

DEP SPECIFICATION

CHIMNEYS SELECTION, DESIGN AND ENGINEERING (BASED ON EN 1992-1-1, EN 1993-3-2, EN 1443, EN 13084-PARTS 1, 2, 4, 5, 6, 7 AND 8)

DEP 34.24.26.31-Gen.

September 2012

DESIGN AND ENGINEERING PRACTICE



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1. INTRODUCTION

1.1 SCOPE

This DEP specifies functional, structural requirements, indicates required standards and gives recommendations for the design, engineering, inspection and construction of chimneys and their foundations, based on EN 1992-1-1, EN 1993-3-2, EN 1443 and EN 13084-Parts 1, 2, 4, 5, 6, 7 and 8.

This DEP is a revision of the DEP of the same number dated April 2003 and DEP 34.24.27.31-Gen., dated April 2006. A summary of the main changes is given in (1.5).

Both specifications of concrete and steel chimneys are combined in this revised DEP.

Requirements for selection criteria are given based on EN 1443 and EN 13084-Parts 1, 2, 4, 5, 6, 7 and 8.

Specific requirements are given, not covered by industry standards.

The DEP is divided into four parts:

- Introduction
- Selection and Functional Requirements
- Structural Design and Construction Requirements
- References

This DEP Specification is not applicable for North America. For North America a separate project specification shall be developed and should be based on the information given in this DEP Specification. All clauses of EN 1992-1-1, EN 1993-3-2, EN 1443 and EN 13084-Parts 1, 2, 4, 5, 6, 7 and 8 not modified by this DEP Specification remain valid as written.

Selection criteria to arrive to a type of chimney (or chimneys) and related design not given in this DEP shall be given by the Principal.

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 Technical definitions

This technical definition table defines the general terms that are commonly used in the design and construction of reinforced concrete and steel chimneys.

Description	Definition
Accessible Space	Space between windshield and liner that is designed for entry by personnel, for inspection and maintenance purposes.
Annular Space	Space between concrete shaft and liner. It can be accessible or inaccessible.
Aerodynamic Device	A device fitted to the chimney to reduce vortex excitation without increasing the structural damping.
Aviation Warning Lights	Warning lights, located at the top of the concrete shaft, which are required by local civil or military aviation authorities.
Base Plate	A horizontal plate fixed to the base of a chimney.
Down Draught	Negative pressure on the lee-side of the chimney top, which can cause the flue gases to be drawn down
Chimney	Often also called "Stack". Vertical construction works or building components that conduct and convey flue gases (and waste gases).
Chimney Cap	Protective cap at the top of the chimney that covers the top of the chimney
Commissioning	Process by which an equipment, facility, or plant (which is installed, or is complete or near completion) is tested to verify if it functions according to its design objectives or specifications.
Corbel	Structural element integrated with the concrete shaft at a certain elevation to support the brick lining.
Damping Device	A device fitted to the chimney to reduce vortex excited oscillations by increasing the structural damping. Often also fitted to the internal steel liner.
Double-Wall Chimney	A chimney consisting of an outer concrete or steel structural shell or windshield and one inner liner which conducts and convey the flue gases. The inner liner may be steel, bricks or refractory concrete.
External Steel Platform	Steel structure built externally at a certain elevation of the concrete chimney for access by personnel. Usually in the circumferential form.
Flue Gas	Gaseous products of combustion or other processes, which may comprise solids or liquids (e.g., soot).
Internal Steel Platform	Steel structure built internally at a certain elevation of the concrete chimney for access by personnel. Usually in circumferential form.
Intransient Heat Flow	Flow of heat, where the temperature of each point does not change with time.

Description	Definition
Helical Strakes, Shrouds or Slats	Devices fitted to the outer surface of the chimney to reduce cross wind response.
Liner	Structural and protection membrane contained in a concrete or steel chimney, either carbon/alloy steel, brickwork, FRP (Fibre Reinforced Plastic) or refractory concrete.
Lining System	Total system, if any, which separates the flue gases from the windshield. This comprises a liner and its supports, the space between liner and windshield and/or insulation, where existing.
Multi-Flue Chimney	A group of two or more chimneys structurally interconnected or a group of two or more liners within a structural concrete shell.
Natural Draught	A temperature difference between the outside and inside air will create a "natural draught" forcing air to flow via the furnace through the chimney.
Negative Pressure	Pressure inside the liner which is lower than the pressure outside the liner.
Positive Pressure	Pressure inside the liner which is greater than the pressure outside the liner.
Protective Cap	Cap at the top of the chimney which covers the space between windshield and liner
Parapet	A low reinforced concrete protective wall along the edge on the top of the concrete chimney.
Refractory Brickwork	Brickwork that has a high melting point and often chemical protection properties. The brickwork acts as a protective barrier for the concrete shaft.
Refractory Concrete	Special concrete mix capable of retaining its physic-mechanical properties within predetermined limits during prolonged exposure to high flue gas temperatures to protect structural steel chimney.
Reinforced Concrete Shaft	Structural element to protect the internal flue lining from wind actions and other forms of degradations.
Self-Supported Chimney	A chimney whose supporting shaft is not connected with any other construction above the base level.
Single-Wall Chimney	A chimney whose structural shell also conducts and convey the flue gases. It may be fitted by thermal insulation and/or internal lining.
Soot	The fine black particles, chiefly composed of carbon, produced by incomplete combustion of coal, oil, wood, or other fuels.
Soot Door	A door located at the bottom of the shaft for the entry of personnel to remove the soot.
Spoiler	A device attached to the surface of a chimney with the objective of reducing cross wind response.
Steel Duct	An enclosed steel passage conveying flue gas.
Stiffening Rings	Horizontal members to prevent ovaling and to hold the chimney shell round during fabrication and transport. Horizontal members to provide stiffeners at cut outs and openings or possibly at changes in slope of the structural shell.
Structural Shell or Windshield	The main load-bearing concrete or steel structure of the chimney, excluding any flanges.

Description	Definition
Ventilation Hole With Louvre	A framed opening, fitted with fixed horizontal slats for admitting air.

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 (4) and in detail (if required) in separate tables, in which cross-references or related sections are indicated.

1.5 SUMMARY OF MAIN CHANGES

This DEP is a revision of the DEP of the same number dated April 2003 and DEP 34.24.27.31-Gen, dated April 2006. This has been a major rewrite and it is impractical to list the changes here.

New EN standards are included, along with US and CICIND standards.

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be submitted to the Administrator using the DEP Feedback Form by:

- Entering comments directly in the DEP Feedback System on the Technical Standards Portal <http://sww.shell.com/standards> (mandatory for users with access to Shell Wide Web);
- Clicking on the DEP Feedback Form button on the DEPs DVD-ROM main page (for users without access to Shell Wide Web);
- Requesting a copy of the DEP Feedback Form from the Administrator at standards@shell.com (for users without access to Shell Wide Web).

For the last two options, the completed DEP Feedback Form can be attached to an email and submitted to the Administrator at standards@shell.com. Only feedback that is entered into the Feedback Form will be considered.

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. SELECTION CRITERIA AND FUNCTIONAL REQUIREMENTS

2.1 CHIMNEY AND CHIMNEY PARTS

Chimney and/or chimney parts shall conform to the standards as mentioned in Table 1.

Table 1 Applicable standards

Chimney and/or chimney parts	EN standard	US standard ^{a)}	CICIND code ^{c)}
General requirements chimneys	EN 13084-1 EN 1443		
Concrete	EN 13084-2	ACI 307	Model Code Concrete Chimneys, including commentary
Brick liners	EN 13084-4	ASTM C980	Model Code Concrete Chimneys with Brick Liner Part B
Material internal brick liners	EN 13084-5	ASTM C1298	Model Code Concrete Chimneys with Brick Liner Part B
Steel liners: Single wall Base supported Sectional Top hung	EN 13084-6	ASME STS-1	Model Code Steel Chimney 2010 Model Code Concrete Chimney with Steel Liner Part C
Product specifications: Steel single wall Steel liners	EN 13084-7		Metallic Materials Manual 2003
Support mast construction with satellite pipes	EN 13084-8		Not covered
Protective coatings and coating systems for concrete and steel chimneys	EN 14879-3 ^{b)}		CICIND Chimney Coating Manual
a. US standards should be used to develop a project specification for North America. b. For concrete: EN 14879-3 and for steel: DEP 30.48.00.31-Gen. shall be applied. c. CICIND codes may be consulted.			

2.1.1 Flue gas considerations

The Contractor shall submit calculations for review by the Principal based on EN 13084-1.

2.2 DESIGN PARAMETERS

Prior to the preparation of the detailed design, a selection shall be made from the various types of chimneys and materials specified in this DEP based on the following design parameters:

Table 2 Design parameters

ID	Description Parameters	Remarks
1	Nature of chimney operation, whether continuous, intermittent or occasional.	Amount of operation hours per year; any possible bypass operation, which may cause higher flue gas temperatures. Amount of flue gas streams.
2	Planned frequency of shut-downs for internal inspection and maintenance (including inspection and maintainability requirements).	Shutdown cycles; Shutdown time for inspections and maintenance; Access possibilities for inspection and maintenance.
3	Composition of the flue gases and concentrations of chemicals in the flue gases deleterious/harmful for the chimney.	Any possible foresee variation (worst scenario) of flue gas composition or concentration shall be included; Required for material selection.
4	Concentration of dust and particularly of abrasive dust in the flue gas.	Required erosion resistance of material.
5	Mass flow of each flue gas stream.	Required to determine amount of chimneys or chimney with internal liner(s).
6	Flue gas temperature at entry of each flue gas duct into chimney.	Required for material selection.
7	Range of maximum acid dew point temperatures of the flue gases.	Required for material selection.
8	Admissible or required pressure at entry of flue gas ducts into chimney.	
9	Altitude of the site and any special local topographic features (e.g., nearby hills, cliffs) and height of chimney.	Height chimney often based on local environmental requirements.
10	Maximum, average and minimum outside temperature.	Required for material selection.
11	Maximum, average and minimum atmospheric pressure.	Required for material selection and natural draught calculation.
12	Maximum, average and minimum humidity of the ambient air.	Required for draught calculation.
13	Relevant design parameters used for appliances (for example boiler) to which the chimney is connected.	
14	Life Cycle Costs (the total discounted € or \$ cost of owning, operating, maintaining, and disposing of a chimney system over a period of time).	Requires input service life chimney and calculations of the best chimney options.

Based on the design parameters, the chimney shall be classified in accordance with the standards as mentioned in Table 1 (2.1).

2.3 FLUE GAS TEMPERATURES AND PRESSURES

The impact of the flue gas temperatures, pressures and chemical load shall be included for selection of materials and design of chimney. The classification of flue gas temperatures shall be obtained from the EN standards as mentioned in Table 1 (2.1)

2.4 CHEMICAL LOAD

The Contractor shall determine the chemical load based on the input of EN standards as mentioned in Table 1 of (2.1).

2.5 ENVIRONMENTAL ASPECTS

The following environmental aspects shall be covered:

- Noise;
- Outer surface temperature;
- Protection against falling ice;
- Gas tightness.

The Contractor shall submit the environmental design aspects for review by the Principal.

2.5.1 Noise

The noise produced shall not exceed the permissible noise levels. Under normal conditions this requirement shall be met, if the velocity of the flue gas at the top is < 25 m/s (82 fps). The Contractor shall verify this requirement and shall take action if the requirement is not met, by means of additional design measurements.

2.5.2 Outer surface temperature

The Contractor shall take into account the outer surface temperature based on the requirements of EN standards as mentioned in (2.1).

2.5.3 Protection against falling ice

The Contractor shall check the possibility of falling ice and shall take into account the requirements of standards as mentioned in (2.1).

2.5.4 Gas tightness

The Contractor shall submit a test methodology to ensure gas tightness of the chimney system for review by the Principal.

2.6 INSULATION SYSTEMS

The insulation system(s) shall comply with DEP 30.46.00.31-Gen.

If applicable, the insulation system(s) shall reduce:

- The thermal gradient and, therefore, the thermal stress in the liner material.
- The heat loss of the flue gases as they flow upwards, when conveying the flue gas through the liner. The thermal gradient and thermal stress in the windshield.

In selecting the insulation system, the following characteristics shall be taken into account:

- a) Its long term structural stability;
- b) Its thermal conductivity;
- c) Its performance and integrity at the temperatures it will be subjected to in service;
- d) The acid resistance and moisture absorption of the insulating material and its supports. This is important in brickwork liners, as limited quantities of flue gas can permeate through the liner, condensing as they pass to the cool side of the insulation;
- e) Its accessibility.

The thermal insulating material and/or system shall be incombustible.

2.7 VENTILATED AIRSPACE FOR CONCRETE CHIMNEYS

If applicable, a ventilated airspace shall be provided between liner and concrete windshield. The purposes of this air space are:

- To help eliminate flue gases which may have leaked through the liner due to diffusion or to positive pressure conditions;
- To reduce the partial vapour pressure of the sulphur oxides of any flue gas that may have leaked through the liner, thereby reducing its acid dew point and minimizing deposition of acid on vulnerable surfaces;
- To allow access for maintenance and inspection into an air space large enough for this purpose.

The ventilation shall be operative at all times. Where an accessible space is provided, its efficacy shall be verified by thermal and flow calculations.

A clear path shall be provided for vertical passage of the air through the total or sectional height of the air space. This requires provision of adequately sized openings through corbels or slabs supporting sectional liners or in the windshield, respectively.

2.8 PROTECTIVE COATINGS

The chimney(s) shall be protected against corrosion or chemical attack by means of protective coatings. A distinction shall be made between attack by the flue gases and attack by environmental conditions.

Protective coatings shall be chemically and thermally resistant, impermeable to liquids and adequately resistant to diffusion and to ageing. The Contractor shall design a suitable coating system. In case of steel surfaces, DEP 30.48.00.31-Gen. shall be used. For concrete surfaces, the Contractor shall submit a coating system based on EN 14879-3 for review by the Principal.

2.9 FOUNDATION

The foundation shall be protected against thermal and chemical effects. If condensation is to be expected, the upper surface of the foundation shall be sloped and provided with a coating which is acid-resistant and impervious to liquids. The Contractor shall submit a coating system based on EN 14879-3 for review by the Principal.

A space between liner (starting at the flue gas entry) and foundation as indicated in EN13084-1 shall be provided. This space shall be accessible by a door.

2.10 ACCESSORIES

2.10.1 Access

Chimneys of more than 5 m (16.4 ft) height above a structurally accessible level (for example, a platform of an adjacent steel structure) shall be provided with an access system from this level to the top with the purpose of allowing inspection and maintenance of the following particular items:

- Aircraft warning lights (if required);
- Instrumentation, like thermocouples, flue gas analyzers, opacity (smoke) meters or manometers (if required);
- Lightning conductor system;
- Chimney cap;

The access system, however, shall allow the inspection of other critical items such as:

- a) Outside of the windshield: Provisions shall be made to facilitate the use of a "sky-climber" (mainly in the upper part of the chimney) where there will be a local heavier chemical attack and where maintenance may be required;