

DEP SPECIFICATION

THERMAL INSULATION

DEP 30.46.00.31-Gen.

February 2017

DESIGN AND ENGINEERING PRACTICE



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1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for external thermal insulation of above ground surfaces of equipment and pipe. It also includes the application requirements for acoustic insulation.

Design requirements for acoustic insulation are covered in DEP 31.46.00.31-Gen.

Design requirements for thermal insulation of LNG tanks are outside the scope of this DEP.

This is a revision of the DEP of the same number dated February 2015; see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

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This DEP is intended for use in facilities related to oil and gas production, gas handling, LNG, oil refining, chemical processing, gasification, distribution and supply/marketing. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process shall be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1. The word **may** indicates a permitted option.

1.3.2 Specific definitions

Term	Definition
Acoustic Insulation	Insulation installed to reduce the amount of noise radiated from a surface.
CINI	Committee Insulation Netherlands Industry
CINI Manual	The CINI Manual is a detailed reference handbook with material and construction specifications for thermal and acoustic insulation systems The references to the CINI Manual in this DEP shall be used
CFC	Chlorofluorocarbon
Cold Insulation	Insulation used to avoid condensation at the outer surface under conditions assumed during detailed design and to reduce heat gain for economic or process reasons.
Condensation	Moisture forming at the surface of uninsulated or insufficiently insulated pipe/equipment when the process temperature is below ambient. The rate of condensation depends on ambient temperature, relative humidity, and emissivity of bare surface or insulation jacketing, wind velocity and process temperature.
CSPE	ChloroSulphonated PolyEthylene
CUI	Corrosion Under Insulation
DN	Diameter Nominal
Dual Process Temperature	Process temperature cycling between ambient (or lower) and 320 °C (1068 °F) (or lower).
EPDM rubber	Ethylene Propylene Diene Monomer rubber
ESCC	External Stress Corrosion Cracking
FEF	Flexible Elastomeric Foam
GRE	Glass-fibre Reinforced Epoxy
GRP	Glass fibre Reinforced Polyester
Heat Gain	Heat ingress from the outside in cold insulation systems or heat loss from the inside in hot insulation systems.
HCFC	Hydrochlorofluorocarbon
Hot Insulation	Insulation used to save energy for economic reasons; typically applied for process temperatures between 60 °C and 600 °C (140 °F and 1112 °F)
Insulation System	Combination of insulation materials and jacketing designed to achieve the most economic solution and service life.
LNG	Liquefied Natural Gas

Term	Definition
ITP	Inspection and Test Plan
Metallic Jacketing	Jacketing which consists of aluminium or aluminized steel cladding or stainless steel.
NB	Nominal Bore
Nano porous insulation material	Nano porous insulation material is a manufactured material which is derived from a gel in which the liquid component of the gel has been replaced with a gas.
Non-Contact Insulation	Insulation system in which spacers are used to avoid contact between bare surfaces of pipe/equipment and the insulation material. The annular space between insulation material and bare surface is not intended to be ventilated, however openings or drains are provided and are located at the lowest point of the pipe or equipment and at potential moisture traps.
Non-Metallic Jacketing	Jacketing consisting of GRE, GRP, and polymeric compound or modified EPDM; often used in conjunction with a multiplex primary vapour barrier.
OCP	One Component Polymer
PIR	Polyisocyanurate rigid foam
PUR	Polyurethane rigid foam
Personnel burn Protection	Barrier system consisting of insulation material or metal screens, to prevent people from touching hot surfaces (or exceptionally very cold surfaces) of pipe or equipment.
Process Insulation	Insulation required to avoid freezing, internal condensation or solidification, or to control product viscosity. This type of insulation is often used in conjunction with heat tracing.
QA/QC	Quality Assurance / Quality Control
RBI	Risk Based Inspection
Thermal Insulation	Generic term covering hot, cold, process and personnel protection insulation.
TOW	Temperature Operating Window
TSA	Thermal Sprayed Aluminium
UV	Ultra Violet
Vapour barrier	A layer as part of the cold insulation systems to prevent transport of water vapours into the insulation material.

Term	Definition
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Vapour stop	A provision as part of the cold insulation system to prevent transport of water vapours in longitudinal direction of pipe compartments and at terminations.
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1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section or clause number is shown in brackets (). Other documents referenced by this DEP are listed in (6).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a minor revision of the DEP of the same number dated February 2015. The following are the main, non-editorial changes.

Section/Clause	Change
All	Restructured and clarified requirements, enforced use of shall/should/may for normative statements.

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be submitted to the Administrator using one of the following options:

Shell DEPs Online (Users with access to Shell DEPs Online)	Enter the Shell DEPs Online system at https://www.shelldeps.com Select a DEP and then go to the details screen for that DEP. Click on the "Give feedback" link, fill in the online form and submit.
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DEP Standard Form (other users)	Use DEP Standard Form 00.00.05.80-Gen. to record feedback and email the form to the Administrator at standards@shell.com .

Feedback that has been registered in the DEP Feedback System by using one of the above options will be reviewed by the DEP Custodian for potential improvements to the DEP.

1.7 DUAL UNITS

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

1.8 NON NORMATIVE TEXT (COMMENTARY)

Text shown in italic style in this DEP indicates text that is non-normative and is provided as explanation or background information only.

Non-normative text is normally indented slightly to the right of the relevant DEP clause.

2. GENERAL

2.1 RELATIONSHIP WITH EXTERNAL DOCUMENTS

1. This DEP provides specifications for the insulation system and insulation and jacketing material selection. Details from the CINI manual (latest edition) shall be used for material specifications and design and construction detailing.
2. The selection of insulation and related jacketing materials shall be based on this DEP.
3. For material specifications, drawings and construction details, reference is made to the CINI manual. Where CINI is contrary to this DEP, the requirement from this DEP shall prevail.
4. For material specifications, drawings and construction details reference is made in this DEP to specific sections of the CINI manual. Amendments to these requirements shall be subject to approval by the Principal.
5. For material properties and testing a wide range of external standards are referred to in this DEP. Deviations from the systems and material requirements and from the material properties and testing requirements provided in this DEP shall be subject approval by the Principal.

2.2 INSULATION DESIGN CRITERIA

2.2.1 General engineering practices

1. Before design of insulation systems, the necessity of insulation shall be assessed by using the flow diagram provided in (Appendix A).
2. The following criteria shall be used in both determining the need for and in designing insulation systems:
 - a. CUI and ESCC risks – where CUI and ESCC risks are present, reference is made to CUI and ESCC mitigation (3.1.2);
 - b. Process reason – to minimize heat gain or heat loss for process reasons to avoid process instability, disruption or solidification. In such cases, insulation may be combined with heat tracing;
 - c. Economics – to minimize heat loss and reduce emissions.
 - i. In hot service the optimum economic insulation thickness shall be calculated according to the "Minimum Total Cost Method" (3.1.1).
 - ii. For a given thickness the total cost is the sum of the cost of the investment and maintenance of the insulation system and the cost of the energy lost through the insulation.
 - d. Personnel burn protection – to protect personnel from heat or cold burns;
 - e. Cold Service – Cold service insulation shall be installed to limit surface condensation, icing, to conserve refrigeration (limit heat gain) or to limit boil off;
 - i. Surfaces that operate below the local ambient dew point for more than 5 percent of the time require insulation.
 - ii. The maximum heat gain in cold service to conserve refrigeration shall be 25 W/m^2 (8 Btu/hr/ft²).

In some circumstances boil-off is the dominant criteria e.g., rundown/loading lines, liquefied gas spheres or LNG tanks. For spheres, a separate calculation to determine insulation thicknesses is required to meet the specified boil-off rate and the related maximum heat gain. For LNG tanks, reference is made to DEP 34.51.01.32-Gen.
 - f. Acoustic reasons – to manage noise control. Acoustic insulation may be combined with thermal insulation;
 - g. Fire protection – to protect pipes and equipment from heat radiation from fires;
 - h. Winterizing – avoiding freezing of product in pipe, instruments, and equipment.
3. Calculations for heat transfer shall be based on ISO 12241 or ASTM C 680.
4. All insulation shall be designed so that water ingress and capillary action is not possible and that potential leaked product and water vapour or condensation can escape or drain off.
5. The design of the insulation systems shall take into account the optimum life cycle costs, energy savings, process requirements and maintenance aspects, as well as present and future equipment integrity implications due to corrosion under insulation (CUI) and external stress corrosion cracking (ESCC).
6. Insulation shall not be applied to pipes and equipment that has been designed to emit heat or where cooling is required.
7. Where personnel burn risk is present from uninsulated pipes and equipment then personnel protection sheets shall be installed.

8. If the 80% rule for bolting has been applied to flanges in accordance with ASME B31.3, then flanges shall not be insulated. Refer to DEP 31.38.01.11-Gen.
9. For insulation of valves, flanges, nozzles and pumps in hydrogen and “sour” service or in system containing hydrocarbons above their auto ignition temperatures reference is made to DEP 31.38.01.11-Gen.
10. Name plates, identification plates and stampings shall be left clear of insulation or shall be fitted outside the cladding.
11. For insulation of pressure relief valves and vents reference is made to DEP 80.45.10.10-Gen.
12. The following documents shall be developed during the design of insulation systems:
 - a. a detailed project specification;
 - b. isometric drawings;
 - c. line designation tables.
13. The documents developed during the design of insulation systems shall be subject to approval by the Principal.
14. The documents developed during the design of insulation systems shall provide:
 - a. the operating temperatures, type of insulation, insulation code, insulation thicknesses and layering, insulation and finishing materials, insulation thicknesses and layering, application and QA/QC requirements;
 - b. areas of removable insulation;
 - c. extent of insulation designated as fireproofing;
 - d. location of insulation expansion/contraction joints;
 - e. location of insulation support rings.
15. The design of insulation systems shall take into consideration thermal stress.
16. Thermal stress calculations shall indicate the requirements and position of expansion or contraction possibilities in longitudinal and circumferential directions in insulation and jacketing materials.

2.2.2 Insulation codes

1. An insulation code to designate insulation systems as a two- or three-number/letter code combination shall be provided as follows:
 - the first number to indicate the temperature operating window (TOW);
 - the third letter to indicate the secondary insulation function.
2. The applicable codes are provided in Table 2.1. Reference is also made to DEP 01.00.09.10-Gen.

Table 2.1 Insulation codes

Temperature operating window	Temperature indication	Process temperature	CUI category
1	Cold or cryogenic	All process temperatures < -5 °C (25 °F)	Low cold
2	Ambient (+/-)	Process temperatures between -5 °C and 50 °C (25 °F and 121 °F)	Medium
3	Hot	Process temperatures between 50 °C and 175 °C (122 °F and 347 °F)	High
4	Very hot	All process temperatures > 175 °C (347 °F)	Low hot
5	Variable or cycling	Cycling or dual process temperatures between -20 °C and 320 °C (-4 °F and 608 °F) (or lower)	Extreme
Primary insulation function	Description primary insulation function		
A	Acoustic (or noise control) insulation system: reducing/controlling noise in pipe, valves or equipment (see DEP 31.46.00.31-Gen).		
C	Cold insulation system: to minimize cold energy loss and (heat gain) mitigate condensation by keeping surface temperature above the dew point of surrounding air.		
F	Freeze protection (winterisation): minimizing energy required for heat tracing systems and/or extending the time to freezing in the event of system failure.		
H	Hot insulation systems, always energy conservation: minimizing unwanted heat loss/gain from pipe and equipment, as well as preserving natural and financial resources (reducing CO ₂ emissions)		
N	Not Required (e.g., pipe/equipment only used for start up or venting, etc.)		
P	Personnel protection: controlling surface temperatures to avoid contact burns (hot or cold)		
S	Fire safety: provide passive fire protection of critical products in pipe and/or equipment.		
T	Temperature control: temperature control of processes or products, to avoid, e.g., solidification or changing of viscosities.		
V	Insulation system for dual, cycling or variable operating temperatures		

Secondary insulation function	Description secondary insulation function
a	Acoustic insulation system class A
b	Acoustic insulation system class B
c	Acoustic insulation system class C
d	Acoustic insulation system class D
e	insulation system for electrical heat traced pipe
g	Guards by means of metal screens for personnel protection
h	heat gain and energy conservation (including CO ₂ reduction)
i	Ignition prevention
j	Jacketed (pipe in pipe)
n	Non contact insulation
o	Insulation system for hot oil heat traced pipe
s	Insulation system for steam traced pipe
u	Buried
w	Avoiding condensation and water dripping of cold insulation systems
x	Avoiding condensation and water dripping of cold insulation systems and reducing of heat gain
Blank	Secondary function not required

2.3 INSULATION SYSTEM REQUIREMENTS

1. All metal surfaces under insulation shall be suitably protected with a complete coating system in accordance with DEP 30.48.00.31-Gen. or a thermal spray metal coating in accordance with DEP 30.48.40.31-Gen.
2. All insulation, jacketing and auxiliary materials shall be asbestos free.
3. Each line shall be insulated separately.
4. Combined insulation of heat traced small bore pipe ($\leq$ DN40, 1 1/2"NB) with equal process operating conditions is allowed.
5. Insulation covers for valves and flanges in pipe systems shall be removable and reusable:
 - a. the mass of each removable part shall be less than 25 kg (55 lb);
 - b. sharp edges shall be avoided.
6. All insulation materials shall be stored in a dry place and be protected from any contact with water, water vapour or other destructive substances, e.g., salts, from the time it is produced until it is installed and protected by the cladding.
7. All pressure testing and repairs shall be completed prior to the application of any insulating materials.
8. Insulation and accessory materials shall be applied only to surfaces that are clean, dry, and frost-free.

9. Insulation expansion or contraction joints shall be provided, taking into account the following:
 - a. the expansion or contraction of the pipe or equipment based on the design temperature of the item;
 - b. the expansion, contraction, or shrinkage of the insulation material, based on the design temperature of the item;
 - c. the resilience of the insulation;
 - d. the method of supporting the insulation.
10. Spacing of expansion or contraction joints should be based on the Insulation Manufacturer/Supplier's recommendation for pipe size and design temperature. Reference is made to CINI 1.3.53.
11. Insulation systems for equipment and pipe shall permit access to parts requiring maintenance without destruction of the adjacent insulation system.
12. When dual layer insulation systems, employing different insulation materials are used for combined thermal and noise control, the acoustic insulation shall be installed as the outer layer.
13. All materials shall be supported by test certificates from a qualified laboratory and/or test reports.
 - a. Material tests shall be carried out in accordance with the applicable test method as defined in (3) and (4) of this DEP.
14. Insulation collars, if not provided by the Equipment Vendor shall be identified and communicated to the Principal.
 - a. Insulation collars shall be fitted to avoid water ingress.
15. Insulation adjacent to flanges in pipe and equipment shall be terminated to allow removal of bolts without damage to that insulation.
 - a. Bolt clearance from the flange to the insulation jacketing shall be at least the bolt length plus an additional 30 mm (1 $\frac{1}{8}$ in).
 - b. If hydraulic bolt tension or torque equipment is used, a greater bolt clearance may be required.
16. The termination of the jacketing shall be water tight.
 - a. In metal jacketing drain holes shall be provided at the lowest point.
 - b. The drain holes are to allow drainage of condense water that may have entered the insulation system.

2.4 REQUIRED METEOROLOGICAL DATA

1. For the calculation of heat transfer and insulation thicknesses, meteorological data shall be collected. In Table 2.2 and Table 2.3, the required parameters are provided for hot service and cold service respectively.

Table 2.2 Required meteorological data for hot service

Meteorological parameter	Unit
Annual Mean Daily Average Temperature	°C (°F)
Annual Mean Wind Speed	m/s (ft/s)
Annual Average Wind Direction	°

Table 2.3 Required meteorological data for cold service

Meteorological parameter	Unit
Annual Mean Daily Maximum Temperature	°C (°F)
Annual Mean Daily Minimum Temperature	°C (°F)
Annual Mean Wind Speed	m/s (ft/s)
Annual Mean Lowest Wind Speed (5%)	m/s (ft/s)
Annual Average Wind Direction	°
Annual Mean Relative Humidity	%

3. HOT INSULATION SYSTEMS

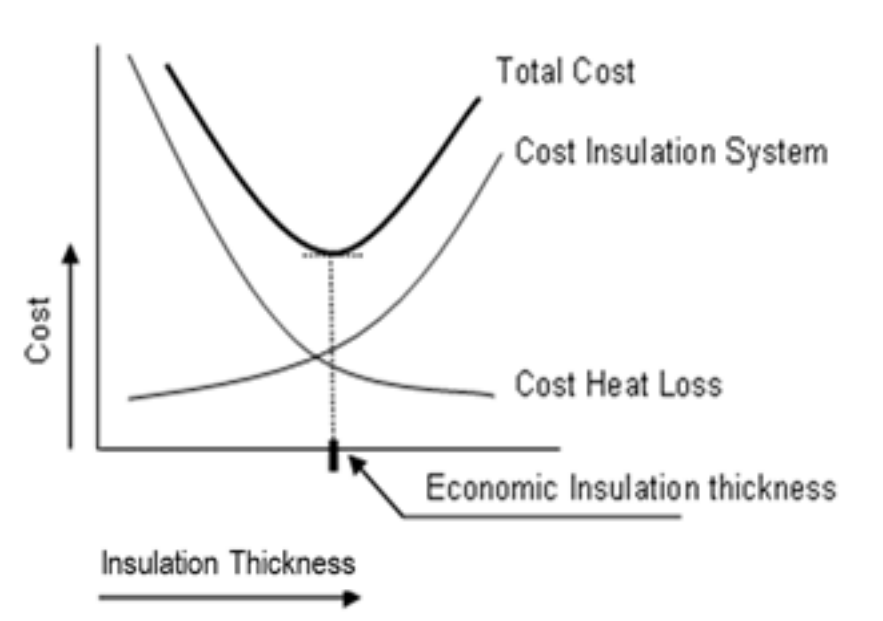
3.1 ENGINEERING DESIGN

1. Hot insulation systems are to be defined as insulation systems for pipes and equipment that operate above ambient temperatures.
2. In hot service, thermal insulation is required for:
 - a. thermal conservation of equipment and pipe if economically justified;
 - b. temperature control of processes or products e.g., to avoid solidification or too high viscosity possibly combined with trace heating;
 - c. personnel protection, e.g. on surfaces with a temperature of 250 °C (482 °F) or higher if these surfaces present a danger (between 60 °C (140 °F) and 250 °C (482 °F) open mesh guards are preferably used).
3. Pipe and equipment provided with internal refractory shall not be insulated.
4. A combination of no more than two different insulating materials shall be used.
5. The use of insulative coatings shall be subject to approval by the Principal and shall demonstrate the ability to provide conductive insulation capability across the thickness of the material exclusive of any boundary layer effects.

3.1.1 Insulation thickness calculations

1. For hot services, the optimum economical insulation thickness shall be calculated according to the minimum total cost method.
2. For a given thickness, the total cost is the sum of the investment and maintenance of the insulation system and the cost of energy losses through the insulation as shown in Figure 3.1.
3. Tables for thermal insulation thickness shall be created for each insulation system and each project site similar to the referenced tables with various input parameters provided in (Appendix E).
 - a. These calculations shall be based on ISO 12241 or ASTM C 680.

Figure 3.1 Minimum total cost method for insulation thickness design



In some cases a separate insulation thickness evaluation is required to fulfill specific process, safety, environmental or technical requirements. The following additional calculations can apply:

- *the temperature changes of a flowing fluid in an insulated and an uninsulated pipe;*
 - *the time in which a stagnant fluid in an insulated or an uninsulated pipe changes to a certain temperature;*
 - *the temperature change of a stagnant fluid in an insulated or uninsulated pipe in a certain time;*
 - *the insulation thickness for a pipe to limit the temperature change of a flowing fluid to a certain value.*
4. Insulation design temperature for heat conservation shall be the normal operating temperature.
 5. Insulation system materials shall be selected to withstand the emergency and maximum (or minimum) operating temperature.
 6. A commercially available thickness shall be specified.
 - a. The thickness specified shall be equal to or greater than the actual thickness required.

For insulation used on pipes and equipment in buildings or hulls, other requirements might apply depending on climate, heat emission and HVAC requirements.

3.1.2 CUI and ESCC mitigation

3.1.2.1 Risk Based Inspection (RBI) CUI categories

CUI and ESCC are considered a major risk to equipment integrity with a potential safety and cost impact. Therefore, categories has been developed indicating the vulnerability to CUI and ESCC. To manage CUI and ESCC, effective barriers shall be put in place.

1. Three different barriers shall be adopted in the material selection to manage CUI and ESCC:
 - a. surface protection of the pipe or equipment that will be insulated;
 - b. the insulation material;
 - c. the jacketing material.
2. Reference is made to the flow diagrams in (Appendix B).
3. CUI risks for ferritic steel are identified in relation to the operating temperature and shall be applied in Risk Based Inspection as Table 3.1.
4. ESCC risks for stainless steel are identified in relation to the operating temperature and shall be applied in Risk Based Inspection as Table 3.2.

Table 3.1 CUI risk categories

Operating temperature	CUI risk
< -5 °C (25 °F)	Low
> 175 °C (347 °F)	Low
-5 °C to 49 °C (25 °F to 121 °F)	Medium
50 °C to 175 °C (122 °F to 347 °F)	High
Cycling temperatures between -20 °C and 320 °C (-4 °F and 608 °F)	Extreme

Table 3.2 ESCC risk categories

Operating temperature	ESCC risk
< 50 °C (122 °F)	Low
50 °C to 175 °C (122 °F to 347 °F)	High
>175 °C (347 °F)	Low

5. For the first barrier against CUI and ESCC, the surface protection, reference is made to DEP 30.48.00.31-Gen. and to DEP 30.48.40.31-Gen.
6. Within the Extreme CUI risk category TSA shall be applied as the preferred surface protection.

7. In the High CUI risk category TSA should be the preferred surface protection.
8. When an organic coating system is selected in the High CUI risk category, refer to (Appendix B) and (Appendix C) for additional requirements for the insulation and jacketing materials.

The flow diagrams for the insulation and jacketing material selection are based on the risk categories as described in Table 3.1 and Table 3.2.

Dead legs in pipe systems and equipment often operate at a colder/warmer temperature than the actual operating temperature of the pipe system or equipment. This could have an effect on the selected surface protection and insulation materials.

3.1.2.2 Non contact insulation

Non-contact type of insulation is an insulation system in which there is limited contact between bare surface of pipe/equipment and the insulation material.

1. Non contact insulation shall be applied only for vessels and large diameter pipes within the Extreme CUI category.
2. Non contact insulation should be applied in acoustic insulation systems without thermal requirements. See also (3.1.4).
3. Refer to CINI 4.1.34 and 4.2.18.

3.1.3 Personnel burn protection

1. Surfaces at temperatures above 60 °C (140 °F) and accessible from normal working areas and access ways shall be provided with personnel protection to a height of 2000 mm (80 in) above the walking level.
 - a. The personnel protection shall be extended a minimum of 800 mm (32 in) horizontally from the access ways and normal working areas.
2. When personnel protection is required, physical barriers such as open mesh guards, protective metal sheeting/screens or hand railings and hazard markings shall be used instead of insulation at surface temperature below 250 °C (482 °F).
3. Sheet thickness for personnel protection shall be 1 mm (0.04 in).
 - a. Perforation holes shall be minimum 5 mm (0.2 in), with minimum 40% free passage.
 - b. Steel sheet shall be stainless steel in accordance with ASTM A240: type 304.
 - c. Wired mesh is allowed.
 - d. Reference is made to CINI 2.25.01.
4. Shields on flanged connections and equipment shall be designed for convenient removal for maintenance access.
 - a. Individual sections shall not weight more than 25 kg (55 lb).
5. For surface temperatures higher than 250 °C (482 °F), the insulation thickness shall be calculated.

In (Appendix D), reference tables are provided with the distance from the sheet/guard to the bare surface for pipe with temperatures below 250 °C (482 °F), and for insulation thicknesses for pipe and equipment with temperatures above 250 °C (482 °F).

6. Tables for thermal insulation thickness shall be created for each project site similar to the one provided in (Appendix D).
7. The use of personnel burn protection insulative coating shall be subject to approval by the Principal.