Office for Nuclear Regulation

ONR GUIDE			
STAFFING LEVELS AND TASK ORGANISATION			
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1. INTRODUCTION

1.1 ONR has established its Safety Assessment Principles (SAPs) 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 duty-holders. 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 is one of these guides.

2. PURPOSE AND SCOPE

2.1 The Office for Nuclear Regulation (ONR) of the Health and Safety Executive (HSE) has the responsibility for regulating the safety of nuclear installations in Great Britain. The Safety Assessment Principles (SAPs) for Nuclear Facilities [1] provide a framework to guide regulatory decision-making in the nuclear permissioning process. They are supported by Technical Assessment Guides (TAGs) which further aid the decision-making process.

2.2 This TAG gives guidance to help Inspectors assess a licence applicant's/ licensee's arrangements for staffing and task organisation. In the context of this document '*Staffing*' refers to the arrangements to ensure an appropriate number of Suitably Qualified and Experienced Persons (SQEPs) are in place to remain in control of activities that could impact on nuclear safety under all foreseeable circumstances throughout the life cycle of the facility. '*Task organisation'* refers to the way tasks are organised to ensure compatibility with human cognitive and physiological characteristics, and in a way which ensures that nuclear safety is maintained at all times. This includes considerations such as the design of shift work systems, workload and team design. (See also definitions at 1.6 below. The term nuclear safety within the context of this document encompasses both nuclear and radiological safety.)

2.3 This TAG has been written primarily for use by ONR Human Factors specialist Inspectors. It provides detailed guidance to support the assessment of the approaches and methods used by applicants and licensees to derive, validate and monitor staffing arrangements; and to specify task organisation, in particular, the design of shift work systems and team design.

2.4 The guidance in this TAG is intended for use during the assessment of safety cases for new and existing nuclear facilities, covering areas such as:

- review of arrangements for staffing and task organisation as part of licensing of new facilities;
- review of proposed changes to staffing arrangements or task organisation under LC 36 (e.g. move to 12 hour shift schedule, introduction of a multi-skilling programme);
- review of design changes under LC 22 which may impact on staffing or task organisation (e.g. major change to the level of automation);
- other regulatory interventions (e.g. follow up to an event linked to staffing or task organisation).

2.5 Site Inspectors can also use the guidance contained in this TAG during inspections (e.g. of emergency arrangements under LC 11) and other interventions. However, specialist Human Factors support should be sought for detailed assessments relating to the topics in this document.

2.6 The following definitions apply in using this Guide:

Concept of Operations

A description of how the licensee or licence applicant's organisational structure, staffing and management framework relate to the systems, design and operational characteristics of the plant.

Minimum staff complement

The minimum number of qualified workers who must be present at all times to ensure the safe operation of the nuclear facility and to ensure adequate emergency response capability.

Nuclear Baseline

The means by which the licensee demonstrates that its organisational structure, staffing and competencies are, and remain, suitable and sufficient to manage nuclear safety throughout the full range of the licensee's business.

Multi skilling

This incorporates two levels:

Skill broadening – where minor elements and tasks are learned on top of the predominant activity (major task). So expertise is maintained in the major task with elements added to increase efficiency. For example, a mechanical engineer may learn how to isolate and disconnect a motor to avoid the use of an electrician.

Cross skilling/dual skilling – where another major activity is learned in addition to the main craft and a person is considered competent to carry out any activity in these two main disciplines. For example, multi-skilled craftsmen considered competent to carry out both mechanical and electrical tasks. Typically some limits will be placed on the types of safety critical work that can be carried out.

Workload

The mental and/or physical demands placed on a user by the task requirements, the workplace and the environment (including the organisation).

2.7 This TAG is intended to supplement the guidance in NS-TAST-GD-065, The Function and Content of the Nuclear Baseline, by providing additional information on methods and approaches to derive and validate staffing requirements. This includes inputs from the duty holder's Human Factors Integration Programme (ref to NS-TAST-GD-058, Human Factors Integration). The guidance in this TAG should be used in conjunction with NS-TAST-GD-065 on the Nuclear Baseline, and other relevant TAGs.

2.8 The following topics are outside the scope of this TAG; Allocation of Function (refer to NS-TAST-GD-064), Human Machine Interface design (NS-TAST-GD-059), and the design of procedures and administrative controls (NS-TAST-GD-060).

3. RELATIONSHIP TO LICENCE AND OTHER RELEVANT LEGISLATION

3.1 The Nuclear Site Licence Conditions place legal requirements on the licensee to make and implement arrangements to ensure that safety is being managed adequately. The following Licence Conditions are relevant to this TAG:

LC 11 - EMERGENCY ARRANGEMENTS

(1) Without prejudice to any other requirements of the conditions attached to this licence the licensee shall make and implement adequate arrangements for dealing with any accident or emergency arising on the site and their effects.

LC 12 - DULY AUTHORISED AND OTHER SUITABLY QUALIFIED AND EXPERIENCED PERSONS

(1) The licensee shall make and implement adequate arrangements to ensure that only suitably qualified and experienced persons perform any duties which may affect the safety of operations on the site or any duties assigned by or under these conditions or any arrangements required under these conditions.

(2) The aforesaid arrangements shall also provide for the appointment, in appropriate cases, of duly authorised persons to control and supervise operations which may affect plant safety.

LC 22 – MODIFICATION OR EXPERIMENT ON EXISTING PLANT

(1) The licensee shall make and implement adequate arrangements to control any modification or experiment carried out on any part of the existing plant or processes which may affect safety.

LC 23 – OPERATING RULES

(3) The licensee shall ensure that operations are at all times controlled and carried out on compliance with such operating rules.

LC 26 - CONTROL AND SUPERVISION OF OPERATIONS

The licensee shall ensure that no operations are carried out which may affect safety except under the control and supervision of suitably qualified and experienced persons appointed for that purpose by the licensee.

LC 36 – ORGANISATIONAL CAPABILITY

(1) The licensee shall provide and maintain adequate financial and human resources to ensure the safe operation of the licenced site.

(2) Without prejudice to the requirement of Paragraph 1, the licensee shall make and implement adequate arrangements to control any change to its organisational structure or resources which may affect safety.

(5) The aforesaid arrangements shall provide for the classification of changes to the organisational structure or resources according to their safety significance. The arrangements shall include a requirement for the provision of adequate documentation to justify the safety of any proposed change and shall where appropriate provide for the submission of such documentation to the ONR.

(6) The licensee shall if so directed by the ONR halt the change to its organisational structure or resources and the licensee shall not recommence such change without the consent of the ONR.

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

Safety Assessment Principles (SAPs)

4.1 The following SAPs and their supporting paragraphs are relevant to this TAG:

MS.2 - The organisation should have the capability to secure and maintain the safety of its undertakings

(para 62) The organisation should have adequate human resources. This includes having the necessary competences and knowledge in sufficient numbers to provide resilience and maintain the capability to govern, lead and manage for safety at all times.

EHF.1 A systematic approach to integrating human factors within the design, assessment and management of systems and processes should be applied throughout the facility's lifecycle.

EHF.3 A systematic approach should be taken to identify human actions that can impact safety for all permitted operating modes and all fault and accident conditions identified in the safety case, including severe accidents.

EHF.5 Proportionate analysis should be carried out of all tasks important to safety and used to justify the effective delivery of the safety functions to which they contribute.

(Para 449) This analysis should be applied to all actions and controls identified under Principles EHF.3 and EHF.4 so that the safety case demonstrates high confidence in the feasibility of completing these tasks within requisite timescales. In so doing, the analysis should inform the way tasks are designed and supported to achieve reliable and effective task performance.

(Para 450) The analysis should evaluate the demands these tasks place upon personnel in terms of perception, decision making and action. It should also take into account the physical and psychological factors that could impact on human performance.

(Para 451) The analysis should be sufficiently detailed to provide a basis for developing user interfaces, procedures and job aids, as well as helping define operator roles and responsibilities, staffing levels, personnel competence and training needs, communication networks and workspace design. Further principles related to these topics are provided below.

(Para 452) The workload of personnel required to undertake these actions and controls should be analysed and demonstrated to be reasonably achievable. Where practicable, this demonstration should form part of the inactive commissioning of the facility. The workload of personnel and its impact on the effective completion of tasks important to safety should be reviewed in periodic safety reviews and as part of emergency demonstration exercises.

EHF.11 There should be sufficient competent personnel available to operate the facility in all operational states.

(Para 462) Task Analysis completed under Principle EHF.5 should provide the basis for establishing required staffing levels for normal operation, fault and accident conditions. Further guidance on staffing levels in accident conditions is provided in paragraph 786.

EHF.12 A management process should be in place to ensure the fitness for duty of personnel to perform all safety actions identified in the safety case.

(Para 463) Safety actions should be identified as per Principle EHF.3. Management controls should then be established to control fatigue arising from shift patterns and hours worked.

(Para 464) management controls should also be established to identify and manage the effects of wider factors impacting fitness for duty, including occupational stress and drug and alcohol use.

DC.7 Organisational arrangements should be established and maintained to ensure safe and effective decommissioning of facilities.

(Para 863) The safety case should demonstrate an appropriate management organisation, and adequate personnel resources, to ensure that decommissioning can be completed safely. The continued suitability of these should be demonstrated through an organisation and staffing baseline. The

design of the organisational structure will depend upon the activities to be carried out and will need to be determined on a case-by-case basis

AM.1 Strategies and plans should be in place to prepare for and manage accidents at the facility and/or site.

WENRA 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 IAEA safety standards. Their Safety Reference Levels (SRL), 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 In accordance with our obligations as a WENRA member state the guidance in this TAG is consistent with the WENRA Reactor Harmonization Working Group Safety Reference Levels for Existing Reactors, 2014: [2]. In particular it is consistent with Issue B (Operating Organisation) section 3, which deals with the sufficiency and competency of staff and Issue D, which covers training and authorisation of nuclear power plant (NPP) staff.

IAEA Safety standards

4.4 The IAEA Safety Standards (Requirements and Guides) were the benchmark for the revision of the SAPs in 2006 and 2014 and are recognised by ONR as relevant good practice. They should therefore be consulted, where relevant,

by the assessor as complementary guidance, although it should be appreciated that they are design standards rather than regulatory standards. The following documents are relevant to this TAG:

- IAEA Safety Guide NS-G-2.4 'The Operating Organization for Nuclear Power Plants' [3]
- IAEA Safety Guide NS-G-2.14 Conduct of Operations at Nuclear Power Plants [4]
- IAEA-TECDOC-1052 'NPP Organization and staffing for improved performance – lessons learned' [5]

5. ADVICE TO INSPECTORS

Introduction

5.1 Ensuring that the appropriate number of competent people are organised and deployed in the right way (i.e. task organisation) is fundamental to nuclear safety. The diversity of nuclear facilities and activities means that no one approach to defining staffing needs and task organisation is universally applicable. The approach taken may be influenced by a number of factors, including facility design (including level of automation, size and layout); material condition of the facility; lifecycle phase; type of process (e.g. batch versus continuous operation); operating state (e.g. at power or shutdown operations); regulatory requirements; training and competency models (e.g. use of shift personnel to perform minor maintenance) and use of in-house versus contract resources.

5.2 The guidance in this section is structured as follows:

The General Principles Section provides advice to Inspectors on general principles that ONR expects Duty Holders to apply to establish or substantiate arrangements for staffing and task organisation. These include the principles of a learning organisation and use of relevant standards and good practices.

The subsequent three Sections provide background and guidance to Inspectors on the following key aspects of staffing and task organisation that are important to nuclear safety:

- Staffing Arrangements
- Team Design
- Design of Shiftwork Systems

The penultimate section discusses some specific considerations for new nuclear facilities or the introduction of new technology into existing nuclear facilities and guidance on assessing changes is outlined in the final section.

General Principles

5.3 ONR expects management at the appropriate level in the duty holder's organisation to understand staffing needs, maintain oversight and ensure that any proposed changes go through due process to avoid negative impacts on nuclear safety. Inspectors should confirm that duty holders apply the following fundamental principles, irrespective of the specific approaches taken to staffing and task organisation.

Learning Organisation

5.4 Learning from both internal and external experience, including from other industries, is fundamental to establishing and continuously improving arrangements for staffing and the organisation of tasks. Deficiencies in staffing and task organisation have been identified as contributing factors in a number of high profile events including Three Mile Island, Chernobyl, BP Texas City and the Challenger Space Shuttle.

5.5 ONR expects that duty holders' arrangements for learning will explicitly identify events and experience relating to staffing and task organisation. Duty holders should also seek and learn from good practices both within and outside the organisation.

5.6 ONR expects the duty holder to demonstrate that it has considered the following methods and approaches for initial establishment of arrangements for staffing and task organisation, and as part of continuous improvement activities.

Use of Operating Experience Feedback

5.7 ONR expects that the duty holder's arrangements for operating experience feedback (OEF) and organisational learning will explicitly identify events and experience related to staffing and task organisation.

5.8 Inspectors should consider the following:

- Has the duty holder identified and acted on lessons learned relating to staffing and task organisation? These include problems and good practices learned from the implementation of similar technologies and concept of operations in the nuclear and other industries.

- Has OEF been used as an input to the definition of staffing levels and the approaches used to organise tasks - e.g. to identify problem areas for additional analysis or scenarios for validation exercises?

- Does the duty holder's event reporting and analysis process consider the potential contribution of staffing and task organisation (e.g. work patterns, communication and coordination problems, and inadequacies in the number of workers with the required competencies)?

Benchmarking

5.9 ONR encourages duty holders to compare their approaches to staffing and task organisation to those used by other organisations to identify issues and areas for improvement. Inspectors should consider the following:

- Has the duty holder compared its arrangements for staffing and task organisation against those of comparable facilities?
- Has information collected through benchmarking been used as an input to decisions such as the short and long term plans for the number and type of resources required to meet nuclear safety and other goals?
- Has benchmarking been used to identify areas for improvement such as areas/functions where staffing may be insufficient or activities that are not being performed which may have short or long term impacts on nuclear safety?
- In cases where benchmarking is being used in support of a reduction in staffing levels or task organisation, has a comprehensive assessment of potential impacts on nuclear safety been carried out e.g. on morale or ability to deliver short and long term work to required standards?

5.10 Additional useful guidance on benchmarking NPP staffing is provided in IAEA-TECDOC-1052 [5].

Use of Relevant Standards and Good Practices

5.11 Inspectors should ensure that the duty holder's arrangements are consistent with relevant standards and good practices outlined in this document, and are appropriate to the facility/activity. Novel or unfamiliar methods and standards used to develop, substantiate or make changes to arrangements should be scrutinised by Inspectors to confirm their technical credibility and appropriateness.

Staffing Arrangements

5.12 This section provides guidance to Inspectors regarding the assessment and inspection of the duty holder's staffing arrangements, including general considerations and the use of formal analytical methods to establish or demonstrate the adequacy of existing arrangements.

General Considerations

5.13 There are a number of methods and approaches for establishing staffing arrangements. ONR acknowledges that in some cases, staffing models may be based on approaches from predecessor or similar facilities, rather than a detailed, auditable analysis. In such cases, the Inspector should request a comprehensive description of the staffing model and justification for its selection. In some instances, for example roles with a high potential impact on nuclear safety, formal analysis may be required to demonstrate adequacy of proposed or existing staffing arrangements.

5.14 The Inspector should consider the following:

- In cases where staffing arrangements are based on an existing or predecessor facility, has the duty holder considered and addressed any differences that may affect the appropriateness of the model (for example in design or operating concept or philosophy, licensing practices etc)?

- Where significant human-based claims are made in the safety case, has the duty holder demonstrated that individual and team performance is supported by adequate supervision?

- In situations where staffing requirements vary depending on different operational modes or states and situations (e.g. night, weekends) can the duty holder demonstrate that there are adequate resources for the most resource-intensive conditions feasible in each operational mode/state?

- If applicable, have the potential implications of sharing staff between multiple units or facilities been considered, including where staff are co-opted from a shared work pool? These include competence requirements (e.g. understanding of the safety case), workload (in normal and emergency conditions) and other factors such as the potential for errors related to operational or design differences between units/facilities).

- Have any reviews been carried out to assess the adequacy of the staffing model, such as Periodic Safety Reviews, Self Assessments, Benchmarking (see Para 5.9, 5.10 above) or Peer Reviews? Have any deficiencies raised through the reviews been adequately addressed?

- Do the staffing arrangements allow sufficient time for training and development, and for rest and recovery, particularly during busy periods such as maintenance outages?

- Is there evidence of effective management of staffing levels above the required minimum, for example rapid call-out due to unexpected absence?

- Do qualitative and quantitative indicators support claims regarding adequacy of staffing levels and task organisation? Indicators of potential problems include:

    - High levels of maintenance or procedure modification backlogs
    - Events relating to staff shortages, work patterns, communication or co-ordination issues within or between teams, or inadequate supervision
    - High levels of overtime
    - Deferrals or significant delays to nuclear safety related work programmes
    - Large numbers of outstanding actions
    - Symptoms of personnel stress due to under or overload (e.g. high levels of sick leave, union grievances).

Formal Methods to Establish or Substantiate Staffing Arrangements

1) Task and Workload Analysis

5.15 As stated in NS-TAST-GD-065, ONR does not expect detailed task analysis to underpin the resource/competence allocation for all activities within the scope of the Nuclear Baseline because this would not be practicable. However, SAP EHF 5

requires an analysis of tasks important to safety to determine demands on personnel in terms of perception, decision making and action and, amongst other things, to provide the basis for staffing levels.

5.16 In addition, SAP EHF 5 states that:

> *'The workload of personnel required to undertake [safety related] actions and controls should be analysed and demonstrated to be reasonably achievable. Where practicable, this demonstration should form part of the inactive commissioning of the facility'.*

5.17 As noted in Para 5.15 above, in some cases, for example, roles with a high potential impact on nuclear safety, formal analysis may be required to demonstrate adequacy of proposed or existing staffing arrangements. ONR expects the duty holder to identify those roles and tasks that it will subject to formal analysis, based on their nuclear safety significance.

5.18 The Inspector should consider the following:

- Has the duty holder used a generally recognised approach for identifying roles and tasks important to nuclear safety to establish their staffing needs?
- Has the duty holder carried out task and workload analysis where appropriate to determine the appropriate staffing arrangements for actions claimed within the safety case, and other tasks important to nuclear safety?
- Has the analysis been applied to both individual and team activities, as appropriate?
- Have suitable task and workload analysis methods been used? Is the method selected appropriate for the nature of the activity (for example timeline analysis for proceduralised control room based tasks)? NUREG/CR 6838 [6] includes a review of state of the art methods for assessing cognitive workload.
- Does the method used have a sound technical basis? It should be noted that there is no empirical basis for workload 'ranges' that are sometimes used in analyses (for example, the claim that a range of 50-80% workload is acceptable). The method used should be justified, and any assumptions should be both explicit and substantiated.
- Does the analysis define the minimum staff complement required to deal with all credible events from the safety case, including the most resource-intensive scenario? Reference [7] provides additional guidance on the assessment of minimum staff complement.
- Does the analysis consider the full range of tasks to be performed by facility personnel for the event(s) considered (e.g. control room staff, field operators, stores, radiation protection technicians, maintenance staff, management and engineers)?
- Have the results of the analysis been used as an input to the Nuclear Baseline?
- Have the results of the analysis been used to document the basis for staffing requirements for each design basis accident procedure?

2) *Validation*

5.19 ONR expects duty holders to validate the minimum staff complement to demonstrate that a sufficient number of qualified workers are present at all times to ensure the safe operation of the nuclear facility and to ensure adequate emergency response capability. Various validation methods and approaches exist, including:

- Data from operating experience programmes
- Emergency exercises
- Table top analysis such as the 'Safe Staffing Arrangements' method developed by Entec [8]
- Simulator studies of scenarios involving claims on the operator
- Human performance modelling (for example Task Network Modelling).

5.20 Additional information on the above methods, including strengths and weaknesses, can be found in NUREG/CR- 6838 [6].

Team Design

5.21 Inadequacies in team design have been implicated in major events in the nuclear and other industries. Key factors which contribute to effective team design include team size and composition, clarity of roles and responsibilities, communication and supervision, including spans of control, (i.e. the number of sub-ordinates that can be effectively managed by a supervisor or manager). There are advantages and disadvantages to both wide and narrow spans of control. For example, organisations with narrow spans of control are more hierarchical and have more reporting layers. Supervisors may therefore be able to spend more time with staff, but conversely, communication difficulties can occur if there are a large number of reporting layers. Wide spans of control may create a flatter, more flexible organisation but may result in supervisors being overloaded.

5.22 Inspectors should consider the following:

- Does the composition of teams involved in nuclear safety related work include the necessary mix of skills, in sufficient numbers to effectively carry out the functions and tasks required of them? Inspectors should consider both front line functions such as operations, maintenance and radiation protection teams, and support functions whose decisions impact on nuclear safety e.g. engineering, safety case, oversight functions.
- Has the duty holder established appropriate spans of control? There are differing views on what constitutes an optimal span of control (ranging from 5 to 20 people). The duty holder should demonstrate that they have considered factors such as level of competency of the supervisor and team members, culture (for example the degree of alignment of goals), and task characteristics.
- Have supervisory requirements for claims on control room and field teams been systematically identified? (See Para 5.16ff on task analysis).
- Are the following clearly defined, including for different operating modes/conditions where applicable?
    - Roles, responsibilities and accountabilities within teams
    - Interfaces between teams, including contractors where applicable.

- Are there effective formal and informal mechanisms in place for communication between teams (e.g. between central support teams and teams at local sites? Between shifts? For high workload conditions such as during upsets, emergencies, and start up operations?)

- Has the duty holder assessed the impact of approaches such as skill broadening and self managed teams on claims made in the safety case? (E.g. credit taken for independent verification, number and location of staff, and supervision). Additional information on assessing changes is provided at Para 5.28ff below.

Design of Shiftwork Systems

5.23 Fatigue is generally considered to be a decline in mental and/or physical performance that results from prolonged exertion, sleep loss and/or disruption of the internal clock. Fatigue makes it harder to concentrate, reduces short term memory and attention, impairs decision making, reduced motivation or interest in work, and slows reaction time [10].

5.24 A US Nuclear Regulatory Commission document in support of rule making on fatigue of workers at nuclear power plants [11] states that '*studies from a broad range of industries concerning extended work hours (more than 12 hours per shift) suggest that fatigue-induced personnel impairment can increase human error probabilities by a factor of more than two to three times the baseline human error probability*'.

5.25 A number of factors can cause fatigue, including loss of sleep (acute or cumulative), poor quality sleep, long working hours, poorly designed shift schedules, and inadequate breaks. There are a number of HSE publications on shift schedule design, see for example refs [10, 12 and 13].

5.26 Inspectors should consider the following:

- Has the duty holder carried out an assessment of proposed or existing shift schedules to highlight potential issues and compare different schedules e.g. using the HSE fatigue and risk index tool [12]?

- Is the shift schedule designed in accordance with good practice [10, 13]? Some key considerations are:

    - Direction of rotation. Studies suggest that forward rotations (mornings/ afternoons/ nights in a clockwise direction) result in better quality sleep and less work-family conflict.

    - Speed of rotation. Either a very fast shift rotation (every 2-3 days) or very slow rotation (every 3-4 weeks) is recommended.

    - Provision of regular breaks. Short breaks (5-15 minutes) every 1-2 hours may help maintain performance.

    - Adequate rest and recovery periods between individual shifts and following a series of consecutive shifts to ensure that fatigue and sleep deficit do not adversely impact upon performance.

    - Start times. Early start times (before 7am) can increase sleepiness and fatigue.

    - Type of work. For example, shorter shift lengths (e.g. 8 rather than 12 hour) are preferable for work that is complex, monotonous, machine

paced or requires constant vigilance, as these factors are known to increase the risk of fatigue.

- Does the licensee have management arrangements in place for the following?
    - Control the number of consecutive shifts (particularly night shifts).
    - Cover absences through illness, vacation and training (e.g. 'spare' shift).
    - Monitor and control hours work, including overtime. Limits on hours worked should be set out in a policy/procedure and be consistent with the Working Time Regulations [14] and HSG 256 [13]
    - Control and assess derogations to limits (e.g. during outages and other special circumstances), including risk assessments where appropriate.
    - Control shift-swapping and second jobs.
- Do the duty holder's arrangements to control fatigue cover management and engineering groups as well as operations and maintenance staff?
- Has an assessment of the risks associated with shift work been carried out, and actions taken to mitigate the risks? Examples of risk mitigation measures include:
    - Provision of controlled rest areas on site. Note that 'napping' should only be used as a strategy under supervision as naps of longer than 20 minutes (e.g. 40-60 minutes) can make people feel more tired than before taking the nap.
    - Measures to aid alertness for night shift workers e.g. comfortable temperatures, bright lighting. Specialist advice should be sought before implementing such measures.
    - Ensuring, where practicable, that tasks are planned and organised to reduce the risk of fatigue adversely impacting on human performance (e.g. avoid planning safety-critical work between 2am and 6am and towards the end of a long shift, increased supervision during periods of low alertness).
    - Training and guidance for managers and staff on fatigue management. This should include guidance on recognising and responding to signs of fatigue, particularly during high workload periods such as maintenance outages.

Specific considerations for new nuclear facilities or the introduction of new technology into existing nuclear facilities

5.27 For new facilities or major design modifications to existing facilities, the analyses carried out as part of the Human Factors Integration Programme (refer to SAP EHF 1) provide an important input to the definition and substantiation of arrangements for staffing and task organisation. These analyses include operating experience review, function analysis and allocation, task analysis, human reliability analysis and human factors validation exercises [17]

5.28 New technologies such as passive safety features requiring minimal operator intervention, increased automation and operator support technologies are likely to impact on the concept of operations for nuclear facilities including the number of staff required. This applies to both advanced reactor designs and to the introduction of new automated or digital systems into existing nuclear facilities [6]. There is some evidence, reported for example in [9] [19] that computerised interfaces and plant design features do not automatically reduce staffing needs. The licensee should therefore be able to demonstrate the validity of any assumptions relating to levels of automation and staffing.

5.29 High levels of automation also impact on the organisation and design of tasks. For example, if control tasks are highly automated, operations staff may be able to perform other duties e.g. maintenance tasks. This raises issues such as competence requirements, and the prioritisation of tasks [16].

5.30 NS-TAST-GD-064 on Allocation of Function and NS-TAST-GD-058 on Human Factors Integration provide additional guidance for Inspectors on allocating tasks to humans and automation, and the design of tasks for safe and reliable human performance.

5.31 Inspectors should consider the following:

- Has the duty holder produced a description of the concept of operations for the facility which describes how the design, systems and operational characteristics of the plant relate to the licensee or applicant's organisational structure, staffing and management framework?
- Are staffing levels and task organisation considered as an integral part of the design process?
- Are analyses carried out as part of the Human Factors Integration Programme (e.g. operating experience review, task analyses, human reliability analyses) used as an input to the derivation and validation of staffing and task organisation? Note that in accordance with SAP EHF.5 and EHF.11, for new nuclear facilities or major modification projects, workload assessment should be included in the validation of design and staffing arrangements during inactive commissioning, where possible.
- Do the results of the human factors analyses support the proposed arrangements?
- Are any claims relating to passive safety features, such as increased operator response time, and reduced staffing levels supported by task analysis and other relevant information e.g. OEF, results from simulator trials?
- Does the engineering analysis substantiate the ability of passive safety features to deliver any grace time that is claimed in the safety case?

Changes to Staffing and Task Organisation

5.32 Considerations such as improving efficiency, reducing costs, achieving required levels of reliability and increasing production may lead duty holders to consider approaches to optimise task organisation, such as multi-skilling (e.g. skill broadening, self managed teams), job rotation or temporary teams (e.g. for outages, decommissioning). Lessons learned from events reinforce the need to consider the potential implications of staff reductions made possible through approaches such as multi-skilling. A HSE research report on multi-skilling [15] includes a detailed review of the potential risks associated with multi-skilling and risk mitigation strategies.

5.33 Inspectors should consider the following:

- Do the licensee's LC 36 and LC 22 arrangements include triggers to assess potential impacts of design and organisational changes on staffing and task organisation?
- Where design or organisational changes are proposed to an existing plant, has a comprehensive Management of Change assessment been carried out and submitted to ONR in accordance with LC 36?
- Where a proposed change impacts on actions claimed in the safety case, has an analysis been carried out to verify that the actions can still be accomplished?
- Has the duty holder considered the potential negative effects of organisational approaches such as skill broadening? Important considerations include:
    - The potential for conflicting priorities and distractions;
    - Clarity of roles and responsibilities;
    - Communication and co-ordination between individuals and teams;
    - Workload (including consideration of peak periods);
    - Job satisfaction and morale;
    - Competence e.g. breadth and depth of knowledge, long term skill retention (LC 12);
    - Control and supervision (LC 26), including error checking and independent oversight during abnormal/emergency conditions, safety and engineering decisions.
- Is there evidence of staff involvement in the development of the proposed changes to staffing and task organisation?
- Have lessons learned from previous changes been considered and applied?
- Has a pilot study been carried out to test out the proposed arrangements prior to full-scale implementation?
- Have the necessary 'enablers' been identified and implemented prior to the change? (e.g. changes to procedures and work practices to allow fewer staff to manage the work)
- Is there a clear transition plan to ensure that the change from existing to new arrangements is effectively managed?
- Has the applicant/licensee established appropriate performance indicators and other mechanisms for monitoring the impact of the change in arrangements on safety? These may include data on backlogs (e.g. plant modifications, procedure revisions), event data; quality measures such as re-work; overtime data; absence and sickness data, and results of staff surveys or simulator exercises.

6. REFERENCES

(Note that the content of these new references remains unchanged for the human factors aspects):

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