

## DEP SPECIFICATION

# **HUMAN FACTORS ENGINEERING - DESIGN AND PROCUREMENT OF SKID-PACKAGED UNITS**

DEP 30.00.60.18-Gen.

September 2012

## **DESIGN AND ENGINEERING PRACTICE**



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The objective is to set the 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.

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## 1. INTRODUCTION

### 1.1 SCOPE

This DEP specifies requirements and gives recommendations for the Human Factors Engineering (HFE) aspects to be applied to the design and procurement of skid-packaged units to comply with the Human Factors Engineering requirements contained in the Shell Group HSSE & SP Health Standard and the HSSE & SP Control Framework Health Manual Section, 'Human Factors Engineering'.

This DEP applies to new facilities and modifications to existing facilities; it is not intended to apply to existing facilities that are not being modified.

This is a revision of the DEP of the same number dated January 2010; see (1.5) regarding the main 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 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
<b>HFE Technical Authority</b>	The individual assigned as Technical Authority for HFE on the project in compliance with Business Unit and Group standards.
<b>HSSE CF</b>	Shell Group HSSE Control Framework
<b>Human Factors Engineering (HFE)</b>	A multidisciplinary science that focuses on the interaction between the human and the work system in order to design human-machine interactions that optimize human and system performance. See ISO 6385.
<b>HSSE Critical Activity</b>	As defined in HSSE CF Glossary – an activity necessary for the development, implementation or maintenance of a Barrier established for managing Hazards with RAM red Risks (and yellow 5A and 5B Risks for Asset Integrity – Process Safety). HSSE Critical Activities comprise (in the context of Competence Management) Front Line Operational HSSE Critical Activities and Planning/Supervisory HSSE Critical Activities.
<b>Skid-packaged Unit</b>	Equipment designed and supplied as a largely self-contained physical unit, and mounted on a portable skid. Skid-packaged units are designed, built and tested at the Manufacturer/Supplier's premises and delivered for integration into the overall plant or facility.

### 1.3.3 Abbreviations

Term	Definition
<b>EPC</b>	Engineering, Procurement and Construction
<b>FAT</b>	Factory Acceptance Test
<b>MSD</b>	Musculoskeletal Disorders
<b>SAT</b>	Site Acceptance Test
<b>TA</b>	Technical Authority
<b>TRA</b>	Task Requirements Analysis

### 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 January 2010. Background and explanation content in the previous DEP has been moved to a companion Informative document. Some minor editorial changes have been made. The following are the main, non-editorial changes.

Old section	New section	Change
Appendix A	-	Simplified process and moved to Informative
Appendix B	-	Removed
Appendix C	3.1.1, 3.1.2	Requirements moved into main body of DEP Specification
Appendix D	4.0	Moved Appendix D – HFE Design Requirements to main body

## 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](mailto: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](mailto: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. GENERAL

### 2.1 APPLICATION OF HFE

HFE is the process of integrating knowledge and operational experience of human capabilities and limitations into the design of products, workplaces and work systems (plant and facilities) to ensure effective, efficient, safe and healthy functioning of human beings, thereby improving operational and maintenance task performance. Benefits of effective HFE in design can be both tangible (such as improved utilisation and performance of assets and resources and reduced overheads) and non-tangible (reduced risk, improved working conditions, improved workforce motivation, etc.).

### 2.2 KEY PRINCIPLES OF HFE DESIGN ANALYSIS PROCESS FOR SKID-PACKAGED UNITS

Elements of skid packaged units that are subject to HSSE Critical Activities or are potentially hazardous to health shall be designed in such a way that the risk to health, safety or human unreliability in operating, maintaining or supporting them is reduced to a level that can be demonstrated to be as low as reasonably practicable. Elements that are not involved in HSSE Critical Activities, but are considered critical to production should be designed to ensure ease of access and ease of operation.

#### 2.2.1 Off-the-shelf units

This DEP recognizes that many skid packages are procured “off-the-shelf” with minimal opportunity to modify an existing Manufacturer/Supplier design. Skid procurements that are entirely off-the-shelf are handled differently from projects where the procurement includes design activity.

Skid packages that are procured “off-the-shelf” do not have to adhere to requirements in this DEP unless there are grounds, based on previous experience or risk assessment, to believe there are significant issues that require an HFE focus. The decision whether to apply the requirements in (3) and (4) to “off-the-shelf” skids shall be made jointly between Operations, discipline or package engineer and HFE TA.

### 2.3 AIMS AND BENEFITS

Poor HFE design in skid-packaged units has been found to impact business performance in a number of ways:

- Potential for human unreliability in performing HSSE Critical Activities;
- Risks to personal safety and risk of musculoskeletal injury (MSD);
- Inefficiency in operations and maintenance, such as maintenance activities being more complex, and requiring longer shutdowns than necessary.

### 2.4 TIMING OF PROCESS

The HFE process described in this DEP should be initiated during either the DEFINE or EXECUTE phase, as soon as it is reasonably clear which work systems are likely to be procured as skid-packaged units. This ensures that the results can be factored into skid procurement and design.

The requirement to include this DEP in the project technical baseline should be identified as part of the project HFE Strategy (required by the HSSE Control Framework and Project Guide 1).

### 3. SKID CRITICALITY ANALYSIS

A Skid Criticality Analysis shall be conducted during either DEFINE or EXECUTE phase where this DEP is applied, as soon as it is reasonably clear which work systems are likely to be procured as skid-packaged units. This ensures that the results can be factored into skid procurement and design.

The Skid Criticality Analysis results shall be appropriately documented. The associated HFE control actions and HFE design criteria presented in (4) shall be included in the appropriate project specifications and bid documentation. Deviations shall require the approval of Operations and the HFE TA.

Compliance with the specified requirements shall be validated throughout the EXECUTE (Engineering, Procurement and Construction) Phase of the project and during FAT.

#### 3.1 SKID CRITICALITY RATING

Skid Packages shall be rated by criticality. HFE Critical Skids are rated as Category 1 and non-critical Skids are Category 2.

Recommended checklists for rating Skid Packages are available from the Principal on request.

##### 3.1.1 Category 1 - HFE critical skids

The requirements in this section apply to skid-packaged units categorised as Category 1 - HFE Critical, featuring either an entirely new design, or significant modification to an existing design.

For Category 1 skid-packages, a Task Requirements Analysis (TRA) shall be conducted on any HSSE Critical Activities where the means of performing the Activity is not clear, or where the risk of human unreliability is considered significant. A TRA may also be conducted where there is considered to be significant risk of injury or exposure to health hazards.

The TRA may be conducted in EXECUTE phase when more details on critical activities are available.

The following shall be included in procurement contracts –

- Design Requirements arising from the design analysis
- Generic Design Requirements from (4) of this DEP
- Stipulation for the Manufacturer/Supplier to hold a design review with Operations, Maintenance and HFE, at the appropriate stage (e.g., 30 %, 60 % and 90 %).

As part of their tender response, Manufacturer/Suppliers should:

- a) Document all activities that are considered HSSE Critical.
- b) Identify with which HFE design standard they intend to comply. Should Manufacturer/Suppliers propose their own in-house standards, these shall be approved by the HFE TA.
- c) Confirm their intention and ability to comply with (4) of this DEP.
- d) Identify the design tools proposed to assist designers, engineers, and operators and maintain representatives to review the layout. As a minimum, composition layout drawings shall be proposed showing all elements, which occupy physical space, in order to enable adequate detailed reviews of Operations and Maintenance aspects. Depending on the complexity of the work, the use of 3D CAD-system may be required.
- e) Provide details of areas where changes to existing components required to satisfy the requirements of this DEP will influence cost and/or delivery.

Once the equipment has been built, but before installation on-site, the Manufacturer/Supplier shall:

- Hold an Operability and Maintainability walk-through as part of FAT, to demonstrate that the key tasks identified via the TRA are adequately supported in the as-built package.

Once the equipment has been installed on-site, the EPC Contractor shall:

- Hold an Operability and Maintainability walk-through as part of the SAT, to ensure that installation and field run equipment has not violated the HFE design intent.

## 4. GENERAL DESIGN REQUIREMENTS

### 4.1 SKID-PACKAGED UNIT DESIGN

Where a skid-packaged unit/design solution identified as Category 1 deviates from requirements and data in this DEP, the Manufacturer/Supplier shall obtain approval from the Principal, and is directed to the project or regional Human Factors Engineering (HFE) Technical Authority (TA2) as detailed in the Project Controls and Assurance Plan (PCAP) or Discipline Controls and Assurance Framework (DCAF) Discipline Authorities Manual.

### 4.2 ANTHROPOMETRICS

Skid packages shall be designed to suit the anthropometric dimensions of the 5<sup>th</sup> percentile female Southeast Asia and 95<sup>th</sup> percentile male Northern European population unless stated otherwise within this DEP. For variances, projects should seek the assistance of the regional HFE TA.

NOTE: Throughout this DEP, dimensions, where appropriate and depending on the source data, have been rounded off to the nearest 10 mm (0.5 in).

### 4.3 LIFE-SAVING RULES

Skid-packaged units shall be designed and laid out to support safe ways of working. Equipment shall not be laid out, or access provided, in ways that will make any task (operational, inspection, maintenance or testing) easier or faster by violating a life-saving rule.

### 4.4 POSTURE

The design of workspaces shall take account of the number of personnel required to perform tasks, the actions (physical movements and application of force) to be undertaken and the postures that operators will be required to assume.

Kneeling and squatting operator positions should be avoided as much as possible for tasks performed on a regular basis (more than once per shift). They are only permitted for maintenance or non-routine and infrequent jobs, and where the need to adopt such postures is unavoidable without significant increase in cost or footprint of the unit. These postures should not be used for tasks that require operators to assume them for extended periods of time or to handle heavy loads or manually apply significant forces.

### 4.5 PERSONAL PROTECTIVE EQUIPMENT

PPE requirements for skid packages should be specified at the procurement specification stage by Operations, HSSE (or Technical Safety) and the HFE authorised person and any impacts on the design should be identified and communicated to the Manufacturer/Supplier.

### 4.6 ENVIRONMENTAL CONDITIONS

Design of skid units, and the work imposed on humans in operating and maintaining them, shall take into account and be appropriate to the anticipated work environment. This includes consideration of the following issues:

- Issues associated with local weather conditions (extremes of heat or cold, wind, rain, etc.). Rain/snow/ice may make walkway surfaces slippery, and possibly obscure gauges and window displays;

- local lighting at the expected site of the package (both natural and artificial lighting); and,
- noise, both arising from the procured skid, as well as from machinery located on the site.

The Manufacturer/Supplier shall comply with relevant local and national standards and regulations on work environment as well as specified DEPs.

## 5. DETAIL AND EQUIPMENT SPECIFIC REQUIREMENTS

### 5.1 LAYOUT

#### 5.1.1 General

Layout of skid mounted packaged equipment shall be such that operational and maintenance activities can be carried out in a way that makes efficient use of manpower, minimizes the likelihood of human error, and avoids placing operators or maintainers in situations with the potential for damage to their health or safety.

If it is necessary to trade-off HFE considerations against other design aspects, frequently operated/maintained elements or parts shall be given a high priority.

#### 5.1.2 Obstruction of components

Components shall be arranged so that items requiring human intervention are not obstructed (e.g., cabinet in front of a filter, cables in front of a valve, etc.). Requirements for dismantling components of the unit to gain access for maintenance should be avoided.

#### 5.1.3 Visibility of monitored/inspected items

Items requiring regular visual monitoring/inspection (including, for example, reading of gauges, valve positions and visual inspection for leaks or signs of corrosion) shall be located so that they are clearly visible and accessible appropriate to their service. Identification and status shall be clearly visible to an approachable operator position, i.e., on an adjacent walkway, access platform, or in space around equipment that is intended for human access.

#### 5.1.4 Operation and maintenance spaces

As a minimum, adequate standing workspace shall be provided wherever an operator or maintainer is required to work. Dimensions for workspaces for standing, squatting and other positions are provided in DEP 30.00.60.20-Gen., Sections 3.1, 3.2, and 3.4, respectively.

#### 5.1.5 Accessibility and reach

Where relevant, stairs, ladders, walkways, platforms, guard/handrails and toe-boards, shall comply with DEP 30.00.60.20-Gen., Section 3.5 and Section 3.6.

Items most critical to skid-packaged unit operations and which require rapid maintenance shall be easily accessible from on-skid walkways or from the edge of the skid (adjacent walkways). When relative criticality is not a factor, items requiring most frequent access shall be most accessible. High-failure rate items shall be accessible for replacement without removing non-failed items.

The required reach distance for any given task will vary depending on the task requirements. Assistance of the regional HFE TA should be sought, where the data provided may not be commensurate with the task requirements (i.e., manual handling).

At no time shall an operator or maintainer be required to stand on any surface not specifically designed to be used as a standing surface (such as a structural member in the base frame) in order to see, reach or perform an anticipated manual operation.

Emergency egress requirements shall comply with DEP 30.00.60.20-Gen., Section 3.8.

The design of workspaces shall take account of all necessary tools, materials and test equipment required to be used in the workspace.

#### **5.1.6 Equipment/materials handling**

Skid-packaged units shall comply with the manual handling requirements in DEP 30.00.60.20-Gen., Section 4.

#### **5.1.7 Instructions/labels on equipment**

Requirements for instructions and labels on equipment shall comply with DEP 30.00.60.21-Gen.

#### **5.1.8 Final facility positioning**

Layout shall take into account the final positioning and orientation of the skid package in the plant/facility, taking account of issues such as:

- a) access and clearance for loading/unloading using mechanical equipment,
- b) sufficient access/egress once interconnected with non-skid equipment,
- c) requirements of line-of-sight communications,
- d) access for emergency response and fire fighting, and
- e) potential sources of lighting and glare.

### **5.2 BASE FRAMES FOR EQUIPMENT**

#### **5.2.1 Base plate**

Base plates which are designed with walkway areas that are higher than 760 mm (30 in) above grade shall be equipped with a guard railing surrounding the walkway area. If there is a high frequency of activities, and the top of the base frame is higher than 1220 mm (48 in), consider whether access to the base frame can be by stairs.

#### **5.2.2 Base frame**

Corners of base frames located adjacent to walkways and which may present a tripping hazard shall be guarded by a railing to guide operators on a wide path around these corners.

#### **5.2.3 Drain pans**

Drain pans under base frames shall be covered with open grating of suitable strength. The pans shall be completely self-draining with no liquid retention. Grating shall be removable in sufficient areas to allow cleaning, inspection, and painting of these drain pans.

### **5.3 ROTATING EQUIPMENT**

#### **5.3.1 Visibility**

Manholes, hand holes, coupling guards, covers, junction boxes, etc., shall not be obscured by stairs, ladders, railings, piping, conduit, etc.

#### **5.3.2 Driving gear**

Driving gear (belts, chains) and cogwheel-unit designs shall ensure ease of dismantling and sufficient workspace to allow ease of access for routine adjustments of belts/chains, etc.

#### **5.3.3 Accessibility for torquing**

Where balanced torquing is required as part of maintenance activities, the design shall minimize the likelihood of operator error, e.g., by provision of adequate space around flange and bolts for even torquing. See also DEP 30.00.60.20-Gen., Section 5.8 for piping and flange clearances.

#### **5.3.4 Machinery cover and coupling accessibility**

Machinery cover bolting on major equipment items shall be accessible for removal and tightening without having to climb on surrounding equipment. Couplings and their guards shall be accessible from both sides. Consideration should be given to provide sufficient access between machinery components by use of spacer couplings.

5.4 ELECTRICAL COMPONENTS

**5.4.1 Junction boxes**

Junction boxes shall be located so that terminal strips are between 540 mm (21 in) and 1770 mm (70 in) above grade/flooring or any other means of permanent standing surface being provided. Cable shall enter these boxes from the underside. Junction box covers shall not be obstructed or obstruct other equipment and shall be easily accessible.

**5.4.2 Cable trays and conduits**

Horizontal runs of cable trays and conduits shall be installed to avoid obstructing access or visibility of machinery requiring inspection or interaction during operations or maintenance.

**5.4.3 Motor cable connections**

Equipment installation height shall take into account motor cable installation and the space required by cable minimum bending radius. Motor connection boxes shall, wherever possible, have removable gland plates to assist cable connection.

**5.4.4 Cable routing**

Cable routing shall be such that accessibility during machine maintenance shall not be restricted. Cables shall not block access for operation or maintenance.

**5.4.5 Motor accessibility**

Electric motors shall be located to provide for easy access and handling.

5.5 LOCAL CONTROL PANELS

**5.5.1 Orientation**

Indicators and controls in local panels shall be oriented to ensure consistency in reading and operation, and shall be consistent with local conventions (e.g., all switches pointing the same way for "Open" or "Closed"). Graduations shall be static and pointers moveable.

**5.5.2 Information displayed**

The information displayed to an operator shall be limited to only that which is necessary to perform specific actions. Trademarks, Manufacturer data, or other similar markings not providing usable information to the operator shall not be displayed on the panel face or on the displays themselves. This information may be placed on the side or back of the console or instrument face if needed for maintenance purposes.

**5.5.3 Presentation of information**

Information shall be presented in a directly usable form and shall not require personnel to mentally transpose, compute, interpolate, or translate information presented in one form into other units.

**5.5.4 Display failure**

A method shall be provided to determine if a display or circuit has failed. Failure of the display or its circuit shall not cause a failure in the associated equipment.

**5.5.5 Absence of signal**

The absence of a signal or visual indication shall not be exclusively used to denote a malfunction or out-of-tolerance condition. Similarly, the absence of a signal shall not be used to indicate a ready or in tolerance condition.

**5.5.6 Accuracy and legibility**

Displays/gauges on panels shall be located and designed so that they may be read to the degree of accuracy required by personnel in the normal operating or servicing positions. All displays shall be legible under all anticipated viewing conditions considering ambient lighting and viewing distance. Flashlights or other special equipment shall not be required in order to read the display.

**5.5.7 Mounting height**

Mounting heights for displays located on flat surfaces for use by a standing operator shall be a minimum of 1120 mm (44 in) and a maximum of 1730 mm (68 in) above the standing surface. The preferred range for working displays is 1390 mm (55 in) to 1590 mm (63 in). These preferred dimensions shall apply to controls and displays that require precise, frequent, and/or emergency use/review.

**5.5.8 Indicating instruments attached to pipe**

Indicating instruments, such as temperature and pressure gauges, which are attached directly to a pipe, shall be mounted so that they read upright, or turned no more than 90° from the upright position.

**5.5.9 Reflections**

Displays shall be constructed, arranged, and mounted to prevent reduction of information transfer due to the reflection of the ambient illumination from the display cover. Reflection of instruments and consoles in windows and other reflective enclosures shall be avoided.

**5.5.10 Grouping**

All displays/controls necessary to support an operator activity or sequence of activities shall be grouped together.

**5.5.11 Functional grouping and viewing flow**

Displays/controls shall be arranged in functional relation to one another and according to their sequence of use. They shall be arranged in sequence within functional groups, whenever possible, to provide a viewing flow from left to right (preferred) or top to bottom.

**5.6 VALVES**

The design, layout and location of valves shall comply with the requirements in DEP 30.00.60.13-Gen.

## 6. REFERENCES

In this DEP, reference is made to the following publications:

NOTES:

1. Unless specifically designated by date, the latest edition of each publication shall be used, together with any amendments/supplements/revisions thereto.
2. The DEPs and most referenced external standards are available to Shell staff on the SWW (Shell Wide Web) at <http://sww.shell.com/standards/>.

### SHELL STANDARDS

Human factors engineering – Valves	DEP 30.00.60.13-Gen.
Human factors engineering – Workspace design	DEP 30.00.60.20-Gen.
Human factors engineering - Labelling of facilities, equipment and piping	DEP 30.00.60.21 Gen.
Discipline Controls and Assurance Framework Discipline Authorities Manual.	DCAF
HSSE Control Framework and Project Guide 1	HSSE CF
Project Controls and Assurance Plan	PCAP

### INTERNATIONAL STANDARDS

Ergonomic principles in the design of work systems	ISO 6385
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