

DEP SPECIFICATION

THERMAL INSULATION

DEP 30.46.00.31-Gen.

September 2011

(DEP Circular 70/12 has been incorporated)

DESIGN AND ENGINEERING PRACTICE



© 2011 Shell Group of companies
All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, published or transmitted, in any form or by any means, without the prior written permission of the copyright owner or Shell Global Solutions International BV.

PREFACE

DEP (Design and Engineering Practice) publications reflect the views, at the time of publication, of Shell Global Solutions International B.V. (Shell GSI) and, in some cases, of other Shell Companies.

These views are based on the experience acquired during involvement with the design, construction, operation and maintenance of processing units and facilities. Where deemed appropriate DEPs are based on, or reference international, regional, national and industry standards.

The objective is to set the recommended standard for good design and engineering practice to be applied by Shell companies in oil and gas production, oil refining, gas handling, gasification, chemical processing, or any other such facility, and thereby to help achieve maximum technical and economic benefit from standardization.

The information set forth in these publications is provided to Shell companies for their consideration and decision to implement. This is of particular importance where DEPs may not cover every requirement or diversity of condition at each locality. The system of DEPs is expected to be sufficiently flexible to allow individual Operating Units to adapt the information set forth in DEPs to their own environment and requirements.

When Contractors or Manufacturers/Suppliers use DEPs, they shall be solely responsible for such use, including the quality of their work and the attainment of the required design and engineering standards. In particular, for those requirements not specifically covered, the Principal will typically expect them to follow those design and engineering practices that will achieve at least the same level of integrity as reflected in the DEPs. If in doubt, the Contractor or Manufacturer/Supplier shall, without detracting from his own responsibility, consult the Principal.

The right to obtain and to use DEPs is restricted, and is granted by Shell GSI (and in some cases by other Shell Companies) under a Service Agreement or a License Agreement. This right is granted primarily to Shell companies and other companies receiving technical advice and services from Shell GSI or another Shell Company. Consequently, three categories of users of DEPs can be distinguished:

- 1) Operating Units having a Service Agreement with Shell GSI or another Shell Company. The use of DEPs by these Operating Units is subject in all respects to the terms and conditions of the relevant Service Agreement.
- 2) Other parties who are authorised to use DEPs subject to appropriate contractual arrangements (whether as part of a Service Agreement or otherwise).
- 3) Contractors/subcontractors and Manufacturers/Suppliers under a contract with users referred to under 1) or 2) which requires that tenders for projects, materials supplied or - generally - work performed on behalf of the said users comply with the relevant standards.

Subject to any particular terms and conditions as may be set forth in specific agreements with users, Shell GSI disclaims any liability of whatsoever nature for any damage (including injury or death) suffered by any company or person whomsoever as a result of or in connection with the use, application or implementation of any DEP, combination of DEPs or any part thereof, even if it is wholly or partly caused by negligence on the part of Shell GSI or other Shell Company. The benefit of this disclaimer shall inure in all respects to Shell GSI and/or any Shell Company, or companies affiliated to these companies, that may issue DEPs or advise or require the use of DEPs.

Without prejudice to any specific terms in respect of confidentiality under relevant contractual arrangements, DEPs shall not, without the prior written consent of Shell GSI, be disclosed by users to any company or person whomsoever and the DEPs shall be used exclusively for the purpose for which they have been provided to the user. They shall be returned after use, including any copies which shall only be made by users with the express prior written consent of Shell GSI. The copyright of DEPs vests in Shell Group of companies. Users shall arrange for DEPs to be held in safe custody and Shell GSI may at any time require information satisfactory to them in order to ascertain how users implement this requirement.

All administrative queries should be directed to the DEP Administrator in Shell GSI.

TABLE OF CONTENTS

1.	INTRODUCTION	4
1.1	SCOPE.....	4
1.2	DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS	4
1.3	DEFINITIONS	4
1.4	CROSS-REFERENCES	6
1.5	SUMMARY OF MAIN CHANGES	6
1.6	COMMENTS ON THIS DEP	6
1.7	DUAL UNITS.....	6
2.	GENERAL.....	7
2.1	RELATIONSHIP WITH EXTERNAL DOCUMENTS	7
2.2	INSULATION DESIGN CRITERIA.....	7
2.3	INSULATION SYSTEM REQUIREMENTS	10
2.4	REQUIRED METEOROLOGICAL DATA.	11
3.	HOT INSULATION SYSTEMS	12
3.1	ENGINEERING DESIGN	12
3.2	MATERIALS.....	15
3.3	APPLICATION	23
4	COLD AND DUAL INSULATION SYSTEMS.....	26
4.1	ENGINEERING DESIGN	26
4.2	MATERIALS.....	27
4.3	APPLICATION	31
5.	QUALITY ASSURANCE & QUALITY CONTROL	34
5.1	QUALITY PLAN	34
5.2	QUALITY CONTROL	34
6.	REFERENCES	36

APPENDICES

APPENDIX A	FLOW DIAGRAM TO ASSESS THE NEED FOR THERMAL INSULATION IN HOT SERVICE.....	39
APPENDIX B	FLOW DIAGRAM TO SELECT THERMAL INSULATION AND JACKETING MATERIALS IN HOT SERVICE.....	40
APPENDIX C	FLOW DIAGRAM TO SELECT THERMAL INSULATION AND JACKETING MATERIALS IN COLD AND DUAL SERVICE	41
APPENDIX D	REFERENCE TABLE FOR THERMAL INSULATION THICKNESS FOR PERSONNEL BURN PROTECTION	42
APPENDIX E	REFERENCE TABLES FOR ECONOMICAL THERMAL INSULATION THICKNESS IN HOT SERVICE.....	43
APPENDIX F	REFERENCE TABLES FOR THERMAL INSULATION THICKNESS IN COLD SERVICE TO AVOID CONDENSATION AND REDUCE HEAT GAIN.....	48
APPENDIX G	REFERENCE TABLE FOR THE LAYERING OF COLD INSULATION	52
APPENDIX H	APPLICATION INSTRUCTIONS FOR CSPE JACKETING.....	53

1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for external thermal insulation of above ground surfaces of equipment and piping. 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 covered in DEP 34.51.01.32-Gen.

This is a revision of the DEP of the same number dated September 2010; see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorised access to DEPs does not for that reason constitute an authorization to any documents, data or information to which the DEPs may refer.

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 should 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.

1.3.2 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, which may be used for project specifications and tailor made detailed and/or construction specifications.
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 piping/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.
Dual Process Temperature	Process temperature cycling between ambient (or lower) and 320°C (or lower).
EPDM rubber	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.
Hot Insulation	Insulation used to save energy for economic reasons; typically applied for process temperatures between 60°C and 600°C
Insulation System	Combination of insulation materials and jacketing designed to achieve the most economic solution and service life.
Metallic Jacketing	Jacketing which consists of aluminium or aluminized steel cladding or stainless steel.
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 piping/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 piping 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.

Term	Definition
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 piping 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.
Thermal Insulation	Generic term covering hot, cold, process and personnel protection insulation.
TSA	Thermal Sprayed Aluminium
Vapour barrier	A layer as part of the cold insulation systems to prevent transport of water vapours into the insulation material.
Vapour stop	A provision as part of the cold insulation system to prevent transport of water vapours in longitudinal direction of pipeline compartments and at terminations.

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section 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 revision of the DEP of the same number dated September 2010. The DEP has been completely restructured. The previous version of the DEP was an amendment on the CINI manual where this version is a stand-alone document for the selection and specifications of insulation and jacketing materials.

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be sent to the Administrator at standards@shell.com, using the DEP Feedback Form. The DEP Feedback Form can be found on the main page of "DEPs on the Web", available through the Global Technical Standards web portal <http://www.shell.com/standards> and on the main page of the DEPs DVD-ROM.

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.

2. GENERAL

2.1 RELATIONSHIP WITH EXTERNAL DOCUMENTS

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.

The selection of insulation and related jacketing materials shall be based on this DEP. 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 prevails. For material specifications, drawings and construction details reference is made in this DEP to specific sections of the CINI manual. Amendments to these requirements are subject to review and comments by the Principal.

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 are subject to the Management of Change (MoC) process.

2.2 INSULATION DESIGN CRITERIA

2.2.1 General engineering practices

Before design of insulation systems, the necessity of insulation shall be assessed by using the flow diagram provided in (Appendix A).

The following criteria shall be used in both determining the need for and in designing insulation systems, using good engineering practices:

- a) CUI and ESCC risks – where CUI and ESCC risks are present, careful consideration shall be given to the necessity of thermal insulation.
- b) Process reason – to minimize heat gain or heat loss for process reasons to avoid process disruption or solidification. In such cases, insulation may be combined with heat tracing.
- c) Economics – to minimize heat loss and reduce emissions. In hot service the optimum economic insulation thickness shall be calculated according to the "Minimum Total Cost Method". 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. Surfaces that operate below the local ambient dew point for more than 5 percent of the time require insulation. The maximum heat gain in cold service to conserve refrigeration shall be 25 W/m^2 (8 Btu/hr/ft^2). In some circumstances boil-off is the dominant criteria e.g., 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 pipelines and equipment from heat radiation from fires.
- h) Winterizing – for heat traced piping, instruments, and equipment.

Calculations for heat transfer shall be based on ISO 12241 or ASTM C680.

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.

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).

Insulation shall not be applied to pipelines and equipment that has been designed to emit heat or where cooling is required but areas where personnel burn risk is present protective insulation or sheets shall be installed.

Valves, flanges, nozzles and pumps shall be insulated, except for in the following circumstances:

- a) In hydrogen services, valves, flanges, nozzles and pump seals shall not be insulated.
- b) In systems containing hydrocarbons above their auto ignition temperature valves, flanges, nozzles and pump seals shall not be insulated.
- c) If the 80 % rule for bolting has been applied to flanges in accordance with ASME B31.3, these flanges shall not be insulated. Refer to DEP 31.38.01.11-Gen.
- d) Where calculations show that conductive heat loss is insignificant to the project.

Name plates, identification plates and stampings shall be left clear of insulation or shall be fitted outside the cladding.

The following documents shall be developed during the design of insulation systems:

- A detailed project specification
- Isometric drawings
- Line designation tables

The documents mentioned above shall be submitted to the Principal for review and comments and shall provide:

- The operating temperatures, type of insulation, insulation code, insulation thicknesses and layering, insulation and fining materials, insulation thicknesses and layering, application and QA/QC requirements;
- Areas of removable insulation;
- Extent of insulation designated as fireproofing;
- Location of insulation expansion/contraction joints;
- Location of insulation support rings.

The design of insulation systems shall deal with thermal stress. 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

This DEP uses an insulation code to designate insulation systems as a two- or three-number/letter code combination, as follows:

- The first number shall indicate the category tag.
- The second letter shall indicate the requirement tag.
- The third letter shall indicate the additional requirement type.

The applicable codes are provided in Table 2.1.

Table 2.1: Insulation codes

Category Tag	CUI category	Process temperature
1	Extreme	Cycling or dual process temperatures between –20 °C and 320 °C (–4 and 608 °F) (or lower)
2	High	Process temperatures between 50 °C and 175 °C (122 and 347 °F)
3	Medium	Process temperatures between –5 °C and 50 °C (25 and 121 °F)
4	Low hot	All process temperatures > 175 °C (347 °F)
5	Low cold	All process temperatures < –5 °C (25 °F)
Requirement tag	Description requirement	
A	Acoustic (or noise control): reducing/controlling noise in piping, valves or equipment.	
C	Condensation control: mitigate condensation by keeping surface temperature above the dew point of surrounding air.	
E	Energy conservation: minimizing unwanted heat loss/gain from piping and equipment, as well as preserving natural and financial resources (reducing CO ₂)	
F	Freeze protection: minimizing energy required for heat tracing systems and/or extending the time to freezing in the event of system failure.	
N	Not Required (e.g., piping/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 piping and/or equipment.	
T	Temperature control: temperature control of processes or products, to avoid, e.g., solidification or changing of viscosities.	
Additional requirement tag	Description	
c	Contact type of insulation	
e	Electrical heat tracing	
h	Hot oil heat tracing	
i	Insulation for personnel protection	
m	Metal screens for personnel protection	
n	Non-contact type of insulation.	
s	Steam tracing	

2.3 INSULATION SYSTEM REQUIREMENTS

All metal surfaces under insulation shall be suitably protected with a complete coating system in accordance with DEP 30.48.00.31-Gen. and DEP 70.48.11.30-Gen. or a thermal spray metal coating in accordance with DEP 30.48.40.31-Gen.

All insulation, jacketing and auxiliary materials shall be asbestos free. No Chlorofluorocarbon (CFCs) or Hydrochlorofluorocarbon (HCFCs) shall be used in the production of insulation materials.

Each line shall be insulated separately.

Insulation covers for valves and flanges in piping systems shall be removable and reusable. The mass of each removable part shall be less than 25 kg (66 lb). Sharp edges shall be avoided.

All insulation material shall be stored in a dry place and shall 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.

All pressure testing and necessary repairs shall be satisfactorily completed prior to the application of any insulating materials.

Insulation and accessory materials shall be applied only to surfaces that are clean, dry, and frost-free.

Insulation expansion joints shall be provided, taking into account the following:

- The expansion or contraction of the piping or equipment based on the design temperature of the item,
- The expansion, contraction, or shrinkage of the insulation material, based on the design temperature of the item,
- The resilience of the insulation,
- The method of supporting the insulation.

Spacing of expansion joints shall be based on the Insulation Manufacturer's recommendation for pipe size and design temperature. Reference is made to CINI 1.3.53

Insulation systems for equipment and piping shall permit access to parts requiring maintenance without destruction of the adjacent insulation system.

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.

All materials shall be supported by test certificates from a qualified laboratory and/or test reports. These tests shall be carried out in accordance with the applicable test method as defined in (3) and (4) of this DEP.

Insulation collars, if not provided by the Equipment Vendor shall be notified and communicated to the Principal and shall be fitted to avoid water ingress.

Insulation adjacent to flanges in piping and equipment shall be terminated to allow removal of bolts without damage to that insulation. Bolt clearance from the flange to the insulation jacketing shall be at least the bolt length plus an additional 30 mm (1½ in). If hydraulic bolt tension or torque equipment is used, a greater bolt clearance may be required.

The termination of the jacketing shall be water tight. In metal jacketing drain holes shall be provided at the lowest point to allow drainage of condense water that may have entered the insulation system.

2.4 REQUIRED METEOROLOGICAL DATA.

For the calculation of heat transfer and insulation thicknesses, meteorological data needs to 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 Average 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

Hot insulation systems are to be defined as insulation systems for pipelines and equipment that operate above ambient temperatures.

In hot service, thermal insulation is required for:

- Thermal conservation of equipment and piping if economically justified;
- Temperature control of processes or products e.g., to avoid solidification or too high viscosity possibly combined with trace heating;
- 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).

Piping and equipment provided with internal refractory shall not be insulated.

A combination of no more than two different insulating materials shall be used.

Insulative coatings shall not be used without approval of 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

For hot services, the optimum economical insulation thickness shall be calculated according to the minimum total cost method. 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. Tables shall be created for each insulation system and each project site similar to the referenced tables with various input parameters provided in (Appendix E). These calculations shall be based on VDI 2055.

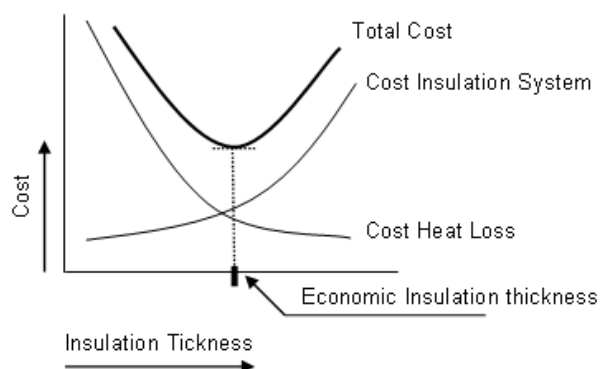


Figure 3.1: Minimum total cost method for insulation thickness design

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

- a) The temperature changes of a flowing fluid in an insulated and an uninsulated pipeline,
- b) The time in which a stagnant fluid in an insulated or an uninsulated pipeline changes to a certain temperature,
- c) The temperature change of a stagnant fluid in an insulated or uninsulated pipeline in a certain time,
- d) The insulation thickness for a pipeline to limit the temperature change of a flowing fluid to a certain value.

Insulation design temperature for heat conservation shall be the normal operating temperature. Insulation system materials shall be selected to withstand the emergency and maximum (or minimum) operating temperature.

A commercially available thickness shall be specified. The thickness specified shall always be equal to or greater than the actual thickness required.

For insulation used on pipelines and equipment in buildings or hulls, other requirements may 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. Three different barriers can be recognized:

- Surface protection of the pipe or equipment that will be insulated
- The insulation material
- The jacketing material

A holistic approach, considering all three barriers, shall be adopted in the material selection to manage CUI and ESCC. Reference is made to the flow diagrams in (Appendix B).

CUI risks for ferritic steel are identified in relation to the operating temperature and are presented in Table 3.1. ESCC risks for stainless steel are also identified in relation to the operating temperature and are presented in Table 3.2.

Table 3.1: CUI risk categories

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

Table 3.2: ESCC risk categories

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

For the first barrier against CUI and ESCC, the surface protection, reference is made to DEP 30.48.00.31-Gen. or DEP 70.48.11.30-Gen. and to DEP 30.48.40.31-Gen. Within the extreme CUI risk category TSA shall be applied as the preferred surface protection. In the high CUI risk category TSA is also the preferred surface protection. When in this category an organic coating system is selected, additional requirements will apply 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.

It shall be recognised in the design of insulation systems that dead legs in piping systems and equipment operate in a colder temperature than the rest of the systems, which could have a effect on the selected surface protection and insulation material.

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. Non contact insulation shall be applied only for vessels and large diameter pipelines within the extreme CUI category and in acoustic insulation systems without thermal requirements. See also (3.1.4). Reference is made to CINI 4.1.34 and 4.2.18.

3.1.3 Personnel burn protection

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. The protection shall be extended a minimum of 800mm (32 in) horizontally from the access ways and normal working areas.

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).

Sheet thickness shall be 1 mm (0.04 in). Perforation holes shall be minimum 5 mm (0.2 in), with minimum 40 % free passage. Steel sheet shall be stainless steel in accordance with ASTM A167: type 304. Wired mesh is allowed. Reference is made to CINI 2.25.01

Shields on flanged connections and equipment shall be designed for convenient removal for maintenance access. Individual sections shall not weight more than 25 kg (66 lb).

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 piping with temperatures below 250°C (482°F), and for insulation thicknesses for piping and equipment with temperatures above 250°C (482°F). Tables shall be created for each project site similar to the one provided in (Appendix D).

For personnel burn protection insulative coating may be used after approval by the Principal.

3.1.4 Hot insulation combined with acoustic insulation

Acoustic insulation shall be designed in accordance with DEP 31.46.00.31-Gen. and ISO 15665.

Acoustic insulation shall consist of:

- A porous layer, which absorbs noise and supports the cladding, the finishing outer layer,
- A closed cladding, which is a barrier to the noise and protects the porous layer.

If hot insulation is combined with acoustic insulation the same materials may be used. The thickness of the insulation system shall be determined by the more stringent of the two systems.

If the system is within the CUI range extreme as defined in (3.1.1), non contact insulation shall be designed and applied. Reference is made to CINI 4.1.34 and 4.2.18.

A porous insulation material shall always be applied at the outer acoustic layer of the insulation system. Reference is made to CINI 9.5.00 to 9.5.10.

In acoustic insulation systems, an aluminized steel or stainless steel jacketing shall be applied.

3.1.5 Hot insulation combined with fire protection

If fire protection of pipelines or equipment is required, cellular glass shall be used as the insulation material. Alternative materials for fire protections may be used after approval of the Principal.

If fire protection of pipelines or equipment is required, only aluminized steel or stainless steel jacketing material shall be used.

3.1.6 Hot insulation combined with heat tracing

For insulation systems combined with heat tracing, a separate calculation shall be made to determine the required insulation thickness. For the design, reference is made to DEP 31.38.30.11-Gen. and DEP 33.68.30.32-Gen. Also, reference is made to CINI 4.1.04.

3.2 MATERIALS

For all materials, documentation such as certificates of origin, quality control records, product information and safety material data sheets shall be made available and shall indicate HSE-related hazards during application, use, removal and disposal.

3.2.1 Material selection

For the insulation and jacketing material selection, reference is made to the flow diagram in (Appendix B).

3.2.2 Insulation materials

Only the materials provided in this DEP are allowed for use. Other materials require approval from the Principal.

Extruded polystyrene foam shall not be used.

Glass wool insulation shall not be used.

3.2.2.1 Cellular glass

Cellular glass shall be finished with weather resistant bitumen-based vapour barrier (cell filler) in cold climates to prevent frost damage.

Cellular glass shall be used in insulation collars and for fire protection purposes. For details on insulation collars, reference is made to standard drawing S.10.056.

Cellular glass material properties shall comply with the requirements in Table 3.5. The material properties shall be demonstrated by the applicable test standard provided in Table 3.5.

Table 3.5: Cellular glass material properties

Data	Acceptable	Applicable standard
Temperature range	From +427°C to -200°C (800°F to -328°F)	N.A.
Density	115 kg/m ³ (7.2 lb/ft ³)	ASTM C303
Closed cell content	100%	ASTM D6226
Water vapour permeability	Maximum 0 gr/m ² .hr at 23°C (73°F and 50% relative humidity	ASTM E96/E96M, proc. A
Leachable chlorides	Maximum 45 ppm	ASTM C871, proc. 2
pH value	Between 6 and 10	ASTM C871
Flame spread index	Maximum 0	ASTM E84
Compressive strength	500 kPa (72.5 psi), from +427°C to -200°C (800°F to -328°F) in all directions	ASTM C165

The thermal conductivity values of cellular glass shall be based on measurements performed by an independent institute in accordance with ASTM C177 and shall be as per Table 3.6.

Table 3.6: Cellular glass maximum thermal conductivity values

Mean material temperature in °C	Maximum thermal conductivity in W/m.K	Maximum thermal conductivity in BTU/(hr.ft.F)
+ 400 °C (752 °F)	0.130	0.076
+ 350 °C (662 °F)	0.120	0.070
+ 300 °C (572 °F)	0.100	0.058
+ 250 °C (482 °F)	0.087	0.051
+ 200 °C (392 °F)	0.074	0.043
+ 150 °C (302 °F)	0.063	0.036
+ 100 °C (212 °F)	0.053	0.031
+ 50 °C (122 °F)	0.044	0.025
0 °C (32 °F)	0.036	0.021
- 50 °C (-58 °F)	0.029	0.017
-100 °C (-148 °F)	0.023	0.013
-150 °C (-238 °F)	0.018	0.011
-180 °C (-292 °F)	0.016	0.009

Furthermore reference is made to CINI 2.9.01

3.2.2.2 Mineral wool

Mineral wool shall be moulded pipe insulation per ASTM C547.

Mineral wool blankets shall be used only for shapes for which pre-formed pipe sections are not available.

Loose mineral wool shall be used only in a removable metal box reinforced with angle iron and filled with loose insulation materials.

Mineral wool section and prefabricated elbows shall be mildew-free and free of rot and shall not have heat-evolving properties or show exothermal reactions.

Mineral wool materials properties shall comply with requirements provided in Table 3.7 and Table 3.8.

Table 3.7: Mineral wool temperature range-volumetric mass

Temperature range/volumetric mass:	
Temperature in accordance with ASTM C447	Volumetric mass unloaded in accordance with ASTM C302
1 st heating to 200°C (390 °F); for further use to 750°C (1380 °F)	100-135 kg/m ³ (6.24 – 8.43.lb/ft ³)

Table 3.8: Mineral wool material properties

Data	Acceptable level	Applicable standard
Water absorption	≤ 10% volume	AGI Q136
Leachable chlorides	≤ 10 mg/kg (ppm)	ASTM C871
pH value	Between 6 and 10.5	ASTM C871
Flame spread index	Maximum 0	ASTM E84
Compressive strength	8 kPa (1.16psi) at 10% compression	ASTM C165
Dimensional stability	In accordance with	ASTM C547

The thermal conductivity values of mineral wool shall be based on measurements performed by an independent institute in accordance with ASTM C177 and shall be as per Table 3.9.

Table 3.9: 135 kg/m³ (8.43 lb/ft³) mineral wool maximum thermal conductivity values

Average temperature in °C	Thermal conductivity in W/m.K for density 135 kg/m ³	Thermal conductivity in BTU/(hr.ft.F) for density 8.43 lb/ft ³
500 (932°F)	0.148	0.086
400 (752°F)	0.110	0.064
300 (572°F)	0.082	0.047
250 (482°F)	0.070	0.040
200 (392°F)	0.059	0.034