DEP SPECIFICATION

HUMAN FACTORS ENGINEERING – CONTROL ROOM DESIGN

DEP 30.00.60.15-Gen.

February 2012

ECCN EAR99

DESIGN AND ENGINEERING PRACTICE

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3) Contractors/subcontractors and Manufacturers/Suppliers under a contract with users referred to under 1) or 2) which requires that tenders for projects, materials supplied or - generally - work performed on behalf of the said users comply with the relevant standards.

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1. INTRODUCTION

1.1 SCOPE

This DEP specifies Human Factors Engineering (HFE) quality control requirements and gives recommendations for the design of control suites, control rooms and related workstations used in facilities.

These requirements are intended to ensure that Project teams (and their Contractors and Vendors) apply good practice in developing control rooms that support high levels of usability and situation awareness among panel operators and others who have to monitor and control complex automated systems in process-related facilities.

This DEP should be read in conjunction with other HFE DEPs in the 30.00.60.XX series. In particular, this DEP should be used in association with DEP 30.00.60.10-Gen. and DEP 30.00.60.16-Gen.

This DEP addresses the “hardware” aspects of control suite, control room and related operator workstation design. The design of on-screen Human Machine Interface (HMI) is addressed in DEP 30.00.60.16-Gen.

This is a revision of the DEP of the same number dated January 2010; see (1.5) regarding the 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 authorization 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 may 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 regard 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 its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant, authorized 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

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control room /CR</td>
<td>Core functional entity, and its associated physical structure, where operators are stationed to carry out centralized control, monitoring and administrative tasks.</td>
</tr>
<tr>
<td>Control suite</td>
<td>Group of functionally related rooms, co-located with and including the control room, which houses the functions supporting the control room.</td>
</tr>
<tr>
<td>Controlled system</td>
<td>A process unit, plant or production facility, pipelines, tank farms, supply and distribution terminals, etc.</td>
</tr>
<tr>
<td>Control console</td>
<td>Structural framework which supports equipment, work surfaces and storage and which together comprises a control workstation.</td>
</tr>
<tr>
<td>Control panel</td>
<td>Discrete surface on which groups of displays and controls are mounted; control panels may be mounted on the control workstation or on walls.</td>
</tr>
<tr>
<td>Display</td>
<td>Device for presenting information that can change or a software component that determines the spatial format and layout of visual outputs of the human machine interface on the hardware elements referred to in this DEP as screens.</td>
</tr>
<tr>
<td>HFE Authorised person</td>
<td>A person authorised and assigned responsibility to develop and approve procedures for HFE. An HFE authorised person has proficiency assured at skill level and is accredited at a professional level in HFE.</td>
</tr>
<tr>
<td>HFE Technical Authority</td>
<td>Individual responsible for quality assurance of HFE work performed on a project.</td>
</tr>
<tr>
<td>Human-Machine Interface</td>
<td>The combination of software and hardware elements that determines the nature of human interactions with equipment and people in the workplace through command inputs and data outputs.</td>
</tr>
<tr>
<td>Panel/Control Room Operator</td>
<td>An individual who fulfils their work obligations, whether full or part-time, by interaction with a process control system. Panel/Control Room operators are usually provided with workstations comprising a combination of screens, work-surfaces, a chair and associated devices (such as phones, radios, and keyboards).</td>
</tr>
<tr>
<td>Screen</td>
<td>A hardware component that supports viewing the visual outputs of the human-machine interface.</td>
</tr>
<tr>
<td>Situation Awareness</td>
<td>The mental state of being aware of what is happening around you and the associated understanding of what that means now and in the future relative to a particular job, function or goal.</td>
</tr>
<tr>
<td>Task, work task</td>
<td>An activity required to achieve an intended outcome of the work system.</td>
</tr>
<tr>
<td>Task analysis</td>
<td>Systematic breakdown of work tasks into their elements, including a description of both manual and mental activities, task durations, task frequencies, task allocation, task complexity, environmental conditions, equipment, and any other unique factors involved in or required for one or more human beings to perform a given task.</td>
</tr>
<tr>
<td>Usability</td>
<td>The property of a human machine interface that is measured in terms of its ease of use, learnability, efficiency, and error tolerability.</td>
</tr>
</tbody>
</table>
Validation
The process of determining the extent to which a system meets its requirements.

Work environment
Physical, chemical, biological, organizational, social and cultural factors surrounding a person in his or her work tasks.

Work station
Combination of work equipment in a work space, including the work environment, where one or more work tasks have to be carried out by a person.

NOTE: It is possible that several persons share a specific work station, or that several persons alternate work stations within any period of time (i.e. hourly, daily, weekly).

1.3.3 Abbreviations

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>BDEP</td>
<td>Basic Design Engineering Package</td>
</tr>
<tr>
<td>BfD</td>
<td>Basis for Design</td>
</tr>
<tr>
<td>BoD</td>
<td>Basis of Design</td>
</tr>
<tr>
<td>CS</td>
<td>Control System</td>
</tr>
<tr>
<td>C&amp;I</td>
<td>Control and Instrumentation</td>
</tr>
<tr>
<td>DCS</td>
<td>Distributed Control System</td>
</tr>
<tr>
<td>DEP</td>
<td>Design and Engineering Practice</td>
</tr>
<tr>
<td>EPC</td>
<td>Engineering, Procurement and Construction</td>
</tr>
<tr>
<td>EPCM</td>
<td>Engineering, Procurement and Construction Management</td>
</tr>
<tr>
<td>FEED</td>
<td>Front-end Engineering Design</td>
</tr>
<tr>
<td>FRC</td>
<td>Fire-resistant clothing</td>
</tr>
<tr>
<td>HFE</td>
<td>Human Factors Engineering (synonymous with “Ergonomics”)</td>
</tr>
<tr>
<td>HMI</td>
<td>Human-Machine Interface</td>
</tr>
<tr>
<td>HVAC</td>
<td>Heating, Ventilation and Air-Conditioning</td>
</tr>
<tr>
<td>PS</td>
<td>Project Specification</td>
</tr>
<tr>
<td>SA</td>
<td>Situation Awareness</td>
</tr>
<tr>
<td>SCADA</td>
<td>Supervisory Control And Data Acquisition</td>
</tr>
<tr>
<td>TA</td>
<td>Technical Authority</td>
</tr>
<tr>
<td>TRA</td>
<td>Task Requirements Analysis</td>
</tr>
<tr>
<td>UPS</td>
<td>Uninterrupted Power Supply</td>
</tr>
<tr>
<td>VDU</td>
<td>Visual Display Unit, i.e. a cathode ray tube (CRT), liquid crystal display (LCD), plasma panel, and other screen or visual display device</td>
</tr>
</tbody>
</table>
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 (5).

1.5 SUMMARY OF CHANGES
This DEP is a revision of the DEP of the same number dated January 2010. This has been a major rewrite and it is therefore impractical to summarize the changes here.

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.
2. AIMS AND BENEFITS – THE ROLE OF THIS DEP

2.1 GENERAL

The job of the panel operator can at times be very demanding and the consequences of inappropriate operator action in control rooms, e.g. acts of omission, commission, timing, sequence, etc., can be potentially disastrous. Therefore, a fully functional control suite/room that satisfies the operational requirements of all end users is essential. To help achieve this, Human Factors Engineering shall be applied during the design of a control suite/room with the objective to eliminate or minimize the potential for human error, avoiding risk to health or personal safety, and enhancing the effectiveness and efficiency with which human work is carried out.

2.2 PURPOSE OF THIS DEP

This DEP sets out the minimum requirements for application of the principles of Human Factors Engineering in the design and development, including change and upgrade, of control suites, control rooms and related operator workstations.

This DEP, therefore, does two things:

• It defines a minimum level of quality control to be applied to the process of specifying, developing and validating control suite, control room and related operator workstation designs;

• It provides guidance on minimum HFE technical requirements that a project should apply to the design and validation of control suite, control room and related operator workstation designs.

2.3 PRINCIPLES

This DEP is based on the following principles:

1. The design of control suites, control rooms and related operator workstations shall satisfy the operational requirements for all expected end users in all anticipated modes of operation:
   o Steady state operation
   o Normal transient operation (start-up, shut-down)
   o Emergency/abnormal operation*
   o Maintenance (scheduled or unscheduled)*

   NOTE: Greater end-user involvement is often required for defining end-user needs for emergency operations and maintenance than for the normal steady state).

2. To provide a physical work environment that reduces stress and fatigue and minimizes the risk of injury or illnesses to the expected end users.

3. To ensure end user participation in the design development, through representation by operators, team leaders, and maintenance personnel.

4. To apply learnings from experience, including re-use of experience and existing good practices, as well as learning lessons about the impact of poor control room design from major incident investigations.

5. To ensure HFE requirements are identified and specified in time to be included in the Basis for Design (BfD) or contractual documents for front-end engineering or detailed design.

6. To ensure designs are adequately reviewed and validated to ensure Human Factors as well as operational requirements and objectives are achieved.
3. CONTROL SUITE/ROOM DEVELOPMENT PROCESS

3.1 CLARIFICATION

This process should be initiated as part of the HFE Screening conducted in time to be incorporated in the BID or contractual requirements for front-end engineering or detailed design. The HFE Screening will determine:

- Whether this DEP shall be included in the project BID or contractual requirements for front-end engineering or detailed design, and, if so,

- The level of quality control to be applied to the control suite/room design.

Figure 1 shows the decision tree to be used to screen projects for inclusion of this DEP and the level of HFE quality control to be applied.

![Decision Tree Diagram]

**Figure 1  Decision tree regarding whether to include this DEP in project baseline (BoD)**

**NOTES:**
1. As a guide, a ‘major change’ would cover projects where
   - One or more new process control workstations will be introduced;
   - Changes to the layout and arrangement of control suite/room are made.

2. As a guide, the term ‘Minor change’ means:
   - Replacement of screens (e.g. CRT with LCD) and/or worn-out furniture; or
   - Changes affect operator interaction with less than approximately 20% of the existing workstations; and
   - The changes will be implemented in the existing control room and utilizing the existing workstations.

3. ‘Critical’ activities include, for example:
   - Startup or shutdown of process units;
   - Communications, including shift-handovers, start-of-shift-orientation, shift team meetings;
   - Proactive monitoring of process units;
   - Managing abnormal situations;
   - Responding to emergencies;
   - Performance of tasks that are known to be particularly difficult, time-consuming, stressful, or that may be carried out over extended periods;
   - Execution of activities identified in Safety Critical Elements or shown as barriers in Bow-Ties at the asset (including responding to alarms).
Projects identified as CR Category 1 should follow the development process defined in (3.2). Category 2 projects should follow the process as defined in (3.3).

3.2 CATEGORY 1 CR PROJECTS

Figure 2 summarizes the HFE quality control activities required for a Category 1 control suite/room development project (i.e. projects involving the development of a new control suite/room, or a major change to an existing system).

3.2.1 Activities to be conducted during the DEFINE phase

The following activities shall be performed to ensure the HFE requirements included in the Project Definition Package meet the specific needs of the asset. These activities shall be completed before the end of the DEFINE (i.e., FEED) phase.

Step 1: Functional and role analysis

Projects shall identify all the functions expected to be integrated into the control suite, and the related facilities and equipment necessary to support them. The roles expected to be involved in performing or supporting those functions shall also be identified.

This step should deliver a Function-to-Role matrix. Section 3.2.1 of the companion Informative to this DEP illustrates the format such a matrix might take.

Based on this analysis, the project should define who the primary and secondary end users in the design of the control suite and control room are:

- Primary users shall have all of their needs met.
- Secondary user needs can be compromised if necessary to optimise design for Primary users.

Step 2: Task analysis of key roles

Projects shall perform a Task Requirements Analysis (TRA) of each of the roles identified as being Primary users. The analysis shall identify:
• Main role/responsibilities;
• Key tasks for each role, (this should include consideration of tasks identified through compliance with DEP 30.00.60.16-Gen. and DEP 32.80.10.14-Gen;
• Equipment and other facilities needed to support each key task;
• Who needs to be communicated with in performance of each key task;
• Performance standards where appropriate for key tasks (i.e. the conditions that are essential to be able to do the tasks safely and efficiently).

An example control room TRA is provided in Section 3.2.1 of the companion Informative to this DEP.

Step 3: Functional relationship and adjacency analysis

For all identified functions, roles (primary and secondary) and equipment, Projects shall perform Functional Relationship and Adjacencies analysis against; a) other functions, b) other roles, and c) equipment. Functional relationships and adjacencies should be assessed using criteria such as the following example for Role-to-Role relationships:

Low Low (LL): Need for face-to-face interaction very rare.
Low (L): Very occasional interaction. Should be in same building.
Medium (M): Occasional need for face-to-face interaction. Some travel time acceptable, e.g. should be located on the same floor.
High (H): Regular unplanned face-to-face interaction. Should be accessible with short walk from primary work location, e.g. should be within the same physical space/area/room.
High High (HH): Very regular face-to-face interaction, often with little prior notice. Shall be easily accessible from primary work location, e.g. should be directly adjacent to each other.

An example is provided in Section 3.2.1 of the companion Informative to this DEP, including criteria for assessing the three types of relationships.

Step 4: Concept design and review

Using the results of the functional analysis (Steps 1 to 3), Projects shall produce an initial conceptual design of:

• the control suite layout (showing proposed locations to support identified Functions);
• the layout of primary workstations, key equipment and facilities.

The Conceptual design shall go through a design review, leading to an updated design concept before end of the DEFINE phase. This review shall assess the concept against design requirements DR1 to DR6 in Section (4) of this DEP.

Step 5: Develop HFE design requirements

A specification of HFE design requirements shall be identified or developed. These HFE requirements shall be based on a review of Section (4) of this DEP. As a minimum, the HFE design requirements shall include:

EITHER: a statement that all of (4) shall be adopted as HFE design requirements;
OR: a list of specific requirements from (4) that shall be treated as contractual for the project;
OR: reference to an alternative international, industry or other standard (approved for use by a regional HFE Authorized Subject Matter Expert) for HFE requirements for control suite/room applications that shall be adopted as specifying the project HFE requirement.
These HFE design requirements shall be used as the basis for the verification and validation process to ensure that the final design conforms to the end-user needs.

**Step 6: Include HFE requirements in project definition package**

The HFE requirements shall be included as a stand-alone section in the Project Design Package and shall be referenced in tender material used to select a Contractor.

The concept design material (i.e. Task Requirements and Adjacency Analyses) should be made available to the Contractor for information.

### 3.2.2 Activities to be conducted during the EXECUTE phase

The following activities are required to be completed during the EXECUTE phase for a project where the control suite/room project development is identified as Category 1 (Figure 1).

These activities ensure an appropriate level of visibility, structure and control over the Contractors' control suite/room development and validation activities.

**Step 7: Detail design**

As soon as possible after an EPC or EPCM Contractor is contracted, a review meeting shall be held with the following objectives:

- Ensure the Contractor understands the functional and HFE requirements and identify any potential issues.
- Agree to the process for operator involvement in reviewing and approving detail designs, equipment and furniture selections. Consideration should be given to the development of 3D modeling and renderings for visual illustration and review purposes.

Any changes to the functional and HFE requirements arising from this review shall be subject to formal change control and approval. The objective is to balance the functional and HFE requirements identified during FEED with what is technically and financially feasible given any HMI constraints imposed by the selected Vendor.

**Step 8: Verify and validate detail design**

The detailed design shall be formally verified to ensure that it conforms to the design specifications and furthermore validated to ensure it conforms to the end-users needs.

The contract shall define the expected general review approach, the personnel and resource requirements, and the number of reviews to be conducted.
3.3 CATEGORY 2 CR PROJECTS

Figure 3 HFE quality control activities for a Category 2 CR project

Figure 3 summarizes the HFE quality control activities required for a Category 2 control suite/room development project. (Category 2 projects involve significant changes to existing control suites/rooms, or changes to existing workstations supporting critical activities).

3.3.1 Activities to be conducted during the DEFINE phase

The following activities are required to be completed before the end of the DEFINE phase for a control suite/room project that is identified as being Category 2 (see Figure 1).

The purpose of these activities is to ensure that HFE scope requirements and validation methods are adequately defined prior to beginning the Execute phase of the development.

Step 1: Develop HFE design requirements

The appropriate HFE design requirements shall be identified or developed. These HFE requirements shall be based on a review of Section (4) of this DEP. As a minimum, the HFE design requirements shall include:

- Either a statement that all of (4) shall be adopted as HFE design requirements, OR
- A list of specific requirements from (4) that shall be treated as contractual for the project, OR
- Reference to an alternative international, industry or other standard (approved by Regional HFE Authorized Subject Matter Expert) for HFE requirements for control suite/room applications that shall be adopted as specifying the project HFE requirement.

These HFE design requirements shall be used as the basis for the verification and validation process to ensure that the final design conforms to the end-user needs.

Step 2: Include HFE requirements in project definition package

The HFE requirements shall be included as a stand-alone section in the Project Design Package and shall be referenced in tender material used to select a Contractor.

The concept design material should be made available to the Contractor for information.
3.3.2 Activities to be conducted during the EXECUTE phase

The following activities are required to be completed during the EXECUTE phase for a control suite/room project that is identified as being Category 2 (see Figure 1). These activities ensure an appropriate level of visibility, structure and control over the Contractors’ control suite/room development and validation activities.

Step 3: Detail design

As soon as possible after the contract is awarded, a review meeting shall be held with the following objectives:

- Ensure the Contractor understands the functional and HFE requirements and identify any potential issues;
- Agree to the process for operator involvement in reviewing and approving detail designs, equipment and furniture selections.

Any changes to the functional and HFE requirements arising from this review shall be subject to formal change control and approval. The objective is to balance the functional and HFE requirements identified during FEED with what is technically and financially feasible given any HMI constraints imposed by the selected Vendor.

Step 4: Verify and validate detail design

The detailed design shall be formally verified to ensure that it conforms to the design specifications and furthermore validated to ensure it conforms to the end-users needs.

The contract shall define the expected general review approach, the personnel and resource requirements, and the number of reviews to be conducted.

3.4 SUMMARY OF RESPONSIBILITIES

Table 1 summarizes each of the Control Suite/room development activities for both Category 1 and 2 projects. Discipline responsibilities identified in Table 1 are recommended, but are not intended as a standard for all situations; allocation of responsibilities to disciplines may vary between individual projects.
### Table 1  Responsibility matrix

<table>
<thead>
<tr>
<th>Activity</th>
<th>Project Manager</th>
<th>HFE Authorised person</th>
<th>HFE Co-ordinator&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Architect/ Civil Engineer</th>
<th>Operations/ Maintenance</th>
<th>C&amp;I Engineer/CS Specialist</th>
<th>EPC or EPCM Contractor</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR Category 1 projects (i.e. new Control Suite/Room development)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Function and Role Analysis</td>
<td>APP</td>
<td>EXE</td>
<td>CON</td>
<td>CON</td>
<td>CON</td>
<td>CON</td>
<td>CON</td>
</tr>
<tr>
<td>2. TRA of Key Roles</td>
<td>APP</td>
<td>EXE</td>
<td>CON</td>
<td>CON</td>
<td>CON</td>
<td>CON</td>
<td>CON</td>
</tr>
<tr>
<td>3. Functional Relationship &amp; Adjacency Analysis</td>
<td>APP</td>
<td>CHK</td>
<td>EXE</td>
<td>CON</td>
<td>CON</td>
<td>CON</td>
<td>CON</td>
</tr>
<tr>
<td>4. Concept Design &amp; Review</td>
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<td>6. HFE Requirements in PS or BDEP</td>
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<td>7. Detail Design</td>
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| CR Category 2 projects (i.e. significant change to existing Control Suite/Room, or change to existing CR equipment supporting critical activities) |
| 1. Develop HFE Requirements | APP | CON | CHK | CHK | CON | EXE |
| 2. HFE Requirements in PS or BDEP | APP | CON | APP | CHK | CON | EXE |
| 3. Detail Design | APP | CON | CON | EXE | CON | CON |
| 4. Verify and Validate Detail Design | APP | CON | CHK | CON | CHK | CON | EXE |

<sup>a</sup> The HFE Co-ordinator is the individual from within the project team appointed by the Project Manager to lead and organise HFE effort on the project. Details of responsibilities and competence requirements are contained in DEP 30.00.60.10-Gen.

**Key:**
- EXE = Execute
- CON = Consult
- CHK = Check and verify results
- APP = Approve
4. CONTROL SUITE/ROOM DESIGN REQUIREMENTS

There are a number of international and industry standards or guidelines available on the Human Factors Engineering/Ergonomics of Control Centers, including ISO 11064. Compliance with ISO 11064 will satisfy this DEP; (see 2.1.1 of companion Informative).

4.1 GENERIC REQUIREMENTS

Control rooms shall satisfy six generic human-centred design requirements:

- **DR1:** Support efficient working and interaction between functions internal and external to the control suite.
- **DR2:** Support efficient and reliable working and movement within the control room.
- **DR3:** Support high levels of concentration and sustained working by individual operators.
- **DR4:** Provide a work environment that makes it easy to follow company procedures.
- **DR5:** Avoid risks to health and safety arising from the design and layout of the work environment and individual workstations.
- **DR6:** Provide an acceptable and comfortable working environment.

The following sub-sections define generic requirements supporting each of these human-centred design requirements. These are non-functional requirements (i.e. performance or quality related).

**DR1: Support efficient working and interaction between functions internal and external to the control suite**

This requirement is dependent upon consideration of a number of factors:

1. The location of the control building relative to the rest of plant;
2. The ease and speed with which people can move between the control suite and other work areas (including process areas, warehousing, administration buildings, etc.);
3. The ability of personnel within the control suite to maintain awareness of the location and state of outside activities. (For example, panel operators nearly always need to know the relative location and orientation of plant areas, and, in the case of a gas release for example, other areas or work parties that might be affected depending on wind direction. In some sites the control room operators also control access of vehicles onto the site and therefore need direct visibility of the main traffic and pedestrian entrances);
4. Considerations relating to fieldworkers supporting a pipeline control centre.

The location and orientation of the control building shall take account of these and other performance factors that affect the ability of people to work and interact efficiently and effectively between the control building/room and other functional areas of the asset.

**DR2: Support efficient and reliable working and movement in and around the control room**

Control room personnel have a number of generic requirements necessary to ensure they can work effective both individually, within their designated sub-teams, and with others. These include:

1. Easy access to all information, control and other resources needed to perform their work;
2. A well-designed primary workplace that allows them to perform all core tasks, including integrating information from all required resources, efficiently and without undue effort or having to adopt awkward or unsafe working postures;
3. The ability to communicate easily and reliably. This can range from simply being able to see what other operators in the control room are doing and the state they are in, to being able to exchange information verbally either in a group or one-to-one, especially during shift handover;

4. Being able to maintain and hand over at the end of the shift, a shared understanding of the overall state of the process, and the location of work parties, and particularly any areas that are in an abnormal state (being maintained, shut-down, in alarm, etc.);

5. Work processes such as shift handover, start of shift orientation, shift team meeting and planning and end of shift reporting are all critical for communicating the status of ongoing tasks and plans between team members and thus supporting individual as well as shared SA. Control room layout and design shall therefore accommodate these and other work processes intended to support shared situation awareness;

6. The ability to move around within the control room, efficiently and safely, including movement of goods, without distraction or interference with other control room personnel.

**DR3: Support high levels of concentration and sustained working by individual operators**

The control room environment, as well as the design of information displays, shall allow individual operators to concentrate on their work over the full period of a shift. In terms of control room design and layout, this involves:

1. Designing roles and allocating responsibilities in such a way that individuals are able to organise their work and to allocate the necessary time to individual task demands;

2. Providing a workplace optimised to avoid discomfort over a normal working shift;

3. Avoidance of distractions from other people, unnecessary noise, glare from lighting, workstations or windows;

4. Consider providing dedicated facilities that allow individual operators to maintain alertness or to recover from fatigue during night shifts.

**DR4: Provide a work environment that makes it easy to follow procedures**

The design and layout of the control room shall not introduce any features that interfere with compliance with procedures. This includes:

1. Ensuring individuals with responsibility for supervising or checking the work of others are able to maintain awareness of the location and state of work, and to meet those responsibilities easily from their core working location, as far as practical.

2. Ensuring the design or layout does not make it unnecessarily difficult for individuals to seek input from Supervisors or others in the performance of their work. Examples of non-compliance with this would include:
   a. locating meeting rooms so that Supervisors and others involved in regular management meetings are frequently physically removed from their normal work location so that it can be difficult to access them;
   b. locating a Supervisor’s office in a clean area so that operators in dirty work areas are required to change in order to consult them.

3. Ensuring procedures and other instructions or technical manuals that may need to be consulted to comply with procedures are easily accessible where and when they are needed, and that facilities (desk space, photocopiers, etc.) are easily available if necessary.
4. Ensuring space and facilities are available and in an environment that is conducive to performing shift handovers and team meetings in a way that is effective in communicating information between individuals and teams.

5. Providing space and facilities that make it easy to record significant events in shift logs.

DR5: Avoid risks to health and safety arising from the design and layout of the work environment and individual workstations

This includes:

1. Ensuring workstations, control consoles and related seating are designed in accordance with ergonomic standards both for normal operation and maintenance;

2. Ensuring the design and layout of other equipment and facilities do not require personnel to work in postures for extended durations with the potential for musculo-skeletal injury or illnesses;

3. Avoidance of tripping hazards (cable runs, changes in floor level, design of steps, etc.);

4. Avoidance of exposure to electrical hazards (for example during equipment maintenance);

5. Ensuring the design and layout do not interfere with the use of mechanical aids for manual handling heavy items, if required.

DR6: Provide an acceptable and comfortable working environment

This includes:

1. Providing a work environment that is appropriately lit, with good climate control, and free from draughts and unpleasant odours;

2. Avoiding the use of bright or highly saturated primary colours or finishings;

3. Ensuring individuals have sufficient personal space and, as appropriate, privacy, so that they do not feel imposed on or threatened by others (for example by being under undue scrutiny from management);

4. Providing a traffic-flow/control design that balances access to the control room with the need for the control room to be an environment conducive to analysis and reflection;

5. Being sensitive to issues that might give rise to sources of tension between different work groups on the same site (for example, on a site with two or more control rooms, providing one with significantly better kitchen or rest facilities than the other, or where one is able to exert more influence on management due to their physical location or function);

6. Providing sufficient rest, refreshment as well as male and female toilets and changing facilities as appropriate.

4.2 FACILITY-SPECIFIC AND ERGONOMIC REQUIREMENTS

(Appendix A) contains a comprehensive set of technical requirements for control room and workstation ergonomics. These requirements are derived from relevant industry and international guidelines and standards.

In the absence of a more specific ergonomic control room standard, Appendix A shall be adopted as the control room ergonomic technical specification. DEP Standard Form 30.00.60.82-Gen. is a checklist for the application of (Appendix A).

Instrumentation contractors and architects responsible for the design of control rooms often have their own technical standards for control room ergonomics, or prefer to comply with published international, national or industry standards. In such cases, the HFE Technical Authority (as detailed in the Project Controls and Assurance Plan (PCAP) or Discipline
Controls and Assurance Framework (DCAF) Discipline Authorities Manual) for the project shall be consulted to approve adoption of any such alternative standards or deviations from this DEP.

The full set of requirements in (Appendix A) will not apply to all projects. Where appropriate, e.g. small offshore installation control rooms, the requirements of (Appendix A) can be customised to the specific needs. In such cases, the HFE Technical Authority for the project shall be consulted for approval, prior to the adoption of any such amended requirements.
5. REFERENCES

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

NOTE: 1. Unless specifically designated by date, the latest edition of each publication shall be used, together with any amendments/supplements/revolutions 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 in projects ................................................. DEP 30.00.60.10-Gen.
Human factors engineering – Human machine interface design for situation awareness .......... DEP 30.00.60.16-Gen.
Standard Form – Checklist for control room design .................................. DEP 30.00.60.82-Gen.
Heating, ventilation and air-conditioning for plant buildings ....................... DEP 31.76.10.10-Gen.
Alarm management ................................................................................. DEP 32.80.10.14-Gen.
Design and engineering of buildings ....................................................... DEP 34.17.00.32-Gen.
Design of blast resilient and blast resistant onshore buildings, control rooms and field auxiliary rooms .......... DEP 34.17.10.30-Gen.
Laboratories .......................................................................................... DEP 34.17.10.31-Gen.
CONNECT Workplace Design Standards Toolkit (for use only by Shell companies)

AMERICAN STANDARDS

Human factors engineering of computer workstations ................................ HFES 100-2007

BRITISH STANDARDS

Process plant control desks utilizing human-computer interfaces – A guide to design, operational and human interface issues .......... EEMUA 201

INTERNATIONAL STANDARDS

Ergonomic requirements for office work with visual display terminals (VDTs) – Part 4: Keyboard requirements ................ ISO 9241-4
Ergonomics of human-system interaction – Part 400: Principles and requirements for physical input devices .......... ISO 9241-400
Ergonomics of human-system interaction – Part 410: Design criteria for physical input devices .......... ISO 9241-410
Ergonomic design of control centres ..................................................... ISO 11064
Ergonomic design of control centres – Part 4: Layout and dimensions of workstations .......... ISO 11064-4
APPENDIX A  FACILITY-SPECIFIC AND GENERIC ERGONOMIC REQUIREMENTS

A.1  CONTROL SUITE (BUILDING)

A.1.1  Location (plot plan)

A.1.1.1  The location of the control suite/room (building) is mostly determined by non-HFE factors such as safety, blast modelling, wind direction, desired free space around the building, potential for expansion, emergency response, type and number of plants/units that are to be controlled from the control room, etc.

A.1.1.2  Locating the control suite near to the plant/unit, has the benefit of operations and other functions being in closer contact with plant/unit with shorter movement distances. The disadvantage is potentially increased civil engineering costs due to safety (facility siting) constraints.

Locating the control suite some distance from the plant/unit, has the benefit of being less subject to plant noise and odours, increased feeling of safety and lower civil engineering costs.

A.1.1.3  If it is important that a process or site/area is visible to particular operators from within the control room, then control suite/room, work area or station should be located so that visual monitoring/observation is unobstructed and appropriately lit at all times.

A.1.1.4  User task interaction with equipment, adequate space for service and maintenance activities as well as movement of operators, other personnel and visitors shall be considered, when deciding on the location of a control suite/room.

A.1.1.5  The location of the control room should permit easy access to all areas that might need to be visited on a regular basis. The location shall be reviewed to ensure it does not encourage the use of undesirable, even if easier or faster, routes to and from the control building (such as short cuts using emergency exits or walking through the control room).

NOTE:  See DEP 34.17.10.30-Gen. and DEP 34.17.00.32-Gen. for additional building location requirements.

A.1.2  Traffic, routing and entrances

A.1.2.1  Access to buildings should take account of movement of equipment as well as personnel. It shall be possible to transport equipment through the building easily and safely. If necessary, lifting and/or transport facilities or other aids shall be provided.

A.1.2.2  Accessibility legislation (i.e. governing access by mobility impaired users) appropriate to the location of the facility shall be complied with.

A.1.2.3  Movement of personnel during peak traffic times (i.e. shift handovers and other meetings) shall be supported.

A.1.2.4  Requirements for special security checks and gates controlling access to the control suite shall be considered.

In addition to security features to control access, the design of the control room entry and ambience should facilitate awareness that personnel are entering an area where people are required to concentrate.

A.1.2.5  Distances internal to the control suite (building) should be minimized to take travel and communication needs into account.

A.1.2.6  Any restrictions placed on access for unauthorized personnel should not impede access for authorized personnel.

A.1.2.7  Doors and passageways internal to the control suite (building) shall enable access to and transport of equipment. Consideration shall be given to future extensions of equipment and to maintenance and replacements, which might require access through the floor or ceiling/roof.

A.1.2.8  Ready access shall be provided to first aid equipment, emergency equipment and emergency exits in accordance with local regulations.
A.1.3 Location of functional areas / within control suite (building)

A.1.3.1 The location and layout of functional areas within the control suite (building) shall be based on the Functional Relationship and Adjacency Analysis (see Section 3).

A.1.3.2 Clean and dirty traffic associated with control room tasks shall be routed separately as necessary. (For example, field operators requiring access to the control room might be routed via the locker/change rooms. In the case of offshore control rooms, traffic routing associated with control room activities shall take into consideration noisy and quiet (sleeping) areas. Personnel shall not have to pass through a sleeping area to reach the control room.

A.1.4 Visitors and communication

A.1.4.1 The design of facilities for visitors should be taken into consideration from the beginning of the project and treated as a normal function to be accommodated by the control suite.

A.1.4.2 Professional and public visitors shall be distinguished and their respective needs systematically determined.

A.1.4.3 Control room operators’ needs for privacy, confidentiality and protection from distraction from visitors shall be met by architectural or design features that impress on visitors this imperative; doors, barriers, windows, floor demarcations (carpet color change).

A.1.4.4 If required, a desk should be provided for issuing permits and receiving visitors. The desk shall comply with the ergonomics requirements provided in CONNECT Workplace Design Standards (Chapter 10 - Ergonomics and Health).

A.1.4.5 See lobby and branding requirements from CONNECT Workplace Design Standards Toolkit.

A.1.4.6 Visitors’ car park, number of spaces and location (i.e. adjacency to the control room main entrance) should be considered in design.

A.1.4.7 The design should consider how Public visitors will be guided through the control suite in a way that minimizes disturbances to the control room operators.

A.1.4.8 In large centralized control buildings, a floor plan of the building should be provided at a conspicuous place near the main entrance as well as in the control room if it is to function as an emergency control centre or incident command centre.

A.1.4.9 Signage and emergency lighting shall comply with local building codes/standards as appropriate and shall be installed at clearly visible points.

A.1.4.10 Bulletin board or electronic display media should be considered where essential communications are to be posted.

A.1.5 Cleaning & maintenance

A.1.5.1 The use of durable building or construction materials, including non-toxic paint, which require minimum cleaning and are easy to clean, should be considered.

A.1.5.2 Provisions shall be made to minimize dirt and contaminates in the control suite.

A.1.5.3 Storage and use of cleaning agents shall not present a health risk to personnel from fumes or contact.

A.1.5.4 It shall be possible to perform maintenance with the minimum disturbance to the operation of the control suite.

A.1.5.5 Equipment shall be easily accessible for maintenance purposes. Account shall be taken of equipment requiring frequent maintenance (for example lighting, fire and gas detection systems and environmental or climate control systems).

A.1.5.6 Cabling, ventilation ducts, conduit etc., should be appropriately concealed, but be easily accessible at all times for maintenance and repair. Possible future expansion of cabling and ventilation should be taken into consideration.
A.1.6 **Specific functional requirements**

A.1.6.1 Training/Simulation facility. Training and simulator facilities shall be based on a structured training needs analysis to determine training objectives and thus facility design requirements.

A.1.6.2 Consider providing an exercise facility/area either adjacent or in close proximity to the control room. Exercise equipment, such as a treadmill, stationary bicycle and another small piece of cardiovascular equipment, should be considered for alertness maintenance purposes.

A.1.6.3 Consideration should be given to providing an Alertness Recovery Room in close proximity to the control room.

NOTE: This function may be combined with the Hurricane Relief Room where one is provided.

Alertness recovery rooms have been implemented in some facilities with the aim of sustaining the alertness levels of control room operators during night shifts and reducing the risk of fatigue.

If provided, an Alertness Recovery Room shall not replace the requirement to ensure shift structures and working hours that provide minimal risk of operator fatigue and that ensure adequate sleep opportunity. The Alertness Recovery Room shall not be utilized without an acceptable Fatigue Management plan in place at the site and approved by all appropriate parties (e.g., Management, Operations/Production, Union and Health & Safety). The room should include a recliner as well as suitable lighting and noise control to facilitate undisturbed sleep/nap for a maximum 20 minute period.

A.1.6.4 For assets subject to risk of hurricanes or typhoons, a Hurricane/Typhoon Relief Room (or alternative suitable accommodation) with bunk beds and recliner chairs shall be provided for the purpose of accommodating all control room staff not able to vacate the site due to hurricane/typhoon or other extreme weather conditions.

A.1.6.5 A good quality vending machine area should be provided or integrated with kitchen facilities when specified.

A.1.6.6 Assembly/muster area: it may be necessary in a large control suite (building) to provide an assembly area (temporary refuge). This area could be combined with the dining hall/cafeteria, in which case this should be taken into account when sizing the facilities.

A.1.6.7 Restroom/toilets, washing and changing rooms: these areas shall be located in close proximity to the control room. The areas shall have all the standard facilities in the numbers required by the number of people to be present, be large enough and reflect the composition of the workforce (male and female).

A layout design with “clean” and “dirty” areas should be considered, and also the provision of access security (e.g. by means of a key-card).

A.1.6.8 Separate male and female locker/change rooms shall be provided.

- Consider providing capability to change the ratio between male/female locker requirements as demographics change in the future.

- Locker rooms, if specified, shall have adequate space for personnel to change clothes, full-length lockers with sloping tops, and benches.

- At small facilities (accommodating less than, nominally, 10 people), male and female locker room can be combined if separate restrooms are available that allow adequate privacy for changing and personal cleanliness.

- Facilities in the locker rooms shall be designed and installed for easy cleaning, with full consideration that extensive clean-up may be required if operating maintenance is likely to occur.

- Consideration shall be given to providing storage for incoming, clean FRC clothing in locker rooms and separating and drying out of “dirty” or wet gear/boots due to wet/muddy/snow conditions outside.
• Showers shall be provided if showering facilities are not provided elsewhere and the operation is particular dirty or staff may be exposed to rain, dust, air-borne chemicals and other severe weather conditions.

A.1.6.9 Conference/meeting room(s) shall be provided for meetings, training etc. At least one conference room should be located adjacent to the control room. Storage for audio-visual equipment shall be provided inside the conference/meeting room.

A.1.6.10 To avoid disruption/distraction of panel operators in case of emergency, provision shall be made to avoid the need for the emergency response or incident command team to congregate inside the control room. Audio and visual technology for this room shall be determined based on task and communication requirements. Local IT representatives shall be contacted during project planning and design for specific IT and hardware guidance.

A.1.6.11 Library/document storage and filing. A separate area for document storage and filing of control room associated documentation, e.g. procedures/manuals/P&IDs/records, shall be provided.

A.1.6.12 Kitchen facilities shall be provided for the exclusive use of control room staff where no cafeteria or other catering facilities are available:
  • The kitchen facilities shall be located in close proximity, preferably adjacent, to the control room and shall include food storage, preparation, cleaning and seating areas.
  • The kitchen shall be designed for best life cycle efficiency and industrial hotel quality appliances consisting of at least: a refrigerator; double sink; hot/cold water; microwave; range/grill and oven (depending on local building codes and regulations); cabinets and lockable food storage lockers for each shift member.
  • Space allocation shall take into consideration the anticipated number of control room staff, participation rate, types of food to be prepared, local cultural practices pertaining to food, availability of other food/catering services in close proximity. Recycling needs shall be accommodated.

A.1.6.13 Storage for bunker/emergency gear. A rack for clothes, hard hats, rain gear, PPE and emergency gear (such as bunker gear and SCBA equipment) shall be located adjacent to entrance/exit used by operators. Emergency gear shall not be located within a non-blast resistant vestibule if the control building is designed to be blast resistant.

A.1.6.14 Equipment/rack rooms. In practice it is desirable to create separate workplaces for the computer, electrical and mechanical equipment in the control suite (building). These areas shall be located near or adjacent to the computer area.

A.1.6.15 The computer area (equipment/rack room) shall be located adjacent to the control room and should include an unallocated workstation (open work style) for engineering tasks (e.g. SCADA or DCS maintenance) with a minimum size of 1.8 m (6 ft) x 0.9 m (3 ft).

A.1.6.16 A separate room for UPS batteries shall be provided. Where the batteries require mechanical handling equipment due to their weight and the number of batteries, the battery room shall open directly to the outside through double-doors where necessary.

A.1.6.17 Computer floor and conventional floor shall be at the same elevation throughout the control suite (building).

A.1.6.18 Mechanical Room/HVAC shall be located so that noise and vibration transfer to the control room and other areas occupied by personnel is minimized. Where the mechanical/HVAC plant is large and requires handling equipment, the room shall open directly to the outside with appropriately sized door(s).

A.1.6.19 Storage rooms. Sufficient space should be provided in the control suite (building) for storing consumables and other equipment. A separate Janitor’s Closet/room with a mop sink and suitable storage for toilet consumables and cleaning supplies etc., shall be provided.

A.1.6.20 Laboratory. Refer to DEP 34.17.10.31-Gen.
A.1.7 Individual office type workstations

A.1.7.1 Allocated workstations for individual staff shall be provided as determined by the functional and role requirements for a specific control suite or room. They may include enclosed work settings (offices) as required, e.g. such as for a shift supervisor:

- The shift supervisor’s office shall be located adjacent to or in the immediate vicinity of the control room.
- The shift supervisor/coordinator office should not be accessible solely via the control room.
- A glass wall should not be fitted as partition between the shift supervisor/coordinator room and the control room, (to avoid operators feeling under constant surveillance). If visual communication is necessary, a glass strip is an acceptable alternative.
- The shift supervisor/coordinator office shall be large enough for administrative work (minimum 3 m x 3 m (10 ft x 10 ft)) as well as accommodating four person meetings (minimum 4.5 m x 4.5 m (15 ft x 15 ft), if no other meeting or conference facility/area is being provided.
- The design of the shift supervisor/coordinator office shall comply with Ergonomics and Health requirements as provided in CONNECT Workplace Design Standards (Chapter 10 – Ergonomics and Health).

A.1.7.2 Allocated open-type workstations shall be provided with a minimum area of 2.4 m x 1.8 m (8 ft x 6 ft) and be designed based on task requirements (e.g. shift logging, permitting, engineering, maintenance or logistics). These workstations shall comply with Ergonomics and Health requirements as provided in CONNECT Workplace Design Standards (Chapter 10 – Ergonomics and Health), so as to provide sufficient deskspace to provide space for drawings, manuals and procedures.

The entire workstation area should accommodate the DCS or SCADA and any other computers required for access to site documentation (Variable Table, P&IDs), maintenance system and personal login if a site chooses to accommodate this at the workstation.

A.1.7.3 The requirement for unallocated workstations or visitor/mobile touchdown stations in close proximity to control room shall be considered for internal or external visitors or highly mobile (< 2 hours) users. If required, these workstations shall be a minimum size of 1.8 m x 0.9 m (6 ft x 3 ft). They shall provide for “laptop” connectivity solution to optimize available worksurface. Data/voice/power connectivity access at the worksurface shall be provided.

A.1.7.4 Unallocated enclosed workspaces (i.e. phone booth type) with a minimum size of 1.8 m x 0.9 m (6 ft x 3 ft) shall be considered for control room operators and other open area occupants where there is a requirement for privacy and confidential activities. These areas shall have a full height partition enclosure for sound attenuation, but shall allow an individual to identify whether the room is occupied without disturbing the occupant. They should have a horizontal work surface (min 0.9 m (3 ft)) and adjustable task chair with data/voice/power connectivity at the worksurface.

A.2 CONTROL ROOM

A.2.1 Architectural and building requirements

A.2.1.1 Control room space requirements should be based on a Task Requirements and Adjacency analyses (see Section 3).

A.2.1.2 Space provision should consider requirements over the full planned lifespan of the control room and account should be taken of start-ups, turnarounds and other future increases in workloads, staffing and equipment. Up to 25% additional space should be allowed for as an estimate for 10 to 20 year projects, though this should be verified. Additionally, consideration should be given to designing the building/room and its layout such that breakthrough expansion through a particular external wall is allowed for.
A.2.1.3 Area calculations shall be based on useable area, not gross area: Obstructions and structural features, such as pillars and awkward corners, within a proposed/planned control area will severely reduce the useable area and could result in poor or inefficient work layouts.

A.2.1.4 As a rule-of-thumb, 9 m² to 15 m² (100 ft² to 160 ft²) should be allowed per control workstation.

A.2.1.5 If additional staff needs to be accommodated within the control room for training or during off-normal operations, then sufficient space should be allowed for these additional staff to be housed.

A.2.1.6 Consideration shall be given to provision of temporary positions alongside permanent control room operator positions (for example during shift handovers or for training).

A.2.1.7 Vertical space provision should consider a single finished floor height since it offers greater flexibility for future change and for the movement of equipment and personnel, especially mobility impaired persons.

A.2.1.8 As a rule of thumb, “slab to slab” heights should preferably be a minimum of 4 m (13 ft), to include false floors, false ceilings, indirect lighting systems and the accommodation of shared off-workstation displays. In practice this would result in finished floor-to-finished ceiling heights of at least 3 m (10 ft). (This assumes a 99th percentile North American/North European male: lower values may be used for regions where the populations are significantly smaller in stature).

A.2.1.9 Ceilings, walls and structural elements that avoid any distractions or stray reflections from luminaires are preferred.

A.2.2 Windows

A.2.2.1 A glare free view of displays from designated operator working positions shall be guaranteed.

A.2.2.2 If permitted as per the type of building as listed in DEP 34.17.10.30-Gen., windows may be provided in control rooms for operational, psychological and physiological reasons, not necessarily for illumination. Where it is possible, windows with a direct view onto the plant are preferred.

A.2.2.3 Workstations shall not face windows unless they are a primary information source. For those cases where operational information is obtained via windows, the need for direct viewing through windows shall be clearly established.

A.2.2.4 Windows shall not be located directly behind the operator workstations (to avoid glare or disturbing reflections on visual displays).

A.2.2.5 Windows shall have user-operable blinds.

A.2.2.6 Windows that are located to the left or right of the workstation shall be a minimum distance of 3 m (10 ft) from the workstation.

A.2.2.7 If possible, windows should be included in meeting and relaxation areas to offer an alternative visual environment to that in the control room.

A.2.2.8 Primary control workstations shall be shielded from windows present in non-operational areas of the control suite.

A.2.2.9 Where windows are provided, their size shall allow the control room user to see the outside environment; a light neutral tint is acceptable to reduce sky brightness. Dark tints should be avoided.

A.2.2.10 The ratio of luminances for task areas that are frequently viewed in sequence (e.g. screen, document and windows) should be lower than 10:1 (i.e. the brightest work area should be not more than 10 times more luminance than the darkest work area).
A.2.3 Exit, entrances and walkways

A.2.3.1 Emergency exits and escape routes shall be provided as per local building codes. See DEP 34.17.10.30-Gen. and DEP 34.17.00.32-Gen. for additional requirements.

A.2.3.2 The location, number and sizing and expected usage of exits and entrances, shall be consistent with the generic principles defined in (4.1).

A.2.3.3 Entrance location should be considered in relation to supporting functions situated around the control room such as toilets, relaxation areas, supervisors, offices, etc.

A.2.3.4 Where access into the control room is required (e.g. for permit signatures, keys or documents), account should be taken of circulation routes and temporary waiting areas.

A.2.3.5 Main entrances and exits should not form part of the working visual fields of the control room operator.

A.2.4 Control room layout

A.2.4.1 Control room layout shall meet the requirements identified in the Functional and Adjacency Analyses (see Section 3). Different ways of laying out workstations will carry advantages and disadvantages. A range of options should be considered when developing the design and making layout choices.

A.2.4.2 Apart from the available space, adjacencies and existing shape constraints, other factors in laying out the control room include:

- The number of primary user workstations and the number of screens per workstation.
- Sight lines and access to shared off-workstation visual displays (such as wall-mounted large screen displays, CCTV monitors, Fire and Gas panels, etc.).
- Operational links between control room operators, sub-teams and contact between supervisors and operators.
- Optimising the number of movements needed by primary users to access the key equipment and facilities identified in the Task Requirements Analysis (Section 3).
- Movement of other personnel around the room.
- Maintenance access.

A.2.4.3 The control and other workstations should be grouped functionally (e.g. by process area or department) and clearly separated for each part of the process.

A.2.4.4 Control and other workstations shall be located so that there is no discomfort or disability glare caused by light sources reflecting onto screens.

A.2.4.5 A lighting plan shall be drawn up after the console location and layout has been determined to ensure that luminaires (light fixtures) do not form sources of disability or discomfort glare.

A.2.4.6 Operational links between control room operators, e.g. speech, sightlines or direct voice communication, should be identified, prior to developing control workstation layouts, and should provide a benchmark against which alternative or concept layouts can be assessed. A Link analysis should be performed as a preferred means of identifying and optimising required operational links.

A.2.4.7 Where ventilation systems, light fittings and windows have already been installed, positioning of control workstations should take account of these to avoid draughts, glare and reflections on visual display screens.

A.2.4.8 Control workstation layouts should meet the operational objectives and support the task requirements analysis under both maximum and minimum staffing levels.

A.2.4.9 Control workstation layouts should provide for the convenient storage, access and use of all necessary reference documentation that control room operators require to access as part of their normal duties as well as items that may be required in emergencies.
A.2.4.10 Special consideration should be given to the information and other needs of standing personnel (e.g. a site or installation manager may wish to stand while assessing emergency situations from within the control room).

A.2.4.11 Spacing between control room operators should take account of the need for personal space or relative privacy. Spacing should take into account shared equipment, where consideration of common reach zones or potential problems of interference due to noise need to be applied.

A.2.4.12 There shall be a minimum of 1070 mm (42 in) of clear space between consoles, furniture or other fixed obstacles for general circulation. This figure may need to be greater to accommodate maintenance and cleaning requirements.

A.2.4.13 Adequate provision should be made for the general circulation of personnel, so that panel operators are not distracted. Particular care should be taken to provide adequate circulation areas where shift changeover is conducted and two shifts are present at the same time.

A.2.4.14 Approximate control workstation sizing for initial control room layout purposes should take account of such factors as equipment sizes, flat worktop provision, and the requirements for on-workstation storage, and accommodation for workers with impaired mobility; any such layouts should be fully checked through workstation and room layout reviews prior to being finalised.

A.2.4.15 When selecting room layouts, attention should be paid to training requirements for control room operators – e.g. additional space for equipment adjacent to a normal operators position or a separate, discrete training workstation.

A.2.4.16 For workstations intended for use as a supervisory workstation, the need for additional equipment or reference should be considered.

A.2.4.17 The need for additional personnel movement around supervisory positions and for the temporary accommodation of visitors should be considered.

A.2.4.18 Whenever possible, facilities and space for managing emergency and other incidents should be located separately from the main control room. If such a facility is adjacent to the control room, then it should be separated by a door that can be closed.

A.2.4.19 Where it is not practical to provide a separate area where major incidents can be handled, the provision of extra vertical display surfaces needs to be considered inside the control room for the presentation of maps, charts, or procedures (e.g. white boards for event logging and tracking) and consideration for extra staff in emergencies.

A.2.4.20 Where it is impractical to store all equipment or reference material at the control workstation (or a position included which can deal with an overflow of tasks during peak workloads), the provision of a secondary workstation should be considered. The layout and design of any such workstations should adhere to the same ergonomic principles as laid out for primary positions and their layout based on a task requirements analysis (TRA).

A.2.4.21 Adequate provision should be made for storage of personal items, both in the control room, at the control workstation or outside the control area in locker rooms.

A.2.4.22 The layout of the control room shall allow for the orderly and rapid evacuation of the room.

A.2.5 Maintenance access

A.2.5.1 Layouts should take account of maintenance requirements and access space for technicians and equipment removal, particularly where this involves bulky items.

A.2.5.2 Space shall be allowed for maintenance so that inadvertent activation of equipment or systems is avoided.

A.2.5.3 Rear access to control workstations is recommended, since it allows control staff to continue their operations. Where rear access is provided, adequate clearance behind the control workstation should be allowed for a kneeling maintenance engineer.
A.2.5.4 Off-workstation panels and displays sometimes require maintenance access to the rear. For such units, adequate space shall be allowed and consideration given to the use of ladders and carrying of toolboxes.

A.2.5.5 Where heavy or bulky items of equipment need to be removed, the appropriate manual handling guidelines should be consulted. It is sometimes necessary to provide mechanical assistance or hoist points.

A.2.5.7 Access to service ducts and serviced equipment should, wherever practical, be from outside the control room.

A.2.6 Cleaning

A.2.6.1 Inadvertent activation of process or safety-related controls shall not be possible during cleaning.

A.2.6.2 An adequate number of power outlets should be provided which will enable cleaning appliances to be used, and maintenance to be undertaken, without causing electrical interference, disturbing control room operations, or leading to long trailing cables during cleaning.

A.2.6.3 Where gaps occur between items of equipment or furniture, adequate clearances should be allowed for cleaning.

A.2.6.4 It should be possible for all cleaning to be undertaken without interruption to control room activities

A.2.6.5 The control room layout should not give rise to unsuitable working postures or working movements for cleaning staff.

A.3 LAYOUT AND DIMENSIONS OF CONTROL WORKSTATIONS

A.3.1 General control workstation layout considerations

A.3.1.1 Workstations shall be designed to support human capabilities, limitations and needs. (i.e. seated and/or standing postures, postural variation, visual and aural needs, reach envelopes and their collective influences on workstation layout and dimensions).

A.3.1.2 Workstations shall be designed based around human factors engineering principles and data, to accommodate from the 5th percentile female to the 95th percentile male of the user population. Regionalized design requirements are provided in Figures A.1 to A.8 and Tables A.1, A.2 and A.3.

A.3.1.3 Workstation design should be based on the results of a Task Requirements Analysis (Section 3) to determine the information, equipment, control and communication functions required at the workstation.

A.3.1.4 Workstations should be designed to accommodate task zones for administration, documentation, communication, training on the job and/or supervisory tasks. Task zones may give rise to requirements including space for the layout of drawings or short meetings (during shift handover for example).

A.3.2 Detailed seated control workstations dimensions

A.3.2.1 Adjustable work surface height and viewing distances should be provided especially if the user population is highly variable in size. Figures A.1 to A.4 and Table A.1 show key dimensions for adjustable control workstation/console design, regionalized for Northern Europe, North America and Southeast Asia. Other regions should seek the assistance of the regional HFE TA for support to establish region specific dimensional requirements.

A.3.2.2 Fixed height workstations may be considered if space or other constraints make adjustable work surface heights impractical, provided the workstation is only used occasionally and for limited time periods by any individual operator. Figures A.5 and A.6 and Table A.2 show key dimensions for fixed height workstation design/console design, regionalized for Northern Europe, North America and Southeast Asia. Other regions should seek the assistance of the regional HFE TA for support to establish region specific dimensional requirements.
A.3.3 Seating

A.3.3.1 Operator and other chairs shall comply with the ergonomic requirements provided in CONNECT Workplace Design Standards (Chapter 10 - Ergonomics and Health).

A.3.3.2 Chairs for panel operators shall have a full length back and headrest suitable to accommodate the erect seated height of the 95th percentile male.

A.3.3.3 The quality and durability of chairs used should take into account that operator chairs are normally used 24 h a day, 7 days a week and by more than one user.

A.3.3.4 Chairs shall be chosen following suitable user trials.

A.3.3.5 Footrests shall be provided when the range of adjustment of the chair, work surface, or both, does not permit the person’s feet to be supported on the floor.
Seated eye height:
- the range to be accommodated

95th %ile male
6th %ile female

Secondary vision cone

Primary vision cone

Figure A.1 Optimal Vertical Visual Zone – Seated, Erect

Refer to Table A.1.

Figures and layouts are for illustration purposes only, based on 22" monitor.

Figure A.2 Main Anthropometric Design Criteria – Adjustable Workstation
### Table A.1 Minimum Anthropometric Design Criteria – Adjustable Workstation

<table>
<thead>
<tr>
<th>Parameter – to be determined for project:</th>
<th>Sample Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Northern Europe (UK)</strong></td>
</tr>
<tr>
<td>A</td>
<td>Seated eye-height – 5(^{th}) percentile female to 95(^{th}) male range to be accommodated</td>
</tr>
<tr>
<td>80°</td>
<td>Optimal vertical viewing arc</td>
</tr>
<tr>
<td>B</td>
<td>Work surface height range – determined from seated elbow height range of 5(^{th}) percentile female to 95(^{th}) percentile male</td>
</tr>
<tr>
<td>C</td>
<td>Minimum range of height/clearance of underside of work surface – determined by politeal plus thigh height of seated 95(^{th}) percentile male</td>
</tr>
<tr>
<td>D</td>
<td>Minimum clearance for feet, legs, knees – there shall be no obstructions whatsoever – determined from 95(^{th}) male data</td>
</tr>
<tr>
<td>E</td>
<td>Max reach distance – determined by 5(^{th}) percentile female</td>
</tr>
<tr>
<td>F</td>
<td>Min depth of workstation/console work surface</td>
</tr>
<tr>
<td>G</td>
<td>Min / max distance to screen</td>
</tr>
<tr>
<td>H</td>
<td>Min horizontal workspace per operator</td>
</tr>
<tr>
<td>I</td>
<td>Clearance from workstation to obstacle behind</td>
</tr>
</tbody>
</table>

*It is also important for the project to define the above data for the population in question. This is particularly the case where the sample dimensions are not representative of the population concerned. The project should verify if there is a set of tables available for the country or region in question.*

Sample dimension sources:
1. HSE/Pheasant, S.: UK
2. HFES 100-2007 & PeopleSize 2008
3. Singapore Ministry of Manpower, 2005
Figure A.3  Optimal Horizontal Visual Zone – Plan view

Figure A.4  Optimal Vertical Visual Zone and Single-tier Arrangement
Figure A.5  Optimal Vertical Visual Zone – Seated, Erect – Fixed Height Workstation

Figure A.6  Main Anthropometric Design Criteria – Fixed Height Workstation
Table A.2  Minimum Anthropometric Design Criteria – Fixed Height Workstation

<table>
<thead>
<tr>
<th>Parameter – to be determined for project:</th>
<th>Sample Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Northern Europe (UK¹)</td>
</tr>
<tr>
<td>A</td>
<td>Seated eye-height, above fixed-height work surface – 5th percentile female to 95th male range to be accommodated</td>
</tr>
<tr>
<td>B</td>
<td>Minimum work surface height – determined from seated elbow height range of 95th percentile male</td>
</tr>
<tr>
<td>C</td>
<td>Minimum height/clearance of underside of work surface – determined by politeal plus thigh height of seated 95th percentile male</td>
</tr>
<tr>
<td>D</td>
<td>Minimum clearance for feet, legs, knees – there shall be no obstructions whatsoever – determined from 95th male data</td>
</tr>
<tr>
<td>E</td>
<td>Max reach distance – determined by 5th percentile female</td>
</tr>
<tr>
<td>F</td>
<td>Min depth of workstation/console work surface</td>
</tr>
<tr>
<td>G</td>
<td>Min / max distance to screen</td>
</tr>
<tr>
<td>H</td>
<td>Min horizontal workspace per operator</td>
</tr>
<tr>
<td>I</td>
<td>Clearance from workstation to obstacle behind</td>
</tr>
<tr>
<td>A*</td>
<td>A fixed-height work surface will be dictated by the larger members of the population. Therefore, to arrive at an appropriate ‘fit’ with the work station, smaller members of the population will have to raise their seat-pan height to achieve the correct reference level of the underside of their elbow with the level of the work. Foot-rests will be required for these individuals.</td>
</tr>
</tbody>
</table>
It is also important for the project to define the above data for the population in question. This is particularly the case where the sample dimensions are not representative of the population concerned. The project should verify if there is a set of tables available for the country or region in question.

Sample dimension sources:

(1) HSE/Pheasant, S.: UK
(2) HFES 100-2007 and PeopleSize 2008
(3) Singapore Ministry of Manpower, 2005
(4) Singapore code of practice for Office Ergonomics (Standard SS 514:2005)
A.3.4 Standing control workstations

A.3.4.1 Displays, mimic panels and controls mounted on flat vertical surfaces for use by standing operators shall be located as shown in Figure A.7 and Figure A.8, and accompanying Tables A.3 and A.4. The dimensions listed accommodate 5th percentile females through 95th percentile males within the given regionalised populations as provided in the accompanying tables. Other regions should seek the assistance of the regional HFE TA, for support to establish region specific dimensional requirements.

![Figure A.7](image_url)

**Figure A.7 Control Mounting Height for Standing Personnel**

**Table A.3 Control Mounting Heights – Standing**

<table>
<thead>
<tr>
<th>Parameter – to be determined for project:</th>
<th>Sample Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Northern Europe (UK)</td>
</tr>
<tr>
<td></td>
<td>(UK)</td>
</tr>
<tr>
<td>Maximum reach height (Overhead pinch grip of 5th percentile female)</td>
<td>1820 mm (72 in)</td>
</tr>
<tr>
<td>Preferred maximum reach height* (Shoulder height of 5th percentile female)</td>
<td>1240 mm (49 in)</td>
</tr>
<tr>
<td>Preferred minimum height* (Hand grip height of 95th percentile male)</td>
<td>850 mm (34 in)</td>
</tr>
<tr>
<td>Minimum height (Knee height of 95th percentile male)</td>
<td>540 mm (21 in)</td>
</tr>
</tbody>
</table>

*Values may vary based on specific regional populations.
<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>Minimum depth or clearance behind console/cabinet façade, where no work or interactions require the operator to squat or kneel down to a lower level</td>
<td>910 mm (36 in) for all regions</td>
</tr>
<tr>
<td>F</td>
<td>Preferred minimum depth or clearance behind console/cabinet façade</td>
<td>1070 mm (42 in) for all regions</td>
</tr>
</tbody>
</table>

*Preferred dimensions are for those displays that require precise, frequent, or emergency reading. [All standing dimensions to include 25 mm allowance for foot-wear.]*

Sample dimension sources:
1. HSE/Pheasant, S.: UK
2. HFES 100-2007 & PeopleSize 2008
3. Singapore Ministry of Manpower, 2005

**Figure A.8  Display Mounting Height for Standing Personnel**
## Table A.4  Display Mounting Heights – Standing

<table>
<thead>
<tr>
<th>Parameter – to be determined for project:</th>
<th>Sample Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Northern Europe (UK)</td>
</tr>
<tr>
<td>A Maximum height (Standing eye height of 5th percentile female wearing shoes, upward viewing angle of 25° above horizontal and 830 mm viewing distance)</td>
<td>1780 mm (70 in)</td>
</tr>
<tr>
<td>B* Preferred maximum height * (Standing eye height of 5th percentile female wearing shoes, upward viewing angle of 25° above horizontal and 500 mm viewing distance)</td>
<td>1640 mm (65 in)</td>
</tr>
<tr>
<td>C* Preferred minimum height * (Standing eye height of 95th percentile male wearing shoes, downward viewing angle of 55° below horizontal and 500 mm viewing distance)</td>
<td>1360 mm (54 in)</td>
</tr>
<tr>
<td>D Minimum height (Standing eye height of 95th percentile male wearing shoes, downward viewing angle of 55° below horizontal and 830 mm viewing distance)</td>
<td>1090 mm (43 in)</td>
</tr>
<tr>
<td>E Minimum depth or clearance behind console/cabinet façade, where no work or interactions require the operator to squat or kneel down to a lower level</td>
<td>910 mm (36 in) for all regions</td>
</tr>
<tr>
<td>F Preferred minimum depth or clearance behind console/cabinet façade</td>
<td>1070 mm (42 in) for all regions</td>
</tr>
</tbody>
</table>

* Preferred dimensions are for those displays that require precise, frequent, or emergency reading.  
[All standing dimensions to include 25 mm allowance for foot-wear.]

Sample dimension sources:  
1. HSE/Pheasant, S.: UK  
2. HFES 100-2007 & PeopleSize 2008  
3. Singapore Ministry of Manpower, 2005

### A.3.5 Auditory tasks and communication devices

A.3.5.1 The location of auditory and communication devices should be based on a task requirements analysis and as determined by operating practices, areas of responsibility, shared or dedicated control workstation allocations etc.

A.3.5.2 Sound producing devices shall be located and mounted so that their function is not compromised.

A.3.5.3 The impact of background noise shall be considered when designing auditory alarms. A signal-to-noise ratio of at least 20 dB(A) shall be provided in at least one octave band.
A.3.5.4 The loudness of an audible alarm signal shall be designed to be adjustable. The control mechanism shall be restricted and administratively controlled to prevent reducing the volume to an inaudible level or increasing it to an unacceptably high level. “Ringing volume” on communication devices should be locally adjustable.

A.3.5.5 Where silencing of specific auditory alarms is permissible (i.e. where alarm indications for those alarms are to be provided by independent visual means in addition to the auditory alarm), silencing should be possible from the normal working position of the operator.

A.3.5.6 In control rooms with multiple control workstation configurations, it shall be possible to readily associate a particular audible signal with a unique workstation.

A.3.5.7 Spatial separation should be considered to aid identification when multiple auditory sources are present.

A.3.5.8 Relevant requirements for audible alarms from DEP 32.80.10.14-Gen. shall be consulted.

A.3.5.9 Communications systems should be designed to minimize required user actions.

A.3.5.10 Communications equipment worn by the user (such as headsets) should be designed for comfort and avoid any health risk.

A.3.5.11 Where multiple channels are being monitored, e.g. via a number of loudspeakers, sources should be separated to ease intelligibility.

A.3.5.12 Handset/headset cord length should be of sufficient length to permit reasonable user mobility.

A.3.5.13 Cords for communications equipment (such as headsets) should be positioned so as to avoid entangling critical controls or endangering passing traffic.

A.3.5.14 Sockets for headsets/handsets should be provided on both the left and right-hand sides of the workstation to allow for user choice.

A.3.5.15 Controls for communications equipment should take account of both right- and left-handed users.

A.3.5.16 The systems should provide rapidly intelligible messages to all areas where personnel subject to recall may be located (e.g. toilets/restrooms).

A.3.5.17 Where additional communications facilities are being introduced into an existing operating environment full account should be taken of the combined use of all communications systems.

A.4 VDU SCREENS, PANELS AND CONTROLS

A.4.1 General requirements

A.4.1.1 The overall design should accommodate the operator's visual, tactile, and aural needs in relation to the display, control and communication tasks, as well as consideration for operators' physical anthropometrics.

A.4.1.2 The workspace shall be located central to the position of the operator. Visual displays requiring frequent or critical monitoring such as alarms, overviews, interactive control displays, etc., shall be centrally located in front of the operator in the primary display zone.

A.4.1.3 The arrangement of particular task areas and equipment should consider both the horizontal (plan view) and vertical (elevation view) planes. The primary display zone shall, in the vertical plane, be within an angle of 40° above and below the normal line-of-sight (see Figures A.1, A.4 and A.8). In the horizontal plane, this range shall be approximately 35° left and right of the line-of-sight for monitoring tasks and more if head and body movement are taken into account (see Figure A.3).

A.4.1.4 Where information from off-workstation displays (such as large screens, wall and mimic panels, etc.) is required for the operator's task, this shall be fully visible from all expected
working positions in the control room. Viewing off-screen displays required as a core information source for a role shall be possible without the operator having to adopt a twisted or otherwise awkward body posture.

A.4.1.5 Where the operator requires access to a relative large number of displays (nominally > four), then the design should consider using curved or a segmented workstation design, provided the operator’s seat allows for flexibility in movement in front of the workstation.

A.4.1.6 The arrangement of displays should consider operator tasks that may require access while sitting, standing or both. It should be possible to tilt and swivel the display screens. Preferably, the user should be able to adjust the workstation easily to ensure a good ergonomic or working posture.

A.4.1.7 In the case of a non-adjustable working height or fixed display location/orientation such as on panels and cabinets, special attention should be given to the vertical position of the displays. Important factors are eye height, viewing distance, field of vision, cone of fixations and the normal line-of-sight. See Figure A.8. The dimensions listed accommodate 5th percentile females through 95th percentile males within the given regionalised populations as provided in the accompanying table.

A.4.1.8 Operators shall not be required to adopt awkward body or neck positions in order to view any display.

A.4.1.9 Access requirements for maintenance and cable management shall be considered.

A.4.1.10 Requirements for future change should be considered (e.g. spare space for additional equipment, modified working practices and task allocations).

A.4.2 Viewing Distances

A.4.2.1 Where speed of recognition of information presented on displays is important, the viewing distance shall be determined based on the height of alphanumeric characters (e.g. smallest on the screen or display). These characters shall subtend a minimum of 16 minutes of viewing angle, with 18-20 minutes of angle being preferred.

A.4.2.2 Where speed of recognition is not important (e.g. footnotes) a minimum of 10 minutes of angle is acceptable. Viewing distances for varying minimum and preferred character heights (16 and 20 minutes of arc) are provided in Table A.5.

A.4.2.3 Where discrimination of the colours of alphanumeric text is required, the character height should subtend at least 20 arc minutes at the design viewing distance. Where accurate colour discrimination of an individual character or symbol is required, then the image should subtend at least 30 arc minutes at the design viewing distance.

A.4.2.4 Arial (font size 12) should be used for a viewing distance of between 700 mm (28 in) and 830 mm (33 in) for optimal character height. Character heights may be increased as a means of visual information coding.
Table A.5 Viewing distances for character heights based on minimum and preferred viewing angles (minutes of arc)

<table>
<thead>
<tr>
<th>Viewing Distance</th>
<th>Minimum Character Height (16 min. of arc)</th>
<th>Preferred Character Height (20 min. of arc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inches</td>
<td>*mm</td>
<td>Inches</td>
</tr>
<tr>
<td>18</td>
<td>457</td>
<td>0.08</td>
</tr>
<tr>
<td>24</td>
<td>610</td>
<td>0.11</td>
</tr>
<tr>
<td>30</td>
<td>762</td>
<td>0.14</td>
</tr>
<tr>
<td>36</td>
<td>914</td>
<td>0.17</td>
</tr>
<tr>
<td>42</td>
<td>1067</td>
<td>0.20</td>
</tr>
<tr>
<td>48</td>
<td>1219</td>
<td>0.22</td>
</tr>
<tr>
<td>54</td>
<td>1374</td>
<td>0.25</td>
</tr>
<tr>
<td>60</td>
<td>1524</td>
<td>0.28</td>
</tr>
<tr>
<td>66</td>
<td>1676</td>
<td>0.31</td>
</tr>
</tbody>
</table>

* The millimetre dimensions in the second column have been rounded to the nearest whole millimetre after conversion from the inch values.

Viewing distance is calculated by:

\[ d = \frac{h \times 3439}{\sigma} \]

NOTE: 
- \( d \) = viewing distance
- \( h \) = character height
- \( \sigma \) = minutes of arc (viewing angle)

(Source: Adapted from ISO 11064-4)

A.4.3 VDU screens

A.4.3.1 The actual number of displays on which data are to be presented shall be based on task and HMI requirements and also take account of workstation equipment layout constraints as well as any control room layout requirements.

A.4.3.2 The maximum number of displays which can be used at a single control workstation should be based on a task requirements analysis. As a rule-of-thumb, the maximum number of displays that an operator can monitor in real-time under normal conditions is 4 displays (25 in diagonal). The maximum number of displays that an operator can monitor in real-time under abnormal (upset) conditions is generally 3 displays (25 in diagonal). However, these rules-of-thumb are highly dependent on both the size, density and complexity of the displayed information, and the rate of change of the process. A full range of operational scenarios should be considered when determining the quantity and arrangement of the displays and associated controls.

A.4.4 Shared and/or off-workstation visual displays

A.4.4.1 Shared and/or off-workstation visual displays can be generated using a range of technologies (e.g. CCTV, projected displays, hard-wired mimics etc.). When such displays are to be used, control room layouts for these differing solutions should take account of the constraints imposed by the various solutions. Such constraints include limitations on
viewing angle, contrast ratios and image construction. Relevant human factors engineering principles and guidance should be used to determine the optimal design and layout, for the task requirements and task demands imposed.

A.4.4.2 The size of an off-workstation display or CCTV monitor shall be related to the nature of the visual task, the level of detail required and the distance at which the operator is positioned from it and ambient lighting conditions.

A.4.4.3 A shared or off-workstation display used for detail work should be capable of adjustment to suit the needs of individual operators.

A.4.5 Controls

A.4.5.1 A variety of technologies may be incorporated into the control workstations’ design to enable an operator to exercise control over the displayed data, input of data and text, or the manipulation of control states, modes, etc. The features to be controlled shall have been identified during the task requirement analysis.

A.4.5.2 Emergency controls shall be protected against accidental activation.

A.4.5.3 The number of controls and devices per operator position competing for console space shall be limited. Input devices shall not compete for work surface space with other items, such as radio, telephones, operating manuals, log books, etc. These items should have their own space as dictated by their physical size, frequency of use, emergency priorities, etc.

A.4.5.4 The use of shared devices, i.e. one keyboard, mouse, etc., for multiple display devices is preferred over having dedicated keyboards for each display device.

A.4.5.5 In some cases (e.g. safety reasons) it may be advisable to have a dedicated control for each display. In those cases, these controls shall be unambiguously related to their associated displays.

A.4.5.6 Frequently used controls shall be within anthropometric reach of the operator working in an erect work posture and from the expected work locations at the control workstation or panel. (See Figures A.2, A.3, A.6 and A.7 and accompanying tables)

A.4.5.7 Input devices (controls, keyboard, mouse) should preferably be freely moveable over the work surface in front of the displays. They may be built-in, if there are special requirements (e.g. motion, vibration, earthquake conditions).

A.4.5.8 Input devices (controls, keyboard, mouse) should have their own space as dictated by their physical size, frequency of use, emergency priorities, etc.

A.4.5.9 The need for task lighting to illuminate controls shall be considered as well as possible shielding or dimming of any light generating controls to prevent glare.

A.4.5.10 The height of keyboards, mice, trackballs and other input devices should be approximately at or below the elbow height of the seated operator, adjusted anthropometrically for the specific user group.

A.4.5.11 Qwerty keyboards shall conform to the GID and Shell IT design specifications.

A.4.5.12 Functional / Operator Keyboards should comply with the requirements of international, industry or other standards such as ISO 9241-4, ISO 9241-400 and ISO 9241-410, or HFES 100-2007 Section 6.2.2 (subject to approval by Regional HFE TA).

A.4.5.13 The number of keyboards at any workstation shall be reduced to the minimum. Where technically and commercially possible, a single keyboard should be provided that allows interaction with all interactive systems at the workstation.

A.4.5.14 Keyboards should be located in the center of the operator's usual workspace. This could be in front of a single display or centered between two displays as determined by the task requirements analysis, HMI design and information allocation, etc.

A.4.5.15 A minimum horizontal surface of 150 mm (6 in) deep and as wide as the keyboard shall be available for supporting the operator's forearms and wrists in front of the keyboard.
A.4.5.16 The control workstation design shall be “ambidextrous” as far as the placement of one-handed devices, such as a mouse, trackball, etc., i.e. there shall be adequate space and cabling facilities to place such devices to the left or right of the user. Similar ambidextrous requirements shall be considered for “mouse-only” control workstation designs.

A.4.5.17 The desk-top surface should allow operation of a ‘mouse’. Where this is not possible, a space shall be available for placement of a 200 mm (8 in) x 250 mm (10 in) mouse pad. A minimum space of 150 mm (6 in) depth and the width of the mouse pad shall be available for supporting the operator's forearms and wrists in front of the mouse pad.

A.4.5.18 Trackball should be considered where there is insufficient space for accommodating mouse and pad or control workstation is subject to facility motion. Space for trackball operation shall be provided and comply with the same requirements as for a mouse regarding forearm support.

A.4.5.19 Cables attached to input devices should be located, or attached to, the input device so that they do not interfere with use. The weight, flexibility, tension, and attachment location of the cable, and its potential to become entangled, should be taken into account when designing cabling. A wireless mouse should not be used due to the risk of being inadvertently misplaced.

A.4.6 Selecting hardware

A.4.6.1 The selection of display types and quantities has an impact on the control workstation layout. Attributes such as size, weight, heat dissipation, electromagnetic interference/radio frequency interference susceptibility, response time, etc., are factors to consider when selecting display technology for a control workstation.

A.4.6.2 When choosing the materials, account shall be taken of their acoustic properties (e.g. density of rubber), light (disturbing reflections) and temperature (cold to the touch).

A.4.6.3 Materials shall in general be antistatic, (including flooring).

A.4.6.4 When selecting floor covering, account shall be taken of ease of moving office chairs past the consoles, and ease of cleaning.

A.4.6.5 There are specific requirements governing the choice of materials for furniture, see CONNECT Workplace Design Standards.

A.5 ENVIRONMENT

A.5.1 Natural and artificial lighting

A.5.1.1 Materials used for floors, walls and ceilings shall be such that glare, reflections and areas of large luminance contrasts are avoided.

A.5.1.2 In general the design of lighting shall provide flexibility for a range of different visual tasks (including, for example, paper-based as well as electronic work), to be undertaken by a range of different operators of varying ages, etc.

A.5.1.3 Lighting levels shall provide for illuminance on the control workstation (work surface level) of between 0 lux (0 foot candles or “Off”) and 500 lux (approx. 50 foot candles). This can be done by means of either task lighting integral to the console/work station or general area lighting. In either case it shall be adjustable by each workstation user.

A.5.1.4 General area lighting of around 500 lux (approx. 50 foot candles) shall be provided for maintenance activities inside the control room or when conducting meetings. This lighting shall be able to be turned off or dimmed when not in use.

A.5.1.5 Traffic or walk areas inside the control room shall provide at least 50 lux (approx. 5 foot candles) at floor level.

A.5.2 Noise

A.5.2.1 Measures shall be taken to reduce the noise levels and enhance intelligibility of speech especially to mitigate the higher number of personnel present during peak usage times,
such as shift handovers and shift team meetings (adjustable volume of auditory signals, "trunking" of communication means and clustering workstations).

A.5.2.2 Computers and peripherals with the potential to produce noise and heat shall be installed in a separate area from normal work locations.

A.5.2.3 Noise levels in the control suite (building) shall comply with the maximum levels provided in Table A.6 in order to facilitate speech intelligibility, audibility of alarms and warning signals and shared and team situational awareness.

**Table A.6 Maximum noise levels in control suite areas**

<table>
<thead>
<tr>
<th>Area</th>
<th>Maximum noise level (dB(A))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control room</td>
<td>45</td>
</tr>
<tr>
<td>Conference room</td>
<td>45</td>
</tr>
<tr>
<td>Offices</td>
<td>55</td>
</tr>
<tr>
<td>Passageways</td>
<td>55</td>
</tr>
<tr>
<td>Kitchen/Social rooms</td>
<td>55</td>
</tr>
<tr>
<td>Changing rooms</td>
<td>55</td>
</tr>
<tr>
<td>Computer rooms</td>
<td>60</td>
</tr>
</tbody>
</table>

A.5.2.4 If there are several control workstations in a control room, account shall be taken of noise sources from equipment integrated into the consoles, such as cooling fan noise, that could disturb voice communication or disrupt concentration.

A.5.2.5 Where a control room is located in the immediate vicinity of the plant or equipment (such as on many offshore or marine facilities), extra attention shall be devoted to measures for controlling air-borne and structure-borne sound transmission.

A.5.2.6 Noise levels in control rooms shall be periodically monitored to ensure levels are below the criteria provided in Table A.6.

A.5.3 Environmental Conditioning (HVAC)

A.5.3.1 The control suite (building) shall provide indoor environmental conditioning in the form of heating, ventilation and/or air-conditioning in order to maintain the temperature, relative humidity and air quality within defined limits for safe and comfortable working conditions as follows:

- Air temperature (mean over seasons): 19 °C to 26 °C (66 °F to 79 °F)
- Radiant temperature: 18 °C to 25 °C (64 °F to 77 °F)
- Relative Humidity: 30 % to 70 %
- Maximum air velocity: 259 mm/s (0.82 ft/s).

A.5.3.2 Air temperature gradient shall be no greater than 3 °C (5.4 °F) between the three levels of measurement: 300 mm (12 in) at feet height, 700 mm (28 in) at waist height, and 1.0 m (39 in) at head height for seated work and 600 mm (24 in) at feet height, 1.0 m (39 in) at waist height, and 1.7 m (5 ft 7 in) at head height for standing work.

A.5.3.3 Floor surface temperature under normal conditions shall be between 19 °C and 26 °C (66 °F and 79 °F) and sub-floor heating systems with a design temperature of 29 °C (84.2 °F).

A.5.3.4 Thermostatic control shall be available at multiple points throughout the control suite (building) where effects such as heat generated by office equipment, shading or direct sunlight on windows and walls can create significant temperature fluctuations.
A.5.3.5 Fresh air intake in the environmental control system shall be calculated to ensure an appropriate supply of air to the persons in the control suite (building) and for future flexibility and increased density.

A.5.3.6 In case of a mechanical ventilation system, a minimum of 29 m$^3$ (1024 ft$^3$) per person per hour shall be required.

A.5.3.7 Supply and return ducts shall be positioned in the suspended ceiling. Directional grilles, which can cause downdraughts, shall be avoided in all cases.

A.5.3.8 The quality of the outside air shall be taken into account when designing a mechanical ventilation system (e.g. type of filters).

A.5.3.9 For further information regarding air quality and indoor climate, and for HVAC requirements under abnormal and emergency situations, see DEP 31.76.10.10-Gen.

A.5.4 Use of colour

A.5.4.1 Colours, textures and materials shall be selected to avoid invoking strong negative reactions from the expected workforce.

A.5.4.2 Wall finishes shall be pale rather than bright and with textured or matte finishes to help reduce reflected glare.

A.5.4.3 The excessive use of either dark or light finishes on building structures or on furniture shall be avoided.

A.5.4.4 Excessively strong patterns, seen as a backdrop to visual display units or other control equipment, shall be avoided.

A.5.4.5 Large differences in colour contrast shall be avoided on workstations, general furniture and equipment finishes.

A.5.4.6 For additional colour and branding requirements see CONNECT Workplace Design Standards.