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PIPE AND EQUIPMENT INSULATION

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DESIGN AND ENGINEERING PRACTICE

DEM1



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1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements for insulation systems of external surfaces belonging to all equipment and piping except for the following:

- Vacuum insulated pipe;
- Pre-insulated tubing;
- Facilities (e.g., buildings and floating structure hulls);
- HVAC ducts;
- LNG tankage;
- Buried equipment and piping systems;
- Systems operating with metal temperatures above 750 °C (1382 °F).

The insulation system requirements in this DEP are for the following:

- Thermal insulation;
- Insulation performing as passive fire protection;
- Acoustic insulation.

The CINI manual (latest edition) is to be used as the primary reference document for material properties, material specifications and design and construction detailing. It is expected that the CINI manual is amended using the content of this DEP in developing project documentation.

This DEP contains mandatory requirements to mitigate process safety risks in accordance with Design Engineering Manual (DEM) 1 – Application of Technical Standards.

This is a revision of the DEP of the same number dated February 2017; 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 capitalised term **SHALL [PS]** indicates a process safety requirement.

The word **should** indicates a recommendation.

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

1.3.2 Specific definitions

Term	Definition
Acoustic Insulation	Insulation installed to reduce the noise radiated from a surface of piping and valves (noise attenuation).
CINI Manual	The CINI Manual is a detailed reference handbook with material and construction specifications for thermal and acoustic insulation systems, which can 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.
Cold Service	Piping systems and equipment with cold insulation are classified as being in cold service.
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.
Corrosion Under Insulation	An acceleration of corrosion due to ingress of moisture into external insulation where the operating temperature is in the range of -5 °C (23 °F) to 175 °C (347 °F).
Design Ambient Dew Point Temperature	The lowest dew point temperature chosen by the design below which the airborne water vapor will condense to form liquid water.
Dual-Layer Insulation system	When the insulation layer in the insulation system is multi-layer and one or more layer are of different materials (e.g. FAM or CG and Mineral wool, PIR or FEF).

Term	Definition
EO Service	EO service is considered when the process fluid contains more than 10 wt% ethylene oxide (EO).
Fire Protection Insulation	Insulation applied as PFP to pipe and equipment in FPZs as protection against the adverse thermal effects of fire for a defined period and a defined degree of exposure.
Flexible Aerogel	A manufactured material which is derived from a gel in which the liquid component of the gel has been replaced with a gas. The term “nano” and “micro” refer to the size of the voids inside the material.
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 (140 °F and 1112 °F)
Hot Service	Piping systems and equipment with hot insulation are classified as being in ‘hot service’.
Installer	The party applying the insulation system specified by the Contractor.
Insulation System	Combination of insulation materials and jacketing designed to achieve the most economic solution and service life.
Jacketing	Jacketing is provided to protect the insulation materials from foreign elements, especially water and external mechanical abuse.
Metallic Jacketing	Jacketing which consists of aluminium or aluminized steel cladding or stainless steel.
Micro Porous Blanket	A manufactured material, similar to flexible aerogel material derived from a gel, in which the liquid component of the gel has been replaced with a gas. Unlike flexible aerogel which has “nano- sized” voids inside the material, the microporous materials have “micro-sized” pores.
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-Metallic Jacketing	Jacketing consisting of GRE, GRP, and polymeric compound or modified EPDM; often used in conjunction with a multiplex primary vapour barrier.
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.

Term	Definition
Removable insulation enclosures	Insulation enclosures that are expected to be removed and reinstated during the operation.
Scrim	Scrim as used in this specification refers to a reinforcing mesh that is included within the thickness of the material. Scrim (cloths) provide tension reinforcement and puncture resistance.
Thermal Insulation	Generic term covering hot, cold, process and personnel protection insulation.
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 pipe compartments and at terminations.

1.3.3 Abbreviations

Term	Definition
CFC	Chlorofluorocarbon
CG	Cellular Glass
CINI	Committee Insulation Netherlands Industry
CMS/AES	Calcium magnesium silicate wool/ Alkaline earth silicate wool high temperature fiber blanket materials.
CoC	Certificate of Conformance
CSPE	ChloroSulphonated PolyEthylene
CUI	Corrosion Under Insulation
DN	Diameter Nominal
EO	Ethylene Oxide
EPDM rubber	Ethylene Propylene Diene Monomer rubber
FAM	Flexible Aerogel / Micro Porous Blanket
FEF	Flexible Elastomeric Foam
FPZ	Fireproofing Zone (specifically, pool-Fire Proofing Zone)
GRP	Glass-fibre Reinforced Polyester/Plastic (GRP is a generic term which also covers the specific case of GRE, glass-fibre reinforced epoxy material)
HCFC	Hydrochlorofluorocarbon

Term	Definition
HD	High density
ITP	Inspection and Test Plan
LNG	Liquefied Natural Gas
NB	Nominal Bore
PCBs	Polychlorinated biphenyls
PDS	Product Datasheet
PIR	Polyisocyanurate rigid foam
PUR	Polyurethane rigid foam
QA/QC	Quality Assurance / Quality Control
SDS	Safety Data Sheet (formerly MSDS)
SUIS	Safe Use Instruction Sheet
TAMAP	Technically Accepted Manufacturers And Products
TSA	Thermally Sprayed Aluminium
UV	Ultra Violet Light

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 complete revision of the DEP of the same number dated February 2017.

Section/Clause	Change
2.2.1, Item 7	New DEM1 clause
2.2.5, Item 1	New DEM1 clause

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. ENGINEERING DESIGN

2.1 DESIGN PHILOSOPHY

1. The design philosophy shall include the justification for when insulation systems are provided for all asset types relative to the life cycle cost.
 - a. The documentation should provide justification for use of insulation in the CUI range.
2. The design philosophy shall include documentation of how and to what extent the facility will maintain and measure integrity of the insulation system to meet each stated justification over the life of the asset.
3. The design philosophy shall include the selection methodology of passive fire protection (PFP) materials and insulation systems on piping and equipment.
 - a. The design philosophy shall include the criteria to determine the extent to which a component that protrudes through the insulation system requires PFP insulation, based on its relative size to the equipment and specified scenario for the FPZ.

Reference NORSOK S001 Cutback of PFP on structural elements Section 19.4.2.

4. The design philosophy shall include the design and procurement process flow that ensures that the following details will align with the thickness and termination requirements of the insulation system while not posing a barrier to safely access and operate the facility's valves:
 - a. valve extensions;
 - b. weather shield closure fittings;
 - c. standard valve and stem orientation.
5. The design philosophy shall include clash detections and clash resolutions in all phases of the design, including within modules and packaged equipment that will ensure the insulation system is clash free during the installation.

Where clashes are unavoidable, before completing final model review, the clash resolution ensures the integrity of the insulation system at the clash location.

Clash detection includes all piping, equipment (including boxes around valves and flanges) and structural elements.

6. The design philosophy shall include the design process flow to ensure the mechanical design detailing of the equipment that requires insulation are provided with fixings and support points for installing the insulation system on schedule.
 - a. The process flow shall address the standoff requirements of platforms and ladders based on insulation thickness.
 - b. The process flow shall address the temperature isolation or insulation support-extension that is needed to prevent hot spots in cold insulation.
7. The design philosophy shall include the construction methodology/staging and expected needs for temporary insulation system's protection system and material selection from beginning of insulation works (e.g., module yard, shop work) to final installation and acceptance.
8. The design philosophy shall include the requirements of field execution documents.

Rationale: To convey the details about the insulation systems (e.g., fire protection and acoustic), insulation thickness and insulation system execution (including types of insulation and the areas of removable insulation).

9. The design philosophy shall include the measures that will ensure personnel responsible for the selection, design, installation, inspection and testing of insulation systems are competent.

Competence in working the insulation system scope can be met by ensuring personnel meet the requirements set out in the Energy Institute - Guidelines for the design, installation and management of thermal insulation systems, Annex D.

10. Tank roofs that are required to be insulated and vessel shells that require personnel protection shall be provided with mechanical anchorages and fixings from the Manufacturer/Supplier of the vessel or tank.

2.2 DESIGN REQUIREMENTS

2.2.1 General

1. Unless where specified otherwise in this DEP, all layering, detailing, and application of the insulation system, shall be in accordance with the requirements of the Manufacturer/Supplier of each component of the system.
2. Insulation shall not be applied to the following piping systems and equipment:
 - a. where the design intent is to emit heat or where cooling is required (e.g., coolers and condensers);
 - b. on the bottom heads of vertical vessels where insulated skirts provide the required heat loss or fire protection;
 - c. if the asset has internal refractory.
3. The Contractor shall detail the transition between any external insulated section and the internal refractory lined section.
4. The primary thermal insulation system materials selection shall be per the minimum and maximum process operating temperature ranges defined in (Appendix A).

A key variable in the selection of the insulation system is the selected surface protection for an asset. DEP 30.48.00.31-Gen. can be used for a complete coating system and DEP 30.48.40.31-Gen. for thermally sprayed aluminium coating.

The table in (Appendix A) can be used for selection of acoustic insulation, process stabilisation design, fire protection design and combinations thereof. However, these services can have factors that force composite designs or special alternative materials.

5. Materials shall be compatible with the substrate and all other insulation materials with which they have contact.
6. The selection of materials, detailing and protection plan for prefabricated/shop application, module or packaged skids shall be based on the conditions of final location of the asset (e.g., the environment and conditions for installation, staging, storage and shipment).
7. For insulation of equipment and piping in ethylene oxide (EO) service, an insulation material with a closed cell structure that is non-reactive to EO (e.g., CG – Cellular Glass) SHALL [PS] be used.
8. For insulated flanges in EO service, a leak detection tube shall be installed through the insulation layer to enable EO leak monitoring.
9. Only aluminised steel or stainless steel jacketing material shall be used if fire protection of pipes or equipment is required.
10. Aluminium and aluminised steel jacket and jacket accessories shall not be used if the equipment will be in operation in a marine environment.

Rationale: To maximize the life cycle of the insulation system.

11. A chloride protective coating should be applied to aluminium jacketing when the jacketed asset is to be transported overseas or when the asset will be dressed, stored or staged in a marine environment.

Rationale: To maximize the life cycle of the insulation system.

12. Thicknesses listed on execution documents shall be based on commercially available products, with the installed material thicknesses meeting the minimum calculated thickness required for the defined in-service performance.
13. The insulation system design shall mitigate water ingress from precipitation and capillary action.
 - a. The insulation system design shall allow any liquid within the system, (e.g., potential leaked product, water, condensation) to drain.
 - b. On vessels with metallic jacketing, the vertical joint should be detailed with a thixotropic silane modified polymer sealant/adhesive or non-curing butyl rubber-based sealant between successive jacketing sheets that are pulled together with self-tapping screws (3.3.5, Item 4).
 - c. If an asset is placed below grade in a trench or pit that could be sufficiently filled with precipitation or other liquid so that the jacketing will be below liquid level, then the drain hole in the jacketing should be eliminated.
14. A heat-traced insulation system shall be provided where operational or non-operational process fluids are predicted to freeze or experience frazil ice conditions.

Frazil ice has been known to form and plug orifices and strainers in cooling water systems.

 - a. Refer to DEP 31.38.30.11-Gen. and either DEP 33.68.30.34-Gen. or DEP 33.68.30.32-Gen., whichever is applicable, for designing heat-traced insulation;
15. Cable and tubing terminations for heat-traced insulation shall be routed and sealed to mitigate any water penetration of the weather jacketing.
 - a. The tracer tubing or cables shall enter and exit the insulation on the underside of the pipe on horizontal runs and on the opposite side from the prevailing wind on vertical runs.
 - b. Joints in steam tracer tubing shall only be made outside of the insulation.
16. The design for cold insulation pipe shoes shall ensure isolation of different cold insulation material, membrane placement, termination, jacketing interface, and thermal conductivity of the shoe and force transfer to the structural support.
17. The design drawings and specifications shall provide details of vertical tees and penetrations that are skyward (i.e., inside the envelope of 10 o'clock to 2 o'clock position), details of non-cylindrical equipment enclosures and cold insulation pipe support details (2.2.2).
 - a. Intermediate construction interface locations should be identified on the drawings.
18. If acoustic insulation is the only insulation system that is required for piping systems or equipment in the CUI range, and if the substrate is not protected by TSA, then the insulation material against the pipe or equipment shall be FAM or FEF based on material temperature limitations defined in (Appendix A).

2.2.2 Cold insulation system

1. Inspection windows shall not be installed for cold insulation.
2. The spacing of the joints shall be sufficient to provide stress relief to all parts of the insulation system, based on the specific jacket material limitations

3. If a PFP system is not integral with the insulation system (e.g., added as a coating on top of the jacketing), then the spacing and detailing of joints shall be modified to suit the PFP material.

Rationale: Joints in cladding with insufficient adhesives or restraint will move causing the PFP coating to crack and be ineffective in providing the required protection.

4. For vertical piping and equipment, the contraction joints shall be positioned directly below a support ring.

Refer to Drawing S 40.001 for an example contraction joint detail.

5. All metallic components exposed to cold service temperature shall be insulated or isolated from becoming a thermal hot spot or bridge.

Rationale: Hot spots are sources of condensation and have been known to be sources of system failure.

- a. Pipe supports shall not be insulated to the extent of the supporting infrastructure.
6. Pipe support selection shall detail the interface between the insulation system (especially the vapour barrier) and the mechanical support in order to prevent local hot spots from being formed and to maintain the integrity of the vapor barrier.
 - a. Contraction joints for dissimilar insulation and metallic materials at pipe supports shall be detailed.
7. The insulation thickness at pipe supports should be the same as the pipe insulation.
8. The dimension of pipe supports shall be calculated with the following governing factors:
 - a. The maximum design load of the support based on two span lengths;
 - b. Safety factor of 5:1 for the compressive strength of the insulation material or isolation block at minimum operating temperatures;
 - c. Load transfer through insulation material or isolation block based on 60° load spread.
9. If the design is a HD-PIR/HD-PUR pipe support, the following shall be determined:
 - a. load spread underneath the brackets/steel support cradles during fixing of the bolt and at final design to stay within allowable compressive strength of the materials;
 - b. required clamping forces on the pipe, such that:
 - i. the support does not move across the insulation system (jacketing);
 - ii. the pipe does not move inside the insulation system.
10. The details of cold insulation pipe shoes shall be submitted to Principal for review and approval.

Rationale: To verify that the design addresses the isolation of different cold insulation material, membrane placement, termination, jacketing interface and thermal conductivity of the shoe and force transfer to the structural support.

2.2.3 Hot insulation system

2.2.3.1 General

1. The following components shall not be insulated unless otherwise specified for acoustic attenuation, personnel protection, process stabilisation/winterisation or fire protection:
 - a. Components which become hot intermittently (e.g., vents, steam-out and snuffing steam systems, flare and blow down systems);

- b. Piping supports;
 - c. Steam Traps;
 - d. Expansion joints, hinged joints and hose assemblies;
 - e. Instrument connections;
 - f. Sight flow indicators.
2. If piping or equipment expansion bellows are insulated, a specific detail that provides for the required movement shall be provided.
 3. Refer to Part II, Section 10 of DEP 31.38.01.24-Gen. for insulation of valves, flanges, nozzles and pumps in hydrogen and sour service or in systems containing hydrocarbons operating above their auto-ignition temperatures.
 - a. Open cell and fibrous type insulation materials (e.g., FAM, mineral wool) shall not be used adjacent to (within 0.3 m (12 in) of) flanges, nozzles, pumps or sample points if the temperature differential between operating and the process fluid auto-ignition temperatures is $\leq 60\text{ }^{\circ}\text{C}$ ($\leq 108\text{ }^{\circ}\text{F}$).
 - b. Cellular glass should be used adjacent to (within 0.3 m (12 in) of) flanges, nozzles, pumps or sample points if the temperature differential between operating and the process fluid auto-ignition temperatures is $\leq 60\text{ }^{\circ}\text{C}$ ($\leq 108\text{ }^{\circ}\text{F}$).
 4. Insulation installation adjacent to flanges in piping and equipment shall be terminated to allow removal of bolts without damage to the insulation.
 - a. Bolt clearance from the flange to the insulation jacketing shall be at least the bolt length plus an additional 30 mm (1 ½ in).
 - b. Where bolt tension or torque equipment will be used, a bolt clearance dimension shall be determined based on the selected equipment requirements and detailed on the drawings or specifications.
 5. A removable flange belt with a resealable port for leak detection shall be used for the flanges that will be insulated.
 6. A collar shall be provided at nozzles or protrusions, where it is expected that a splash (from a sampling point or other dispensing location) of flammable products could enter the insulation system.
 - a. The insulation material at the termination points adjacent to potential splash areas shall be insulated with cellular glass or other resistant material (refer to Figure 2.1).

Figure 2.1 Insulation termination detail - insulated flanges

