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| ONR Technical Assessment Guide  Staffing Levels and Task Organisation |



ONR Technical Assessment Guide (TAG)

Staffing Levels and Task Organisation

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Issue No.: 5

Publication Date: Jun-23

Next Major Review Date: Jun-28

Doc. Ref.: NS-TAST-GD-061

Record Ref. No.: 2020/127012

Table 1 - Revision commentary

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| Issue No. | Description of Update(s) |
| 4.3 | Minor update to remove extant URLs from the document to mitigate potential configuration control issues arising because of changes to third-party web domains. |
| 5 | Major update to section 5 to incorporate new and additional advice to inspectors. |

Contents

[1. Introduction 4](#_Toc138663603)

[2. Purpose and Scope 5](#_Toc138663604)

[3. Relationship to Licence and other Relevant Legislation 8](#_Toc138663605)

[4. Relationship to Safety Assessment Principles, WENRA Reference Levels, and IAEA Safety Standards and Guides 10](#_Toc138663606)

[5. Advice to Inspectors 13](#_Toc138663607)

[References 29](#_Toc138663608)

# Introduction

1. ONR has established its [Safety Assessment Principles](http://www.onr.org.uk/saps/saps2014.pdf) (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 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 (TAG) is one of these guides.

# Purpose and Scope

1. The primary aim of the document is to provide guidance to ONR Inspectors in the exercise of their regulatory judgement when assessing a licence applicants/ licensee’s arrangements for staffing and task organisation.
2. 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 lifecycle of the facility. The term nuclear safety within the context of this document encompasses both nuclear and radiological safety.
3. ‘Task organisation’ in this context refers to the way in which work and associated 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. Task organisation encompasses or is linked to a number of related topics including the design of shift work systems, team design and workload (refer to the definitions in paragraph 9).
4. 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 licence applicants and licensees to derive, validate, and monitor staffing arrangements and task organisation, including the design of shift work systems and team design.
5. This TAG has been written with ONR’s Nuclear Safety purpose in mind, however, the principles within this TAG may be applicable to other purposes, such as Conventional Health and Safety, Safeguards and Security.   
   Where specific queries arise, advice on applicability should be sought from a Human Factors Specialist Inspector
6. The guidance in this TAG is intended for use during the assessment of safety cases for new and existing nuclear facilities, for example:

* The review of arrangements for staffing and task organisation as part of the design and licensing of new facilities.
* The review of proposed changes to staffing arrangements or task organisation under Licence Condition (LC) 36 (for example, changes to   
  12-hour shift patterns, introduction of a multi-skilling programme, downsizing).
* The review of design changes made under LC 22 which may impact on staffing or task organisation (for example, major change to the level of automation).
* Other regulatory interventions (for example, follow up to an event linked to staffing or task organisation).

1. The guidance in this TAG may also be of relevance to Site Inspectors during inspections (for example, 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. The following definitions apply in using this Guidance.

* **Concept of Operations** - A description of the design, systems and operational characteristics of the plant. In this context this relates to the licence applicant’s or licensee’s organisational structure, staffing and management framework and how they support the proposed operations.
* **Staffing Levels** – Having the right numbers of the right people, in the right place at the right time.
* **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 and plant lifecycle and for all operational states.
* **Target Audience Description** (TAD) - A description of the demographic of people who will use a facility or proposed design including information on their physiological, psychological and behavioural characteristics and limitations.
* **Workload** - The mental and/or physical demands placed on a user by the task requirements, the workplace and the environment (including the organisation).
* **Multi skilling** - This incorporates two levels as follows:
  + **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.
* **Shift Pattern -** refers to the way that shifts are scheduled for employees or members of a team. Shift patterns can vary greatly from business to business and are determined by multiple factors from the total number of staff, to the length of time each shift covers, to how often the shift pattern repeats or rotates and when.

1. This TAG is intended to complement the guidance in the TAG on the Function and Content of the Nuclear Baseline [2], by providing additional information on methods and approaches to derive and validate staffing requirements. This includes inputs from the duty holders’ Human Factors Integration Programme (refer to [3] for further information). The guidance in this TAG should be used in conjunction with [2] and other relevant TAGs.

# Relationship to Licence and other Relevant Legislation

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 LCs 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 Suitable 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 licensed 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.

1. **The Management of Health and Safety at Work Regulations** **1999** is relevant to the guidance in this TAG as follows:

* **Regulation 5** requires employers to have arrangements as appropriate for the effective planning, organisation, control, monitoring and review of the preventive and protective measures
* **Regulation 7** requires an employer to appoint competent persons to assist him in undertaking the measures he needs to comply with the requirements and prohibitions imposed on him.

# Relationship to Safety Assessment Principles, WENRA Reference Levels, and IAEA Safety Standards and Guides

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

* **MS.1** - Directors, managers and leaders at all levels should focus the organisation on achieving and sustaining high standards of safety and on delivering the characteristics of a high reliability organisation.
* **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.

* **MS.3** - Decisions made at all levels in the organisation affecting safety should be informed, rational, objective, transparent and prudent.
* **MS.4** - Lessons should be learned from internal and external sources to continually improve leadership, organisational capability, the management system, safety decision making and safety performance.
* **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

1. 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.
2. 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 [4]. 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

1. 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 IAEA documents are relevant to this TAG:

* IAEA Safety Guide, ‘The Operating Organization for Nuclear Power Plants’ [5].
* IAEA Safety Guide, ‘Conduct of Operations at Nuclear Power Plants’ [6].
* IAEA Technical Document, ‘NPP Organization and Staffing for Improved Performance – Lessons Learned‘ [7].

# Advice to Inspectors

## Introduction

1. Ensuring that the appropriate number of competent people are organised and deployed in the right way 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, such as facility design (including level of automation, size and layout); material condition of the facility; lifecycle phase; type of process (for example, batch versus continuous operation); operating state (for example, at power or shutdown operations); regulatory requirements; training and competency models   
   (for example, use of shift personnel to perform minor maintenance) and use of in-house versus contract resources.
2. The guidance in this section is structured in line with the phases shown in Figure 1 and is set out in the following sub-sections:

* 5.2 - General Principles
* 5.3 - Establishing the Early Staffing Concept
* 5.4 - Determining the Staffing Levels and Task Organisation
* 5.5 - Determining the Shift Pattern
* 5.6 - Verification and Validation
* 5.7 - Implementation and Monitoring of Staffing Levels
* 5.8 - Periodic Review of Safety
* 5.9 - Management of Change
* 5.10 - Management of Fatigue and Fitness for Duty

1. Whilst this guidance is structured in line with Figure 1, it is noted that proportionate integration of Human Factors to Staffing levels and task organisation assessment will occur throughout the design and safety case lifecycle, with evidence being developed in an iterative manner.

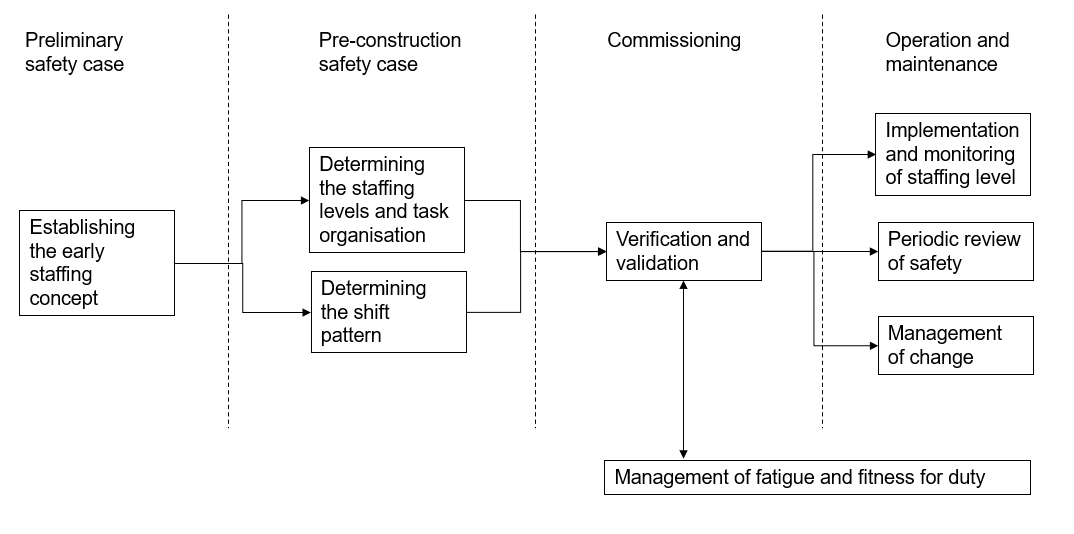


Figure 1 - Stages in determining Staffing Levels and Task Organisation

## General Principles

1. ONR expects management at the appropriate level in the licensee’s organisation to understand staffing requirements, maintain oversight and ensure that any proposed changes go through due process to avoid negative impacts on nuclear safety.
2. Licensee’s arrangements for staffing and organisation should be consistent with relevant standards and good practices and be appropriate to the facility/activity.
3. Novel or unfamiliar methods used to develop, substantiate or make changes to arrangements should be scrutinised by Inspectors to confirm their technical credibility and appropriateness. Specialist Human Factors and/or Leadership and Management for Safety (LMfS) support should be sought for assessments of this type.

### Learning Organisation

1. 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 both for new and existing facilities. 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. Key factors have included team size and composition, clarity of roles and responsibilities, communication and supervision.
2. ONR expects that a licensee’s arrangements for learning (including use of operating experience feedback (OEF) will explicitly identify events and experience relating to staffing and task organisation. This learning should be actively used to inform improvements and any proposed changes or modifications to the facility and its staffing.
3. ONR encourages licensees to benchmark their approaches to staffing and task organisation to those used by other organisations to identify issues and areas for improvement. Additional useful guidance on benchmarking NPP staffing is provided in [7].

## Establishing the Early Staffing Concept

1. In the early stages of the design process, it is important to consider the basic premise or principles upon which staffing will be determined and any analysis which is required to inform this. Analysis at this stage is likely to involve a multi-disciplinary approach, and may draw on for example, operational research, workforce planning, activity and function analysis, throughput analysis and learning from existing facilities.
2. At this stage, Inspectors should seek to gain confidence that licensees have given sufficient consideration to the way a facility will be staffed in order to determine an approximation of the number of roles/people required and associated skillsets. This is important both to inform the design and safety analysis, and to facilitate timely workforce planning.
3. Inspectors should consider:

* Whether the licensee has made suitable use of OEF and has identified and acted on lessons learned relating to staffing and task organisation?
* The staffing concept at other similar facilities, for example, has the licensee performed benchmarking to compare its arrangements for staffing and task organisation against those of comparable facilities within or outside of the licensee? Have they considered problems and good practices learned from the implementation of similar technologies and concept of operations in the nuclear and other industries.
* Potential for a shared resource pool, for example, have the potential implications of sharing staff between multiple units or facilities been considered, including where staff is co-opted from a shared work pool? These include competence requirements (for example, 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.
* The likely use of technology on the site, for example, has the licensee considered the equipment and technology likely to be used on the site and associated allocation of function? Consider:
  + 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 (refer to [8] for further information). There is some evidence reported, for example in [9] and [10], that computerised interfaces and plant design features do not necessarily reduce staffing needs. The licensee should therefore be able to demonstrate the validity of any assumptions relating to levels of automation and staffing.
  + Has the licensee followed an adequate Allocation of Function (AoF) process? The TAGs on Human Factors Integration [3] and Allocation of Function Between Human and Engineering Systems [11] provide additional guidance for Inspectors on allocating tasks to humans and automation, and the design of tasks for safe and reliable human performance.
* The likely skills required to operate the site and how these will be gained, for example, is a dedicated in-house training organisation required?

1. Inspectors should also seek to confirm that the output of this early analysis has been used to inform the design and has been suitably captured.   
   Details of staffing and task organisation can usefully be detailed within the Concept of Operations and Target Audience Description (TAD).

## Determining the Staffing Levels and Task Organisation

### Staffing Levels

1. The diversity of nuclear facilities and activities means that no one approach to determining staffing levels and task organisation is universally applicable. However, staffing levels should be informed by proportionate analysis of the activities, tasks and job functions to be performed.
2. As stated in the Function and Content of the Nuclear Baseline TAG [2],   
   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, 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. The inspector should consider whether the licensee has used a recognised approach for identifying roles and tasks important to nuclear safety to establish their staffing needs.
3. There are a number of methods and approaches to establishing staffing arrangements. These analyses include OEF review, function analysis and allocation, task analysis, human reliability analysis and human factors validation exercises (refer to [12] for further information). The inspector should consider:

* Has OEF been used as an input to the definition of staffing levels and the approaches used to organise tasks, for example, to identify problem areas for additional analysis or scenarios for validation exercises?
* Are analyses carried out as part of the Human Factors Integration Plan and supporting programme used as an input to the derivation and validation of staffing and task organisation?
* 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, justified by task analysis and other relevant information, for example, 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 and is this considered in relation to the staffing levels required?
* Where significant human-based claims are made in the safety case, has the licensee demonstrated that individual and team performance is achievable and is supported by adequate supervision?
* Can the licensee demonstrate that there are adequate resources for normal, fault recovery and emergency conditions including the most resource-intensive scenarios?
* Do the staffing arrangements allow sufficient time for training and development, and for rest and recovery, particularly during busy periods such as maintenance outages?

1. Following this analysis and determination of the staffing levels, Inspectors should consider:

* Is the output of this fed into the design process and updates to the concept of operations and TAD. Has the licensee 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’s or applicant’s organisational structure, staffing and management framework?
* Are staffing levels and task organisation considered as an integral part of the design process and captured where appropriate in a TAD?

1. 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.
* Consider whether the licensee 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.)?
* Consider whether formal analysis is required to demonstrate the adequacy of the existing staffing arrangements, for example where there are roles with a high potential impact on nuclear safety.

### Workload

1. In addition to the requirements for analysis of tasks, 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’.

1. For roles with a high potential impact on nuclear safety, formal analysis may be required to demonstrate the adequacy of proposed or existing staffing arrangements. For example, predictive workload analysis techniques could be used as an input when determining staffing levels. These should consider both the physical and cognitive demands placed on humans during safety case claimed tasks.
2. The Inspector should consider the following aspects:

* Has the licensee carried out task and workload analysis where appropriate to determine the necessary 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?
* Has the analysis appropriately considered both physical and cognitive workload?
* 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)?   
  [13] includes a review of 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). Simply complying with a range of workload may not be acceptable, for example, when considering a high vigilance task (where a reasonable expectation might be less than 50% workload). Therefore, 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? [14] provides additional guidance on the assessment of minimum staff complement.
* Has the most-resource intensive scenario been accurately identified? The most significant fault sequence in the safety case is not necessarily the scenario that would be most challenging to the operators   
  (for example, a task that has less risk significance but is not clearly proceduralised may require more decision-making than a post-trip action).
* Has the licensee demonstrated consideration of how onerous both the cumulative and peak demands on the operators are across a range of scenarios?
* Does the analysis consider the full range of roles and tasks to be performed by facility personnel for the event(s) considered,   
  for example, 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 or review of the Nuclear Baseline?

### Team Design

1. 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).
2. Inspectors should consider the following aspects:

* 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 for example, engineering, safety case and oversight functions.
* Has the licensee established appropriate spans of control? There are differing views on what constitutes an optimal span of control   
  (ranging from 5 to 20 people). There are advantages and disadvantages to both wide and narrow spans of control. Narrow spans of control are usually 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 also result in supervisors being overloaded. The licensee should demonstrate that they have considered these factors as well 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? (refer to paragraph 32 on task analysis). Are those requirements adequately communicated to those with supervisory responsibilities? Are they understood by the supervisors and is there sufficient time for supervisors to perform their supervisory duties?
* Are the following clearly defined 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 for example, central control teams and field teams, respective shifts, central support team (including those external to site)? As part of this, consideration should be given to high workload conditions such as during faults, emergencies, outages and start-up operations.
* Where appropriate has the licensee assessed the impact of approaches such as skill broadening and self-managed teams on claims made in the safety case (for example, credit taken for independent verification, number and location of staff, and supervision)?

## Determining the Shift Pattern

1. The design of shift systems is an important part of organisational system design. The type and nature of the shift system design can impact both positively and negatively on worker health and wellbeing which in turn impacts performance.
2. Poorly designed shift systems can increase fatigue which 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, reduces motivation or interest in work and can slow reaction time [15]. There are a number of HSE publications on shift pattern design ([15], [16] and [17]. Additionally, the Energy Institute have published a document on how to develop a Fatigue Risk Management Plan which provides useful guidance [18].
3. Inspectors should consider whether the licensee has carried out an adequate assessment of proposed or existing shift patterns to highlight potential issues, to compare them and to identify a suitable pattern. This is applicable to shift patterns for normal operations and during outages. Inspectors should consider:

* Has the assessment been undertaken using appropriate qualitative criteria (for example, those outlined under paragraph 43) and, where required, an appropriate tool such as the HSE fatigue/risk index [16]? Has the assessment been undertaken by those with an appropriate level of expertise related to shift pattern design and fatigue risk   
  (noting this may not always be HF)?
* Has consideration been given to any OEF that could usefully inform the assessment?
* Have reasonably practical changes/mitigations to shift patterns and their implementation which could reduce the potential for fatigue and improve alignment with good practice, been considered and either implemented or justified as ALARP where not implemented?
* Where changes are proposed to existing shift pattens, has a suitable plan for trialling and implementation of the revised shift pattern been developed? Is this supported by an appropriate suite of indicators and success criteria to identify and evaluate the extent of any performance detriments or impacts on wellbeing as a result of the change in shift pattern? Refer to Section 5.9.

1. When considering specifics of shift design, the Inspector should consider whether the shift pattern is consistent with good practice principles (refer to [15] and [17]). 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 two-three days) or very slow rotation (every three-four weeks) is recommended.
* Length of shift. Scheduled shifts longer than 12 hours should be avoided (including handovers). A US Nuclear Regulatory Commission document in support of rulemaking on fatigue of workers at nuclear power plants [19] 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’.

* Type of work. Shorter shift lengths (for example, 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.
* Number of consecutive night shifts. Studies suggest that the number of scheduled consecutive night shifts should be limited to three [18]   
  (due to increase in risk and reduced ability to detect decreasing human performance).
* Rest and recovery periods. Adequate periods should be scheduled between individual shifts (11 hours) and following a series of consecutive shifts (for example, 48 hours after two or more consecutive night shifts) in order 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.

1. The working environment and available facilities can have an impact on fatigue and performance, and should be considered in the context of the chosen shift pattern (for example, to support night-time working if 24-hour manning is required)? The Inspector should consider the following:

* Are any necessary facilities available for shift workers as well as daytime workers (for example, access to canteen or kitchen facilities)?
* Do shift workers have access to a rest area? Has the Licensee considered what facilities are appropriate within the rest area (for example, a gym and/or a place to lie down/nap)?
* Are temperature and lighting levels appropriate to aid alertness?   
  Are shift workers able to adjust these within their work area?   
  Specialist advice should be sought before implementing such measures. The TAG on Workplaces and Work Environments provides further information [20].

1. Proposed changes to shift patterns should, where appropriate, trigger assessment under the licensee’s LC 36 arrangements.

## Verification and Validation

1. 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’
2. ONR expects licensees 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 the following:

* Data from operating experience programmes.
* Learning from emergency exercises.
* Findings from tabletop analysis such as the ‘Safe Staffing Arrangements’ method developed by Entec [21].
* Results of simulator studies of scenarios involving claims on the operator.
* Data from trials and inactive commissioning.
* Output from human performance modelling (for example Task Network Modelling).

1. Additional information on the above methods, including strengths and weaknesses, can be found in [13].
2. The validation exercises should demonstrate that the following can be achieved by the minimum staff complement for all validation scenarios [14]:

* The relevant procedures can be effectively implemented in a timely manner.
* There is an effective and timely response to anticipated operational occurrences, design-basis accidents, and emergencies.
* The facility can be effectively monitored, controlled and stabilised.
* There is effective communication and coordination of required actions.
* Workers are able to maintain awareness of facility conditions.
* The physical and mental workload of minimum staff complement is achievable.
* All safety-critical human actions are achievable.

## Implementation and Monitoring of Staffing Levels

1. Inspectors should consider whether the licensee has adequate arrangements for the implementation and ongoing monitoring of staffing levels. Specific questions for Inspectors to consider include:

* Is there evidence of effective management of staffing levels above the required minimum, for example rapid call-out due to unexpected absence and appropriate decision making to support this?
* Do qualitative and quantitative indicators support claims regarding adequacy of staffing levels and task organisation? Indicators of potential problems include the following:
  + 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   
    (for example, high levels of sick leave, union grievances)
* Does the licensee’s event reporting and analysis process include the potential contribution of staffing and task organisation?
  + Where event reports identify challenges in relation to staffing or repeated breaches of minimum staffing levels, are the root causes evaluated and action taken to ensure adequate staffing levels are maintained?

## Periodic Review of Safety

1. SAP EHF5 states that:

‘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’.

1. More detailed guidance for Inspectors on periodic reviews can be found in [22]. Inspectors should consider whether the periodic review has adequately considered the validity of the staffing levels and task design, taking into consideration potential operational changes over the forthcoming review period.
2. Inspectors should consider whether any reviews have been performed to assess the adequacy of the staffing model, for example, as part of Periodic Safety Reviews, Self-Assessments, Benchmarking or Peer Reviews. Where these reviews have been performed, any deficiencies raised through the reviews should be adequately considered and addressed. For example, has benchmarking been used to identify areas for improvement such as areas/functions where staffing may be insufficient? Similarly, have areas/functions been identified where activities are being omitted due to staffing shortages which may impact nuclear safety?

## Management of Change

1. Any proposed change to staffing and task organisation arrangements should be considered in a systematic and structured way giving due consideration to their potential impact on safety. Drivers to change may include improving efficiency (including multi-skilling), reducing costs, achieving required levels of reliability, increasing production or changes of lifecycle stage.
2. Lessons learned from events reinforce the need to consider the potential implications of any reductions to staff numbers, for example through multiskilling or skill broadening. A HSE research report on multi-skilling [23] includes a detailed review of the potential risks associated with multi-skilling and risk mitigation strategies.
3. Inspectors should consider the following aspects.

* 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, for example, on morale or ability to deliver short- and long-term work to required standards?
* 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?
* Has the licensee taken a structured approach to evaluating the potential effects of the proposed organisational change? Important considerations include the following:
  + 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 for example, 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
* 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 with the required level of reliability?
* Is there evidence of staff involvement in the development of the proposed changes to staffing and task organisation? Although it is appropriate to involve staff in the process, it is important that this is considered as one part of a balanced assessment of risk.
* Have lessons learned from previous changes been considered and applied?
* Has a pilot study (where appropriate) been carried out to test out the proposed arrangements prior to full-scale implementation and any learning used to make appropriate improvements?
* Have the necessary ‘enablers’ been identified and implemented prior to the change (for example, 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 licence 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 (for example, 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.

## Management of Fatigue and Fitness for Duty

1. As well as designing a suitable shift pattern in order to reduce the likelihood of fatigue, it is also important that the licensee actively manages fatigue levels of all staff in all operational states (including outages). The Canadian Nuclear Safety Commission document provides further guidance on management of fatigue [24]. The Inspector should consider whether the licensee has suitable fatigue management arrangements in place and whether these apply to engineering groups as well as operations and maintenance staff. Inspectors should consider whether the licensee’s arrangements are adequate to:

* Actively monitor and control both the cumulative component (the effect of the entirety of a shift pattern), and the duty timing component (the effects of the individual shifts and their design).
* Control the number of consecutive shifts worked (particularly night shifts and during outages).
* Monitor and control hours worked, including overtime. Limits on hours worked should be set out in a policy/procedure and be consistent with the [Working Time Regulations](https://www.legislation.gov.uk/uksi/2007/2079/made) [25] and [HSG 256](https://www.hse.gov.uk/pubns/books/hsg256.htm) [17].
* Cover absences through illness, vacation and training   
  (for example, ‘spare’ shift).
* Ensure a risk assessment is undertaken to demonstrate that fatigue is adequately managed where deviations to the normal shift pattern are proposed.
* Control shift-swapping and second jobs.
* Ensure and monitor fitness for duty of all staff, as appropriate and establish effective processes for the management of any staff found not fit for duty, including managing the impact on staffing levels and other team members.

1. The Inspector should also consider whether the licensee aids its staff, as appropriate, to manage their fatigue during a shift, for example by:

* Providing 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 outages.
* Ensuring, where practicable, that tasks are planned and organised to reduce the risk of fatigue adversely impacting on human performance (for example, avoid planning safety-critical work between 2am and 6am and towards the end of a long shift, increased supervision during periods of low alertness).
* Allowing staff to manage their breaks effectively across a shift and, where appropriate (for example, longer breaks), ensuring responsibilities can be handed over during breaks to another duly authorised person such that the break time can be fully utilised.
  + Short breaks (5-15 minutes) every 1-2 hours may help maintain performance levels.
  + Alternatively, a longer break may be required if a staff member wishes to nap. Note that ‘napping’ should only be used as a strategy under supervision as naps of longer than 30 minutes (for example, 40-60 minutes) can make people feel more tired than before taking the nap.
  + Ensuring sufficient levels of supervision of tasks in a timely manner
  + Ensuring effective handover protocols
  + Ensuring effective processes are in place for staff working remotely.

1. Management of fatigue is one element of ensuring staff fitness for duty with another key element being a programme related to alcohol and drug use. Inspectors should consider whether licensees have implemented an effective fitness-for-duty programme that provides reasonable assurance that workers have the capacity and are free of impairment that could hinder their ability, to competently and safely perform the duties of their position, and as such do not pose a safety or security risk [26]. As part of this, Inspectors should consider whether the licensee has guidelines and policies on fitness for duty related to substance use. The policy statements should provide workers with information on what is expected of them and the consequences that may result from policy violations.
2. Inspectors should also consider whether the licensee has in place processes to allow the fitness for duty of shift personnel to be observed, verified and controlled (for example, screening process). The process should include actions for a supervisor to take if they believe – through self-reporting, peer reporting, observed behaviour, physical condition, a fitness-for-duty screening or assessment, a health professional’s report or after receiving credible information – that a worker may be unable to perform their assigned duties competently and safely because of alcohol or drug use or abuse.   
   The licensee should also ensure that those with authorities, accountabilities, and responsibilities for monitoring alcohol and drug use and abuse, including workers, receive initial and continuing training commensurate with their authorities, accountabilities and responsibilities.
3. The Canadian Nuclear Safety Commission document [26] and HSE guidance on Managing drug and alcohol misuse at work [27] provide further guidance on this.

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