

ONR GUIDE

WORKPLACES AND WORK ENVIRONMENT

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1. INTRODUCTION

- 1.1. The Office for Nuclear Regulation (ONR) has established its Safety Assessment Principles (SAPs) [1] which apply to the assessment by ONR specialist inspectors of safety cases for nuclear facilities that may be operated by potential licensees, existing licensees, or other dutyholders. The principles presented in the SAPs are supported by a suite of guides to further assist ONR's inspectors in their technical assessment work in support of making regulatory judgements and decisions. This Technical Assessment Guide (TAG) is one of these guides.

2. PURPOSE AND SCOPE

- 2.1. The ONR has the responsibility for regulating the safety of nuclear installations in Great Britain. SAPs [1] provide a framework to guide regulatory decision-making in the nuclear permissioning process. They are supported by TAGs which further aid the decision-making process.
- 2.2. This TAG provides guidance to aid inspectors in the interpretation and application of those SAPs that relate to the design of workplaces/spaces. Specifically these are EHF.6, ELO.1 and ELO.4. Further detail on these is provided at section 3 of this document.

This TAG is not intended to be a detailed design guide; nor does it prescribe specific methods and approaches for assessing a dutyholder's actual or proposed workplaces/spaces. It provides broad expectations on key points that the experienced Human Factors (HF) inspector may wish to consider. The aim of the TAG is to advise and inform ONR inspectors in the exercise of their professional regulatory judgement concerning the demonstration of As Low As is Reasonably Practicable (ALARP) with respect to the design of workplaces/spaces on nuclear licensed sites. As with all guidance, inspectors should use their judgement and discretion in the depth and scope to which they apply the guidance provided.

Work Environment

- 2.3. Humans play a vital role in the safe and efficient operation of nuclear facilities. Human actions (or inactions) that fail to achieve what should be done in a given situation can be important contributors to facility risk. Operators contribute to a plant's defence-in-depth hierarchy in a number of ways and nuclear safety cases may make human-based safety claims in respect of reliable interventions for monitoring and control of both normal and abnormal conditions.
- 2.4. Workplaces and the work environment in which human-based safety actions are conducted are potentially significant human performance influencing factors. As such inspectors need to be satisfied that a dutyholder's actual or proposed workplaces/spaces are compatible with the types of task to be conducted and human characteristics, in order that risks to the health and safety of workers and the potential for human error is reduced to ALARP.
- 2.5. It therefore follows that relevant good practice in ergonomics should be included and evident in the design and modification of all workplaces/spaces. Application of HF good practice can also have a positive effect in promoting efficiency and productivity in the workplace.

3. RELATIONSHIP TO LICENCE AND OTHER RELEVANT LEGISLATION

- 3.1. The Nuclear Site Licence Conditions (LCs) [2] place legal requirements on the licensee to make and implement arrangements to ensure that safety is being managed adequately. The licence conditions provide a legal framework which can be drawn on in assessment.
- 3.2. LC 14 and LC 15 (preparation and review of safety cases) apply particularly, and also of relevance is LC 11 (emergency arrangements). Other LCs that relate to the design, commissioning and maintenance phases of workplaces/spaces are LCs 19 – 22 and 28.
- 3.3. The Health and Safety at Work etc. Act 1974 s2(2), amongst other things, places general duties on employers, so far as is reasonably practicable, as regards any place of work under the employer's control, to maintain it in a condition that is safe and without risks to health, including the means of access to and egress from it; to provide and maintain a safe working environment that is so far as is reasonably practicable, safe and without risks to health.
- 3.4. Regulation 3(1) of The Management of Health and Safety Work Regulations 1999 places a legal requirement on duty holders to produce suitable and sufficient risk assessments. In order to be considered suitable and sufficient, such assessments may need to identify and consider the influence of workplaces and the work environment on the duty holder's measures for controlling risk.
- 3.5. Other relevant statutory provisions (and their associated Approved Codes of Practice (ACoPs) that contain implicit or explicit requirements relating to workplaces/spaces and environmental factors are:
 - The Workplace (Health, Safety and Welfare) Regulations 1992.
 - The Provision and Use of Work Equipment Regulations 1998.
 - The Manual Handling Operations Regulations 1992.
 - The Control of Noise at Work Regulations 2005.
 - The Control of Vibration at Work Regulations 2005.
 - The Personal Protective Equipment Regulations 1992.
 - The Construction (Design and Management) Regulations 2007.
 - The Confined Spaces Regulations 1997.

4. RELATIONSHIP TO SAPS WENRA REFERENCE LEVELS, IAEA AND OTHER SAFETY STANDARDS

SAPs

- 4.1. ONR's expectations concerning the suitability of workplaces/spaces are primarily set out in the following SAPs:

EHF.6 Workspaces in which plant operations and maintenance are conducted should be designed to support reliable task performance, by taking account of human perceptual and physical characteristics and the impact of environmental factors.

Closely linked to EHF.6 are SAPs EHF.1 (Integration with design, assessment and management – see T/AST/058 [3]), EHF.5 (Task Analysis - see T/AST/063 [4] and EHF.7 (Human Machine Interfaces - see NS-TAST-GD-059 [5]).

ELO.1 The design and layout should facilitate access for necessary activities and minimise adverse interactions during such activities.

Para 205 [1] expands upon ELO.1:

“The layout should:

- a) ensure that sufficient access, lighting etc. is available to be able to carry out all necessary operational, maintenance, inspection and testing activities;
- b) ensure that radiation doses to workers carrying out operational, maintenance, inspection and testing activities are ALARP;
- c) minimise adverse interactions during operational, maintenance, inspection and testing activities with other structures, systems or components;
- d) provide an alternative means of access to facilities and control functions essential to safety that may require local manual intervention.”

ELO.4 The design and layout of the site and its facilities, the plant within a facility and support facilities and services should be such that the effects of incidents are minimised.

Para 206 expands upon ELO. 4:

“For example, the design and layout should:

- d) facilitate access for necessary recovery actions following an event.”

WENRA Reactor Safety Reference Levels

- 4.2. The objective of the Western European Nuclear Regulators Association (WENRA) harmonization programme is to develop a common approach to nuclear safety in Europe by comparing national approaches to the application of International Atomic Energy Agency (IAEA) safety standards. Their Safety Reference Levels (SRL) [6], which are based on the IAEA safety standards, represent good practices in the WENRA member states and also represent a consensus view of the main requirements to be applied to ensure nuclear safety.
- 4.3. The guidance in this TAG is consistent with WENRA Reactor Safety Reference Levels [6]:

Issue B (Operating Organisation): Reference Level 2. Management of safety and quality.

Appendix E (Design Basis Envelope for Existing Reactors), Section 10 Control Room.

IAEA Safety Standards

- 4.4. The IAEA Safety Standards (Requirements and Guides) were the benchmark for the revision of the SAPs in 2006 and are recognised by ONR as relevant good practice. They should therefore be consulted, where relevant, by the assessor as complimentary guidance, although it should be appreciated that they are design standards rather than regulatory standards.
- 4.5. The guidance in this TAG is broadly consistent with IAEA standards and guidance:
- SSR-2/1: Safety of Nuclear Power Plants: Design [7]
 - SSG-2: Deterministic Safety Analysis for Nuclear Power Plants [8]
 - NS.G.1.3 Instrumentation and Control Systems Important to Safety in Nuclear Power Plants [9]

Other

- 4.6. The advice contained herein is also reflected to a greater extent in a number of other standards and guidance related to the effective design of workplaces/spaces. Examples of comprehensive standards which ONR recognises as sources of relevant good practice are:
- BS EN ISO 11064 Ergonomic Design of Control Centres, Parts 1-7 [10];
 - NUREG 0700 Human-System Interface Design Review Guidelines [11];
 - Defence Standard 00-250 Human Factors for Designers of Systems, All Parts [12]; etc.
- 4.7. Specific references to all the available standards and guidance on the design of workplaces/spaces are not made in the text as they would be too numerous.

5. ADVICE TO INSPECTORS

Introduction

- 5.1. This TAG provides guidance to inspectors regarding relevant good practice expectations relating to what a dutyholder's workplace/space design and design practices should demonstrate to support effective human performance. In particular, those expectations regarding the dutyholder's demonstration of the feasibility of delivering human-based safety claims and reducing risks so far as is reasonably practicable. The guidance provided in this section is applicable to the assessment of all types of workplaces/spaces.

- 5.2. Where safety important human actions are required and their need is justified by the dutyholder, the feasibility and reliability of those actions should be demonstrated to be effectively supported by the working environment. Inspectors should have confidence in the dutyholder's process for adequately specifying and designing workplaces/spaces to support human reliability, and the demonstration of their ergonomic adequacy to ensure, so far as is reasonably practicable, the effective management of plant safety and delivery of human-based safety claims.
- 5.3. There are many requirements relating to the design and specification of workplaces/spaces. These are considered too numerous and specific to include within a TAG, whose purpose is to support regulatory judgement in relation to permissioning decisions. Therefore, only general good practice expectations are provided in order to present a consistent framework applicable to workplace/space design (and modifications) for all nuclear facilities. Specificity is included where this is judged to be necessary in order to expand on the general guidance.

General Workplace/Space Expectations

- 5.4. The key elements for ensuring the provision of suitable and sufficient workplaces/spaces to support safe management and operation of nuclear plant are the understanding of:
- the plant operational philosophy;
 - the plant context as it actually is;
 - the nature of the tasks and human-based safety claims related to the delivery of plant safety functions; and
 - end-user characteristics.
- 5.5. These understandings should be incorporated into an effective and integrated through-life process for the design of workplaces/spaces. In addition, this process should also ensure that plant and equipment selected/provided by dutyholders are designed to be compatible with human capabilities and limitations, appropriate for the tasks to be undertaken and the work environment.
- Inspectors may consider whether:
- 5.6. The dutyholder's specifications and requirements for the design (modification) of workplaces/spaces are demonstrated in an overall design philosophy and approach. This takes into account the operational philosophy of the plant and required tasks in all locations under all operational modes, states and conditions, including fault/emergency response and recovery.
- 5.7. The dutyholder has used its safety case, operational (and maintenance) philosophy, allocation-of-function studies and proportionate task analysis and related techniques (e.g. link analysis) to inform the design (and modification) of its workplaces/spaces. This also accounts for foreseeable effects of internal and external hazards on access and habitability of essential workplaces/spaces.

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- 5.8. Where novel or potentially hazardous workplaces and environmental factors cannot be avoided, the dutyholder has conducted necessary research to evaluate the impact on human performance, or has used appropriate research data to inform its decision-making.
- 5.9. The dutyholder has assessed the impact of environmental factors on human cognitive and physical performance and reasonably foreseeable variations in these during abnormal conditions. This also takes into account:
- any direct effects on health and safety; and whether reasonably practicable measures have been proposed or implemented to minimise any detrimental effects of these factors; and
 - any potential adverse environmental conditions when making safety-claims on operators for post fault action/emergency response completion times.
- 5.10. The dutyholder has integrated human factors/ergonomics best practice in all workplaces/spaces (internal and external) and not just focussed on the more high profile areas such as the control rooms. The workplace/space design is included as part of the dutyholder's Human Factors Integration (HFI) process [3].
- 5.11. The dutyholder has considered and taken into account the capabilities, characteristics and numbers of the target users who will use the workplaces/spaces. Relevant good practice is for such information to be presented in a Target Audience Description (TAD) document. This avoids unsubstantiated assumptions about end users being made throughout the design process.
- 5.12. The dutyholder has declared and justified the appropriate standards/references used for the design/modification and substantiation of its workplaces/spaces. A style guide or similar document, based on agreed workplace/space design requirements and specifications, should be developed by the dutyholder to demonstrate the philosophy underlying the design. Note that where non-UK standards are proposed/used the dutyholder has considered any differences in conventions, which are contrary to United Kingdom (UK) good practice standards.
- 5.13. Where dutyholders themselves develop and adopt in-house standards, the dutyholder has clearly set out the standards and guidance proposed/used and justified them to extent that ONR inspectors can judge them relevant good practice when viewed against the SAPs and this TAG.
- 5.14. The dutyholder has demonstrated that the physical arrangements of the workplace/space (internal and external) have taken account of, and are compatible with, human perceptual and physical characteristics and limitations, as well as task demands, attributes and characteristics. Inspectors should look for whether the dutyholder has:
- incorporated appropriate anthropometric and biomechanical considerations and data into its workplace/space and equipment design, dimensions and layout (common practice is to use the 5th percentile female to 95th percentile male range);
 - ensured that workplaces/spaces and all doors, access and egress routes will accommodate appropriate male and female percentile ranges and comply with relevant legislative requirements;

- demonstrated that workplaces/spaces, means of access and egress (normal and emergency) and the equipment and furniture therein can be used safely and effectively by all potential members of the user population;
- ensured that workplaces/spaces and the layout of equipment and furniture therein minimise physical and cognitive demands on personnel and the potential for human error caused by disturbances, distractions and disruptions to task performance (e.g. due to movement of people, visitors, location and access/egress routes, briefing rooms, concurrent tasks);
- ensured that the layout of identical/similar safety-related plant and equipment in different locations is, so far as is reasonably practicable, consistent and avoids mirror imaging (where such plant and equipment are grouped together/co-located there is a method of clearly differentiating between the plant and equipment to avoid confusion);
- designed its workplaces/spaces to facilitate access to plant and equipment requiring operation or shut-down during an emergency, and with sufficient space to accommodate any additional plant and equipment that may be need to be introduced during an emergency;
- ensured that emergency escapes comply with relevant legislative requirements and the routes are adequately sized to cater for everyone. It is good practice to design for the 99th percentile male;
- ensured that personnel are able to leave workplaces/spaces and workstations therein swiftly and safely in the event of an emergency.

5.15. The dutyholder has demonstrated that the design and layout of the workplaces/spaces are sufficient in size such that:

- workers are not cramped or obstructed in any way that would cause distraction of discomfort and encourage hurrying of a task leading to increased potential for human error;
- equipment, tools and spares can be appropriately located for the tasks involved;
- appropriate storage is available for equipment, tools, spares and instructions that is close to hand without unnecessarily cluttering the workspace;
- there is sufficient space around plant and equipment so that maintenance, inspection, repair and housekeeping can be performed safely and efficiently with no unnecessary restrictions or risk of injury from contact with dangerous parts or surfaces;
- the workspace dimensions take account of any requirements for the wearing of protective clothing and use of tools.

5.16. Where a workplace/space cannot be designed to accommodate all the range of users, there is a clear documented process that demonstrates how the dutyholder has managed and resolved any conflicts and trade-offs associated with workplace/space design and has provided a basis for the dimensions, layout etc. that have been used. For example, safety constraints such as provision of shielding, access to containment areas or criticality control constraints may conflict with preferred ergonomic requirements.

- 5.17. The dutyholder has considered the potential for significant changes in workplace/space layout, dimensions and environmental factors during plant outages and decommissioning (when plant configuration changes). Appropriate steps have been taken to anticipate and control any impacts on claimed human performance and health and safety.
- 5.18. The dutyholder has carried out an operational experience review (existing or similar plants), including, where reasonably practicable to do so, a review of any mock-ups of its workplace/space design or modification, particularly for plants with a similar concept of operations.
- 5.19. The dutyholder has conducted a suitable human factors/ergonomics evaluation and testing/trials of the design, development and use of its workplaces/spaces. This has demonstrated its effectiveness in the context of the design and operational philosophy, safety case claims and assumptions.
- 5.20. The dutyholder has used its design and/or review of its workplace/spaces and environmental factors to inform the assumptions and claims made in its Human Reliability Analysis (HRA) / Probabilistic Safety Analysis (PSA). Without such a review statements made in the safety case regarding human performance and human error probabilities in different working areas are not adequately informed, and may result in a failure to identify reasonably practicable improvements.

Environmental Factors

- 5.21. Environmental factors can increase both physical and mental stress, resulting in distortion or filtering of important sensory information and increased human error potential and/or direct health and safety risks. This section provides general advice to inspectors regarding good practice expectations for those key environmental factors that are likely to be encountered on nuclear sites/facilities e.g. visual environment, thermal and auditory environment and vibration.

Visual Environment

- 5.22. Inspectors may consider whether:
- 5.23. The dutyholder has demonstrated adequate lighting provisions for all operational tasks, their demands and foreseeable working conditions, including any tasks required to be performed during emergencies. Adequate provision has been made for any requirements for equipment identification, reading textual information, detailed inspection tasks and any fine precision work. Adequate back-up or portable illumination is available during emergencies. These requirements are formally and periodically checked.
- 5.24. The dutyholder has used appropriate design standards and guidance to derive the lighting levels required for tasks to support reliable human performance. Factors such as contrast, glare and reflections have been identified and appropriately considered.
- 5.25. Where the dutyholder exploits advanced technologies to display information within control rooms (e.g. large wall-mounted display screens generated by plasma displays, Liquid Crystal Display (LCD) etc) the legibility and visibility of information displayed by these devices, has been carefully considered taking into account proposed, or existing, lighting

arrangements. Issues of clarity and contrast can seriously degrade the quality of the perceived information.

- 5.26. Where instruments or displays are situated outside the control rooms in local-to-plant locations, the dutyholder's lighting is adequate to meet the local task requirements. Adequate lighting should also be demonstrated along all potential routes/work areas during night time and in adverse weather.
- 5.27. The dutyholder has considered lighting requirements for maintenance tasks. The requirement for access in order to maintain equipment may be infrequent so fixed illumination may not always be practicable. In such cases, appropriate portable or temporary lighting provision should be specified and provided and adequate space available to locate it during the task. Adequate fixed lighting should be available along all potential access routes to maintenance work areas.
- 5.28. The dutyholder has provided sufficient illumination along all access, egress and escape routes, including emergency lighting, to ensure that personnel can escape safely. The emergency lighting system is assured and adequate for all escape routes (including junctions, doorways and stairways, fixed ladders, temporary workplaces) and muster points.

Thermal Environment

- 5.29. Inadequately controlled thermal environments can lead to discomfort and reduced performance. There should be reference to appropriate standards used in specifying heating and ventilation in the various workplaces. The proposed systems should be shown to meet the accepted design standards.
- 5.30. Inspectors should consider whether:
- 5.31. The dutyholder's Heating, Ventilation and Air Conditioning (HVAC) system is capable of sustaining an adjustable range of comfortable air temperatures and desirable relative humidity. Temperature gradients should be minimal and ventilation should meet accepted standards.
- 5.32. Where a significant modification is proposed within a workplace/space, the dutyholder has considered whether any new plant and equipment may affect the existing heating and ventilation provision.
- 5.33. The dutyholder has considered and mitigated reasonably foreseeable impacts on health and safety and human error potential associated with the wearing of air-fed suits, impermeable clothing and other similar Personal Protective Equipment (PPE). The wearing of such clothing creates a micro-climate that gives rise to a hot work environment. The dutyholder should include the following factors in its risk assessment and ensure, so far as is reasonably practicable, that they are adequately controlled:
- Potential for heat stress and fatigue;
 - Ability to operate plant equipment to desired performance standards;
 - Feasibility of achieving claimed evacuation and other operator response times;

- Potential for reduced visual access; and
 - Potential for degraded tactile and kinaesthetic feedback and loss of situational awareness.
- 5.34. The dutyholder has given consideration to the thermal environment (hot and cold) and its impact on human performance in workplaces/spaces where maintenance is to be carried out.
- 5.35. The dutyholder has provided as much physical shelter as practicable where operational tasks, maintenance or emergency/post fault recovery tasks are required on equipment in exposed/outdoor positions (bulky clothing may impede the operator's access and movement so that tasks can take longer than expected. Problems of dexterity and accuracy may also be encountered).
- 5.36. The dutyholder has taken into account potential adverse environmental conditions when making claims for task feasibility and completion times. In particular, the effects of climatic conditions may be exacerbated for emergency tasks as the situation will be less planned and less subject to control than routine activities. This should be reflected in the claims made for operator safety action in the HRA/PSA.

Auditory Environment

- 5.37. Noise in the workplace can be a source of distraction, discomfort and can lead to decrements in human performance and ineffective communication. Exposure to high and/or prolonged levels of noise can also lead to hearing damage. Workplace noise can also have a strategic effect on human performance causing an individual to modify their style of task performance which can lead to increased human error potential.
- 5.38. Inspectors should consider whether:
- 5.39. The dutyholder has specified acceptable noise levels for all workplaces/spaces and provided an adequate and justifiable hierarchy of noise controls. Such noise levels and controls comply with statutory requirements and have been specified and implemented with reference to appropriate good practice standards.
- 5.40. The dutyholder is able to demonstrate that all audible alarms and warnings can be heard, or otherwise detected, at all working locations and in all foreseeable conditions (including temporary work that may increase ambient noise levels) and that alarms do not have a startle effect. Where there is reliance on Public Address (PA) for communication, its intelligibility is regularly checked. The impact of audibility issues should be reflected in the claims made for operator safety action in the HRA/PSA.
- 5.41. The dutyholder has ensured that the background noise level in control rooms does not impair speech comprehension.
- 5.42. The dutyholder has ensured that emergency procedures and arrangements take account of the possibility for poor communications and subsequent errors or delays in task performance, where communication may be required in places where there is excessive ambient noise (permanent or transient) when dealing with an emergency.

Vibration

- 5.43. Whole body and hand-arm vibration issues are generally only likely to be encountered for some glove box activities, construction and decommissioning activities in the nuclear context. Dutyholders should recognise that as well as physical health effects, vibration can affect human input process (e.g. vision) and output process (e.g. manual control), and should therefore implement suitable and sufficient control measures with reference to relevant statutory requirements and good practice standards.

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