories that should be included, and references sections in this document that provide additional relevant information.

**Table 2.5.1 – Installation Review Checklist and Cross Reference**

Checklist Category	Description	Reference Sections
Safety (Personnel Protection and Fire)	Protect people from injury	Table 2.2.2 - Key Design Objectives by System Type and Temperature Range
BC Building Code	Primarily flame spread, smoke developed and fire stopping	Appendix B, Materials Reference Tables; Section 2.4, Building Envelope, Air Barrier and Fire Stopping.
Application	Which systems require insulation <sup>21</sup>	Tables 2.2.2 Key Design Objectives by System Type and Temperature Range, 2.2.3 Mechanical Insulation Commercial and Institutional System Components Check List, and 2.3.1 Material Selection Considerations by Temperature Range
Material Selection	Material suitable for application <sup>22</sup>	Appendix B, Materials Reference Tables; 2.3.2 Mechanical Insulation Temperature Selection Table
Installation Standards	Weatherproofing, jacketing, pipe support <sup>23</sup> , vapour barrier	Table 2.3.11 - Mechanical Insulation Covering Types and Descriptions

<sup>21</sup>Attention should be paid to proper insulation of fittings and equipment such as flanges and valves, which are often missed.

<sup>22</sup> Many materials look alike but are not; attention should be paid to ensure materials and labels match specifications.

<sup>23</sup>Most pipe support systems require insulation between the pipe and hangar; in this case care must be taken to protect insulation from damage from the hangar.



## 2.6 Industrial Systems

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. The following table provides an overview of some of the considerations in design and application for industrial systems. However, for detailed information on mechanical insulation for industrial systems, refer to the TIAC Best Practices Guide and Process Industry Practices resources referenced earlier.

**Table 2.6.1 - Key Design Considerations for Industrial Applications**

Parameter	Description
Temperature	Temperature parameters may be much more stringent and variable over time than with commercial systems.
Corrosion	There may be risks of corrosive gases or process chemicals which may be factor.
Fire	Fire hazards may be severe owing to the presence of volatile substances.
Personnel Safety	It may be necessary for personnel to work in close proximity to mechanical insulation and therefore surface temperatures must be accurately known.
Sanitary Contamination	The process industry may involve food, meat packing, soap, cosmetic, dairy or brewery processes.
Mechanical Abuse	Abuse to insulations from excessive handling, foot traffic on vessel tops and lines, and the added movement of expansion, contraction and vibration.
Maintenance	It may be necessary to remove insulation for maintenance.
Accessibility/ Clearance	Critical clearance and space limitations coupled with the need for greater thickness of insulations.
Radiation	There may be radiation hazards.
Scheduling for installation	Complex construction and installation schedules.
Electrical properties	Insulation may have to be grounded or non-conductive.

### 3.0 Developing Project Specifications

There are multiple references from which specifications for a given project may be developed (see the Summary of Key Codes and Standards section earlier) including:

- BCICA Quality Standards for Mechanical Insulation
- Thermal Insulation Association of Canada

Appendix C includes reference specifications that cover the most common scenarios.

Four 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).

**Table 3.0.1 – Specification Numbering Formats**

NMS Numbering Matrix MasterFormat 1994 to 2004 and UniFormat (2010)					
1995 Format		2004 Format		UniFormat	
15075	Thermal Insulation for Piping	23 05 54	Thermal Insulation for Piping	D2010.40	Domestic Water Piping
				D2020.40	Sanitary Sewage Piping
				D2030.20	Stormwater Drainage Piping
				D2060.50	Process Water Systems
				D3050.10	Facility Hydronic Distribution
				D3050.30	Facility Steam Distribution
15082	Thermal Insulation for Ducting	23 07 13	Thermal Insulation for Ducting	D3050.50	HVAC Air Distribution
				D3050.10	Supply Air
				D3060.20	Return Air
				D.3060.30	Exhaust Air
				D3060.40	Outside Air
15083	Thermal Insulation for Equipment	21 07 18	Thermal Insulation for Equipment	D3020.10	Heat Generation

NMS Numbering Matrix MasterFormat 1994 to 2004 and UniFormat (2010)					
1995 Format		2004 Format		UniFormat	
				D3020.20	Thermal Heat Storage
				D3030.50	Thermal Cool Storage
15084	Acoustic Duct Lining	23 33 53	Acoustic Duct Lining	D3050.50	HVAC Air Distribution
				D3050.10	Supply Air
				D3060.20	Return Air
				D.3060.30	Exhaust Air
				D3060.40	Outside Air

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.

## 4.0 Glossary and References

General glossaries applicable to mechanical insulation can be found in these references:

- BCICA Quality Standards for Mechanical Insulation
- Thermal Insulation Association of Canada Mechanical Insulation Best Practices Guide

### 4.1 References

ASHRAE. 2005. ASHRAE Handbook-Fundamentals. Atlanta: American Society of Heating Refrigeration and Air Conditioning Engineers, Inc.

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HB Lanarc. 2010. Pipes Need Jackets Too – Improving Performance of BC Buildings through Mechanical Insulation Practice and Standards – A White Paper. Prepared for the International Association of Heat and Frost Insulators and Allied Workers (IAHFIAW) – Local 118.

Lawrence, Tom Ph.D., P.E. LEED-AP. 2010. The (Proposed) ASHRAE 189.1 Standard High Performance Green Buildings. Taken from the Mississippi Valley web site in 2011. <http://www.mississippivalleyashrae.org/archive/stds189.pdf>.

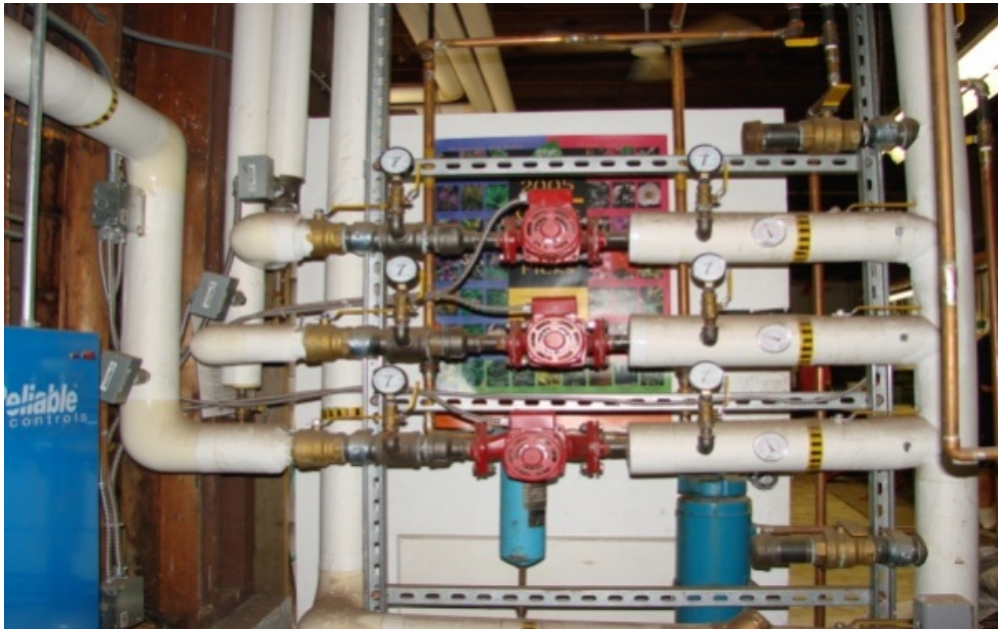
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## 5.0 Appendices

### 5.1 *Appendix A: Photographs of Mechanical Insulation Issues*

This section illustrates examples of some mechanical insulation issues from the field<sup>24</sup>.



**Photo 1 - Detail showing circulation pumps on a hydronic distribution system**

When installed properly (Photo 1), the service life of the insulation will usually match the service life of the piping, ducts or equipment it is installed on.

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<sup>24</sup> Pipes Need Jackets Too: Conserving Energy, Saving Money and Reducing Greenhouse Gas Emissions in BC Buildings through Mechanical Insulation Practice and Standards. HB Lanarc, January 2011.



**Photo 2 - Detail showing un-insulated hydronic distribution system and heat exchanger for domestic hot water system**

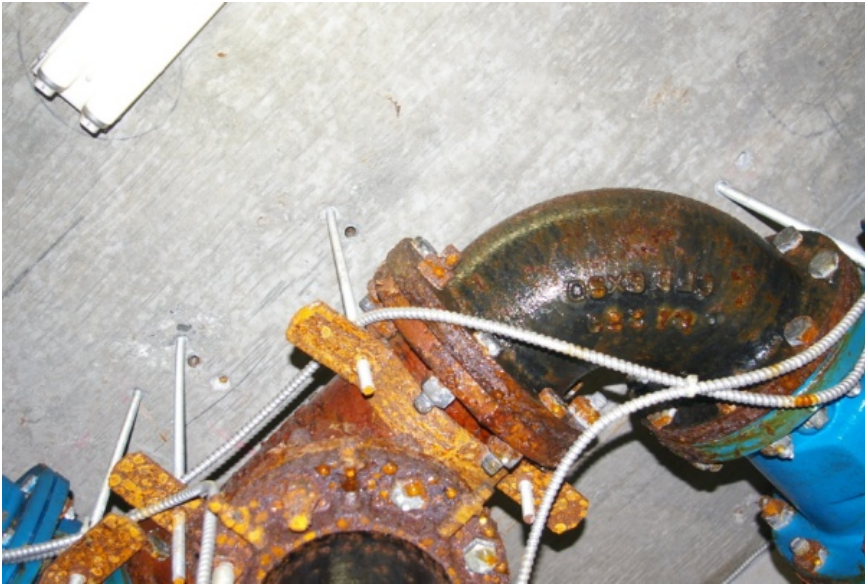
However, it is common to not see insulation (Photo 2) in mechanical rooms and on pipe and duct runs through buildings. Energy is often wasted by transfer into unheated areas that don't need any heat (e.g. mechanical rooms) or pipe chases.



**Photo 3 - Detail showing backflow preventer on domestic water supply line. Note the water dripping from the device.**



It is common to see condensation on un-insulated sections of domestic water piping and fittings. The preceding photo (Photo 3) shows condensation on a backflow preventer. Generally fittings are made of brass or stainless steel and these are not affected by some condensation; however, there will be an increased heat transfer rate due to condensation. Where carbon steel piping or fittings are used, the affects of condensation may be more serious (Photo 4 and 5). Also, condensation can damage building elements such as drywall, ceiling tile and concrete below dripping pipes.



**Photo 4 - Detail showing corrosion damage to pipe fittings as the result of condensation.**



**Photo 5 - Detail showing heat exchangers used with domestic water system approximately 12 years old. Note the build up of deposits on the heat exchangers.**



**Photo 6 - Detail showing rubber insulation on a hot gas refrigerant line. The insulation should be jacketed to protect it from sun and birds.**

Problems with insulation are not limited to whether there is insulation installed or not. Sometimes designers or contractors have made poor choices or have not adequately protected the insulation from environmental damage. The preceding photo (Photo 6) gives an example of rubber closed cell foam insulation that has been attacked by birds. At the time this photo was taken, the insulation was less than one year old. When installed properly, this kind of insulation would have a PVC jacket which prevents damage from pests and from the ultraviolet rays from the sun, extending the insulation service life.



## 5.2 *Appendix B: Materials Reference Tables*

The following tables provide descriptions of common mechanical insulation materials. This information is primarily based on the Thermal Insulation Association of Canada Mechanical Insulation Best Practices Guide<sup>25</sup>, the text *Introduction to Heat Transfer*<sup>26</sup>, and discussions with an expert reviewer<sup>27</sup>. Some additional information sources were used in specific sections as noted.

DRAFT

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<sup>25</sup> <http://www.tiac.ca/en/specifications/download.shtml>; May 2012.

<sup>26</sup> Incropera, Frank P. and David P. De Witt. *Introduction to Heat Transfer*. John Wiley & Sons, New York, 1990.

<sup>27</sup> Interview with Chris Ishkanian, SPI/Burnaby Insulation (Div. of Superior Plus LP), May 29, 2012.

## Polyethylene Pipe Insulation



### Description

Polyethylene insulation is a low density, polymer-based and easy-to-apply tubing product that is available in a wide variety of sizes in semi-slit and self-sealing designs. This material is low cost, generally best for indoor and domestic applications such as domestic water piping. It is not suitable for hot water heating piping because of the upper temperature limits. This material typically comes pre-formed with self-sealing lap joints. It is easy to install, and is often able to bend around fittings. Polyethylene should always be jacketed outdoors with a PVC or metal jacket to avoid shortening of the service life.

The flame spread/smoke developed rating is understood to be 25/50, however designers should exercise some caution in applying these numbers. If these are critical factors, foam based plastic insulations are not the best choice.

Elastomeric insulation is a higher quality product.

Additional information sources cited:

<http://www.tundrafoam.com/uploads/file/3 ITP%20Sellsheets PolyPipe Insulation.pdf>

### Physical Properties

Installed Cost Ref	Density	Temperature Range	Thermal Conductivity
Low	24 kg/m <sup>3</sup>	-68 to 80°C	0.036 W/m°K
UV Resistance	Flame Spread	Smoke Developed	Compressive Strength
Low	25	50	Low

### Polyisocyanurate Insulation with All Service Jacket (ASJ)



#### Description

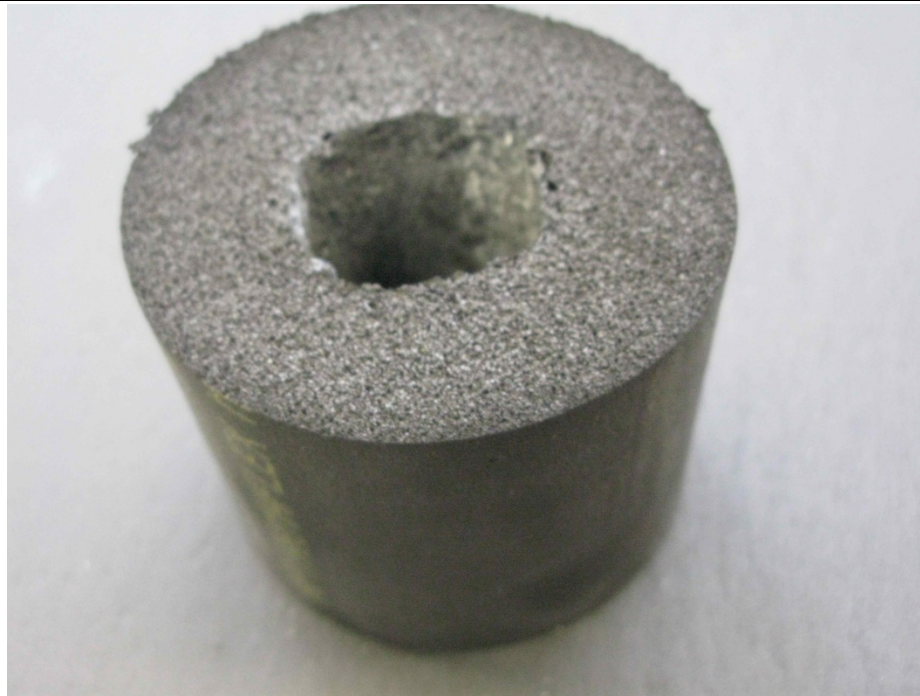
Polyisocyanurate is often referred to as “polyiso” by industry. It is a closed cell, high performance insulation for pipe, vessels, and equipment. It has a very low thermal conductivity and dimensional stability over a broad temperature range and it is a cost-effective choice for chilled water, hot water and other pipe insulation systems with service temperatures from -183°C to 149°C. It is available in a variety of densities and compressive strengths.

It is shown in the picture above with an ASJ cover, however it is commonly supplied to the distributor in billet form. The distributor must have special equipment to prepare pipe insulation in the form shown above; this would contribute to the finished product lead time. The material requires a vapour barrier when used in low ambient temperature applications. Further, off-gassing is an issue throughout the early service life of the material. Care must be taken to protect this material from UV, to avoid shortening the service life.

#### Physical Properties

Installed Cost Ref	Density	Temperature Range	Thermal Conductivity
Low	26 kg/m <sup>3</sup>	-183°C to 149°C	0.023 W/m²K
UV Resistance	Flame Spread	Smoke Developed	Compressive Strength
Medium	25	130 (It is available in smaller thicknesses with a 50 smoke developed rating.)	860 kPa (or 125 PSI)

## Elastomeric Insulation



### Description

Elastomeric insulation is produced from foaming plastic resins to create predominately closed cellular rigid materials, providing lower thermal conductivity. It is light-weight with excellent cutting characteristics. Available in pre-formed shapes including tube and boards, it is generally used in the lower intermediate and the entire low temperature ranges, for example in heat preservation of central air-conditioning systems, chilled water pipes, condensate pipes, air ducts and hot-water pipes of HVAC equipment. It is the preferred material for low temperature pipes because of the moisture-proof property.

While it has fire retarding capabilities, it is important to keep in mind that it is a plastic material.

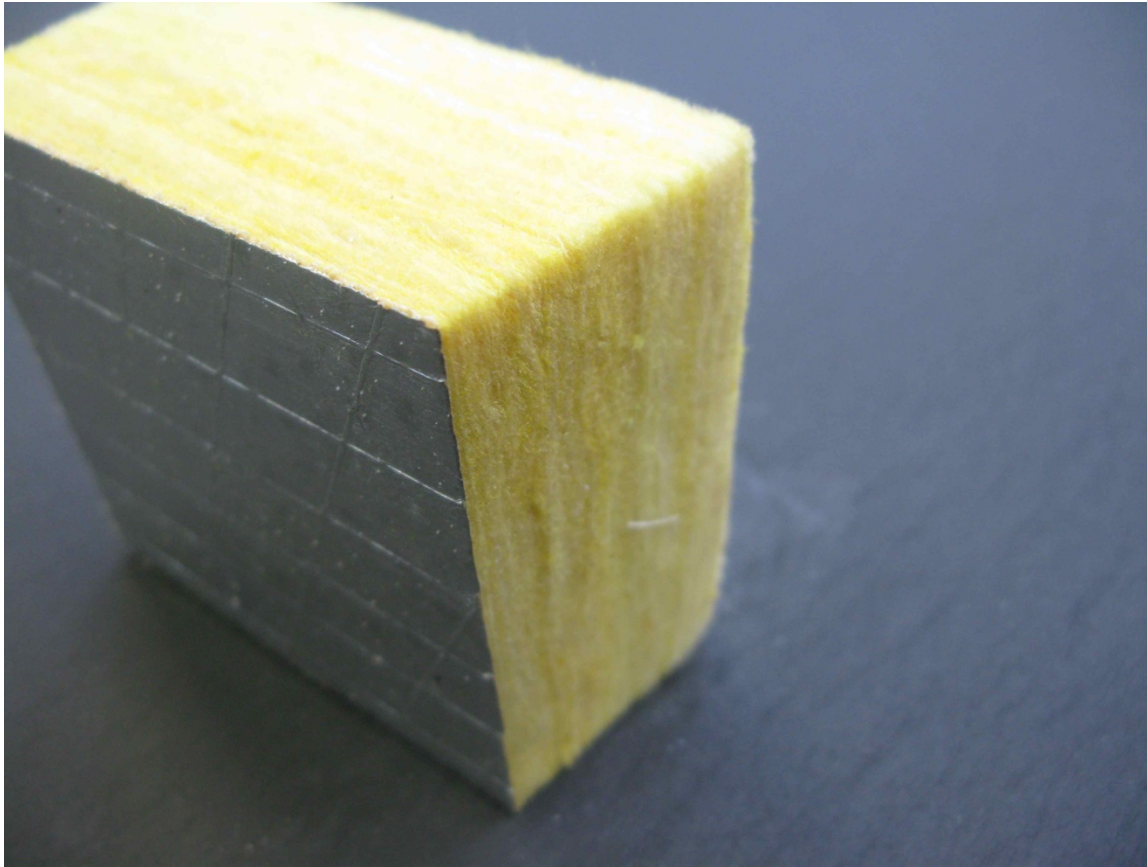
Also note that thermal resistance declines and thermal conductivity increases after initial use as the gas trapped within the cellular structure is eventually replaced by air.

### Physical Properties

Installed Cost Ref	Density	Max working temp	Thermal Conductivity
Medium (more expensive than polyethylene)	55 kg/m <sup>3</sup>	125°C	.03 W/m*°K
UV Resistance	Flame Spread	Smoke Developed	Compressive Strength
Typically poor, however light stabilized materials perform better	95	Over 50	< 480 kPa (or <70 PSI)



## Fibreglass with Foil Scrim Vapour Retarder



### Description

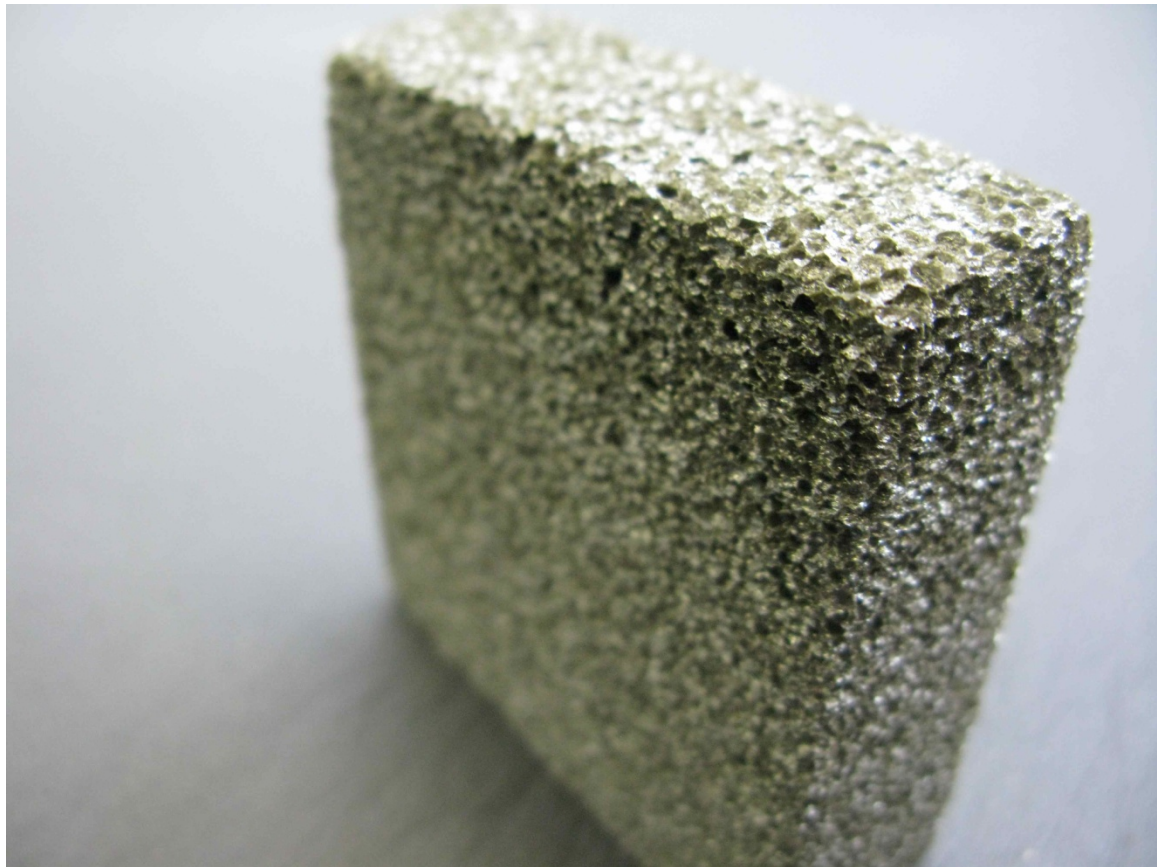
Fibreglass insulation is available in board and block form, capable of being fabricated into pipe covering and various shapes. Low to medium temperature equipment and rectangular duct applications are common. A low skill level is required for flat products over pipe insulation. Note that the binder may break down at high operation temperatures.

Fibreglass has good structural strength, but poor impact resistance. It is non-combustible, non-absorptive and resistant to many chemicals. It has low water vapour permeance and does not support fungus or mould according to ASTM C1338-96.

### Physical Properties

Installed Cost Ref	Density	Max Temp	Thermal Conductivity
Low	40 kg/m <sup>3</sup>	232°C	0.04 – 0.08 W/m*°K
UV Resistance	Flame Spread	Smoke developed	Compressive Strength
Low	25	50	Moderate to low

Cellular Glass



**Description**

Cellular Glass insulation has become widely accepted as the preferred material in numerous piping, vessel, roofing and underground applications. It has exceptional water resistance with no increase in weight at up to 90% humidity, can outperform other insulation materials in high moisture conditions, and is resistant to swelling and shrinkage.

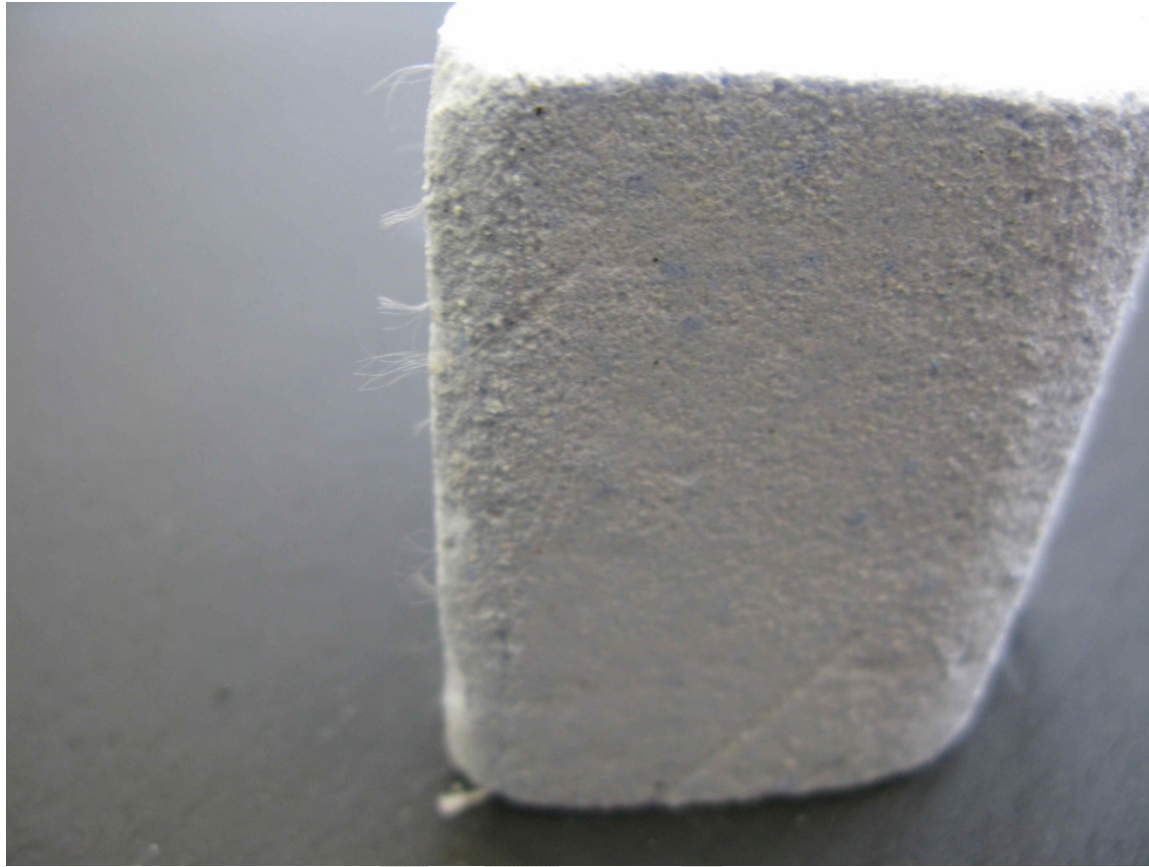
It comes in a variety of shapes and can easily be cut to install on pipes, ducts and equipment. It is often used in low temperature or extreme cold applications.

Cellular glass remains non-combustible in extreme fire hazard conditions, with excellent flame spread and smoke developed ratings. It is also extremely stable throughout its service life.

A less expensive alternative that can be used for some low temperature applications is polyisocyanurate.

Physical Properties			
Installed Cost Ref	Density	Maximum Service Temperature	Thermal Conductivity
Low to medium	128 kg/m <sup>3</sup>	500°C	.044 W/m²K
UV Resistance	Flame Spread	Smoke Developed	Compressive Strength
High	0	0	>689 kPa (or >100 PSI)

## Perlite (or Expanded Silica)



### Description

Perlite masonry insulation is an inert volcanic rock expanded by a special heat process and is often treated with water repellent material. The resulting granular product is lightweight with countless tiny, sealed air cells, which account for its excellent thermal performance and fire resistance. It also has very high water repellency, and sometimes used where there are risks of moisture ingress. It is most common in industrial applications; in non-industrial settings, calcium silicate is more common. Perlite insulation has been proven over a period of many years in the insulation of storage tanks for liquid gases at temperatures as low as -240°C. The material is very brittle, consequently it is difficult to work with, resulting in higher labour costs.

### Physical Properties

Installed Cost Ref	Density	Max working temp	Thermal Conductivity
Med-High	48 kg per cubic meter	650 °C	0.071 W/m*°K
UV Resistance	Flame Spread	Smoke Developed	Compressive Strength
High	25	<50	500 kPA (or 73 PSI)



**Mineral Fibre with FSK Vapour Retarder**



**Description**

Mineral fibre (or mineral wool) is available as flexible blanket, rigid board, pipe covering and other pre-moulded shapes. It is generally a lower cost material that is more commonly used in the mid-temperature range.

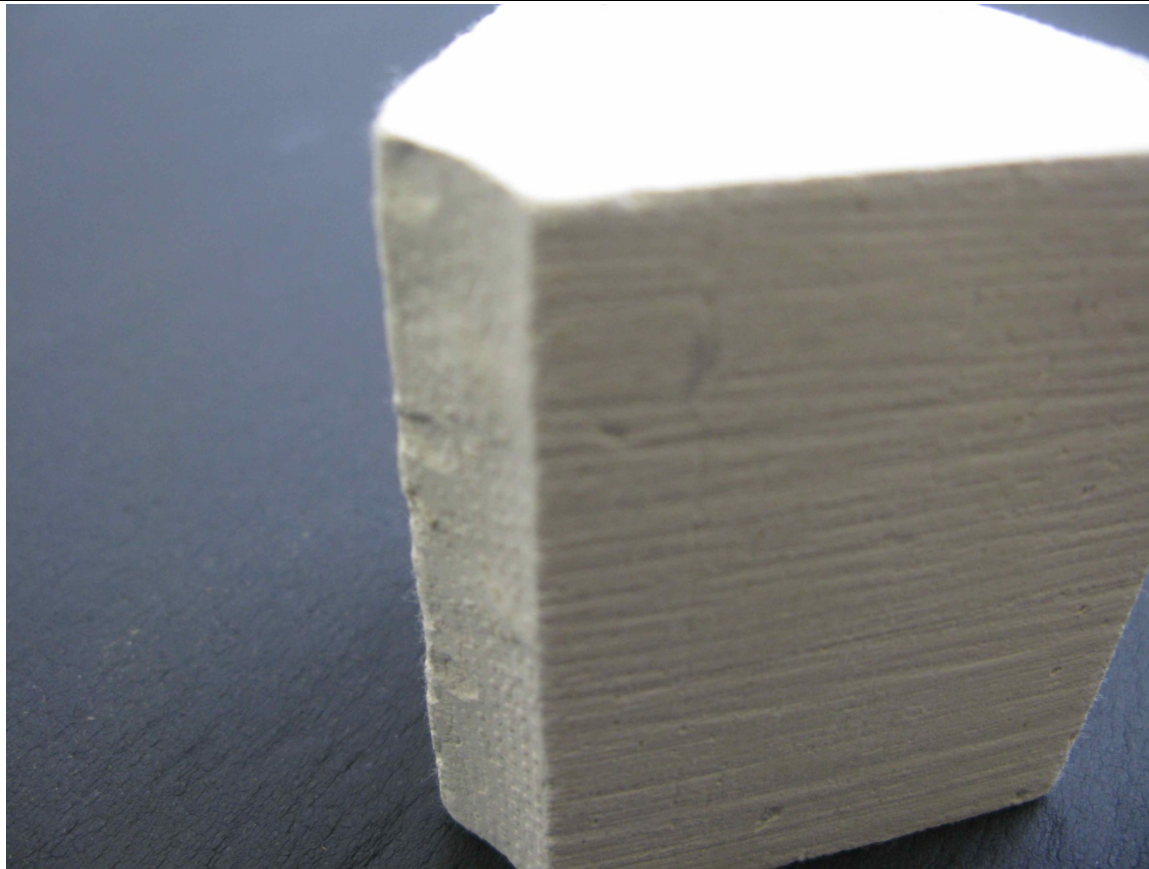
The product is non-combustible and has good sound absorption qualities. It has low compressive strength (the compressive strength of Perlite and Calcium Silicate is much higher). Also, the binders can begin to burn off above about 200 °C, and the material can sometimes slump over time.

**Physical Properties**

Installed Cost Ref	Density	Max Temp	Thermal Conductivity
Low	430 kg per cubic meter	982°C	0.071 W/m*°K
UV Resistance	Flame Spread	Smoke Developed	Compressive Strength
High	25	0	<8 kPA (or < 1 PSI)



## Calcium Silicate



### Description

Calcium silicate insulation is composed principally of hydrous calcium silicate that usually contains reinforcing fibres; it is available in moulded and rigid forms.

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.

Historically, common practice was to use calcium silicate for applications with operating temperatures between 200 °C and 650 °C; however mineral wool can be used in the range 90 °C to 425 °C and has slightly better thermal resistance than calcium silicate at lower temperature ranges, and is typically less costly. However calcium silicate has better compressive strength and therefore is generally more durable.

### Physical Properties

Installed Cost Ref	Density	Max Temp	Thermal Conductivity
Low to medium	190 kg per cubic meter	647°C	0.055 W/m*°K
UV Resistance	Flame Spread	Smoke Developed	Compressive Strength
High	0	0	860 kPa (or 125 PSI)

## Refractory Fibre



### Physical Properties

Refractory Fibre insulations are mineral or ceramic fibres, including alumina and silica, bonded with extremely high temperature inorganic binders, or a mechanical interlocking of fibres eliminates the need for any binder. The material is manufactured in blanket or rigid form.

The material is non-combustible and has tremendous high temperature characteristics.

If the material has been placed in service, there is serious potential health issues associated with its removal. It has to be treated like asbestos to be removed safely. Consideration should be given to using other materials where possible. If it is an extremely high temperature application refractory fibre may be the only suitable material.

Consideration should be given to using this material in combination with other lower temperature materials (such as fibreglass or mineral fibre) in the outer layers to reduce cost and reduce the use of refractory fibre.

### Physical Properties

Installed Cost Ref	Density	Temperature Range	Thermal Conductivity
Medium to high and can be expensive to remove	2,115 kg per cubic meter	1,399°C	0.153 W/m*°K
UV Resistance	Flame Spread	Smoke Developed	Compressive Strength
Low	0	0	Low

## MI Guide & Specifications for BC

The following two materials, silica aerogel and polyimide, are uncommon in commercial and residential applications. Some general information is provided for additional reference.

### Silica Aerogel



#### Description

Aerogel is a manufactured porous solid consisting almost entirely of gas (air) with a very fine latticework of solid material in a spherical shape. This solid material makes up anywhere from one to five percent of the volume of the aerogel. Despite the name aerogels do not contain a gel; though they begin life as a material matrix with liquid (gel) supporting the lattice.

Aerogel is available for some high-performance applications, but due to its high cost, it has not been widely used. However, new research offers the potential to drastically reduce the cost of producing aerogel, and could lead to new possibilities for its use as a building and insulation material.

Aerogels can be destroyed by water.

Working with aerogel, as with many other insulating materials, requires attention to health and safety, including avoidance of inhalation of aerogel dust.

Additional information sources cited:

<http://liambean.hubpages.com/hub/AeroGel-The-Perfect-Home-Insulation>

[http://greenbuildingelements.com/2008/04/11/aerogel-insulation-](http://greenbuildingelements.com/2008/04/11/aerogel-insulation-advances/http://www.sps.aero/Key_ComSpace_Articles/TSA-009_White_Paper_Silica_Aerogels.pdf)

[advances/http://www.sps.aero/Key\\_ComSpace\\_Articles/TSA-009\\_White\\_Paper\\_Silica\\_Aerogels.pdf](http://www.sps.aero/Key_ComSpace_Articles/TSA-009_White_Paper_Silica_Aerogels.pdf)



## Polyimide



### Description

This material has very good moisture and fire resistance properties, is lightweight, has high thermal performance, and has a wide operating temperature range. It typically comes in billet form and needs to be fabricated to suit the specific applications. However, the cost is high, therefore there has to be a good justification for its use. It is most suitable for high humidity and marine applications.

Additional information sources cited:

<http://www.aerospace-technology.com/contractors/thermal/evonik/>

## 5.3 *Appendix C: Reference Specifications*

### Notes on Reference Standards

Specifications often use reference standards. In doing so they rely on work undertaken by other agencies to test materials, design and installation practices. The advantage for the designer and specification writer is that they “inherit” the knowledge developed by other agencies for use in the specification. This should be done with caution however.

There are few good reasons for this caution:

1. Specification writers should ensure that the standards they reference are consistent with their objectives for the project and with the elements of the design and specifications.
2. Specification writers should not place an unnecessary burden on the bidding contractors by using multiple reference standards that are either redundant, or inconsistent; this will add costs for the contractor. Specifiers should read the contents of standards to make sure that they are consistent with their objectives for the specifications.
3. Specifications should try to use the most commonly used standards. Listing obscure reference standards may actually drive up the cost of the project without adding any significant benefits.

The use of reference standards in specifications has always been slightly problematic because the agencies that publish these standards do not necessarily coordinate their efforts. This leads to problems of overlap and redundancy.

At the time of writing, it is understood that the Thermal Insulation Association of Canada is working on a research project on this issue.

## .1 Appendix C.1 - Thermal Insulation for Piping

Use this Section to specify requirements for Piping and Equipment Insulation. This Master Specification Section contains:

- .1 This Cover Sheet
- .2 Specification Section Text:
  - 1. General**
    - 1.1 Related Requirements
    - 1.2 Reference Documents
    - 1.3 Product Options and Substitutions
    - 1.4 Shop Drawings and Product Data
    - 1.5 Definitions
    - 1.6 Flame/Smoke Development Ratings
  - 2. Products**
    - 2.1 Hot Pipe Insulation
    - 2.2 Hot Equipment Insulation
    - 2.3 Engine Exhaust Insulation
    - 2.4 Cold Pipe Insulation
    - 2.5 Cold Equipment Insulation
    - 2.6 Accessories
    - 2.7 Recovery Materials
  - 3. Execution**
    - 3.1 Installation, General
    - 3.2 Hot Pipe Insulation Application
    - 3.3 Hot Equipment Insulation Application
    - 3.4 Engine Exhaust Insulation Application
    - 3.5 Cold Pipe Insulation Application
    - 3.6 Cold Equipment Insulation Application
    - 3.7 Insulation Type Thickness Schedule

Consider carefully all requirements relating to recovering of exposed insulation surfaces. Specify recovering materials as follows:

- .1 Canvas: if surfaces are to be painted.
- .2 PVC: if surfaces are subject to damage or abuse.
- .3 Aluminum: if surfaces are subject to damage or abuse or where appearance is important.

END

OF

DATA

SHEETS

**GENERAL****1.1 RELATED REQUIREMENTS**

1. Mechanical General Requirement

**1.2 REFERENCE DOCUMENTS**

1. American Society for Testing and Materials (ASTM):
  - .1 ASTM C411 05 Hot Surface Performance of High Temperature Thermal Insulation
  - .2 ASTM E84 10b Surface Burning Characteristics of Building Materials
2. American Society of Testing and Materials (ASTM)
  - C549 Specification for Perlite Loose Fill Insulation
  - C578 Specification for Rigid, Cellular Polystyrene Thermal Insulation
  - E90 Standard Test Method for Laboratory measurement of Airborne Sound Transmission Loss of Building Partitions and Elements
  - E119 Test Method for Fire Tests of Building Construction and Materials
  - E136 Test Method for Behavior of Material in a Vertical Tube Furnace at 750 Degrees C.
3. Underwriters Laboratories, Inc. (UL)
  - Fire Resistance Directory

4. National Fire Protection Association (NFPA):

- |    |                 |   |
|----|-----------------|---|
| .1 | NFPA 255 2006   | Method of Test of Surface Burning Characteristics of Building Materials Underwriter Laboratories Canada (ULC) |
| .2 | CAN/ULC S102 10 | Surface Burning Characteristics of Building Materials and Assemblies  |

**1.3 PRODUCT OPTIONS AND SUBSTITUTIONS**

1. Refer to Division 01 for requirements pertaining to product options and substitutions.

**1.4 SHOP DRAWINGS AND PRODUCT DATA**

1. Comply with requirements of Section 20 00 13.
2. Submit an insulation schedule. For each application include the following information:
- |    |           |
|----|-----------|
| .1 | Materials |
| .2 | "k" value |
| .3 | Thickness |
| .4 | Density   |
| .5 | Finish    |
| .6 | Jacketing |
3. Submit product data and test reports when requested to substantiate that insulation and recovery assemblies meet flame/smoke development ratings and performance requirements for the assembly and thickness used.

**1.5 DEFINITIONS**

1. For the purposes of this Section, the following definitions apply:
- |    |   |
|----|---|
| .1 | Concealed: piping systems and equipment in trenches, shafts, furring, and suspended ceilings. |
|----|---|



- .2 Exposed: piping systems and equipment in mechanical rooms or otherwise not "concealed".
- .3 "k" Value: thermal conductivity of insulating material per unit of thickness (W/m°C).

## 1.6 FLAME/SMOKE DEVELOPMENT RATINGS

1. Pipe insulations, recovery materials, tapes, vapour retarder facings and adhesives shall have maximum flame spread rating of 25 and maximum smoke developed rating of 100 except in plenum spaces and air handling systems where maximum smoke development rating shall be 50, when tested in accordance with CAN/ULC-S102, NFPA 255, or ASTM E84.

**SPEC NOTE: Specify smoke development of 50 when a building is classified as a "high rise".**

2. Insulating materials and accessories shall withstand service temperatures without smoldering, glowing, smoking or flaming when tested in accordance with ASTM C411.

## 2. Products

### 2.1 HOT PIPE INSULATION

1. Hot Pipe Insulation - Mineral Fibre:
  - .1 Material: formed rigid mineral fibre insulation sleeving.
  - .2 "k" Value: maximum 0.035 W/m°C at 24°C mean temperature.
  - .3 Service Temperature: up to 150°C.
  - .4 Jacket: factory applied general purpose jacket.
2. Hot Pipe Insulation - Black Rubber:
  - .1 Material: flexible elastomeric unicellular preformed pipe covering.
  - .2 "k" Value: 0.04 W/m. °C at 24°C mean temperature.
  - .3 Service Temperature: up to 100°C.
  - .4 Maximum Allowable Thickness: 25 mm.

## 2.2 HOT EQUIPMENT INSULATION

1. Hot Equipment Insulation - Flat Surfaces:
  - .1 Material: rigid mineral fibre.
  - .2 "k" Value: maximum 0.035 W/m°C at 24°C mean temperature.
  - .3 Service Temperature: 20°C to 120°C.
2. Hot Equipment Insulation - Curved Surfaces:
  - .1 Material: mineral fibre blanket.
  - .2 "k" Value: maximum 0.035 W/m°C at 24°C mean temperature.
  - .3 Service Temperature: 20°C to 120°C.

## 2.3 ENGINE EXHAUST INSULATION

1. Material: formed rigid hydrous calcium silicate for piping (however where extremely high temperatures are required it may be necessary to consider refractory fibre).
2. "k" Value: maximum 0.059 W/m°C at 93°C mean temperature.
3. Service Temperature: up to 750°C.

## 2.4 COLD PIPE INSULATION

1. Cold Pipe Insulation: Mineral Fibre:
  - .1 Material: formed mineral fibre rigid insulation sleeving.
  - .2 "k" Value: maximum 0.035 W/m°C at 24°C mean temperature.
  - .3 Service Temperature: -14°C to 100°C.
  - .4 Jacket: factory applied vapour barrier jacket.
2. Cold Pipe Insulation - Black Rubber:
  - .1 Material: flexible elastomeric unicellular preformed pipe covering.
  - .2 "k" Value: 0.04 W/m. °C at 24°C mean temperature.
  - .3 Service Temperature: -4°C to 100°C.
  - .4 Maximum Allowable Thickness: 25 mm.

## 2.5 COLD EQUIPMENT INSULATION

1. Cold Equipment Insulation - Flat Surfaces:
  - .1 Materials: rigid mineral fibre.
  - .2 "k" Value: maximum 0.035 W/m°C at 24°C mean temperature.
  - .3 Service Temperature: -14°C to 100°C.
  - .4 Jacket: factory applied vapour barrier jacket.
2. Cold Equipment Insulation - Curved Surfaces:
  - .1 Material: mineral fibre blanket.
  - .2 "k" Value: maximum 0.035 W/m°C at 24°C mean temperature.
  - .3 Service Temperature: -14°C to 100°C.
  - .4 Jacket: factory applied vapour barrier jacket.

## 2.6 ACCESSORIES

1. For mineral fibre insulation materials:
  - .1 FSK Tape: vapour barrier tape consisting of laminated aluminum foil, glass fibre scrim and paper, with pressure sensitive self adhesive.
  - .2 ASJ Tape: vapour resistant tape consisting of all service jacket material with pressure sensitive self adhesive.
  - .3 Adhesive: quick setting adhesive for joints and lap sealing.
2. Black Rubber Insulation Adhesive: manufacturers recommended contact cement.
3. Finishing Cement: mineral fibre hydraulic setting thermal insulating and finishing cement for use up to 650°C.
4. Insulating Cement: mineral fibre thermal insulating cement for use up to 870°C.

- Type 1: Mineral fibre hydraulic setting thermal **insulating and finishing cement** for use up to 650°C.
- Type 2: Mineral fibre thermal **insulating cement** for use up to 870°C.
- Type 3: Expanded or exfoliated vermiculite thermal **insulating cement** for use up to 980°C.

## 2.7 RECOVERY MATERIALS

1. Canvas: ULC listed, 220 g/m<sup>2</sup> plain weave cotton fabric.
2. Aluminum: to 0.5 mm thick with longitudinal slip joints and 50 mm end laps, 0.4 mm thick die shaped fitting covers with factory attached protective liner on interior surface.
3. PVC: [0.38] or [ ] mm thick for interior use [and [ ] mm thick for exterior use], off-white in colour with one-piece premoulded fitting covers.
4. Black Rubber Finish: insulation manufacturers recommended vinyl lacquer type coating.

## 3. Execution

### 3.1 INSTALLATION, GENERAL

1. Apply insulation after required piping system tests have been completed and inspected.
2. Ensure insulation is continuous through walls and floor penetrations.
3. Ensure piping surface is clean and dry before insulating.
4. Locate cover seams in least visible locations.
5. Stagger butt joints where multi-layered insulation is used.
6. On vertical piping with diameters 25 mm and larger, use insulation supports welded or bolted to pipe directly above lowest pipe fitting. Repeat supports on 4.5 m centers and at each valve and flange.

7. Tightly fit insulation sections to pipe to make smooth and even surfaces. Cut insulation for proper fit where weld beads protrude. Bevel away from studs and nuts to allow their removal without damage to insulation. Trim closely and neatly around extending parts of pipe saddles, supports, hangers, clamp guides and seal with insulating/finishing cement.

### 3.2 HOT PIPE INSULATION APPLICATION

1. Apply mineral fibre insulation when pipe surface temperatures are 50°C to 60°C.
2. Apply mineral fibre insulation and recovery over full length of pipe without penetration of hangers, interruption at sleeves and fittings. Seal butt joints with 100 mm wide ASJ tape.
3. Terminate mineral fibre insulation at each end of unions and flanges. Trowel finishing cement into bevel.
4. Cover fittings and valves with equivalent thickness of finishing cement. Apply finishing cement over exposed fittings and valves before applying canvas recovering.
5. Cut mineral fibre insulation layers straight on 10 m centers with 25 mm gap to allow for expansion between terminations. Pack void tightly with insulation and protect joints with aluminum sleeves.
6. Seal black rubber insulation butt joints and seams with black rubber insulation adhesive.
7. Recover exposed mineral fibre insulated piping with [canvas] [PVC] [aluminum].
8. Recover mineral fibre insulated piping exposed to outdoors with aluminum.
9. Coat exposed black rubber insulation with two coats of black rubber finish material.
10. Do not insulate the following piping system components:
  - .1 Hot water heating piping in radiation cabinets.
  - .2 Unions, flanges, strainers, expansion joints, flexible piping connectors.
  - .3 Condensate trap assemblies and drip legs.
  - .4 Chrome plated or stainless steel piping.
  - .5 Valve bonnets on domestic water systems.

**3.3 HOT EQUIPMENT INSULATION APPLICATION**

1. Use rigid fibreboard for flat surfaces and blanket for curved surfaces.
2. Tightly butt edges and stagger joints. Weld mechanical fastener pins to equipment where necessary.
3. Cover insulation with 25 mm galvanized hexagonal mesh and 12 mm coat of insulating cement. Finish with a final 12 mm coat of finishing cement and recover with canvas.

**3.4 ENGINE EXHAUST INSULATION APPLICATION**

1. Ensure insulation is continuous through the wall or roof to point of termination.
2. Cover elbows and fittings with equivalent thickness of insulating cement.
3. Recover all piping, including muffler, with aluminum.

**3.5 COLD PIPE INSULATION APPLICATION**

1. Insulate 2 m portion of plumbing vents measured from roof outlet back. Do not insulate remaining vent piping.
2. Insulate storm sewer piping throughout. Insulate final 2 m portion from outlet drain back with 25 mm insulation.
3. Apply mineral fibre insulation and recovery over full length of pipe without penetration of hangers, interruption at sleeves and fittings. Apply adhesive to ends of butt joints and seal joint seams with 100 mm wide strips of joint tape.
4. Insulate complete system including valves, unions, flanges, strainers. Cover fittings and valves with equivalent thickness of finishing cement. Cover finishing cement with open mesh glass cloth and adhesive. Seal lap joints with 100% coverage of joint tape and seal the assembly with adhesive.
5. Seal black rubber insulation butt joints and seams with black rubber insulation adhesive.
6. Recover exposed mineral fibre insulated piping with [canvas] [PVC] [aluminum].
7. Recover mineral fibre insulated piping exposed to outdoors with [aluminum] [PVC].

8. Coat exposed black rubber insulation with two coats of black rubber finish material.

### 3.6 COLD EQUIPMENT INSULATION APPLICATION

1. Tightly butt edges and stagger joints. Seal joints with 100 mm wide FSK tape.
2. Cover insulation with 25 mm galvanized hexagonal mesh and 12 mm coat of finishing cement. Finish with a final 12 mm coat of finishing cement and recover with canvas.

### 3.7 INSULATION TYPE AND THICKNESS SCHEDULE

**SPEC NOTE:** Insulation thicknesses generally conform to ASHRAE recommendations.

See Table 6.8.2B in ASHRAE 90.1 Standard or Table C-10 in ASHRAE 189.1 Standard (latest edition) for current thickness requirements.

Service Type and Nominal Pipe Diameter (mm)	Insulation Type	Insulation Thickness Range (mm)
Hot water heating		
50 and smaller	Hot pipe	25 to 50
65 and larger	Hot pipe	40 to 75
Low pressure steam		
50 and smaller	Hot pipe	40 to 75
65 and larger	Hot pipe	50 to 75
Condensate		
25 and smaller	Hot pipe	25 to 50
30 to 50	Hot pipe	40 to 75
65 and larger	Hop pipe	50 to 75
Domestic hot water and recirculation		
40 and smaller	Hot pipe	12 to 25
50 and larger	Hot pipe	25 to 50
Chilled water		
25 and less	Cold pipe	12 to 25
30 to 50	Cold pipe	20 to 40
65 and larger	Cold pipe	25 to 50

Continued next page



**3.7 INSULATION TYPE AND THICKNESS SCHEDULE (Cont'd)**

Service Type and Nominal Pipe Diameter (mm)	Insulation Type	Insulation Thickness Range (mm)
Refrigerant & Chilled glycol		
25 and smaller	Cold pipe	25 to 50
30 and larger	Cold pipe	40 to 75
Domestic cold water		
40 and smaller	Cold pipe	12 to 25
50 and larger	Cold pipe	25 to 50
Condenser water, All sizes	Cold pipe	25 to 50
External sprayed coil All sizes	Cold pipe	12 to 25
Condenser water piping indoors		
25 and smaller	Cold pipe	25 to 50
30 and larger	Cold pipe	40 to 75
<b>SPEC NOTE: Specify insulation for "Condenser water piping indoors" only when free cooling chillers or exchangers are specified.</b>		
Plumbing vents All sizes	Cold pipe	25 to 50
Storm sewer piping, All sizes	Cold pipe	12 to 25
Final 2 m section	Cold pipe	25 to 50

**END OF SECTION**

**.2      Appendix C.2 - Ducting Equipment and Acoustical Insulation**

.1      This Cover Sheet

.2      Data Sheet - Reference Standards

.3      Specification Section Text:

**1.      General**

1.1      Related Requirements

1.2      Reference Documents

1.3      Product Options and Substitutions

1.4      Submittals

1.5      Definitions

1.6      Flame/Smoke Development Ratings

1.7      Delivery, Storage, and Handling

1.8      LEED Requirements

**2.      Products**

2.1      Hot Duct Insulation

2.2      Cold Duct Insulation

2.3      Acoustic Duct Insulation

2.4      Breeching Insulation

2.5      Accessories

2.6      Recovery Materials

**3.      Execution**

3.1      Installation, General

3.2      Hot Duct Insulation Application

3.3      Cold Duct Insulation Application

3.4      Acoustic Duct Insulation Application

3.5      Breeching Insulation Application

3.6      Exposed Ducts

3.7      Insulation Type and Thickness Schedule

**LEED/Green Building Notes:**

Refer to Section 01 35 18 – LEED Requirements for:

1. Requirements necessary for this project to obtain points and prerequisites required for certification.
2. Confirmation of LEED prerequisites and credits affecting this Section; not all are mandatory for certification.

Maintain built-in sustainability regardless of LEED requirements for:

- .1 Maximizing energy performance.
- .2 Recycling, reuse of materials, components and assemblies.
- .3 Diversion of construction waste from landfills.
- .4 Use of recycled materials, local materials, rapidly renewable and durable materials.
- .5 Maintain healthy indoor environment during constructing.
- .6 Provide for thermal comfort, access to views and daylight for indoor spaces.
- .7 Foster innovation into facility design and planning.

**LEED Credits****Energy & Atmosphere:**

***SPEC NOTE: Though prerequisites do not contribute to a projects point score, they are mandatory and must be met for a project to receive LEED certification.***

Prerequisite 2 – Minimum Energy Performance

Credit 1 – Optimize Energy Performance

**END OF DATA SHEETS**

## **1.            General**

### **1.1           RELATED REQUIREMENTS**

1.       Mechanical General Requirements: Section 20 00 13.

### **1.2           REFERENCE DOCUMENTS**

1.       American Society for Testing and Materials (ASTM):
  - .1       ASTM C411 05                    Standard Test Method for Hot Surface Performance of High Temperature Thermal Insulation
2.       American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE):
  - .1       ASHRAE 90.1-2007                Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings (or most recent version)
3.       Canada Green Building Council (CaGBC):
  - .1       LEED    Canada    2009    LEED Canada for New Construction and Major Renovations.  
Rating System                LEED Canada for Core and Shell Development. Website:  
[www.cagbc.org](http://www.cagbc.org)

**SPEC NOTE: SPECIFY THE ABOVE ONLY IF THIS IS A LEED PROJECT**

4.     Model National Energy Building Code of Canada for Buildings, 1997
5.     National Fire Protection Association (NFPA):
  - .1     NFPA (Fire) 255 2006     Standard Method of Test of Surface Burning Characteristics of Building Materials
6.     Underwriters Laboratories of Canada (ULC):
  - .1     CAN/ULC S102 07     Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies

**1.3            PRODUCT OPTIONS AND SUBSTITUTIONS**

1.     Refer to Division 01 for requirements pertaining to product options and substitutions.

**1.4            SUBMITTALS**

1.     Product Data:
  - .1     Submit manufacturer's product data
    - .1     Submit product data and test reports when requested to substantiate that insulation and recovery assemblies meet flame/smoke development ratings and performance requirements for the assembly and thickness used.
2.     Shop Drawings:
  - .1     Submit shop drawings in accordance with Mechanical General Requirements.
    - .1     Submit an insulation schedule, for each application include the following information:
      - .1     Materials
      - .2     "k" value
      - .3     Thickness
      - .4     Density
      - .5     Finish
      - .6     Jacketing

## **1.5            DEFINITIONS**

1.     For the purposes of this section, the following definitions apply:
  - .1     Concealed: ductwork and equipment in shafts, furring, suspended ceilings and attics.
  - .2     Exposed: ductwork and equipment in mechanical rooms or otherwise not "concealed".
  - .3     "k" Value: thermal conductivity of insulating material per unit of thickness (W/m.°C).

## **1.6            FLAME/SMOKE DEVELOPMENT RATINGS**

1.     Duct insulation, recovery materials, vapour barrier facings, tapes and adhesives shall have maximum flame spread ratings less than or equal to 25 and maximum smoke developed less than or equal to 50, when tested in accordance with CAN/ULC S102.
2.     Insulating materials and accessories shall withstand service temperatures without smoldering, glowing, smoking or flaming when tested in accordance with ASTM C411.

## **1.7            DELIVERY, STORAGE, AND HANDLING**

1.     Separate waste materials for [reuse] [and] [recycling] in accordance with Section 01 74 19 – Waste Management and Disposal.

**SPEC NOTE: Delete LEED requirements if Project is not pursuing LEED certification.**

## **1.8            LEED REQUIREMENTS**

1.     EA Prerequisite 2 – Minimum Energy Performance
2.     EA Credit 1 – Optimize Energy Performance
  - .1     Performance rates of tanks and pipes have been designed to meet a predetermined level of energy performance and efficiency in accordance with ASHRAE 90.1 (most recent version).

- .2      Submit information showing installed insulation and membrane products meet the requirements of ASHRAE 90.1.

## **2.            Products**

### **2.1           HOT DUCT INSULATION**

- 1.      Hot Duct Insulation - Round and Oval:
  - .1      Material: flexible mineral fibre blanket insulation.
  - .2      "k" Value: maximum 0.038 W/m.°C at 24°C mean temperature.
  - .3      Service Temperature: 20°C to 65°C.
- 2.      Hot Duct Insulation - Rectangular
  - .1      Material: rigid mineral fibre insulation.
  - .2      "k" Value: maximum 0.035 W/m.°C at 24°C mean temperature.
  - .3      Service Temperature: 20°C to 65°C.

### **2.2           COLD DUCT INSULATION**

- 1.      Cold Duct Insulation - Round and Oval:
  - .1      Material: flexible mineral fibre blanket insulation.
  - .2      "k" Value: maximum 0.038 W/m.°C at 24°C mean temperature.
  - .3      Service Temperature: -40°C to 65°C.
  - .4      Jacket: factory applied reinforced aluminum foil vapour barrier.
- 2.      Cold Duct Insulation - Round (Exposed to Outdoors):
  - .1      Material: semi-rigid mineral fibre in roll form.
  - .2      "k" Value: maximum 0.038 W/m.°C at 24°C mean temperature
  - .3      Service Temperature: -40°C to 65°C.
  - .4      Jacket: factory applied reinforced aluminum for vapour barrier.
- 3.      Cold Duct Insulation - Rectangular:

- ~~1~~      Material: rigid mineral fibre insulation to.
- .2      "k" Value: maximum 0.038 W/m.°C at 24°C mean temperature.
- .3      Service Temperature: 20°C to 65°C.
- .4      Jacket: factory applied reinforced aluminum foil vapour barrier.

### **2.3            ACOUSTIC DUCTWORK INSULATION**

- 1.      Material: flexible or rigid mineral fibre acoustical insulation.
- 2.      Acoustic Properties: minimum NRC or 0.75 for 25 mm thickness.
- 3.      "k" Value: maximum 0.035 W/m°C at 24°C mean temperature.
- 4.      Service Temperature: -40°C to 65°C.
- 5.      Surface Finish: air stream side coated to prevent fibre erosion. Surface roughness not exceeding 0.58 mm.

### **2.4            BREECHING INSULATION**

- 1.      Material: Semi-rigid mineral fibre with glass mat.
- 2.      "k" Value: Maximum 0.038 W/m°C at 24°C mean temperature.
- 3.      Service Temperature: 65°C to 450°C.

### **2.5            ACCESSORIES**

- 1.      FSK Tape: vapour barrier tape consisting of laminated aluminum foil, glass fibre scrim and paper, with pressure sensitive self adhesive.
- 2.      ASJ Tape: vapour resistant tape consisting of all service jacket material with pressure sensitive self adhesive.
- 3.      Contact Adhesive: quick setting, adhesive to adhere flexible or rigid mineral fibre insulation to ducts.
- 4.      Lap Seal Adhesive: quick setting adhesive for joints and lap sealing of vapour barriers.



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5. Canvas Adhesive: dilute, washable, fire retardant lagging adhesive for cementing canvas jacket to duct insulation.
6. Pins: welding pins 4 mm diameter shaft with 35 mm diameter head for installation through the insulation. Length to suit thickness of insulation with 32 mm square nylon retaining clips.
7. Finishing Cement: to CAN/CGSB-51.12-95, Type 1 - mineral fibre hydraulic setting thermal insulating and finishing cement for use up to 650°C.

**Type 1:** Mineral fibre hydraulic setting thermal **insulating and finishing cement** for use up to 650°C.

**Type 2:** Mineral fibre thermal **insulating cement** for use up to 870°C.

**Type 3:** Expanded or exfoliated vermiculite thermal **insulating cement** for use up to 980°C.

## **2.6 RECOVERY MATERIALS**

1. Canvas: ULC listed, 220 g/m<sup>2</sup> plain weave cotton fabric.
2. Aluminum Jacket: to 0.5 mm thick with aluminum alloy butt straps, secured with mechanical fastener.

### **3. Execution**

#### **3.1 INSTALLATION, GENERAL**

1. Dimensions shown are clear inside free area measurement regardless of insulation placement. Fabricate ducts accordingly.
2. Apply insulation after required duct system tests have been completed.
3. Ensure duct surfaces are clean and dry before installing insulation.
4. Install insulation over entire surface of duct, for full length of duct run including portions of duct passing penetrations through walls and floors.
5. Install insulation in a manner to insure hangers and standing duct seams do not penetrate insulation.
6. Locate finished seams in least visible location.
7. Do not insulate ductwork with external thermal insulation where acoustic duct insulation has been specified.
8. Install insulation at ambient temperatures within acceptable ratings for tapes, sealants and adhesives.

#### **3.2 HOT DUCT INSULATION APPLICATION**

1. Adhere insulation to round and oval ductwork with contact adhesive applied in 150 mm wide strips on 400 mm centres. Band on outside with wire until adhesive has set.
2. Butt insulation and seal joints with lap seal adhesive; cover joint ASJ tape.
3. Secure rigid insulation on rectangular ducts with 50% area coverage using contact adhesive, impale on pins located 400 mm on centre, secure in place with retaining clips.
4. Butt rigid insulation on rectangular ducts and seal joints with lap seal adhesive; cover joints with 100 mm strips of open mesh cloth imbedded between two coats of lap seal adhesive.

### **3.3 COLD DUCT INSULATION APPLICATION**

1. Adhere mineral fibre insulation to round and oval ductwork with adhesive applied in 150 mm wide strips on 400 mm centres. Band on outside until mastic sets then remove bands.
2. Butt mineral fibre insulation and seal joints with lap seal adhesive; cover joint with FSK tape.
3. Secure rigid insulation on rectangular ducts with 50% area coverage of adhesive and impale on pins located 400 mm on centre and secure in place with the retaining clips.
4. Butt rigid insulation on rectangular ducts and seal joints with lap seal adhesive; cover joints with 100 mm strips of open mesh cloth imbedded between two coats of lap seal adhesive.

### **3.4 ACOUSTIC DUCT INSULATION APPLICATION**

1. Line ducts with flexible or rigid acoustic insulation. Line plenums with rigid acoustical insulation. Adhere insulation to duct with 100% coverage of contact adhesive and pins located 400 mm OC each way. Secure in place with retaining clips. Remove excess length of pins and cover with brush coat of lap seal adhesive.
2. Bevel corners at joints and butt together. Brush coat all cut edges with lap seal adhesive. Install acoustic gauze over all cut corners and joints and brush coat with lap seal adhesive.
3. Where duct velocities exceed 20 m/s, cover insulation with 0.8 mm perforated galvanized steel with 24% free area.

**SPEC NOTE: Specify acoustic duct insulation when the intention is to install acoustic duct insulation on site. Where only prefabricated acoustic lined ducts are desired delete Acoustic Duct Insulation requirements and specify requirements in Section 23 31 13 - Ductwork. Re- think wording for clarification**

**3.5                    BREECHING INSULATION APPLICATION**

1.      Face breeching with 9.5 mm rib lath turn out to provide 12 mm space between insulation and hot surface and 12.5 mm mesh expanded lath on the outside.
2.      Butt insulation firmly together and secure with 1.6 mm galvanized wire.
3.      Lace metal mesh together. Coat with 12 mm thick finishing cement. Finish with a final 12 mm coat of finishing cement with 25% by weight of Portland cement. Trowel to a smooth hard finish.

**3.6                    EXPOSED DUCTS**

1.      Finish exposed ducts with canvas jacket suitable for paint finish.

**OR**

**SPEC NOTE: Use canvas jacket finish if ductwork is to be painted.**

2.      Finish ducts exposed to outdoors with aluminum jacket. Caulk all joints on jacket for weathertight finish. Locate longitudinal joints in least weather exposed position.

**3.7 INSULATION TYPE AND THICKNESS SCHEDULE**

**SPEC NOTE:** Insulation thicknesses generally conform to ASHRAE recommendations.

**See Table 6.8.2B in ASHRAE 90.1 Standard or Table C-10 in ASHRAE 189.1 Standard (latest edition) for current thickness requirements.**

Service Type	Insulation Type	Insulation Thickness (mm)
Exhaust and relief ducts within 3 m of exterior openings	Hot duct	25
Supply ducts and plenums	Hot duct	25
Combustion air	Cold duct	50
Outside air	Cold duct	50
Mixing plenums	Cold duct	50
Supply air plenums	Cold duct	25
Medium pressure supply ducts	Cold duct	25
Low pressure supply ducts	Cold duct	25
Supply and return ducts exposed to outdoors	Cold duct	50
Supply and return ducts in cold attic spaces	Cold duct	50
Ventilation equipment	Cold duct	50
Evaporative condenser intake and exhaust	Cold duct	25

Continued next page

**3.7 INSULATION TYPE AND THICKNESS SCHEDULE (Cont'd)**

**SPEC NOTE:** Insulation thickness recommendations to be reviewed by an acoustical engineer and mechanical engineer. These thicknesses may not be adequate for personnel protection of maximum thermal efficiency.

Service Type	Insulation Type	Insulation Thickness (mm)
High and Medium pressure supply ducts	Acoustic	25
Low pressure supply and return	Acoustic	25
Plenums	Acoustic	25
Boilers	Breeching	50
Domestic hot water heaters, atmospheric burners	Breeching	25
Domestic hot water heaters, forced air burners	Breeching	50
Furnaces	Breeching	25
Gas-fired unit heaters	Breeching	25
Indirect gas-fired air handling units, forced air burners	Breeching	25
Indirect gas-fired air handling units, atmospheric burners	Breeching	50

**END OF SECTION**