

IAEA Nuclear Energy Series

No. NG-T-1.5

Basic
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Leadership, Human Performance and Internal Communication in Nuclear Emergencies



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LEADERSHIP, HUMAN PERFORMANCE
AND INTERNAL COMMUNICATION
IN NUCLEAR EMERGENCIES

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INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2018

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FOREWORD

One of the IAEA's statutory objectives is to "seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world." One way this objective is achieved is through the publication of a range of technical series. Two of these are the IAEA Nuclear Energy Series and the IAEA Safety Standards Series.

According to Article III.A.6 of the IAEA Statute, the safety standards establish "standards of safety for protection of health and minimization of danger to life and property". The safety standards include the Safety Fundamentals, Safety Requirements and Safety Guides. These standards are written primarily in a regulatory style, and are binding on the IAEA for its own programmes. The principal users are the regulatory bodies in Member States and other national authorities.

The IAEA Nuclear Energy Series comprises reports designed to encourage and assist R&D on, and application of, nuclear energy for peaceful uses. This includes practical examples to be used by owners and operators of utilities in Member States, implementing organizations, academia, and government officials, among others. This information is presented in guides, reports on technology status and advances, and best practices for peaceful uses of nuclear energy based on inputs from international experts. The IAEA Nuclear Energy Series complements the IAEA Safety Standards Series.

Many of the challenges facing the nuclear industry highlight the important role played by management and leadership in successful safety and business performance. A distinction can be made between management and leadership. While both are important, this publication will focus particularly on leadership in nuclear emergencies and on the challenges of human performance and communication within the organization during such emergencies.

Many recent IAEA publications have emphasized the importance of leadership and of tasks related to it (e.g. creating a proper organizational culture, managing change, continually improving performance, becoming a learning organization). In addition, communication with national and international organizations, governments, the public and the media during a nuclear or radiological emergency is covered in the IAEA publications Operations Manual for Incident and Emergency Communication (EPR-IEComm 2012) and Communication with the Public in a Nuclear or Radiological Emergency (EPR-Public Communications 2012). However, comprehensive guidance on leadership, human performance and internal communication in severe nuclear emergencies — as covered in this publication — has been lacking.

The IAEA wishes to thank and acknowledge the efforts of the contributors who are listed at the end of this publication for their valuable assistance in its development. Particular thanks go to S. Haber for her aid in its preparation. The IAEA also wishes to thank the organizations of the contributors. The IAEA officers responsible for this publication were J.P. Boogaard, B. Molloy and P.T. Pyy of the Division of Nuclear Power. IAEA Incident and Emergency Centre staff also provided valuable support.

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1. INTRODUCTION

1.1. BACKGROUND

Nuclear organizations have achieved major successes over the past fifty years in improved safety, reliability and overall performance. The growth of new nuclear capacity in emerging markets and the life extension of many older nuclear facilities increase the pressure for sustainability. However, recent nuclear emergencies and challenges continue to highlight the significant impact that human behavioural issues can have on the effective management of these events.

The human behaviours that are important during emergency situations might differ from those that are important in normal operations. Consequently, Member States have shown great interest in receiving guidance on this topic. The 2011 accident at the Fukushima Daiichi nuclear power plant in Japan accelerated the need for a publication providing specific guidance, because that event highlighted the significant impact of leadership, human performance and communication. In addition, every organization should establish an integrated management system that supports leadership and creates a good organizational culture.

In emergencies, it is imperative that leaders be able to draw organizational and human needs closely together. This publication focuses in particular on the aspects internal to the organization during an emergency. Communication with other national and international organizations and with other governments is covered in Ref. [1], and communication with the public and the media during a nuclear or radiological emergency is covered in Ref. [2].

The challenges faced by the nuclear industry have highlighted the role played by people in successful safety and business performance. The significant role that leadership plays in creating a positive organizational and safety culture, managing change, ensuring continuous improvement and creating a learning organization has been stressed. The role of effective leadership for the successful implementation of a formal management system has also been emphasized. The attributes associated with management systems are relevant for all aspects of nuclear emergencies. Information on these attributes is given in IAEA publications on responses to nuclear or radiological emergencies [3–5].

A competency framework for emergency situations, which leaders may develop to help select their staff, would ideally include attributes that provide both technical and experience based knowledge. The leaders and staff chosen should meet the requirements set by the management system. Consideration of the unique aspects of emergencies in the development of emergency response (ER) plans will help to ensure that the appropriate leadership qualities, human performance capabilities and internal communication mechanisms are in place if and when an organization needs to respond to an emergency.

1.2. OBJECTIVE

The aims of this publication are to:

- (a) Identify the necessary attributes of leadership in nuclear emergencies.
- (b) Identify the leadership behaviours, human performance capabilities and internal communication aspects that are important for managing nuclear emergencies.
- (c) Provide guidance on how the strength of leadership, human performance and internal communication in nuclear emergencies can be sustainably anchored in an effective emergency response organization.

1.3. SCOPE

This publication presents key concepts related to leadership, human performance and communication, especially how they relate to an organization's ability to successfully manage an emergency. The focus is especially on what happens inside the emergency organization located at a nuclear site. Day to day leadership in normal

operating conditions falls outside the scope of this publication. Similarly, management and management systems, which are vital elements in ensuring preparation for emergencies, mainly fall outside the scope of the discussion.

External communication in emergencies is covered in Refs [1, 2] and is otherwise excluded from the scope of this publication.

1.4. STRUCTURE

This publication presents the general structure of an emergency response organization (ERO) and discusses the characteristics that are significant for human behaviour in Section 2. Section 3 discusses the attributes required for emergency leadership and advises how to ensure the necessary competencies. In Section 4, important human performance elements in emergencies, such as decision making and extreme stress, are discussed, together with ways to mitigate adverse effects. Finally, ways to ensure effective internal communication in emergencies — with issues for consideration, barriers to overcome and mitigating strategies — are discussed in Section 5.

1.5. USERS

The target individuals for this publication are officials and senior managers of governments, local authorities, regulatory bodies and nuclear facility personnel. Those who have an influence on the style of leadership and personnel development and training that is applied in their organizations and those who are involved in emergency preparedness and response would also benefit from this publication.

2. EMERGENCIES AND HUMAN BEHAVIOURAL CHARACTERISTICS

2.1. EMERGENCIES AND EMERGENCY RESPONSE ORGANIZATIONS

Before discussing the leadership behaviours, human performance capabilities and internal communication mechanisms needed to effectively manage nuclear emergency situations, it is important to clarify why the ERO necessitates separate consideration from the organization during normal operations. Specifically, the change in formal reporting and decision making relationships, the pace of activities that can occur, the potential need to develop ad hoc decisions in response to the event, the adoption of a modified organizational structure to handle the event and the potential for increased interaction with a variety of external agencies, all create a situation that requires some different organizational behaviours than would be necessary during normal operations.

When senior operations staff become aware of plant abnormal status (or plant disturbance), a specially pre-prepared ERO will be activated (on the basis of agreed criteria and according to a pre-established response plan). In addition, designated members of a first response team will be called to assist in coping with the event [5]. Initially, the senior operations staff member on duty has the authority to make all necessary decisions and becomes the response leader.

If initial actions taken do not contain the event, additional capabilities will be called on, with the structure of the ERO scaled to the type of response functions needed to deal with the scope of the emergency. In that case, the function of the initial response leader will likely be transferred from the senior operations staff member to another designated internal group as per the individual facility's ER procedures. The ER is highly procedure based to enable the ERO to be fully staffed and capable of facing the challenges of the emergency.

It is critical that, at all stages of ER, any individual who will perform leadership activities has the necessary skills and competencies to perform these activities. This is especially important during an ER because of the quickly changing nature of events and the multiple individuals and organizations likely to be involved in the response. Additionally, the organization needs to provide effective means of supporting human performance during the event.

Experience has shown that human performance is a key factor in the outcome of events. By providing effective human performance support tools to the individuals who are responding to the event, organizations are more likely to have a favourable outcome at the end of the event. Finally, effective communication and coordination are critical to a positive event response. By developing methods to promote effective communication among all members of the ERO, the likelihood of a positive ER outcome is increased.

2.2. CHARACTERISTICS OF EMERGENCIES SIGNIFICANT FOR HUMAN BEHAVIOUR

If attention is paid to the following characteristic issues, the ability of an organization to effectively respond to an emergency situation will be significantly improved. While not intended to be comprehensive, the list below represents the types of issue to be considered in ER situations, focusing on the characteristics of leadership, human performance and internal communication:

- (a) The strengths and weaknesses inherent in any organization will likely be exacerbated in an emergency situation, and therefore it is critical that they be understood and integrated into the emergency preparedness plans developed for the facility. For instance, in some situations, a command and control type of response (e.g. hierarchical reporting structure) is perceived to be most beneficial and to lead to the most effective response; in other situations, a team concept may be perceived to be most effective for ER. Regardless of which type of response would be most beneficial, there are inherent benefits and weaknesses to both approaches. In a hierarchical reporting structure, the organization still needs to ensure that members feel free to voice concerns, when appropriate, and that they do not just blindly follow orders. In a culture that is more team oriented, the organization needs to ensure that decisions are made with the rapidity required for the situation and are not paralyzed by dissension or indecision. Organizations may find it useful to spend time considering the specific nature of their organization, the environment it operates in, and the potential strengths and weaknesses that could result.
- (b) People's behaviour during normal operations will influence the manner in which others within the organization respond to them during off-normal operations. For example, if ER leaders have not established trust among themselves and others during normal operations, their ability to effectively lead during an accident situation may be inhibited because organizational members may question leaders' actions and the rationale behind decisions that are being made.
- (c) Effective horizontal and vertical coordination and communication is a key element to successful ER. This is especially important for individuals and groups who may not interact frequently during normal operations but must interact to a high degree during emergency situations. Similarly, any issues related to horizontal and vertical coordination and communication during normal operations can further degrade and potentially impact the ability of various groups and levels within the organization to effectively respond to an event.
- (d) During an emergency situation, staff and facilities need to be capable of transitioning from their normal role to their emergency role. This may mean taking on new responsibilities or working with different groups and individuals within the organization. If not clearly documented in response procedures and practised in drills and exercises, these unfamiliar roles and relationships can have a significant effect on the manner in which the event unfolds. Therefore it is important that these roles and relationships are well defined, understood, trained for and practised by all parties ahead of time.
- (e) Behaviours and habits become ingrained in people over time. Bad work habits and behaviours that are allowed to occur during normal operations are not likely to change when a person is faced with an emergency, but good work habits and behaviours that are frequently used are likely to also be used in an emergency. In fact, people tend to revert to the behavioural patterns they are most familiar with during times of high stress or uncertainty [6]. This makes it imperative that organizational members are held to high standards of performance during normal operations (e.g. a questioning attitude; the stop, think, act, review process; or three way communication¹) to ensure that these same performance standards are strongly ingrained and followed during emergency situations. The actions carried out, including the review results, also need to be communicated.

¹ Message given, message received and message understood.

- (f) Emergency situations often do not follow the path that prior analysis has assumed they will take, and not all emergency situations have been conceived of before they are encountered. Organizations need to be able to exhibit flexibility and agility in their response to an event, which is a concept often referred to as organizational resilience. Organizations that have resilient capabilities are able to avoid disruptions, adapt to events and continue on, even in the face of adversity. Such organizations also create an environment that is likely to produce resilient leaders.
- (g) All organizations have individuals that are recognized as leaders by others, even though they may not hold a formal leadership title. Ignoring the importance of these individuals to the organization could have a detrimental impact on the organization's ability to respond effectively to an emergency situation.
- (h) Several lessons learned from the human and organizational factors analysis of the Fukushima Daiichi accident that was conducted by the IAEA need to be considered in trying to understand human behaviour during an ER [7]. In particular, the assumptions that guide human behaviour, often subconsciously, need to be recognized. Preparation for the unexpected is necessary, and the level of complexity around emergency situations demands that a systemic approach be used to provide a comprehensive picture of the situation.

3. ATTRIBUTES AND CORE COMPETENCIES OF LEADERSHIP IN AN EMERGENCY

3.1. ISSUES FOR CONSIDERATION

Many of the challenges facing the nuclear industry highlight the important roles of management and leadership. Recent IAEA publications [8–11] have stressed the important role that leadership plays in creating a strong organizational and safety culture, managing change, ensuring continuous improvement and creating a learning organization. The IAEA Safety Standards in Refs [12–15] stress the importance of proper leadership and management of nuclear facilities, which certainly includes the management of nuclear emergencies.

A distinction also needs to be made between management and leadership. IAEA Safety Standards Series No. GSR Part 2, Leadership and Management for Safety [13], defines management as a “formal, authorized function for ensuring that an organization operates efficiently and that work is completed in accordance with requirements, plans and resources” and adds that “Managers at all levels need to be leaders for safety.” In comparison, GSR Part 2 defines leadership as “the use of an individual’s capabilities and competences to give direction to individuals and groups and to influence their commitment to achieving the fundamental safety objective and to applying the fundamental safety principles, by means of shared goals, values and behaviour.” Good managers are not necessarily good leaders, and vice versa. While both are needed, the focus here is on individuals performing leadership functions within an emergency situation.

Leadership that successfully utilizes the staff and supporting organizations in the management of an emergency emphasizes the relationship between leadership, communication and human performance. However, because emergencies are rare, being able to demonstrate that the required leadership competencies for dealing with an emergency are present is not a simple matter. The selection and preparation of leaders and staff to form an ER team requires specific measures to ensure that the competencies needed for successful ER are considered.

There is substantial literature (e.g. Ref. [16]) about the competencies of effective managers, in general, and also of managers in the nuclear power sector. Reference [17] provides detailed information concerning the training of personnel, including training for managers and for handling emergency tasks. These publications include aspects of essential management competencies.

Often, techniques such as the use of ‘competency wheels’ (like the one shown in Fig. 1) can be utilized and may be helpful in the selection of leaders, because competencies can be described and weighted. The wheel in Fig. 1 details the desired competencies for a particular manager or leader. The degree to which the ideal leader would exhibit each competency is shown in blue. The ideal leader is expected to be trained and prepared, decisive and assertive, goal oriented, able to listen and communicate, and able to think critically. To a lesser extent, although still important, the ideal leader would be experienced, open minded, responsible and adaptive; able to facilitate,

prioritize, and handle stress; and have personal drive and energy. This gives the organization a means of identifying which individual competencies are most important for any specific position. Then, candidate ratings on these same competencies can be compared with the ideal to determine the match between actual and ideal. The weighting of individual competencies can be particularly important when:

- (a) Comparing potential candidates, because no one person will ever be the perfect leader for all situations;
- (b) Preparing individual training and development plans for individuals in leadership positions to strengthen and develop critical competencies;
- (c) Considering different leadership roles such as control room operator, incident commander and plant supervisor, because the various roles will require a different balance of skills under the same core competency such as ‘critical thinking’;
- (d) Ensuring that the individual embraces the perspective that a leader is part of a larger system, and that this system needs to support leadership to become effective.

The identification of competencies required for effective leaders also helps to distinguish between competencies that are trainable and those that are more difficult to develop. This aspect needs special attention when selecting managers for emergency teams. While it is not possible to present here all the various models on leadership competencies that could be considered, a few relevant competency sets are discussed.

Competencies such as those shown in Fig. 1 may be clustered into groups of similar competencies. Other perspectives [19–22] on competency clusters include:

- *Self-awareness*. This competency involves being aware of one’s own behaviour, particularly with regard to how that behaviour influences the behaviour of others.

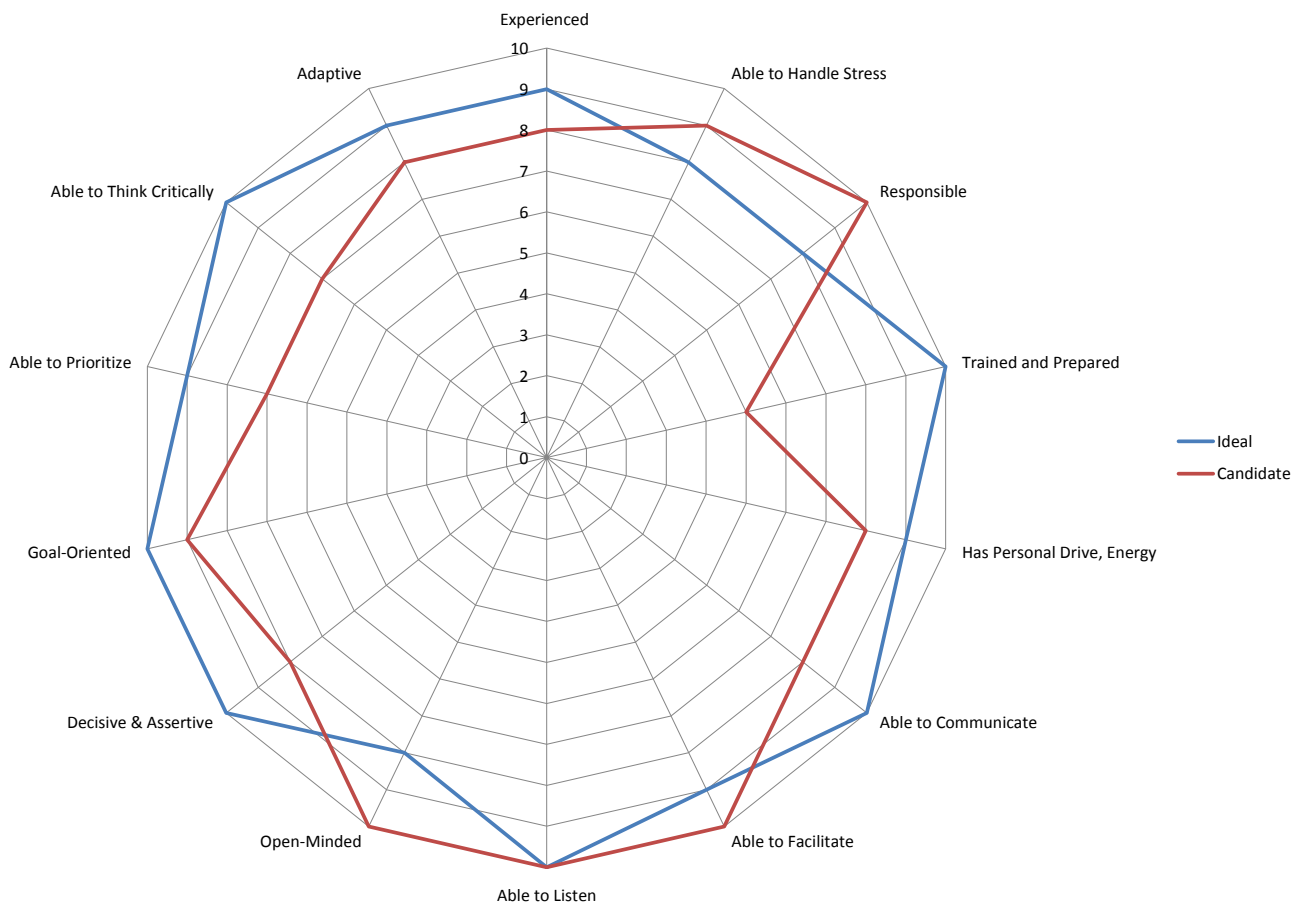


FIG. 1. Competency wheel — example of a leader profile. Adapted from Chandler [18].

- *Relationship building*. Communication and relationship building often go together and are keys to good leadership. Collaboration and trust are foundational to building strong relationships, as are active and empathetic listening and respecting colleagues. A good leader is also willing to invite and accept challenges from subordinates.
- *Practical capability*. Having the necessary nuclear knowledge, as well as the relevant behavioural and technical ability, is important. Capabilities in team building, delegation of work, decision making, project management, conflict resolution and providing appropriate motivation should also be considered. Relevant past experience is a highly desirable trait and can ensure that the leader has some level of intuition in dealing with an event.
- *Strategic action*. Thinking strategically requires the ability to uncover and question the assumptions being made in the presenting situation. Leaders have to be able to ensure the response team has a consistent, simple, clear and easily understood statement of the emergency situation and the objectives they are being asked to meet. Leaders who are able to think strategically are better able to ensure the appropriate information is provided in a way that will be most helpful to the individuals who use it.
- *Authenticity*. Authenticity, consistency and integrity of leader behaviours and actions are critical elements to promote credibility and inspire trust among those that they are leading.

Leaders in emergency situations must confront a number of challenges; how these challenges are addressed is affected by leader competencies, attitudes and efficacy. Leaders need to be aware of the situation and — recognizing the often large uncertainties — maintain control over the events that are under their influence, take effective actions with the available resources and develop a response that will positively impact the course of the event.

Considering the context of this publication, the following leadership competencies are especially relevant for the management of nuclear emergencies and need to be kept in mind in the selection and development of ER team leaders.

3.1.1. Situational awareness

Participants in an emergency situation who possess good awareness are able to identify, process and comprehend the critical elements of an emergency. The concept of situational awareness is important for coping successfully with emergency demands. Situational awareness can be defined as “the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future” [23]. It means that the leader understands the situation and knows what to do to effectively mitigate the event. Leaders who possess good situational awareness are able to:

- (a) Assemble a plausible picture of the event, consistent with known information and possible outcomes;
- (b) Acquire, interpret and use relevant information to make sense of current events, anticipate future events and make intelligent decisions;
- (c) Stay aware by continually assessing and reassessing the situation.

In nuclear power plants, the following have been identified as areas where improved situational awareness would be beneficial: planning, problem solving, perception, team coordination, knowledge building and communication [24].

3.1.2. Decision making, including strategic thinking

Leaders who demonstrate decision making, including strategic thinking, are able to make critical and timely decisions with limited and ambiguous information. Leaders with this competency are able to:

- (a) Gather facts, solicit input, make good assumptions and consult with stakeholders to weigh benefits and risks, and quickly make and execute decisions with limited and incomplete information;
- (b) Apply the appropriate decision making process for the situation (i.e. systematic versus derived from experience);
- (c) Anticipate the impact and implications of the decisions they make;

- (d) Continuously assess and adjust decisions and actions as new information becomes available;
- (e) Be mindful about cognitive slips, lapses and errors that may occur in a critical situation;
- (f) Comprehend the complexity of the situation and be reluctant to oversimplify.

3.1.3. Team management of emergency response teams

An effective ER is dependent on successful team management by the leader of the ER team. The team members execute their tasks, share an understanding of the evolving emergency and work on the same response plan towards a common goal. Good team management will help to prevent people from abandoning their posts, reacting with panic and being uncooperative. Leaders with this competency:

- (a) Exemplify appropriate behaviours for other team members;
- (b) Provide the team members with the resources and information required for a successful response to the event;
- (c) Delegate appropriately within the team and allow team members the necessary autonomy to make decisions within established guidelines;
- (d) Address conflicts between team members positively and constructively;
- (e) Develop, communicate and monitor team performance expectations.

3.1.4. Coordination

ER team leaders have to be able to effectively coordinate the work activities of the team while also managing demands and pressures, both external and internal, to the organization. If the organization does not have a clear understanding of the various roles and responsibilities, then responses may become uncoordinated and mitigating measures may be ineffective or even contradictory. Even when an emergency event is contained inside an organization, outside stakeholders need to be informed and prepared for possible future coordinated action if the event spreads over organizational boundaries. When more organizations become involved, there is a demand for good coordination among them and clear divisions of roles in order to achieve the most effective ER and resource management. Leaders with this competency:

- (a) Interact with individuals across various agencies and organizations to ensure information is shared and collaboration is achieved;
- (b) Set priorities to deal with conflicting demands and build consensus among affected parties on what those priorities would be;
- (c) Have the knowledge necessary to link the required groups (internal and external to the organization) to ensure that the goals of the ER are achieved;
- (d) Have the capability to communicate in a stringent and concise manner.

3.1.5. Professionalism, integrity and honesty

Professionalism, integrity and honesty are key attributes for leaders in the establishment of trust and confidence with the members of the ER team. It is especially important for a leader to demonstrate these attributes when the leader is new to the team. A leader who is viewed as having integrity will earn the respect and the willingness of the team to follow the leader's direction. Leaders with this competency are able to:

- (a) Demonstrate knowledge and experience, as well as recognize when additional expertise is needed;
- (b) Determine what information needs to be shared;
- (c) Be aware of and sensitive to the health risks the team and public may be exposed to as a result of the event.

3.1.6. Stress management

Effective leaders are able to recognize the symptoms of stress in themselves as well as within the people they are leading. This competency is especially important during an emergency situation when the people who must respond to the event experience tremendous stress as they face what is often an uncertain situation. Even with

appropriate training, it is very difficult to know how people will react during an actual situation (as opposed to a simulated situation), when they are concerned for their own safety as well as perhaps the safety of their families and larger community. Leaders with this competency have to be able to:

- (a) Persevere under difficult circumstances;
- (b) Adhere to the priorities of radiation safety of the public, even if such adherence potentially puts themselves at risk;
- (c) Recognize the impact of stress on themselves and those they are leading and take appropriate action if they determine that the stress is impeding their or other team members' abilities to effectively perform their roles on the ER team;
- (d) Demonstrate mental discipline and maintain control;
- (e) Know when to take a short break to ease the tension from stress.

It is advantageous to make provisions in the emergency procedures to have periodic turnovers, if feasible, in the emergency posts, including for the leaders. Turnovers will help to minimize fatigue and promote a higher level of effectiveness while dealing with an emergency situation (e.g. in some plants, emergency procedures dictate a routine turnover every 12 hours). When such turnovers are not feasible, as was seen during the Fukushima Daiichi accident where fresh and rested crew members were not able to get to the plant for days, other steps might need to be considered to offset the impact of prolonged stress and fatigue.

Organizations also need to recognize the stress that is caused to workers who are uncertain of what their families may be dealing with and whether or not they are safe. It is wise to have mechanisms to facilitate workers to get information about their families and to let their families know they are safe. Emergencies demonstrate how difficult this can be. However, by establishing a protocol ahead of time, the organization is more likely to be able to provide workers with information about their families, which will allow them to better focus on responding to the emergency without additional distraction.

While not all leaders will display all competencies, organizations need to carefully consider these competencies when making decisions about individuals who will lead ER efforts and the roles they will play in those efforts. In addition, organizations need to actively pursue opportunities to strengthen these competencies within their leaders to ensure they have the most effective leadership available in the event of an emergency situation.

3.2. ENSURING THE NECESSARY LEADERSHIP COMPETENCIES

It is apparent that effective emergency management is dependent on the abilities of the leaders directing the ER. Fortunately, organizations do not frequently encounter emergencies; however, this also makes it difficult to determine whether or not leaders have the necessary competencies to cope with an event. There are some actions that an organization can take to help develop leadership qualities in individuals who may need to take on leadership roles during an emergency, and these are discussed below.

3.2.1. Selection criteria for leaders

Some aptitudes relevant for ER team leaders and members are very difficult to develop through training. One example of this is stress resistance or stress tolerance: a person's ability to perform well under stress. Team members with a low stress tolerance can encounter conditions in which they are unable to perform as required because of stress, despite having excellent technical knowledge and managerial skills. If this were to happen to the emergency team leader, the consequences of cognitive failure under high stress conditions could be severe, in terms of both plant damage and contamination of the environment.

Industries or other organizations that use comparable EROs to those used by nuclear facilities (e.g. airlines or military forces) have implemented measures to predict the performance of applicants under stressful conditions [25]. Even if a nuclear operating organization does not typically use psychometric tests in its recruitment/selection process, it might be worth while to consider their use in the selection of emergency teams. Such psychometric tests can include the assessment of stress resistance, as well as other relevant areas for effective emergency teams (e.g. strategic thinking, motivation and self-confidence). Multiple psychological and sociopsychological factors

come into play in emergencies, which are very situation dependent and impossible to completely predict, so trusting psychometric testing solely may not be recommended.

Another important dimension may be that managers during normal operations may not be designated as managers during the emergency situation but are reluctant to give up their manager role. A subordinate of that manager may be placed into a leadership role during an emergency, and it may be difficult for subordinates not to be influenced by the fact that their normal managers are working for them or under them during the emergency, only to return as their managers after the emergency.

3.2.2. Training for leaders

3.2.2.1. General

There may be several individuals designated to perform different leadership functions during a nuclear emergency situation. For example, one may be assigned by the nuclear facility in the first response to the immediate area of activity, another to an on-site coordination room and still others to site evacuation or to the chief of the regional fire brigade. For this reason, both individual and group training is important to gain maximum benefit in the event of an emergency.

Emergency exercises often attempt to engage as many people from different EROs as might be involved in an ER, including the local emergency services. It is also important that emergency exercises be practised at regional and national levels, so that individuals in leadership positions gain valuable insights into some of the organizations they may need to deal with should an event occur, as well as have an opportunity to interact with leaders across all levels and organizations that might be involved in an ER. Emergency exercises may be developed, conducted and evaluated in a manner consistent with the guidance provided in the IAEA publication *Method for Developing Arrangements for Response to a Nuclear or Radiological Emergency* [26].

Recognizing that nuclear emergencies are infrequent events, every opportunity may be considered to place leaders in situations that will simulate some of the types of activities they might encounter. For example, placing ERO leaders with a local fire brigade or other ERO that deals with emergencies on a frequent basis will demonstrate how these organizations and their leaders cope with emergencies and what principles for coping are employed.

Competency assessment results may be used to identify and seize opportunities to train individuals in situations that take them out of their 'comfort zone'. Such examples may include learning to dive while on holiday, organizing a local fete or show as part of normal life, or conducting a confined space entry while at work on a reactor site.

3.2.2.2. Types of training for emergency situations

Various methods can be used to train leaders in the necessary competencies. Clearly, background reading is a good start and can be supplemented by lectures, films, group exercises, case studies and computer based training. There are assessment exercises available that leaders can engage in to determine their own personal style of leadership as well as what the strengths and weaknesses of this style might be. Such exercises provide the leader with useful insight and can highlight areas of focus for future development.

Exercises of all types are useful, for example, a tabletop exercise or the larger scale version conducted as a walkthrough, simulators and full scale on-site exercises or those involving external agencies. However, there is little substitute for hands-on experience, even if it is gained in allied fields. The only requirement is that those being trained experience first hand the actual stress of leadership in difficult situations. Ultimately, this will serve to extend candidates' comfort zones, which would make them more effective in real emergency situations.

A note of caution may be made about 'overpreparation' resulting from routine on-site exercises. Continued use of the same or similar scenarios in emergency preparedness exercises can induce a false sense of confidence in people's ability to respond to an event, which may quickly evaporate in a real emergency, to everyone's detriment. Some good practices that can be conducted to prevent this include:

- (a) Training leaders in thinking the unthinkable. What if the indications, alarms and other received information are not telling the staff what they think they are? One famous example of this occurred in the Three Mile Island accident in the United States of America [27]. As the operators were not able to see one of the indicator

lights on the control room alarm panels, the automatic emergency cooling system was manually overridden because the operators believed there was too much coolant water in the reactor when, in fact, the opposite was true. Training in the unthinkable may extend to team training in which unexpected events are imagined and discussed in a brainstorming session (e.g. the plant is not near an airport, but imagine that an aircraft has crashed on it).

- (b) Training leaders in stakeholder needs. It is important that ER leaders have a good understanding of all the needs of the various stakeholders, as there are times when these needs might conflict. By developing a better understanding of these needs, the leaders will be able to interact in a more constructive manner during an event, as there is greater appreciation of why various stakeholders may be behaving the way they are or seeking specific types of information. One option to improve leader understanding of stakeholder needs is for leaders to participate in stakeholder exercises.
- (c) Involving leaders in providing team emergency preparedness training, in order to set the example of following emergency plan procedures, as well as looking for improvement opportunities for future training and performance.
- (d) Involving leaders in providing training (including training of new personnel and permanent contractors) on the history of significant nuclear emergencies. This sends a key message to the staff that emergencies can occur and inspires trust in the leaders because they will be seen as knowledgeable about events that have occurred. It also shows that, as a learning organization, the leaders can learn and minimize the likelihood of similar events within their own plant. At the same time, leaders can make it clear that newcomers have a role to play in preventing a nuclear emergency by exercising professionalism in all that they do. For example, in some nuclear plants, plant superintendents give lectures to newcomers about significant nuclear emergencies, stressing the importance of being ‘nuclear professionals’.
- (e) Training leaders in situations that are as realistic as possible (e.g. requiring them to conduct a plant tour with blacked out masks or imagine a scenario in which one of the senior leaders in the emergency response centre (ERC) suffers a heart attack mid-crisis). By providing such training, leaders will have an understanding of the myriad of events they could encounter and be equipped to deal with a wide range of potential events and scenarios.
- (f) Training leaders in the use of communication tools, such as shared space and mindfulness [28], that foster trust, motivation and openness.

3.2.3. Developing leaders during normal operations

Some procedures that can be followed during normal operations within a facility will develop leadership skills and instil employee confidence in the leaders of the organization to ensure effective ER:

- (a) Leaders may be expected to encourage and promote the use of emergency decision making protocols (e.g. emergency operating procedures) that were developed for emergency situations whenever something unexplained happens at the plant. While this is always a useful exercise to engage in, the opportunity to take early action will be increased should the unexplained situation turn out to be an event. Use of these emergency decision making protocols for all unexplained events will also increase familiarity with these protocols, which will increase the likelihood of success in their use during an emergency.
- (b) Leaders may be expected to support and encourage staff to express their attitudes and ideas/concerns. This is true during normal operations as well as during abnormal and emergency operations. Organizations should ensure that a ‘no blame culture’ exists at all times. If people feel comfortable and free to express their attitudes and ideas or concerns during normal operations, they are much more likely to be able to express their attitudes and ideas or concerns during abnormal operations. Leaders also need to be able to recognize their limitations and the limitations of their organization and be open to involving experts from outside the organization to ensure the successful resolution of the problem.
- (c) In ER training, leaders need to try to anticipate how the event may develop in the future, as well as possible lines of action that may need to be taken. This reflects a strategic way of thinking and normally would incorporate both anticipated and unanticipated sequences of events. This will encourage members of the response team to keep an open mind about the incident and not ignore symptoms that may not fit the probable or anticipated event sequence.

- (d) Brainstorming is an excellent method for use in strategic thinking, and leaders may consider soliciting such input from their staff as part of normal operations and ER training activities. Incorporating the expertise of additional experts external to the facility can provide another perspective and is also recommended as part of training.
- (e) Communication tools that quickly and effectively create a shared understanding may be utilized.

In summary, leaders within the organization will play an integral role in ER. Any activities that can be undertaken to strengthen and improve the required leadership competencies will lead to stronger leadership and support for that leadership by the ER team. Additionally, good leaders will provide support for strong human performance and communication, which are two other elements critical to the effectiveness of ER.

4. HUMAN PERFORMANCE IN AN EMERGENCY

4.1. ISSUES FOR CONSIDERATION

When a serious emergency occurs, that emergency will have to be managed by people who will need to diagnose unfamiliar situations, make decisions about what actions to take, choose goals to be met and undertake action plans that have been previously developed or develop new plans based on the situation. The humans making the decisions are likely to be under enormous levels of stress and pressure to make those decisions and take action quickly and in a manner most likely to mitigate the event with the least amount of damage to the plant, personnel and the surrounding environment and community. In unusual situations, which any real emergency will certainly be, human beings are a more adaptable and intelligent resource than any machine logic. However, human beings also have limitations and do not behave perfectly, even in the most ideal situations. Therefore, to have a greater likelihood of successful management of an emergency, it is important to understand what human limitations exist, what problems may arise because of those limitations, and what can be done to minimize the potential impact of those limitations and ensure that the benefits of having intelligent and autonomous people working together in teams are gained at the least cost.

This section outlines the human performance elements that need to be considered, specifically during an emergency situation and especially in the areas of decision making, stress management and group interaction. Consideration of these issues in ER preparation activities, as well as within the whole management system of the organization, will help to promote effective human performance during an event. This publication focuses on the personnel on-site for the emergency, including site management, operational staff, vendors and contractors. However, the presented concepts may also be extended to off-site professionals, who can contribute to the successful management of an emergency (e.g. corporate staff, regulatory staff and external experts), as well as off-site emergency resources — such as fire brigades, the military and civil defence forces — that may be involved in ER.

4.1.1. Decision making

During an emergency, the real time requirements for making decisions can differ from everyday decision making requirements. The immediate importance of making decisions may be more critical, the information required to make decisions may be missing or delayed, and less time may be available to make decisions than under normal conditions. All of these factors make it essential to understand what can be done to support effective decision making and reduce the chances of making poor decisions.

Personnel also have to be able to cope and make these decisions in emergency situations with issues and conditions that are non-standard because, for instance:

- (a) Emergencies do not often unfold as they have been modelled. In fact, what appears common may be misleading, while what appears different may be consistent and understandable once an adequate mental model of the situation has been developed.

- (b) Individuals may be restricted in their ability or willingness to believe or understand such non-standard situations. Denial is a common way of coping with the stress that an emergency may bring.
- (c) The mental models of normal operations may not fit the emergency situation.
- (d) Decisions may have to be made before all the information can be gathered or processed. Lack of information is one of the greatest contributing factors to making poor decisions [29].
- (e) The accuracy of the information may be questionable. In emergency situations, normal information systems may not be available and there will be a greater level of uncertainty about the status of the facility; consequently, a greater effort in challenging any information source is required, which may not be necessary under normal conditions.
- (f) Time stress generates the greatest chance of making an incorrect decision, oversimplifying complex situations or not knowing what to do at all [30].
- (g) Emergencies require team activity; it is crucial that the teams operate as effectively as possible and that good leaders are in place who understand the normal social dynamics that can influence emergency activity, whether positively or negatively.
- (h) In emergencies, people do not typically have the luxury of selecting a special team; those who are present as the emergency unfolds compose the team that has to respond to the event.

4.1.1.1. Biases in thinking and problem solving

There are biases in thinking processes that can influence both how people think of problems in advance — risk perception — and how they solve problems when faced with them directly. The cognitive biases that have been identified are not just bad habits that people have acquired; if they were, they could be trained out relatively simply. Cognitive biases are the consequences, or downsides, of highly effective ways that people solve most of their problems and make the most of their everyday decisions. Cognitive biases are tendencies to think in certain ways. They can lead to systematic deviations from a standard of rationality or good judgement. Knowledge about these biases has been developed to understand decision making under uncertainty, which is considerable in emergency situations. Some examples of cognitive biases that can influence human performance during emergency situations follow:

- (a) *Slow versus fast modes of thinking.* Distinct from the actual time frame within which an event may unfold (from initial indication of a problem to the days and/or weeks over which the event may occur), there are ongoing cognitive processes that relate to the rapidity of the thought process itself. Considerable evidence has demonstrated that people have two modes or systems of thinking [31]. One mode is slow, conscious, methodical, takes effort and can be comprehensive and therefore takes time. The other is rapid, subconscious, immediate, effortless and generally effective, but can be influenced by emotional factors. This distinction is particularly relevant for decision making and problem solving in emergency situations because of what can be perceived as the need to move forwards and make decisions in a rapid time frame. Many examples of poor decision making and problem solving from the nuclear industry, as well as in other high hazard industries such as commercial aviation, can be understood in this light. The rapid thought process, which also carries with it the feeling that one is right, often just because the answer came so quickly, is a very attractive path during emergency conditions. The solution to prevent people from following the rapid process of thinking is to require people to reveal and communicate their thought processes and ensure they do not miss vital steps. Moreover, following the ER procedures and checklists step by step should ensure that vital steps are not missed, although it should always be borne in mind that emergencies often create unexpected scenarios.
- (b) *Availability.* People have a tendency to overestimate the likelihood of events with greater ‘availability’ (i.e. more easily recalled) in memory, which can be influenced by how recent the memories are or how unusual or emotionally charged they may be [32]. What people remember most easily, and hence first, sets the context for how they proceed in their thinking, but what comes easily may not be what is needed or appropriate. People also confuse ease of recall or construction of information, such as a scenario, with the probability that such a scenario is actually the case.
- (c) *Overconfidence.* People who feel confident in their ability and knowledge feel that they make better decisions — this is not always true, especially when their confidence is not fully justified [33]. The Kruger and

Dunning [34] effect means that the best informed may actually feel less confident, while the less informed tend to feel more confident.

- (d) *Representativeness*. When people encounter a new event, they have a tendency to pay attention to those characteristics of an event that are most similar to other ‘known’ events [35]. This can result in them missing or ignoring pieces of information that do not fit within that mental model.
- (e) *Anchoring or focalism*. This occurs when people take a starting point and then move towards a solution by adjusting what they are thinking about from that anchor [36]. Unfortunately, the anchor used may be influenced by previous, irrelevant factors. This can result in people relying too heavily on one piece of information when making decisions (often the first piece of information acquired).
- (f) *Confirmation bias*. People have a tendency to search for, interpret, focus on and remember information in a way that confirms their preconceptions [37]. When making a decision, this can cause people to look for confirming evidence that will prove their hypothesis and to not seek out potentially disconfirming evidence.
- (g) *Conservatism bias or belief revision*. This is a bias in how people process information and more specifically how they incorporate new information with what they already know. This bias causes people to update their opinions or beliefs as new evidence is obtained but more slowly than would be expected if they were using a completely rational process, so they overestimate the significance of prior evidence and underestimate the significance of new evidence [38].

These are just some examples of the types of cognitive biases people can have in making decisions. While these biases can often be helpful when making decisions, as they can provide a short cut to arriving at an appropriate and effective decision, their impact on decision making during emergency operations can be negative if not properly understood and managed.

4.1.1.2. Errors in decision making

The ways in which decision making processes can fail are well understood, and this information can be used in training for defining support mechanisms and processes for emergency decision making. An incorrect diagnosis will lead to the selection of incorrect courses of action to solve the wrong problem. When people make decisions, they tend to shut out what has gone into the decision and move on so that once a decision has been made, any counter-evidence to that decision tends to be ignored, rejected or explained away. James Reason [39] defines human error as “a generic term to encompass all those occasions in which a planned sequence of mental or physical activities fails to achieve its intended outcome, and when these failures cannot be attributed to the intervention of some chance agency”. While there are many different models of error, one that is especially helpful to think about in terms of human performance during an emergency situation is Reason’s framework of slips, lapses and mistakes:

- (a) Slips are typically considered to be actions that are not carried out as intended or planned and usually occur during task execution. Slips are often considered attention failures as they result from inattention or misplaced attention. For instance, miskeying a command into a computer system or turning the wrong valve are both examples of a slip.
- (b) Lapses are missed actions and omissions that occur when someone fails to do something because of lapses of memory or because they have forgotten something. An example of a lapse would be when a person forgets to restore normal valve settings after performing maintenance.
- (c) Mistakes are a specific type of error brought about by a faulty plan or intention and often involve somebody doing something they believed to be correct when it was, in fact, wrong, resulting in a plan being developed that is not going to achieve the desired results. These types of error typically occur during the planning stages and are often affected by some of the cognitive biases that were discussed earlier. They can result from choosing an inappropriate rule or from an incomplete or inaccurate understanding of a system.

Examples of mistakes that have occurred during serious events at nuclear power facilities include the following:

- (i) During the event at Three Mile Island [27], the operators prematurely disabled the high pressure injection pumps. While they believed this to be the appropriate action to take, it actually resulted in exacerbating the

event as they did not have a complete understanding of what was occurring. Mistakes can be particularly problematic during an emergency because people often have a difficult time revisiting decisions that have been made, leading to rejection or misinterpretation of additional evidence and data in favour of the mistaken hypothesis.

- (ii) In the minutes after the initial earthquake at Fukushima Daiichi, the backup cooling system or isolation condenser started up automatically [7]. This system relied on convection and gravity to perform its cooling function and should have helped to keep the water level high in the core of unit 1 throughout the crisis. But operators soon noticed that the isolation condenser was cooling the core too quickly, which could stress the pressure vessel, so they shut the system down. Although this was the appropriate decision according to prevailing convention at that time, it did not take the ensuing tsunami into account. The tsunami led to a total loss of power at the plant, and having turned off the system just before the tsunami, there was no electric power to reopen the valves for the system to let steam and water flow to keep the core covered.

It is important to understand the distinction between slips, lapses and mistakes, as there are different actions that can be taken to manage these various types of error. Also, it is important to understand that these are different in nature to wilful acts such as violations, where, for example, a procedure is violated but intentions are basically good (see the next subsection), and acts of sabotage, where intentions are malevolent. Some specific actions will be discussed later in this section.

4.1.1.3. Variation from procedures

Another issue to be considered related to decision making during an emergency is the concept of variation from emergency operating procedures, accident management guidelines or other instructions. This issue is important during an emergency situation because, by its nature, the emergency most often involves events or event sequences that have not been accurately modelled and considered by the organization in advance. The operators may discover that the procedures available are not suitable to deal with the circumstances of the event. Thus, calling this kind of act simply a violation would not be justified.

Decision making and actions that are outside of the standard rule base are a result of a deliberate deviation from established procedures. Additionally, the deterministic safety management approach is often built on the assumption of full procedural compliance. However, as seen in the previously mentioned example of the operators closing the valves to the isolation condenser during the Fukushima Daiichi accident, full procedural compliance may not be the best option in all cases. It is critical that procedural deviation not be considered in isolation, but rather in terms of the interaction of that deviation with other activities and actions being taken.

People are more likely to deviate from procedures when they are under high levels of stress or feel they have the competencies and knowledge to do so and that the procedure is inaccurate or getting in the way of a higher goal. While procedural deviations can be successful, especially when carefully considered using all available knowledge, they can become extremely dangerous and exacerbate the situation, which is more likely when the deviation is accompanied by other unforeseen circumstances (e.g. by independent error).

Therefore, while it is clear that there are times when deviations from procedures are necessary, the issue for nuclear power plants is how to manage this within the existing safety management framework. When personnel have been trained and managed to fully comply with procedures, even if they know they have to deviate, it is not a comfortable experience for them. Doubt and concern over consequence, to them or to the organization, can be influential. The organization has to be sensitive to this and ensure that personnel that are responding to an event have the necessary knowledge and tools to make any deviations more likely to lead to a successful outcome.

4.1.1.4. Other suboptimal behaviours associated with decision making

In addition to the tendency for people to not revisit decisions once they have been made, there are other suboptimal behaviours associated with decision making that can occur. These are particularly relevant in an emergency situation and need to be identified, especially by those who have the task of challenging those making the decisions:

- (a) *Premature closure*. People often conclude with insufficient data; picking a solution that is ‘good enough’ is a strategy that is usually effective but formally suboptimal. The need to make a decision can be great, but it is essential to have, where at all possible, an agreed set of minimum criteria against which decisions can be assessed to see if closure is appropriate [40].
- (b) *Thematic vagabonding*. This is a behaviour where people move between options on the basis of ease or opportunity rather than on the basis of the priority set by the situation. Clear prioritization of actions and frequent checks against that prioritization can help contain inappropriate opportunistic behaviours [39].
- (c) *Paralysis by analysis*. This behaviour is characterized by a failure to progress as a result of overanalysing the situation and the possible actions that can be taken. Given the nature of emergency situations and the lack or inaccuracy of data, this can become a serious issue. It is the opposite of premature closure, but the same support mechanisms can help and will be discussed later in this section.
- (d) *Functional fixity*. This behaviour results from an inability to see beyond the original function of something to new and novel ways of its use, resulting in using that item only as originally intended. Thus, this bias prevents people from thinking ‘outside the box’ and coming up with new and novel ways to deal with something [41].
- (e) *Cognitive dissonance*. This refers to a tendency for people to strive for consistency in their thoughts, beliefs and opinions. When faced with making a decision, especially when the outcome of that decision is unknown, people will tend to increase the attractiveness of the chosen alternative and decrease the attractiveness of the alternative that was not chosen simply as a means of decreasing the dissonance [42].

4.1.2. Stress

Managing and understanding stress is one of the most important tasks in an emergency, especially for the leader. The term ‘stress’ implies psychological distress and discomfort, and it occurs when the perceived demands (stressors) exceed the perceived resources for coping with these demands [43]. If resources are judged to be equal to or to exceed the demands, the individual feels in control, but when demands exceed the resources, stress responses (mental, physical and emotional) start to occur. While a moderate degree of stress can have a positive effect on individual functioning, it is also recognized that stress can lead to errors, particularly because people will revert to using some of the cognitive biases discussed earlier, in an attempt to relieve some of the stress they are experiencing.

While many different kinds of stress exist, the focus of this guide is on acute or emergency stress, when individuals or groups are suddenly exposed to a threatening situation (e.g. an event in a nuclear power plant). Stress increases when people encounter situations and conditions that are unfamiliar, such as those that can occur during an emergency. During acute stress, individuals experience physiological and psychological reactions (decrement in performance or self-report of stress), which, although often adaptive, can manifest in undesirable ways (e.g. panic attacks, freezing or tunnel vision). The function of the stress reaction is to prepare the body for action under threat (fight or flight response), but in a complex environment, this is not always useful.

Another aspect of stress is that the same situation could be stressful for one individual but not for another, depending on each person’s available resources (e.g. expertise, experience or human and material resources). The differences in stress levels between individuals make this an important area for a leader to manage.

4.1.2.1. Causes of stress

There are a number of causes of stress [24, 43]:

- (a) *Physical*. For example, fatigue, noise, time of day, temperature, weather, rapid changes, wide geographical impact, exposure to radiation or long lasting environmental impact.
- (b) *Psychological*. For example, threat to important values; exposure to danger; fear of death, personal loss or injury; witnessing losses; difficult choices; workload; time pressure; information load or lack of information; lack of control; strain of responsibility; mission failure; chaotic conditions; monotony; isolation; role conflict; crowding; or seeing and handling dead people.
- (c) *Social*. For example, interpersonal relationships, group cohesion, group pressure, emergence of subgroups or large numbers of stakeholders with different demands.

During an emergency, all three of the above causes may occur. A stress process for an emergency leader is given in Fig. 2, where feedback loops are omitted.

The impacts of the stressors depend on different factors that range from personal to social. The most important factors for minimizing the impacts of stress are training, experience and practice. Emergency operating procedures help provide some control in ambiguous and demanding situations as they normally include symptom based initial actions and, when the event diagnosis is confirmed, event based actions. However, the more the emergency scenario proceeds, the more it takes an individual course.

Fitness and fatigue, as well as social support (or lack of it) from colleagues and superiors, influence the impacts of stressors. With regard to personality traits, the situation is not as clear, and there is no consistent set of personality traits that could be considered as crucial for coping with stress in emergencies [44].

4.1.2.2. *Impacts of stress on behaviour*

Reactions to stress fall into four categories:

- (1) Physiological:
 - Trembling;
 - Sweating;
 - Nausea;
 - Frequent urination.
- (2) Emotional:
 - Excitement;
 - Anxiety;
 - Loss of emotional control;
 - Surprise;
 - Anger;
 - Fear;
 - Helplessness.
- (3) Behavioural:
 - Avoidance;
 - Hyperactivity;
 - Irritability;
 - Shouting;
 - Withdrawal;
 - Disengagement.
- (4) Cognitive:
 - Self-delusion;
 - Regression;
 - Inability to prioritize;
 - Disorientation;
 - Mental confusion;
 - Difficulty in naming objects;
 - Loss of objectivity;
 - Memory deficit.

Effects can be positive or negative, depending on the circumstances, and of the general type ‘flight, fight or freeze’.

Contrary to the prevailing opinion connecting people’s behaviour in emergencies with panic, flight, regression, selfishness and irrational behaviours, there is substantial evidence to suggest that people in danger usually behave functionally, appropriately to the situation and supportively of each other [45]. One need look no further than the behaviour of the first responders during the attacks in New York City on 11 September 2001 or the behaviour of the employees at the Fukushima Daiichi nuclear power plant to see that these individuals stayed at their posts and did their best to perform their duties during extremely stressful situations. For this reason, leaders

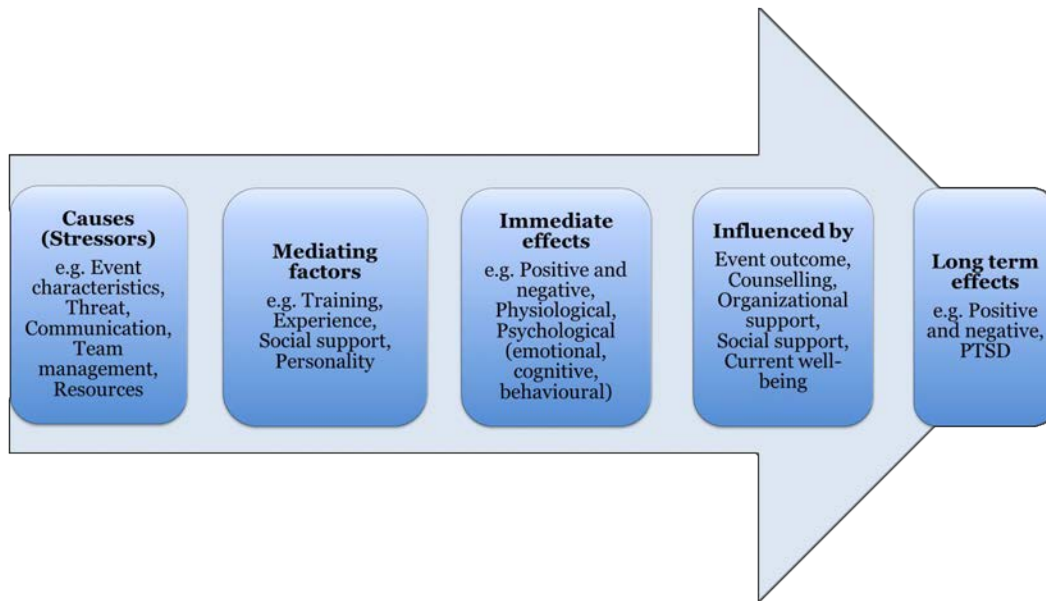


FIG. 2. Emergency stress process for an emergency leader. Adapted from Flin et al. [24]. PTSD: post-traumatic stress disorder.

cannot delay in immediately warning people about danger because, in most cases, the warning will not cause a panic but will prepare and guide people. By issuing timely and adequate warnings, leaders can provide confidence that the situation is being addressed, which prevents unnecessary activities and uncoordinated behaviours.

Behaviours such as abandoning the post, not helping co-workers, not considering orders, and so on, are rare, and depend on factors such as the safety culture, social climate and relationships in a group; the credibility of the leader; training; decision support systems; and the norms of the organization in normal operations. In principle, establishing a good social climate, ensuring competent personnel are in place, and having credible and responsible leaders help to guarantee adequate behaviour in emergencies. As the effects of nuclear emergencies can potentially influence a wide area, the establishment of good relationships between the nuclear facility and the local community, including common training exercises, is necessary and beneficial. In communities located near a nuclear facility, a so called ‘nuclear’ community culture could develop, meaning greater understanding of what is going on or what could happen in a facility, greater preparedness for possible emergencies, and so on. Of course, the behaviours exhibited will be dependent on pre-existing relationships, which emphasizes the importance of developing positive relationships between groups during normal operations so that they are in place and functioning appropriately should an emergency occur [7].

One exacerbating factor to be considered associated with ERO members and stress is that workers may have family members in the immediate area around the nuclear facility who they will be concerned about. During the accident at Fukushima Daiichi, many of the workers were not able to contact their family members for extended periods of time and had no way of knowing if they were safe or in danger. Therefore, in addition to dealing with the stress of the actual accident and what could be done to mitigate the damaging effects, these workers had the added stress of not knowing the statuses of their families. There are steps that nuclear facilities can take to put mechanisms in place in advance of an event that could help in such situations and would thereby potentially remove at least one level of stress the workers are undergoing. These steps are addressed later in this section.

In summary, stress is one of the critical variables that influences decision makers dealing with an emergency at a nuclear power plant for a variety of reasons. By recognizing the very real impact of stress in the emergency environment, organizations and leaders within the organizations can take steps to minimize the potential for negative impact.

4.1.3. Group processes and dynamics

While group decision making has the potential to overcome many of the individual cognitive biases discussed earlier, if not properly managed it can result in extreme outcomes that lack deliberate assessment, planning and

execution [46]. Many of the cognitive biases discussed earlier can also occur within a group setting. This can amplify the impact of these biases and cause them to be even more severe if there is no one within the group who can look beyond the bias. For example, confirmation bias, or the tendency to pay attention to information that ‘confirms’ what is already thought can be amplified if an entire group is behaving in this manner and there is no one with an independent voice to question the path the group is following. There are some other well known dysfunctional group behaviours that can also impact the group process, particularly during an emergency, for example:

- (a) *Groupthink*. This is the tendency for individuals in a group to attempt to minimize conflict and thereby reach consensus without conducting a critical evaluation of alternative viewpoints [47]. Dissenting views are typically suppressed, or group members isolate themselves from any outside influence. This can cause group members to avoid raising alternative solutions or controversial issues, and independent thinking by members of the group can be lost.
- (b) *Blind adherence to authority*. This phenomenon in groups causes people to assume that something is true solely because of the authority of the person making the claim. This can be especially problematic when individuals within the group hold positions of authority, are held in high esteem by other group members or use their power and position as a means to convince other group members that they are correct. Sometimes, this can occur on a subconscious level.
- (c) *Shared information bias*. This bias within groups can cause people to spend more time discussing information that is shared among or known by all or most members of a group and less time discussing information that fewer people in the group share [48]. This can lead the group to be less knowledgeable about critical pieces of information that are significant to dealing with the effect.
- (d) *Group polarization*. Some research suggests that decisions made by groups tend to be more extreme and riskier than the average of the individual decisions made by group members would have been [49]. This has implications during an emergency situation, as it suggests that actions taken by a group may be prone to being riskier than actions taken by an individual, although there could also be a beneficial impact of this behaviour in that people may be more prone to thinking outside the box.

All members of the ERO need to be aware of these potential issues. In particular, leaders ought to be knowledgeable about them and know what warning signs to look for to ensure such behaviours do not have undue impact on the decisions and actions being taken in response to an event.

4.2. MITIGATING ISSUES ASSOCIATED WITH HUMAN PERFORMANCE DURING AN EMERGENCY

While the issues around human performance are often built into the human thinking apparatus, which makes them difficult to counter, there are ways to mitigate their effects. Specifically, managers can try to put in place mechanisms that will prevent workers from making errors as well as install controls to prevent errors that are made from having an effect. Research shows that approximately 80% of all incidents are initially attributed to human error [38], with the remainder being a function of equipment or material failures. Of the incidents with initial attribution to human error, only approximately 30% are the result of a worker incorrectly interfacing with equipment and/or systems [50]. The rest of the events have been found to be associated with underlying organizational weaknesses (e.g. issues with processes or cultural factors) that can either be a precipitating event to someone making an error or weaken the controls put in place to prevent errors from having a negative effect. There is no reason to believe that these same issues would not be inherent in human performance when dealing with an emergency. Therefore, the importance of having effective error prevention tools and mitigating controls in place cannot be overstated when dealing with an emergency situation.

To understand the types of tools that are useful during an emergency to help people perform in the desired manner, it is important to acknowledge the following three modes of human performance [51]:

- (a) *Skill based performance*. When workers perform skill based activities, they are performing actions, often from memory and without obvious thought or attention (e.g. driving a car or turning a valve). People tend to be very familiar with these tasks and therefore attach low perceived risk to them, which can make people

somewhat unaware of the potential hazards in performing the task. Of course, during an emergency, even simple skill based actions that are performed on a routine basis can become significant, and people are more likely to pay greater attention to their actions (just think of driving a car during a blizzard), but people will still tend to have higher confidence in their ability to perform those actions and perceive lower risk in the task performance. When performing skill based activities, inattention is the primary reason that errors are made. Ensuring that appropriate mechanisms are in place to promote paying proper attention in the performance of the activity, such as peer checking, procedure checklists with systematic checking and other attention focusing mechanisms, is the primary means of dealing with these types of errors during an emergency.

- (b) *Rule based performance.* Rules are often used when workers perform activities that they are less familiar with and have not practised as much. Workers are likely to encounter rule based performance during an emergency situation, particularly when it is necessary to change their otherwise skill based performance to deal with some unexpected condition. When performing rule based activities, workers often use memorized or written procedures or instructions. However, the workers need to be able to recognize the appropriate rules to follow given the circumstances they are encountering. Misinterpretation of the event is the primary cause of errors made when performing rule based activities. Providing ERO members with appropriate decision aids to assist in their identification and proper interpretation of the circumstances is a key aspect of preventing this type of error.
- (c) *Knowledge based performance.* Knowledge based performance occurs when workers are uncertain about what to do and must use the knowledge and information they have available to make a decision about a path forward. Therefore, knowledge based performance and prevention of associated errors become acutely important during ER. Skills in diagnosis and problem solving are important when performing knowledge based activities. The chance for error when involved in such activities is especially high, and errors that do occur are primarily the result of inaccurate mental models.

As knowledge based performance is the most likely mode to lead to error, as well as the most likely mode to be encountered during an emergency situation, this publication will now largely focus on actions that nuclear facilities can take to mitigate associated knowledge based error. This is not to say that performance mitigating tools and techniques are not also useful for skill and rule based performance during emergencies, but rather that the tools and techniques helpful for skill and rule based performance are typically in use during normal operations and are already covered in Ref. [11]. Effective implementation and reinforcement of human performance tools to support skill and rule based performance during normal operations (e.g. procedure use and adherence, three way communication) is expected to transfer to the performance of these same types of activities during emergency situations.

4.2.1. Techniques for supporting human performance during an emergency

There are some significant actions that organizations can take to reduce the potential for the occurrence of human error during an emergency situation. Again, many of the techniques critical to reducing the potential for error making when performing skill and rule based activities are techniques that are implemented during normal operations to help support human performance. Some of these techniques include three way communication, procedure use, procedure adherence, promoting a questioning attitude, and pre-job and post-job briefings. Reference [11] provides guidance on the implementation of these human performance techniques during normal operations. To the extent that these techniques can be used to help decision making, they can definitely be used and applied in an emergency situation. The consistent use, expectation for and reinforcement of these techniques during normal operations will better ensure their continued use during an emergency operation. The focus of this publication is on specific techniques that are associated with the knowledge based performance and decision making that is required to support such performance, particularly during an emergency situation.

4.2.2. Pre- and post-task briefings

While pre- and post-task briefings are a common occurrence in nuclear power plants during normal operations, there are some aspects that might be considered for incorporation to ensure these briefings will strongly support performance during emergency operations. Specifically, pre-job briefings may be structured in a way that

ensures the workers are engaged and take ownership for the jobs. This is often done by having the workers that will be performing the task conduct the briefings, while supervisors and other relevant parties listen to the briefing and provide feedback and ask questions. This is often referred to as 'reverse pre-job briefing'. Such briefings can be especially useful to discuss critical tasks and any potential hazards, what safety precautions need to be taken and any error traps that could be present in the work. Additionally, post-task briefings carry specific significance during an event or emergency as the workers can provide important feedback regarding any unanticipated conditions that were encountered or anything out of the ordinary that was noted. Such information could be vitally important in responding to an emergency, and post-job briefings provide a formal mechanism to ensure this information is effectively transmitted to other members of the ER team.

4.2.3. Job site review

As with pre- and post-task briefings, worker review of the job site prior to actually conducting work is a critical activity during an emergency situation and requires some effort on the part of the individuals performing the work, especially as they may be doing so under difficult conditions, with time pressure for task completion. However, by pausing briefly and reviewing the job site, the worker can take note of any discrepancies between what is expected and what actually exists in the environment. These discrepancies could in fact lead the ER team to re-evaluate planned actions. Similarly, if workers encounter a situation that differs from what is expected, they ought to be trained to stop and seek clarification from the ER team before moving forward.

4.2.4. Inquiring attitude

One of the most significant things organizations can do during normal operations that will aid in response to abnormal situations is to instil an inquiring attitude within their workforce. People need not be afraid to raise concerns or ask thought-provoking questions. An inquiring attitude is a very useful mentality to combat some of the cognitive and social biases that are bound to be exhibited during an ER. A particularly important aspect of developing an inquiring attitude is that people are able to support their positions on the basis of identifiable facts and not just opinions or assumptions. At the same time, people deserve to be encouraged to think outside the box and consider all possibilities so that there is a greater awareness among the ER team of what they could be encountering.

4.2.5. Decision making support tools

The best way to ensure good decisions are made involves practising making decisions in advance and providing decision makers with a decision making template or process that they can follow to support them in making the best decision possible. Examples include the operational decision making procedure developed by the Institute for Nuclear Power Operations [52] or systemic mapping [53]. Good decision making, supported through effective leadership and leadership competencies such as situational awareness and strategic thinking, can be broken down into the following steps:

- (a) Making an adequate diagnosis of the situation that is as comprehensive as possible given the situation and the information available;
- (b) Generating feasible plans of action to address the diagnosis;
- (c) Carrying out the plans of action to impact the physical situation and hopefully alter it in the desired direction;
- (d) Examining and evaluating feedback on the actions taken in order to move on if successful; repair and, if necessary, recover if less successful; and learn as the decision makers proceed.

Decision making is a skill that can be trained for and a process that can be supported. Structured support for critical decision making can help to ensure that inappropriate or inadequate information is not given undue weight and that the potentially negative impact of cognitive biases is controlled. Many organizations have implemented decision making methodologies (e.g. decision tree models) that are useful to ER participants.

Practice in decision making, at least in the types of critical decision expected, can also help. Often, structured decision making methodologies are implemented across the organization for all types of decisions. This ensures

that individuals are familiar with the methodology and gives them practice in its use so it is not an unfamiliar activity when encountered during an emergency. Additionally, practising the use of these structured decision making methodologies will help to identify any potential issues with the methodologies prior to implementation during an event.

One particular form of support is the presence of an informed and positive critic whose task is to ensure that the best decisions are made and that traps to good decision making are avoided. This person is outside the actual decision making process but provides input and serves as a line of defence to the organization and the ER team by critically examining and questioning the decisions that are made and the processes used to arrive at those decisions.

4.2.6. Emergency operating procedures

The IAEA report on the development and review of emergency operating procedures [54] discusses the development and implementation of emergency operating procedures in detail. What is significant to note is the role such procedures can play if effectively developed and implemented in mitigating human performance deficiencies as well as the negative impact that poorly developed emergency operating procedures can have on human performance. Organizations are expected to put emphasis on development, testing and training in emergency operating procedure use to ensure they can provide the maximum support possible to personnel responding to emergencies, while understanding that emergencies often develop in ways that may not be completely in accordance with any emergency operating procedure.

4.2.7. Human performance considerations in training for emergency response

Providing training and practice in dealing with an emergency situation can be carried out in a variety of ways. Paper or computer based training problems can allow individuals to exercise basic rational processes. Simulator training can add elements to the complexity of responding to an event, such as time pressure, and can provide feedback with knowledge of results. Group exercises can develop group skills and allow the introduction of a human critic (possible, but different in nature from a computer system) and can also be run in simulations.

One problem that has to be faced in training people to deal with emergency situations is that the best performance, especially as measured in the face of a real emergency situation, requires 'requisite variety' [55]. 'Requisite variety' refers to the range and variety of problems practised being sufficiently varied that individuals develop capabilities in solving new and unknown problems rather than simply solving the examination set.

If a limited set of emergency conditions is used in training for dealing with emergencies, and adequate variations to those conditions are not introduced, people may perform poorly under emergency conditions, when the problem they have to solve may not fit the script that they have been taught in advance. For instance, people may have to cope with situations that in everyday activities are recognized as normal but which may need to be considered as abnormal, or at least anomalous, in emergency situations. For example, what might be considered a nuisance alarm during operations may be indicative of a more serious situation during an emergency or event.

An alternative way to provide experience with emergency situations is by providing people with an opportunity to spend time with emergency services such as the fire brigade or military. The ability to cope successfully and rapidly with such deviations from day to day routines also needs to be taken into account in both the selection and training of operators and managerial staff.

There are limitations associated with training that are important for the ERO personnel to understand. Specifically, the training is only as good as the models and assumptions behind it. The most significant and consequential events within the nuclear industry have followed paths that had not previously been conceived. Simulators may not simulate failures or the development of emergency processes well. This problem can also apply to brainstorming by groups on unexpected events, when they may lack the ability to move past the most obvious failure modes, especially where people are involved rather than just technical equipment and processes. ER personnel need to be aware of the following issues associated with the training they have received so that they are able to look at the event with a critical mind and keep all possibilities open:

- (a) The models that humans create to help understand situations and processes, often referred to as mental models, which are used in the development of exercise scenarios are often restricted to well understood

situations. Mental models are limited by capabilities, and well understood scenarios can be modelled most realistically and easily.

- (b) Complex technical failures may be well understood but not integrated into the simulation model because the understanding and representation of those failures do not lend themselves to the simulation methodology being used.
- (c) If simulation is used frequently, people will learn in ways that are limited by the simulator. Cross training not only has general benefits for daily operations but also can provide extra skills in emergency situations as well as requisite variety in decision making.
- (d) Simulations usually concentrate on technical issues and may miss the human and organizational elements that will also be influential in a real situation. In an emergency situation, there are many people involved, and they will likely need to interact with one another, which, as discussed throughout this publication, can lead to a host of other issues, particularly if these interrelationships and interdependencies have not been previously managed.

Another variable to consider is the frequency of recurrent training for emergencies. Organizations need to take the following factors into account:

- (i) The frequency of practice determines the ease and speed with which people can switch from a normal to an emergency operating mode.
- (ii) Infrequent practice means that people can forget what they learned, so learning has to be considered in the light of forgetting.
- (iii) Less frequent practice means that the default behaviour, which is what people will revert to under stress and other emergency related conditions, is the normal behaviour rather than the emergency one.
- (iv) If exercises are not taken seriously and are not as realistic as possible, then the learning will be limited. There has to be a mechanism to ensure that emergency exercise training is considered important enough by the organization to ensure people are intrinsically motivated to take the activity seriously.
- (v) Different groups (e.g. operators, managers) may practise with different scenarios and not practise working together (e.g. field operators, maintenance staff, non-licensed individuals and groups). Different groups may also use similar terms with different meanings (or different terms with similar meanings). It is essential to ensure that everyone, both internal and external to the organization, who might be involved in handling a real emergency is using the same terminology and understands the same concepts.
- (vi) Exercises are usually carried out at convenient times and under agreeable conditions. A real emergency may, and probably will, occur at the wrong time and leave the plant with insufficient power, some smoke and a great deal of confusion. Organizations may need to take steps to provide training opportunities that are likely to closely mimic the types of conditions that would be encountered in an emergency. This will make it more realistic for the people who are learning and is more likely to provide them with a sense of confidence when they encounter an emergency that they have been well prepared to handle.
- (vii) Many organizations conduct ER training, especially the training that involves multiple organizations and agencies, with a team comprising their top performing employees. Such a team is not likely to be in place during an actual event, which may occur off-shift or on weekends or during holidays. All training for ER needs to take the variety of personnel that are likely to be on-site during a real event into account when selecting people to participate in that training.

4.2.8. Organizational knowledge

Generational differences between skill based, rule based and knowledge based performance may mean that more experienced workers have a greater base knowledge, while younger, less experienced workers and contractors have a more limited experience and have received limited exposure to the fundamental knowledge and the physical reality of their operating environment. Therefore, the technical basis required for deep troubleshooting may not be present in younger generations of workers and contractors, unless the organization takes steps to counter this.

For example, organizations need to provide opportunities to physically touch the equipment and not just learn about it through lectures or readings. This can help make the equipment more 'real' and help people to better understand the reasons it might fail to work. Additionally, having seasoned employees mentor newer employees

and involving contractors can be helpful in ensuring that the knowledge they have gained through the years of working at the facility is transferred effectively to other groups of workers.

5. ENSURING EFFECTIVE INTERNAL COMMUNICATION DURING AN EMERGENCY

There are two overriding objectives of communication during a nuclear or radiological event:

- (a) To support the recovery of the nuclear facility experiencing the emergency by providing a means of sharing information on emergency status and establishing communication channels for making decisions for all employees and contractors directly involved in the ER;
- (b) To provide information about the emergency in a timely manner to the rest of the stakeholders, both internal (employees and contractors not directly involved in the emergency, all employee families and potential visitors to the nuclear facility where the emergency happened) and external (e.g. governments, regulators, the public) and receive and respond to their feedback and concerns about the emergency.

The focus of this publication is on the first objective, the communication that occurs primarily within organizations, including with headquarters, with employees at all levels and in all departments, and with contractors. This is referred to as ‘internal communication’.

Although it will be briefly discussed here, external communication with outside authorities and the public during a nuclear or radiological emergency is covered in detail in Ref. [2]. In real emergencies, as discussed in Sections 5.2 and 5.3, it may be impossible to separate these internal and external communication situations totally, as enquiries via modern information technology from outside the facility will undoubtedly interfere with internal communication. A leader, therefore, needs to be prepared to deal with both external and internal communication requirements simultaneously and often under considerable stress.

Effective internal communication is a vital component of ER to ensure that all members of the ERO receive the most up to date information available to be able to perform ER functions. Plans and procedures for effective internal communication can be developed in advance of an emergency. These plans and procedures will need to be integrated within the overall planning and arrangements for managing emergencies. They should detail the roles and responsibilities of various individuals as they relate to communication, both internal and external, as well as the activities to be carried out during the ER. Many organizations assign dedicated communicators to the ERO(s). These communicators have the primary responsibility of providing and receiving all communication into and out of their organization related to the event as well as keeping a detailed log of that communication. Procedures and checklists should be developed that provide specific instructions to individuals assigned to fulfil various roles and to undertake communication activities.

5.1. ISSUES FOR CONSIDERATION

Emergency situations present numerous unique and complicating factors that can impact the effectiveness of communication. Some of the factors to be considered in the communication process include:

- *Communication source*. The originator of the message.
- *Message*. The actual information being conveyed by the source.
- *Channel*. The means or method of communication used by the source.
- *Receiver*. The audience to whom the message is intended.
- *Effect*. The possible effects of the message (e.g. message intended to transmit information versus information to be acted on).
- *Feedback*. The information received back in response to the message — communication needs to be a two way process.

Potential issues associated with each of these factors are outlined below.

5.1.1. Communication source

The person delivering the message or the source of the communication has an impact on how the communication is received. Establishing trust is not likely to occur during an emergency but is more likely to be based on relationships that are built prior to the event's occurrence (i.e. during normal operations). If the communication source is perceived to be truthful, open and knowledgeable, the communication is more likely to have the intended impact on the receiver.

5.1.2. Message

Delivering the right message is a critical part of communication. The reason, the usefulness and the accuracy of the message will affect how the message is received. Information has to be useful, timely, consistent, complete and correct. Insufficient, inaccurate or incomplete information can impede proper situation assessment, while too much information can overload personnel and cause confusion. Human information processing capabilities are limited, and consideration of this is important in the communication that is provided during an ER.

5.1.3. Channel

The means through which a message is conveyed is known as the channel. Various channels are available for communicating during an emergency, including face to face, loudspeaker, radio, written emergency operating procedures and accident management guidelines, written material, and telephone or videoconferencing. It is important to recognize that some channels that might ordinarily be available during normal operations are not available during an emergency (e.g. telephone communication may be limited, or loss of power could impact other communication methods available). This needs to be recognized by the organization and given proper consideration in ER planning. Different channels have different strengths and weaknesses, as well as varying impacts on the forcefulness of the message. For example, critical actions to be taken may not be best communicated via text message or email unless adequate steps are taken to ensure that the message has been received and understood. As another example, it is not particularly effective to give a long list of directions verbally, and it is better to have them written out and communicated. Visualization of information is powerful; using whiteboards to structure information can also be helpful in channelling information.

5.1.4. Receiver

The person for whom the message is intended is the receiver. Although the message sender may have specific actions or reactions in mind that they intend the receiver to get from the message, the sender has to bear in mind that each individual enters into the communication process with their own ideas and feelings as well as specific environmental conditions that will undoubtedly influence their understanding of the message and their response. This deserves consideration in formulating and delivering the message, and appropriate modifications may need to be made. For instance, certain individuals that are being communicated with in an emergency may be in extremely difficult and stressful environments or situations. Not taking this into account when formulating and delivering the message could lead to problems with the receiver's understanding of the information being communicated.

5.1.5. Effect

The sender of the message has an intended effect in sending the message — it may be purely informational or with the intent that the receiver acts on it in some way. However, it must be clear what the intended effect is so that the receiver is able to respond accordingly.

5.1.6. Feedback

Effective communication is a ‘looped’ process, not a one way process. Mechanisms need to be considered to ensure that the people receiving the communication have a method by which to provide information back to the sender. This will ensure that communication can be verified and questioned as necessary, and updates or corrections to the communication can be provided, if appropriate, by the receiver.

5.2. POTENTIAL BARRIERS TO COMMUNICATION DURING AN EMERGENCY

It is clear that even during the best of circumstances, breakdowns in single or multiple communication factors can occur. The potential for such breakdowns is exacerbated during an emergency situation, so it is especially important that ERO members are aware of the potential pitfalls and have the knowledge and skills to recognize means through which they can better improve communication during an event.

Potential issues with communication increase with the involvement of more people and participating organizations, as is likely to be the case during an emergency. Assigning roles and responsibilities relating to communication is critical, especially as many people and organizations become involved. Ensuring that all intended recipients of communication have actually received the message and understood it can become a monumental task if steps have not been taken ahead of time by the organization to ease this process. Also, determining who needs to receive what information is a crucial element of communication during an emergency. It is vital to ensure that important information does not get lost or forgotten. Providing unnecessary information to members of the ERO increases the information ‘noise’ and can decrease the perceived urgency of the information provided.

Barriers to communication can emerge due to factors internal to the participating parties (e.g. language differences, culture, motivation, expectation, past experience, prejudice, status, emotions, hearing or voice level) as well as external (e.g. noise, interference or distractions, separation in location and/or time, lack of visual clues, collapse of the communication system). Simple measures, such as limiting personnel access to rooms where decisions or important communication is occurring, can be helpful. Identification of these potential barriers ahead of time can facilitate the development of means to manage them.

Additionally, while the overriding concern of members of the ERO is to effectively mitigate the event, there is also a need to ensure that the public has the necessary information to deal with the potential consequences of the event. The organization also needs to ensure that information necessary for proper record keeping and preparation of status information for competent authorities and technical support organizations is available and communicated.

5.3. MITIGATING ISSUES ASSOCIATED WITH COMMUNICATION

Systematic planning, implementation and evaluation of communication with internal stakeholders (under normal conditions and during unexpected events) are essential and represent an important investment for a robust organization in terms of financial and human resources. Planning for communication needs during an emergency is the best defence an organization has in mitigating potential communication problems. Through anticipation of all potential issues with communication that could arise, organizations can attempt to put defences in place to protect the organization from those issues. This is well documented in the IAEA emergency preparedness and response methodology [5].

5.3.1. Use of dedicated communication professionals

Experience shows that communication specialists, both under normal conditions and during an emergency, can provide useful and professional support and assistance to the organization to improve communication. Many organizations have communication professionals who work to assist the organization in identifying the communication barriers within the organization as well as to aid in the development of a communication plan for ER. The mechanisms for effective communication are not necessarily apparent to all, as evidenced by the examples of communication breakdowns in the literature during ER [56–58]. The potential for these breakdowns increases exponentially during an emergency.

In addition to the trained communication professionals on the ERO staff, designated communicators are often integrated into the ERO to coordinate communication activities during an event. Designated communicators are typically assigned to each of the primary ERCs that are activated. These individuals are the liaisons between their particular centre and all other ER groups, both internal and external to the organization. Providing a mechanism for all communication to flow through one central individual, whose only responsibility is communicating during the course of the event, helps to ensure that all communication is documented and distributed appropriately within the ER team. This is useful to help prevent information from getting lost or forgotten, to provide an important documentation function for informing others who may enter into the ERO at a later point in time, and to enable the organization to reconstruct the event after it has concluded.

5.3.2. Leadership competencies in communication

It is important for ER leaders to establish effective communication with their employees during routine operations in order to clarify expectations about the organization and the leader's vision and philosophy, and to build mutual trust. When there is existing trust, it can reinforce employee loyalty to the organization and the leadership and ease internal communication. During an emergency, appreciating the time pressure, leaders need to maintain an open communication channel face to face or via videoconferencing or audio conference calls, particularly with the ER team (at the site under emergency and at the headquarters/corporate offices), and to provide regular updates on the emergency status and answer any questions.

At the same time, the perceived accuracy and clarity of the information provided regarding the emergency can strengthen the image of transparency of the organization, both internally and externally. When people receive information that they perceive as inaccurate or unclear, they are less likely to pay attention to or believe future communication. When communication is clear and accurate, people are more likely to believe the organization is being open with the information provided.

Clear communication of the overall vision and of the basics is important. 'Keep the core covered with water', 'get as much cooling capacity mobilized as possible' and 'maintain containment integrity' are examples of the organizational priorities in the face of an emergency event. When leaders concisely and simply state these organizational priorities, there is full understanding among ER personnel about what their primary focus is during the event.

In communicating with all the internal stakeholders, the organization and its leaders have to provide accurate, factual and complete information and manage a 'one voice policy' (i.e. the same message is delivered, regardless of who it comes from) to ensure consistency of messages (and also through which channels that message is delivered); this principle also applies to external stakeholders. When the flow of information is not properly managed and the role of the spokespersons is not properly defined, it can result in confusion among employees and cause additional stress as well as have an impact on external communication.

It is essential that all levels of leadership within the organization foster a safety culture in which communication is promoted by encouraging appropriate inquiring. Appropriate inquiring should always be encouraged during training activities as well as during actual operations, and it should be clear that there will be no negative repercussions for appropriate questioning of decisions or actions proposed or taken. The organization should focus on developing skills for effective inquiring so that organizational members can feel confident in how they go about questioning others within the organization.

5.3.3. Communication skills for all emergency response team members

Good listening is an important quality for all members of an ER team. Effective communication results from listening to other team members as fully as possible, given the time constraints, and ensuring that there has been nothing important left unsaid. If team members feel that they do not have an opportunity to inform their team properly, then frustration and annoyance will result, and communication within the team will deteriorate. Leaders play a key role in communication by the model they set. Leaders who ensure that they listen to input from all members of the team are much more likely to be able to respond to the event effectively.

Effective and proven communication techniques should be modelled and reinforced during normal operations to ensure that their use is carried over into emergency operations. For example, three way communication should be promoted. Three way communication and the phonetic alphabet should be used as standard communication during

normal operations to ensure that their use is transferred across to the ERO. Also important is the use of repetitive messaging. Communication of information that is especially critical or vital for the ER team to understand should be repeated multiple times. This will help to ensure not only that the message is heard but also that the significance of the information is understood.

Training in communication skills should be provided to all potential members of an ERO with specialized training on communication for ER leaders. This training should cover the potential issues with communication that could be encountered during an emergency event, the things that can be done to ensure communication is successful during an emergency and other relevant topics associated with ER communication. Emergency exercises conducted on simulators should reinforce the communication concepts. ER exercises with the various emergency organization elements fully activated should also occur and provide an opportunity to practise communication during a simulated emergency situation.

5.3.4. Contingencies for communication with external stakeholders

Organizations need to be able to ensure that they can communicate vital information to the public. Contingencies should also be considered in the event that certain mode(s) of communication become unavailable during the event. Loss of power or significant degradation to the infrastructure in the area surrounding the nuclear facility could make certain planned communication mechanisms unavailable. Facilities should consider this ahead of time and put in place alternative mechanisms that could be used should planned mechanisms fail.

5.3.5. Organizational infrastructure for communication

A survey of good practices in the nuclear industry suggests the following infrastructure guidelines should be considered to mitigate some of the issues associated with communication that can arise during an emergency [2]:

- (a) Establish clear lines of communication and primary points of contact for each group that is part of the ERO. By identifying this information ahead of time, along with defined roles and responsibilities related to communication activities, clear communication paths among those involved in ER will be facilitated.
- (b) Individuals with operational experience should be considered as dedicated internal communicators during an emergency. Ideal candidates are prior licensed or non-licensed operators, operations instructors, operational support engineers and system engineers. These individuals should be identified by name and actively participate in a comprehensive training programme.
- (c) Adequate tools, instruments, supplies, equipment and documentation such as procedures, checklists, telephone numbers, preformatted templates and plant status whiteboards (together with flipcharts, pens, etc.) should be provided to summarize and share key information among various internal stakeholders. Preapproved communication templates could be prepared to expedite information sharing.
- (d) Organizational procedures to manage internal communication need to be defined, standardized and agreed on, both with those internal to the organization and with external stakeholders. These procedures should include clarification of the roles and responsibilities of entities and individual officials in internal communication (e.g. main control room, site ERC, employees, plant managers, engineers, field operators and communication specialists). For instance, in the case of a multiplant emergency, communication related to each plant may be assigned to separate individuals to avoid overload of information for any one individual. At the same time, it is useful to have a mechanism in place to ensure that these individuals have a means to communicate and share information with one another and that they are not working at cross purposes.
- (e) External stakeholder intervention should be monitored, and in fact, only specific teams or individuals should respond to external stakeholder enquiries.
- (f) Overflow of information has to be managed. In the case of the Fukushima Daiichi accident, interviews with company officials from the Tokyo Electric Power Company working at the Daiichi ERC showed that managers responsible for more than one plant were challenged by the amount of data for each of the plants. In this case, either reassignment of responsibility or support in the management of the flow of information could have helped.
- (g) A single point of contact for communication between the site and external organizations should be provided. At Fukushima Daiichi, between 11 and 15 March 2011, there was an internal communication challenge between

the ERC and the corporate ERC; this led to both entities communicating with external stakeholders, resulting in conflicting and inconsistent information. After 15 March 2011, some of the key external stakeholders (e.g. the cabinet, fire brigade, police, self-defense force) started sharing the physical space with the corporate ERC (integrated ER headquarters in Tokyo), so that the site ERC had only one entity to communicate with, which helped to avoid miscommunication.

- (h) Examples from nuclear operators show the efficacy of organizing internal meetings during the course of an event to provide information and to show the company's position and answer employee questions. Such an effort can also be supported by establishing an intranet site to answer employee questions and provide any additional information.

5.3.6. Communication plan

Nuclear facilities need to develop and implement a communication plan in case of an emergency. The internal and external emergency communication plan or communication strategy is a vital part of the organization communication plan or strategy, and needs to be integrated into the overall emergency preparedness plan. It is critical that senior management support for the plan is obtained. The communication plan supports the infrastructure, but having the appropriate infrastructure is also a critical requirement for the plan. As the communication plan provides information on how communication should take place among the various units, the infrastructure also needs to be effectively developed to allow those communications to take place.

It is useful to keep in mind the following general concepts in developing the communication plan:

- (a) The plan needs to be as simple as possible. Development of a well organized and systematic plan that contains all relevant information regarding communication in one centralized place will generally be suitable to guide organizations in their communication through most incidents.
- (b) The plan has to ensure that communication is appropriately focused on relevant information. The plan aids in ensuring that only the relevant facts as they are available are provided, that those facts are distributed quickly and proactively, that regular follow-up is ensured and that relevant parties are appropriately informed. The plan would also ideally provide a mechanism to ensure that any incorrect information is resolved as quickly as possible.
- (c) The plan needs to be regularly reviewed and tested to ensure that it makes sense and that all supporting materials (e.g. press release forms, media briefing arrangements, lists of critical contacts) are up to date.
- (d) The plan has to allow for some degree of flexibility and not be so prescriptive that changes or unforeseen circumstances cannot be effectively handled. In most cases, a basic plan template with supporting document files will be sufficient.
- (e) The plan needs to be coordinated with all relevant organizations at the site. While, in many cases, the public relations or communication organization will be the group that coordinates external and internal communication, it will need to work closely with the other ER personnel at the site. By ensuring that the plan is coordinated with all of these groups prior to the occurrence of an event, the organization is much more likely to provide effective internal and external communication during the event.

Typical emergency communication plans need to contain sufficient details to ensure they provide effective guidance on communication during emergencies. Discussion of procedures such as how internal alerts are to be sent deserves to be detailed in the plan. Examples of this include guidelines on the use of email, public announcement systems, voice messages, text messages and cell/smartphones. Where possible, the communication plan could provide detailed preformulated messages that could be used to deliver information such as instructions on building evacuations, assembly point information, updates on the status of the situation and notification of when it is safe to return to work. The manner in which external emergency communication will occur also needs to be included in the plan and should cover topics such as notifying family members of an injury or death, discussing the disaster with the media and providing status information to stakeholders. What is most important is that each message needs to be prepared with the receiving audience (e.g. employees, media, families, government regulators) in mind; broad general announcements may be acceptable in the initial aftermath of an incident, but these will need to be tailored to the audience in subsequent releases.

The emergency situations and disasters that a nuclear facility may have to contend with are broad and range from fires, floods and severe weather to kidnappings, bomb threats and vandalism. The emergency communication plan developed has to be sufficiently encompassing to ensure that all types of emergencies can be addressed under the plan. The plan has to be able to launch quickly, provide senior management with a briefing of the situation, identify the company spokesperson and provide him or her with a briefing of the situation, assist in the preparation of company statements to the media and other organizations, organize and facilitate broadcast media coverage, communicate situation information and procedural instructions to employees and other stakeholders, communicate with employee families and the local community, and continually adapt to changing events associated with the emergency.

The plan may be divided into three general sections: communication preparation, communication during the event and follow-up after the event. Details on the types of information to be included or referenced in each of these sections are provided below [2, 59]. While some reference to external communication is made, the focus here is on how the organization can best internally plan to address all aspects of communication necessary in the emergency situation.

5.3.6.1. Communication preparation

The following items need to be prepared and included in the communication plan to facilitate communication during an emergency:

- (a) List of internal points of contact (e.g. employee list, ER team members).
- (b) List of external points of contact (e.g. media, vendors, government agencies).
- (c) Any special forms to be used in the course of emergency communication. Examples of such forms include call logs to track inquiries from the media and others, an emergency contact directory and an incident description report.
- (d) Any prewritten communication such as press releases, initial announcements and follow-up statements.
- (e) Identification of an area where media can assemble.
- (f) Identification and the detailed roles and responsibilities for a trained emergency communication team.
- (g) Identification and detailed roles and responsibilities for a trained company spokesperson.
- (h) Information regarding use of available technology for providing emergency information to employees, stakeholders, suppliers, clients, government agencies and other external entities. In addition, backup communication technology needs to be available in the event that any of the normally used mechanisms are not available due to the emergency.
- (i) A company policy with regard to all aspects of emergency communication. For instance, any communication channels that should not be used during an emergency need to be identified in this policy. Also, how employees should respond to media requests deserves to be identified in this policy (e.g. refer them to the company spokesperson).
- (j) Statements to inform all involved in the emergency situation that the information will evolve over time and will therefore be dynamic. Issued statements may be changed owing to contradictory information as time elapses.

By developing these items prior to an emergency, the facility will be in a position to effectively communicate if and when an emergency should occur.

5.3.6.2. Communication during the event

The communication plan ideally also provides a means to ensure that information is consistently collected and retained during the course of the event. In some cases, collection of this information will assist in the ongoing ER, and in other cases, it will assist in later reconstruction of the event. Regardless of the purpose it is being collected for, the plan would provide ER personnel with an outline of the type of information to be collected:

- (a) The facility would need to ensure that it can adequately account for the location of all employees, contractors and visitors believed to be at the plant. Employees not directly involved in the incident response should be

directed to leave the facility if possible or congregate in a central and previously designated location. It is vital that the ERO has a good understanding of what resources are available to them on-site as well as the ability to account for all employees to ensure their safety and well-being.

- (b) The communication plan would need to ensure that updated status reports on the incident are developed at regular intervals. This will help to ensure that any new individuals coming into the organization to aid in the event response have the most up to date information available in a consistent format. The status reports should provide details on actions taken during the incident, any problems encountered and how they were resolved, and any persistent problems that require additional resources so that they are effectively dealt with.
- (c) A log of any communication made in the course of the event, internal or external to the organization, would need to be maintained and to include the purpose of the contact, the information transmitted or received from that contact and any follow-up actions to be taken as a result of that contact.

5.3.6.3. Follow-up communication after an event

Once an event has concluded, there will still be communication activities that need to occur. Those activities may have to do with the emergency itself and/or with the communication related to the event. There will also be lessons learned that could be helpful in dealing with future emergencies. Some examples of the things the communication plan would need to consider during a follow-up, at the conclusion of an event, include:

- (a) Confirmation that all employees are accounted for.
- (b) A completed narrative of the incident with details on what happened, what was done, the results and the outcomes. All status reports issued in the course of the event, any individuals contacted (internal or external to the organization) and a complete list of problems encountered and how they were resolved would also ideally be included.
- (c) A documented and annotated emergency communication plan detailing any revisions that were made, any issues encountered in communication and the lessons learned for future use of the plan.
- (d) Feedback on what worked particularly well with regard to communication and what aspects of communication failed or presented problems. This is critical for future learning and development for the organization and for sharing with other external stakeholders and organizations with an interest in the event.

5.3.7. Training on effective communication during an emergency

Communication is a skill that can be improved on with practice and training. Organizations need to implement training programmes that will allow personnel to strengthen communication skills as well as develop relationships among organizational members that do not normally interact but may need to interact in the event of an emergency. Training for improved emergency communication could include:

- (a) Identification of personal styles of communication that could affect communication effectiveness.
- (b) Definition of the roles and responsibilities related to communication during an emergency, including third party roles.
- (c) Understanding of the communication process and barriers to effective communication.
- (d) Development of shared space to increase the understanding of key messages and communication of those messages to maximize receiver understanding.
- (e) Implementation and use of the facility communication plan.
- (f) Use of a simulation exercise to practise communication across all organizational groups that may be involved in event response. This is especially important because groups or individuals who do not normally communicate may be required to communicate during an event. Additionally, the normal modes of communication may not be available, and use of simulated events will assist personnel in better understanding what alternative modes are available and what limitations they might present.
- (g) Investigation of previously identified gaps and/or strengths in the organization's communication process. Communication issues that are not resolved will only be exacerbated during an event, and training is one tool that can be used to determine whether these gaps have been effectively closed.

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DEFINITIONS

The definitions given below may not necessarily conform to definitions adopted elsewhere for international use.

cognitive biases. Errors in thinking that occur as people process and interpret information in the environment around them and often occur as people try to simplify information processing. In everyday life, there are broad rules that people use to make sense of the world and reach decisions with relative speed. As these biases are not appropriate for every situation, they can lead to poor outcomes in certain circumstances.

emergency response organization (ERO). The authority within the Member State that is responsible for mitigating an emergency.

human performance. Comprises the many variables that influence the observable behaviours used to accomplish specific task objectives, or what we know as results. It refers to the manner in which tasks are accomplished to ensure they meet predefined standards. The standards could be in the form of accuracy, efficiency and/or any other measure, as defined by the organization.

internal communication. The process through which information is transferred within the organization — be it among members of the same group and level of the organization, up and down through the organization and/or across groups within the organization.

leadership. The ability of a person to have an influence on the thoughts, attitudes and behaviour of others.

management system. A set of interacting elements for establishing policies and objectives and enabling the objectives to be achieved in an efficient and effective manner. The management system integrates all elements of an organization into one coherent system to enable all the organization's objectives to be achieved. These elements include the organizational structure, resources and processes. The objectives may deal with health, safety, environment, security, safeguards, economy or other quality requirements.

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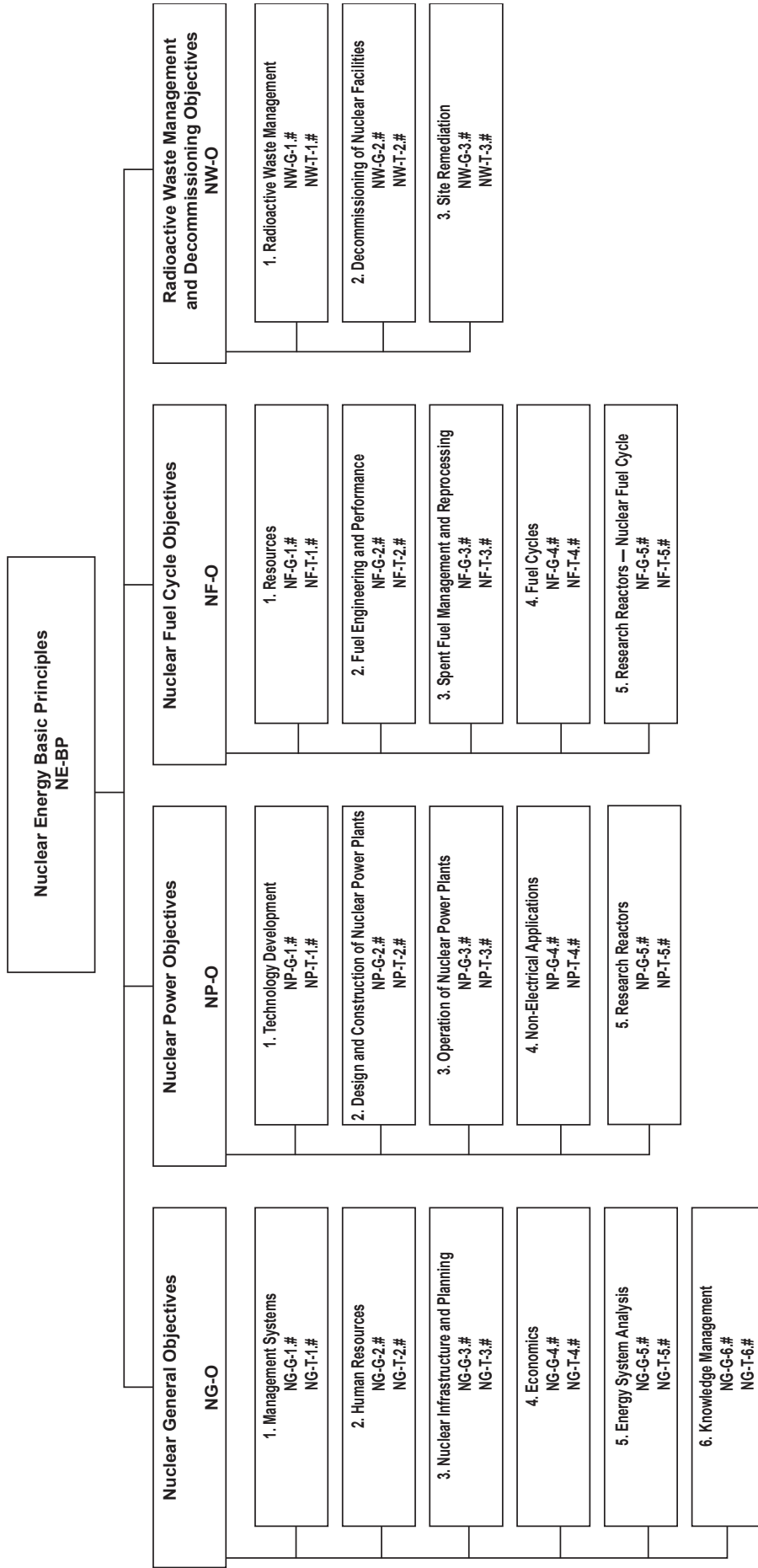
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