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Finnish Institute of Occupational Health

Workload management in an external crisis

Recommendations for the work of nuclear industry control room operators and emergency response organisation personnel

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Similar recommendations are also available for the work of health care professionals, rescue workers and paramedics: www.ttl.fi/teemat/tyohyvinvointi-ja-tyokyky/tyokyky/tyokuormituksen-hallinta-ja-palautuminen-kriisissa

1 Introduction

External crises challenge the well-being of employees, which also affects the workplace's resilience to crises. The purpose of these recommendations is to assist nuclear industry workplaces draw up a concrete plan to prevent excessive strain in control room operators and emergency response organisation personnel during an external crisis.

In a crisis, which can be caused by, for example, radiation and nuclear accidents at home and abroad, extreme weather or cyber threats, the mental, social and physical workload increases, as does the workload associated with changes to working time and rest break arrangements. The employee's work-related strain and recovery are also influenced by their individual characteristics and life situation, as well as the nature of the work.

Workload can be managed by modifying the work and strengthening the employee's resources. Workload management is supported by the assessment of employee strain and recovery. These three areas will be discussed later in this document based on both research and experiential knowledge. The data was obtained from the Finnish Institute of Occupational Health's Workload Management in Safety-critical Work During an External crisis project (www.ttl.fi/en/research/projects/workload-management-in-safety-critical-work-during-an-external-crisis), in which the participants included experts from Teollisuuden Voima Oyj's Olkiluoto power plant, Fortum Oyj's Loviisa power plant and the Radiation and Nuclear Safety Authority. The experiential knowledge is based on their views and assessments. In addition, the draft version of the recommendations has been reviewed by a group of other nuclear industry experts.

2 Job accomodation

Workload can be managed by modifying work arrangements, working methods and working practices. The measures include:

1. appropriate leadership, management, and information flow
2. ergonomic working practices that prevent excessive strain
3. working time arrangements
4. rest break arrangements
5. clearly defined tasks, roles and responsibilities
6. guidelines and checklists that support the work
7. technical solutions that support decision-making
8. comprehensive management of the control room workload
9. human resource planning

Table 1. Workload management measures related to work arrangements, working methods and working practices.

	Workload management measures related to work arrangements, working methods and working practices
1	**Appropriate leadership, management, and information flow** prevent excessive strain caused by psychosocial factors in particular. When managing issues, it is important that the employees are familiar with the management relationships, information flow processes and the model by which their day-to-day work is managed. In leadership, encouragement and interaction are key. In information flow, regularity, transparency and the usefulness of shared information to the target group are important.
2	**Working practices that prevent excessive strain** can be promoted with ergonomic solutions. The main solutions pertain to the workstation and tools. They affect physical and cognitive strain in particular. Ergonomic workstation solutions can reduce, for example, prolonged sitting and strenuous movements and positions, and make the detection of relevant information easier. Ergonomically designed tools can also prevent excessive cognitive load caused by the complexity and large amounts of information. The technical solutions that support decision-making and comprehensive control room workload management included in this table are part of these solutions.
3	**Working time arrangements** can prevent excessive strain in a comprehensive manner. Central working time characteristics include (some limit values in brackets): • the duration of shifts (max. 12 h) • the duration of the working period between two days off (up to 48 h) • the duration of time off between shifts (minimum 11 h and minimum 28 h after the last shift of a night shift period) • the number of consecutive shifts (maximum five shifts) • the number of consecutive night shifts (maximum three shifts)
4	**Rest break arrangements** provide comprehensive support for recovery during the work shift. A rest break should be taken before excessive fatigue, and it must offer the opportunity to detach from work. The frequency and duration of rest breaks must be proportionate to the requirements of the work.
5	**Clearly defined tasks, roles and responsibilities** can help prevent excessive strain caused by psychosocial factors in particular. Therefore, it is important that the employees are familiarised in advance with their tasks, roles and responsibilities in a crisis situation.
6	**Guidelines and checklists** can be used to prevent excessive cognitive strain in particular. In terms of their level of detail, it is important to consider how clear and predictable the work situations are. It is good to involve end users in the development of guidelines and checklists.
7	**Technical solutions that support decision-making**, including the use of AI, prevent excessive cognitive and mental strain in particular. They facilitate decision-making, identifying relevant information, and establishing and maintaining situation awareness, for instance.
8	**Control room workload management** can be promoted by assessing control room work as a whole. In this case, in addition to the measures already listed in this table, it is essential to assess the number and quality of ancillary work tasks and their effects on the performance of the primary work tasks, as well as the possibilities of supporting alertness when there is no need to actively control the production process.
9	**Human resource planning** can be used to prevent excessive strain in a comprehensive manner. In a crisis situation, the use of this measure is facilitated by having ready-made plans at the workplace for: • the tasks and roles of the personnel and their orientation • job rotation between more and less demanding tasks • float pool personnel and their orientation • the recruitment and orientation of additional personnel.

2.1 What do we know about job accommodation?

2.1.1 Emergency response organisation personnel

Based on experiential knowledge, excessive strain in emergency response organisation personnel in a crisis situation can best be prevented with

- appropriate leadership, management, and information flow
- clearly defined tasks, roles and responsibilities
- guidelines and checklists that support the work

In terms of management and information flow, it is advisable to switch to a crisis model that has been tested in advance. The model includes a clear process for information flow both within one's own organisation and with other organizations. The crisis model also includes a plan that specifies the tasks, roles and responsibilities of various parties.

Guidelines and checklists create the basis for consistent and error-free operations in a crisis situation. The challenge is that the situations may be rare and complex, and therefore more difficult to instruct in advance than under normal circumstances. It is therefore advisable to allocate more resources than usual to the preparation, maintenance and testing of crisis guidelines and checklists.

Based on experiential knowledge, **working time and rest break arrangements** are also important means for managing workload in crisis situations. Utilising these arrangements may be challenging due to limited financial and human resources, and the unpredictability associated with crises. It is recommended that principles for work shift and rest break arrangements that support recovery are established in advance at the workplace. These principles can then be applied to crisis situations, taking into account situational factors that are often unpredictable.

There is insufficient research evidence available on managing the workload of emergency response organisation personnel in crisis situations in order to properly assess the benefits of job accommodation measures. Instead, similar studies are available on nuclear power plant control room operators (see section 2.1.2) and health care personnel. The latter studies support the notion of the importance of leadership and information flow in particular in managing workload in crisis situations[1–7].

2.1.2 Control room operators

Based on experiential knowledge, excessive strain in control room operators in a crisis situation can best be prevented with:

- appropriate leadership, management, and information flow
- working-time arrangements that support recovery
- clearly defined tasks, roles and responsibilities
- guidelines and checklists that support the work
- technical solutions that support decision-making

Experiential knowledge also suggests that developing control room operators' workload management in case of crises is beneficial. Development areas include, for example, opportunities to limit ancillary work, and ways to maintain alertness when the production process does not require any action from the control room operator.

Research evidence shows that excessive strain in control room operators in a crisis situation can be prevented with

- technical solutions that support decision-making[8–25]
- guidelines and checklists that support the work[26–37]

In addition, research evidence supports the notion that both the information that flows between people and the system information that describes the state of the production process both need to be easily available and understandable in a crisis situation. [38–50].

3 Strengthening employees' resources

Workload can be managed by strengthening employees' resources before and during a crisis with the following means:

1. crisis training
2. ensuring professional competence and functional capacity
3. support provided by the workplace and the work community
4. methods that support mental health and well-being

Table 2. Workload management measures related to strengthening the employee's resources.

	Workload management measures related to strengthening the employee's resources
1	**Regular and sufficiently frequent crisis training** prevents excessive strain in a crisis situation in a comprehensive manner. The training can be carried out in • the real world • a simulator • a virtual learning environment • In connection with a "classroom" or online training.
2	**Ensuring professional competence and functional capacity** prevents excessive strain in a comprehensive manner. The more flexibility employees have in terms of resources, the more likely they are to avoid excessive strain in a crisis situation. In addition to crisis training, it is important that the workplace also supports the employee in maintaining competence and functional capacity in other ways. These include, for example, enabling on-the-job learning, providing training and encouraging exercise during free time.
3	**The support provided by the workplace and the work community** prevents excessive strain caused by psychosocial factors at work in particular. This support includes material, functional and emotional support. Workplace support also includes the provision of such working conditions in which the work can generally be performed without high time pressure and repeated unreasonable challenges.
4	**Mental health and well-being support** can prevent and reduce excessive strain caused by psychosocial factors at work in particular. These methods include training to support mental well-being, mental exercises, psychological briefing and debriefing methods, self-care and therapies. Organising this kind of support is part of what the workplace can do to support its employees in a crisis situation.

3.1 What do we know about strengthening the employee's resources?

Based on experiential knowledge, crisis training and other activities that support competence and functional capacity are the most effective measures for strengthening the resources of both emergency response organisation personnel and control room operators in case of crises. Research evidence on nuclear power plant control room operators supports the importance of crisis training in particular. According to research, learning outcomes are significantly influenced by the frequency and amount of training[51]. In practice, the optimal amount and frequency of training should be assessed on a task-specific basis at the workplace. It is also important to make the training as realistic as possible to strengthen the competence and stress management required in a real situation.

There is little data available on **the importance of the support provided by the workplace and the work community** in the nuclear industry. Based on research in the health care sector, this area/field/aspect of support is one of the most important factors when it comes to strengthening employees' resources in crisis situations[2,5,56,57].

Based on experiential knowledge, it is advisable to utilise the methods of mental health and well-being support, such as psychological debriefing, in both employee groups as needed. It is advisable that is done under the guidance of trained professionals and on a voluntary basis. As the research evidence on the methods of mental health and well-being support in the nuclear industry is lacking, it is not possible to evaluate their effectiveness in crisis situations. Yet, studies in the health care sector have provided some positive evidence of the benefits of these methods (e.g. mindfulness exercises and brief therapy) in crisis situations[52–55]. A key factor is the availability of support in its various forms in crisis situations.

4 Assessing employee strain and recovery

Assessing the strain and recovery of personnel helps the workplace select and schedule management measures in crisis situations. The assessment can be targeted at those employee groups whose duties change significantly in a crisis situation and/or whose contribution has a significant impact on the work community as a whole.

In order to assess employee workload and recovery in a crisis situation, it is beneficial if the workplace has conducted a similar assessment before the crisis. This makes it easier to assess the additional burden caused by the crisis situation. However, assessments alone are not enough, as the workplace must have processes and procedures in place in order to utilise the assessment results.

Based on experiential knowledge, assessing employee workload and recovery in crisis situations is challenging because the situations are often rare and unique and because practical implementation and the use of the information gained from the assessment require effort. The assessment is best suited for prolonged crisis situations. Employee strain and recovery can also be assessed in connection with crisis training. This facilitates the planning of work tasks in crisis situations in a way that reduces the risk of excessive strain.

Based on research evidence in general, the key factors to be assessed include mental and/or physical strain, sleep, as well as alertness and fatigue during the shift. The assessment can be based on, for example, questionnaires completed every 3–6 months and field measurements carried out in periods of 1–2 weeks at work and in free time. The most common questionnaires and field methods suitable for this purpose are described in Appendix 1. In addition, the employee can choose to use smart devices available on the market to measure strain and recovery.

It is advisable for the employer to co-operate with occupational health care when assessing employee workload and recovery and utilising the results.

5 Recommendations for workload management

Based on experiential knowledge and research, it is recommended that nuclear industry workplaces support the well-being of control room operators and emergency response organisation personnel in crisis situations through job accommodation and by strengthening the employees' resources. Preparing for crisis situations in advance is essential because familiarising oneself with different workload management measures during a crisis is very challenging. In addition, some of the measures, such as crisis training, need to be implemented before an actual crisis occurs.

Based on experiential knowledge, all the workload management measures described in Tables 1 and 2 are at least reasonably effective and feasible. Of them, the following are recommended for emergency response organisation personnel in particular:

- appropriate leadership, management, and information flow
- clearly defined tasks, roles and responsibilities
- guidelines and checklists that support the work
- regular crisis training in advance
- ensuring professional competence and functional capacity

Corresponding workload management measures for control room operators include:

- appropriate leadership, management, and information flow
- recovery-promoting working time arrangements
- clearly defined tasks, roles and responsibilities
- guidelines and checklists that support the work
- technical solutions that support decision-making
- regular crisis training in advance
- ensuring general competence and functional capacity

In the nuclear industry, research is available on crisis training as well as guidelines and checklists that support the work of control room operators. The results support the use of these management measures.

Based on research in the health care sector, it is also recommended to develop the workplace and the work community to offer practical, functional, and emotional support to their members. Similarly, it is recommended that the workplace organises the possibility for its employees to receive mental support from a professional in the event of a crisis.

Assessing employee workload and recovery through questionnaires and field measurements is best suited for prolonged crisis situations. In this case, it is important that the workplace has processes and procedures in place for utilising the results of the assessment. It is also a good idea to assess employee strain and recovery when practising for crisis situations. This facilitates the planning of work tasks in crisis situations in a way that reduces the risk of excessive strain.

6 Recommendations for creating a workplace-specific plan

In order for the workplace to have an effective plan for workload management in the event of a crisis situation, it is recommended that different levels and operators of the organization participate in its creation. The main principles of the plan are as follows:

- Management commits to the creation of the plan and organises the process.
- Different parties and organisational levels highlight key aspects from their point of view.
- The plan is produced as part of the management, occupational safety and health, and risk assessment processes and is compiled by a group appointed by the management.
- The plan is integrated into a broader crisis preparation protocol, such as the preparedness plan.

It is recommended that the plan includes at least the following:

- What is the purpose of the plan?
- Who does the plan apply to?
- Who is responsible for the plan?
- Who are informed about the plan?
- How is the plan updated?
- As concrete descriptions as possible of the workplace measures used to manage the workload in crisis situations. If necessary, the measures can be described separately for different crisis situations and occupational groups.
- Who is responsible for which management measures? For example, descriptions of who is responsible for preparatory crisis training and mental health and well-being support during a crisis.
- How are management measures integrated into the workplace's operations? For example, descriptions of how crisis training is integrated into a personnel training programme and how mental support is integrated into occupational health collaboration.

Table 3 helps the workplace outline which workload management measures it will include in the plan. The plan should be so concrete that it can be used as a manual in a crisis situation.

Table 3. In the table, mark the workload management measures that are necessary and possible at your workplace in crisis situations. In addition, assess whether these measures are already in place or require further development. If development is required, assign a responsible party and determine the development schedule.

Management measure	Necessary and possible	In order	Requires develop-ment	Party responsible for de-velopment	Development schedule
JOB ACCOMMODATION MEASURES					
Appropriate leadership, management, and information flow					
Preventive ergonomic working practices					
Recovery-promoting working time and rest break arrangements					
Clearly defined tasks, roles and responsibilities					
Guidelines and checklists that support the work					
Technical solutions that support decision-making					
Comprehensive control room workload management					
Human resource planning					
Other, please specify:					

Management measure	Necessary and possible	In order	Requires develop-ment	Party responsible for de-velopment	Development schedule
MEASURES TO STRENGTHEN THE EMPLOYEE'S RESOURCES					
Crisis training					
Ensuring professional competence and functional capacity					
Support provided by the workplace and the work community					
Methods for supporting mental health and well-being					
Other, please specify:					

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APPENDIX 1 Methods for assessing employee workload and recovery

The tables in the appendix have been prepared by the Finnish Institute of Occupational Health's working group, which includes Satu Mänttäri, Janne Halonen, Mikael Sallinen, Maria Sihvola and Pihla Säynäjäkangas.

Questionnaires and field methods for assessing mental strain

The superscript numbers refer to the references list at the end of the appendix.

Method	Description
QUESTIONNAIRES	
General Health Questionnaire 12[1]	A questionnaire for assessing mental workload, well-being and functional capacity. Filling out the questionnaire is quick, and the total score is easy to calculate. No special training is required to use the questionnaire. Available free of charge in Finnish.
Need for Recovery[2]	A questionnaire for assessing recovery from work at a general level. Predicts perceived health relatively well over the next few years, for instance. Filling out the questionnaire is quick, and the total score is easy to calculate. No special training is required to use the questionnaire. Available free of charge in Finnish.
FIELD METHODS	
NASA Task Load Index[3]	A relatively easy-to-use self-assessment tool that can mainly be used to assess the situational psychological and physical workload caused by the work during the shift. The data can be collected either with a smartphone, for example, or by the traditional pen-and-paper method. Available free of charge in Finnish.
Heart rate and heart rate variability measurement[4]	An easy-to-use and relatively inexpensive measurement method that is suitable for measuring over long periods of time and several people at the same time. Threshold values have been defined, but the interpretation of the results requires expertise. The measurement does not pose an occupational safety risk, and the method is also suitable for demanding work environments.

Questionnaires and field methods for assessing physical strain

The superscript numbers in the Method column refer to the references list at the end of the appendix.

Method	Description
QUESTIONNAIRE	
Work Ability Index[5]	A comprehensive questionnaire that covers different areas of work ability. Can also be used in conjunction with physical workload assessment to describe individuals' work ability. Filling out the questionnaire is quick, and the total score is easy to calculate. No special training is required to use the questionnaire.
FIELD METHODS	
Borg Rating of Perceived Exertion[6]	A reliable self-assessment method for measuring physical exertion and fatigue. The method is very easy to use and practically free. Available in Finnish.
Heart rate and heart rate variability measurement[4]	An easy-to-use and relatively inexpensive measurement method that is suitable for measuring over long periods of time and several people at the same time. Threshold values have been defined, but the interpretation of the results requires expertise. The measurement does not pose an occupational safety risk, and the method is also suitable for extremely demanding work environments.
Physical activity measurement	An easy-to-use method that is well suited for use in the work environment. Recommended for use with other physiological measurements. When used correctly, it also measures the physical requirements of the job. Various commercial measuring devices are available. The privacy protection of the collected data may vary depending on the device and its manufacturer.

Questionnaires and field methods for sleep assessment

The superscript numbers in the Method column refer to the sources in the references list below the tables.

Method	Description
QUESTIONNAIRES	
Pittsburgh Sleep Quality Index[7]	The most used questionnaire for measuring sleep quality. The questionnaire takes 5–10 minutes to complete. The scoring is easy, and threshold values for sleep quality are available. The Finnish version is subject to a fee.
Jenkins Sleep Scale[8]	Used to identify sleep problems. An effective and short questionnaire (four questions) that is easy to score. Threshold values for assessing sleep problems are available. A Finnish version is available.
Insomnia Severity Index[9]	Used to assess the severity of insomnia. The questionnaire is quick (seven or eight questions) and easy to score. Threshold values for assessing insomnia are available. A Finnish version is available.
Basic Nordic Sleep Questionnaire[10]	Used to obtain an overview of sleep and associated symptoms. Includes 21 questions.
FIELD METHODS	
Sleep diary[11]	An easy-to-use and practically free method. Suitable for measuring large groups of people. Accuracy depends on the subject's motivation and memory, so pairing it with an objective method is recommended.
Accelerometer-based activity monitors or actigraphs[12]	A widely used method for measuring sleep. The devices are relatively inexpensive and suitable for long-term measurements. Analysing and interpreting the results requires expertise.
Wearable smart devices	Various commercial measuring devices are available. The devices are easy to use, relatively inexpensive and suitable for measuring long periods of time and several people at the same time. No separate training is required for the measurement process and analysing the results. The reliability and accuracy of the measurement and privacy protection may vary depending on the device and manufacturer.

Field methods and mathematical modelling methods for assessing alertness and fatigue during work shifts

The superscript numbers in the Method column refer to the references list at the end of the appendix.

Method	Description
FIELD METHODS	
Karolinska Sleepiness Scale[13]	An easy-to-use and free method for the self-assessment of situational alertness (sleepiness) during a work shift. Also suitable for measuring large groups and several people at the same time. Can be used for different types of jobs, either with a smartphone app or the traditional pen-and-paper method. Available free of charge in Finnish.
Samn-Perelli Fatigue Scale[14]	An easy-to-use and free method for the self-assessment of situational fatigue during a work shift. Also suitable for measuring large groups and several people at the same time. Can be used for different types of jobs, either with a smartphone app or the traditional pen-and-paper method.
Psychomotor Vigilance Task[15]	Measures situational alertness and psychomotor reaction speed. The usability may be impaired by the fact that the duration of the vigilance task varies between three and ten minutes, depending on the test version. The test requires commercial software and a measuring device.
MATHEMATICAL MODELLING METHODS	
Sleep, Activity, Fatigue, and Task Effectiveness[16]	The method predicts alertness during work shifts based on their start and end times. The method is based on a so-called three-process model that consists of the relationship between sleep and wakefulness, the time of day and sleep inertia. The method has been validated in laboratory and field studies.
Fatigue Audit Inter Dyne[16]	The method predicts fatigue during work shifts based on their start and end times. The method is based on a so-called two-process model that consists of the relationship between sleep and wakefulness and the time of day.

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