Report 454: Human factors engineering in projects

International Association of Oil & Gas Producers

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REPORT 454: HUMAN FACTORS ENGINEERING IN PROJECTS

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FOREWORD

Human Factors Engineering (HFE) focuses on the application of human factors knowledge to the design and construction of socio-technical systems. The objective is to ensure systems are designed in a way that optimises the human contribution to production, and minimises potential for design-induced risks to health, personal or process safety or environmental performance. This publication adopts a practical, cost-effective and balanced approach to applying HFE on projects.

The publication was jointly developed by the Energy Institute (EI) and International Association of Oil and Gas Producers (IOGP), and supersedes the first edition of IOGP 454 *Human factors engineering in projects*.

This publication has been updated primarily with the intention to ensure the guidance is applicable to both large-scale and smaller-scale projects, and to provide additional guidance and examples to help operators carry out HFE.

The guidance in this publication is primarily intended for:

- non-human factors specialists, but can act as a high-level reference source for human factors (HF) specialists to encourage a consistent approach to the integration and application of HFE;
- project managers, safety and technical leads and senior engineers within organisations who are responsible for planning and managing engineering projects and project activities, and
- personnel employed by facility operators, front end engineering design (FEED) and engineering procurement and construction (EPC) design contractors, equipment vendors and other engineering contractors.

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1 INTRODUCTION

1.1 BACKGROUND

The International Association of Oil and Gas Producers (IOGP) issued the guidance document *Human factors engineering in projects* (report 454) in 2011. The aim of the document was to provide the oil and gas industry with recommended good practice on the effective application of human factors engineering (HFE) on oil and gas projects. A previous research report from the Health and Safety Executive (HSE) entitled *Human factors integration: Implementation in the onshore and offshore industries* (RR001) had been issued in 2002.

In 2017, IOGP and Energy Institute (EI) Human and Organisational Factors Committee (HOFCOM) jointly commissioned a project to review, revise, update and expand upon the original report 454. The objectives were as follows:

– To update the guidance as necessary to reflect current good practice in the integration of HFE, based on consideration of other relevant high-hazard industry guidance and the views of HFE practitioners and oil and gas industry representatives.
– To provide additional information and guidance within the document to help improve usability and encourage its use among companies in the oil and gas sector.

This publication represents the output from this project, superseding the 2011 first edition of report 454 *Human factors engineering in projects*.

1.2 OBJECTIVES

The objective of this publication is to provide industry with guidance and a recommended approach for the effective application of HFE for oil and gas projects.

The guidance is not intended to provide detailed information on how to carry out different HF activities; instead the aim is to provide guidance on how to include due consideration of HFE within the design process for engineering projects, and to outline the overall approach to be followed, and therefore to encourage early and appropriate application of HFE.

Following the approach described in this publication should allow projects to demonstrate that sufficient consideration has been given during the design process to reducing any risks associated with HFE and the potential for human error to a level that is as low as reasonably practicable (ALARP).

1.3 SCOPE AND APPLICATION

The scope and intended application of this guidance is as follows:

– The guidance is intended for use in engineering projects being undertaken within the energy and allied sectors, relating to both upstream and downstream operations, offshore and onshore.
– The guidance is concerned with HF issues that can reasonably be expected to fall within the scope of engineering projects, including the design and layout of onshore

and offshore facilities and systems. The focus is therefore primarily on HFE (see 2.1 and 2.2 for definitions). Areas of HF input that are predominantly under operational control, including consideration of staffing, shift scheduling, organisational and supervisory arrangements, competency managements and organisational/safety culture, are outside the scope of this guidance and covered by brief reference only where considered appropriate.

- The guidance focuses on HFE application to the project life cycle from concept design through to construction/commissioning. Brief reference is provided to HF considerations during operations and decommissioning.
- For any project, ranging from minor modifications to existing systems to the construction of a new facility, HF issues should be considered, and HFE requirements determined. The guidance therefore covers HFE application to the full range of projects in terms of size and complexity.
- The focus of the publication is on describing the process and identifying the activities recommended for ensuring effective integration and management of HFE considerations throughout the project design life cycle. The publication is not intended to provide detailed guidance on ergonomic principles (e.g. for human machine interface (HMI) design, equipment accessibility, etc.).
- This publication is considered to be reflective of current good practice but is not mandatory. Compliance with the guidance should normally satisfy requirements from national regulators for evidence that HFE has been adequately considered during the design process. Nevertheless, where national regulatory requirements and/or company-specific requirements for HFE apply to a project, these should be taken into account, particularly with respect to any mandated activities.

1.4 TARGET AUDIENCE

This guidance is primarily intended to be used by project managers, safety and technical leads and senior engineers within organisations who are responsible for planning and managing engineering projects and project activities.

The guidance is intended to provide an overview of the process for consideration of HFE in projects, suitable for non-HF specialists. This includes personnel employed by facility operators, FEED and EPC design contractors, equipment vendors and other engineering contractors.

The guidance is also intended to act as a high-level reference source for HF specialists, to encourage a consistent approach to the integration and application of HFE.

1.5 HOW TO USE THIS PUBLICATION

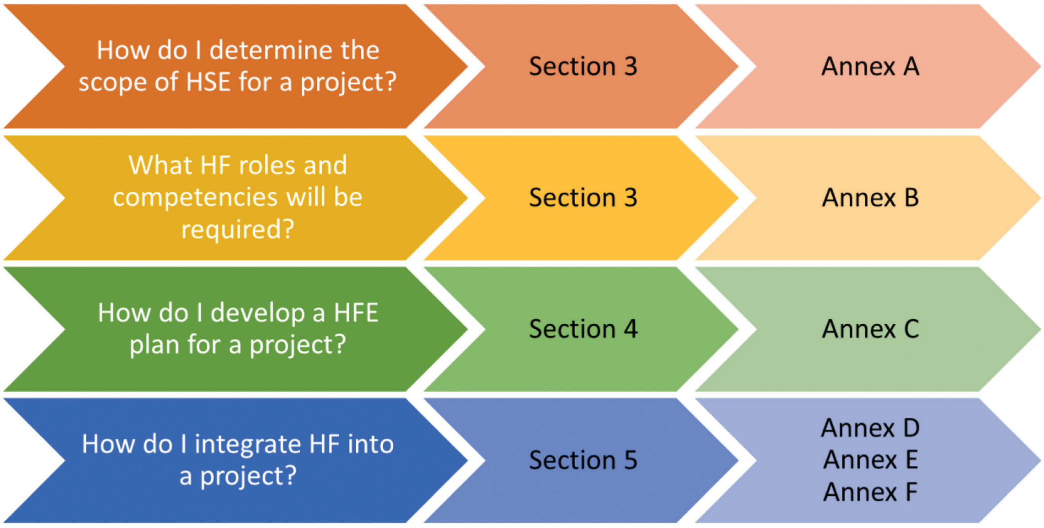

Figure 1: How to use this document

The document is structured as follows:

Section 1 (this section) introduces the guidance and describes its scope, area of application and target audience.

Section 2 introduces what is meant by HF and HFE, discusses the difference between prescriptive, goal-oriented and process HFE requirements, and presents the benefits to be gained from effective integration of HFE.

Section 3 provides information on how to determine the scope of HFE for a given project. It includes guidance on HFE screening and defining HFE roles and responsibilities.

Section 4 provides guidance on developing an HF integration plan (HFIP)[1] and the tasks associated with HFE planning that will inform the content of the plan, including:

– setting HFE requirements and acceptance criteria;
– establishing the mechanism for managing HFE issues, and
– establishing the process for end-user involvement.

Guidance is also provided on the factors that can influence the effectiveness or otherwise of HFE integration and implementation within projects.

Section 5 provides an overview of the HFE activities typically required at each stage of the project design life cycle, and shows how the activities described in sections 3 and 4 fit into this process.

The annexes provide additional supplementary information, as follows:

– Annex A provides further guidance on HFE screening;

1 The term human factors integration plan (HFIP) has been adopted throughout this guidance. It should be noted that depending on the organisation and/or location, this plan may be alternatively referred to as a human factors implementation plan or human factors engineering integration plan (HFEIP). All are interchangeable terms that are routinely used by HF practitioners.

- Annex B provides further information on HFE competency requirements, roles and responsibilities;
- Annex C provides a template for an HFIP;
- Annex D provides further information on key HFE activities that are typically carried out to support the project design process;
- Annex E provides guidance on consideration of HF during safety assurance and risk management activities;
- Annex F provides further information on developing an HFE plan for construction;
- Annex G lists references and provides a bibliography, and
- Annex H lists abbreviations used in the guidance.

2 BACKGROUND ON HUMAN FACTORS ENGINEERING

2.1 WHAT IS HUMAN FACTORS?

HF is wide ranging, and there are a number of different formal definitions that are used to describe the scope of HF. For the purpose of this document, commonly used definitions are provided below.

The International Ergonomics Association (IEA) defines HF (ergonomics) as:

> '*the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance*'.

The UK HSE uses the following definition of HF, taken from its publication *Reducing error and influencing behaviour* (HSG48):

> '*Human Factors refer to environmental, organisational and job factors, and human and individual characteristics, which influence behaviour at work in a way which can affect health and safety. A simple way to view Human Factors is to think about three aspects: the job, the individual and the organisation and how they impact on people's health and safety-related behaviour.*'

The HSE website states:

> '*Human Factors is concerned with what people are being asked to do (the task and its characteristics), who is doing it (the individual and their competence) and where they are working (the organisation and its attributes), all of which are influenced by the wider societal concern, both local and national.*'

The scope of what is covered by the term HF therefore encompasses the consideration of organisational systems and factors and is broader than just a focus on the physical design of the workplace. The UK Chartered Institute of Ergonomics and Human Factors (CIEHF) states:

> '*The terms 'ergonomics' and 'human factors' can be used interchangeably, although 'ergonomics' is often used in relation to the physical aspects of the environment, such as workstations and control panels, while 'human factors' is often used in relation to (the) wider system in which people work.*'

2.2 HUMAN FACTORS ENGINEERING (HFE)

The focus of this publication is on the application of HF considerations to the design phases of engineering projects. For this reason, HFE is used throughout this publication. HFE is a term that is commonly used by organisations in the energy sector to describe the incorporation of HF within the engineering design process.

HFE focuses on the application of human factors knowledge to the design and construction of socio-technical systems. The objective is to ensure systems are designed in a way that optimises the human contribution to production and minimises potential for design-induced risks to health, personal or process safety or environmental performance.

The application of HFE considers the capabilities and limitations of people and uses this information to ensure the optimal design of workplace, systems, equipment and the working environment. It is primarily focused on the physical aspects of the workplace, including ensuring equipment is easily accessible, operable and maintainable.

The CIEHF states:

> *'Rather than expecting people to adapt to a design that forces them to work in an uncomfortable, stressful or dangerous way, ergonomists and human factors specialists seek to understand how a product, workplace or system can be designed to suit the people who need to use it.'*

2.3 REQUIREMENTS FOR APPLICATION OF HFE IN PROJECTS

Across high-hazard industries there is an increasing regulatory requirement for integrating HFE within projects (otherwise known as human factors integration [HFI]).

Within the energy sector, regulators in countries including the UK, Norway, Singapore and Australia all provide guidance and set expectations for the integration of HFE within the project design life cycle.

Legislation requiring consideration of HFE includes the Workplace safety and health (major hazard installations) regulations 2017 set by the Singapore Ministry of Manpower (MOM) and the UK HSE Offshore installations (offshore safety directive) (safety case etc.) regulations 2015 which requires safety cases of offshore platforms in UK waters to provide evidence that safety risks associated with HFE in design have been reduced to ALARP. In the UK, the regulator also requires HFE issues to be specifically considered for onshore control of major accident hazard (COMAH) sites.

In addition to regulatory requirements, technical requirements for HFE also exist in international, national and industry standards, as well as company-specific standards and specifications for the major oil companies. A key example of an industry standard requiring consideration of HFE is the NORSOK S-002 *Working environment* standard developed by the Norwegian petroleum industry.

Figure 2 shows how HFE requirements may be a combination of prescriptive, goal-oriented, and process requirements. For most complex projects, all three types of requirements are likely to exist. Further guidance on these different types of HFE requirements is given in 2.3.1 –3.

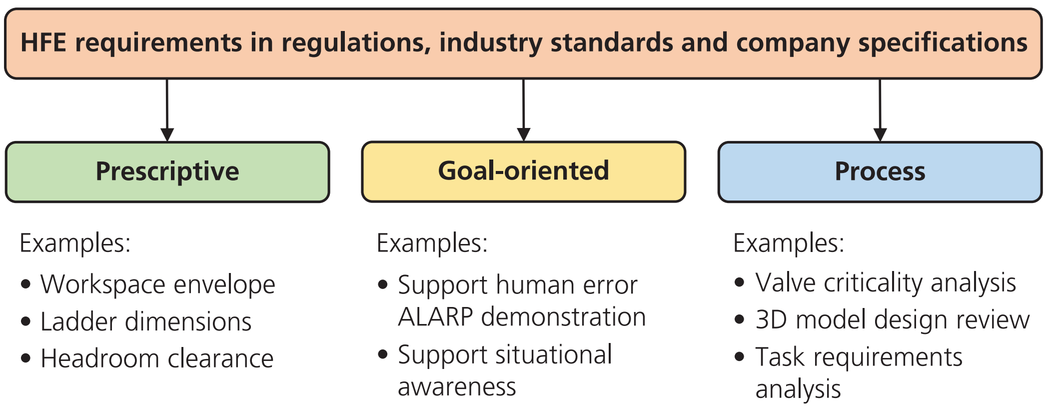

Figure 2: HFE requirements

2.3.1 Prescriptive requirements

Prescriptive HFE requirements specify distances, sizes, space, weight, etc. that engineers and designers can directly apply to technical drawings, use in calculations, etc. An example would be the specification for clearance for headroom above walkways, which can be found in many standards.

Once an appropriate technical baseline has been agreed, the HFE process during design and development is focused on ensuring that these requirements have been complied with. This is usually achieved via appropriate design reviews (e.g. reviews of isometric design drawings, 3D models, control room layouts, HMI graphics prototypes, etc.). As there is very often a need to trade-off HFE requirements against other constraints, a change management process should be in place to control derogations from these requirements.

2.3.2 Goal-oriented requirements

Project-specific goal-oriented HFE requirements may be identified in regulations or standards, derived from specified project safety requirements, or identified from hazard and operability (HAZOP) studies, hazard identification (HAZID) studies, etc.

Goal-oriented HFE requirements specify the goal or objective that is to be achieved, but not the specific design parameters to be applied. Examples would be requirements to 'reduce the potential for human error to ALARP' or to 'provide HMI graphics that support control room operator situational awareness'.

A range of HFE analyses and activities is typically required to turn the identified goals into specific technical requirements that can then be implemented in design. These types of analyses are discussed further within this guidance.

2.3.3 Process requirements

Process requirements specify the activities that are expected to be carried out in order to implement HFE on a project (for example, task requirement analysis, etc.). The activities defined in an HFIP (and the recommended HFE activities as defined in this guidance) are effectively process requirements.

2.4 BENEFITS OF HFE

Adequate and timely integration of HFE within the project design life cycle is essential in order to encourage the necessary buy-in and appreciation of the importance of HF considerations among project personnel. This is particularly important during the early phases of major projects. Ensuring that HFE is properly addressed means that plant, systems and equipment will be designed to effectively support operator tasks, taking account of human capabilities and limitations. This in turn reduces the likelihood of human errors and leads to improved operational efficiency.

Key benefits of achieving effective integration of HFE on projects include:

- improved safety and reduction in risks by reducing the likelihood of human errors and violations, increasing the likelihood that tasks are successfully completed;
- reduction in project costs by ensuring 'right first time' design and avoiding the need for expensive changes and/or rework later in the design process;
- improved human performance and task efficiency, leading to higher productivity and operational capacity, and reduced costs for operating and maintaining facilities;
- reduced health problems (mental and physical), and
- improved working conditions for operators, leading to higher job satisfaction, reduction in staff absenteeism and staff turnover.

Several academic studies have confirmed the cost benefits of applying HFE early in the design stage. The CIEHF has published two documents (*The human connection*, and *The human connection II*) that present a set of case studies from across industry sectors that serve to illustrate the benefits of applying HF and ergonomics, and are intended to increase understanding of the complexity, range and value of the discipline.

2.4.1 Examples of design-induced human unreliability

Example 1: Vinyl chloride monomer explosion

What happened?

An operator opened the bottom valve on an operating pressurised polyvinyl chloride reactor, releasing its highly flammable contents. The safeguards to prevent bypassing the interlock were insufficient for the high risk associated with this activity. Two similar incidents highlighted problems with safeguards designed to prevent inadvertent discharge of an operating reactor.

Consequences

Five dead. Three injured. Community evacuated.

Root causes

- Current and previous owners did not adequately address the potential for human error.
- Overreliance on a written procedure to control a hazard with potentially catastrophic consequences.

Human performance

- Operator interacted with the wrong reactor. Meant to work on a reactor that was not in service, involved in cleaning process. Actually acted on a reactor that was in mid-process.
- Operator did not realise that the reactor was in operation.
- Operator tried to open bottom valves to drain reactor. Safety-interlock operated, as designed, to prevent valve opening. Operator used emergency air to override safety interlock, leading to release.
- Operator did not request permission to bypass interlock.

Design issues

- Recognise the potential for the operator to go to the wrong reactor (24 identical reactors in groups of four).

- Ensure the identity and status of the reactor is perceptually very clear to anyone in the vicinity of the reactor.
- Consider automatic detection in case of bypassing interlocks.

Recommendations made by investigators

- Companies need to evaluate factors that alone do not create high-risk situations, but combined, make human error more likely.
- Implement policies and procedures to ensure that chemical processes are designed to minimise the likelihood and consequences of human error that could result in a catastrophic release.

Other factors involved

- Current and previous owners did not learn from similar incidents or implement recommendations identified in earlier hazard analysis activities.
- Operators working on the lower level had no means to communicate with operators on the upper level who had ready access to reactor status information (operators did not normally carry radios).
- New owners reduced manning, removing role of area group leader, making it more difficult for operator to easily access Supervisor in case of doubt.
- Various failures in emergency response.
- Reactor cleaning procedure was never subject to hazard analysis.
- Uncontrolled access to valve interlock bypass. Bypass could be used without detection.

Further information

Chemical Safety Board report no. 2004-10-I-IL, *Vinyl chloride monomer explosion*. Report and safety video available at https://www.csb.gov/

Example 2: Major fire in resid hydrotreater unit (RHU)

What happened?

Maintenance contractor accidentally switched an 8-inch diameter carbon steel elbow with an alloy steel elbow during a scheduled heat exchanger overhaul. The alloy steel elbow was resistant to high temperature hydrogen attack, but the carbon steel elbow was not. The carbon steel elbow ruptured after operating for only three months. The escaping hydrogen gas from the ruptured elbow quickly ignited.

Consequences

1 minor injury. $30 Million property damage.

Root causes

Construction costs may have been saved by making three elbows on each heat exchanger assembly dimensionally identical. Doing so requires fewer pipe assembly fabrication drawings and weld joints in each assembly.

Human performance

Because the elbows are dimensionally identical, the piping contractor had to ensure that the low alloy steel elbows 2 and 3 were installed in the correct locations when the RHU was built. Contractor was not aware of the different materials and switched elbows after maintenance.

Design issues

- Had the elbow design dimensions been different, elbow 1 would not have been interchangeable with elbows 2 or 3.
- Piping systems can be designed such that incompatible components cannot be interchanged.
- Recognise the safety critical nature of the task of verifying the correct elbow.

Recommendations made by investigators

Human factors based design: designers should consider the entire process system life cycle, including planned maintenance, to avoid piping configurations that allow critical alloy piping components to be interchanged with non-compatible piping components.

Other factors involved

- Maintenance contractor was unaware of the material differences in the elbows. Company did not require the contractor to implement any special precautions to prevent inadvertently switching the elbows or any post-reassembly testing to confirm the alloy elbows were reinstalled in the correct locations.
- Material verification procedure did not require critical piping component testing during equipment maintenance, even though the incompatible components could be inadvertently switched.
- Company did not alert the maintenance contractor that two of the three elbows were alloy steel piping components and must not be interchanged with the carbon steel elbow.

Further information

US Chemical Safety and Hazards Investigation Board Safety Bulletin No. 2005-04-B, 12 October 2006, *Positive material verification: Prevent errors during alloy steel systems maintenance*. Available from https://www.csb.gov/

Example 3: Propane release from drain valve

What happened?

As part of a cat cracking unit (CCU) turnaround, a vessel that normally separated liquid propane/propylene (C3) from a liquid solvent was steam purged to allow entry for inspection. This required opening all drain valves on the level bridle assembly connected to this vessel. After the turnaround, operators prepared the unit for start-up, which included 'walking the line' and ensuring all valves were in the correct position. However, a drain valve and port on the level bridle assembly remained opened (the gate valve was open and the plug was missing). An operator installed a plug into the screwed opening at the bottom of the level bridle. Following pressure tests, 10 days later C3 feed was introduced and the system reached its normal operating pressure of 260 psig (17.9 barg). Twenty hours later, the plug was expelled from the level bridle assembly drain valve body and the leak occurred.

Consequences

Release of 13–16 000 kg (30–35 000 lbs) propane and propylene (C3). A vapour cloud developed, but did not ignite. There were no injuries. High potential incident which could have resulted in multiple fatalities and significant asset damage.

Root causes

- The drain valve was opened and remained open.
- The plug was partially engaged in the threads.
- The plug was expelled 20 hours after operating pressure was reached.

Human performance

- The operators could not see the drain valve and did not check its status during pre-start-up review. It was assumed to be in its normal position. It was inaccessible, not visible, and had been covered by insulation.
- The operator struggled to install the plug and did not fit it securely into the drain. The drain was awkward to access with no direct sight line.

Design issues

During design of new equipment, do not underestimate the importance of drain valve and plug visibility.

Investigation insights

- When valves are difficult to see (under insulation, scaffolding or other obstructions), valves may potentially be left open and plugs missed.
- Indirect indicators that the drain plug was sufficiently seated may not be as reliable as visually aligning the plug to the port and observing the plug entering the port through multiple rotations (i.e. more direct indicators).

3 ESTABLISHING THE LEVEL OF REQUIRED HFE INPUT

3.1 OVERVIEW

For any new engineering project, whether large or small, HFE screening should be carried out at an early stage to identify whether there is a need for HFE to be considered.

The outcome of the HFE screening should then be used to develop the plan for implementation of HFE on the project (see 4.2).

Many major organisations have their own in-house approaches to HFE screening; there is no single definitive approach to HFE screening that can be applied across the energy sector to suit all variations of projects and circumstances.

This publication describes what HFE screening should achieve and provides a suggested approach to the HFE screening process, based on a review of current good practice. This includes indicative templates for HFE screening questions and workshop approaches (Annex A).

The final decision on the detailed screening questions to be used on any project, along with the required competencies of the personnel who should undertake the screening, should be confirmed on a project-specific basis, taking account of any relevant company requirements.

3.2 HFE SCREENING

HFE screening should be the first HFE-related activity that is undertaken in the Select (concept section) phase of any engineering project (see 5.2).

The screening process should aim to answer the following questions:

– Does the project require consideration of HFE?
– If so, what is the required level of HFE input?
– What level of HF-competent resource will be required and what roles should be established?
– What HFE activities will be required?
– What specific HF risks and opportunities exist based on the scope of the facilities being developed? (see Annex A.3)

For large or complex projects, it may be appropriate for HFE screening to be divided into two separate screening exercises: a preliminary HFE screening at an early stage, and then to revisit the screening (with a detailed screening) once the details of the project are finalised.

The use of two HFE screening exercises (preliminary and detailed HFE screening) is discussed in 3.2.1 and 3.2.2.

An overview of the suggested screening process, assuming two levels of HFE screening, is shown in Figure 3.

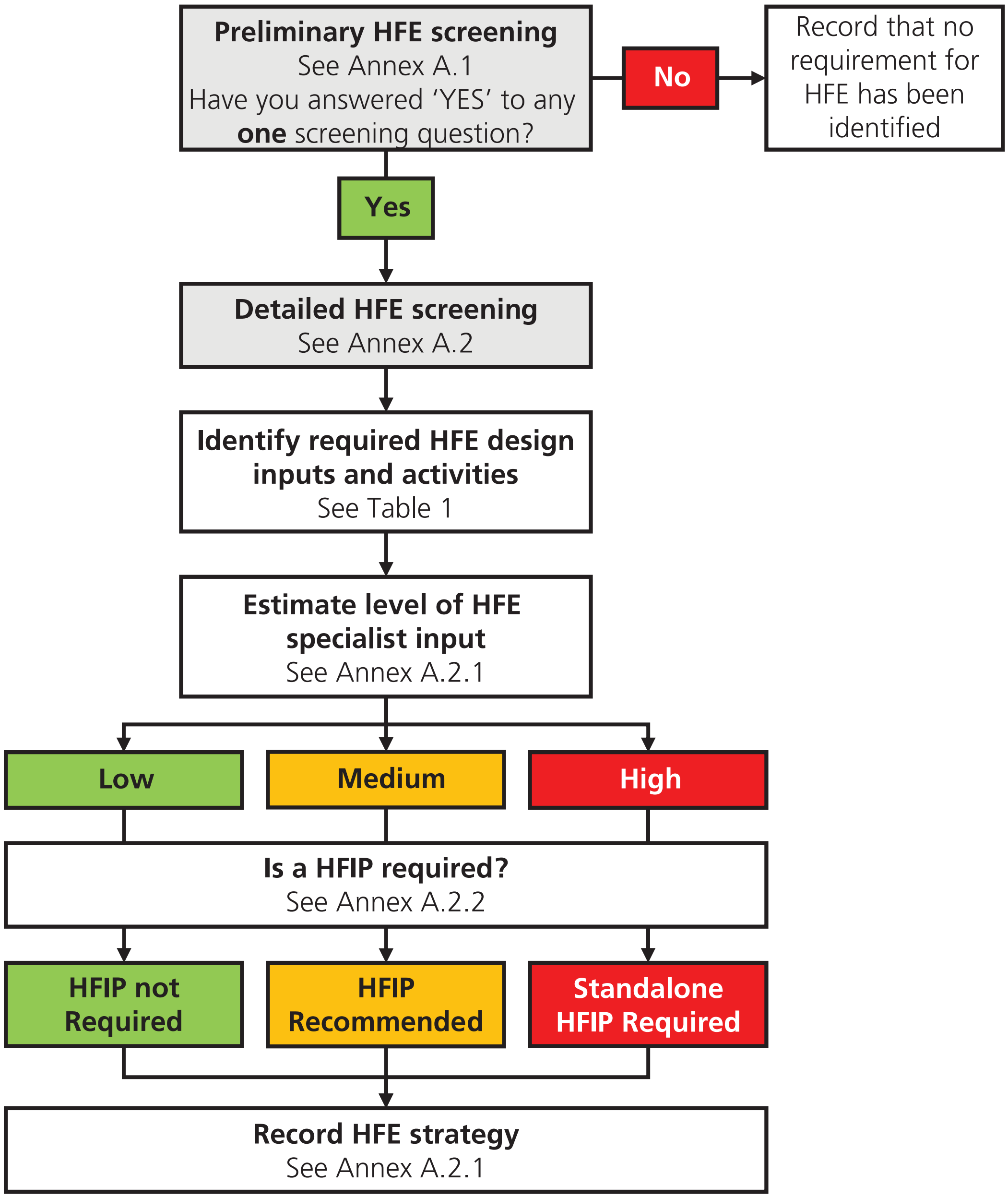

Figure 3: HFE planning and resourcing

3.2.1 Preliminary HFE screening

The objective of the preliminary HFE screening is to establish whether HFE input is required and to gain an understanding of the level of specialist HFE input that is likely to be needed.

This initial HFE screening should ideally be undertaken as a group exercise, involving a cross-sector of personnel who have a good understanding of the scope of the project.

For most major design projects and modifications, it is likely that the preliminary screening will conclude that there will be a need for some level of HFE input to the design process.

However, where new projects intend to apply standardised processes and proven design solutions with no novel or unique elements (e.g. 'like for like' replacements), then HFE input may be limited to confirming compliance with previously defined and agreed HFE requirements. Similarly, where there are minimal proposed changes to a plant or facility then HFE input may be focused on ensuring that the requirements of applicable HF/ergonomics standards and guidance are being met. However, caution should be exercised here: a 'proven' design means it has been previously designed with HF principles applied and has good acceptance by end-users (i.e. no incidents or issues raised by end-users). However, just because a design is 'not new' or 'like for like' does not mean it should not be reviewed. The organisation should consider the criticality of the equipment or process to determine the level of review required; the preliminary screening will help determine this.

N.B. In some instances, it may be a contractual requirement for there to be HFE input on the project.

Annex A.1 provides an example question set for preliminary HFE screening.

3.2.2 Detailed HFE screening

Following confirmation that HFE input is required, a detailed HFE screening exercise should be carried out once the scope of the project is confirmed and details of the proposed design are known.

If a preliminary HFE screening exercise was initially performed, the detailed HFE screening provides an opportunity to revisit the findings of the earlier analysis to confirm their validity.

The detailed screening should be carried out as a group exercise involving personnel with suitably detailed knowledge of the proposed project design scope and programme, and the implications for operations and maintenance activities. This should include an individual(s) with a suitable level of competence and understanding of HFE to be able to identify required HFE input and activities.

The aim of the detailed screening exercise is to explore the scope of the project in detail in order to determine:

- the HFE design inputs and activities that should be undertaken;
- the level of specialist HF input required to support the project;
- the most appropriate HFE strategy for the project;
- the identification of specific HF risks related to the equipment scope developed, and
- whether an HFIP is required.

N.B. Consideration should also be given as to what the contract states is required (i.e. it may be that the contract explicitly states the HFE activities to be performed).

Annex A.2 and A.3 provide methods and tools to support screening.

3.3 IDENTIFYING HFE DESIGN INPUTS AND ACTIVITIES

Table 1 provides guidance to help identify the types of HFE inputs and activities that may be required for different types of project (N.B. where applicable, this will also be informed by the outcome of the preliminary HFE screening, see Annex A.1).

Note that this is not intended to represent an exhaustive or definitive list, as the specific requirements for each project will be different.

Table 1: HFE design inputs and activities – indicative project look-up table

Scope of project design/ modification includes:	Indicative HFE design inputs and activities	See:
Construction of complete new plant or facility	Development of HFE design specifications	4.3
	HFE awareness training	4.8 5.4 Annex F
	Task requirements analysis (TRA)	Annex D.1
	Valve criticality analysis	Annex D.2
	Vendor package screening and review	Annex D.3
	Control room analysis and review	Annex D.4
	HMI analysis and review	Annex D.5
	Alarm system analysis and review	Annex D.6
	Facility/plant layout design review	Annex D.7
	HF input to safety assurance and risk management activities (including safety critical task analysis (SCTA), HAZOP, human reliability assessment (HRA), etc.)	Annex E
Introduction of new HMIs/ significant modification of existing HMIs (including changes to alarm system design/alarm handling)	Development of HFE design specifications	4.3
	TRA	Annex D.1
	HMI analysis and review	Annex D.5
	Alarm system analysis and review	Annex D.6
	HFE input to safety assurance and risk management activities (including SCTA, HAZOP, HRA, etc.)	Annex E
Changes to plant layout that could potentially impact on the accessibility and operability of valves and other equipment	Development of HFE design specifications	4.3
	HFE awareness training	4.8 5.4 Annex F
	TRA	Annex D.1
	Valve criticality analysis (VCA)	Annex D.2
	Facility/plant layout design review	Annex D.7
	HFE input to safety assurance and risk management activities (including SCTA, HAZOP, HRA, etc.)	Annex E

Table 1: HFE design inputs and activities – indicative project look-up table (continued)

Scope of project design/ modification includes:	Indicative HFE design inputs and activities	See:
Introduction of new systems or equipment which have not previously been used on site, or represent non-tested technology	HFE awareness training	4.8 5.4 Annex F
	TRA	Annex D.1
	Vendor package screening and review	Annex D.3
	HFE input to safety assurance and risk management activities (including SCTA, HAZOP, HRA, etc.)	Annex E
Introduction of new control room or control facilities	Development of HFE design specifications	4.3
	TRA	Annex D.1
	Control room analysis and design review	Annex D.4
	HMI analysis and review	Annex D.5
	Alarm system analysis and review	Annex D.6
	HFE input to safety assurance and risk management activities (including SCTA, HAZOP, HRA, etc.)	Annex E

The activities listed in Table 1 relate specifically to HFE design-related inputs and activities, which are the focus of this publication. It should be noted, however, that input from HF specialists may also be required to support other non-design related HF activities, including:

– HF input to development/review of operating and maintenance procedures and work instructions;
– HF input to the competency assurance process, and
– HF input to workload assessment/staffing studies.

In relation to workload assessment, for most proposed modification projects, detailed workload assessment is unlikely to be required. However, if a new facility is being constructed or major changes being proposed to existing processes, workload assessment may be necessary to demonstrate that staffing arrangements are suitable to cover the range of normal and abnormal operational scenarios, including emergency situations. If workload assessment is required, then HF specialist input is considered essential.

Further guidance is provided in Table 6 on these HF inputs, where they are discussed in the context of HF considerations during operations.

3.4 IDENTIFYING LEVEL OF HF SPECIALIST INPUT REQUIRED

Detailed HFE screening should determine the level of HF specialist input that will be required on the project, based on an understanding of the project scope, complexity and requirements. However, in general terms, the following apply:

- Where the project is limited to minor modifications to existing plant/facility layout and there are no new HMIs or new equipment being introduced, less HF specialist input is likely to be required.
- Where the project involves major modifications to the plant/facility or the construction of new facilities and introduction of new systems, more HF specialist input is likely to be required.
- Whether or not a dedicated HFE lead is required to coordinate and manage HFE activities will depend to an extent on the complexity of the project and whether or not HFE-led activities are required.

Annex A.2.1 provides a template to help identify the level of HF specialist input required on a project.

3.5 DETERMINING WHETHER AN HF INTEGRATION PLAN (HFIP) IS REQUIRED

The development of an HFIP may be a contractual or company requirement.

Where this is not the case, then a decision should be taken as to whether an HFIP is required to document the HFE strategy for the project – this should form part of the detailed HFE screening.

Annex A.2.2 provides a decision tool to help determine if an HFIP is required.

Guidance on the recommended content of an HFIP is provided in 4.2 and Annex C.

3.6 HUMAN FACTORS ROLES AND RESPONSIBILITIES

For any project where HFE input has been confirmed as a requirement, specific HFE roles and responsibilities should be defined in the HFE strategy for the project, and HFIP where applicable (see Section 4).

For most projects, required responsibilities to support HFE activities are likely to fall into the following three broad categories:

- coordination and management of the HFE work;
- undertaking HFE reviews and activities;
- applying HF/ergonomics standards only.

Table 2: HF responsibilities and roles

Responsibility	HFE role
Manage HFE work	HFE lead/HF integration manager (HFIM)
Perform HFE reviews/HFE analyses	HFE practitioner
Apply HF/ergonomics standards only	HFE support

3.6.1 Guidance on HFE roles

For the purpose of providing guidance on suggested competency requirements to support these responsibilities, the following competency framework is presented (also see Annex B.1):

HFE lead/HF integration manager (HFIM):

The HFE lead should have overall responsibility for coordination and management of all HFE work on the project, and for working closely with the project team and all relevant parties to ensure appropriate and effective integration of HFE activities across the project and within the project programme.

For projects where a **high** level of HF specialist input is identified, the HFE lead is commonly assigned the more formal role of HFIM[2], and in many cases this role may be a specific requirement.

Depending on the complexity of the project and the number of parties involved, the senior HFIM may be based within the operating company or the design contractor. For large and highly complex projects, there may be a requirement for different HFIMs to be appointed within each of the relevant parties, reporting to a senior HFIM.

The HFIM should be an HF specialist who is able to demonstrate competency at the 'HFE lead' level (see Annex B.1).

HFE practitioner:

For most projects where the need for HF input has been identified, HF specialist support is likely to be required to support the HFIM in carrying out specific HFE activities and reviews.

HF specialist support should be provided by HF professionals who can demonstrate competency at the 'HFE practitioner' level as a minimum (see Annex B.1).

HFE support:

For projects where a **low** level of HF specialist input is identified, it may be acceptable for non-HF professionals to apply HF/ergonomics standards and guidance. HF awareness training is recommended (see Annex B.1).

Annex B provides the following supporting information:

– B.1 Suggested HFE competency framework.
– B.2 Certification for HF and ergonomics professionals.
– B.3 Examples of HFE responsibilities on complex projects.

4 HFE INTEGRATION PLANNING

4.1 OVERVIEW

Where HFE screening identifies the need to consider HFE on a project, an HFE strategy should be written to detail how HFE is going to be managed. Depending on the complexity of project, there may be a need to produce a formal HFIP (see 3.5 and Annex A.2.2).

This section provides guidance on developing an HFE strategy/HFIP and the tasks associated with HFE planning that will inform the content of the strategy/HFIP, including:

– setting HFE requirements and acceptance criteria;
– establishing the mechanism for managing HFE issues, and
– establishing the process for end-user involvement[3].

Guidance is also provided on the factors that can influence the effectiveness or otherwise of HFE integration and implementation within projects.

4.2 HUMAN FACTORS INTEGRATION PLAN (HFIP)

Where a medium to high level of required HFE input has been identified then an HFIP should be produced (see 3.5 and Annex A.2.2).

The objective of the HFIP is to describe in detail how HFE considerations will be integrated and managed through the project. The HFIP should do the following:

– Define HFE roles and responsibilities on the project, including key interfaces between HFE roles with other project disciplines, and any dependencies between organisations/requirements for HFE coordination.
– Define any HF/ergonomics standards that are to be applied, including any company-specific standards that may apply.
– Define the HFE approaches and methods that will be used on the project, including how end-user involvement will be ensured.
– Describe the process that will be used to track, manage and resolve HFE issues (such as use of a human factors issues register [HFIR]), including dealing with any necessary 'trade-offs'.
– Describe the HFE activities and detailed work packages that will be carried out, including details of required inputs and proposed outputs/deliverables, and the acceptance criteria that will be used to judge success.
– Show how HFE activities will be integrated into the overall project work programme, including timescales and key milestones.
– Describe how the HFIP will be maintained and updated.

An indicative structure for an HFIP is provided in Annex C.

3 End-users are the personnel (operators, maintainers, etc.) that will be the users of the plant, systems or equipment.

The HFIP should be written by an HF specialist who can demonstrate competency at the 'HFE practitioner' level as a minimum. For complex projects, the author should have the 'HFE lead' level of competence (see 3.6, Annex B.1).

The HFIP should be produced early in the project, at the Define (early design/FEED) stage, and then updated if necessary throughout the project life cycle – it should be a 'living document'. For long timescale, complex projects, an HFIP may be produced to cover the Define (early design/FEED) stage and then subsequently revisited and revised for the Execute (detailed design) stage – this is particularly likely to be the case if different design contractors are appointed for the FEED and EPC phases of design. In addition, the HFIP should be updated if there are any significant changes to the project scope and/or requirements that may have implications for HFE.

For particularly complex projects where multiple organisations are involved over a long period of time (e.g. operating company, design contractor, vendors) it may be necessary for the main HFIP to refer out to smaller sub-HFIPs that describe the approach being taken to HFE for each of the respective parties.

The activities identified in the HFIP should be aligned with the overall project implementation schedule/programme. The HFE work programme should take due consideration of any dependencies between HFE inputs/outputs and other project activities and milestones.

For complex projects, it is highly recommended that the proposed HFE activities are integrated within the overall project programme and review processes, to ensure HFE considerations receive sufficient management attention, and to ensure that the impact of any major changes in schedule or deliverables upon HFE can be assessed.

The relationship between the HFIP and other project plans, including (where applicable) the project safety plan, reliability, availability and maintainability (RAM) plan, etc. should be clearly identified.

4.3 DEFINING HF STANDARDS AND HFE DESIGN SPECIFICATIONS

One of the activities to be undertaken as part of the development of the HFIP is to confirm the HF/ergonomics standards and guidance that will apply to the project. This may include legislative or regulatory requirements, international standards, company-specific standards or a combination of these sources (2.3.1 provides further information on prescriptive requirements).

Where the standards to be applied are not stated as part of the contract, then it is recommended that, as a minimum, an HF specialist should be consulted to confirm which standards and requirements should apply, taking account of any legislative or company requirements and also considering factors such as the location(s) of the facility under design and the target end-user population (anthropometrics). If there are any conflicting requirements, then it will be the responsibility of the designated HFE lead to agree a suitable resolution, including mandating order of priority.

Where HFE design guidance is spread across several standards or sources of guidance, it may be beneficial for project-specific HFE design specifications to be produced. These specifications can be used to collate relevant HFE guidance within a single document that can then be provided to the design team and/or equipment vendor to act as a single source for

HFE design guidance. For major projects, HFE design specifications may typically be developed to cover key aspects of facility design including:

- control rooms and workspaces;
- living quarter layout;
- access and egress routes;
- stairways and ladders;
- valve locations, and
- labelling and signage.

Customised/bespoke HFE specifications may also be required if there are novel aspects of the system or project under design for which standards do not exist (which may require studies to be undertaken). HFE specifications should be clearly written at an appropriate level for the project (i.e. should be 'fit-for-purpose').

Further detailed guidance on the development of HFE design specifications, suitable for inclusion in vendor specifications in relation to offshore projects, can be found in the American Bureau of Shipping (ABS) document *Guidance notes on the implementation of human factors engineering into the design of offshore installations*.

4.4 DEFINING HFE ACCEPTANCE CRITERIA

For any project, appropriate HFE acceptance criteria should be defined. These are the criteria to be used to assess whether HFE considerations have been adequately addressed and to demonstrate that any identified specific HFE-related user requirements have been met. HFE acceptance criteria should be defined within the HFIP.

Where minor modifications/projects are being undertaken, and HFE input is limited to demonstration of compliance with relevant standards and/or HF design specifications, then HFE acceptance criteria should be defined in relation to compliance with these standards and specifications.

For projects where the need for more significant HFE input has been identified, a wider set of HFE acceptance criteria should be defined, in relation to the specific HFE activities that are being carried out.

In most instances, HFE acceptance criteria will be a combination of:

- demonstrable compliance with relevant HF standards and guidance;
- positive results arising from appropriate HFE review, testing and assessment activities such as user trials, HMI assessments, etc., and
- end-user acceptance and approval of design.

Where HFE requirements and acceptance criteria are not already contractually defined for a project, the establishment of agreed HFE acceptance criteria should be the responsibility of an HF specialist working in close collaboration with the wider project. If an organisation has specific, strict acceptance criteria defined in relation to design approval and sign-off, HFE acceptance criteria should be closely aligned with this process.

The HFIP should provide an overview of the type of HFE acceptance criteria that will be adopted for the project. In addition, specific HFE acceptance criteria should be defined for each HFE activity that has been identified in the HFIP.

For complex projects where progression from one design phase to the next is dependent on the design passing a formal 'gate review' process, HFE acceptance criteria should form part of the gate review (i.e. they should be defined in such a way that they can be passed or failed). It may also be appropriate for the HFIP to explicitly define any requirement for HF specialists to be involved in the 'gate review' process and to review and sign-off design elements from an HFE perspective as being suitable to proceed to the next phase.

4.5 DOCUMENTING EVIDENCE OF HFE COMPLIANCE

The HFIP should describe how evidence is to be documented, demonstrating adequate consideration of HFE and compliance with identified standards and requirements.

Demonstration of the resolution and closure of any identified HFE issues will form part of the HFE compliance evidence. Where applicable, this may include the close-out of issues in an HFIR (see 4.6.2).

Depending on the size and complexity of the project, it may also be appropriate for documentation of HFE compliance to include one or more of the following:

– the use of concise HFE 'compliance statements' to demonstrate that specified HFE-related requirements have been met;
– individual reports summarising the findings from the different HFE activities that have been conducted, and
– the completion of a final HFE compliance or 'close-out' report to summarise all HFE input provided to the project and present evidence of the accessibility of the design from an HFE perspective.

The HFE lead should decide upon the appropriate level of documentation required, and this should be reflected in the HFIP.

4.6 MANAGING HFE ISSUES

4.6.1 Logging and tracking HFE issues

Any HFE issues that are raised during a project should be logged, managed and tracked to resolution via the use of an appropriate 'issues register' mechanism. HFE issues may arise from specific HFE-led activities (e.g. control room studies, HMI reviews, etc.), other project activities, hazard analysis processes (e.g. HAZOP, HAZID, etc.) or communications.

Where a general issues register or 'actions tracker' has been set up for the project then it may be sufficient and appropriate for HFE issues to be tracked within this tool. There is an argument that capturing HFE issues within the general project issues register or actions tracker is a good way to promote HFE integration within the project. However, where this arrangement is adopted, it is essential that HFE issues are tagged as HFE-related to ensure their visibility to the HFE lead/HFIM who will be responsible for approving their resolution.

For major and complex projects which require significant specialist HF input, including HFE-specific activities, then consideration should be given to the use of a separate HFIR. Using a standalone HFIR can make it easier to keep track of all HFE-related issues on a project, and to ensure that all HFE issues are adequately captured and recorded in the first instance.

The decision on whether or not a separate HFIR is required is likely to be dependent on both the nature and size of the project and on a particular organisation's own preferred approach. Whichever approach is adopted, it is essential the HFE issues are given equal weight and priority for resolution as other identified project design issues.

The HFE lead should be responsible for agreeing the mechanism to be used for tracking HFE issues, and this should be documented within the HFIP.

4.6.2 Human factors issues register (HFIR)

If a separate HFIR is used to manage HFE issues, it should be set up at the start of the project.

The HFE lead should be ultimately responsible for managing the HFIR, and work to ensure that all HFE issues are actioned and closed-out, but may assign responsibilities to others to maintain and update the HFIR.

The HFIP should state the terms of reference for the HFIR, including:

- the mechanism for populating the HFIR;
- the frequency with which it will be reviewed and updated;
- the means by which it will be circulated within the project, and
- the mechanism for closing HFE issues (for example, on complex projects this may involve final sign-off by an HFE technical authority – see Annex B.3.2).

It is recommended that HFE-related issues are captured solely in the HFIR, and cross-referenced if necessary from other project issues registers in order to avoid unnecessary duplication of issues and attendant difficulties in keeping track of issue status.

The HFIR should be regularly reviewed and updated throughout the project life cycle. It provides an audit trail to demonstrate that all HFE issues have been tracked and closed-out, and should therefore be issued alongside, or as an annex to, the HFE close-out report (see 5.4). For complex projects, where HFE close-out reports are issued at the end of each design phase, the HFIR should show the current status of all HFE issues, including any that are still open and are to be transferred to the next design phase for resolution.

4.6.3 Resolving HFE issues – dealing with constraints and trade-offs

On any given project, there are likely to be practical constraints and issues arising that may impact on the ease of addressing identified HFE requirements.

For example, on a modification project, if legacy systems exist for HMIs that are non-compliant with current HF good practice and cannot be easily modified, short-term interim measures may need to be put in place to ensure any significant HFE concerns are mitigated while a longer-term programme of improvements is developed. Another example could be restrictions in the scope to modify the plant layout that make it difficult to ensure full compliance with required clearances for maintenance activities or accessibility to equipment.

Several factors are likely to play a part in any HFE 'trade-off' decisions, including:

- the cost of making recommended design changes versus the benefits in terms of demonstrable risk reduction, etc.;
- the criticality of the operations that the HFE issue/design element impacts upon, and the level of risk tolerance of the organisation and/or project, and
- whether compliance with the HFE requirement is statutory or mandated.

The HFE lead should be responsible for working closely with project discipline engineers to review and discuss any potential problems in meeting HFE requirements, and agree an appropriate resolution. HFE requirements should be taken seriously and given an appropriate level of consideration when compared to other 'trade-off' factors when making these decisions.

Where necessary, specific meetings should be arranged to discuss, agree upon and document any required 'trade-offs' and the best way forward where different options may be available. These meetings should be facilitated by the HFE lead, or a suitably competent assigned deputy, and attended, where appropriate, by project design discipline engineers and appropriate end-user personnel (e.g. operators). Where a human factors working group (HFWG) has been established (see Annex B.3), members of the HFWG should be involved in the meetings.

For complex projects where there is a separate HFE technical authority, this individual will have the final responsibility to approve or reject any proposed project deviations and dispensations from specified HFE requirements.

4.7 ESTABLISHING THE PROCESS FOR END-USER INVOLVEMENT

To ensure the effective consideration of HFE in designing and implementing new plant, systems or equipment, it is essential to ensure appropriate engagement and involvement of end-users, i.e. the personnel (operators, maintainers, etc.) that will be the users of the plant, systems or equipment.

For any project, the HFIP should detail the proposed approach that will be used for ensuring appropriate end-user involvement, dependent on the identified activities to be carried out.

End user involvement

Depending on the nature of the project, end-user involvement is likely to include a mixture of the following:

- walk-through/talk-through with HF specialists to support TRA, user requirements capture, etc.;
- involvement in iterative design reviews;
- involvement in desktop reviews of concept designs;
- involvement in mock-up and simulator trials, if applicable (e.g. for new control room layout, HMI, etc.);
- analysis of a 'reference' situation, if one exists (i.e. an existing functional situation as similar as possible to the proposed new design), and
- involvement in 'trade-off' discussions and agreeing practical resolution of HFE issues.

For complex projects, the establishment of an HFWG (see Annex B.3) may be beneficial to ensure available and appropriate input and representation from relevant project disciplines and representative end-users (operators and maintainers).

4.8 EFFECTIVE HFE INTEGRATION

There are several factors which will determine the effectiveness or otherwise of HFE integration on a project. A key factor is that HFE input is provided from the beginning of the project design process and that HFE requirements are defined at this early stage. Experience has shown that successful HFE integration is also dependent on the following:

Success factors
- Senior project management commitment to HFE.
- The appointment of appropriate HF competence resources with defined roles and responsibilities.
- A formal plan (HFIP) for applying HFE throughout the design life cycle, and active management of this plan throughout the project design process.
- Definition of specific and appropriate performance measures with which to measure progress and judge success of the application of HFE.
- HFE design constraints are considered in the same way, and given equal emphasis, as any other technical constraints.
- A design process that involves a multi-disciplinary approach (e.g. close collaboration between HFE and other engineering disciplines, safety managers, etc.) and includes active participation of end-user representatives throughout the iterative design process.
- Appropriate and robust processes in place for HFE review and validation.

The following recommendations are also made to help increase the likelihood of effective HFE integration and implementation:

- Mandate the need to consider and apply HFE throughout the design process. Specifying the requirement to comply with defined HF standards and specifications will help to ensure HFE issues are addressed. HFE review and sign-off requirements can also be included as a mandatory part of the project's design 'gate review' process.
- Obtain early project leadership (project sponsor) support and approval for the HFE strategy/plan. This will help to ensure that any capital costs and time/resource commitments required to address HFE issues are recognised and supported by the project leadership.
- Ensure the setting of an appropriate budget to cover the required HFE input to the project.
- Ensure an appropriate management structure is in place to promote the necessary level of management commitment to HFE:
  - Responsibilities for HFE should be assigned across the various organisations that are involved in the project, for example within the operating company and individual design contractors (see Annex B.3). Ideally, HF specialists should be physically located with other discipline personnel that they will need to interact with; for example, the design team.
  - The appointment of an HFE 'champion' is also recommended to act as the focal point for HFE within an organisation. Depending on the size of the project and

the nature of the organisation, this person may be someone who is internal to the organisation with a suitable degree of HFE awareness (i.e. competency at the HFE support level) who acts as the bridge between the organisation and a separate HFE lead/HFIM (N.B. this role is described as 'HFE coordinator' in Annex B.3). Alternatively, the HFE champion may be the HFE lead or HFIM on the project, particularly if they are an internal resource with the necessary level of HFE competence (see Annex B.1).

  – ABS *Guidance notes on the implementation of human factors engineering into the design of offshore installations* provides more detailed guidance on suggested organisational arrangements for ensuring management commitment to HFE on offshore design projects.

– Provide HFE awareness training to the project design team and discipline engineers. To help encourage appropriate consideration of HFE throughout the design process, HFE awareness training should be provided at an early stage. This is particularly important on large complex projects where it is not practical for the HFE competent resource to be able to review all aspects of the design in detail for HFE compliance with standards and guidance. Providing HFE awareness training to the design team and discipline engineers is recommended to raise awareness of the key HF and ergonomics principles to be followed, and to ensure that project design personnel know when to seek input from an HF specialist if there are problems with achieving compliance. Where specific HF standards and requirements have been set, the training should be focused on these. In addition to the design team, it may also be beneficial to provide HFE awareness training to senior managers responsible for the overall project programme, focused on the process for integrating HFE within the project (based on the HFIP).

– Ensure there is a robust process in place for applying lessons learned. There should be a formal requirement for an HFE review at the end of the project to identify any lessons learned that should be applied for future projects. This should include consideration of lessons learned in relation to HFE design issues (including any innovative HFE design solutions that may have been identified and/or any 'trade-offs' that may have been required) and any improvements identified for the HFE integration process itself. In addition to learning from the project, lessons learned from incidents and accidents should also be taken into account in order to inform the design process.

5 HFE WITHIN THE PROJECT DESIGN LIFE CYCLE

5.1 OVERVIEW

This section provides an overview of the key HFE activities that should be undertaken throughout the project design life cycle.

Within the onshore and offshore energy sectors, and across different organisations, different terminology can be used to describe the phases of the project life cycle. In this publication, the following life cycle phases are used:

– select;
– define;
– execute, and
– operate.

Figure 4 shows how these design phases map across to other commonly used descriptions of project phases. For each phase the key HFE activities that should be carried out are shown.

Each phase of the design life cycle is discussed, with further information provided on the HFE activities to be undertaken.

The focus of this guidance is on the HFE activities required to support the design process. Additional brief information is provided on wider HF considerations during operations and decommissioning.

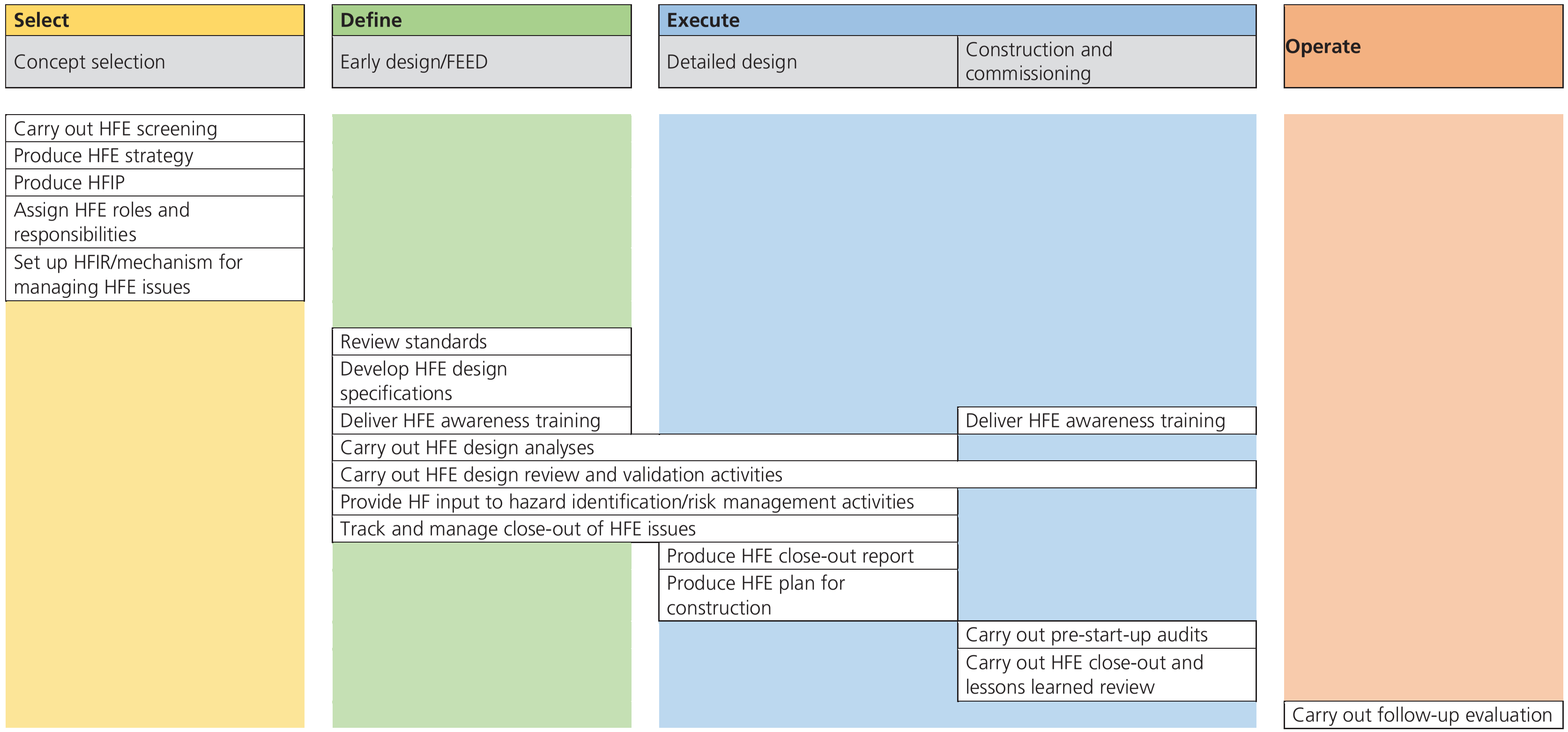

Figure 4: HFE integration within the project design life cycle

5.2 SELECT PHASE HFE ACTIVITIES

Table 3 summarises the HFE activities during the Select (concept selection) phase of the design process. The table provides cross-references to where more detailed information can be found within this publication.

Table 3: Select phase – HFE activities

HFE activity	Description	Further information
Carry out HFE screening	HFE screening should be undertaken as early as possible in order to determine the level of HFE input required on the project and the HFE activities that should be carried out. The findings from the HFE screening will facilitate the development of the HFE strategy/HFIP	3.2 Annex A
Produce HFE strategy/HFIP	Where HFE screening identifies the need to include consideration of HFE on a project, an HFE strategy should be produced. This details how HFE will be managed on the project. Where necessary, a formal HFIP should be written	3.5 Section 4 Annex C
Assign HFE roles and responsibilities	Responsibilities should be assigned for managing HFE and for providing the required competent HFE input throughout the project An HFE lead/HFIM should be appointed. Depending on the complexity of the project and the number of different organisations involved, there may be a requirement for HFE leads/HFIMs to be appointed within each of the relevant parties, reporting to an overall HFE lead/HFIM; there may be a separate HFE technical authority role	3.6 Annex B
Set up HFIR/ mechanism for managing HFE issues	Any HFE issues that are raised during the project should be logged, managed and tracked to resolution via the use of an appropriate issues register mechanism. For major and complex projects which require significant specialist HFE input, including HFE-specific activities, consideration should be given to the use of a standalone HFIR that is separate from other project risk registers and action trackers The formalised process for managing HFE issues should include an agreed method for managing any potential deviations from HFE requirements	4.6

5.3 DEFINE PHASE HFE ACTIVITIES

Table 4 summarises the HFE activities for Define (early design/FEED) phase of the project life cycle. The table provides cross-references to where more detailed information can be found within this publication.

Table 4: Define phase – HFE activities

HFE activity	Description	Further information
Review standards	One of the first steps in the Define (early design/FEED) phase is to review the standards that are proposed for the project (which may include regulatory, international, national and industry standards, as well as company-specific standards and specifications) to ensure they support the defined HFE strategy and adequately cover the scope of the HFE activities, including any prescriptive and goal-oriented requirements If there are any conflicts between standards (e.g. between company and national standards), then it will be the responsibility of the HFE lead to agree a suitable resolution within the project, including determining order of priority	2.3 4.3
Develop HFE design specifications	Where considered beneficial (e.g. for complex projects where relevant HFE design guidance is spread across a number of standards) consider whether project-specific HFE design specifications should be produced The objective of such design specifications is to provide project design engineers with a single reference source for all HFE design requirements. If applicable, they should also be provided to equipment and skid package vendors. For HFE critical equipment, HFE design specifications should be included in the contractual requirements sent to vendors who are tendering to deliver equipment If there are novel aspects of the system or project under design, consider whether customised/bespoke HFE specifications should be developed	4.3
Deliver HFE awareness training	To help encourage appropriate consideration of HFE throughout the design process, it may be beneficial to consider providing HFE awareness training to appropriate project personnel at an early stage in the project design life cycle. This is particularly important on large complex projects where it is not practical for the HFE competent resource to be able to review all aspects of the design in detail for HFE compliance with standards and guidance As a minimum, HFE awareness training should be provided to the project design team and discipline engineers (N.B. for complex projects this may include contractor and vendor personnel). In addition, for complex projects it may also be beneficial to provide training on the approach to be followed for integrating HFE within the project to senior managers who are responsible for the overall project programme, to help ensure effective integration of HFE into the management process	4.8 Annex F

Table 4: Define phase – HFE activities (continued)

HFE activity	Description	Further information
Carry out HFE design analyses	For any given project, a number of different HFE design analyses may need to be carried out. The objective of these analyses is to identify and clearly define the specific operations and maintenance tasks that the design will need to support, and the end-user requirements that will need to be met in order to support safe and effective performance (N.B. these project-specific requirements are in addition to any standards and prescriptive requirements that may have already been identified) The HFE analyses to be carried out on a particular project may vary (based on the scope of the project and the findings from the HFE screening). However, the HFE analyses most commonly required for oil and gas projects include: – task requirements analysis (TRA); – valve criticality analysis (VCA); – vendor package screening and review; – control room analysis and review; – HMI analysis and review; – alarm system analysis and review, and – facility/plant layout design review Further information on these analyses is provided in Annex D Early HFE design analysis work may result in the identification of additional HFE requirements to be included in project specifications and, if applicable, procurement specifications for vendors. Similarly, analysis activities may identify specific HFE issues to be resolved which should then be captured in the HFIR (or other agreed mechanism for tracking and managing HFE issues) for resolution For activities such as VCA, control room analysis and review, and HMI/alarm system analysis and review, the HFE design analysis process will typically start in the Define (early design/ FEED) phase but may continue into the Execute (detailed design) phase as the design progresses, and as more detail becomes available An iterative process should be adopted for the provision of HFE input into the design development process. HFE design analysis activities will help to formalise the requirements to be met, and will result in specific recommendations to be taken forward by the design team. HF specialist resource should then be involved in an iterative design review process, with project design discipline engineers and end-user representatives, to finalise the design and ensure that all identified requirements are met – see HFE design review and validation activities	Annex D

Table 4: Define phase – HFE activities (continued)

HFE activity	Description	Further information
Carry out HFE design review and validation activities	HFE design review and validation activities will begin in the Define (early design/FEED) phase and continue throughout the Execute (detailed design) phase. As noted, HFE design analysis activities will help to formalise the requirements to be met for the design and may also identify additional recommendations to be taken forward by the design team. HF specialist resource should then be involved in an iterative design review process with project design discipline engineers and end-user representatives (operators and maintainers), to finalise the design and ensure that all identified requirements are met Early HFE design review and validation activities may include: – providing support to procurement of vendor-supplied equipment; – reviewing vendor design documentation against HFE specification requirements; – involvement in 30 % 3D model design reviews; – reviewing concept layouts; – reviewing HMI specifications, and – reviewing alarm system philosophy	Annex D
Provide HF input to hazard identification/ risk management activities	HF input should be provided to hazard identification processes (e.g. HAZOP, HAZID, bowtie analysis, etc.) to ensure that the potential for, and consequences of, human errors are considered For the majority of projects, further specialist HF input should then be sought to demonstrate that any risks associated with human error or HF-related issues have been considered and addressed by the design and reduced to ALARP. The level of HF specialist involvement will be dependent, to an extent, on the findings from the HFE screening and the degree to which tasks involve manual operations/human interaction For most projects, some form of qualitative human error assessment (HEA) is likely to be required. Where there are activities with major accident potential, then SCTA is likely to be required – this process involves detailed HEA being undertaken on those tasks that are identified as being safety critical If required, quantitative HEA may also be undertaken to produce human error probabilities (HEPs). This should be led by HF specialists HF input to risk management processes may start in Define (early design/FEED) phase and continue throughout the Execute phase	Annex E

Table 4: Define phase – HFE activities (continued)

HFE activity	Description	Further information
Track and manage close-out of HFE issues	Throughout the Define (early design/FEED) phase, any HFE issues that are identified (as a result of HFE-led activities or other project reviews or processes) should be logged in the agreed issues register mechanism. The HFE lead will be responsible for ensuring that actions are identified, and responsibilities assigned for closing-out issues Any issues that remain open at the end of the Define (early design/FEED) phase should be transferred to the Execute phase for close-out	Section 5.7

5.4 EXECUTE PHASE HFE ACTIVITIES

Table 5 summarises the HFE activities for the Execute phase of the design process. This phase covers the detailed design and construction and commissioning phases of the project life cycle. The table provides cross-references to where more detailed information can be found within this publication.

Table 5: Execute phase – HFE activities

Phase	HFE activity	Description	Further information
Detailed design	Carry out HFE design analyses	Where required, HFE design analyses that have started in the Define (early design/FEED) phase may continue into the Execute (detailed design) phase as the design progresses and more detail becomes available Additional HFE design analyses may also need to be performed – for example, further analyses of critical operations or maintenance tasks not covered in sufficient detailed during FEED	Annex D Annex E
Detailed design	Carry out HFE design review and validation activities	HFE design review and validation activities will begin in the Define (early design/FEED) phase and continue to a greater level of detail as the design progresses throughout the Execute (detailed design) phase HFE review and validation activities may include: – involvement in 60 % and 90 % 3D model design reviews; – review of detailed vendor package isometric design drawings; – valve positioning compliance reviews, and – reviews of HMI graphics screenshots, demos and prototypes HF specialists will be responsible for reviewing the design to confirm that all specified HFE requirements have been met. For projects with major accident potential, this will include ensuring that the design has incorporated features identified as being necessary to reduce any risk associated with human error to ALARP Throughout the design review and validation process, HF specialists will be responsible for identifying any potential areas of non-compliance with standards or defined HFE requirements, and should work closely with designers, discipline engineers and end-user representatives (operators and maintainers) to agree suitable design solutions, considering 'trade-offs' where necessary The output from these HFE design and validation activities will also form part of the demonstration that the design will minimise the risk of human error to ALARP	Annex D

Table 5: Execute phase – HFE activities (continued)

Phase	HFE activity	Description	Further information
Detailed design	Provide HF input to hazard identification/ risk management activities	As stated, HF input to risk management processes is likely to start in the Define (early design/FEED) phase and continue throughout the Execute (detailed design) phase Detailed SCTA and/or HEA should ideally take place during Define (early design/FEED), but may need to be revisited during the Execute (detailed design) phase if details of operations and maintenance activities are still in the process of being defined	Annex E
Detailed design	Track and manage close-out of HFE issues	Throughout the Execute (detailed design) phase, any HFE issues that are identified (as a result of HFE-led activities or other project reviews or processes) should be logged in accordance with the agreed issues register mechanism. The HFE lead is responsible for ensuring that actions are identified and responsibilities assigned for closing-out issues All HFE issues should be closed at the end of detailed design. However, there may be further design verification and validation activities to be undertaken during construction and commissioning for final close-out	5.7
Detailed design	Produce HFE close-out report	The formal deliverables required for documenting the HFE input to the design process should be defined within the HFIP and may differ according to the complexity of the project and the specific requirements for HFE that apply. Separate deliverables may or may not be required for HFE-led activities such as VCA, control room studies, etc As a minimum, for all projects where HFE input has been provided, the HFE inputs that have been provided and HFE activities undertaken on the project should be documented, along with evidence of compliance with the project's defined HFE requirements (and/or cross-reference to where this evidence can be found) For major projects where there is significant HFE input, a formal HFE close-out report should be produced. The report should present (or summarise) the output from the HFE activities that have been undertaken, in line with the approach as specified in the HFIP. The report should demonstrate how all HFE issues have been closed-out, appending the final HFIR and/or cross-referencing the project issues register/actions tracker as appropriate	5.7

Table 5: Execute phase – HFE activities (continued)

Phase	HFE activity	Description	Further information
		The HFE close-out report should be produced at the end of the Execute (detailed design) phase N.B. For particularly large and complex projects, it may also be appropriate to issue an HFE close-out report at the end of the Define (early design/FEED) phase, if a different design contractor is responsible for the Define (early design/FEED) and Execute (detailed design) phases	
Detailed design	Produce HFE plan for construction	An HFE plan for construction should be produced at the end of the Execute (detailed design) phase to cover the HFE verification and validation activities to be carried out during construction and commissioning. The content of the plan, and the specific activities required, will be project-dependent, but may typically include: – HFE awareness training for construction personnel; – details of any HFE issues to be checked during validation walk-arounds, including the use of any checklists, and – an agreed schedule for HFE verification and validation audits and reviews The plan may be a standalone document. However, for less complex projects it may be enough for the HFE plan for construction to be included within the HFE close-out report or to be an annex to the report. It should be confirmed at the Select (concept selection) phase, and documented in the HFIP, whether or not a standalone HFE plan for construction is required for a particular project	Annex F
Construction and commissioning	Deliver HFE awareness training	The key HFE consideration during the construction and commission phase is to ensure that facilities and equipment are installed as planned and agreed, and that no compromises are made in relation to clearances, sightlines, etc. which could adversely impact on safe and efficient operator performance. It should also be checked that any outstanding HFE issues are addressed In order to support the necessary HFE verification and validation activities, those individuals tasked with undertaking the audits and reviews should have a sufficient understanding of HFE issues For smaller or less complex projects where design modifications are being made directly by an operator that has access to competent HF resource, then it may be that HFE audits can be carried out directly by HF specialists	4.8 Annex F

Table 5: Execute phase – HFE activities (continued)

Phase	HFE activity	Description	Further information
		However, in most cases, HFE awareness training should be provided to construction personnel and members of the inspection and commissioning team, to enable them to carry out the reviews The objective of such training is to ensure that all personnel involved in the verification process have a suitable level of understanding of HFE considerations (for instance, the operational and maintenance difficulties that can result from incorrect equipment installation) and are able to identify and deal with any issues that may arise. The aim of the training is to create a culture of operability and maintainability (O&M) awareness The training should be delivered by HF specialists. Training content should be informed by: the output from the HFE close-out report for detailed design, and any actions and/ or issues that have been identified as needing to be taken forward or given particular consideration during the construction phase	
Construction and commissioning	Carry out HFE verification and validation activities	As noted, the HFE verification and validation activities to be undertaken during construction will include checking that any specifically identified HFE issues or concerns raised have been addressed and that the 'as built' design is in line with the final agreed design specification In most cases, it is likely to be acceptable for HFE verification and validation activities to be undertaken by non-HF specialists working with checklists produced by HF specialists, providing they have received appropriate HFE training The checklists used to inform the HFE walk-downs and reviews of the facility should be tailored to the project, and should contain a sufficient level of detail to direct the attention of those performing the verification activity to the most critical aspects that should be checked and verified, including any impact on operability, maintainability, access, egress or safety	Annex F

Table 5: Execute phase – HFE activities (continued)

Phase	HFE activity	Description	Further information
Construction and commissioning	Carry out pre-start-up audits	For projects where high risks associated with HFE have been identified, there may be a requirement for an HF specialist to be involved in any pre- start-up audits and inspections. Where this is a requirement it should be specified in the HFIP	
Construction and commissioning	Carry out HFE close-out and lessons learned review	Dependent on the complexity of the project, there may be a requirement for a final HFE close-out review to be carried out prior to start-up, to confirm that: – all HFE issues have been closed; – HFE verification and validation reviews and pre- start-up audits have demonstrated that all HFE requirements have been met, and – any residual risks associated with human error have been reduced to ALARP A 'lessons learned' review should be carried out at the conclusion of the project. This should identify any lessons learned on the project in relation to HFE design issues (including any innovative HFE design solutions that may have been identified and/or any 'trade-offs' that may have been required) and any improvements identified in relation to the HFE integration process itself	5.7

5.5 OPERATE PHASE HFE ACTIVITIES

5.5.1 Post-start-up follow-up HFE evaluation

A follow-up HFE evaluation should be undertaken approximately one year after start-up (or after a suitable period as agreed by the project). This should involve a structured meeting with operations personnel during which operational feedback is reviewed and discussed. The review should include consideration of:

- the level of operability and maintainability (O&M) achieved;
- any HFE issues identified over the operational period, changes made and/or proposed modifications to HFE considerations;
- any incidents, near misses and/or other operational difficulties that have occurred that are considered to be related to HFE aspects;
- any 'lessons learned' to be fed back, and
- determination of the value provided to the project by the HFE input, determined (if possible) by comparison to similar projects at a similar stage of operation.

Ideally, this follow-up evaluation should be undertaken by an HF specialist. However, for smaller and less complex projects it may be sufficient for it be carried out by someone with an appropriate level of HFE awareness, using a suitable prompt list.

Any findings arising from the evaluation relating to design aspects, including any issues that arose during the project, potential areas for improvement, or things that could have been done better or more efficiently, should be fed back to the project design team so that lessons can be learned for subsequent projects.

5.5.2 HF considerations during operations

The focus of this publication is on the HFE input to the project design life cycle. However, brief guidance is provided on wider HF considerations during the operations phase.

HF input should continue to be provided throughout operations in line with recommended good practice. The operating company should ensure that an appropriate framework is in place for integrating HF methods and procedures into the organisation and for ensuring ongoing and appropriate consideration of HF issues and input, where required, from HF specialists.

Table 6 summarises some of the key areas where HF input may be required throughout operations, particularly where changes are proposed to ongoing processes.

N.B. Depending on the project, some of these activities may need to be started and/or completed prior to the transition to operations. For instance, where totally new processes and systems are being introduced, procedures and working instructions should be written and in place ready for operations to begin. Similarly, if optimal staffing levels need to be determined, then workload analyses and staffing studies should have been completed.

Table 6: HF inputs during Operate phase

Activity	HF Input
Development, review and updating of procedures and working instructions	The application of HF good practice during the development of procedures and working instructions ensures that procedure layout and content is optimised for usability and readability. This in turn helps to maximise procedural compliance, minimise the likelihood of human errors and procedural violations, and increase the likelihood that tasks are successfully completed. This is particularly critical for procedures that relate to safety critical operations and maintenance tasks HF good practice should be applied wherever there is a requirement to produce new procedures and/or update existing procedures or working instructions. This would include when new processes/procedures are being introduced and/or when significant changes are proposed to existing processes/procedures
Establishment and management of safe and effective working processes	HF should be considered to ensure that tasks and working arrangements are designed to minimise the likelihood of human error, maximise efficiency and support operator health, safety and well-being HF input may include providing specialist guidance on task design, allocation of function, shift scheduling and fatigue management, shift-handovers and permit to work arrangements
Staffing studies and workload analysis	Workload assessment describes the process of evaluating the physical and mental workload on individuals associated with the performance of their tasks, in order to ensure that they are able to carry out their duties safely and efficiently and are not subject to adverse overload or underload effects Staffing studies are concerned with determining the optimal number of personnel required to support specific activities, taking into account required roles and responsibilities and proposed organisational arrangements, likely individual workloads, specific competency requirements, etc Some form of staffing study should be carried out in the following circumstances: – proposed changes to staff numbers; – proposed changes to existing roles and responsibilities, and – the introduction of new roles and responsibilities For such staffing studies, HF specialist input is recommended Where changes relate to the performance of safety critical tasks and activities, any potential impact on operator workload and staffing requirements should be evaluated to ensure the potential for human error is reduced to ALARP For most proposed modification projects, detailed workload assessment is unlikely to be required. However, if a new facility is being constructed or major changes being proposed to existing processes, workload assessment may be necessary to demonstrate that staffing arrangements are suitable to cover the range of operational scenarios, including emergency situations. If workload assessment is required, then HF specialist input is considered essential

Table 6: HF inputs during Operate phase (continued)

Activity	HF Input
Support to risk assessment activities and incident/ near miss investigations	Appropriate HF input should be provided whenever there is a need to carry out risk assessments for new or modified tasks or to investigate potential issues arising during operations. This is to ensure that any risks associated with human error or HF-related issues will be duly considered and reduced to ALARP. Where necessary, HEA and/or SCTA should be carried out Similarly, HF considerations should form part of any incident or near miss investigation process
Ongoing design support	HF input to system and equipment design may be required if any new equipment, hardware or systems are introduced and/or if there are significant changes proposed to the design of existing equipment or systems. Similarly, HF input should be provided to support any proposed modifications to existing plant or facilities, as discussed within this publication
Support to competency management processes	The implications for staff competence requirements should be considered when: – introducing new staff, roles and responsibilities, and – proposing changes to existing roles and responsibilities HF specialist input may be beneficial to support the organisation's competency management processes. This might include providing support to training needs analysis (TNA), the identification of individual competence requirements and the establishment of competency management frameworks

5.6 DECOMMISSIONING PHASE HFE ACTIVITIES

The decommissioning of a facility at the end of its operating life is a complex process that typically involves the dismantling of all or part of the facility. In carrying out decommissioning works, consideration should be given to many HF issues, including the procedures to be followed, the staff that will be involved and the organisational arrangements that will be put in place. Issues of task, system and equipment design (for instance, where particular tools or equipment may be introduced to support dismantling operations) should also be considered.

HFE considerations should therefore be integrated into decommissioning work plans from the earliest stages and an HFIP should be developed that describes the HFE activities to be undertaken at each stage.

Further detailed guidance on the HF and HFE issues to be considered during decommissioning is provided in the EI publication *Human and organisational factors in end of service life and decommissioning*.

5.7 HFE DELIVERABLES

The deliverables that will be required as a result of HFE input to the project life cycle will vary, depending on the scale and complexity of the project and the specific requirements for documentation that have been agreed with the project (see 4.5).

The HFIP should describe the HFE deliverables that will be required. For projects where there is significant HFE input, a formal HFE close-out report should be produced at the end of the Execute (detailed design) phase as a minimum. This report should summarise the output from the HFE activities that have been undertaken and demonstrate how all HFE issues have been closed-out (see 5.4).

If an HFIR has been used to manage the close-out of HFE issues (see 4.6.2), then the HFIR should be issued alongside, or as an annex to, the HFE close-out report. For large projects, there may also be a need to develop an HFE plan for construction (see Annex F).

Depending on the size and complexity of the project, it may be appropriate for individual reports to be produced that present the detailed output from the different HFE activities that have been conducted (e.g. VCA, control room studies, etc.).

In addition to the production of specific HFE deliverables, on most projects HF specialists may also be required to provide support to the development of other project documents and deliverables. Typically these may include (but not be limited to):

– design specifications;
– O&M procedures and working instructions;
– emergency plans, and
– operational readiness reports.

The identification of where such HFE input is required should be included in the HFIP.

ANNEX A
HFE SCREENING

For any new design project, whether large or small, HFE screening should be carried out at an early stage to identify whether there is a need for HFE to be considered.

This annex describes two suggested approaches to HFE screening, based on a review of current good practice. This includes indicative templates/question sets for preliminary and detailed HFE screening.

A.1 and A.2 provide examples of preliminary and detailed screenings respectively, aimed at determine the HF challenges on the project and the level of specialist HF resource likely required. A.3 presents an example of an HFE equipment screening tool, intended more for assessing HF challenges of equipment.

N.B. The final decision on the detailed screening questions to be used on any given project, along with the required competencies of the personnel who should undertake the screening, should be confirmed on a project-specific basis, taking account of any relevant company requirements, project complexity, availability of HF specialist resource, etc.

A.1 PRELIMINARY HFE SCREENING

Table A.1: Example question-set for use in preliminary HFE screening

Question	**Answer**	
Will the new project/change involve the construction of new plant or facility that will require manual operations and/or local on-site maintenance?	Yes	No
Will the new project/change involve the introduction of new human machine interfaces (HMIs) or significant modification of existing HMIs?	Yes	No
Will the project/change introduce new systems or equipment that have not previously been used on site, or that involve non-tested technology?	Yes	No
Will the new project/change involve modifications to systems that are heavily reliant on manual human interactions (e.g. operation of manual valves, etc.).	Yes	No
Will the new project/change involve changes to the layout of the plant or facility that could potentially impact on the accessibility and operability of equipment?	Yes	No
Will the new project/change involve the introduction of a new control room or significant modifications to an existing control room?	Yes	No
Will the new project/change introduce new operational processes or result in significant changes to existing operations, resulting in the need to revise procedures or work instructions?	Yes	No
Will the new project/change have any implications for the performance of safety critical tasks?	Yes	No

Table A.1: Example question-set for use in preliminary HFE screening (continued)

Question	Answer	
Will the new project/change involve any changes to the working environment (e.g. temperature, lighting, noise levels, etc.)?	Yes	No
Are there known HF issues associated with the plant or facility that is being modified (including any incidents or near misses where HF issues were identified as a contributing factor, workforce complaints, absenteeism, personal injuries etc.)?	Yes	No
Does the project have a key design objective to incorporate HFE considerations in order to improve safety and/or improve operational efficiency?	Yes	No

- If the answer to **any** of the above questions is YES, consideration of HFE should be incorporated within the project design process. A greater number of YES responses is likely to indicate the need for a higher level of HFE input.
- If there are **no** YES answers, then HFE input is unlikely to be required.

Based on the results of the preliminary screening, is HFE input required on the project?

YES / NO

Based on the results of the preliminary screening, list the key HF risks/areas likely to require HF input.

A.2 DETAILED HFE SCREENING

A.2.1 Identifying level of HF specialist input required on a project

Instructions:

1. Think about the potential areas of HFE input identified from preliminary HFE screening.
2. Consider the statements in Table A.2 to select those that best describe the scope of the project
3. Use Table A.2 to help estimate the level of HF specialist input that may be required.

Table A.2: Indicative HFE strategy based on the estimated level of HF specialist input

Statements	Estimated level of HF specialist input	Indicative HFE strategy
The project involves small changes to simple tasks performed by operators and maintainers There is limited to no scope to influence the design of equipment from an HFE perspective (e.g. project is using off the shelf equipment/like for like replacement) Any prescriptive HFE requirements are likely to be covered by existing HF/ergonomics standards/ guidance	**Low**	Confirm relevant HF and ergonomics standards/guidance to be applied for design and include in project design requirements/ specifications Check and confirm compliance with HF and ergonomics standards/guidance Seek HF specialist advice if required to resolve any issues of non-compliance/advise on 'trade-offs'
The project involves changes to tasks that are complex, time-consuming and/or reliant on high levels of human reliability There is significant scope to influence the design of new equipment from an HF perspective Mandated need for HFE input (e.g. goal-oriented requirement to demonstrate application of HFE)	**Medium**	**As for 'low' plus:** Involve HF specialists in design reviews Involve HF specialists in design verification and validation reviews Involve HF specialists in hazard identification and risk assessment activities
The project involves changes to tasks that are complex, time-consuming and/or reliant on high levels of human reliability There is significant scope to influence the design of new equipment from an HF perspective Mandated need for HFE input and specific HFE-led activities (i.e. process requirement) Specific HFE studies will be required such as a control room study, HMI review, etc The project has implications for performance of safety critical tasks and/or could have the potential to initiate a major accident	**High**	**As for 'medium' plus:** Complete detailed equipment screening (A.3) Appoint individual with a suitable level of HF specialist competence to coordinate and manage HFE input to the project Plan to undertake HFE-led studies and activities Plan for greater involvement of HF specialists Greater degree of HFE validation likely to be necessary HF specialist input required to demonstrate mitigation of risks associated with safety critical tasks

A.2.2 Determining whether an HFIP is required

Instructions:

1. Review the output from the previous HFE screening activities.
2. Consider level of HF specialist input identified.
3. Use Table A.3 to consider requirement for HFIP.

Table A.3: Determining whether an HFIP is required

Estimated level of HF specialist Input	HFIP required
Low	Not required HFE strategy to be documented in project safety plan (or equivalent planning document)
Medium	HFIP recommended Can be included as a section or annex to the project safety plan (or equivalent planning document) rather than standalone document
High	Standalone HFIP required

A.3 HFE EQUIPMENT SCREENING TOOL

This section provides an example of a tool (the HFE equipment screening tool) for conducting an HFE screening. The tool involves a structured and facilitated review of the characteristics, as well as operational experience with the individual process units and equipment involved in the project.

The tool is suitable for projects where the major units and equipment items are known, or can be anticipated, but detailed requirements have not yet been specified and contracts have not been placed with equipment vendors.

The tool is usually applied to projects which are at a very early stage of development, where engineering solutions are defined at a high level and specific process units or equipment have not yet been identified. Minor/simple projects can be screened using simpler tools.

The choice of how to conduct an HFE screening for a specific project is a skilled judgement requiring HFE competence at level 3 (as defined in Annex B). Completion of a screening workshop using the HFE screening tool could be completed for projects that have been identified as requiring a 'high' level of HF specialist input (Annex A.2) and standalone HFIP (Table A.3).

A.3.1 Overview

The HFE equipment screening tool quickly identifies whether there are any significant issues or opportunities associated with the facilities being developed that would benefit from further HFE activity. The screening provides the basis for preparation of an HFE strategy.

The tool is usually applied within a workshop format attended by an experienced facilitator, representatives of O&M, relevant discipline engineers and other specialists as appropriate. During the workshop, the results should be projected on a screen such that all team members can see what is being recorded.

Facilitator

For complex projects, use of the HFE equipment screening tool should be facilitated by the project technical authority, authorised person or HFE specialist. For less complex projects, the HFE coordinator may be able to facilitate use of the tool.

The facilitator has a critical role in ensuring important assumptions and expectations about human performance with the new facility are made explicit and are challenged. This includes challenging assumptions about the role of people – particularly how the human role might change compared with previous systems – and how users and other stakeholders might be affected, or how they might react or behave with the new facility.

Operations and maintenance input

The tool depends critically on interaction between the facilitator, discipline engineers and O&M representatives. The screening cannot be completed without the presence of operations and maintenance representatives. For projects involving significant development or change of instrumentation, panel operators should be involved.

A.3.2 Applying the tool

During the screening session, the team first decides the level at which to apply the tool. The level chosen might be:

- An overall process area or processing unit (such as a processing train, sub-sea well-heads, buildings, tank farms or area of a refinery).
- Individual equipment items (such as compressor packages, gas dehydration units, flow-lines and manifolds, control room, distributed control system (DCS), etc).
- Operations (such as turnarounds on individual units, unit start-ups, oil movements, ship loading, etc).

Once the screening level has been agreed and a list of relevant units or items compiled, the team systematically reviews each item against the following six screening factors:

1. The complexity of the manual activities involved in operating, maintaining and supporting the item.
2. Whether the item is critical for operations or hazard control, or is involved in hazardous service.
3. The frequency with which people need to interact with the item (other than routine operator rounds).
4. The novelty of the item: whether it will require the workforce to gain new knowledge, or skills, or will introduce new procedures, work practices or organisational structures.
5. The status of design at the time of the screening.
6. Known issues with similar equipment, or areas of particular concern to O&M.

These factors are detailed in Tables A.4 to A.9, together with possible ratings and guide words. For each factor, the team should agree a rating based on consideration of the guide words shown in the tables.

The facilitator (or minute taker) should take careful notes to ensure issues contributing to the rating are properly recorded.

Once an item has been screened against the six factors, the team, guided by the facilitator, decides whether any further HFE quality control activity should be applied to the unit or item.

On completion of the screening, the facilitator should use the results as the basis for preparing the HFE strategy for the project.

Table A.4: Task complexity

How complex are the manual activities involved in operating, maintaining and supporting the item?

Ratings	Meaning
Simple	There are only a few manual tasks and they are inherently simple discrete actions with minimal mental demands (such as pressing start/stop buttons, reading gauges, etc)
Moderate	Neither simple, nor complex
Complex	– There are a reasonable number of tasks to be performed (>10), AND/OR – Tasks can be difficult, complex, time-consuming or require very high levels of human reliability
Unknown	No information available

Guide words	Definition
Operations	Is the item likely to impose a substantial amount of work on operations personnel – plant, field or panel?
Maintenance	Is the item likely to impose a substantial amount of work on maintenance or technical personnel?
Physically demanding	Is the work likely to be physically demanding (climbing, pulling, lifting, etc.)?
Mentally demanding	Does the work require high levels of concentration and vigilance, or does it make a lot of demands on thinking, reasoning, calculating or decision-making? Is a human expected to monitor or take account of trends over time, or to detect relationships between a number of items or parameters?
Labour intensive	Does the task require several individuals to complete, or repetitive actions of the same few individuals?
Time-consuming	Does the task take a lot of time to complete?
Other	

Table A.5: Unit criticality

Is the unit critical for operations or hazard control, or is it involved in hazardous service?

Ratings	Meaning
Yes	No doubt. The item is critical or very hazardous
Probably	More than a 50 % chance that if the unit did not perform as designed, either production would be affected or people would be exposed to hazards
Possibly	There is less than a 50 % chance, but not negligible
No	Would not affect production and would not expose anybody to hazards

Guide words	Definition
Start-up/ shut-down	Is this item integral for safe and efficient started up or shut down?
Production	Is the equipment essential for production/ unit reliability/on stream factor?
Product quality	Is the equipment essential to ensuring product meets quality specifications?
Process safety	If the item did not perform as designed, could it represent a major risk to process safety, or does it provide a control against loss of integrity? (explosion, fire, release of hazardous materials, etc.)
Personnel safety	…could it introduce a major risk to personnel safety? (e.g. loss of protection)
Health	…could it introduce a major risk to health? (e.g. exposure to chemicals, radiation, noise, fumes)
Environment	…could there be a major breach of environmental controls (e.g. spillage of hydrocarbons or chemicals)?
HSE control	Does the equipment keep under control a medium or high risk to people, asset, and environment?
Sour service	Yes: Hydrogen Sulfide (H2S) in the process stream is >10 % Possibly: H2S in the process stream >1 %
Benzene	Yes: More than >10 % benzene? Possibly: More than 1 %
Above auto-ignition temp	Does the item routinely contain hydrocarbons above their auto-ignition temperature?
High pressure service	Is the equipment normally operated under high pressure?
High temperature service	Is the external temperature of the equipment high?
Other	Other ways in which the unit is considered critical (be specific)

Table A.6: Task frequency

How frequently are people likely to need to interact with the item (other than routine operator rounds)?

Ratings	Meaning
Frequent	Significant work on the item more than once every 3 months
Occasional	…more than once per year
Rare	…less than once per year
Unknown	No information available

Guide words	Definition
Start-up/ shut-down	How frequently might the item need to be manually started up or shutdown?
Trips	What is the expected frequency that the item might trip?
Routine operations	The frequency of routine operations?
Routine maintenance	The frequency of routine maintenance activities (including change-out of major components)
Breakdown	The frequency that the unit might be expected to breakdown
Inspections	The frequency of major inspections (other than visual checks)
Cleaning	The frequency of cleaning
Transportation	Frequency of moving the item or its components
Resupply	Frequency of resupplying the item or its components
Other	

Table A.7: Novelty

Will the item require the workforce to gain new knowledge, or skills, or will it introduce new procedures, work practices or organisational structures?

Ratings	Meaning
Same	More or less identical to existing units at the asset
Variant	A variant of items that are well known to the local workforce
Similar	A new type of unit, though generally consistent with existing competencies and experience
New	A new unit. Little or no relevant experience at the asset
Unknown	

Guide words	Definition
Asset	New to the asset, but not new to the business unit. Experience available at other assets
Business	New to the business unit, but not new to the company. Experience available in other business units
Company	New to the company. Experience available in the industry
Industry	Not previously used (or not used in the same way) anywhere in the industry
Capacity	Significant change in capacity from existing units
Feed	Will be used with a different feedstock
Process	Not previously used for the intended process
Competencies	Will introduce requirement for new competencies at the asset
Procedures	Will require new procedures that are significantly different in content, or major changes to existing procedures
Organisation	Will require significant changes to the organisational structure (team-working, supervision, shift-work or overtime arrangements, etc.)
Use of contractors	Reliance on contractors/vendors to carry out new functions
Other	

Table A.8: Design scope

To what extent is there scope to influence control over HFE aspects of the design, procurement or layout of the item?

Ratings	Meaning
A lot	Item will not be 'off-the-shelf' and has not yet been procured. Vendor's scope of supply includes design activity. There is still a lot of scope to influence both item design and positioning on the plant
A little	There is some opportunity to influence the design of the item itself, but it will be limited
Plant layout only	No opportunity to influence the design of the item itself. Can still influence location, orientation and local space on the plant
None	Item has already been bought or will be entirely 'off-the-shelf'. Vendor scope of supply does not include any new design. Location already frozen

Guide words	Definition
Integral	The design, location and positioning of components integral to the item. Includes the location and space around valves, flanges, sample points, etc., as well as the design and location of instruments, labels, and signs. (If there is no opportunity, further screening may be of limited value)
Plant layout	The positioning and orientation of the item on the plant, the space around it, and provision of access (including for escape), walkways, lay-down areas, etc
Control panels	Local instrument panels
HMI	Human machine interface to DCS or other information technology (IT) systems, including graphics
Instrumentation	Design of instrumentation, including alarm set-points, to assist panel operators detect abnormalities and diagnose faults from the control room
Closed-circuit television (CCTV)	Provision of CCTV monitoring of the item, of leakages, or of the safety of people working in the area of the item
Lighting	Local lighting arrangements
Noise and vibration	Noise and/or vibration control measures

Table A.9: Known problems

Is there a history of problems associated with the design or layout of the item? Concern is with issues that can affect operations, health and safety, process safety or environmental integrity.

Ratings	Meaning
Major	There are known to have been significant issues with similar items in the past
Minor	There have been some issues where the design has not been as good as it might have been, though they are not considered major problems
None	Not aware of any previous issues with similar equipment or operations

Guide words	Definition
Escape routes/ congested space	Inadequate escape routes or space for escape, including escape wearing arctic clothing and/or breathing apparatus. Space for stretchers, or ease of access for emergency teams carrying emergency response equipment
Equipment access	Access ways and space to bring in equipment needed to start-up, inspect, or maintain the item
Awkward or static posture	People are forced to adopt awkward or uncomfortable postures, involving twisting or bending of the spine, hips or neck, or excessive reaching with the hands and arms. Especially where there is a need to apply force while twisted or extended, or to maintain a static awkward posture for extended periods
Excessive force/weight	People required to apply unreasonably high levels of force (especially when combined with awkward postures) or to carry heavy weights (especially above torso height, or at a distance from the body)
Repetitive motions	People being required to perform the same physical movements repetitively over extended periods (e.g. regularly having to repeat the same movements of the fingers, hands, arms, legs or head/neck every few minutes over periods in excess of an hour)
Material handling	Difficulties manually handling materials. Due to weight, size or shape, lack of space to adopt safe posture, poor grip, personal protective equipment (PPE), or poor communication/cooperation between people working together
Poor lighting	Inadequately lit workspaces. Lighting not repaired. Lighting too bright. Insufficient light to read, perform visual inspections or to see manual activities
Weather	Exposure to extreme heat, cold, wind, dust, etc
Comms/noise/ radios	Issues around difficulties of communication. As well as high noise levels, could include lack of direct line of sight, radio 'black-spots', cross-language issues, delayed information, errors (e.g. in permits), etc
Procedures – confusing, conflicting	Procedures that are badly written, contradictory, illegible, not clear, unnecessarily complex or otherwise difficult to follow. Documented procedures (including their HMI implementation, e.g. in DCS screens or alarm set points) that do not reflect current operational practice or experience
Mistakes/ human errors	A history of human error, including mistakes, failure to complete tasks correctly, or procedure violations. Situations where human error has led to incidents including breach of safety or environmental control or production upsets. Includes error by 'front-line' workforce, as well as support or admin staff, contractors, or during commissioning, construction or turnarounds
Other	Any other history of known problems affecting the ability to work efficiently and safely

ANNEX B
HF COMPETENCY REQUIREMENTS, ROLES AND RESPONSIBILITIES

B.1 EXAMPLES HFE COMPETENCY FRAMEWORK

Table B.1 provides an example competency framework to help when determining the relative level of HF specialist competence that may be required to fill particular HFE roles on projects.

The framework covers three generic HFE roles, namely 'HFE lead', 'HFE practitioner' and 'HFE support'. The following should be noted:

– For major projects, specific competency requirements for particular roles may be defined as part of project contractual requirements and/or company standards.
– A single HFE practitioner level has been shown for simplicity. It may be appropriate to define different levels (e.g. HF practitioner, senior HF practitioner) for particularly complex projects.
– For some projects where the need for a low or medium level of HF specialist support has been identified, it may be acceptable for the HFE lead to have a lower level of required competence.

Table B.1: Example HFE competency framework

Required competencies	**Minimum training requirements**	**Minimum experience**
Level 1: HFE support		
Knowledge of the scope and relevance of HFE Awareness and ability to apply HF/ergonomics standards	Completion of HFE awareness training by approved training provider Example: *Human performance in the energy sectors* e-learn	No required HF experience
Level 2: HFE practitioner		
Level 1 competencies plus: Ability to support production of HFE plans for low and medium complexity projects Ability to carry out HFE activities and reviews Ability to produce HFE technical deliverables Ability to support identification, tracking and resolution of HFE issues	Appropriate degree level qualification in HF/ergonomics/ applied psychology or other relevant degree, or equivalent occupational qualification Graduate membership of recognised professional HF/ ergonomics body Example: completion of EI/CIEHF *Human performance in the energy sectors* and has attained HF Technical Specialist (Oil and Gas/Process Industries) of CIEHF	1 year experience in application of HF within high-hazard industries

Table B.1: Example HFE competency framework (continued)

Required competencies	Minimum training requirements	Minimum experience
Level 3: HFE lead		
Level 2 competencies plus: Ability to produce HFE plans for high complexity projects Ability to manage HFE activities throughout the project in accordance with the HFE plan, including the monitoring of progress against project programme and defined milestones Ability to lead HF specialist support to the project, including the coordination and management of HF specialists Ability to manage the identification, tracking and resolution of HF issues Ability to produce, review and approve HF technical deliverables	Appropriate degree level qualification in HF/ergonomics/ applied psychology or other relevant degree, or equivalent occupational qualification Certified HF/ergonomics professional (e.g. Certified Professional Ergonomist or equivalent)	Five or more years' experience in application of HFE within high-hazard industries, including at least two years' experience in the energy sector

B.2 CERTIFICATION FOR HF AND ERGONOMICS PROFESSIONALS

Table B.2 provides the IEA endorsed certification systems for professional ergonomists.

Table B.2: IEA endorsed certification systems for professional ergonomists

Region	Name of certification board	Highest level of certification
Australia	Human Factors and Ergonomics Society of Australia (HFESA)	Certified Professional Ergonomist (CPE)
Europe	Centre for Registration of European Ergonomists (CREE)	European Ergonomist (Eur.Erg)
Japan	Japan Ergonomics Society (JES)	Certified Professional Ergonomist (CPE)
New Zealand	Board for Certification of NZ Ergonomists – Human Factors and Ergonomics Society of New Zealand	Certified Professional Member
United States of America	Board for Certification of Professional Ergonomists (BCPE)	Certified Professional Ergonomist (CPE) Certified Human Factors Professional (CHFP)
United Kingdom	Chartered Institute of Ergonomics and Human Factors (CIEHF)	Chartered Ergonomics and Human Factors Specialist (C.ErgHF)

B.3 EXAMPLE HFE ROLES AND RESPONSIBILITIES IN COMPLEX PROJECTS

On any project, there are likely to be multiple parties or organisations involved, with the number dependent on the nature, size and complexity of the project.

Table B.3 summarises the typical parties involved in projects and provides an indication of the types of HFE input that may be required for each. It should be stressed, however, that on any given project, the specific allocation of HFE roles and responsibilities should be agreed and defined within the HFIP.

Table B.3: HFE responsibilities across different organisations

Organisation	Details	Indicative HFE responsibilities
Operating company	The operating company refers to the company that operates, or will operate, the plant or facility Where minor modifications are being proposed to existing facilities, the operating company may be directly responsible for making changes to the design For new facilities and major upgrades, the operating company will be responsible for initiating and paying for the project, but is likely to employ a design contractor(s) to carry out the necessary design work For offshore projects, a company may potentially initiate and run a project under a lease agreement with another company	The operating company has a key role in establishing the requirements to be met by the design, in order to effectively support planned operations. This includes specifying any HFE requirements to be met The operating company may have an in-house HF competent resource that will oversee the HFE work undertaken on the project. Alternatively, an external HF specialist may be contracted to carry out this role The operating company is responsible for specifying the requirements for HFE to be met by any other parties. For complex projects, this is likely to include requiring design contractors and vendors to demonstrate appropriate HF competence (via in-house or contracted HF specialists) and to produce appropriate HFE plans for the scope of their works Throughout the design process, operating company end-user representatives should be available to support HFE activities (e.g. as part of a HFWG) Where a leasing arrangement is in place, the leasing company may have specific design requirements to be met, including HFE requirements
Design contractor	For major construction projects, a design contractor will typically be appointed to carry out the design and construction. Separate design contractors may be appointed for the FEED and EPC phases of design	Typically, design contractors should provide competent HF resource (either in-house or contracted HF specialists) to carry out the required HFE activities as identified within their scope of work If the design contractor changes from FEED to EPC there should be an appropriate handover of HFE responsibilities

Table B.3: HFE responsibilities across different organisations (continued)

Organisation	Details	Indicative HFE responsibilities
Equipment vendors	Equipment from equipment vendors and manufacturers is typically designed and supplied to projects as largely self-contained physical units, which may be mounted on portable skids (referred to as skid-packages) or supplied as standalone modules. These skids or modules are then integrated into the overall facility Packaged units are typically designed, built and tested at the vendor/manufacturer's premises. Equipment may be 'off the shelf' based on standard designs or customised to project requirements	Equipment vendors and manufacturers are unlikely to employ any in-house HF specialists For 'off the shelf' packaged units, vendors should be able to provide evidence to demonstrate how HFE considerations have been addressed in the design, i.e. the standards that have been applied and the anthropometric basis for the operator population that has been assumed For 'category 1' vendor packed units that are considered critical to maintain operations, safety or environmental integrity, and those that are designed customised or bespoke for the project, there should typically be specialist HF input from the project to confirm acceptability of the design

Example HFE roles and responsibilities for major/complex projects are listed in the following:

B.3.1 HFE coordinator

Depending on the size of the project, it may be appropriate to appoint an HFE coordinator to act as the focal point for HFE within an organisation. This may be a beneficial approach if an external HF specialist is appointed as the HFE lead/HFIM. The role of the HFE coordinator is to act as the organisation's internal project 'champion' for HFE and the first point liaison with other project design personnel, to ensure due consideration of HFE throughout the project.

The HFE coordinator role should be performed by someone who can demonstrate competency at the HFE support level as a minimum (see Annex B.1).

B.3.2 HFE technical authority

For large/complex projects where an operating company is responsible for initiating and paying for the project, but is employing a design contractor(s) to carry out the design work, the operating company may appoint someone to act as the HFE technical authority for the project.

In this arrangement, while the HFE work is managed by the appointed HFE lead/HFIM (or HFIMs if there are multiple sub-contractors), the HFE technical authority has ultimate responsibility for sign-off and approval of HFE works. A key responsibility of the HFE technical authority is to review and approve, or otherwise, any proposed project deviations and dispensations from specified HFE requirements.

The HFE technical authority role should be filled by an HF professional who can demonstrate competency at the HFE lead level (see Annex B.1).

B.3.3 HF working group (HFWG)

For very large and complex projects involving multi-parties it may be appropriate to consider the use of an HFWG. The HFWG should be chaired by the HFE lead or a delegated HF specialist and should involve permanent representation from relevant project disciplines and end-user representatives.

The potential benefits of using an HFWG are as follows:

– An HFWG can help to ensure there is an available and informed pool of knowledgeable individuals who can provide input to the project (for example, those with appropriate O&M experience). Many HFE activities require HF specialists to work closely with end-users; therefore, identifying and briefing a number of individuals who can then be made available to provide support throughout the project is a good way of ensuring consistency of input and encouraging 'buy-in'.
– An HFWG can be a good way of ensuring appropriate input and representation from all relevant project disciplines and parties, particularly on complex projects with multiple contractors and vendors.
– An HFWG can provide a forum to help oversee and manage the HFE work programme and to help ensure effective integration and coordination of HFE with other project activities.
– An HFWG can provide a forum to discuss 'trade-offs' and resolve HFE issues.

ANNEX C
HUMAN FACTORS INTEGRATION PLAN (HFIP)

The level of detail to be included in an HFIP will be project-dependent. This annex provides an example template for an HFIP where the need for significant HF input to a project has been identified. Where the required level of HF input is less, some of the detailed content may not be necessary.

Bold text indicates the sections that are recommended for inclusion in any HFIP as a minimum.

Table C.1: HFIP template

Introduction	
Project background	Describes the scope of the project/modification works
HFE risks	Summarises the key risks to the project if HFE issues are not adequately addressed. Any known HFE issues that are related to the project (including any issues that are driving the modification) should be captured
Scope of the HFIP	Describes the scope of the required HFE input as covered by the HFIP, including the design life cycle phases to be covered (if applicable)
Management of the HFIP	Describes how the HFIP is to be managed and updated (if applicable) and how it relates to other project documents (e.g. safety plan)
HFE integration management	
Overview of approach for HFE integration	Provides an overview of how the consideration of HFE will be integrated within the project design process, including how HFE activities will be monitored and controlled
HFE constraints	Details any constraints that may impact on the ability of the project to address HFE issues (e.g. legacy systems that cannot be changed, etc.). The proposed means of working around these constraints should be explained
HFE roles and responsibilities	Describes who will be responsible for HFE on the project, including who will be managing HFE and whether any HF specialist support will be provided Details of any required level of HF competence for defined roles should be included. If there is a requirement for HFE awareness training to be provided (e.g. to project engineers) this should be detailed The section should detail the relationships between any specific HFE roles defined across project organisations, and explain any key interfaces between HFE roles and other project disciplines. Where applicable, this section should also explain the composition and terms of reference for any HFWG

Table C.1: HFIP template (continued)

Management of HFE issues	Describes how HFE issues will be identified, tracked and resolved, including whether a standalone HFIR will be used
HFE deliverables	Describes how evidence of compliance with HFE requirements will be documented, including whether any standalone HFE deliverables will be produced
HFE integration process	
Application of HF standards and guidance	Describes the key HF/ergonomics standards and guidance that are to be applied for the project
End-user involvement	Describes the approach that will be taken for ensuring appropriate end-user involvement
HFE acceptance criteria	Provides an overview of any HFE acceptance criteria that will be used to provide assurance that HFE has been adequately addressed (for instance, demonstrable compliance with relevant HF standards and guidance, positive results from user trials, end-user acceptance, etc.)
HFE review and validation	Summarises the proposed process for ensuring appropriate specialist HFE design review and validation
HFE activities	Describe any specific HFE activities to be undertaken (e.g. control room study, workload and staffing study, etc.) For each HFE activity, it is recommended that the following details should be provided: – activity description; – approach; – resource/inputs required/dependencies; – acceptance criteria, and – output/deliverable
HFE work programme	Describes how the HFE work packages and activities will fit into the overall project programme, including any required milestone and deliverable dates The HFE work programme should take due consideration of any dependencies between HFE inputs/outputs and other project activities and milestones. (For example, confirmation of design acceptability from an HFE standpoint may be a necessary requirement prior to the progression to a more detailed stage of design; the ability to carry out an HF review might be dependent on the design being at a suitable level of detail; HFE requirements may need to be identified and added into the procurement/requisition list for long lead items, etc.)
References	

ANNEX D
KEY HFE ACTIVITIES

This annex contains brief information on some of the key HFE activities that are typically carried out to support the project design life cycle.

The following activities are presented:

- D.1 Task requirements analysis;
- D.2 Valve criticality analysis;
- D.3 Vendor package screening and review;
- D.4 Control room analysis and review;
- D.5 HMI analysis and review;
- D.6 Alarm system analysis and review, and
- D.7 Facility/plant layout design review.

For each activity, the following information is provided:

- **What is it and when it is used?**
  Briefly explains what the objective of the activity is and when it should be carried out.
- **What does it involve?**
  Briefly explains what the activity involves, including practical considerations, key inputs, and output.
- **What level of HF specialist input is required?**
  Provides guidance on indicative resource requirements, whether or not HF specialist input is recommended (or required), and what the responsibilities of the HF specialist would be.
- **Further information**
  Where possible, references are provided for where further information can be found on the activity.

These activities have been consistently demonstrated to be efficient and cost-effective in adding value to projects. To be effective, all of these activities are critically dependent on:

- being led by individuals who have the required level of HF competency and experience in applying them, and
- input from key stakeholders, in particular O&M representatives.

The activities described are not intended to represent a definitive or exhaustive list of the HFE inputs that may be required on a particular project.

D.1 TASK REQUIREMENTS ANALYSIS (TRA)

D.1.1 What is it and when is it used?

TRA describes the process of undertaking a review of the tasks to be performed in order to identify any key HFE requirements to be taken forward for the design. It is a term that is commonly used within the energy sector to refer to a limited form of task analysis that is specifically focused on early identification of design requirements.

The objective of TRA is to enable early identification of any design requirements that should be met to optimise task performance and minimise any risk of unsafe operations. The output from a TRA can also be used to support qualitative risk assessments and, where relevant, safety case submissions.

TRA is typically carried out for tasks that are associated with equipment that is novel, safety critical and/or is associated with known HFE issues. Similarly, it may be focused on particular O&M tasks, associated with the use of a specific unit, that are considered to be safety critical and/or difficult to perform. TRA should only be carried out in relation to equipment and tasks where the results of the TRA are expected to be of significant value to the design.

TRA should be carried out as early as possible in the design stage, once sufficient information on the required O&M tasks associated with the equipment is available.

D.1.2 What does it involve?

The specific approach to be taken for TRA may differ between organisations. In general, TRA involves systematically reviewing the tasks associated with the use of a piece of equipment or vendor packaged unit, taking account of the nature of the task (e.g. the steps involved, task frequency, the number of operators required, task duration, task complexity, etc.) and identifying any safety or production risks associated with human errors in carrying out the task. Specific HFE design requirements necessary to mitigate any identified risks are logged.

A TRA workshop should be facilitated by an HF specialist and attended by equipment designers and end-user representatives who are knowledgeable about the O&M activities that will need to be carried out. The level of detail to which the TRA should be carried out should be commensurate with the potential to reduce risk or add value to the design. The quality of the output from the TRA will be dependent to a large extent on the skill, experience and judgement of the HFE facilitator in focusing the attention of the workshop attendees and probing issues that may require further clarification.
The output from the TRA is a set of clear design requirements to feed into HFE, project design specifications and vendor specifications. Design requirements identified through the use of TRA generally fall into two categories:

– new technical requirements necessary to support effective human performance that are not already specified in existing standards or specifications, and/or
– existing requirements which are specified in existing standards, but which should be emphasised for particular critical tasks.

The scope of the design requirements identified through TRA may include:

- requirements for the design and layout of the physical workspace;
- facilities to aid manual handling and manoeuvring of heavy or awkward items;
- environmental considerations, including provision of adequate task lighting, and
- requirements for the need to work in, or minimise the need for, PPE, or the provision of special tools.

The output from a TRA should be captured in standardised spreadsheet templates. The design requirements that are identified should be taken forward into relevant project specifications (including, where applicable, vendor package invitations to tender [ITT]) and design validation activities. Specific actions arising from the TRA should be captured in the HFIR or other mechanism being used to track HFE issues. The output from TRA can help to transform goal-oriented HFE requirements into prescriptive requirements (see 2.3).

N.B. It should be noted that TRA is a limited version of the more widely adopted task analysis techniques widely used throughout many industries and which form the starting point for many HF analyses. Where HF input is required to assess human error potential, evaluate operator workload, or support the design of training or procedures, more detailed forms of task analysis should be used.

D.1.3 What level of HF specialist input is required?

The TRA workshop should be led by someone who has a minimum HFE practitioner level of HF competency.

D.1.4 Further information

Kirwan, B. and Ainsworth, L.K. (1992), *A guide to task analysis,* Taylor & Francis, London

HSE, *HSE briefing note: Understanding the task*

EI, *Human factors briefing note no. 11: Task analysis*

D.2 VALVE CRITICALITY ANALYSIS (VCA)

D.2.1 What is it and when is it used?

The placement of valves to facilitate safe and efficient access for O&Mis one of the most important aspects of the design of onshore and offshore facilities, given the frequency with which valves need to be accessed.

VCA provides a structured decision process for determining the optimal location of all valves on a facility. It refers to the process by which valves are categorised and prioritised according to their criticality and frequency of operation, and then located appropriately (in accordance with defined guidelines) in order to ensure ease of access and visibility for operation or maintenance. It includes the process of carrying out checks on the emergent design layout to confirm that compliance with the required guidelines can be achieved, and if this is not possible, agreeing acceptable 'trade-offs' if necessary.

The categorisation phase of VCA should be undertaken in the Define (early design/FEED) phase and revisited if any new valves are introduced or changes proposed to existing valve usage. The valve compliance review process will begin in Define (early design/FEED) and typically continue during Execute (detailed design) as the level of detail in the layout design progressively increases.

D.2.2 What does it involve?

The first phase of the VCA process involves categorising valves based on a formal set of agreed priority ranking criteria. Some organisations have agreed criteria for categorising valves. Where pre-existing criteria are not in place, they should be agreed within the project by all relevant disciplines, including representatives from design, engineering, O&M. Typical practice is to rank valves on the following basis:

- Category 1: valves that are essential to normal or emergency operations when rapid and unencumbered access is essential (including access required during start-up or shut-down). For example, emergency shutdown (ESD) valves, valves that have a high level of safety criticality (in terms of the potential for causing or preventing a major accident hazard [MAH]), and valves that have a high frequency of operation.
- Category 2: valves that are not critical for normal or emergency operations but need to be accessed for routine operations or maintenance.
- Category 3: valves that are not critical for normal or emergency operations and are only used or inspected rarely or infrequently. Normally non-operating valves.

Piping and instrumentation diagrams (P&IDs) are typically used to identify and compile a list of all valves on the facility that need to be categorised. For complex projects with a large number of valves, it may be necessary to categorise valves initially by valve type, identifying differences by exception, and then to confirm the accuracy of the categorisation as the design progresses.

Once valves have been categorised, agreed valve categories should be marked on P&IDs. The design team (including piping/layout engineers and, where applicable, vendor package supplier) should then be provided with guidance on the required valve locations and orientations for each category of valve. Typical guidelines are as follows:

- Category 1: valves should be positioned so that valve identification and status is clearly visible and they are easily accessible. Permanent access should be provided at deck or ground level or via a permanent standing elevated surface. If access at ground or deck level is not practical, access by stairs to the elevated platform may be acceptable.
- Category 2: valves should ideally be located with permanent access at deck level, or access via stairs. However, with suitable justification alternative means of access, such as vertical fixed ladders or small standing platforms, may be acceptable.
- Category 3: permanent accessibility to, and visibility of, the valves is desirable but not essential. The use of mobile platforms or scaffolding to access valves is likely to be acceptable, but portable ladders should not be used. It should always be ensured that there is sufficient space and access provided for personnel, tools, parts, and equipment.

It will then be the responsibility of the design team to ensure that the design guidelines for valve location are adhered to during the design process, and to raise any HFE issues if there are any locations where there is difficulty in achieving compliance and/or where HFE input should be sought to agree upon an acceptable design solution.

As the design progresses, compliance with the required guidelines should be checked and confirmed. In the main, this will be the responsibility of the project design engineers. However, HF specialists should also be involved in the compliance review process, to ensure that any potential areas of difficulty are discussed and an acceptable solution reached.

The agreed process for HFE involvement in valve reviews should be documented in the HFIP. Depending on project preferences and factors such as the number of valves to be reviewed, two different approaches may typically be followed:

1. valve compliance reviews may be carried out during the project's scheduled 3D model design reviews, and/or
2. one or more specific valve compliance review workshops may be organised, in which the 3D model will be used to assess and review the valves across the different areas of the facility.

Independently of the approach followed, HFE input is likely to be focused on those valves where potential issues have been identified. Where potential issues of non-compliance are identified, a systematic process should be followed to confirm the proposed usage of the valve, review the 3D model, and determine possible solutions (e.g. temporary access platforms, use of remote actuators, etc.). The results of the review should be recorded and any identified actions and/or recommendations logged in the HFIR or agreed issues register (and/or recorded in the minutes of the 3D model design review if applicable).

D.2.3 What level of HF specialist input is required?

If formal criteria are not in place for categorising valves, HF competent resource at the HFE practitioner level should be used to help develop appropriate criteria and associated design guidance, working with appropriate discipline and design engineers and end-user representatives from O&M.

For large projects with many valves, it will not be practical for HF specialists to review the acceptability of all valve locations. Therefore, it is essential that the design engineers are provided with the required understanding of the valve positioning guidelines and of the key HFE considerations (in relation to accessibility and visibility of valves) so that they can raise HFE issues where necessary. HF competent resource at the HFE practitioner level should therefore be used to provide appropriate HFE awareness training to design engineers (or to develop training material to be circulated to all relevant engineering disciplines) in order to ensure that they can apply the valve design guidelines.

HF specialist input should be used during the design review process to review and agree appropriate design solutions where there are problems in demonstrating valve location compliance with agreed guidelines. If separate valve compliance workshops are arranged, these should be facilitated by HF specialists.

D.2.4 Further information

ASTM International, ASTM F1166-07 *Standard practice for human engineering design for marine systems, equipment and facilities* (chapter 12).

N.B. There is little freely available industry guidance on VCA. Some of the major energy organisations have internal standards and guidance on VCA.

D.3 VENDOR PACKAGE SCREENING AND REVIEW

D.3.1 What is it and when is it used?

Equipment from vendors and manufacturers is typically designed and supplied to projects as largely self-contained physical units, which may be mounted on portable skids (referred to as skid-packages) or supplied as standalone modules; these skids or modules are then integrated into the overall facility. Due to the need to skid packages and modules such that they can be readily transported, they are frequently very compressed, which can create problems of accessibility or ease of operation or maintenance.

Packaged units are typically designed, built and tested at the vendor/manufacturer's premises. Equipment may be 'off the shelf' based on standard designs, or custom designed to project requirements.

For critical vendor packages and those that are customised/bespoke designs for the project, specialist HF input should typically be used to confirm acceptability of the design. The aim of a vendor package review is to identify those vendor packages where, based on the criticality and frequency of manual interaction, HFE aspects of the design and layout of the unit require additional attention.

Vendor package screening should be carried out as early as possible in the Define (early design/FEED) phase, as soon as it is clear which equipment and systems are going to be procured as package units, and when there is an understanding of the functionality of the unit and the O&M tasks that will be performed.

D.3.2 What does it involve?

A comprehensive list of all vendor packaged units should be prepared. The vendor packages should then be screened and categorised as follows:

- Category 1: vendor packages that are considered critical to maintain operations, safety or environmental integrity, or that require frequent manual intervention.
- Category 2: vendor packages where human intervention is infrequent and not critical.

For category 1 packages, HF specialists should be involved in the review of the package designs to ensure that they are acceptable with respect to accessibility, O&M.

For category 2 packages, the vendor should be asked to provide information on the design standards that have been applied and the anthropometric basis for the operator population that has been assumed. No HF specialist review is likely to be required.

N.B. For 'off-the-shelf' packages there is often little scope for redesign for individual projects. Sometimes, however, vendors may be prepared to consider design improvements where there is a clear benefit in O&M of their product.

The approach to be followed for HFE reviews of category 1 vendor packages should be documented in the HFIP. There is no single mandated methodology, but typically this will involve HFE review of isometric design drawings as a minimum. Wherever possible, the optimal approach will be to arrange workshops facilitated by an HF specialist which include the relevant vendor design engineers and end-user representation from O&M.

During these workshops, the package designs should be systematically reviewed, taking consideration of the following:

- task complexity, criticality and frequency;
- number of personnel required;
- access to, and egress from, the unit;
- clearances and available space for operations/maintenance;
- accessibility of valves and controls, and
- visibility of instrumentation/gauges.

When reviewing vendor packages, it should be ensured that consideration is given to accessibility, operability and maintainability of the package when it is *in situ* on the plant, rather than only reviewing the design in isolation. This includes taking consideration of any environmental factors (e.g. noise or vibrations from nearby operations, heat, etc.) and any potential for dropped object hazards.

Any HFE issues to be addressed should be logged in the HFIR or agreed mechanism for tracking HFE issues. Specific design requirements to be met to ensure O&M should be handed over to the vendor for action.

D.3.3 What level of HF specialist input is required?

Initial vendor package screening can potentially be undertaken without specialist HF input, as long as those that perform the screening are clear on the criteria to be used.

For category 1 vendor packages, HF specialist input (at the minimum HFE practitioner level) is recommended to carry out package reviews.

D.4 CONTROL ROOM ANALYSIS AND DESIGN REVIEW

D.4.1 What is it and when is it used?

Specialist HFE input to control room design should be sought if a project involves the construction of new control room or significant changes to existing control rooms (such as the introduction of new equipment, furniture or workstations, changes in control room layout or lighting, etc.). HFE input may also be sought where there is a proposed transfer of operations between control rooms, where there are changes in function, or where local control rooms are integrated into larger centralised facilities.

The design of control rooms is typically considered to be one of the key areas for HFE input, due to the high potential to impact on the control of MAHs. In addition, there are detailed standards, guidelines and the HFE principles to be applied for control room design. Key principles may also apply to the design of drilling or crane cabins, security centres, operations rooms and emergency management rooms.

HFE input to control room design will typically begin during the Define (early design/FEED) phase, when analyses will be performed to confirm the requirements that will need to be met by the design. HF specialists should then be involved in an iterative process of design review and validation throughout Define (early design/FEED) and Execute (detailed design).

D.4.2 What does it involve?

During early design, a workshop should be held, facilitated by an HF specialist, in order to confirm the proposed operation of the control room and define the specific requirements that need to be addressed. The workshop should be attended by relevant discipline design engineers and representative end-users (i.e. control room operators). This initial control room requirements analysis will typically include the following:

- **Confirmation of what the purpose of the control room is**, and its operating philosophy (under both normal and abnormal/emergency conditions). If the project involves modifications to an existing control room, then these proposals should be understood, including how any legacy systems will work alongside the new design.
- **A functional analysis** to document the functions to be supported from the control room, and the required interactions with other areas/operating positions. This may include, for example, any requirements to support functions such as shift handover, permitting, emergency response, personnel monitoring and, for offshore facilities, helicopter or marine management.
- **Identification of equipment requirements.** The functional analysis should include definition of the equipment and any other facilities needed to support each function. For example, there may be a requirement for a large shared wall-based mimic panel/ display screen to support team-shared situational awareness and effective incident management. Typically, a full list of equipment to be included will be produced.
- **Confirmation of the proposed staffing level and the roles to be supported in the control room.** This should include primary roles (those who need dedicated space and facilities within the control room such as panel operators), as well as secondary roles (i.e. personnel who may need to physically access the control room occasionally, but do not require dedicated space or facilities).
- **Task analysis of key operator roles**, including the confirmation of any safety critical tasks to be performed from the control room. Consideration should be given to the workload associated with particular roles in order to help determine how many staff are likely to be required overall to fulfil the required positions (see confirmation of staffing levels).
- **Link/adjacency analysis for both roles and equipment.** Link/adjacency analyses identify and record the expected relationships, in terms of the expected frequency of direct physical contact between different roles, and the frequency with which each role is expected to need access to different equipment or dedicated areas within the control room or surrounding areas.

The output from the control room requirements analysis workshop will identify specific requirements to be taken forward for the design. Any HFE issues to be addressed should be logged in the HFIR or agreed mechanism for tracking HFE issues.

As the control room design is progressed throughout Define (early design/FEED) and Execute (detailed design), HF specialists should work closely with design engineers and end-user representatives to iteratively develop the control room layout, ensuring compliance with HF/ ergonomics good practice principles. This process will typically involve reviews of isometric drawings and, where applicable, 3D models. For major control room construction projects, it may be appropriate to run user trials involving mock-ups in order to fine-tune and sign-off the final design.

N.B. For oil and gas projects in the Norwegian sector, NORSOK S-002 *Working environment* requires a specific analysis to be carried out to evaluate the design, staffing and operation of control rooms. This is the crisis intervention and operability (CRIOP) analysis. A CRIOP analysis includes a checklist review of the static characteristics of the control room and a scenario analysis. The checklist review includes consideration of the control room layout, man-machine interface, physical working environment, control and safety systems, work organisation, procedures, and training programme. In the scenario analysis, step-diagrams of potential accident scenarios are developed, setting out the different 'players' in each scenario (humans, objects) and the time in which particular events occur. Critical actions are identified where human errors may have severe consequences. For each critical action, design, staffing and procedures are then evaluated by considering the operators' possibilities to detect and diagnose hazards and to take the required action.

D.4.3 What level of HF specialist input is required?

HF specialist input (at the minimum 'HFE practitioner' level) should be used to support the control room requirement analysis and the ongoing HFE review and validation of the emerging design.

D.4.4 Further information

International Organisation for Standardisation (ISO) 11064, *Ergonomic design of control centres* (multiple parts)

NORSOK S-002, *Working environment*

SINTEF Technology and Society, report No. SINTEF A4312, *CRIOP: A scenario method for crisis intervention and operability analysis*

D.5 HUMAN MACHINE INTERFACE (HMI) ANALYSIS AND REVIEW

D.5.1 What is it and when is it used?

Where a design project involves the introduction of new HMIs or the modification of existing HMIs, HFE input should be used in order to ensure system 'usability' and reduce the potential for human error. HFE input will ensure that HMIs are designed in accordance with HF/ ergonomics good practice principles, and satisfy defined end-user requirements. In oil and gas projects, HFE input is most often required to support the development of DCS; however, any significant changes to local equipment interfaces should also be subject to HFE review.

HFE input to HMI design will typically begin during the Define (early design/FEED) phase, when analyses will be performed to confirm the requirements that will need to be met by the design. HF specialists will then be involved in an iterative process of design review and validation throughout Define (early design/FEED) and Execute (detailed design).

D.5.2 What does it involve?

The level of HFE input that will be required will be dependent on project size and complexity, the number of different HMI systems involved, and the degree to which these systems are being developed 'from scratch'. The specific approach to be followed for HMI analysis and review should be documented in the HFIP.

For many projects, software vendors may be contracted to provide 'off-the-shelf' DCS systems that will then be adapted as required to suit the specific requirements of the project and plant. For large organisations, a consistent DCS system is likely to (and should) be adopted across all sites. The main suppliers of modern DCS systems for the energy sector are likely to have existing DCS functional design specifications that will demonstrate compliance with HF/ergonomics good practice design principles. Where these 'off-the-shelf' DCS systems are being procured, the initial role of the HF specialists on the project will be to help confirm the specific requirements for the project, and then to subsequently review the customised HMI design specification that is produced by the vendor, in order to check for compliance.

Where new HMI systems are being developed, the level of initial HFE input required will be higher. HF specialists should perform an HMI requirements analysis to confirm the specific requirements to be met by the system to ensure that HF/ergonomics good practice principles will be met and a high level of usability achieved.

Typically, a workshop facilitated by an HF specialist and attended by representative end-users (e.g. control room operators, maintainers, etc.) will be used to discuss and agree requirements. This process will include consideration of who the users of the system will be, what critical tasks will be conducted on the HMI, where HMI screens will be located, whether there is a need to ensure consistency with any legacy systems, etc. Project preferences in relation to key design principles such as colours, visual coding, menu hierarchy and navigation, etc. should also be agreed.

The output from the HMI requirements analysis process should be a list of requirements to be met to be taken forward for the design – if applicable, these requirements should be passed to vendors who are supplying the HMI software. On some projects, there may be a need to produce a detailed HMI style guide. Any specific HFE issues to be addressed should be logged in the HFIR or agreed mechanism for tracking HFE issues.

As the HMI design is progressed throughout Define (early design/FEED) and Execute (detailed design), HF specialists should work closely with design engineers and end-user representatives to iteratively develop the final HMI design, ensuring compliance with HF/ergonomics good practice principles. This process would typically involve the review of HMI design specifications, screenshots and software demos. On complex projects, it may also be appropriate to run user-trials of HMI prototypes.

D.5.3 What level of HF specialist input is required?

HF specialist input (at the minimum 'HFE practitioner' level) should support the HMI requirements analysis and the ongoing HFE review and validation of emerging HMI designs.

D.5.4 Further information

ISO 9241, *Ergonomics of human-system interaction* (multiple parts).

Engineering Equipment and materials Users Association (EEMUA) 201, *Process plant control desks utilising human-computer interfaces. A guide to design, operational and human-computer interfaces issues*, edition 2.

ASM Consortium, *Effective console operator HMI design practices*.

N.B. Some of the major energy organisations have internal standards and guidance that describe the process to be followed for considering HFE during HMI design and the HF/ergonomics requirements that need to be met.

D.6 ALARM SYSTEMS ANALYSIS AND REVIEW

D.6.1 What is it and when is it used?

HFE input to the design of alarm systems typically forms part of the wider input into HMI analysis and review (see D.5). Specialist HFE input will ensure that alarm systems are designed in accordance with HF/ergonomics good practice principles. This is vital, given the importance of alarm systems in the management of safety, including the detection, mitigation and response to MAHs.

HFE input will typically begin during the Define (early design/FEED) phase, supporting the development of an alarm philosophy, the identification of required alarms, and the alarm rationalisation process. HF specialists will then be involved in an iterative process of design review and validation of the alarm system design throughout Define (early design/FEED) and Execute (detailed design).

D.6.2 What does it involve?

As noted previously with respect to HMI design, the level of HFE input that will be required will be dependent to a large degree on whether alarm systems are being developed 'from scratch' or will involve modifications of 'off-the-shelf' systems. The specific approach to be followed for alarm system analysis and review should be documented in the HFIP, based on the specific project requirements.

The first stage in designing a new alarm system or modifying an existing system is to develop an alarm philosophy that documents the objectives of the alarm system, and the processes required to meet those objectives. The alarm philosophy should include the definition of rules for categorising and prioritising alarms and for determining acceptable alarm frequencies and alarm set-points, etc. It should also define the functionality required for alarm handling (annunciation, acknowledgment and reset), alarm shelving, alarm logging, etc. The intended philosophy for the presentation of alarms on the HMI, including coding and colour usage, should also be defined, ensuring consistency with overall HMI design. For new systems, the alarm philosophy should serve as the basis for the development of an alarm system requirements specification document, which will include more detail than the alarm philosophy and provide specific guidance for system design.

Specialist HF input is likely to be required to support the necessary analyses and discussions that will help develop the alarm philosophy. As a minimum, HFE input should be used to review the acceptability of an alarm philosophy that has been produced.

The next step in the alarm design process is to identify the alarms that are required to be included in the alarm system (including any existing alarms that may require modification). Once all required alarms are identified, an alarm rationalisation process should be carried out in order to categorise alarms by priority-based on the rules established in the alarm philosophy. The actions to be taken by operators in response to alarms should be defined during this process. The results of the rationalisation process should be documented, typically in a master alarm database, which should then be maintained and updated when necessary for the life of the alarm system. HFE involvement in the alarm identification and rationalisation process is likely to be beneficial, but may not be essential.

The alarm system design process should then proceed, based on the requirements determined by the rationalisation process, and the design principles as specified in the alarm philosophy and requirements specification document.

As the alarm system design is progressed throughout Define (early design/FEED) and Execute (detailed design), HF specialists should work closely with design engineers and end-user representatives to iteratively develop the final design, ensuring compliance with HF/ergonomics good practice principles. As noted with respect to the wider HMI design, this process may involve the review of design specifications, screenshots and software demos. On complex projects, it may also be appropriate to run user-trials of HMI prototypes to consider the suitability of audible and visual alarm annunciation.

D.6.3 What level of HF specialist input is required?

HF specialist input (at the minimum 'HFE practitioner' level) should support the development of the alarm philosophy and detailed alarm system requirements specification. HF specialist involvement in the alarm identification and rationalisation process is likely to be beneficial but may not be essential; nevertheless, a review by HF specialists of the output from this process is recommended.

HF specialist input should support the ongoing review and validation of the emerging alarm system designs during Define (early design/FEED) and Execute (detailed design).

D.6.4 Further information

EEMUA 191, *Alarm systems. Guide to design, management and procurement*.

British Standards Institution (BSI), BS EN 62682: 2015, *Management of alarms systems for the process industries*.

Norwegian Petroleum Directorate, YA-711, *Principles for alarm system design*.

D.7 FACILITY/PLANT LAYOUT DESIGN REVIEW

D.7.1 What is it and when is it used?

The layout of any workplace should facilitate safe and efficient operations, ensure accessibility to equipment, and enable operators to move around safely, easily and efficiently.

Iterative HF specialist input to the design review process should be sought, to ensure that all workplaces are designed in accordance with HF/ergonomics standards and good practice principles, and to ensure compliance with any project-defined design requirements.

HFE input will typically begin during the Define (early design/FEED) phase and continue throughout Define (early design/FEED) and Execute (detailed design) as the design progresses.

D.7.2 What does it involve?

The ergonomics standards and guidance that will apply for the project should be defined in the HFIP. Where required, project-specific HFE design specifications may also be produced to cover key aspects of facility design, including:

– walkways and emergency egress routes;
– elevated platforms;
– stairways and ladders;

- lighting arrangements, and
- labelling and signage.

HF specialists should work closely with design engineers throughout the design process (from Define (early design/FEED) to Execute (detailed design)) to ensure that all specified HFE requirements relating to the plant/facility layout are met. For any potential areas of difficulty, specific meetings should be arranged to discuss, agree upon and document any required 'trade-offs' and the proposed design solution.

HF specialist input to the iterative design review process will typically involve desktop reviews of 2D general arrangement and isometric design drawings and, where applicable for larger projects, walk-throughs of 3D Models. For larger, more complex projects where there is a formal process of 3D model design reviews, the following HFE input should be considered:

- **30 % model design reviews:** HFE review of model review output recommended as a minimum so that any HFE issues can be identified and logged. HF specialist input at this stage can be very useful; the earlier HF input is obtained the better. The 30 % model review is critical for HFE in ensuring space, clearances, walkways and location of stairs. It is an early opportunity to comment on the general arrangement and influence other disciplines present at the review. Without this, there is a higher likelihood of significant HF issues being raised during 60 % model reviews that could have been prevented had HF been involved earlier.
- **60 % model design reviews:** HF specialist input should be provided, with HFE competent personnel in attendance. At this point in the design, the level of detail will enable HFE to check details such as accessibility to valves and controls, walkway clearances, etc. There may still be scope to make significant changes to the design (although this is not always the case).
- **90 % model design reviews:** HF specialist attendance is beneficial. At this stage, the role of the HF specialist is to verify that previous issues have been addressed and to carry out final checks against the HF specification to ensure that users will be supported in their tasks (e.g. visual envelopes).

Depending on project complexity, scheduling and preferences, it may be more appropriate for separate 3D model design review sessions to be arranged to focus on review of HFE issues.

For complex facilities, it may not be practical for HF specialists to review every aspect of the facility, and so it will be the responsibility of the engineers involved in the layout reviews to identify any areas of HFE concern and raise HFE issues where necessary; this will then provide a focus for the reviews to be carried out by the project's HF specialists. Where access to HF specialist resource is limited, appropriate HFE awareness training should be provided to design engineers (or to develop training material to be circulated to all relevant engineering disciplines) in order to ensure they have sufficient awareness to be able to identify any potential HFE issues requiring further specialist review.

D.7.3 What level of HF specialist input is required?

HF specialist input (at the minimum 'HFE practitioner' level) should be sought to support the ongoing review and validation of the emerging layout/facility design during Define (early design/FEED) and Execute (detailed design).

D.7.4 Further information

ISO 26800:2011, *Ergonomics – General approach, principles and concepts*.

American Petroleum Institute (API), *API Human factors: Human factors in new facility design tool*.

N.B. Some of the major energy organisations have internal standards and guidance that describe the process to be followed for applying HFE to the physical workspaces on onshore/ offshore facilities.

ANNEX E
HUMAN FACTORS INPUT INTO HAZARD IDENTIFICATION AND RISK MANAGEMENT ACTIVITIES

There should be appropriate consideration of HF issues, including the potential likelihood and impact of human errors, as part of a project's safety assurance and risk management activities. HF considerations should form part of hazard identification activities (e.g. HAZOP, HAZID, etc.) and risk assessment processes (including bow tie analysis). Where there is a requirement for a safety case to support the operation of a facility, this will need to include demonstration that HF issues have been considered in relation to the design and proposed operation of the facility, and that any risks associated with human failures have been reduced to ALARP.

The specific activities that will be required to demonstrate that any risks associated with human failures (human errors and violations) have been minimised/reduced to ALARP levels will vary according to the specific project. Most major energy organisations will also have mandated internal processes that will cover the activities to be performed.

For most projects, some form of qualitative HEA is likely to be required.

For some safety cases, quantitative HRA may be needed to generate HEPs to populate fault trees and event trees. Outside of any regulatory requirement, generation of HEPs may also sometimes be considered beneficial to support decision-making, cost-benefit analysis and comparison of risk levels.

Where there are activities with MAH potential, then SCTA should be carried out. HF input to risk management processes is likely to start in the Define (early design/FEED) phase and continue throughout the Execute (detailed design) phase.

The application of HF within risk assessment studies and safety cases is outside of the scope of this publication. However, brief guidance is provided on HF in HAZOPs and SCTA.

Sources of further information on HEA, HRA and HF input to risk assessments and safety cases are provided as follows.

Further Information:

EI/Center for Chemical Process Safety (CCPS), *Bowties in risk management: a concept book for process safety* (chapter 4).

IOGP 434-5, *Human factors in QRA*.

Kirwan, B. (1994), *A guide to practical human reliability assessment*, CRC Press.

CIEHF, *Human factors in barrier management*, white paper.

E.1 HFE IN HAZOP

E.1.1 Determining the level of HF representation required

Hazard and Operability Studies (HAZOPs) are one of the most commonly used hazard analysis techniques in the energy sector.

It should be ensured that due consideration is given to HF issues and the potential for human error when considering potential hazards and their consequences as part of the HAZOP process. Without appropriate HF input, engineers within HAZOPs can sometimes make unreasonable assumptions about the behaviour and performance that can be expected by operators. In turn, this can potentially lead to incorrect assumptions being made that particular hazards can be adequately addressed by training and procedures, rather than recognising the need for engineered solutions and design changes.

The approach to be taken for the consideration of HFE within HAZOPs is likely to vary, depending on the size and complexity of the project, the degree to which plant processes are reliant on manual operator actions, whether operations are safety critical, and the preferred approach of the organisation(s) involved. Prior to the HAZOP, the project should determine, in consultation with the HFE lead, whether or not there is a need to formally incorporate HF considerations into the process and who will be responsible for ensuring consideration of HF issues during the sessions:

- As a minimum, there should be someone in the HAZOP with at least the 'HFE support' level of competency who has the responsibility for making sure that HF issues are given due consideration. Any significant HF related issues identified during the HAZOP should be followed up by an HF specialist and potentially captured in the HFIR or agreed HFE issues register mechanism.
- For projects involving significant human interactions and safety critical tasks, an HF specialist, with a minimum of the 'HFE practitioner' level of competency, should be required to attend the HAZOP sessions.

The agreed approach to be taken for inclusion of HF within HAZOPs should be documented in the HFIP.

The HAZOP chair and HF representative should meet prior to the HAZOP to confirm the approach to be followed and the HF guidewords to be used. The HF representative who will attend the HAZOP sessions should then prepare by reviewing relevant documentation related to the design under review (including P&IDs, layout drawings, etc.).

E.1.2 HAZOP process – using HF keywords and guidewords

HF considerations should be covered within the HAZOP via the use of suitable HF-related guidewords.

Where the HAZOP session is focused only on identifying causes of potential hazards, a recommended minimum approach can be to include 'human error' as a keyword (i.e. alongside 'flow', 'pressure', etc.) and then to record any potential credible causes of human error (e.g. operator omits step in procedure or operator opens wrong valve, etc.). The assessment of the likelihood of such errors and any required mitigation measures will then be undertaken following the HAZOP by HF specialists as part of further HEA activities.

During the HAZOP sessions, the HF representative should contribute to the discussion like any other HAZOP member, focusing on the potential impact of human performance issues.

This includes considering any potential consequences of human errors, including where such errors could impact on barriers and controls protecting against hazards. It should be the HF representative's responsibility to bring to the HAZOP team's attention any known instances of human error relating to items under discussion and, where necessary, to challenge any assumptions made by the team about the standards of human performance or behaviour that can reasonably be expected by staff.

Following completion of the discussion of the standard keywords and guidewords (modifiers) for each node, the HF representative should summarise any significant HF concerns that have been identified. The guidewords shown in Table E.1 can also be used to summarise any issues identified and to prompt further discussion, if necessary, to capture any additional HF issues that might not have been previously identified during the session.

Table E.1: Guidewords for summarising HF impact in HAZOPs

Keyword (parameter)	Modifier (guideword)	Meaning	Example HF issues
Human factors	Operational barriers (operability)	Are there any specific human activities or behaviours expected of normal operations associated with the node that are directly relied on as a barrier preventing an event or incident occurring, or to mitigate the consequences?	– Operator may not always appreciate the significance of an alarm (e.g. fail to realise a known nuisance alarm is actually real in this instance) – Detecting signs of corrosion during visual inspection – Operator may not act on the correct unit or equipment (e.g. where there are multiple or similar units)
	Maintenance barriers	Is the HAZOP team aware of any instances where human performance or behaviour during maintenance has led to failure to properly maintain a safety critical barrier?	– Incorrect isolations – Fitting of incorrect gasket on a manifold – Replacing valves in wrong orientation following turnaround – Fitting incorrectly threaded – Taking oil sample from filter under pressure
	Escalation factors	Are there any credible factors specifically associated with the node that could increase the likelihood of human unreliability	– Particularly difficult tasks, especially involving complex cognition, reasoning or reliance on memory – Lack of space causing poor accessibility – Difficult viewing conditions (sight lines, legibility, lighting, etc.)

Table E.1: Guidewords for summarising HF impact in HAZOPs (continued)

Keyword (parameter)	Modifier (guideword)	Meaning	Example HF issues
		in operating or maintaining an identified safety barrier, or in responding to an event at the node?	– Associated safety hazards (hot surfaces, falls from height, radiation sources, etc.) – PPE, breathing air or winter clothing – Particularly difficult or unpleasant working conditions

N.B. It should be noted that, typically, general HAZOP sessions are not used to systematically identify all possible human errors for a system. Where the need for detailed human error identification is required, it would be more common to convene a specific 'human HAZOP' session or similar workshop. Similarly, the SCTA process involves error identification as a first step.

If there is judged to be a need to consider the potential for human errors in detail, then more detailed HF related guidewords can be used as shown in Table E.2 (Ellis and Holt [2009]):

Table E.2: 'Human-HAZOP' guidewords

HF keyword	HF guideword (modifier)
No/none	Not completed
More/less	Too fast/much/long Too slow/little/short
Reverse	In the wrong direction
Sooner/later	Too early/too late At the wrong time In the wrong order
Part of	Partially completed
Other than	On the wrong object
As well as	Wrong task selected Task repeated

E.1.3 Following the HAZOP

Typical deliverables from an HAZOP are the HAZOP worksheets and the HAZOP report. Both should contain a record/audit trail including the identification of key HF issues (and associated assumptions).

Where actions have been identified in relation to HF issues, the HF representative should be responsible for ensuring these are recorded in the HFIR (or other agreed mechanism for logging HFE issues) and where appropriate (i.e. if the HAZOP was attended by someone with 'HF awareness' competence only), bringing in further HF specialist resource to support resolution. In most instances, there will potentially be a requirement to carry out further HEA activities following the HAZOP. Actions may also be assigned to design discipline engineers to address any identified issues.

E.1.4 Further information

Ellis G. R. and Holt, A. *A practical application of human-HAZOP for critical procedures*, Symposium Series No.155. IChemE, HAZARDS XXI, 2009

Kletz, T. *HAZOP AND HAZAN: Identifying and assessing process industry hazards*, 4th Edition, IChemE

E.2 SAFETY CRITICAL TASK ANALYSIS (SCTA)

E.2.1 Introduction

SCTA is sometimes also called safety critical task assessment or critical task analysis. It is a methodology for undertaking human error identification and assessment to demonstrate that any risks associated with human error will be reduced to ALARP.

The key aspect of SCTA that differentiates it from other similar techniques is that it focuses on analysing in detail those tasks which are identified as being 'safety critical'. For complex projects with many activities, SCTA can therefore be a useful approach to take to help focus HF specialist input on analysing those tasks that are the most critical to safe operations. SCTA is an approach that is now commonly used across the energy sector and is heavily promoted as reflecting good practice by the UK regulator, the HSE.

E.2.2 Approach

The detailed approach to be followed for SCTA may vary according to the specific requirements of the project and the preferences of the organisation(s) involved. However, the overall basic approach can be summarised below in Figure E.1 (adapted from EI *Guidance on safety critical task analysis (SCTA)*):

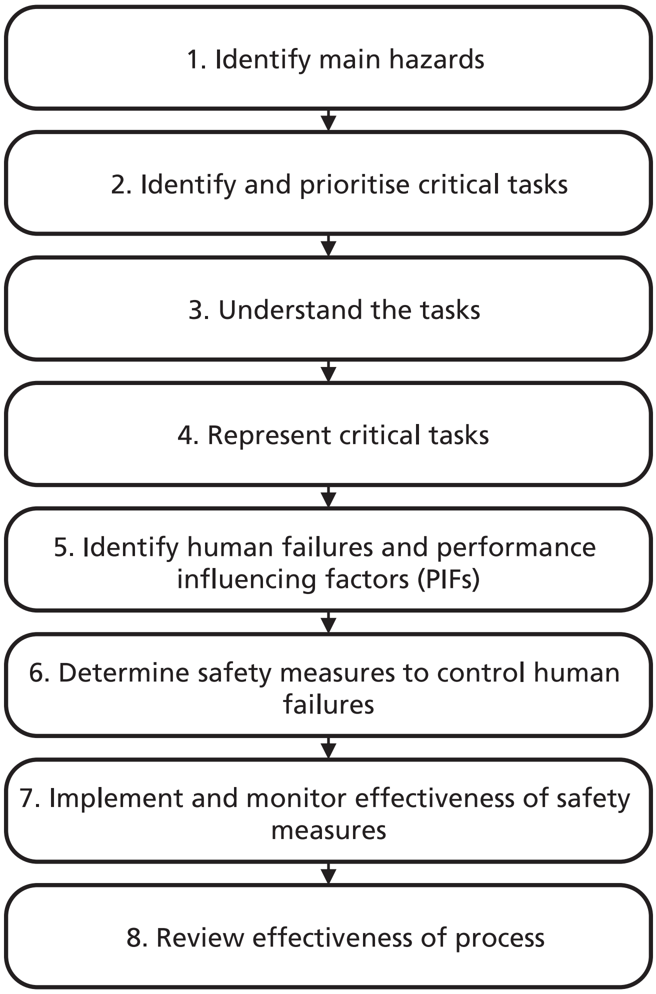

Figure E.1: SCTA process

Depending on the size of the project, a critical task inventory (CTI) may be produced to identify all tasks that impact on MAHs. Tasks for inclusion in the CTI may be identified from HAZOPs and other hazard identification activities. Where a CTI is present, this can be used as the key initial source for identifying potential safety critical tasks (SCTs). If a CTI is not available, then a list of potential SCTs and activities may need to be identified through discussions with project discipline engineers and end-user representatives and reviews of available documentation on O&M procedures.

The definition of an SCT is likely to be agreed on a project-specific basis; however, SCTs are typically defined as tasks where a human failure could:

- lead directly to a major accident;
- result in the escalation of a major accident;
- reduce the effectiveness of a barrier against a major accident, or
- impact on the potential to recover from a major accident.

Typically, once potential SCTs have been identified, an initial high-level screening will be undertaken to rule out any operations that have no safety critical implications (for example, where the system or piece of equipment being operated has no safety critical functionality). The next step is then to review the remaining SCTs systematically to determine the consequence of failure and whether these consequences could be safety critical.

Additional data collection or task analysis may be undertaken at this point, if considered necessary, to develop descriptions of the tasks in sufficient detail to be able to carry out detailed HEA.

The detailed HEA process is then typically performed in the form of a workshop facilitated by an HF specialist and attended by appropriate end-user representatives and discipline engineers with knowledge of the tasks under assessment. The HEA workshop process involves reviewing each SCT in turn, normally by breaking tasks down into sub-tasks. For each sub-task the potential 'worst case' consequence of a credible human error or violation is considered. Where an unrecovered consequence could impact on an MAH then the sub-task is confirmed as safety critical and analysed further. Sub-tasks that are not safety critical are excluded from further analysis. For safety critical sub-tasks, the following systematic HEA is then carried out:

- Relevant performance shaping factors (PSFs)/performance influencing factors (PIFs) are identified. These are factors that could impact on the likelihood of a human failure occurring, such as time pressure, difficult to access equipment, etc.
- The likelihood of the human failure is assessed. This is usually a qualitative ranking (e.g. high/medium/low) in line with any other risk ranking that the project may already be using.
- The consequence of the human failure (if not recovered) is recorded. For instance, overfilling of tank leading to spillage and potential fire.
- The existing control measures (to prevent occurrence of the human failure) are recorded. For instance, this might include supervisory checks or job aids.
- The existing recovery measures (to recover from the human failure before the consequences occur) are recorded. For instance, the use of alarms.
- Any recommendations for additional control and/or recovery measures necessary to reduce risk to ALARP are then discussed, agreed and recorded.

Actions and recommendations arising from the workshop should be captured in a spreadsheet and also recorded in the HFIR (or other agreed mechanism for logging HFE issues), where necessary. HF specialist resource can then support resolution of these issues.

E.2.3 Further information

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ANNEX F
HFE PLAN FOR CONSTRUCTION

F.1 INTRODUCTION AND OBJECTIVES

An HFE plan for construction should be produced to cover the HFE verification and validation activities to be carried out during construction and commissioning.

For large and complex projects, the HFE plan is likely to be a standalone document. However, for less complex projects it may be sufficient for the plan for construction to be included as an annex or section of the HFE close-out report produced at the end of the Execute (detailed design) phase.

The plan should be produced at the end of the Execute (detailed design) phase, but may need to be expanded and up-issued at the beginning of the construction phase as more detail becomes available on the construction schedule.

The objective of the HFE plan for construction is to specify the HFE activities that will need to be carried out and the HFE issues to be considered during the construction phase. Ensuring proper consideration of HFE during the construction phase will help ensure that the operational and maintenance HFE criteria specified during the previous design phases are verified and validated.

The plan should be used to guide the construction contractor to ensure HFE requirements are met and to avoid any requirement for rework. It should help guide the construction contractor on how to install equipment not usually shown in 3D computer aided design (CAD) models, including 'field-run' installed equipment (e.g. small-bore piping, instrument cabling, secondary cable trays, etc.). The aim is to ensure that the HFE design intent is assured throughout the construction phase and will not be compromised by the location of 'field-run' items.

F.2 SUGGESTED CONTENTS

The content of the plan and the specific activities required will be project-dependent. However, as a minimum the plan should cover the following:

- the HFE organisational arrangements that should be applied;
- the HFE design standards and specifications that should be applied;
- the HFE awareness training that should be provided to construction personnel;
- the HFE verification and validation activities that should be carried out;
- the process that should be followed for logging HFE issues and resolving any HFE non-compliances, and
- the requirements for any final HFE in construction report that is required to be produced.

Further guidance is provided in this Annex.

F.3 HFE ORGANISATION AND RESPONSIBILITIES

The plan should specify the requirement for an HFE lead/HFIM or HFE coordinator to oversee HFE during the construction phase. The key responsibilities of the HF specialist(s) appointed to support the construction phase should include:

- management of the HFE plan for construction;
- providing HFE awareness training;
- preparing a schedule for HFE verification and validation activities;
- preparing checklists and carrying out HFE walk-downs and verification reviews, and
- producing a final HFE in construction report if required.

F.3.1 HFE design standards and specifications

The plan should list the HF/ergonomics standards that should be applied during the construction phase and include any project-specific specifications or requirements that need to be passed to the construction contractor.

F.3.2 HFE awareness training

The plan should confirm the method(s) to be used for delivery of HFE awareness training. This training should be provided to ensure that all construction personnel have a suitable level of understanding of HFE considerations and are able to identify and deal with any issues that may arise. The preparation of training material should be undertaken by an HF specialist, based on an appreciation of the key issues that are applicable to the project. This should be informed by the output from the HFE close-out report for the Execute (detailed design) phase and any actions and/or issues that have been identified as needing to be taken forward or given particular consideration during the construction phase.

F.3.3 HFE verification and validation activities

The plan should specify the HFE verification and validation activities to be carried out. The objective of these reviews and audits will be to check that facilities and equipment are being installed as planned and that no compromises are being made in relation to clearances, sightlines, etc. which could adversely impact on operations or maintenance.

The plan should include details of who will carry out the verification and validation activities (including any required competency requirements, which should be addressed by the HFE awareness training), any checklists or tools to be used, and how the output should be documented. HFE checklists and prompts for use during these audits and reviews may be included as appendices within the plan.

Once the timeline and schedule of activities for the construction phase is defined, then the HFE lead/HFIM should propose an appropriate schedule for undertaking the HFE verification and validation activities. It may be possible to combine these reviews with other O&M surveillance activities.

F.3.4 HFE issues management

The plan should specify the process to be followed for logging HFE issues and resolving any HFE non-compliances. If an HFIR is already in place from earlier design phases, then it is likely to be beneficial to continue to use it to track and manage HFE issues to their resolution.

F.3.5 Requirement for HFE in construction report

The plan should specify whether or not a separate HFE in construction report will need to be produced. For many projects, documented output from the HFE verification and validation reviews, along with demonstration of the closure of any outstanding HFE issues, is likely to be sufficient.

ANNEX G
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ANNEX H
ABBREVIATIONS AND ACRONYMS

ABS	American Bureau of Shipping
ALARP	as low as reasonably practicable
API	American Petroleum Institute
BCPE	Board for Certification of Professional Ergonomists
C.ErgHF	Chartered Ergonomics and Human Factors Specialist
CAD	computer aided design
CCTV	closed-circuit television
CCU	cat cracking unit
CHFP	Certified Human Factors Professional
CIEHF	Chartered Institute of Ergonomics and Human Factors
COMAH	control of major accident hazard
CPE	Certified Professional Ergonomist
CREE	Centre for Registration of European Ergonomists
CRIOP	crisis intervention and operability
CTI	critical task inventory
DCS	distributed control system
EI	Energy Institute
EEMUA	Engineering Equipment and Materials Users Association
EPC	engineering procurement and construction
ESD	emergency shutdown
Eur.Erg	European Ergonomist
FEED	front end engineering design
H2S	Hydrogen Sulfide
HAZID	hazard identification
HAZOP	hazard and operability (study)
HEA	human error assessment
HEP	human error probability
HF	human factors
HFE	human factors engineering
HFEIP	human factors engineering integration plan
HFESA	Human Factors and Ergonomics Society of Australia
HFI	human factors integration
HFIM	human factors integration manager
HFIP	human factors integration (or implementation) plan
HFIR	human factors issues register
HFWG	human factors working group
HMI	human machine interface
HOFCOM	Human and Organisational Factors Committee
HRA	human reliability assessment
HSE	Health and Safety Executive (UK)
I-CAB	International Competency Assessment Board
IEA	International Ergonomics Association
INCOSEC	International Council on Systems Engineering
IOGP	International Association of Oil and Gas Producers
ISO	International Organisation for Standardisation

IT	information technology
ITT	invitation to tender
JES	Japan Ergonomics Society
MAH	major accident hazard
MOM	Ministry of Manpower (Singapore)
PIF	performance influencing factor
P&ID	piping and instrumentation diagram
PPE	personal protective equipment
O&M	operability and maintainability
PSF	performance shaping factor
RAM	reliability, availability and maintainability
RHU	resid hydrotreater unit
SCT	safety critical task
SCTA	safety critical task analysis
TNA	training needs analysis
TRA	task requirements analysis
VCA	valve criticality analysis

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