UKOPA

United Kingdom Onshore Pipeline Operators' Association

Good Practice Guide

Human Factors: An Introduction for Pipeline Operators

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The guidance in this document identifies what is considered by UKOPA to represent current UK pipeline industry good practice within the defined scope of the document. All requirements should be considered guidance and should not be considered obligatory against the judgement of the Pipeline Owner/Operator. Where new and better techniques are developed and proved, they should be adopted without waiting for modifications to the guidance in this document.

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CONTENTS

1. INTRODUCTION

1.1 Background

The United Kingdom Onshore Pipeline Operators' Association (UKOPA) provides pipeline operators with a recognised expert industry voice to influence the development of legislation and standards and helps pipeline operators develop a consistent view of strategic issues that relate to the safe operation and maintenance of onshore pipelines. The UKOPA Process Safety Working Group (PSWG) is formed from a wide range of representatives of our 30 member organisations, and focuses on providing information, direction, and guidance on pipeline process safety matters.

PSWG identified the need to develop a guidance document to provide pipeline operators with an introduction to Human Factors considerations relevant to the industry.

1.2 Objectives and Scope

The guidance in this document provides pipeline operators with an appreciation of the Human Factors considerations that are applicable to pipeline activities. The guidance discusses, at a high level, each of the major Human Factors topic areas that are used by the UK Health & Safety Executive (HSE) when assessing the adequacy of pipeline systems and processes.

The document is only intended to provide an introduction to the Human Factors topic areas. References are provided to where additional information can be found, and it is anticipated that more detailed Human Factors guidance will be issued by PSWG at a later date.

1.3 Legislative and Regulatory Requirements

There are no explicit references to Human Factors or ergonomics within the Pipelines Safety Regulations 1996 (PSR) or the Gas Safety (Management) Regulations 1996 (GS(M)R), and no Human Factors regulatory requirements that relate specifically to pipelines. However, all UK companies have a legal obligation to ensure suitable and sufficient steps are taken to ensure health & safety risks are reduced to As Low as Reasonably Practicable (ALARP) under the Health & Safety at Work Act, and due consideration and application of Human Factors is recognised as an essential part of achieving ALARP. General regulatory guidance on the application of Human Factors in the workplace, including HSG48 'Reducing error and influencing behaviour'[1], also applies.

The Human Factors requirements under Control of Major Accident Hazards (COMAH) apply for terminals and some storage facilities, and for pipelines within the boundary of COMAH establishments; however, they do not technically apply to the pipelines themselves. Nevertheless, for pipeline operators, there is a need to ensure due consideration of Human Factors in relation to operations and maintenance, and the UK HSE typically uses the COMAH Competent Authority (CCA) 'Human Factors Delivery Guide'[2] as a means of assessing compliance with 'best practice'. The following is an extract from the Delivery Guide:

> *"The General Duty under COMAH requires that every operator must take all measures necessary to prevent major accidents and limit their consequences for human health and the environment. Where reliance is placed on people as part of those necessary measures, human factors and human reliability should be addressed with the same rigour as technical and engineering measures. Duty-holders at non-COMAH sites may be required to address HF with a similar degree of rigour under other legislation - including COSHH - if they rely heavily on people to manage high-hazard risks."*

1.4 Application

This document is intended to be used by members of UKOPA to help understand the Human Factors considerations for safe and efficient pipeline operations, including pipeline maintenance, inspection, and emergency preparedness. Guidance is also provided on the sorts of Human Factors inputs and activities that may be required to support the design and commissioning of new pipelines, or major modifications to existing infrastructure. Additionally, the document is intended to help members to understand and satisfy the requirements of the UK regulator on the topic.

The guide is provided as an aid to decision making and should not be treated as a definitive or exhaustive guide on all Human Factors requirements, as these will vary by project, asset, and operational phase.

1.5 Abbreviations

ALARP	As Low as Reasonably Practicable
CCA	COMAH Competent Authority
CIEHF	Chartered Institute of Ergonomics and Human Factors
CIS	Chemical Information Sheet
CMS	Competence Management System
COMAH	Control of Major Accident Hazards
COSHH	Control of Substances Hazardous to Health
CP	Cathodic Protection
EI	Energy Institute
GS(M)R	Gas Safety (Management) Regulations 1996
HAZID	Hazard Identification study
HAZOP	Hazard and Operability Study
HFA	Human Failure Assessment
HFE	Human Factors Engineering
HFI	Human Factors Integration
HPOG	Human Performance Oil & Gas
HSE	Health and Safety Executive
IOGP	International Association of Oil & Gas Producers
IPIECA	International Petroleum Industry Environmental Conservation Association
ISC	IChemE Safety Centre
KPI	Key Performance Indicator
MA	Major Accident
MAH	Major Accident Hazards
MAPD	Major Accident Prevention Document
MATTE	Major Accident to the Environment
MIT	Maintenance, Inspection & Testing
PIF	Performance Influencing Factor
PSR	Pipelines Safety Regulations 1996
PSWG	Process Safety Working Group
PtW	Permit to Work
SCTA	Safety Critical Task Analysis
UKOPA	United Kingdom Onshore Pipeline Operators' Association
WTTT	Walk, Through Talk, Through

1.6 Document Structure

Section 2 of this guidance provides a number of Human Factors definitions and discusses the overall application of Human Factors for pipelines.

Section 3 then provides specific guidance, structured around the ten Human Factors 'key topics' as documented by the UK HSE (https://www.hse.gov.uk/humanfactors/top-ten.htm).

2. INTRODUCTION TO HUMAN FACTORS

2.1 What is Human Factors?

The terms 'Human Factors' and 'ergonomics' can be used interchangeably, with some sectors preferring one term over the other. For the oil & gas & petrochemicals sector, the term Human Factors is preferred.

The Chartered Institute of Ergonomics & Human Factors (CIEHF) provides the following definition from the International Ergonomics Association (https://iea.cc/about/what-is-ergonomics/):

> *"Ergonomics is 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 Human Factors, taken from its publication Reducing error and influencing behaviour (HSG48)[1]:

> *"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."*

Consideration of Human Factors therefore means ensuring that built designs, systems and work processes effectively support the tasks that individuals are required to carry out. Human Factors Engineering (HFE) is a term that describes this incorporation of Human Factors within the engineering design process. The following definition is from EI / IOGP Report 454[3]:

> *"HFE focusses 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 focussed on the physical aspects of the workplace, including ensuring equipment is easily accessible, operable, and maintainable."*

2.2 Scope of Human Factors for Pipelines

Human Factors considerations apply across the lifecycle of pipeline projects and operations, including: the design and construction of new pipelines; the modification of existing pipelines; pipeline operation, maintenance, and inspection; and pipeline decommissioning. While the application of Human Factors is necessary to ensure safe and efficient operations, it becomes critical when safety critical pipeline activities are undertaken which could result in major process safety consequences. In these instances, the regulator will have rigorous expectations for the application of Human Factors good practice.

This document introduces Human Factors by briefly discussing the ten 'key topics' used by the HSE. The application of these topics to each phase of the project lifecycle is summarised below in Table **2.1**.

<table>
<tr><th>Pipeline Lifecycle Phase</th><th>Concept Development, Optioneering and Project Specification</th><th>Basic Design/ Concept</th><th>Detailed Design</th><th>Construction & Commissioning</th><th>Operation, Maintenance and Modification</th><th>Decommissioning</th></tr>
<tr><td>Human Factors in Pipeline Design
See 3.1</td><td colspan="5">Human Factors Engineering (HFE) should be integrated into the design lifecycle and applied for any major design modifications that are made during operations.</td><td></td></tr>
<tr><td>Managing Human Failures
See 3.2</td><td></td><td colspan="5">The potential for human failures during pipeline operations should be minimised by designing systems and processes in line with Human Factors and ergonomics principles.
Consideration of Human Factors risks, and human failure potential should be part of the risk assessment activities undertaken to support the introduction of new facilities or processes, and whenever changes are proposed to existing arrangements.
Initial Safety Critical Task Analysis (SCTA) screening is likely to be required during the design and commissioning phase for new pipeline facilities. There may then be an ongoing requirement for SCTA during the operational phase. If new procedures and activities are required to support decommissioning, these may also require SCTA.</td></tr>
<tr><td>Human Factors in Maintenance, Inspection and Testing (MIT)
See 3.3</td><td></td><td></td><td colspan="4">Considerations for MIT should be taken into account during the detailed design of equipment. There will then be an on-going requirement to consider Human Factors during MIT during the operational and decommissioning phases.</td></tr>
<tr><td>Procedures
See 3.4</td><td></td><td></td><td></td><td colspan="3">Human Factors best practice principles should be applied for the development of new procedures, and wherever changes or updates are proposed during operations and / or emergency response.</td></tr>
<tr><td>Training and Competence
See 3.5</td><td></td><td></td><td></td><td colspan="3">Training and competence considerations should form part of the design and commissioning process for any new pipeline facilities. There is then an ongoing requirement to effectively manage staff competence during the operational phase of the pipeline.</td></tr>
<tr><td>Staffing
See 3.6</td><td></td><td></td><td></td><td colspan="3">Staffing decisions should form part of the design and commissioning process for any new pipeline facilities. There is then an ongoing requirement to effectively manage staffing arrangements during the operational phase of the pipeline.</td></tr>
<tr><td>Organisational Change
See 3.7</td><td></td><td></td><td></td><td></td><td colspan="2">Consideration of Human Factors issues for any proposed organisation change will apply during the operational and decommissioning phases.</td></tr>
<tr><td>Safety Critical Communications
See 3.8</td><td></td><td></td><td></td><td></td><td colspan="2">Consideration of safety critical communications will apply during the operational and decommissioning phases.</td></tr>
<tr><td>Fatigue and Shiftwork
See 3.9</td><td></td><td></td><td></td><td colspan="3">The design of the shift system should form part of the design and commissioning process. Fatigue and shiftwork considerations will then apply during the operational and decommissioning phases.</td></tr>
<tr><td>Organisational Culture
See 3.10</td><td></td><td></td><td></td><td></td><td colspan="2">Consideration of organisational culture issues will apply during the operational and decommissioning phases.</td></tr>
</table>

Table 2.1: Application of Human Factors to Pipeline Lifecycle

For pipeline operators, one of the key focuses for Human Factors is the operational phase. It needs to be ensured (and demonstrated to the regulator) that pipelines can be safely and effectively operated. The potential for human failures, which could introduce significant hazards, should be eliminated, or minimised through the application of appropriate designs, systems, and processes.

PSR 1996 Regulation 10[4] states:

> *"The operator shall ensure that modification, maintenance or other work on a pipeline is carried out in such a way that its soundness and fitness for the purpose for which it has been designed will not be prejudiced."*

3. HUMAN FACTORS GUIDANCE

3.1 Human Factors in Pipeline Design

To minimise the potential for human errors and ensure a safe working environment when personnel are working on and maintaining pipelines, facilities must be designed in line with ergonomics 'good practice' principles. These principles, and the application of HFE, should be applied wherever there is a requirement for personnel to interface with equipment for operations or maintenance. This will apply where new pipelines are being designed, or where major changes are being proposed to existing pipeline assets.

For most projects, the focus of the application of HFE in design will be on ancillary pipeline facilities like Control Rooms and pig launchers where there are multiple Human Machine Interfaces (HMIs). For pipelines themselves, the key requirement is to ensure operability and maintainability of the assets.

The Energy Institute (EI) / International Association of Oil & Gas Producers (IOGP) Report 454 guidance 'Human Factors Engineering in Projects'[3] describes the HFE process to be followed during the project design lifecycle. The starting point for any modification or development of a new asset is to conduct Human Factors screening to determine the level of HFE support needed and the type of HFE design inputs and activities that may be required. Report 454 provides guidance on these, along with guidance on effective Human Factors Integration (HFI) throughout the design lifecycle.

3.2 Managing Human Failures

For any activities that are conducted on pipelines, there will be the potential for human failures to occur, with potential adverse consequences for safety, reliability, and operability. Human failures are errors (unintended actions or decisions) or violations (deliberate deviations from rules or procedures) and cannot be totally eliminated. HSG48 provides a fuller description of the types of human failure[1].

It is critical to reduce the potential for human failures as much as possible by designing systems and processes appropriately and optimising the Performance Influencing Factors (PIFs) that can impact on failure likelihood.

There is a need to apply appropriate processes to demonstrate that the risks associated with human failures have been reduced to the lowest level that can be achieved without excessive cost, effort, or time (i.e. to ALARP).

Consideration of the impact of Human Factors is also required as part of incident investigation so that any relevant Human Factors-related root causes can be identified and addressed. An appropriate taxonomy (such as that used in the Energy Institute guidance on Safety Critical Task Analysis [SCTA] [5]) should be used to ensure that the full range of possible Human Factors related causes associated with pipeline incidents is systematically explored.

3.2.1 Human Factors in Risk Assessment

Consideration of Human Factors and the potential impact of human failures should form part of the risk management activities that apply to pipeline operations, including hazard identification and risk assessment processes.

Human Factors and the potential for human failures should be considered when assessing potential hazards and their consequences during HAZOPs (Hazard and Operability Studies) and HAZID (Hazard Identification) studies. As a minimum, Human Factors considerations should be covered within HAZOPs and HAZIDs via the use of Human Factors related guidewords. Bowtie analyses should also consider Human Factors, both as threats and barriers / controls. For pipelines where there is process safety risk, the involvement of a Human Factors specialist in HAZOP, HAZID and bowtie workshops is recommended.

3.2.2 Safety Critical Task Analysis

A safety critical task can be defined as:

> *"A task in which human action or inaction could initiate, fail to control or fail to mitigate a Major Accident (MA)."*[6]

This definition can be extended to tasks that are environmentally critical and can impact on the potential for Major Accidents to the Environment (MATTE). Both operations and maintenance tasks can be safety critical, as well as specific steps to be taken in response to an emergency.

Examples of safety critical errors for pipelines might include omitting to isolate a valve prior to pipeline maintenance or incorrect fitment of a blank following completion of the work, both leading to a potential loss of containment. Similarly, errors made in carrying out specific maintenance steps on pipeline plant and equipment could increase the potential for later mechanical failure or result in safety instrumented systems not working as intended. Lastly, a failure to correctly take the required actions in the event of a loss of containment or other pipeline emergency could increase the severity of the safety consequences and prolong the incident, reducing the opportunity for an effective and timely recovery.

Where pipeline operations involve safety critical tasks or activities which could have a potential consequence for process safety (i.e., a MA or MATTE), then there will be a requirement to conduct systematic Human Failure Assessment (HFA) for these activities. SCTA is seen by the UK HSE as the primary means of doing this and demonstrating human reliability for safety critical activities.

An overview of the SCTA process is shown in Figure 3-1.

The first part of the SCTA process involves reviewing and screening activities to identify those that are safety critical, based on an understanding of potential MA and MATTE consequence, and to prioritise them for detailed assessment (step 2). For pipelines, safety critical activities are likely to be those that may intentionally or unintentionally result in the breaking of containment and/or disabling of safety protection systems. Pigging operations, involving the operation of pig launchers and receivers, are likely to be identified as safety critical in most scenarios.

Once activities have been identified for detailed HFA, then there is a need to gain an accurate understanding of the steps involved, typically by carrying out walk-throughs and talk-throughs (WTTT) with those operators who participate in the task. For pipelines, this may involve observations of personnel involved in pipeline maintenance.

The detailed HFA (step 5) is undertaken in a workshop environment, with the involvement of personnel who are experienced in conducting the activities that are under assessment. Each step in the activity should be reviewed in turn and credible human failures identified, along with the potential consequences of these failures. A taxonomy of human failures, such as the one provided by the Energy Institute[5], should be used to inform this systematic review. For task steps identified as safety critical, any PIFs that could increase the likelihood of the human failures occurring should then be identified and discussed (e.g., for pipeline operations, these may include issues associated with accessibility or environmental stressors). The effectiveness of existing control measures in reducing the potential for human failures and minimising their consequence should then be assessed to determine if any additional control measures or safeguards are required to reduce risk to ALARP. Dependent on the specific situation and any issues identified, additional measures might include the introduction of additional engineered safeguards or making improvements to procedural controls (e.g., including additional independent checks and signoffs).

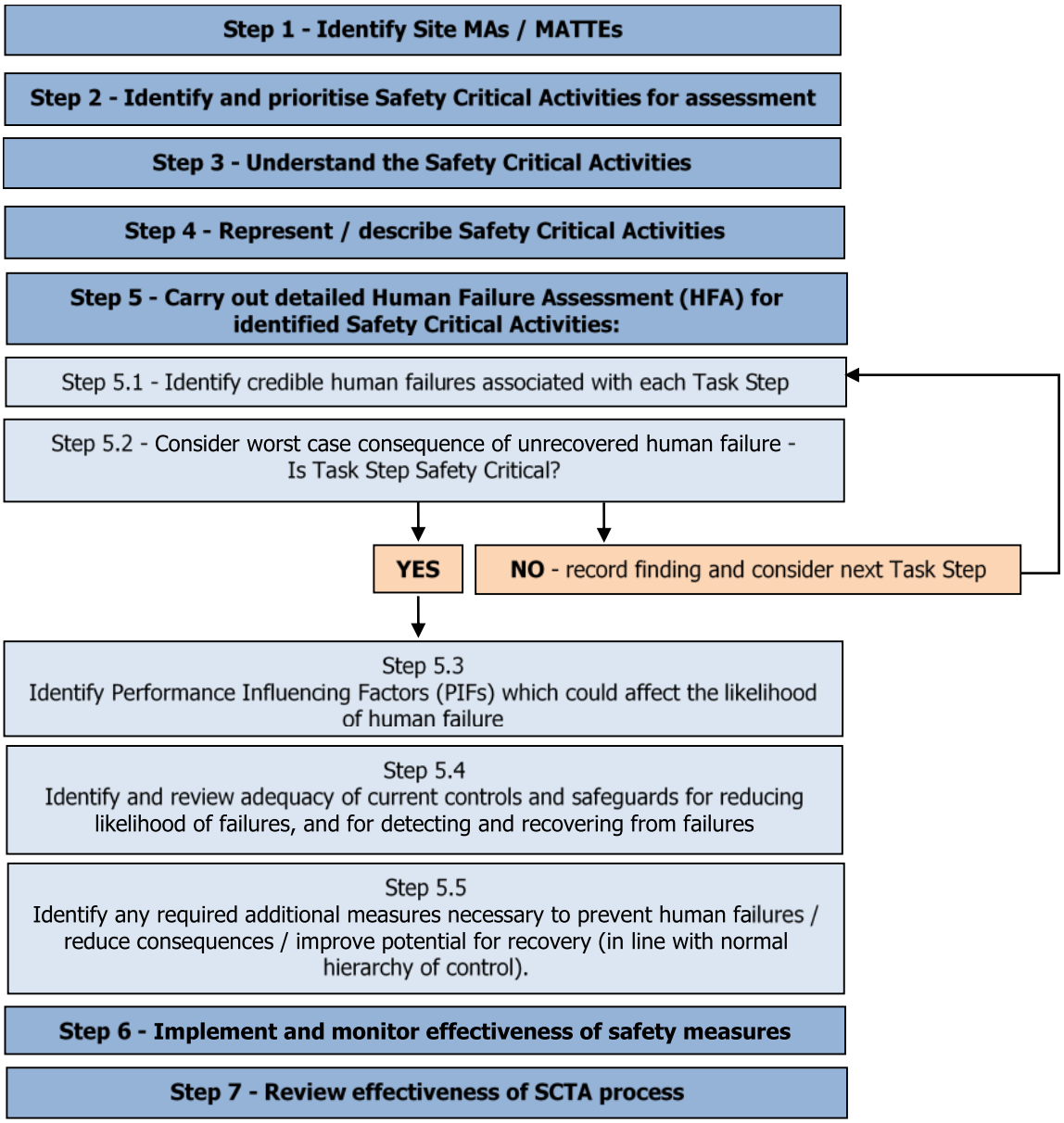

Figure 3-1 SCTA Process Overview

Detailed guidance on the approach to be followed for SCTA is available from the CIEHF[6] and the Energy Institute[5]. The latter document provides useful practical guidance on the application of the approach, including suggested competence requirements for those who take part in workshops and assessments.

3.3 Human Factors in Maintenance, Inspection and Testing (MIT)

Maintenance, Inspection and Testing (MIT) are key activities for pipeline operators and should be a key focus when thinking about the potential risks associated with human failures. It must be ensured that suitable arrangements are in place for personnel to conduct MIT tasks safely and efficiently, taking account of Human Factors considerations.

During MIT of safety critical pipeline equipment there may be the potential for Major Accident Hazards (MAH). For example, this may be due to breaking of containment, making critical joints, and ensuring re-instatement of engineered protection measures following the completion of maintenance. PIFs that

can impact on the MIT of pipelines may include problems with accessibility to equipment, degraded labelling, and the availability of tools and spares. There may be particular challenges in conducting MIT in remote areas, where personnel may be working alone, or where there are adverse environmental working conditions.

Some key Human Factors considerations for MIT are as follows:

- Any equipment that is identified as an active or passive engineered safeguard against a MAH, including critical safety-instrumented systems, should be included in safety critical equipment registers for maintenance management purposes, and the MIT activities associated with them should be listed in the critical task register. MIT activities associated with safety critical equipment should be subject to SCTA or a similar human reliability assessment process to ensure that any risks associated with human failures are reduced to ALARP.
- A robust process needs to be in place for determining the number of staff required to safely carry out MIT activities, and how responsibilities should be allocated between them (see Section 3.6). Consideration needs to be given to any tools that will need to be used, any requirements for lifting of heavy equipment, and the need for supervision, checking and sign-off.
- A suitable competence management system is required to ensure that the personnel undertaking MIT activities, and those supervising them, are competent to do so, and that there is a robust process in place to monitor and manage this requirement. There is also a need to assure the competence of any sub-contracted MIT resource.
- The procedures and working instructions that are used for MIT need to be designed in line with Human Factors 'good practice' principles for usability. This is particularly important for complex maintenance that is undertaken infrequently where personnel will be reliant on following the step-by-step instructions correctly.
- Suitable arrangements must be in place to ensure effective communications between personnel involved in MIT on pipelines, including between individuals who may be working for different organisations.

Links to guidance on the management of maintenance errors can be found on the HSE website:

https://www.hse.gov.uk/humanfactors/topics/error.htm.

A Human Factors briefing note on this topic is available from the Energy Institute:

https://publishing.energyinst.org/topics/process-safety/leadership/human-factors-briefing-note-no.4-maintenance

3.4 Procedures

Inadequacies associated with the design and management of procedures and working instructions are a commonly cited contributor to failure to prevent or effectively respond to incidents and accidents. There must therefore be a robust and demonstrable process in place for the development and ongoing management of procedures associated with pipeline operations, MIT, and emergency response.

Human Factors 'good practice' principles of usability must be applied when producing and updating procedures to ensure they can be easily followed and that the potential for human errors or deviations from required task steps is minimised. This requirement is especially critical where procedures and working instructions relate to safety critical activities. It is also critical that emergency response procedures are easy to follow, have clearly define roles and responsibilities, and support fast and effective decision-making.

Some of the key principles that should be applied for the design of step-by-step procedures and instructions design, include:

- Use a single action per procedural step.
- Begin each step with an action verb (e.g., 'Start,' 'Check').
- Use the present tense.
- Use simple language (e.g., 'Start' not 'Commence').
- Use positive commands, avoid double negatives.
- Support place-keeping (e.g., by providing check boxes).
- Clearly mark and differentiate safety critical steps and include a warning of the MAH risk prior to the step.
- Use safety information symbols (e.g., for Danger, Warning, Caution).
- Utilise job aids such as flowcharts, diagrams, and decision tables to aid decision making.

Detailed guidance on the development and design of effective procedures is provided in the Human Performance Oil & Gas (HPOG) document 'Best Practice in Procedure Formatting'[7].

3.5 Training and Competence

> *"Competence can be defined as the ability to undertake responsibilities and perform activities to a recognised standard on a regular basis. It is a combination of practical and thinking skills, experience, and knowledge."*[8]

It is essential to ensure that the personnel who engage in pipeline operations and MIT have the requisite training and competence to carry out their tasks safely to help minimise the potential for human failures and incidents. Where safety critical activities and tasks are conducted that could have a MAH consequence, then it is critical to ensure that the individuals with responsibility for performing these tasks have the right competencies (skills, knowledge, and experience) to carry them out safely and effectively. There is a need to be able to clearly demonstrate this linkage to the regulator.

All pipeline operating companies should have a suitable Competence Management System (CMS) in place that details how the competence requirements of personnel will be identified, developed, and maintained.

The general approach for the development of a new competence management framework can be summarised as follows:

Confirm the personnel to be covered by the competence framework.

- For the identified personnel, confirm roles, responsibilities, and tasks.
- Identify, define and map required competencies to tasks and responsibilities, including any required safety critical competencies.
- Establish competence level definitions for each competence element and determine the required training and experience required to satisfy each of these levels.
- Develop the competence assessment process (e.g., peer assessment or self-assessment), the evidence sources to be used, and the system for recording and reporting.
- Develop detailed guidance for roll-out of the competence framework.
- Implement the framework: map personnel competencies (and levels) to roles, conduct assessments and deliver training / take other developmental actions to address any 'gaps.'

The ORR document 'Developing and Maintaining Staff Competence'[8] provides detailed guidance on the steps involved in the development and management of an effective CMS.

The IChemE Safety Centre (ISC) provides a process safety competency model that can be used to support implementation of process safety competency criteria within a CMS.

A Human Factors briefing note on this topic is also available from the Energy Institute:

https://publishing.energyinst.org/topics/process-safety/leadership/human-factors-briefing-note-no.-7-training-and-competence

3.6 Staffing

It is important to ensure that there are adequate numbers of competent personnel assigned to conduct pipeline activities, based on the tasks that need to be performed. Staffing levels need to be appropriate to ensure that the workload on individuals is not too high, or too low. If individuals are subject to overload or underload this will increase the likelihood of performance issues and errors and impact on their health and wellbeing.

In determining minimum required staffing levels, consideration needs to be given to the nature of the tasks being performed, including:

- Do tasks require more than one operator?
- Is there a need for separate tasks to be carried out concurrently?
- Where are the tasks performed?
- What is the estimated workload (physical and cognitive) associated with completing the tasks?

The Energy Institute provides guidance on the approaches that can be used to assess workload and to determine and assess the adequacy of staffing levels[9].

The HSE Contract Research Report (CRR) 348/2001 describes a process that can be used to assess the safety of staffing arrangements for process operations in the chemical and allied industries[10] and is often cited by the HSE. However, this approach is focussed primarily on determining staffing levels for Control Room operations and so will only apply for pipelines where design and staffing of ancillary Control Rooms is a consideration.

The other areas of focus for Human Factors in relation to staffing, are the need to ensure that supervisory arrangements are robust and that there are suitable processes in place to manage the use of contractors. The HSE website provides further guidance on these topics:

https://www.hse.gov.uk/humanfactors/topics/supervision.htm

https://www.hse.gov.uk/humanfactors/topics/contractors.htm

A Human Factors briefing note on workload and staffing levels is available from the Energy Institute:

https://publishing.energyinst.org/topics/process-safety/leadership/human-factors-briefing-note-no.-23-workload-and-staffing-levels

3.7 Organisational Change

Human Factors implications must be considered as part of the management of change process that should be applied whenever changes are proposed to pipeline plant, equipment, or processes. For example, the introduction of new equipment for pipeline maintenance is likely to have implications for operator training and could potentially impact on individual workload.

Human Factors considerations are particularly critical in relation to proposed organisational changes such as:

- Changes to staffing numbers and staffing levels (e.g., associated with downsizing, outsourcing, re-structuring, etc.).
- Changes to organisational arrangements and management structure.
- Changes to staff roles and responsibilities.
- Changes associated with staff competence, health, and availability.

A failure to effectively assess and manage the impact of organisational changes can have an adverse impact on both operational efficiency and safety. Where safety critical activities are involved (e.g., associated with high pressure pipelines) this can include increasing the potential for MAH consequences. It is therefore important to follow an appropriately structured process to assess the Human Factors implications of any proposed changes.

The HSE Chemical Information Sheet (CIS) CHIS7 'Organisational Change and Major Accident Hazards'[11] provides guidance on the process to be followed for the assessment of organisational change. A Human Factors briefing note on this topic is also available from the Energy Institute:

https://publishing.energyinst.org/topics/process-safety/leadership/human-factors-briefing-note-no.-3-organisational-change

3.8 Safety Critical Communications

3.8.1 Verbal and Non-Verbal Communications

Clear and effective spoken, written, and non-verbal communications are critical to maintain the safety of pipeline operations, both within organisations and between different parties. Examples of key communications include:

- Work-related communications between team members, different teams and different organisations involved in pipeline operations and MIT activities.
- Effectively communicating the actions to be taken in response to incidents and during emergencies, including liaison with emergency services.
- Dissemination of essential risk and safety information to personnel, including required changes to processes.
- Transfer of critical information during shift handovers.
- Permit to Work (PtW) processes.

Where workers involved in UK pipelines work do not have English as a native language then these language barriers can raise the potential for miscommunication; similarly, the meaning of hand signals (such as those use for banksmen during lifting operations) can vary between countries and cultures. These factors need to be taken into consideration when establishing suitable and sufficient communication protocols.

3.8.2 Shift Handovers

Inadequacies in shift handover arrangements are often identified as key contributory factors to major incidents and accidents and so require particular attention.

Pipeline operators must ensure that formal and effective arrangements are in place for shift handovers to ensure that critical information is effectively transferred between shifts. Some key principles include:

- Shift handovers should be conducted face-to-face and involve a two-way process in which both participants take equal responsibility for the accurate transfer of information.

- Handovers should include a written element, and not be purely verbal.
- Sufficient time must be provided for the handover.
- There should be a cross-check of information by the in-coming personnel.

The HSE website provides links to some useful sources of guidance on designing effective shift handovers:

https://www.hse.gov.uk/humanfactors/topics/shift-handover.htm

3.8.3 Permit to Work

PtW arrangements should be developed in line with relevant good practice. Some key principles include:

- The Permit should contain all relevant information, be factually correct, and presented in a suitable format.
- Details of applicable hazards and controls should be communicated to all personnel involved in the work.
- All personnel at the site should be able to maintain an accurate and up-to-date situational awareness of the work being undertaken under permit. To support this, operations and other personnel must be made aware and kept informed of what maintenance staff are doing, and vice versa. If there are a number of separate permits in operation, they should be displayed at an appropriate location, and in a suitably systematic and straightforward way that enables staff to easily check which equipment is isolated, undergoing maintenance, etc. at any one time.
- The PtW system should include a clear and formalised process for the hand-over of plant on completion of the work.

The HSE document HSG250 ‘Guidance on Permit to Work Systems’[12] provides detailed guidance on this topic.

3.8.4 Key Principles for Safety Critical Communications

The HSE lists the following key principles for safety critical communications:

- Identify who needs to communicate, and what their communication needs are - this could be identified during risk assessment.
- Consider the best medium (e.g., face-to-face, procedure, radio) and method (e.g., written, verbal) of communication.
- Consider the required timings of key communications (e.g., draw attention to hazards before people are required to carry out tasks).
- Ensure the language is appropriate to the workforce (consider literacy, first language) and use appropriate terminology.
- Highlight safety critical steps in procedures and draw attention to them in training.
- If communication is critical, then consider using two or more methods or media for communication (e.g., follow verbal communication with a written back-up).
- Remember that putting signs up is not a substitute for communicating, though it may be part of it.

Links to further useful guidance on ensuring effective communications are provided here:

https://www.hse.gov.uk/humanfactors/topics/communications.htm

3.9 Fatigue and Shiftwork

Definitions of fatigue vary between industries, regions, and professional perspectives. A useful definition in the context of pipeline operations is:

> *"The decline in mental and/or physical performance that results from prolonged exertion, lack of quality sleep or disruption of the internal body clock."*[13.]

Fatigue negatively impacts human performance and increases the likelihood of human errors. Complex decision making becomes more difficult, the ability to retain and recollect information decreases, attention narrows, and it takes longer to notice changes and react to events, among other effects. There is also a negative impact on health and wellbeing. It is therefore critical that the potential for fatigue, and its impact on safe operations, is recognised by both employers and employees so that the risks can be effectively risk assessed and managed.

Working on a shift system, which is applicable for most pipeline operations, increases the likelihood that staff will be affected by fatigue as shift working disrupts the circadian body clock. In addition to working long hours without suitable breaks, other factors such as the time of day, the type of work being carried out (i.e. the degree of physical and/or mental exertion required) and the working environment may also affect the extent to which fatigue effects are experienced on any particular shift.

The way in which the shift system is designed can make a difference in terms of minimising the potential for fatigue effects. It is therefore important that, as far as reasonably practicable, shift arrangements for pipeline work are designed to take consideration of these recognised good practice principles. Some good practice guidelines for shift design include:

- Limit consecutive working days to a maximum of five to seven days and restrict number of consecutive night shifts to a maximum of four if possible.
- When switching from day to night shifts or vice versa, allow workers a minimum of 2 nights of full sleep.
- Encourage workers to take regular breaks and allow some choice as to when they are taken.
- Rotate shifts quickly (e.g., every two to three days).
- Use forward rotation (i.e., morning to afternoon to night).

An appropriate fatigue management policy and plan should be put in place to manage the fatigue risks associated with pipelines work. The following is recommended:

- Staff should be provided with training and education to enable them to identify the signs and symptoms of fatigue, along with guidance on appropriate coping strategies.
- Appropriate Key Performance Indicators (KPIs) and metrics should be in place to monitor adherence to agreed shift patterns and working hour limits and to provide an early warning of any potential fatigue concerns. Similarly, the contribution of potential fatigue effects to incidents and near misses should be investigated and monitored.
- Any proposed changes to shift arrangements or working hours (including proposals for extended or overtime hours) should be subject to a suitable and sufficient risk assessment.

The HSE publication HSG256[13] provides detailed guidance on optimising shift design and actions that can be taken to improve the workplace environment. Useful guidance on 'managing fatigue in the workplace' is also available from the International Petroleum Industry Environmental Conservation Association (IPIECA) / IOGP[14.]

A Human Factors briefing note on fatigue is available from the Energy Institute:

https://publishing.energyinst.org/topics/process-safety/leadership/human-factors-briefing-note-no.5-fatigue

Lastly, the HSE website lists other useful sources of guidance on this topic:

https://www.hse.gov.uk/humanfactors/topics/fatigue.htm

3.10 Organisational Culture

Organisation culture can be thought of as 'the way we do things around here' – it can be described as the sum of an organisation's beliefs, attitudes, and values and how these influence the way in which the personnel within the organisation behave. Safety culture can be described as:

> *"The product of individual and group values, attitudes, perceptions, competencies and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organisation's health and safety management."*[15]

The organisational and safety culture of an organisation will influence the way in which individuals behave and the degree to which rules will be followed and safety systems adhered to. Regardless of the systems that are in place, if there are issues with the underlying culture of an organisation, then this is likely to significantly increase the likelihood of a major incident or accident occurring.

It is therefore important to be able to obtain an accurate understanding of the culture of the organisation to determine if there are any specific areas that need to be addressed. One way of doing this is to conduct a Safety Climate survey which uses a questionnaire survey and interviews with staff to provide a snapshot of the organisation's culture in relation to safety.

The Energy Institutes provides a 'Hearts and Minds' safety culture toolkit that includes tools and guidance to help organisations to assess their current safety culture and then take the necessary actions to address any identified areas for improvement. The link to the toolkit can be found here:

https://heartsandminds.energyinst.org/toolkit?gclid=EAIaIQobChMIl4CnucfmgAMVjNF3Ch21AQ54EAAYASAAEgJKxfD_BwE

Links to additional sources of guidance on organisational and safety culture can be found at the HSE website:

https://www.hse.gov.uk/humanfactors/topics/culture.htm

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