DEP SPECIFICATION

DESIGN OF BLAST RESISTANT ONSHORE BUILDINGS, CONTROL ROOMS AND FIELD AUXILIARY ROOMS

DEP 34.17.10.30-Gen.

February 2012

DESIGN AND ENGINEERING PRACTICE

DEM1

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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 7
1.7 DUAL UNITS 7

2. LOCATION AND BLAST LOAD DESIGN CONSIDERATIONS 8
2.1 LOCATION CONSIDERATIONS 8
2.2 DESIGN BLAST LOADS 8

3. GENERAL DESIGN CONSIDERATIONS 9
3.1 CONFIGURATION OF BLAST RESISTANT BUILDINGS, CONTROL BUIILDINGS AND FARS 9

4. STRUCTURAL DESIGN 10
4.1 DESIGN METHODS AND PROCEDURES 10
4.2 MATERIALS AND COMPONENT PROPERTIES 10
4.3 LOAD COMBINATIONS 15
4.4 COMPONENT DETAIL DESIGN 16
4.5 FOUNDATION DESIGN 19

5. ANCILLARY AND ARCHITECTURAL ITEMS 20
5.1 GENERAL 20
5.2 BLAST DOORS 20
5.3 WINDOWS 21
5.4 ANCHORAGE OF FRAMES FOR EXTERNAL WINDOWS 24
5.5 BLAST VALVES 24
5.6 EXTERIOR WALL PENETRATIONS 25
5.7 SUSPENDED ITEMS 25
5.8 EXTERNALLY MOUNTED ITEMS AND AIR INTAKE STACK 25
5.9 INTERIOR ITEMS 26
5.10 FLOORS 26
5.11 WALLS AND CEILINGS 27

6. HEATING, VENTILATING AND AIR CONDITIONING 28

7. FIRE-FIGHTING FACILITIES/FIRE PROTECTION/FIRE AND GAS DETECTION 29
7.1 GENERAL 29
7.2 FIRE EXTINGUISHERS 29
7.3 FIRE AND GAS DETECTION 29

8. REFERENCES 30

9. BIBLIOGRAPHY 31

Documents
Document Sharing Hub

Full document details: SHELL 34.17.10.30 0

1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for the design and construction of onshore buildings required to have blast resistance, including new control buildings and field auxiliary rooms (FARs).

This DEP is not applicable to offshore facilities.

This DEP provides additional requirements for these buildings, over and above the general requirements for buildings as stated in DEP 34.17.00.32-Gen.

The requirements for the siting of buildings are defined in DEP 80.00.10.11-Gen. 'Layout of Onshore Facilities'.

For control buildings, it is important that sufficient protection for operators and electronic equipment is provided so that in the event of a calamity, the building remains functional and emergency actions can be taken to minimise the spread of danger and secondary damage.

For FARs, it is only essential to protect the critical equipment. These buildings are normally unmanned.

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 2011; 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, 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.

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The word **shall** indicates a requirement.

The capitalised term **SHALL [PS]** indicates a process safety requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

Term	Definition
Blast Load	Load generated by an explosion.
Blast Resistant	Describes those structures or structural components which are designed for, or verified to withstand, the design blast loads. These can be structures or structural components that: • have already a certain elasticity/flexibility in their conventional design to receive some low (limited) blast loads, • are designed with an improved conventional (enhanced resilient) design to receive limited blast loads, • are specifically designed and detailed to receive significant blast loads.
Blast Wave	A transient change in the gas density, pressure and velocity of the air surrounding an explosion.
Ductility Ratio	A measure of the energy absorbing capacity of a structural member/element. The ratio is defined as the element's maximum deformation divided by its yield deformation.
Duration	The time from initial change in pressure to return to ambient pressure.
Dynamic Increase Factor	The ratio of dynamic to static strength that is used to compute the effect of a rapidly applied load to the strength of a structural element.
Free Field	Air or ground blast waves that are unimpeded by obstructions in the path of the wave.
Impulse	The integrated area under the over-pressure time curve.
Linear	A response limited to the elastic range
Non-linear	A response which includes the elastic-plastic and/or plastic ranges.
Over-pressure	Pressure rise above ambient produced by a shock wave or pressure wave
Peak Side-on Over-Pressure	Initial peak pressure rise, above ambient, produced by a shock wave or a pressure wave as felt by a flat surface orientated parallel to the direction of wave propagation.
Positive Phase	The portion of the pressure time history where the pressure is above ambient pressure.
Pressure Wave	The portion of the pressure time history where the pressure is above ambient pressure.
Process Risk Tool (PRT)	a tool to assess vapour explosions risk at petrochemical processing facilities, e.g. SHEPHERD, FRED.
Reflected Over-Pressure	The rise in pressure produced by a shock wave or a pressure wave as felt by a flat surface oriented perpendicular to the direction of wave propagation.
Resistance-Deflection Function	The value of the stress in a structural element as the deformation is increased from zero through the elastic range, the elastic-plastic range, ultimate capacity, and finally to failure of the element.

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Term	Definition
Safety Glass	Laminated glass panes, consisting of two layers of normal glass (3 mm (1/8 in) thick), with an inner layer of polyvinyl butyral (1.9 mm (1/16 in) thick).
Shock Wave	A blast wave that produced a near instantaneous rise in pressure.
Sideways	The lateral movement of a structure due to vertical or horizontal loads.
Strain Rate	The speed at which a load is applied to material. The higher the strain rate, the higher the observed material strength.
Strength Increase Factor	The ratio of actual to nominal strength of a material. This factor takes into account conservatism in the manufacturing process.
Support Rotation	A measure of the blast absorbing capacity of a structural element. This is the same as hinge rotation except that the angle is computed at the member's support location.
Ultimate Capacity	The load applied to a structural element as the final plastic hinge, or collapse mechanism, is formed.
Ultimate Strength	A method of design in which structural members are proportioned by total section capacities rather than by extreme fibre allowable stresses.
Very toxic (substances)	Substances that are very hazardous for the environment or human health, as specified in DEP 01.00.01.30-Gen. (which also identifies "toxic" substances by reference to chemical substances databases).

1.3.3 Abbreviations

DIF	Dynamic Increase Factor
HVAC	Heating, Ventilation and Air Conditioning
FARs	Field Auxiliary Rooms
MDOF	Multi Degree Of Freedom
PRT	Process Risk Tool
SDOF	Single Degree Of Freedom
SIF	Strength Increase Factor

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 (8).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a revision of the DEP of the same number dated February 2011. The following are the main, non-editorial changes.

Old section	New section	Change
2.1	2.1	In this clause, changed SHALL [PS] to shall.

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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://sww.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.

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2. LOCATION AND BLAST LOAD DESIGN CONSIDERATIONS

2.1 LOCATION CONSIDERATIONS

The siting of buildings shall follow the requirements of DEP 80.00.10.11-Gen. 'Layout of Onshore Facilities'. These requirements specify when a building needs to be designed to resist blast loads using this DEP.

2.2 DESIGN BLAST LOADS

The functional requirements including building criticality, blast load, gas tightness (gas proof) and thermal radiation SHALL [PS] be obtained from either a risk assessment or the technical safety department of the Principal or agreed by the Principal. The design blast loads (specified in free field) SHALL [PS] be based on a Process Risk Tool (PRT) (or equivalent risk assessment) calculated blast pressure and blast duration corresponding to the 1/10,000 year frequency (1E-4). The following parameters, to define the blast load, shall be obtained:

- Peak side-on positive over-pressure, positive phase duration, rise time and the corresponding positive impulse;
- Peak side-on negative pressure, negative phase duration and the corresponding negative impulse.

NOTE: This will result in essentially the same impulse, but in the negative direction. The negative pressures are generally ignored because they are relatively small or are difficult to quantify. However the structural components of the building shall take the rebound effects into account.

The following common requirements shall be applied to control buildings, FARs and other buildings which are subject to blast:

a) Fragment or projectile impacts do not need to be included in the design.

b) Thermal radiation does not need to be included in the design provided either the safety distances detailed in DEP 80.00.10.11-Gen. 'Layout of Onshore Facilities' are met or it is demonstrated not to be required by a risk assessment. The requirements for fire resistance detailed in DEP 34.17.10.32 shall apply.

c) For special situations such as a blast pressure > 65 kPa (> 9.43 psi) or where the blast source is in close proximity to the building, the principal shall be consulted for added guidelines or requirements.

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3. GENERAL DESIGN CONSIDERATIONS

3.1 CONFIGURATION OF BLAST RESISTANT BUILDINGS, CONTROL BUIILDINGS AND FARS

Blast resistant buildings shall be as compact as possible, rectangular in shape without re-entrant angles or protruding canopies. The roof shall be flat or have a maximum pitch of 10°. The overall height of the building and the flat span of the roof shall be minimized to limit the effects of an explosion. Roofs shall not be covered with gravel or loose concrete tiles or other objects that could become flying hazards in the event of an explosion.

Foundations or floor slabs shall not be elevated above ground level or include a ventilated air space under them.

Unless specifically designed for the additional blast load, air-conditioning units should be located either on the ground floor or in the basement.

Control buildings:

a) shall only accommodate personnel and equipment directly related to safe and reliable plant operations

b) should be built as a one-storey building and may have a basement if sufficient space is not available and local conditions permit

c) should not include a general site laboratory

FARs:

a) shall only accommodate essential (electrical and instrument) equipment

b) should be built as a one-storey building.

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4. STRUCTURAL DESIGN

4.1 DESIGN METHODS AND PROCEDURES

All blast resistant buildings and their structural components shall be designed in accordance with the requirements of this DEP, DEP 34.17.00.32-Gen. and local building regulations.

Blast resistant buildings and their structural components SHALL [PS] be designed using acceptable methods provided in ASCE report "Design of Blast Resistant Buildings in Petrochemical Facilities", or an other methods approved by the Principal.

The structure of the building and all related components, such as windows, panes, doors, etc. shall be designed to withstand the blast loads and deform within the prescribed limits detailed in (4.2.5). Unless otherwise specified and agreed with Principal, doors, windows and other items filling openings in the structure shall be designed for the same blast load as the wall or roof they are set in. In all cases the buildings SHALL [PS] not collapse under the design blast load.

The Contractor SHALL [PS] use analysis methods appropriate for the specific blast design. The selected methods shall adequately model the dynamic response of the structure to the applied blast loads and the structural component interaction. The following requirements shall apply:

- **Single Degree-of-Freedom (SDOF)**
  The required resistance for each structural component shall be based on the peak blast pressure (or load) and duration, the natural period of the component, and the maximum allowable response (deformation). A SDOF analysis can be used where the connected component differs in natural period by a factor of 2 or more. The formulas and charts provided in either "Design of Blast Resistant Buildings in Petrochemical Facilities" (8), or other similar references for the approximate solution of the elastic-plastic SDOF system may be used in determining the required resistance.
- **Multi Degree-of-Freedom (MDOF)**
  A MDOF analysis shall be used where the structural component interaction cannot be adequately modelled using the simpler equivalent static load or SDOF methods. This method shall involve finite element analysis requiring the use of a special or general-purpose structural analysis computer program with non-linear transient dynamic analysis capability.

4.2 MATERIALS AND COMPONENT PROPERTIES

4.2.1 General

Brittle constructions, such as un-reinforced concrete, pre-stressed concrete, un-reinforced masonry (bricks or blocks) and cement based corrugated panels, SHALL [PS] not be used for load carrying components of blast resistant buildings.

Advanced materials, such as composites, may be used if adequate test data is available to confirm their satisfactory performance for the intended application, and with the Principal's prior written approval. Such test data shall include the ultimate capacity and behaviour of the material under dynamic conditions representative of blast loading. Performance under seismic conditions below ultimate strength is not sufficient to indicate blast load resistance capacity.

Reinforced concrete or fully grouted reinforced masonry of appropriate strength and thickness should be used as external wall construction where fragment resistance is required.

Buildings subject to very toxic gas clouds exposure SHALL [PS] be designed and detailed to prevent gas entry under operating conditions. Material selection and design details shall be based on this requirement. Homogeneous materials of construction (such as reinforced concrete) for the outer building shell are optimal. Materials with many joints, subject to large

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