DEP SPECIFICATION

HUMAN FACTORS ENGINEERING – HUMAN MACHINE INTERFACE DESIGN FOR SITUATION AWARENESS

DEP 30.00.60.16-Gen.

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DESIGN AND ENGINEERING PRACTICE

PREFACE

DEP (Design and Engineering Practice) publications reflect the views, at the time of publication, of Shell Global Solutions International B.V. (Shell GSI) and, in some cases, of other Shell Companies.

These views are based on the experience acquired during involvement with the design, construction, operation and maintenance of processing units and facilities. Where deemed appropriate DEPs are based on, or reference international, regional, national and industry standards.

The objective is to set the standard for good design and engineering practice to be applied by Shell companies in oil and gas production, oil refining, gas handling, gasification, chemical processing, or any other such facility, and thereby to help achieve maximum technical and economic benefit from standardization.

The information set forth in these publications is provided to Shell companies for their consideration and decision to implement. This is of particular importance where DEPs may not cover every requirement or diversity of condition at each locality. The system of DEPs is expected to be sufficiently flexible to allow individual Operating Units to adapt the information set forth in DEPs to their own environment and requirements.

When Contractors or Manufacturers/Suppliers use DEPs, they shall be solely responsible for such use, including the quality of their work and the attainment of the required design and engineering standards. In particular, for those requirements not specifically covered, the Principal will typically expect them to follow those design and engineering practices that will achieve at least the same level of integrity as reflected in the DEPs. If in doubt, the Contractor or Manufacturer/Supplier shall, without detracting from his own respons bility, consult the Principal.

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2) Other parties who are authorised to use DEPs subject to appropriate contractual arrangements (whether as part of a Service Agreement or otherwise).

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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Without prejudice to any specific terms in respect of confidentiality under relevant contractual arrangements, DEPs shall not, without the prior written consent of Shell GSI, be disclosed by users to any company or person whomsoever and the DEPs shall be used exclusively for the purpose for which they have been provided to the user. They shall be returned after use, including any copies which shall only be made by users with the express prior written consent of Shell GSI. The copyright of DEPs vests in Shell Group of companies. Users shall arrange for DEPs to be held in safe custody and Shell GSI may at any time require information satisfactory to them in order to ascertain how users implement this requirement.

All administrative queries should be directed to the DEP Administrator in Shell GSI.

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APPENDICES

1. INTRODUCTION

1.1 SCOPE

This DEP specifies Human Factors Engineering (HFE) quality control requirements and gives recommendations for the design of Human Machine Interfaces (HMIs) in process control systems.

These requirements and recommendations aim at the development of HMIs that support high levels of usability and situation awareness among panel operators and others who rely on HMIs for awareness and control.

This DEP should be read in conjunction with other HFE DEPs in the 30.00.60.xx series. In particular, this DEP is intended to be used in association with DEP 30.00.60.10-Gen. and DEP 30.00.60.15-Gen. as well as other HMI related DEPs such as DEP 32.30.20.11-Gen., DEP 32.80.10.10-Gen. and DEP 32.80.10.14-Gen.

This DEP is a revision of the DEP of the same number dated August 2009; 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 authorisation to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in oil refineries, chemical plants, gas plants, exploration and production facilities and supply/distribution installations. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process shall be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases, the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

Term	Definition
Action	The activity initiated when an operator invokes a command on the HMI, for example, by selecting a menu option, or action button. Sometimes supported by a double mouse-click. In some cases, the act of selecting an object also implies taking action on it (e.g., where selecting a display name opens that display).
Area of Control	The process areas, including equipment and any other facilities or resources which define the scope of responsibility of an individual panel operator role.
Basic Process Control System	This generic name covers any control system architecture albeit based on a BPCS or a PLC platform. The term includes DCS, PLC and SCADA process control systems but excludes the Safety Instrumented System.
Cognitive Compatibility	The term applied to the Human-Machine Interface (HMI) when the information used by console operators for the mental activities and mental operations that they perform is displayed consistent with how the console operators use that information to make decisions and complete their work activities.
Display	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 document as screens.
HFE Technical Authority	The individual assigned as Technical Authority for HFE on the project in compliance with Business Unit and Group standards.
Human-Machine Interface	The combination of software and hardware elements that determine the nature of human interactions with equipment and people in the workplace through command inputs and data outputs. The Human-Machine Interface includes both visual and audio interfaces.
Overview Display	Higher level abstraction of low-level of detail of the system, covering the areas of control/responsibility. NOTE: An overview display supports a console operator in obtaining an overall view of systems status by bringing to their attention significant changes in system conditions and presenting those that are important. The focus should be on overview displays for operator positions. There may be overview displays for other control room personnel that have different content or scope.
Panel Operator	An individual who fulfils their work obligations, whether full or part-time, by interaction with a process control system. Panel (console) operators are usually provided with workstations comprising a combination of screens, work-surfaces, a chair and associated devices (such as phones, radios, and keyboards).
Proactive Monitoring	The term defined as part of the ESP work process that requires a defined panel round within a defined time frame (e.g., once every three hours). (Source: ESP Documentation)
Proactive Situation Awareness	The Panel Operator shall review, through the use of trends, overview displays, and summary displays of those variables that comprise the set of key process status and leading indicator variables to maintain their continuous moment-to-moment ‘big picture’ situation awareness.
Salience	The attribute of standing out from the background; the attribute of having attention-grabbing qualities.

Salience Coding	The Human-Machine Interface design technique that applies the appropriate salience (i.e., attention-grabbing qualities) to the data and information, based on the importance of that information relative to other content in the display.
Screen	A hardware component that supports viewing the visual outputs of the human-machine interface.
Select	The interaction with the Human-Machine Interface by which an operator indicates an on-screen object or element without invoking any command other than on-screen functionality. For example, selecting an on-screen icon will often open a menu or change a display.
Shared Display	On-workstation visual display which needs to be used by more than one panel operator while at their control workstation.
Situation Awareness	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.
Usability	The property of a human machine interface that is measured in terms of its ease of use, learnability, efficiency, and error tolerability.
Validation	The process of determining the extent to which a system meets its requirements.

1.3.3 Abbreviations

Term	**Definition**
ASM	Abnormal Situation Management
BPCS	Basic Process Control System
ESP	Ensure Safe Production
DCS	Distributed Control System
FAT	Factory Acceptance Test
GAME	Global Asset Management Excellence
HFE	Human Factors Engineering (synonymous with “Ergonomics”)
HMI	Human-Machine Interface
MAC	Main Automation Contractor
PACO	Process Automation, Control and Optimization
SA	Situation Awareness
SAT	Site Acceptance Test
SCADA	Supervisory Control and Data Acquisition
TA	Technical Authority

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 MAIN CHANGES

This DEP is a revision of the DEP of the same number dated August 2009. Background and explanation content has been moved to a companion Informative document. The following are the main, non-editorial changes.

Section	Change
1.3.2	Added Specific definitions
1.3.3	Added Abbreviations
2	Simplified and moved some sections to companion Informative
3.2.2 Step 3(e)	Revised (e) and added (g), (h) and (i)
3.2.2 Step 4	Simplified and moved some content to companion Informative
3.3.2 Step 3	Added (d), (e) and (f)
4	Removed DR1 (Ensure Cognitive Compatibility with Legacy systems) as standalone design requirement (DR) and renumbered the remaining 6 DRs
-	Deleted Bibliography
Appendix 1	Original content moved to companion Informative and replaced with “Dealing with Legacy Systems”
Appendix 3 to Appendix 9	Moved to companion Informative and renamed Annex 1 to Annex 6

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be submitted to the Administrator using one of the following options:

Shell DEPs Online (Users with access to Shell DEPs Online)	Enter the Shell DEPs Online system at https://www.shelldeps.com Select a DEP and then go to the details screen for that DEP. Click on the “Give feedback” link, fill in the online form and submit.
DEP Feedback System (Users with access to Shell Wide Web)	Enter comments directly in the DEP Feedback System which is accessible from the Technical Standards Portal http://sww.shell.com/standards. Select “Submit DEP Feedback”, fill in the online form and submit.
DEP Standard Form (Other users)	Use DEP Standard Form 00.00.05.80-Gen. to record feedback and email the form to the Administrator at standards@shell.com.

Feedback that has been registered in the DEP Feedback System by using one of the above options will be reviewed by the DEP Custodian for potential improvements to the DEP.

1.7 DUAL UNITS

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

2. THE ROLE OF THIS DEP

2.1 THE NEED FOR SITUATION AWARENESS

Panel operators need to be able to perform their tasks proactively, detecting and responding to abnormal situations (including deviations from planned production as well as potentially unsafe situations) before they lead to incidents or production upsets. This contrasts with operators performing re-actively, largely in response to alarms.

Achieving proactive operator performance requires the HMI to have at least the following features:

- Be easy to use. Make minimal demands on the panel operator to understand and interact with the process control system, i.e., allow operators to concentrate on controlling the process rather than interacting with the BPCS.
- Allow operators to develop and maintain a high level of real-time awareness of the state of the process, while also allowing them to work at a detailed level with individual process units and equipment.

Combined, these two features are addressed by this DEP under the overall term ‘Situation Awareness’ (SA).

2.2 PURPOSE OF THIS DEP

1. To define a minimum level of quality control to be applied to the process of specifying, developing and validating HMI designs, where usability and operator situation awareness can be critical to process safety and/or production; and
2. To specify the minimum technical requirements to be applied to the design and validation of HMIs to ensure high levels of usability and situation awareness.

NOTE: The purpose of this DEP is not to unduly constrain the Supplier’s experience or capability. Rather it is to define a minimum degree of control, direction and consistency in how different Suppliers’ systems are used to develop HMIs. This is based on both industry best-practice, as well as experience of where there has been lack of adequate control in the past. The aim is to ensure quality and consistency of HMIs that meet the requirements for process control (as defined, for example, by the GAME ESP processes).

3. HMI DEVELOPMENT PROCESS

3.1 INITIATION

The HMI Development Process shall be initiated as part of the HFE screening conducted during SELECT or DEFINE phase of the project lifecycle (as required by the Shell HSSE & SP Control Framework and DEP 30.00.60.10-Gen.).

The HFE screening shall determine:

- Whether this DEP shall be included in the project baseline, and, if so,
- The level of quality control to be applied to the HMI design.

Figure 1 shows the decision tree to be used to screen projects for these two factors.

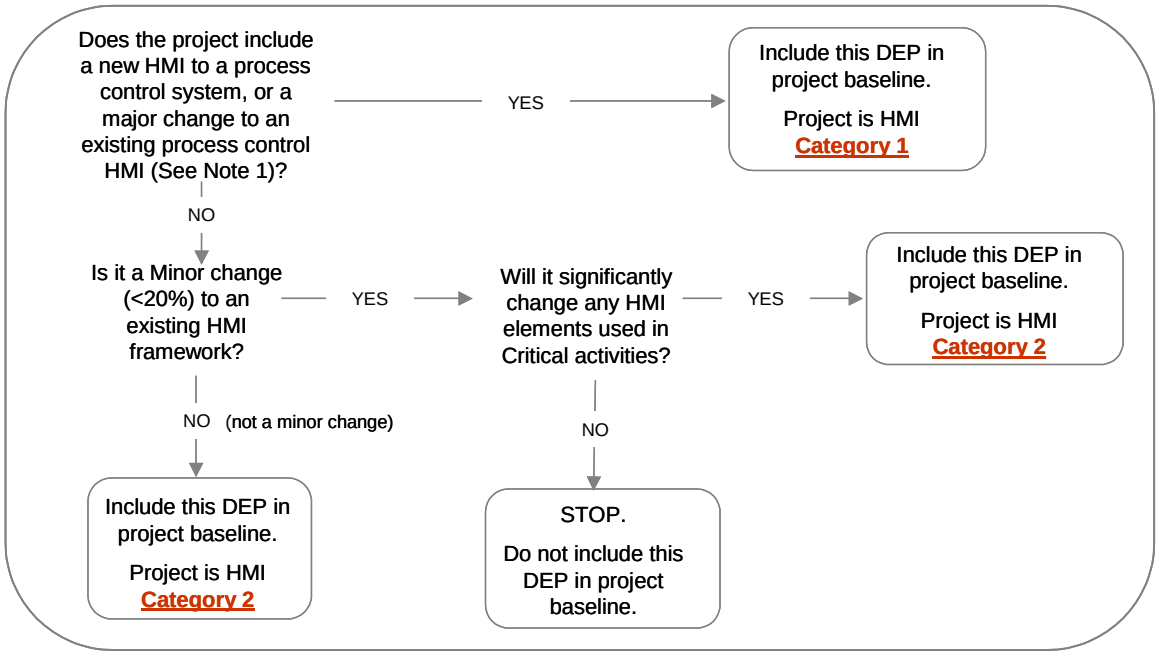

Figure 1 Decision tree for deciding whether to include this DEP in project baseline

NOTES:

1) As a guide, a 'major change' is a project in which:
   - one or more new workstations will be introduced; or
   - more than 50 % of the existing displays will be changed; or
   - the number of new displays to be introduced will exceed 50 % of the existing total.
2) As a guide, a 'Minor change' is a project in which:
   - changes will affect operator interaction with fewer than 20 % of the existing displays; AND
   - the number of new displays will be less than 10 % of the existing total; AND
   - the changes will be implemented in the same software system and version as the existing HMI.
3) 'Critical' activities include:
   - startup or shutdown of process units;
   - communications, including shift-handovers, start-of-shift-orientation, shift team meetings;
   - proactive situation awareness of process units;
   - 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 HMI Category 1 (i.e., projects involving development of new BPCS HMIs or a major change to an existing system) shall follow the development process defined in (3.2).

Projects identified as HMI Category 2 (i.e., projects involving significant change to existing HMI, or change to existing HMIs supporting critical activities) shall follow the process in (3.3).

Recognizing that projects in some cases may have difficulty in deciding which HMI Category is best suited for their project, they are directed to the project or regional Human Factors Engineering (HFE) Technical Authority (TA) as detailed in the Project Controls and Assurance Plan (PCAP) or Discipline Controls and Assurance Framework (DCAF) Discipline Authorities Manual.

3.2 CATEGORY 1 HMI PROJECTS

3.2.1 General

Figure 1 summarises the HFE quality control activities required for a Category 1 HMI development project.

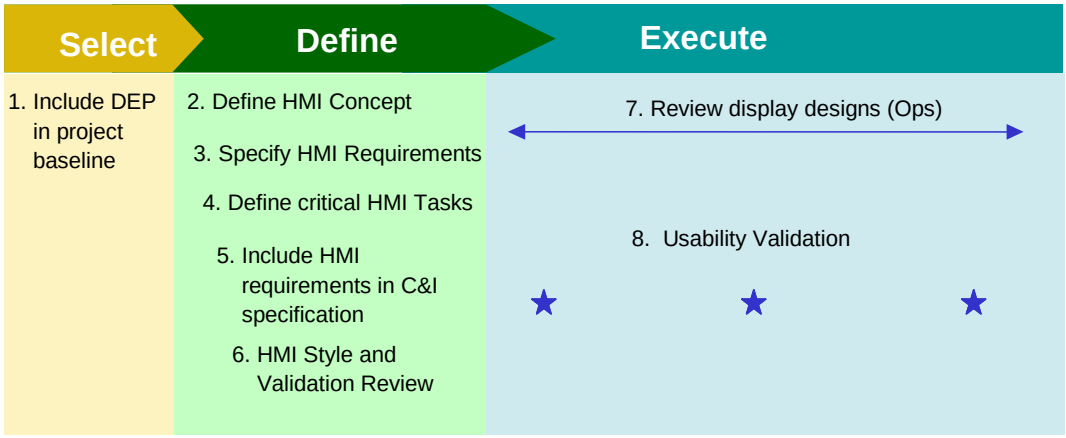

Figure 1 HFE quality control activities for Category 1 projects

3.2.2 Activities to be conducted during SELECT

The following activities shall be completed before the end of SELECT phase.

Step 1: Include this DEP in project baseline

For projects identified as HMI Category 1, this DEP shall be included in the list of DEPs in the project baseline.

3.2.3 Activities to be conducted during DEFINE

The following activities shall be completed before the end of DEFINE phase.

Step 2: Define HMI baseline and concept

Prepare a short description clearly describing the asset's current situation and expectations of the HMI. This description should not be more than two pages in length and shall cover:

- Who will use the system (the number of roles and individual operators, and an indication of their prior experience with BPCS – both years and different systems used);
- Other HMI systems these operators will be expected to interact with during normal, startup/shutdown, upset or emergency situations, indicating their relative importance to process safety and production;
- A summary of specific HMI tasks or situations at the facility that are known to be demanding, difficult, stressful, time-consuming or prone to human error in interacting with the existing HMI;
- A short 'vision statement', in as specific terms as possible, describing the operators expectations of the new HMI. This statement should also describe anything they would expect not to have to do using the HMI.

Step 3: Specify HMI design requirements

A specification of HMI requirements shall be developed. This requirements statement shall be based on a review of (4) of this DEP. As a minimum, the specification shall include:

a) Either;

A statement that all of (4) shall be adopted as HMI design requirements,

OR

A list of specific requirements from (4) that shall be treated as contractual for the project,

b) A definition of the preferred colour palette for both static and dynamic information (alarms, BPCS dynamic shapes, process equipment, background, etc.) to be used for all process displays.

NOTE: This definition can be qualitative: it does not need to be specified in colour coordinates or units of luminance. The requirements could also include the MAC HMI Toolkit color palette/guidelines for a MAC vendor project, as an example of color palette to be used.

The HMI requirements specification shall also define:

c) The information elements to be displayed in the HMI that are considered as Priorities 1 to 5 in terms of importance for capturing visual attention (with Priority 1 being highest). See (4.2) for more information on information priorities.

d) The preferred information coding techniques to be applied to Priority 1 to 5 items. See (4.2) for an example.

e) Requirements for maintaining design consistency between the new HMI and legacy systems.

NOTE: Changes away from legacy design practices and technology to increase the systems' cognitive quality going forward should not be precluded based only on the argument that the new practices conflict with a legacy practice. See (Appendix 1).

f) Any other feature of the HMI appearance or functionality that operations consider critical to the acceptability of the HMI design that is not in conflict with the objectives of this DEP.

Operations shall be consulted while developing the HMI requirements to validate /establish acceptance of:

g) The Supplier HMI tool-box display shape selection and behaviour for each point type for that console's point database.

h) Each console's display hierarchy.

i) Console-wide Overview (Level 1) and Unit-wide Overview (Level 2) content, to meet the intent of this DEP and approval of Operations.

Step 4: Define critical operator (HMI) tasks

Define a sample of operator tasks considered to be critical and especially demanding of the HMI for each of the operator roles to be supported. These task definitions will provide a baseline for review and consideration of the developing HMI. Critical tasks shall be selected based on consideration of:

a) The consequence of human error for process safety or production.

b) The frequency of performance of the tasks that require interaction with the BPCS.

NOTE: Critical tasks performed very infrequently can be particularly prone to error due to lack of familiarity and experience. Non-critical tasks, if performed very infrequently, can also be considered as HMI critical. While easy or familiar, such infrequently performed tasks may be subject to common human errors, such as slips or lapses.

c) Expectations about the mental difficulty of performing tasks, the amount of sustained attention or concentration likely to be required, or the amount of information that an operator might need to remember in order to perform a task.

d) Any other tasks operators consider especially important in using the HMI and supporting Console-wide Overview (Level 1) and Unit-wide Overview (Level 2) proactive situation awareness.

Critical tasks only need to be defined at a high level. There shall be sufficient description to be clear about the situations in which they might need to be performed, which operator roles would be affected, which process units or equipment, and why the task is considered critical.

Critical task descriptions should specify any potential performance measures or other indicators that would reflect how well the task has been supported by the HMI design.

Step 5: Include HMI requirements in project specification

The HMI requirements and critical task list shall be included as a stand-alone section in the Operations Philosophy, Alarm Management Philosophy and HMI or Control and Instrumentation specification for the project and shall be referenced in tender material used to contract a BPCS Supplier.

The HMI baseline and concept shall be made available to the BPCS Supplier for information.

Step 6: HMI Style and Validation Review

As soon as possible after a BPCS Supplier is contracted, a review meeting shall be held with the following objectives:

- Ensure the Supplier understands the HMI requirements and identify any potential issues.
- Review the Suppliers' HMI tool-box, as an extension of Step 3.e., to identify areas where project-specific customisation is required or possible, and define a plan for producing the customisation.
- Review the specified colour palette or set to optimize visual salience, information prioritisation and coding policies and review how they will be implemented.
- Agree on the policy for mapping P&IDs or other process specifications to a display hierarchy that support all levels of situational awareness, as an extension of Step 3.h and 3.i.
- Review the critical task list and identify any potential issues or tasks requiring clarification.
- Agree to the process for operator involvement in reviewing and approving display designs. Consideration shall be given to the use of 'operator walk-throughs' of critical tasks using simulations or emulations as early as possible in development process. Operator involvement should both review display designs against the requirements that results from Step 3 as well as complete Step 7 below.
- Agree the programme of HMI validation, including usability testing and HMI proving in FAT, see (Appendix 2).

Any changes to the HMI requirements arising from this review shall be subject to formal change control and approval by the Operations representative and the HFE Specialist assigned to the Project Team of the Principal.

Following the meeting, the Supplier shall develop a sample of prototype displays illustrating the key elements of the HMI (use of colour, information coding, font type and size, etc.). The display prototypes shall be reviewed by the project team of the Principal and Operations Representative to determine whether any changes to the proposed HMI style are required.

NOTE: This step may have to be delayed to the EXECUTE phase if no Contractor has been appointed at this stage of the project.

3.2.4 Activities to be conducted during EXECUTE phase

The following activities shall be completed during EXECUTE phase. These activities ensure an appropriate level of visibility, structure and control over the BPCS Contractors' HMI development and validation activities.

Step 7: Review display designs

Operations representatives of the Principal shall provide support to the Supplier in reviewing and approving display designs. Opportunities to review techniques for interacting with the HMI displays as well as the dynamic behaviour of display objects will have been identified in Step 6. This Step shall include reviewing the content, layout, and information coding of static displays. Also, navigation mechanisms should be reviewed to confirm that operators can intuitively, quickly and easily navigate to displays with minimal effort and mouse clicks/menu selection.

Step 8: Usability validation

Validation of the HMI for Category 1 projects shall involve three components:

a. Initial usability validation. Operations shall be consulted early on in the EXECUTE phase to validate/establish acceptance of:

   i. Each console's display hierarchy

   ii. The library shape selection and behaviour for each point type for that console's point database

   iii. "Level 1" and "Level 2" content, so as to meet the intent of this DEP

b. Informal usability testing

c. A formal HMI demonstration as part of the FAT programme.

The Usability Validation (test) Plan shall be agreed during the HMI Style and Validation Review (Step 6). The plan shall define the expected general approach, the personnel and resource requirements, and the number of tests to be conducted.

The FAT HMI demonstration is the formal point of agreement that the HMI has met the requirements specified during DEFINE, as modified by any agreed changes during EXECUTE.

(Appendix 2) provides general requirements and guidance on the conduct of usability validation activities.

3.3 CATEGORY 2 HMI PROJECTS

3.3.1 General

Figure 2 summarises the HFE quality control activities required for a Category 2 HMI development project.

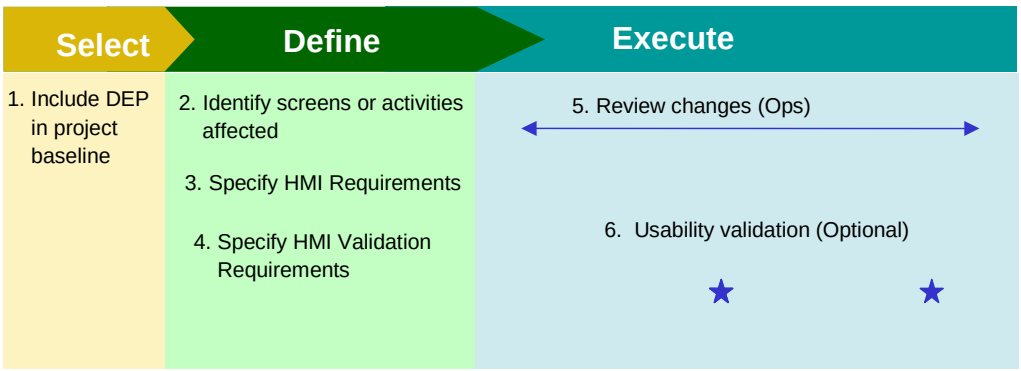

Figure 2 HFE quality control activities for a Category 2 HMI project

3.3.2 Activities to be conducted during SELECT

The following activities are required to be completed before the end of DEFINE phase.

Step 1: Include this DEP in project baseline

For projects identified as HMI Category 2, this DEP shall be included in the list of DEPs in the project baseline.

3.3.3 Activities to be conducted during DEFINE

The following activities shall be completed before the end of DEFINE phase.

Step 2: Identify and assess risk associated with displays or activities affected

During DEFINE, the project shall review the reasons why the HMI change was assessed as Category 2:

- Because it involves significant change to an existing HMI framework

  OR

- Because it will affect the HMI for operator activities assessed as being critical

In either case, the project shall identify the specific displays and/or critical activities likely to be affected, or created by the project.

For each of the identified displays and/or affected critical activities, the project shall estimate the associated risk to process safety, production and operator workload if the HMI does not achieve an adequate level of usability and/or situation awareness support or addressed by appropriate Management of Change or operator training on the new HMI. This risk assessment shall include input from experienced operations representatives.

Step 3: Specify HMI design requirements

Based on the risk assessment in Activity 2, the project shall decide whether there is a need to define project-specific HMI requirements.

The following shall be considered:

a) Include a statement in the Operations Philosophy, Alarm Management Philosophy and Control and Instrumentation Specification that all of (4) shall be adopted as HMI design requirements,

OR

b) Produce an extract from (4) listing those specific requirements that shall be treated as contractual for the project,

If any additional HMI requirements not covered in (4) are considered necessary, these shall also be included. Operations shall be consulted while developing the HMI requirements to validate /establish acceptance of:

c) The Suppliers' HMI tool-box display shape selection and behaviour for each point type for that console's point database.

d) Each console's display hierarchy.

e) Console-wide Overview (Level 1) and Unit-wide Overview (Level 2) content, so as to meet the intent of this DEP and approval of Operations.

The requirements identified shall be specified in the Control and Instrumentation specification or another suitable project document.

Step 4: Specify HMI validation requirements

Based on the results of activities 2 and 3, the project shall specify the level of Validation required during EXECUTE to demonstrate that the HMI is acceptable. Three levels of HMI validation should be considered for HMI Category 2 projects (any combination of these levels can be used):

a) A review of the new or changed HMI elements by operations representatives.

b) Informal usability testing, see (Appendix 2) for guidance.

c) A formal HMI demonstration as part of the FAT programme.

3.3.4 Activities to be conducted during EXECUTE

The following activities are required to be completed during EXECUTE phase.

Step 5: Review changes

Operations representatives shall provide support to the Supplier in reviewing and approving changed or new display designs, including reviewing any legacy displays that have been converted to the new HMI design. It shall include reviewing the content, layout, and information coding of static displays. Also, navigation mechanisms should be reviewed to confirm that operators can intuitively, quickly and easily navigate to displays with minimal effort and mouse clicks/menu selection.

Step 6: Usability validation (optional)

Implement the programme of usability validation as defined in Step 4.

3.4 SUMMARY OF RESPONSIBILITIES

Table 1 summarizes each of the HMI development activities for both Category 1 and Category 2 projects. Discipline responsibilities identified in Table 1 are recommended, but are not intended to act as the Principal's standard. Allocation of responsibilities to disciplines may vary between individual projects.

Table 1 Responsibility matrix

Activity	Project Manager	HFE Coordinator[1]	HFE Specialist	PACO Engineer	Operations/ Maintenance	Procurement	BPCS Supplier
HMI Category 1 projects (i.e., new HMI system development)							
1. Include this DEP in project baseline	APP	EXE	CHK	CON	CON		
2. Define HMI baseline and concept		CON	EXE	CON	CON		
3. Specify HMI design requirements	APP	CON	EXE	CON	CON		
4. Define critical operator tasks		CON	APP	CON	EXE		
5. Include HMI requirements in C&I specification	APP	CON	CON	EXE			
6. Agree HMI style and validation plan		CON	APP	CON	CON		EXE
7. Review display designs		CON	CON		APP		EXE

Activity	Project Manager	HFE Coordinator[1]	HFE Specialist	PACO Engineer	Operations/ Maintenance	Procurement	BPCS Supplier
8. Usability validation			APP		CON		EXE
HMI Category 2 projects (i.e., significant change to existing HMI, or change to existing HMIs supporting critical activities)							
1. Include this DEP in project baseline	APP	EXE	CHK	CON	CON		
2. Identify and assess displays or activities affected		CON		EXE	CON		
3. Specify HMI design requirements		CON	APP	EXE	CON		
4. Specify HMI validation requirements	APP	CON	CON	EXE	CON		
5. Review changes		CON	CON	CON	APP		EXE
6. Usability validation		CON	APP		CON		EXE

Key:

EXE = Execute

CON = Consult

CHK = Check and verify results

APP = Approve

NOTE: 1. The HFE coordinator is the individual from within the project team appointed to lead and organise HFE effort on the project. Details of responsibilities and competence requirements are contained in DEP 30.00.60.10-Gen.

4. HMI DESIGN REQUIREMENTS

This Section defines six generic HMI design requirements (DR) necessary to ensure high levels of usability and situation awareness in process control HMI systems.

The six generic HMI design requirements are:

DR1. Support operator goals and tasks

DR2. Use visual coding to support direction of visual attention

DR3. Let operators concentrate on performing operational tasks

DR4. Support operator mental models

DR5. Support simultaneous awareness at different levels of detail

DR6. Support shared awareness

For each of these generic design requirements, two levels of more detailed requirements are specified that, if achieved, will help to ensure the generic requirements are met:

- **General Requirements:** These are general design objectives that the HMI designer is expected to satisfy in order to meet the DR. There will be many different functional solutions to meet these general requirements.
- **Functional Requirements:** These are requirements for specific aspects of HMI functionality that can help to ensure the overall DR is satisfied.

Note that these requirements are not comprehensive and will not guarantee the required situation awareness is achieved. This is because Situation Awareness is determined by many factors, of which interaction with the BPCS via the HMI is only one part. However, compliance with these requirements will help ensure the HMI does not become a barrier to achieving and maintaining effective Situation Awareness.

Section (4) provides examples that illustrate how some of these requirements can be met by effective HMI design.

Where a project/design solution deviates from requirements and data in this DEP, the designer shall obtain approval from the Principal. The HMI designer is directed to the project or regional Human Factors Engineering (HFE) Technical Authority (TA) as detailed in the Project Controls and Assurance Plan (PCAP) or Discipline Controls and Assurance Framework (DCAF) Discipline Authorities Manual.

4.1 DR1: SUPPORT OPERATOR GOALS AND TASKS

4.1.1 General requirements for DR1

There are six general requirements that support DR1:

DR1.1 Interface content shall support not only monitoring and control activities, but all activities that fall within the panel operator's responsibility. These can include: startup, shutdown, upset response, troubleshooting, shift handover, start of shift orientation, proactive situation awareness, responding to alarms, maintenance support, proactive monitoring, process optimization, batch operations and reporting.

DR1.2 Wherever possible, show the operator information not just data. Consideration shall be given to integrated schematic displays and task-based displays. In general, process data shall be presented in the context of the targets, limits or calculations required to support decision making at that level of the display hierarchy.

DR1.3 Wherever possible, if the process has gone above or below available instrumentation ranges, the display design shall supplement the alarm system by making this obvious to the operator. The display should effectively tell the operator when it is not capable of providing situational awareness.

DR1.4 Information filtering mechanisms should be used to eliminate extraneous or nuisance information to reduce the visual distraction and clutter.

DR1.5 The suite of displays intended to support a single panel operator shall be evaluated against key goals and task requirements for the various modes of operation under the span or area of control for that role.

DR1.6 Information/controls not relevant to panel operators, such as those used for HMI maintenance or technical support shall be hidden—or accessible from detail displays—to reduce screen density and visual clutter.

4.1.2 Functional design elements for DR1

Eight requirements for specific HMI functionality support DR1.

DR1.7. Operator-centered safety-instrumented system information, such as first-out and interlock status, shall be in an easily accessible location appropriate to the level of the display in the defined display hierarchy.

DR1.8. Integrated trending functions, such as x-y trend plots or other time-based indicators, shall be provided to support pattern recognition, detection of change in

values over time and to support the operator in predicting potential future states and when process conditions may exceed a limit. Limit lines should be a natural support mechanism for each trend line.

DR1.9. The qualitative status of parameter values shall be shown with dynamic graphical objects that incorporate alarm or operating limits, particularly for displays at the higher levels of the display hierarchy.

DR1.10. Deviation indicators shall be used to illustrate process value difference from target, SP, or time-marked value.

DR1.11. Related process values and device status shall be shown in close proximity and in arrangements that help establish the context for decision making or assessment.

DR1.12. Routine or critical operational activities shall be supported with task-based displays that are not simply constrained to on-screen representations of P&IDs. For example, consideration should be given to specific task-based displays to support decisions including trending, mass-balance, vessel overfill and furnace negative draft display indicators.

DR1.13. Targets and limits that are specific to particular operational states or modes (such as startups, product run, etc.) shall be considered in display design.

DR1.14. Applications, displays and data from sources other than the control system shall be integrated directly into the operator's main console workspace, either by network integration, HMI integration or console furniture integration.

DR1.15. The HMI shall allow an operator coming on shift to quickly develop an accurate mental model of the current state of the process. (Note that this may involve designing HMI features to support a specific start-of-shift orientation sequence, as required for example by ESP).

DR1.16. The HMI shall support an operator coming to the end of a shift to prepare for shift handover.

NOTE: DR1.14 and 1.15 may involve designing HMI features to support specific start and end-of-shift orientation sequences, as required by GAME ESP for Downstream Manufacturing.

4.2 DR2: USE VISUAL CODING TO SUPPORT ALLOCATION OF VISUAL ATTENTION

4.2.1 General requirements for DR2

There are four generic requirements that support DR2:

DR2.1. A visual coding hierarchy shall be used to ensure the most salient (i.e., attention-catching) codes are used for the most important information. In other words, , the salience of each visual code used should reflect the relative importance of the information type.

DR2.2. The developer shall define the relative priority of all elements to be displayed using at least 3 and no more than 5 levels of priority. This prioritization shall be applied across the entire system, not only individual operator roles. There will likely be the need to differentiate between information within each of the general priority levels, which requires careful application of visual coding methods

DR2.3. In producing the information prioritization, the developer shall take account of an agreed set of critical operations (typically startup/shutdown, pre-defined abnormalities or upsets).

DR2.4. Early in the HMI design activity, the developer shall produce a sample set of screens illustrating how the visual coding techniques are to be applied across the system. These shall be shown to operator representatives for review as they will appear on the delivered system (i.e., representative screen type, lighting and viewing environment).

4.2.2 Functional requirements for DR2

Ten requirements for specific HMI functionality support DR2.

DR2.5. High priority information coding shall be used for real-time data: i.e., key information (process status (e.g., normal versus non-normal) alarm states, or equipment status) that can change in real-time. The actual numerical process values would not fall into this same characterization, although process values should be designed with maximal contrast to their background.

DR2.6. The ambient light level of the control room shall set to the recommended levels to maintain operator alertness. The display background colour shall be chosen to minimize the contrast with this recommended ambient light level. This reduces eye strain and fatigue while supporting appropriate alertness levels.

DR2.7. Visual coding used for each priority level shall be easily identifiable, distinguishable (i.e., the priority level can be identified without reference to another priority level), and, where relevant legible, from the viewers' typical working position. (Note that in deciding whom "the viewer" is, consideration should be given not only to the operator expected to be seated at the console, but also others – or the same operator - who may need to see or read the display from a standing or other position).

- For detailed information, such as numerical process values, the expected viewing distance for on-console screens shall be minimum – 500 mm (20 in); maximum – 830 mm (33 in). See DEP 30.00.60.15-Gen., Table A.1.
- To support viewing information presented on on-console displays beyond this distance, non-numerical visualizations, such as trends or qualitative gauges, should be used.
- For off-console screens that present shared displays, the size of numerical values, trend line width and qualitative gauges will need to be larger to support visual acuity. The necessary size will be a function of viewing distance and will need to be determined on a per case basis.

DR2.8. Coding values for high priority information shall be unique. For example, if red is used to indicate an urgent priority alarm, it shall not also be used to indicate that a pump motor is turned off or a valve is closed.

DR2.9. The visual coding scheme shall include elements that are redundant with colour coding, such as shape/pattern or text, to support individuals with colour vision deficiencies. (For example, "redundant" means using luminance as well as colour to code for priority).

DR2.10. The colour scheme shall ensure that all probable combinations - including foreground combinations on the background and static object colours - are acceptable and provide sufficient contrast for legibility for all user populations, including users that are colour-deficient. For accurate identification of foreground information, the default colour palette or set should consist of no more than 11 colours (ISO 9241-303). This excludes grey scale colours used for background, equipment depiction and status.

DR2.11. Within any coding dimension (e.g., a specific colour, luminance or shape) the number of categories used (e.g., various line thicknesses and pattern to depict primary or secondary process flow lines, utility and instrument lines, etc.) shall be kept to a minimum. Categories intended to indicate different states or levels within the same coding dimension shall be limited to no more than 5 independent meanings.

DR2.12. If time-varying changes in visibility or luminance (i.e., flashing, blinking or pulsing) are used as a code, no more than 3 different states should normally be used.

DR2.13. Avoid clutter, particularly clutter created by the use of too many visual codes (e.g., too many colour codes or line types, too many or unnecessary line bends, unnecessary flow direction arrows, too much text labelling or description, too much detail in static equipment).

DR2.14. Ensure the use of colour does not create unintended visual illusions (for example the appearance of objects 'floating in space' or of an object appearing a different colour than intended due to its' immediate surroundings).

4.3 DR3: LET OPERATORS CONCENTRATE ON PERFORMING OPERATIONAL TASKS

4.3.1 General requirements for DR3

There are four generic requirements that support DR3:

DR3.1. Interfaces shall be based on principles of interaction that are simple, obvious from the visual appearance of the system and that follow user expectations.

DR3.2. The actions necessary to access information or interact with displays shall be intuitive and require minimal effort and time.

DR3.3. As well as imposing minimal mental demands, presentation of information should benefit from familiarity and consistency with users' prior knowledge and experience. However, so as not to preclude HMI improvements, any reduction in training for new qualifying operators as a result of the new HMI design should be considered as an index of improved systems cognitive quality and thus usability.

DR3.4. Demands on human memory to complete on-screen tasks shall be minimized, either through the use of calculation tags or co-presentation of decision-relevant data or information on the same display. (An example would be the memory demands that are often associated with time-to-tank-fill for logistic systems).

4.3.2 Functional requirements for DR3

Thirteen requirements for specific HMI functionality support DR3.

DR3.5. Minimise the need for operators to manage 'windows' and menus on-screen (such as resizing, moving, and minimizing 'windows', or manipulating and making selections from menus).

DR3.6. Navigation to any operating or information displays shall be possible with 4 navigation steps or less and should not require the use of a drop-down menu or menu page.

NOTE: This navigation requirement does not include invoking faceplates.

DR3.7. Modal controls shall be avoided.

NOTE: "Modal controls" are on-screen elements that do, or mean, different things depending on the state of the system.

DR3.8. The number of key strokes or selections required to perform tasks shall be kept to a minimum.

DR3.9. The HMI shall support direct linking between an alarm and a display containing information about what is "in alarm".

DR3.10. On-screen labels, titles, parameters, abbreviations and other descriptions shall be inherently meaningful to the target workforce. Individuals shall not be required to learn new terminology or abbreviations, unless the new design will improve the overall cognitive compatibility of the HMI to the work requirements or pre-existing labels, titles, abbreviations, etc. do not conform to the better HMI design practices. Nor shall the HMI design require individuals to consult other resources to interpret the meaning of information presented on the HMI beyond those changes that could be addressed by appropriate Management of Change or operator training on the new HMI.

DR3.11. The design and technique(s) for accessing and interacting with all data sources for both field and panel operators should be consistent and integrated within a coherent HMI framework. Examples of data sources can include lab results, multivariate predictive control model parameters, daily operating targets, alarm rationalization output (e.g., reason for alarm limit, consequence of deviation, recommended action), and shift logbooks.

DR3.12. Task-oriented displays shall be provided for frequent, routine operations as well as support proactive monitoring as defined by the ESP program. These shall minimize the need to interact across different displays to complete a single activity.

DR3.13. Operators shall not have to master advanced features of software applications in order to be able to complete their operational activities. The features of software applications should be restricted to those necessary to support the full range of operator tasks.

DR3.14. Unless there is a clear task or operationally-based need to do otherwise, displays and pop-up windows shall appear in a consistent, predictable location depending on the display type (e.g., operating display, faceplate, pop-up). Their size shall be appropriate to the display type and information content.

DR3.15. The sequence of accessing displays to monitor or record non-instrumented field equipment status in handheld devices shall be consistent with the order in which operators walk their equipment rounds.

DR3.16. Applications that support operator-preferred configuration or customization (e.g., some trending applications) shall allow individual operators to store their preferences such that they do not have to reconfigure or re-customize the application with each use.

DR3.17. Operators shall not be allowed to reconfigure the coding values for the coding dimensions used in the HMI during normal operations. (Such an example is changing the colour of valve closed status or the luminance of key process indicators).

4.4 DR4: SUPPORT OPERATOR MENTAL MODELS

4.4.1 General requirements for DR4

There are three general requirements that support DR4:

DR4.1. The HMI shall support the development of a correct mental model of the process being controlled.

DR4.2. The HMI shall support the development of a correct mental model of automation, such as the state of all alarms (enabled/disabled), complex cascaded control hierarchies, multivariate predictive control applications, and safety-instrumented systems and their bypass/active status.

DR4.3. Unless there are process control reasons to do otherwise, the layout and behaviour of the HMI shall be consistent with operator expectations or knowledge about the organisation of the real world (including the physical layout and relationships between parts of the process).

4.4.2 Functional requirements for DR4

Seven requirements for specific HMI functionality support DR4.

DR4.4. The status and actions taken by automation should be transparent to the operator and the operator should have controls to intervene if the automation is not working as intended.

DR4.5. The layout of interface elements in the workstation as well as within displays shall be organized in a manner that is intuitive with emphasis on the important functional, physical and temporal relationships between elements in the process.

DR4.6. Where there is a natural order or flow (including process flow) of information on a screen, the screen layout shall reflect the users' expectations. In western cultures the flow should typically be from left-to-right, top-to-bottom. Other cultures might expect a different natural order.

DR4.7. Only task-relevant graphical detail should be shown in the appearance of interface elements.

DR4.8. Information design techniques shall reflect the natural relationships, important behaviours, and states of the process and equipment. For example, a closed valve could be displayed with hollow-fill (i.e., the background colour), indicating a break in the line, whereas an opened valve would be displayed with solid-fill (i.e., in the line colour), suggesting material going through the open valve.

DR4.9. Non-instrumented equipment should generally not be included in control system operating displays. There are exceptions to this where it is important to allow the operator to maintain an accurate mental model of the process. Exceptions might include:

- non-instrumented equipment that add or remove energy from the process, such as a heat exchanger (where the operator needs to know that heat is being taken out of or added to the process),
- in-line or basket filters (to show where there can be a pressure drop)
- a steam vent silencer (to show that the vent goes to atmosphere).
- a check valve (to show that pressure can be trapped, or backflow can be prevented).

4.5 DR5: SUPPORT SIMULTANEOUS AWARENESS AT DIFFERENT LEVELS OF DETAIL

4.5.1 General requirements for DR5

There are five general requirements that support DR5:

DR5.1. The HMI shall simultaneously provide views of the operator's area of control at different levels of detail (or abstraction).

DR5.2. The HMI shall support an overview of the scope of a panel operator's control responsibilities.

DR5.3. The HMI shall provide access to detailed information without removing overview information from view.

DR5.4. The HMI developer shall identify how many levels of detail are required for each panel operator. For a process control panel operator, this will typically be four. A supervisor might need more levels of detail than an individual area operator.

DR5.5. The HMI shall allow the operator to be proactive in maintaining their situation awareness of the state of the process.

4.5.2 Functional requirements for DR5

Nine requirements for specific HMI functionality support DR5.

DR5.6. A display hierarchy shall be used that provides views with different levels of detail.

DR5.7. Overview displays shall be visible at all times on one or more dedicated screens. These displays shall show the key indicators spanning each panel operator's total area of responsibility. Overview displays (Level 1) may include a span-of-control overview display, dedicated trend displays, an alarm summary display, and potentially other support such as CCTV displays.

DR5.8. The display hierarchy shall include Unit-wide Overview displays that represent the major "steps of operation" (Level 2), which will have a broader scope of process coverage than equipment detail (Level 3) displays. The objective of

Level 2 displays is to support routine console operator monitoring and control tasks a majority of the time, reducing the need for excessive navigation between Level 3 displays to otherwise accomplish the same monitoring and control.

DR5.9. The console workstation shall have the minimum number of physical screens necessary to support the simultaneous viewing that the display hierarchy supports including the required overview screens. At a minimum, dedicated screen space shall normally be provided separately for overview screens, process control screens, trends and an alarm summary.

DR5.10. The design and structure of screens shall allow the operator to follow an optimal sequence in proactively maintaining their situation awareness of the state of the process. For example, if the operator regularly needs to view a series of screens in a fixed sequence in order to proactively monitor a process or unit, the operator should be able to access and view the screens in the expected order, without a complex sequence of HMI actions that bears no logical relationship with the operational sequence being followed.

DR5.11. The panel operator shall not be required to remove a display intended as an overview display (schematic, alarm summary, dedicated trends, etc.) in order to view a detailed display.

DR5.12. High priority information and controls shall be positioned within the operator's primary viewing angles while performing their core tasks. If this is not possible, significant changes in high priority information shall be supplement with other highly attention-catching mechanisms (such as audible signals or flashing visual signals).

DR5.13. Acoustic annunciations, including alarm tones, shall have sufficient intensity to be audible above ambient noise but not be startling or distracting. Care should be given to providing volume control to operators. If such volume control is provided, the volume of the alarm shall never be allowed to go below a low audible tone. Simultaneous visual notification (i.e., alarm beacons) is also acceptable but should follow the same color coding as for alarms being presented on the HMI.

DR5.14. Cameras should provide live views of remote equipment and critical process areas, such as flare systems and hazardous units (e.g., HF alkylation unit). The operator should be able to pan, tilt, rotate and zoom on such cameras. Features to prevent burn in of the image on the monitor shall be utilized.

4.6 DR6: SUPPORT SHARED AWARENESS

4.6.1 General requirements for DR6

There are five general requirements that support DR6:

DR6.1. Any information displayed on a console HMI that could need to be communicated or shared with other people shall be in a format that is consistent across all potential users of the information. For example, units of measurement, abbreviations, acronyms, shall be consistent across the facility.

DR6.2. Sufficient and redundant communications channels shall be provided between panel operators and all other roles they may need to interact with in real-time to perform their monitoring and control tasks. These channels may, for example, include field radio, telephone, video, video-conferencing, web-conferencing, and/or public announcement systems.

DR6.3. Field and maintenance activity plans and their current status, including current permits affecting the operators' area of control, should be available to panel operators from their normal working positions.

DR6.4. Communications that span shift handover - including daily shift handover and shift team meetings as well as extended operations (e.g., a plant startup procedure) - should be supported by a formal structure that ensures all safety or process critical information is exchanged and understood.

DR6.5. Consideration shall be given to providing shift handover and high-level real-time situational status information to users located outside control rooms if that information would contribute to improved productivity, or reduced likelihood of loss of shared situation awareness.

4.6.2 Functional requirements for DR6

Nine requirements for specific HMI functionality support DR6.

DR6.6. Live views and/or information on the location of personnel within the battery limits should be easily accessible to control room operators at all times.

DR6.7. Each console position should have a dedicated radio channel for uninterrupted communications to their own field operations team. Maintenance personnel should use radio channels separate from the operations team to minimize interruptions to operations communications during abnormal situations.

DR6.8. An effective protocol for radio communications should be established (e.g., acknowledging a broadcast, repeating of the request, etc.).

DR6.9. Status information shall be available within the control room for requested, planned, in-progress and completed field work activities.

DR6.10. Console areas and spacing shall facilitate multiple operators accessing other panel operator displays where it is useful to facilitate key team-oriented collaborative activities such as troubleshooting equipment problems, assisting in upset response or providing relief.

DR6.11. When using large screens for shared displays, the information content shall be limited to only the information that is needed to support common understanding. Otherwise, role-specific displays that are tailored to the interaction requirements of the job-specific responsibilities should be used. If a shared large screen is required by a facility, its design, location, information content and means of control shall be subject to a Human Factors study.

NOTE: For most operations, large screens are not normally required in centralized control rooms to support effective shared awareness. Poorly implemented large screens can have a larger negative impact on console operations than the benefit they provide.

DR6.12. Providing real-time process status information outside of the control room for key members of the operations team can significantly enhance shared team situation awareness. Locations such as the shift supervisor’s office, administration areas, and field satellite buildings or permitting area should be considered. The specific status information provided should be appropriate to the job and team member responsibilities.

DR6.13. The HMI should support a “view only” access to individuals working outside of the console work area to support their shared situational awareness of process and equipment.

DR6.14. Consideration should be given to providing plant status information outside of the control room for use by personnel involved in Emergency Response or supporting plant upsets.

5. REFERENCES

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

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

SHELL STANDARDS

DEP feedback form	DEP 00.00.05.80-Gen.
Human factors engineering in projects	DEP 30.00.60.10-Gen.
Human factors engineering – Control room design	DEP 30.00.60.15-Gen.
Symbols and identification system - Mechanical	DEP 31.10.03.10-Gen.
Instrumentation symbols and identification on process engineering flow schemes	DEP 32.10.03.10-Gen.
Fire, gas and smoke detection systems	DEP 32.30.20.11-Gen.
Instrumented protective functions (IPF)	DEP 32.80.10.10-Gen.
Alarm management	DEP 32.80.10.14-Gen.
Shell HSSE & SP Control Framework http://sww.manuals.shell.com/HSSE/	
Discipline Controls and Assurance Framework (DCAF) Discipline Authorities Manual. https://sww-knowledge-epe.shell.com/teamsiep/livelink.exe/53120776/DCAF_Standard_v3.pdf?func=ll&objid=53120776&objaction=download	EP.03 ST-06

AMERICAN STANDARDS

Recommended practice for analysis, design, installation, and testing of basic surface safety systems for offshore production platforms - Seventh Edition	API RP 14C

INTERNATIONAL STANDARDS

Ergonomic requirements for office work with visual display terminals (VDTs)	ISO 9241
Ergonomic requirements for office work with visual display terminals (VDTs) Part 11: Guidance on usability - First Edition	ISO 9241-11
Ergonomics of human-system interaction – Part 303: Requirements for electronic visual displays	ISO 9241-303

INDUSTRY DOCUMENTS

Abnormal Situation Management® Design Guidance Effective Operator Display design, version 6, dated December 2008 *Issued by: Abnormal Situation Management (Consortium)* *http://www.asmconsortium.net/*	ASMC ver. 6.00, 2008

APPENDIX 1 DEALING WITH LEGACY SYSTEMS

HMI design practices of legacy systems may or may not have represented the best practices for situational awareness when commissioned. Advances in our understanding of designing for situational awareness, have led to new design recommendations. These recommendations may be seen as in conflict with legacy systems. The overall goal is to achieve operator situation awareness while continuing to support cognitive compatibility. The term “cognitive compatibility” refers to consistency between the way information used in mental operations (decision making, calculations, comparisons, etc.) is displayed on an interface—and how to interact with it on the interface—and the user’s mental model of the process or work task.

Newly developed HMIs shall take full advantage of the functionality, performance and other capabilities offered by the new technology to increase the system’s cognitive quality by improving operator situational awareness, ease of learning, usability and human reliability.

Existing HMI designs that are being upgraded or enhanced shall be reviewed to determine those features that are important to retain for the purpose of supporting situational awareness and cognitive compatibility. Design changes to legacy systems can be justified to achieve benefits. For example, a faster and more accurate detection and diagnoses of abnormal conditions, or reduction in training for new qualifying panel operators, will result in a potential increase in situational awareness and cognitive quality of the new system.

Examples of design features that should be reviewed for potential cognitive compatibility issues between new and legacy systems include (but are not limited to):

- Retaining codes and symbols – e.g., tag names (as detailed in DEP 31.10.03.10-Gen., DEP 32.10.03.10-Gen. and industry standards such as API RP 14C), abbreviations, units of measurement and numbering systems.
- Culturally acquired associations or stereotypes – e.g., the colour red is often associated with “Danger” (i.e., critical limits), but can also mean ‘energized’ for trades such as electricians. However, the two codes may not be consistently in agreement for a console operator, and as such, an alternative visual-coding strategy should be adopted for one of the two instances.
- Pictorial formats, symbols and icons – such as showing level indication as a horizontal bar, or appearance of different alarm prioritisations
- Methods of interaction – e.g., standard faceplates as a means to interact with valves.

Care should be taken not to confuse cognitive compatibility with arbitrary meanings arising, for example, from legacy colour-coding (e.g., using cyan for numerical PV formats in a schematic because the original, Supplier-proprietary “closed” control system only allowed cyan).

The following examples illustrate approaches to enhancing cognitive compatibility when moving from a legacy system to a new HMI design;

- Presenting fire and gas alarms or indication with the legacy practice of a tabular format. Rather, use plot plan-based display formats - e.g., layout of fire and gas equipment that is spatially related to the actual plot plan of equipment in plant/facility - may better support a console operator’s task of responding to and directing individuals in the event of a fire and gas alarm. Faithful replication of P&ID drawings for ‘operating’ displays is not intended by this statement either, as the layouts and spatial orientation of P&ID drawings are typically insufficient for supporting all levels of situational awareness. Moreover, equipment displays are not meant to represent the exact spatial orientation in the field, as this level of detail is typically not required for cognitive compatibility to monitor and control from the console.
- Retaining the legacy practice of presenting process data - either in one or more schematic-based operating displays or tabular overview display - in a numerical format as the means of supporting the operator’s ability to maintain proactive situation awareness. A more cognitively compatible approach would be to display the process

points identified as critical to proactive situation awareness in a set of trending displays. The same points could still appear on their associated schematic displays in a numerical format, though this latter display would not be the main design support for proactive situation awareness.

APPENDIX 2 USABILITY TESTING GENERAL REQUIREMENTS

A2.1 GENERAL

This Appendix summarises what the projects team should expect of a BPCS Supplier in demonstrating that an HMI has been developed to an acceptable level of usability and support to operator situation awareness.

Projects should distinguish between three general types of usability validation activities;

1. Initial usability validation:

   Early on in the design phase, Operations shall be consulted to validate/establish acceptance of:

   i. Each console's display hierarchy

   ii. The library shape selection and behaviour for each point type for that console's point database

   iii. "Level 1" and "Level 2" content, assuming there are no pre-existing Level 1 or Level 2 displays

2. Informal usability demonstrations:

   These are activities held on an ad hoc basis, at the discretion of the development team or Contractor. The purpose is to provide assurance of the quality of the evolving HMI design and to identify any potential risk areas as early as possible before major design freeze points.

   There is no requirement for informal demonstrations to be accepted, documented or observed by a representative of the Principal. However, these controls will often be beneficial in order to show traceability of design decisions.

   There are no specific requirements for the content, format, structure, duration or attendees of an informal usability demonstration. However, the usability demonstration should, if possible, meet the general test requirements set out below.

   An organised programme of informal usability demonstrations, beginning very early in HMI development process, will usually be extremely valuable in reducing risk of significant design change late in development. It will also make a significant contribution to ensuring high quality HMI design.

3. Formal usability validations

   These are the means by which the developer seeks agreement from the project's team that the HMI design is satisfying, or has satisfied, the project HMI requirements, as defined in (3) of this DEP.

   Formal usability validations are documented, and attended by observers of the Principal. Agreed actions arising are entered into the overall project actions register.

   The format and content of a formal usability demonstration should meet both the General and the Specific usability testing requirements set out below.

A2.2 USABILITY DEMONSTRATION/ VALIDATION EVENTS

The number of usability demonstrations or validation events required will depend on the scope, scale, complexity and novelty of the HMI development. As a guide;

- Category 1 HMI projects should expect to run;
  - 1 x Usability Validation as part of the FAT programme;
  - 2 x documented demonstrations at suitable points during development (e.g., one at approximately 30 % development, a second at approximately 60 %), including a validation against HMI requirements.

- Numerous ad hoc trials and demonstrations as part of the on-going HMI development process.

- Category 2 projects, should expect to run;
  - 1 x Usability Validation as part of the FAT programme;
  - 3 or 4 ad hoc trials and demonstrations as part of the on-going HMI development process.

A2.3 GENERAL TEST REQUIREMENTS

- Usability demonstrations or validation events shall be organised and led by an individual with appropriate competence in HFE or Usability testing.
- Usability validation shall be planned as an integral component of the HMI development process and system validation activities.
- There should be a focus on informal demonstrations, beginning early in the HMI development process: projects shall not rely on a single usability demonstration or validation activity at the end of development.
- Usability validation for process control systems do not need to comply with the requirements for usability testing defined in ISO 9241-11.

  NOTE: IT systems for office-type applications should comply with ISO 9241.
- Usability demonstrations should make use of simple measurements as much as possible. Indicators (measures or judgements) should be sufficiently sensitive to identify issues that could represent significant risk to the ability to learn and use the interface reliably and efficiently without excessive effort or support.
- Sophisticated usability measurement tools (including video and/or audio recording) are unlikely to be necessary except in exceptional circumstances. (An example could be if there was significant concern that human error in a HMI task could directly contribute to a significant incident at the asset).

A2.4 SPECIFIC REQUIREMENTS FOR FORMAL USABILITY VALIDATIONS

A usability validation event does not need to be a formal usability trial (i.e., in the sense that usability professionals would expect) using quantitative measures of usability, HMI performance or Situation Awareness. It should normally meet the following requirements, where appropriate;

- The validation shall involve representative users who have not been involved in the development of the HMI. Formal usability validations shall not rely on the opinion or performance of individuals who have been part of the development team or who have reviewed commented and/or approved aspects of the evolving design. This exclusion includes staff of the Principal – whether asset representatives, project engineers or technical advisers – as well as Supplier staff or Contractors.
- The validation shall include operator walk-through of all of the critical HMI tasks identified during the DEFINE phase (see (3.2.3), Step 4).
- The validation shall be conducted on a platform comprising the representative HMI hardware and software in an environment with a lighting scheme as similar as can reasonably be achieved to the expected operational environment.
- The FAT usability demonstration shall take account of design changes that were agreed and implemented as a result of informal usability validation activities earlier in development.
- It should be possible to demonstrate traceability of results from earlier informal usability validation events to the final formal usability validation.