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Accident Management under Extreme Events

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ABSTRACT

Most nuclear power plants have extensive sets of Emergency Operating Procedures and Severe Accident Management Guidelines. These offer protection for a large series of events, both inside and outside the licensed design basis of the plant. For Extreme Events, which are characterised by a large destruction on-site and may include loss of command and control, damage to multiple units on-site, loss of communication both on-site and to off-site centres, staff members wounded or killed, such protection may not be enough. Examples of Extreme Events are air plane crash, site flooding, large earthquake plus possible tsunamis, *etc*. This paper describes what additional procedures, guidelines, hardware and organisational issues are needed to protect a site against such events. It is based on lessons learned from large destructive events in the past, such as the 9/11 attacks in the USA in 2001 and the tsunami at the Fukushima-Daiichi plants in 2011.

Keywords: *Extreme Events, Accident Management, Procedures and Guidelines*

1 INTRODUCTION

Nuclear power plants have been designed to withstand a large series of Postulated Initiating Events (PIEs), up to and including Design Basis Accidents (DBAs), plus a number of events outside this range, so-called Beyond Design Basis Accidents (BDBAs), in the new IAEA terminology called Design Extension Conditions (DECs). Examples of BDBAs/DECs are: Anticipated Transient Without Scram (ATWS)[1], station blackout (SBO) and loss of ultimate heat sink (LUHS). The design offers a demonstrated protection if any of the DBAs or selected BDBAs/DECs happen, by the use of various safety and non-safety systems with application of Emergency Operating Procedures (EOPs), and it offers methods to mitigate the consequences if the EOPs are not effective and fuel damage must be expected. These latter methods make use of Severe Accident Management Guidelines (SAMG).

The set of EOPs and SAMG is designed on the basis of scenarios, often with the help of the Probabilistic Safety Analysis (PSA). They are, however, shaped in such a way that it is not necessary for the operator to recognise the underlying scenario. Actions are taken on the basis of observed parameters to bring the plant in a safe stable state or, if this is not possible, to mitigate possible releases, irrespective of the accident scenario.

Typically for SAMG is that the instructions need not be followed verbatim, as the evolution of the accident may be different from anticipated analysis, also due to deviating instrument behaviour, and to give the accident management team the opportunity to respond to events as they occur with the tools they have available, or can be assumed to be restored to service in due time. Newer designs have features that are specifically designed to mitigate core damage scenarios, such as systems to cool a reactor pressure vessel from outside or, alternatively, a core catcher.

The typical lesson from Fukushima is, however, that events can happen that have not been foreseen and are, therefore, outside the events for which the design offers protection through

[1] These are events which would lead to an automatic reactor scram, but where the scram functions fails.

hardware, procedures/guidelines (EOPs, SAMG) or both. Such events may be called ´Extreme Events` (EEs), or ´Site Disruptive Accidents` (SDAs). They may include a large destruction on-site, multiple failures of protective equipment, simultaneous damage to multiple stations on-site, staff members being wounded or killed, loss of normal command and control (i.e., loss of control room and emergency control room / shutdown room, possibly staff being wounded or killed; see further sec. 2.1), loss of communication systems, etc.

External initiators of Extreme Events can be e.g., air plane crashes, large explosions, big fires, earthquakes, flooding, and destruction caused by third parties. Internal initiators can be reactor vessel failure, widespread fire from internal cause, large scale flooding from internal cause. Not extreme but complicated are multiple steam generator failures.

Unfortunately, we must assume that events which are (far) outside the design basis will continue to happen, as unforeseen events will continue to happen and no technology is perfect. Also operational errors have been made and will continue to be made in future. Therefore, efforts should be taken to mitigate such events to the extent practical with appropriate procedures and guidelines and, where needed, with additional equipment. This document gives an overview of such a set, and indicates where improvements should be made to present-day approaches.

2 MAIN ELEMENTS TO MITIGATE EXTREME EVENTS/SITE DISRUPTIVE ACCIDENTS

For Extreme Events/Site Disruptive Accidents it must be assumed that a precise prediction of actual damage states is not possible. Hence, bounding damage states have little value and a flexible response is desirable, including the use of portable equipment. Additional pre-fixed hardware may have limited value, as it can be damaged by the same event that caused damage to existing hardware. As stated, the damage can include loss of command and control, and it is a first priority to restore a commanding structure, [1].

2.1 Restoring Command and Control

One of the potential consequences of an EE/SDA is the loss of command and control. This can happen through loss of the control room and the emergency control/shutdown room, either by physical damage, intrusion by third parties, loss of control room staff, or a combination of these. Physical damage can be caused by e.g., an air plane crash, a large fire and/or explosion, a big earthquake, site flooding, etc. Intrusion by third parties can include violent actions and may result in inability to access parts of the site. Loss of control room staff may be the consequences of such events, but also internal events may cause this, e.g., if main steam lines run close to the control room and rupture[2]. Hence, the very first action must be to restore command and control, so that a functioning Emergency Response Organisation (ERO) can be (re)created and response can be organised in a structured way.

Restoring command and control should be done in an organised way. For example, it may call for surviving staff to assemble at some pre-defined location and restore a command and control structure with the ´best` people who are available, e.g., a senior reactor operator (SRO) as the preliminary leader of the ERO, until a more qualified person is able to take over command, e.g., a person designated and trained for the function of Emergency Director (which could also be an SRO).

If not a sufficient number of such people are available, then an ERO may be established on the site by the help of a neighbouring NPP or another crisis organisation[3]. If the plant-ERO room is not available, the ERO may assemble in an alternate ERO/TSC facility, possibly off-site, as is often provided for an SDA (TSC = Technical Support Centre).

[2] In some plants, steam lines run over the control room but there is no protection of the control room against a steam line rupture.

[3] In some countries, there is a national crisis organisation for such tasks (e.g., in France)

Note that it may happen that the re-established ERO - at least initially - may not contain qualified reactor operators. Hence, the initial actions to stabilise the plant are separate from the ordinary EOPs and SAMG.

2.2 Actions to stabilise the plant by the ERO and subsequent actions

After re-establishing command and control or directly, if command and control have not been lost, the ERO takes a number of actions, which may - or may not - be in the following sequence (priorities may change due to circumstances):

1. to re-establish communication on- and off-site (if it had been lost),
2. to regain control over the site (if it had been lost),
3. to limit site damage (e.g., fire fighting),
4. to take care of wounded people,
5. to check the condition of the key structures, systems and components, i.e., the reactor, the spent fuel pool, the core and spent fuel pool cooling systems, and the containment, and the conditions in areas where local actions must be executed,
6. to initiate actions to stabilise the plant and to fulfil the main safety functions of shutting down, cooling the fuel (core and spent fuel), providing containment and mitigating any releases,
7. to check the necessary support systems (AC power, DC power, water, pneumatic air, diesel fuel), and necessary staff,
8. to continue the initial actions by initiating the appropriate emergency procedures and guidelines, i.e., Abnormal Operating Procedures (AOPs), EOPs, SAMG, Technical Support Guidelines, as well as their long-term support functions, where applicable,
9. to initiate necessary logistics such as food and lodging for personnel, changes of shift, contact of site personnel with their families, and
10. to execute the site Emergency Plan.

These tasks are further detailed as follows:

Ad 1: To re-establish communication on- and off-site.

For the case normal communication on- and off-site is lost, it may be useful to have dedicated battery-powered portable phones on dedicated locations, which can be assumed to remain unaffected by a site disruptive event. These can be used to re-establish the communications on- and off-site and to alert off-site emergency services, as is described in the plant emergency plan. They include police, medical support, fire brigades, etc., Battery power should last long enough that replacement batteries can be supplied.

Ad 2: To regain control over the site (if it had been lost), and Ad 4: To take care of wounded people.

If the accident involves a violent action by third parties, the ERO must make sure that safe access to all vital areas of the plant will be regained. It is assumed that this task is in the hands of the local security personnel. This action is not discussed here in further detail, as it is in the security domain of the plants. In addition, the ERO must take measures to take care of the wounded and arrange that medical assistance is provided for those in need.

Ad 3: To limit site damage (e.g., fire fighting).

The ERO should estimate the damage at the site and initiate measures to limit such damage. Priority may be successively with the auxiliary/fuel building, control building and turbine building. Measures may include containing and extinguishing fires, evacuating personnel in danger, making sure sufficient water is available. If the threat is from flooding or fire, personnel should be protected, and damage to power sources should be limited / mitigated. Hazardous material should be secured in agreement with applicable plant procedures. Note: if there is a conflict between nuclear safety (core/ spent fuel cooling) and fighting a fire in the turbine building, then nuclear safety has the priority.

Ad 5: To check the condition of the key structures, systems and components, i.e., the reactor, the spent fuel pool, core and pool cooling systems, and the containment and

Ad 6: To initiate actions to stabilise the plant and to fulfil the main safety functions of shutting down, cooling the fuel (core and spent fuel), providing containment and mitigating any releases.

The ERO should initiate actions to stabilise the plant. These are shutdown of the reactor and starting decay heat removal functions. Actions may be done locally/manually, according to pre-established procedures. For example, for a PWR this includes starting the Turbine Driven Auxiliary FeedWater pump (TDAFW) locally and manually, for a BWR starting the Reactor Core Isolation Coolant system (RCIC) locally and manually. This may include the need for emergency lightning, dosimeters, protective clothing, ladders, and other equipment. In addition, a number of other actions are needed, as will be described in the next section.

In a number of these guidelines support by portable equipment may be needed. This equipment should be stored on a safe part of the site (i.e., where it can be assumed that it is not made inoperable by the event).

As it is not a priori clear that sufficient licensed operators are available to execute these actions, other staff members and, possibly, staff from off-site organisations (e.g., fire brigade staff, who have been trained in the procedures) are authorised to execute the actions. The procedures and guidelines need therefore be written in a style and format which makes the actions executable by such personnel. Note: the use of portable equipment includes transporting it to the plant and hooking it on to the connection points. These actions may require quite some additional staff, which should be considered in the ERO.

The ERO should monitor and mitigate releases and make sure working areas are habitable. Where needed, doses should be estimated. If needed, sprays can be used to scrub fission products. The ERO should make sure spent fuel is and remains submerged or, if submergence is impossible, to keep it under spray cooling.

The actions mentioned here and under Ad 7 are often called ´Extensive Damage Mitigation Guidelines (EDMG)`, which are further described in sec. 2.3.

Ad 7: To check the necessary support systems (AC power, DC power, water, pneumatic air, diesel fuel), and necessary staff.

The ERO should establish the needed resources for the various actions. This may include AC power, DC power, air (pneumatic devices), and fuel for diesels. Load shedding may be one strategy to extend battery life. Diesels may be started manually and, if no cooling is available, run with intervals. One should fill necessary water tanks e.g., by the fire extinguishing system. Apart from the hardware provisions, the ERO should assure that sufficient staff is available during all these actions and, if necessary, for prolonged time, i.e., until off-site support is available or on-site resources have been restored. Note: these actions presumably go together with Ad 6, and may even be of higher priority.

Ad 8: To continue the initial actions by initiating the appropriate emergency procedures and guidelines, i.e., AOPs, EOPs, SAMG, Technical Support Guidelines, as well as their long-term support functions, where applicable.

Once the initial actions to stabilise the plant have been completed – which may have been executed by non-licensed personnel – the normal set of procedures, i.e., AOPs, EOPs, SAMG – should be executed by licensed personnel, with the help of the Technical Support Centre. This depends on the fact whether the initial conditions for these procedures / guidelines have been reached, as may be determined from their logic diagrams. Note that these initial conditions may be different from the initial actions to stabilise the plant, as described under Ad 5.

A number of these procedures / guidelines may call for portable equipment. This should be available and its transport, connection to the plant and its operation should be covered in the procedures / guidelines. This is further described in sec. 2.4.

Ad 9: To initiate necessary logistics such as food and lodging for personnel, changes of shift, contact of site personnel with their families.

As a site disruptive accident is a long-term event and may include major damage also off-site (e.g., caused by a major earthquake), it is necessary to take actions for long term accommodation of needed staff on-site. In addition, these people should have the possibility to communicate with their families, as there may be severe consequences also for their relatives. Staff not needed for the accident mitigation should be sent away, so as to minimise the burden on the ERO and on these people themselves.

Ad 10: To Execute the Site Emergency Plan.

The ERO should initiate the site Emergency Plan, which includes radiological assessments. Actions may include evacuation of relevant rooms, including the main control room and the TSC room, and then should make alternate places available from where the plant staff can execute its duties. The Emergency Plan includes also initial protective actions for people off-site, such as sheltering, distribution of iodine pills or evacuation, until the off-site emergency organisation can take over. If releases are high, this action may have a high priority.

The entire tasks to be performed are displayed in Figure 1.

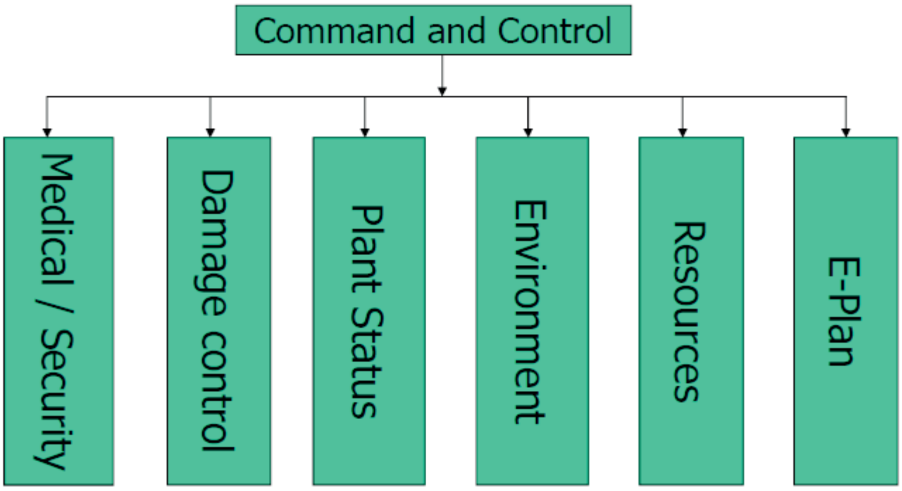

Figure 1: Overview of Tasks in a Site Disruptive Accident (derived from [2])

2.3 Extensive Damage Mitigation Guidelines (EDMG)

The actions mentioned under items 6 and 7 of sec. 2.2 include mainly manual/local actions using, where needed, mobile/portable equipment. They intend to preserve major safety functions and do so by the associated mitigation strategies, see Table 1 (largely derived from [1]).

Whatever system is available to provide cooling water is used. This will also be the fire water system, if still available, or use of a portable pump, stored elsewhere on the site.

Water may come from any source, including the sea. [1] describes various portable/mobile hardware to fulfil these functions. It is usually stored away from the plant, so that there is ample chance it will survive the damaging event. Sec. 2.4 describes such hardware in more detail.

The EDMG which fulfil these functions are typically 10 – 30 guidelines for a plant. In the US, all guidelines are plant specific, as there are no generic guidelines, such as for EOPs and SAMG.

Table 1 Basic Functions and Mitigation Strategies in a Site Disruptive Accident (largely from [1])

Safety Functions:

BWR Safety Functions	PWR Safety Functions
Reactor Pressure Vessel level control	Reactor Coolant System (RCS) inventory control
Reactor Coolant System (RCS) heat removal	RCS heat removal
Containment isolation	Containment isolation
Containment integrity	Containment integrity

Release mitigation	Release mitigation
Spent Fuel Pool (SFP)	Spent Fuel Pool (SFP)

Mitigation Strategies:

BWR Mitigation Strategies	PWR Mitigation Strategies
Manual operation of Reactor Core Isolation Coolant (RCIC) system or Isolation Condenser (IC)	Makeup to Reactor Water Storage Tank (RWST)
DC power supplies to allow depressurisation of RPV & injection with portable pump	Manually depressurize Steam Generators (SGs) to reduce inventory loss
Utilise feed water and condensate	Manual operation of turbine (or diesel-) driven Auxiliary Feed water (AFW) pump
Make up to hot well	Manually depressurise SGs and use portable pump to feed
Make up to Condensate Storage Tank (CST)	Make up to CST or alternate feed source
Procedure to isolate the Reactor Water Clean-Up (RWCU)	
Manually open containment vent lines	
Inject water into the drywell	
Portable sprays	Portable sprays
Internal make-up of SFP	Internal make-up of SFP
External make-up and spray of SFP	External make-up of SFP

2.4 Portable/Mobile Equipment and its use to strengthen Accident Management

Many countries now have decided to have portable equipment available for added capability. As an example in the US, this is called FLEX, which stands for ´flexible and diverse response`. Canada uses a similar term: Emergency Management Equipment (EME). The US industry has set up an approach, documented in NEI 12-06 [3]. It basically consists of three steps:

- Make sure best use is made of existing in-plant equipment, where needed strengthened.
- Have portable equipment on-site, plus ways to transport and connect it to the plant.
- Have portable equipment available off-site, plus a transport means - usually by air - to the stricken site and ways to connect it to the plant; this includes off-site organisational matters.

Other countries have similar or equivalent approaches. But in some countries preference is given to installed and specially protected - often bunkered - hardware such as a diesel generator and/or deep well pumps, despite the risk that this hardware may also be damaged by the event. Portable equipment is then available temporarily, until the new equipment has been installed. In principle, such equipment is available in redundancy and stored separately, so that a single event cannot knock out both stocks of equipment.

The approach assumes that command and control is normally available or has been restored and licensed staff is available to execute emergency procedures / guidelines. Therefore, this portable equipment is meant to add on EOPs with a focus on mitigating Extended Loss of AC Power (ELAP) and Loss of Ultimate Heat Sink (LUHS). Its main function is, hence, preventive, and for selected accidents (ELAP and LUHS). But the portable equipment may also be used for SAMG. Note that it (usually) is not designed to support SAMG. It can of course also contribute to the EDMG.

Figure 2 is an example (from ´FLEX`, [3]) of an overview of the total assembly of procedures and guidelines for plant control. They correspond to the columns ´Plant Status` and ´Resources` in Figure 1. Note: ´broken lines` means that a formal connection between the associated blocks has not yet been established.

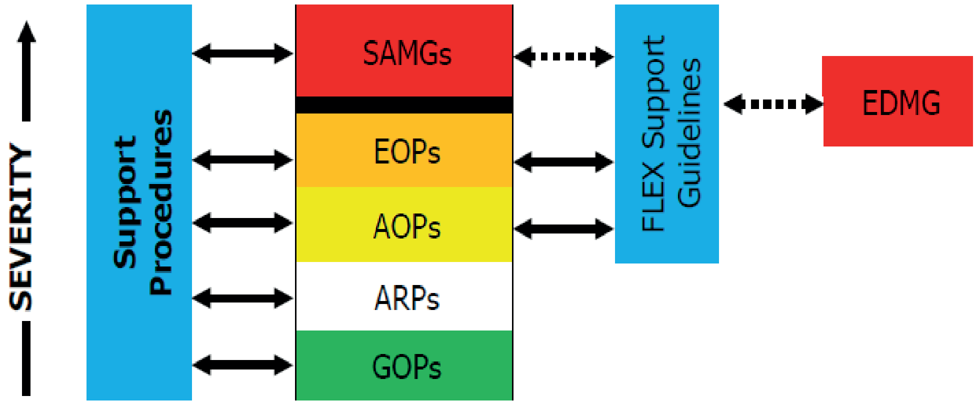

Figure 2: Role and Place of FLEX and EDMG in Assembly of Procedures / Guidelines (from [3]) - GOPs are General Operating Procedures, ARPs are Alarm Response Procedures

Use of portable/ bunkered equipment needs additional procedures/guidelines, such as in the USA the FLEX Support Guidelines (FSG). FLEX equipment or its equivalent usually includes mobile diesel generators, portable pumps, hoses, portable batteries, portable lightning, compressed air bottles, back-up water sources, organised access to alternate water sources (e.g., fire trucks), etc. The equipment should be stored in a place sufficiently protected against external events. Factors to be considered are the following:[4]

- Use of installed equipment as long as is possible, such as the presence of a load shedding program, which sheds loads from all non-essential users.
- Needed portable lighting and communications systems necessary for ingress and egress to plant areas required for deployment of portable equipment.
- Access to areas where local actions must be performed, also under the extended loss of AC, considering also areas locked in absence of AC.
- Effect of loss of ventilation on safety relevant equipment and on access to relevant rooms.
- Operation of containment isolation valves also under the absence of AC/DC.
- Powering igniters for mitigating hydrogen combustion risks.
- Powering relevant instrumentation by portable batteries.
- A sufficient quantity of portable equipment to serve all units on a site simultaneously.
- Possibility to power up local consumers if the plant internal power distribution (LIPD) does not function (requires sufficient number and length of cables and appropriate cable connections).

Portable equipment should be designed appropriately, taking note of needed pump head, head loss in long lines (hoses), back pressure of pressurised volumes (e.g., steam generator), prevention of clogging of inlet lines by debris, ice (winter), etc., taking into account the effect of the external event on the alternate water sources.

The procedures /guidelines to hook on portable equipment should include consideration of difficulty and time involved in its transport to the connection points.

It should be noted that portable equipment may also be needed if the event occurs during an outage. Hence, access routes to transport such equipment and places to hook it on should remain available in an outage. Special attention should be paid to equipment of contractors - of which there are usually many during an outage, plus their equipment - that it does not block routes needed to transport emergency equipment.

Another way to give the structure of plant procedures and guidelines is presented in Figure 3 (derived from [2]).

[4] Largely taken from NEI 12-06, [3]

2.5 Off-site Support

Support from off-site resources requires an appropriate off-site organisation to meet all requirements from the stricken site. This includes provision of equipment and its spare parts and maintenance, consumables, replacement staff, communication means, transport means (trucks, helicopters), personal provisions (food, lodging, medical needs). It should be noted that it will take time before the off-site support is fully available and functional, possibly a whole day. Provisions on-site should be such that this anticipated time lap is appropriately covered:

- The stored equipment must meet appropriate specifications (not necessarily nuclear safety qualifications), have maintenance and regular tests and inspections. Where equipment is out of service for longer times, alternative equipment should be available.
- Transport to the site should not depend on a single transport means or way.
- Plant modifications should be followed and lead to adaptation of equipment or its means of connection to the plant, where needed.
- The off-site organisation should be regularly tested to maintain a high level of alertness and capability to support the stricken plant or site.
- If a multi-unit site is served, it should contain sufficient means to support all units on the site at the same time.

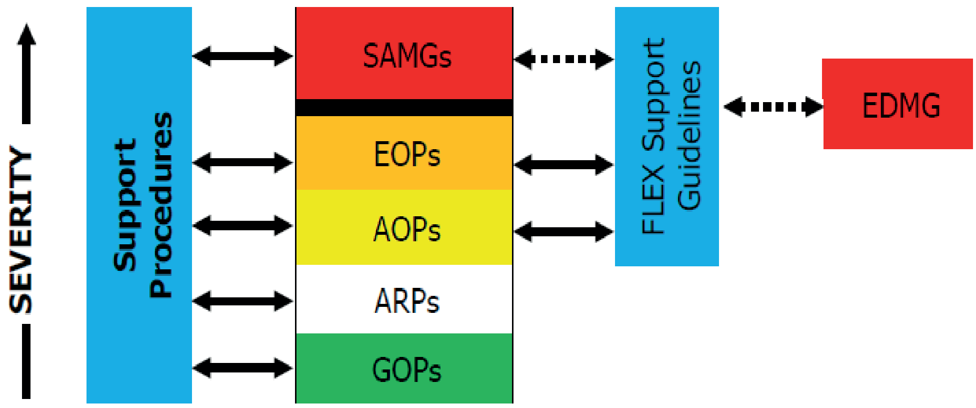

Figure 3: Assembly of Plant Procedures and Guidelines to mitigate Large Scale Events and Accidents; (double arrow: increasing severity; single arrow: information and authority flow).

Teams are available in the US Regional Response Centres to execute these actions. In France there is a Nuclear Rapid Action Force ´FARN` for this purpose.

3 HUMAN ASPECTS OF ACCIDENT MANAGEMENT[5]

Decision making or the preparation of decision making in the Technical Support Centre can be a group decision making process. Groups may act differently from individuals. Group decision making has advantages in that a group may collectively have more knowledge than an individual. As there is deliberation and argumentation, including pros and cons of possible decisions, the final result may be more balanced and better founded. The probability of errors may be smaller as is the chance to overlook important information.

The downside is that group decision making generally, will take more time, and probably is more cautious, due to the long deliberation process. However, groups can also take more risky decisions, because the weight of the decision making is diluted. Due to this dilution, individuals may

[5] This section is drawn from [4]

act differently if placed as an individual for making a decision than as member of a group. The individual contributions may also have different weight, as some people tend to place themselves in the foreground, being ´informal leaders`, whereas others may tend to be more ´followers`. This may also result in a decision process where some are ´winners´ (their arguments have prevailed) and others are ´losers` (their arguments did not prevail).

Consequently, groups can either be more cautious, i.e., trying to avoid risks in decision making, or more courageous, i.e., prepared to take risks in decision making. An example is the need to depressurise the primary system in one of the severe accident guidelines, to avoid high pressure melt ejection. However, the TSC may observe that there is a chance that a lost diesel will be back on line in some hours and so injection into the RCS may be restored, which will prevent vessel failure and all its consequences. Here a cautious TSC will depressurise (the default case), and a courageous TSC will not. The outcome, of course, is only known after the accident evolution is complete.

Unfortunately, there appears to be not much research with respect to the human aspects of decision making in a severe reactor accident, neither application of the extensive work on decision making processes in other disciplines[6]. A recent study in this respect is documented in [6]. Human engineering aspects of nuclear safety are further considered in [7].

4 NEW DEVELOPMENTS IN ACCIDENT MANAGEMENT

Another and important aspect is that the accident management described is of the so-called routine type: ´Routine Accident Management`, i.e., the accident evolves more or less according to scenarios previously analysed. This still can be a large accident, with much damage and the need for large-scale support. But as tasks are well defined and procedures are valid and applicable, accident management can be expected to be effective. An example is a large traffic accident, with big damage and many victims, but the public services (police, fire brigade, medical teams) are trained for such accidents and will know what to do.

However, it can also happen than the accident does not evolve along pre-analysed scenarios or does not result in pre-analysed plant damage conditions, and then many of the procedures and guidelines developed for those scenarios and/or conditions are not effective. In that case, improvisation is needed, with deviations from pre-designed countermeasures. Such accident management is described as `Emergency Accident Management`. It requires a different type of organisation and its success depends also on strong leadership with the decision maker(s). For example, evaluation and decision making are more of cognitive nature than of rule-based nature and, hence, require more knowledge and training. More information is in [5]. It has been argued that the success at Fukushima-Daini was, at least in part, due to this other type of accident management.

Training should, therefore, include this type of training to the extent practical. Good training on ´Routine Accident Management` remains, of course, a basic need.

5 CONCLUSIONS

A Site Disruptive Accident / Extreme Event calls for a large series of actions, which are the subject of an extensive set of procedures and guidelines, and which may require in many cases mobile / portable equipment, stored both on-site and off-site. Still actions may be required beyond the documented set of procedures and guidelines, and these then may require from the ERO an innovative approach. This can only be achieved by a highly skilful ERO which has gone through much in-depth training.

A prime action is to restore command and control, should these have been lost. Then actions must be initiated to stabilise the plant, which include shutting down and removing decay heat as well

[6] See for example http://en.wikipedia.org/wiki/Decision-making

as providing containment. As the event likely has damaged the on-site and off-site power systems, many actions are planned to be locally and manually, where needed with portable batteries, emergency lightning, protective clothing, etc. Apart from the initial actions to stabilise the plant, measures must be taken to provide for needed resources such as cooling water, mobile pumps, mobile power sources, diesel fuel, etc.

The associated assembly of procedures and guidelines are often called ´Extensive Damage Mitigation Guidelines, (EDMG)`. They were first introduced in the US to offer protection against terrorist attacks on nuclear power plants, in the wake of the 9/11 events. In other countries, the approach for site disruptive accidents - if available at all - is not so well documented in the public domain, which prevents proper discussion in a public document as this one is. Together with the execution of the EDMG (or equivalent), the Emergency Response Organisation must take measures to regain control over the site (if lost), limit site damage (fire fighting, etc.), take care of wounded people, provide provisions for lodging and food for plant staff, provide communication for family of staff and initiate the Emergency Plan.

As widespread site damage must be assumed, as well as damage off-site may have occurred, a systematic use of portable /mobile equipment is essential to mitigate the consequences. Counter measures will first try to make best use of surviving plant equipment, but are augmented by equipment stored on-site and off-site. Notably the long term provisions must be provided from off-site sources. The off-site organisation must be well established, its equipment well maintained and regularly inspected and tested. Examples of such methods are the FLEX approach in the US, the use of EME in Canada and the use of the Rapid Response Force (´FARN`) in France.

The total set of procedures and guidelines plus needed equipment and organisational provisions should be regularly inspected and tested.

6 ABBREVIATIONS

AC	Alternate Current (power)
AOP	Abnormal Operating Procedure(s)
ARP	Alarm Response Procedure(s)
ATWS	Anticipated Transient Without Scram
BDBA	Beyond Design Basis Accident
CST	Condensate Storage Tank
DBA	Design Basis Accident
DC	Direct Current (power; usually meaning batteries)
DEC	Design Extension Condition
EDMG	Extensive Damage Mitigation Guideline(s)
EE	Extreme Events
ELAP	Extended Loss of AC Power
EOP	Emergency Operating Procedure
ERO	Emergency Response Organization
FLEX	Flexible and diverse response (includes use of portable equipment)
FSG	FLEX Support Guideline(s)
LUHS	Loss of Ultimate Heat Sink
SAMG	Severe Accident Management Guidance / Guideline(s)
SBO	Station Black Out
SDA	Site Disruptive Accident
SRO	Senior Reactor Operator
TSC	Technical Support Centre

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