Guidelines on Managing Human Factors in Major Hazard Installations

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About this set of Guidelines:

In Major Hazard Installations (MHIs), the human interface with control systems and equipment is crucial in ensuring safe operations and maintenance. Hence, it is important to address human factors in plant and process designs; operational and maintenance procedures; risk assessments; and safety-critical communications, which include shift handover and permit-to-work processes. Significant reliance on human interventions in plant operation can also imply increased susceptibility towards human failures, which can lead to catastrophic consequences.

Guidelines on Managing Human Factors in Major Hazard Installations

1. Objective

1.1 Identifying potential human failures and managing human performance are essential to improving human reliability. This document, "Guidelines on Managing Human Factors in Major Hazard Installations", is intended to highlight key milestones and provide reference guidance to MHIs, on Human Factor elements outlined in Appendix 5B of the Safety Case Technical Guide.

1.2 The desired outcome is demonstration in MHIs' Safety Cases that human factors are integrated into the risk assessment process, with clear links of Safety Critical Events (SCEs) to the assured performance of humans engaged in safety critical tasks. Figure 1 focuses on key elements to identify and optimise human performance so that risks are reduced to as low as reasonably practicable (ALARP).

2. Scope

2.1 This document is intended to aid the implementation of Human Reliability Analysis (HRAs) for both operational and maintenance activities. MHIs could approach the Major Hazards Department (MHD) for consultation if there are difficulties in doing so.

2.2 Further guidance on the following Human Factors elements is included in Section 8 of this document:

- Alarm Handling
- HF in Design
- Performance Influencing Factors (PIFs)
  - Managing organisational change;
  - Shift staffing level;
  - Fatigue management;
  - Site supervision;
  - Critical communications; and
  - Incident investigation covering human factors.

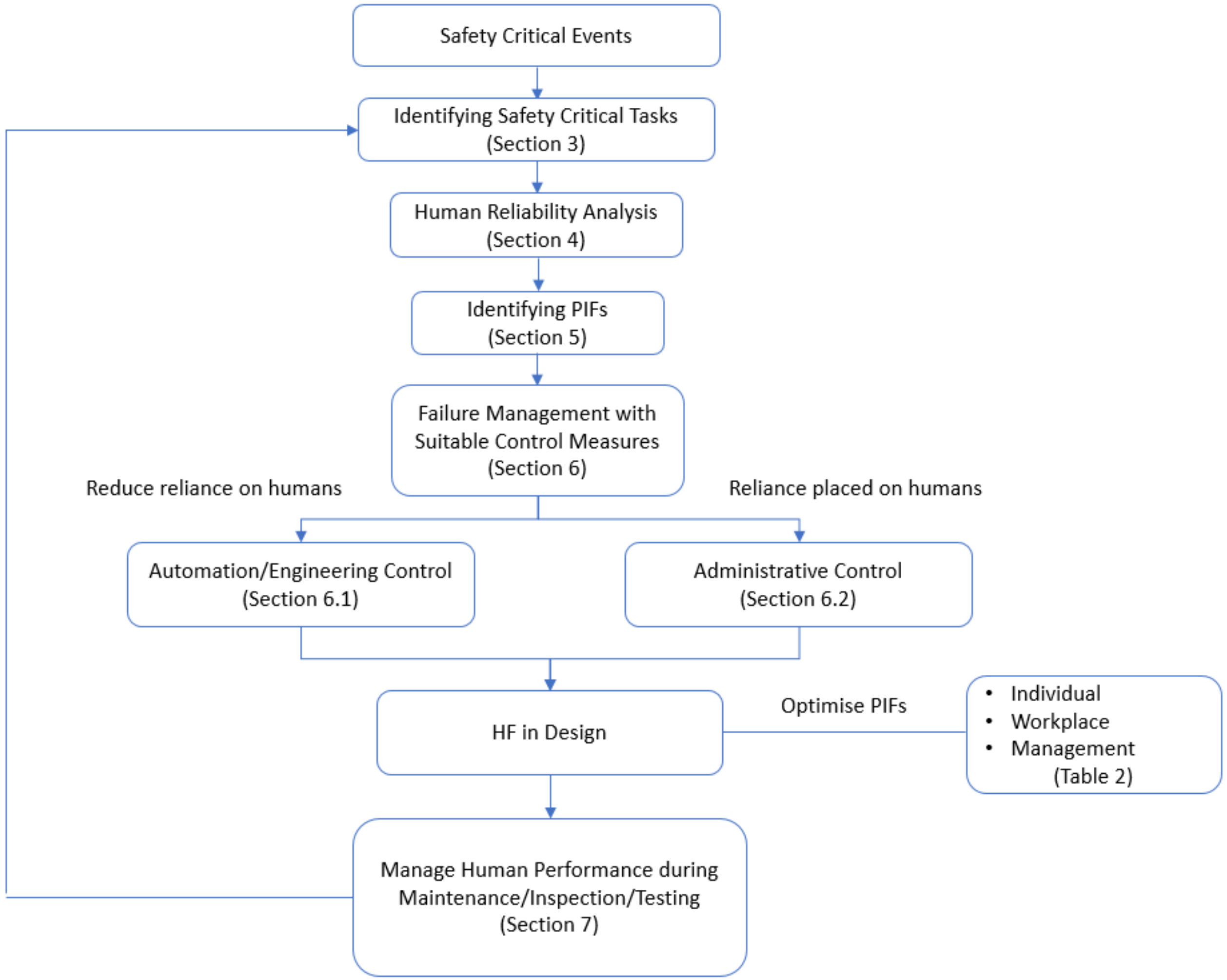

Figure 1: Human Factors Roadmap

3. IDENTIFYING SAFETY CRITICAL TASKS

3.1 For the Safety Case Regime, MHIs shall identify all MAHs and classify them into Major Accident Scenarios (MASs) with a relevant representative set, in accordance with **criterion 4.3** of the Safety Case Assessment Guide (SCAG). Thereafter, the Safety Critical Events (SCEs) shall be identified for ALARP demonstration as set out in **criterion 4.8** of the SCAG.

3.2 From the SCEs identified, all activities that require human interventions should be listed as 'Safety Critical Tasks'.

3.3 Safety Critical Tasks are actions or activities that have the potential to initiate an event sequence, stop an incident sequence, or prevent the escalation of an incident. Similarly, these tasks could be presented in the Bowtie Analysis, either as an initiating event or as a preventive/mitigative barrier or escalation control of a barrier.

3.4 For further analysis, each Safety Critical Task is broken down into key steps in a sequential order. These key steps should be elaborated into more detailed sub-steps. Invaluable insights could be gleaned from feedback from or interactions with operators, reviews of work procedures, job aids and training materials, observations of actual work done as well as, review of relevant risk assessments.

4. HUMAN RELIABILITY ANALYSIS

4.1 From the identified Safety Critical Tasks, a structured analysis is expected to be presented in Safety Cases, utilising suitable and effective analysis techniques to assess human contribution to risk. MHIs are expected to minimally conduct a qualitative analysis to identify credible human failures at each key step, using a recognised approach such as "Human-HAZOP". Examples of guidewords for "Human-HAZOP" are listed in Table 1 below.

4.2 MHIs should also include findings from incident investigations and accidents in the industry, to identify areas and root causes that attribute to human failures. An example of the assessment of human failures is provided in Appendix A.

Table 1: Human Failure Guidewords

Guide Word	Prompt / Parameter	Likely Human Failure
No/None	• Not completed at all	• Operator omits step in sequence • Operator experience level
More/Less	• Too fast/much/long • Too slow/little/short	• Overcharging of catalyst; Large quantity handled • Undercharging of catalyst; Smaller quantity handled
Reverse	• In the wrong direction	• Operator takes action in the wrong order (i.e. close valves instead of opening) • Wrong procedure selected and completed
Sooner/Later	• Too early/too late • At the wrong time • In the wrong order	• Operator takes action before specified time • Operator takes action after specified time
Part of	• Partially completed	• Operator did not carry out all tasks
Other than	• On the wrong object	• Operator acts on the wrong equipment; incorrect material handled
As well as	• Wrong task selected • Task repeated	• Operator takes the wrong action on right equipment
Lesson Learn / Near Misses	• Knowledgeable about prior site incidents	• Wrong calibration of tank reference height

5. IDENTIFYING PERFORMANCE INFLUENCING FACTORS (PIFs)

5.1 From the credible human failures identified, all factors that could affect the likelihood of these failures are identified. PIFs are the characteristics of individual (personal factor), workplace and management that have direct influence on the likelihood of human failures.

5.2 PIFs should be evaluated and optimised for maximising human reliability and minimising failures. When all PIFs relevant to a particular task are optimal, then likelihood of errors will be minimised. Examples of PIFs are tabulated in Table 2 below.

Table 2: List of Performance Influencing Factors

Individual (Personal Factors)	Workplace	Management
• Knowledge (Competency & Training) • Factors affecting mental focus (e.g. fatigue, rest hours) • Stress • Experience • Personal Inclinations • Physical Ability • Work overload/underload	• Task Characterisation • Ergonomics • Environment • Procedures • Routine/Unusual • Difficulty/ complexity of task • Communication with colleague, supervisor, contractor • Time available/required • System/equipment interface (labelling, alarms, error avoidance/ tolerance) • Clarity of signs, signals, instructions and other information	• Safety Culture • Work pressures • (e.g. Production vs safety) • Job Design • Communication • Hazard Identification • Level and nature of supervision/leadership • Manning levels • Clarity of roles and responsibilities • Effectiveness of organisational learning • Management of Organisation Change • Incident Investigation covering Human Factors

6. FAILURE MANAGEMENT WITH SUITABLE CONTROL MEASURES

6.1 Engineering /Automation Controls

6.1.1 Using the hierarchy of control approach in Figure 2, the first step in minimising human failure is to eliminate the reliance on human intervention as a barrier to protect against SCEs, or through the implementation of additional risk reduction measures which do not rely on any human action.

6.1.2 Where elimination of human intervention is deemed not feasible, additional layers of protection which reduce reliance on humans should be taken to manage and prevent risks, such as substituting human intervention with reliable automated system (e.g. implementing high level trip on storage tank or using remote operation instead of local manual operation).

6.2 Administrative Control

6.2.1 After engineering/automation controls, administrative controls are then considered in accordance to the hierarchy of control. Examples include procedures, checklists and training shall be used to assist humans in performing safety critical tasks.

6.2.2 The following factors should be taken into consideration to assure human performance, after evaluating that there is reliance on operator to respond:

- Availability of key personnel to respond to high priority alarms;
- Sufficient time for key personnel to respond and take actions;
- Competency of personnel managing process upsets and abnormal situations, so that detection, diagnosis and recovery to a safe-state can be achieved in a reliable and timely manner;
- Communications such as shift handover and permit-to-work (PTW) systems;
- Organisational factors such as staffing levels versus workload, and shift work versus fatigue.

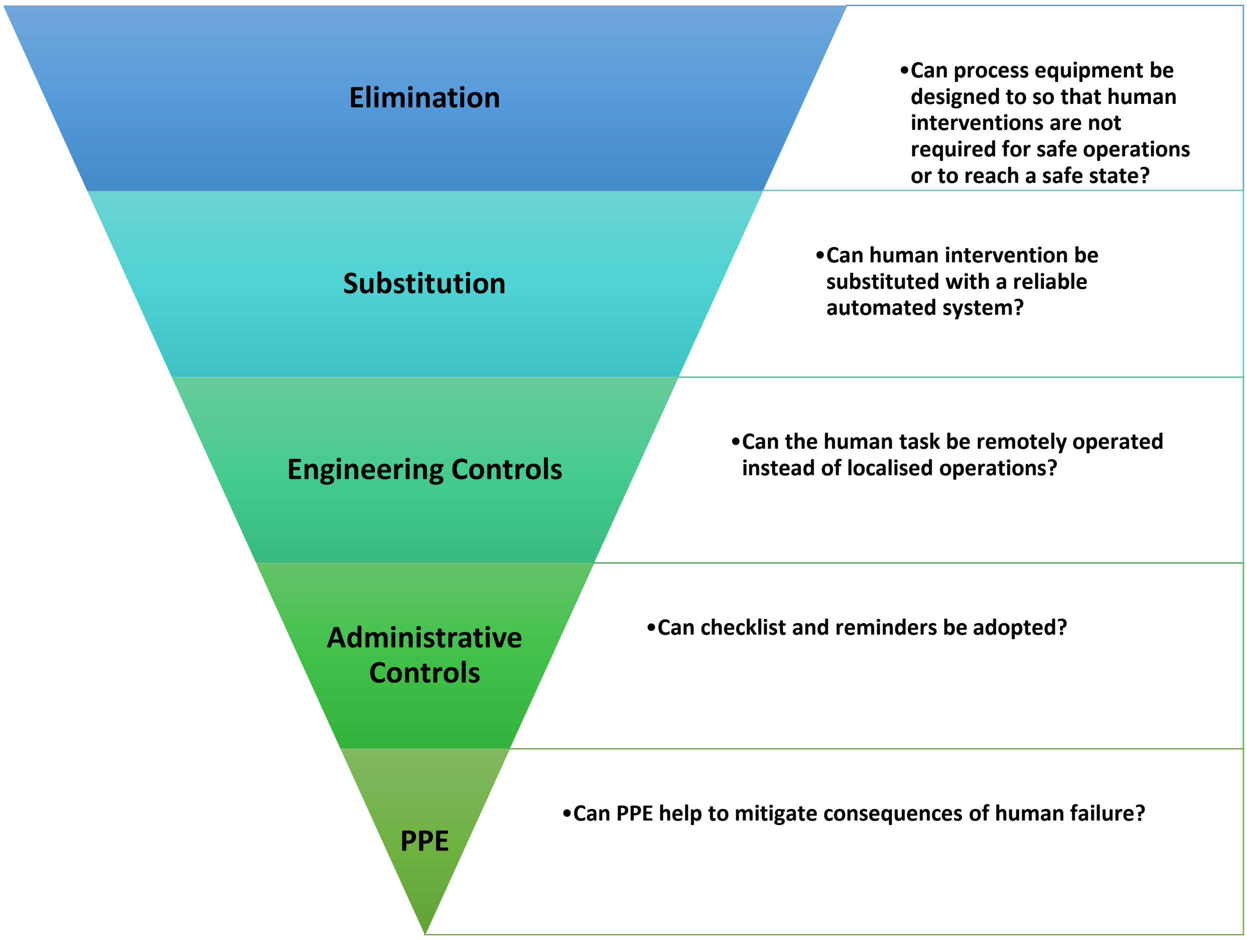

Figure 1: Human Failure Management with Hierarchy of Controls

7. HUMAN FACTORS IN MAINTENANCE AND INSPECTION

7.1 Substituting human interventions with engineering controls does not entirely eliminate human failures. Instead, it re-directs the focus of human failure away from operational activities to Maintenance, Inspection, Testing (MIT) activities.

7.2 Therefore, MHIs should apply the same rigour used in operational activities for MIT activities, to identify 'Safety Critical Tasks' and potential of human failures. The key difference is that MIT activities have the potential to introduce latent errors due to human failure, which may cause failures during operations.

7.3 Similarly, PIFs should be evaluated and optimised for maximising human reliability and minimising human failures during MIT activities. Most of the identified PIFs will be identical to operational activities but there may be PIFs that are more specific to maintenance, such as supervision, PTW and isolation procedures.

8. LIST OF REFERENCES

8.1 The following publications provide further information and guidance on Alarm Handling, HF in Design and PIFs.

(a) EEMUA Publication No 191 Alarm systems, a guide to design, management and procurement

(b) API Human Factors (2006) Human Factors for Existing Operation

(c) API Human Factors (2005) Human Factors in New Facility Design Tool

(d) BS EN ISO 11064 (2001) Ergonomic Design of Control Centres

(e) BS EN ISO 6385 (2004) Ergonomic principles in the design of work systems

(f) BS EN ISO 9421-210 (2010) Ergonomics of Human-System Interaction. Human Centred Design for Interactive Systems

(g) CCPS (1994) Guidelines for preventing human error in process safety, American Institute of Chemical Engineers, New York

(h) ISA 5.5: Graphic Symbols for Process Displays

(i) UK HSE HSG 48, Reducing error and influencing behaviour,

(j) UK HSE HSG 256, Managing Shift Work: Health and Safety Guidance,

(k) UK HSE Chemical Information Sheet No. CHIS7, Organisational Change and Major Accident Hazards,

(l) UK HSE Common Topic 3, Safety Critical Communications, Inspectors Human Factors Toolkit

(m) UK HSE Core Topic 1, Competence Assurance, Inspectors Human Factors Toolkit

(n) UK HSE Core Topic 2, HF in accident investigations, Inspectors Human Factors Toolkit

(o) UK HSE Core Topic 3, Identifying Human Failures, Inspectors Human Factors Toolkit

(p) UK HSE Core Topic 4, Reliability and usability of procedures, Inspectors Human Factors Toolkit

(q) UK HSE Specific Topic 1, Alarm Handling, Inspectors Human Factors Toolkit

(r) UK HSE Specific Topic 2, Managing Fatigue Risks, Inspectors Human Factors Toolkit

Acknowledgements

This guide was jointly developed by the Safety Case Workgroup (SCWG) comprising representatives from the Major Hazards Department (MHD) and industry professionals of the Singapore Chemical Industry Council (SCIC). MHD would like to express its appreciation to SCIC, industry professionals in the SCWG, as well as all stakeholders in the MHI industry for their feedback and support.

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APPENDIX A

Human Factors Analysis of Current Situation				Human factors additional measures to deal with human factor issues	
Task	**Task step description**	**Likely human failures**	**Potential consequences**	**Measures to prevent failure from occurring**	**Measures to reduce the consequences**
Task description taken from procedures, walk through/discussion with operators		***Records types of human error(s)***	***Records consequences arising from human failure***	***Suggestions to prevent error from occurring***	***Suggestions on how to reduce consequences in the event of failure***
Pipeline transfer preparation	Technician onsite to verify line-up is correct	**Check omitted:** Verification not performed	Tank Overfill	Checklist to tick and sign against every task completed	Tank overfill protection
Pipeline transfer Operation	Technician onsite to monitor transfer flow rate and tank level	**Wrong object selected:** Check performed on wrong tank	Tank Overfill	-	Tank overfill protection