

DEP SPECIFICATION

HIGH TEMPERATURE INSULATING MATERIALS FOR REFRACTORY APPLICATIONS

DEP 44.24.32.34-Gen.

February 2014

DESIGN AND ENGINEERING PRACTICE



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1 INTRODUCTION

1.1 SCOPE

This new DEP specifies requirements and gives recommendations for high temperature insulating materials for refractory applications including various classifications.

This DEP also provides installation guidelines for lining systems.

This DEP excludes the following:

- Unshaped insulating refractories (covered in DEP 44.24.32.30-Gen.).
- Shaped insulating refractories (covered in DEP 44.24.90.31-Gen.).

For use of refractory insulation materials specifically for expansion joint median in shaped construction from refractory brick, refer to DEP 44.24.90.34-Gen.

Materials covered in this DEP are subject to additional requirements of the Asbestos and Refractory Ceramic Fibres section in the Shell HSSE & SP Control Framework Health Manual.

Reference is made to the Shell HSSE & SP Control Framework: Asbestos and RCF Guide. However, mandatory requirements are laid down in the Asbestos and RCF section of the Health Manual.

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 authorisation 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, 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.

1.3.2 Specific definitions

Term	Definition
Alkaline earth silicate fibers (AES)	A man-made vitreous fiber (MMVF) composed of at least 18 % alkali earth oxides developed to meet the fiber exemption requirements spelled out in 97/69/EC of the Dangerous Substances Initiative in the EU. These fibers are exonerated from the EU carcinogen classification on the basis of their low bio-persistence. AES fiber may be known as bio-fiber, or low bio-persistence fiber.
Approved construction design detail drawings	Comprehensive drawing(s) which have been provided by applicable Contractor illustrating all aspects of unit to be lined and construction design for any particular material in any particular layer arrangement which have been reviewed and approved by the Principal.
Arch	Term used in reference to fired heater flat horizontal roof
Batten strip	The term given to fiber blanket of similar composition of fiber module and used in folded fiber module construction between rows of modules orientated in soldier orientation
Bio-persistence	Is the ability of fibers to resist removal from the lungs by natural mechanisms (i.e., dissolution and breakage), it is measured by the time it takes for half of the fibers induced to disappear from the lungs.
Blanket insulation	A relatively flat and flexible insulation in coherent sheet form furnished in units of substantial area.
Blanket insulation, metal mesh	Blanket insulation covered by flexible metal-mesh facings attached on one or both sides.
Block insulation	Rigid insulation preformed into rectangular units.
Board insulation	Semi rigid or rigid insulation pre-formed into rectangular units having a degree of suppleness particularly related to their geometrical dimensions.
Bulk fiber	Ceramic fibers in the "as produced" state after fiberization and drying.
Calcium silicate	Insulation composed principally of hydrous calcium silicate, and which usually contains reinforcing glass fibres.
Classification temperature (fiber)	The temperature used for standards committee classification after which the product has a permanent change (shrinkage) not exceeding 4 % for blankets felts, mats or papers and 2 % for boards or vacuum formed shapes.
Cloth (ceramic)	Often referred to as ceramic fiber "textile", it is ceramic fibre yarn woven to cloth.
Cold face layer	The layer of refractory lining directly against the heat enclosure shell.
Compliance physical property data sheets	The guarantee by the Manufacturer or Supplier to the Principal, for physical properties agreed critical to the performance of the material in the intended application and which form part of the project specific quality control plan for qualification testing of materials, applicators and application.

Term	Definition
Continuous (maximum) use temperature	Is the maximum long exposure temperature to which a refractory may be exposed without causing irreversible structural damages to key physical properties. It is also sometimes referred to as the "recommended use limit." or "continuous-use temperature". For fiber, it is the temperature where the fiber maintains a fibrous structure and exhibits very low linear and thickness shrinkages. For fiber, this temperature usually must be confirmed with associated field trial references due to drastic effects from pollutants commonly found in practise.
Edge grain	The orientation of a fiber system in module construction in which strips of ceramic fiber blanket or felt are orientated perpendicular to the plane of the vessel casing.
Felt	A flexible sheet product formed in varying density from bulk fiber, typically orientated in the same direction and held together with a weak bonding agent, minor needling or pressing.
Fibrous glass	A synthetic vitreous fibre insulation made by melting predominantly silica sand and other inorganic materials, and then physically forming the melt into fibres.
Fiberization	Manufacturing process of rapid cooling by air or spinning the molten ceramic glass composition of various grades of fibrous insulation. It is the step where molten glass is transformed into an amorphous fiber structure.
Glass fibre, glass wool	Fibre manufactured as continuous filament from molten glass, normally used for reinforcement, tissue or textiles.
Mastic	A material of relatively viscous consistency that dries or cures to form a protective finish, suitable for application to thermal insulation in thickness greater than 30 mils (0.76 mm) per coat.
Hardware (attachment)	An integral part of the fiber module made from various alloy steel components used to bind and anchor all fiber components of the module and provide attachment to the steel enclosure to be lined. Hardware components typically consist of attachment stud, bolt and washer and various styles and quantities of formed yoke and anchor tynes for binding and support.
Man-made mineral fibre	Inorganic fibre manufactured from molten rock, slag, glass, metal oxides or clays.
Man-made vitreous fibers	Amorphous silicate fibers manufactured from super cooled liquid melts to remain amorphous by blowing or spinning. MMVF include AES, RCF fibers, polycrystalline wool (PCW), glass and rock wools.
Material test report	Quality documentation from the Manufacturer's quality control or engineering department, posting results of applicable compliance physical property testing to specified physical properties of any product based on application specification and purchase requirements.
Microporous insulation	Material in the form of compacted powder with an average interconnecting pore size comparable to or below the mean free path of air molecules at standard atmospheric temperature and pressure. Microporous insulation may contain fibres to add integral strength and may contain opacifiers to reduce the amount of radiant heat transmitted.
Mineral fibre	A synthetic vitreous fibre insulation composed principally of fibres made by melting predominantly igneous rock, and or furnace slag, and other inorganic materials, with and without binders, and then physically cooling and forming the melt into fibres.

Term	Definition
Mineral wool	Synthetic vitreous fibre insulation composed principally of mineral fibres and organic binders.
Module (fiber)	A modular “unit” of fibrous refractory insulation in various sizes and formed thickness, fabricated by stacks or folds of various density blankets or from cutting various density and thickness monolithic fiber mat “logs”. Fiber modules for non-veneer applications include an integrated attachment system and may or may not be pre-compressed.
Needling	A production process in the manufacture of blanket insulation where individual strands or fibers are woven in a relative perpendicular orientation of uniform square pitch to the nominal thickness of the blanket for de-lamination resistance.
Paper	A roll product produced from bulk fibers and organic binders on conventional paper making machinery.
Parquet	A method of installing non-folded ceramic modules so that the edge grain of one module is perpendicular to the edge grain of the adjacent modules.
Pollution	Is the term used in this report and in European MMVF (RCF and AES) Manufacturers literature in reference to elements or oxides which can form a damaging eutectic reaction with MMVF products. The result can then be characterized as, melting, vitrifying, crystallisation and or powdering.
Resilience	Inspection term given describing the ability of fibre products to spring back after being compressed up to 50 % of their initial thickness
Refractory ceramic fibers (Alumina silicate wool)	Man-made vitreous fibers (MMVF) whose chemical constituents are predominantly alumina and silica. • RCF are health classified as possible human carcinogen (Group 2B) by International Agency for Research on Cancer (IARC). • The US National Toxicology Program (NTP) has health classified respirable RCF as a substance reasonably anticipated to be carcinogenic. • The American Conference of Industrial Hygienists (ACGIH) has health classified RCF as category (A2) suspected human carcinogen. • The Canadian Environmental Protection Act (CEPA) has health classified RCF as probably carcinogenic (Group 2). • In Europe, RCF are health classified as a carcinogenic substance in animals (1B under new CLP classification system).
Rock wool, stone wool	Mineral wool manufactured predominantly from molten naturally occurring igneous rocks.
Shot	A glassy material formed during fiberization of liquid that is not fibrous. Shot content is typically used for non-fibrous content used in standards committee test procedures.
Slag wool	Mineral wool manufactured from molten furnace slag.
Soldier course	Is the reference given to the course of modules in construction where the orientation of the long relatively non-compressed dimension of the fold, log or strip is against the dead load of the system (usually vertically) and utilizing a batten strip between adjacent modules.

Term	Definition
Sol Gel process (fiber manufacture)	A process where, liquid raw materials are batched and chilled. Fibers are produced when the liquid-saturated solution is processed through spinning cups. These fibers are then collected, dried and calcined to chemically stabilize the mullite fiber chemistry.
Tyne	Support beam or anchor portion of ceramic module hardware.
Veneer module	A fiber module provided without attaching hardware which is attached by use of high temperature cement.
Vermiculite	Insulation composed of natural vermiculite ore expanded to form an exfoliated structure.

1.3.3 Abbreviations

Term	Definition
AES	Alkaline earth silicate
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
ASW	Alumina silicate wool
EU	European Organization for Standardization
FCN	Field change notice
HSSE	Health safety security and environment
HTIW	High temperature insulation wool
ISO	International Organization for Standardization
ITP	Inspection test plan
MMVF	Man Made Vitreous Fiber
MTR	Material test report
PCW	Polycrystalline wool
PMI	Positive material identification testing
PPM	Parts per million
QC/QA	Quality control and quality assurance
RCF	Refractory Ceramic Fiber

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 (12).

1.5 SUMMARY OF MAIN CHANGES

This DEP is new.

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.
DEP Feedback System (Users with access to Shell Wide Web)	Enter comments directly in the DEP Feedback System which is accessible from the Technical Standards Portal http://www.shell.com/standards . Select "Submit DEP Feedback", fill in the online form and submit.
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 BACKGROUND – CHARACTERIZATION OF MATERIALS

High temperature insulation refractory materials for new construction and/or repairs are generally characterized into the following groups:

- a. Fibrous*
- b. Non-fibrous*

Fibrous refractory materials are further grouped into the following subgroups based on form:

- a. Blanket (RCF, AES, PCW)*
- b. Fiber modules (monolithic, folded, stacked)*
- c. Fibre paper*
- d. Fibre coating: mouldable, mastic and pumpable*
- e. Fibre board and vacuum formed shapes*
- f. Mineral wool rigid board*

Non-fibrous refractory materials are further grouped into the following sub-groups based on composition and form:

- a. Calcium silicate board*
- b. Vermiculite and diatomaceous board*
- c. Microporous board*

2.2 SPECIFYING INSULATING MATERIALS

1. Specification of high temperature insulating materials shall be based on the following (and not based on classification or classification temperature):
 - a. Continuous maximum use temperature.*
 - b. Specific physical properties and characteristics, as outlined in this DEP.*
 - c. Purchase documentation, or individual project specifications.*

2.3 DRAWING APPROVAL

1. Construction design detail drawings shall be approved by the Principal. The approval of drawings shall be documented in the project records.

2.4 MATERIAL TEST REPORTS

1. Material test report (MTR) shall include approved compliance specification and traceable batch and/or date code numbers for traceability.

3. QUALITY ASSURANCE/QUALITY CONTROL

3.1 QUALITY CONTROL

1. Prior to the start of any project, the Supplier/refractory Contractor shall submit an appropriate, project specific quality control plan for approval by the Principal.
2. The quality control plan shall address all of the elements listed in Table 1.
3. Quality control shall be managed with an ITP as further outlined in (3.4).

Table 1 Quality control plan

Engineered Design		
Element	Items	Objective
Design	Design	To have refractory lining meeting all thermal, chemical and mechanical design requirements and to insure all materials are exposed to temperatures less than maximum continuous use temperature as determined by the Manufacturer.
	Drawings	To ensure applicable drawings detail all refractory design, layer thickness, anchoring, openings, changes of plane and nozzle arrangements with related dimensions and labelling and that drawings are pre-approved by the refractory Contractor, the material Supplier (if required) and the Principal, prior to use.
	Material install, start up procedures	To ensure all job specific and properly labelled procedures including install and start up, are provided for every type of material to be installed for every method of installation, including Applicator pre-qualification and workmanship acceptance criteria, mock-up, PPE and safety requirements where required.
	Repair Procedures	To ensure repair procedures are in place for installations failing to meet quality specifications.

Supply of Materials		
Element	Items	Objective
Material Qualification	Material Selection	To select products manufactured and shipped under accepted quality standards with shipping specification meeting defect and physical property design and compliance requirements.
	Material Qualification	To ensure products to be shipped are tested with approved procedures and meet physical property compliance, workmanship and heat treatment requirements (compliance data) and results are recorded in material property test reports (MTR) that are traceable and part of the inspection and test plan.
	Shipment and Storage	To ensure standards are established and approved for warehousing and safe handling of materials prior to and during installation including production (as installed) samples site certification and safety labelling.

Product Installation		
Element	Items	Objective
Applicator Qualification	Applicator Qualification	To ensure intended Applicators are qualified and trained (particularly if not trade union certified "craftsmen") and suitably experienced refractory material installers for method of intended installation. Approval based on criterion mock-up testing or declaration by the refractory Contractor and acceptance by the Principal.
	Equipment pre-qualification	To ensure installation equipment requirements are specified in work instructions and limits of calibration, trueness and fitness are established and inspected.
Installation Monitoring	Installation Monitoring	To ensure application/installation process is inspected/audited with proper documentation to be in accordance with work instructions and within quality workmanship criteria conformance during entire installation processes.

Product Installation		
Element	Items	Objective
	As Installed Testing	To ensure "as installed" product characteristics meet accepted "as installed" project specific requirements.
Inspection and Testing	Pre-Dry-Out Inspection	To confirm installed linings meet specification standards indicated on design detail drawings and other related project specifications. To confirm proper curing or preservation environment has been employed as per approved procedures and specifications.
Post Dry-out Plan/ Turnover	Final Documentation	To confirm installation, including field changes as required, meet specification and that all documentations including, field change notice, red line drawings are completed and turned over to appropriate succeeding Contractor or the Principal as required, and all noted on the ITP.

3.2 CONTINUANCE OF WORK

- Where different Contractors are used for a continuance of work, specifications shall be provided by all Contractors for the use by other Contractor(s) for each intended scope of work.

For example, if one Contractor's scope is to supply materials (presumed the Manufacturer) and another's is to install those materials (presumed refractory installation Contractor), the material Manufacturer is required to make available all "qualifying product" property specifications and procedures (including installation, curing, drying, firing and preservation instructions) to the refractory Contractor. The refractory Contractor receives and acknowledges the Manufacturer's procedures into their own procedures for approval and for inclusion in the quality plan.

- Any conflicting requirements between procedure documents covering refractory systems shall be thoroughly investigated by each Contractor and referred to the Principal for resolution before bidding or proceeding with any specific refractory scope.
- Where the work scope (such as for the drying and initial firing of refractory) uses the services of qualified, specialized Subcontractors to complete the scope, clear demarcation for deliverables shall be established by the refractory Contractor prior to the start of any work.

3.3 QUALITY ASSURANCE

- The Principal through site Operations shall be responsible for quality assurance.
- The Principal may use independent inspection and test Contractors, where applicable, for quality assurance and other site services.

3.4 INSPECTION TEST PLAN (ITP)

- Prior to the start of any project, the refractory Contractor shall submit an appropriate project-specific ITP for approval by the Principal, addressing all of the elements specified in Table 1.
- On the ITP, a covering page should identify all Contractors or inspectors with appropriate signing authority and signature (initial) and designating who is responsible for signing off on actions completed in the work scope.
- The ITP shall identify every work step in the work scope.
- A controlling document that is traceable and that clearly illustrates acceptance criterion for the applicable work step shall be listed under the appropriate title.
- This controlling document may be the actual page and paragraph number referenced from a DEP, the project, standard specification (list section number including latest

revision date), or a drawing number (list Drawing and latest revision number) that outlines the requirement.

6. Where there are several related specifications and where conflicts exist, an approved request for information process (RFI) should be used (and listed on ITP) to create the project-specific and defining control document for that specific work step.
7. In addition, on the ITP for each work step, the "documentation" or "record" shall be identified under an appropriate title where the QC/QA document number and date is listed.

An example is a signed, dated and numbered separate daily checklist audit form which would typically detail the following:

- a. *the task and check points observed,*
- b. *applicators and dates and shifts involved,*
- c. *reference to sketches*
- d. *"red line" drawings photographs properly labelled,*
- e. *Inspection, RFI and FCN documentation to document check witness review and hold points.*

3.5 QUALITY CONTROL TESTING AND INSPECTION

3.5.1 Testing

1. Testing for quality control shall be in accordance with test procedures listed in (Appendix 1).
2. The Manufacturer's normal quality control procedures and results shall be evaluated for incorporation into regular quality compliance procedure of the following:
 - a. declaration and acceptance of applicable physical property guarantees for design approval based on statistical review of in-house quality data or audit by the Principal,
 - b. approval of properties and inspection criterion to be used, type and frequency of inspection and testing for qualification of materials for pre-shipment sampling, testing, recording and approval,
 - c. test result documentation and approval of all material shipments.

3.5.2 Minimum test and frequency requirements

1. The following testing requirements in Table 2 shall be met.

Table-2 Testing requirements

Test/Component	Frequency
Density (all fiber products)	Three tests per shift.
Thermal conductivity (all products - design guarantee)	One test per order of major product application or design application change: • Represented by test certificate of same grade and density of material, • Maximum one year old, done in own or third party laboratory.