OSART Good Practices
ACCIDENT MANAGEMENT
Plant emergency arrangements with respect to SAM

Temelin, Czech

Mission Date; 5-22 Nov., 2012

Expert system for the evaluation of source term based on accident type and status of barriers against fission product releases (ESPRO).

Radiological consequences caused by fission products releases during severe accidents are calculated using RTARC code and depends on existing source term. Selection of proper source term is an essential condition for timely selection of protective measures based on existing radiological consequences. Existing accident conditions (e.g. rapid and sudden conditions changes, unpredictable evolution) could aggravate evaluation of source term. Old method for evaluation of source term is based on TSC personnel judgment. Expert system ESPRO facilitates evaluation of source term based on existing emergency conditions evolution.

For various severe accidents scenarios types source terms are pre-calculated using MELCOR code. Expert system ESPRO is a tool for on-line selection of proper source term based on actual evolution of accident.

Source term evaluation is based on calculation of dominated effects on release path significantly affecting source term magnitude. Such an approach does not require detail knowledge about fission products release paths and certain source term could be common for various emergency sequences. The decision making process is based on knowledge of crucial systems and barriers status significantly affecting a release paths. This method is based on the following assumptions:

- Limited number of severe accidents conditions significantly affecting severe accident progression;
- Several parameters characteristic for severe accident conditions are identified and documented;
- Variable values of parameters are available on-line during severe accident progression.

Source term evaluation algorithms corresponds to symptom oriented EOPs structure and the evaluation of source term is performed automatically based on on-line data provided by unit information system. If on-line data from unit information system are not available the source term evaluation could be performed manually.

Clinton, USA

Mission Date; 11-28 Aug., 2014

The approach taken to severe accident damage mitigation is based on the uniform response of the Clinton Power Station and the whole Exelon fleet of nuclear power plants.

CPS in coordination with other nuclear power plants in the Exelon fleet decided to harmonize the approaches used and to acquire standard (primary and backup) equipment for each plant of the fleet for mitigation of severe accident damage. Each site having unified mitigating equipment, some of which is portable including unified connections points of cables and hoses, will allow transferring and utilizing the equipment at another site if needed. The approach taken would also facilitate sharing experiences and resources in training and maintenance.

In addition, the Clinton Power station is involved in the establishment of regional response centres equipped with additional equipment available for all NPPs in the country, thus providing a cost effective means for NPP responses to emergencies. The National SAFER Response Center is in an advanced stage of implementation.

Due to compatibility of the means which allows sharing them with other nuclear power plants in the Exelon fleet and with the regional centre, the CPS will be better positioned to effectively deal with severe accidents by more powerful means and for a prolonged period of time. In this way also public trust and confidence is further strengthened.

Flamanville, France

Mission Date; 6-23 Oct., 2014

Nuclear rapid response task force (FARN). Availability to support FLAMANVILLE

The nuclear rapid response team (FARN), set up following the Fukushima accident, is tasked with responding within 24 hours at a nuclear power plant affected by a severe accident in order to limit further deterioration of the situation, prevent large off-site radioactive releases and prevent core melt if possible.

FARN is able to provide support in terms of personnel and equipment resources to a plant affected by a severe accident. The taskforce is set up to allow it to respond to accidents involving several reactors on a single site (currently 2 units, to be extended to 4 units from the beginning of 2015 and 6 units from beginning 2016), regardless of site access conditions. Flamanville can currently be supported by FARN, and modifications (scheduled for completion by the end of 2014) are in progress to install connection points for FARN mobile equipment.

FARN is composed of approximately 300 EdF personnel that are able to transport and deploy major specific resources to a site affected by an accident. FARN is set up at 4 regional bases located at Civaux, Dampierre, Paluel and Bugey power stations, with the headquarters located in the Paris region. Every regional base has 5 teams of 14 persons each, all on call for immediate action within 1 hour. The first FARN team arrives on the site affected by the accident in less than 12 hours and is fully operational within 24 hours.

The FARN members are all nuclear workers who split their time throughout the year between their original specialisation at their NPP and activities specific to FARN. During the periods of FARN duty, the team members dedicate most of their time to training, drills and maintenance of the FARN equipment. In the event of response operations, FARN has essential skills (operational, maintenance and logistics) to assist or take over from the site teams.

The team members deployed for response to an NPP affected by an accident under FARN command have to carry out the following priority actions as dictated by the crisis manager (PCD1) at the affected site:

– provide and connect the emergency response equipment (pumps, emergency diesel generators, fuel tanks and air supply)
– carry out appropriate monitoring of operation of the emergency response equipment and ensure related logistics to guarantee operation, especially fuel supply
– participate in assessment of availability and condition of site equipment
– participate in maintenance of site equipment, to guarantee (or restore) its operability
– support the shift team and ensure targeted handover (assessment of the situation, ongoing and forthcoming actions and status of the safety functions)
– participate in priority operating actions (in support of or to take over from the shift crew), required by the situation and especially unit safety status
– operate vital safety systems (especially the steam dump to atmosphere (GCTa), auxiliary feedwater system (ASG) and station blackout diesel generator (LLS))
– carry out plant alignments
– carry out plant monitoring and checking rounds
– deploy the backup means of emergency response communication.

Flamanville, France

Mission Date; 6-23 Oct., 2014

The keys for mobile emergency response equipment are stored in a key box next to the equipment.

The plant currently has 2 mobile emergency diesel generators, 2 pneumatic mobile pumps and 1 mobile air compressor stored in a seismically qualified location on Unit 2. The keys for the mobile emergency diesel generators are stored in a sealed key box next the area where the equipment is stored. Additional sets of keys are available in the emergency control centre bunker and with the maintenance group.

This measure contributes to the operability of the mobile emergency response equipment in severe accident conditions. For example, in case of an earthquake the keys will remain available given the resistance of the storage facility to earthquakes. This measure will also save time by allowing emergency response teams to go directly to the equipment storage area.

Dampierre, France

Mission Date; 31 Aug.-17 Sep., 2015

Protection against extreme winds and associated missiles.

During the third ten-yearly outages from 2011 to 2014, the plant installed metal nets to protect nuclear safety equipment from extreme winds and associated missiles. The Emergency Diesel Generator radiators have additional concrete protection from falling objects.

Benefits:

– Reduced vulnerability of important nuclear safety equipment, such as the emergency diesel generator and ultimate heat sink, from extreme winds and associated missiles,
– Reduced risk of a severe accident by reducing the probability of loss of all AC Power and the ultimate heat sink.

Dampierre, France

Mission Date; 31 Aug.-17 Sep., 2015

Demarcation of signal zones for Irridium satellite telephones.

The plant introduced systematic demarcation of zones where an Irridium satellite telephone signal is available. These areas are specifically located where signal interference from the cooling towers and buildings is minimised and has been tested by telecommunication experts. These areas are clearly sign posted so that response teams do not lose time searching for them during an extreme event.

Benefits:

– Reduced risk of a severe accident since this communication facilitates coordination of accident mitigation activities and
– Less exposure to radiation in the event of airborne contamination or ionizing radiation by minimising the exposure period.

Bruce B, Canada

Mission Date; 30 Nov.-17 Dec., 2015

Emergency Mitigating Equipment (EME) Strategy for Rapid Response

In the event of a station blackout (SBO), enhancements and new installations have been made which would allow Bruce Power to remove decay heat by providing rapidly emergency make-up water to the secondary side of the steam generators and to the primary heat transport systems and secondary fuel bays as well as to provide power to critical instrumentation and components. Bruce Power was the first utility in Canada to put in place this capability.

Emergency Mitigating Equipment (EME) in the form of independent mobile pumps and hoses, as well as portable diesel generators and cables are stored approximately 2 km from the plant. The storage location would not likely be impacted by an external event which impacts on the plant.

The EME provides multiple barriers to prevent or mitigate a severe accident. Hook-up connection are also provided for injection into heat transport system, calandria, vessel and shield tank, aiming eventually at ensuring in-vessel retention, and thus preventing core-concrete interaction. These arrangements allow the EME to be installed on site within 1 hour after the request for deployment.

Following an SBO, mobile pumps and hoses are deployed to the dry hydrants, which have been installed at the plant cooling water exit. The dry hydrants significantly reduce the complexity and physical effort necessary to connect to the supply. In addition to the mobile equipment, permanent connection points have been installed to allow for connection of mobile pumps and portable power generators.

Three custom built fire trucks have the pump capacity of 650 m3/h. This satisfies the flow requirements for cooling the four reactors and fuel bays. Fire trucks were chosen because the Emergency Response personnel (fire brigade) already use fire trucks and so they are familiar with the operation, maintenance and testing requirements. In fact the new fire trucks are operated on rotation as part of the fleet of fire trucks.




Portable generators have been commissioned for the plant to power critical monitoring instrumentation, the Emergency Filtered Discharge System, and Emergency Coolant Injection System motorised isolation valves during a SBO. The circuit breaker connection points for connecting the portable power generators has been installed and commissioned. There is an additional 400 kW generator to provide emergency power to the Emergency Management Centre. Fuel supply for 72 hours is available onsite.

A procedure has been prepared which defines the process and frequencies, by which EME is periodically inspected, inventoried, operationally checked, and are tested. The duties are taken care by the Bruce Power fire brigade, which works on the 24/7 basis. This arrangement ensures that the required EME are always available and operationally ready.

EME Guides and Standard Operating Guides have been prepared and issued and the required training completed to enable deployment, connection and operation of EME when required. The added benefit of using the fire brigade to transport and connect EME is that burden on operations is greatly reduced so they can focus on managing the plant during emergencies. The only tasks required by operations are to open the valves and to close circuit breakers.

A large-scale exercise was utilized to demonstrate operation of the EME for an extended period of 24 hours, when Bruce Power conducted a five-day large area emergency response exercise called the 'Huron Challenge' in 2012, in cooperation with the Office of the Fire Marshall Emergency Management Ontario, The overall objective of the Huron Challenge was to demonstrate and improve emergency preparedness. The exercise included 22 municipalities and regions, in addition to 27 organizations. The basis for the exercise was a large tornado, which caused a total loss of offsite power (major damage to switchyards) and a total loss of backup power. Bruce Power used the Huron Challenge to validate that it had the capability to manage multiple incidents on-site without outside support for 72 hours.

Cernavoda, Romania

Mission Date; 7-24 Nov., 2016

Software application to estimate personnel dose during the implementation of field response actions.

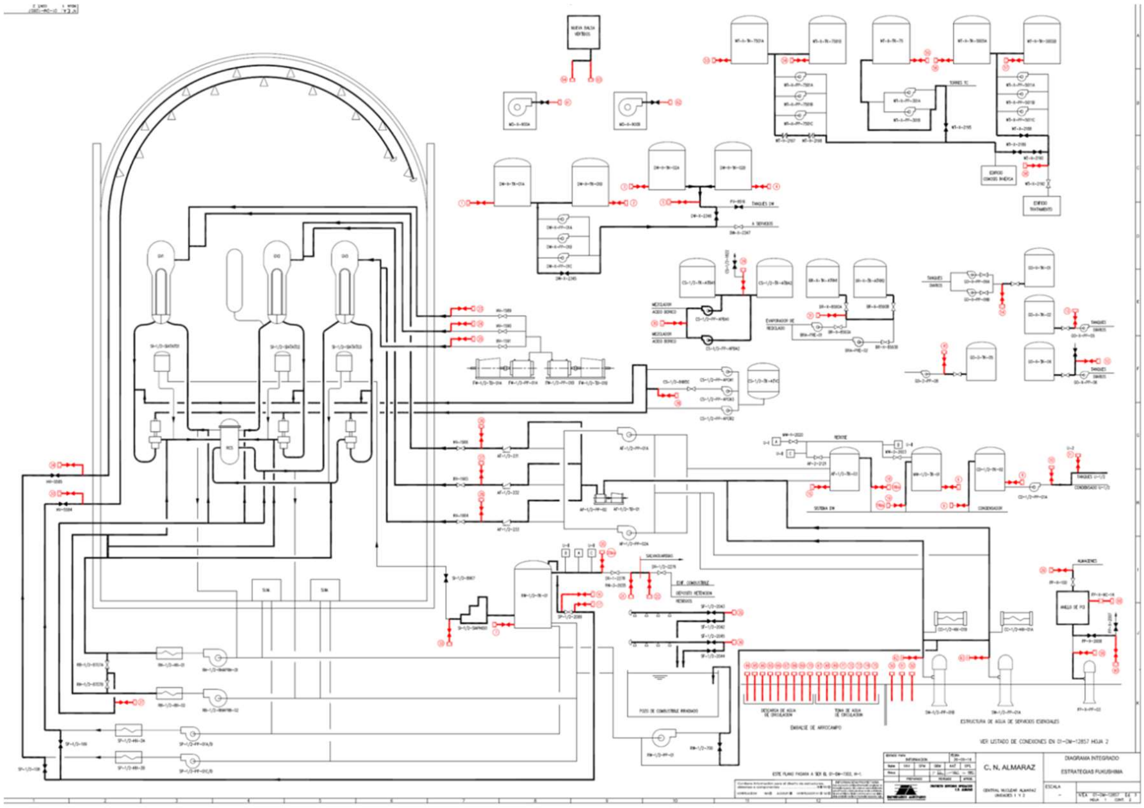
A software application was developed by the plant to estimate the dose that personnel would receive during a severe accident when implementing the Enabling Instructions. The software uses projected radiation fields from a habitability analysis that was performed for Units 1 and 2, and takes into account the anticipated timeline of accident progression. This software application is available to the Emergency Health Physicist in the Emergency Control Centre and can be used if direct dose rate indications on the plant are not available. All Emergency Health Physicists are trained (theoretical and practical training) to use this software application, and the use of the software is tested during routine monthly verifications of the Emergency Control Centre.

Almaraz 2, Spain

Mission Date; 5-22 Feb., 2018

Large number of clearly labelled options for mobile pump deployment.

The plant has installed many clearly labelled suction options (e.g., 11 from the ultimate heat sink & 7 from tanks) for the use of mobile pumps to make-up to the Primary Circuit, Spent Fuel Pool and Steam Generators.



Overview of connections

RCS makeup connection

Pump deployment

Tank connection

Lake connections

Benefits:

- The numerous suction options assist in ensuring successful deployment of the mobile pumps.

- Less exposure to radiation by minimizing the exposure time due to clear labelling.

Belarusian, Belarus

Mission Date; 5-22 Aug., 2019

Beyond Design Basis Accident (BDBA) management panel at MCR

The BDBA management panel is set up next to the operation control panel at the Main control room. It is designed for the dedicated use on control and monitoring key parameters (core temperature, pressure and reactor water level, pressure and radiation level in the containment vessel, cooling status of the passive heat removal systems and the core catcher, etc.) under post-accident states.

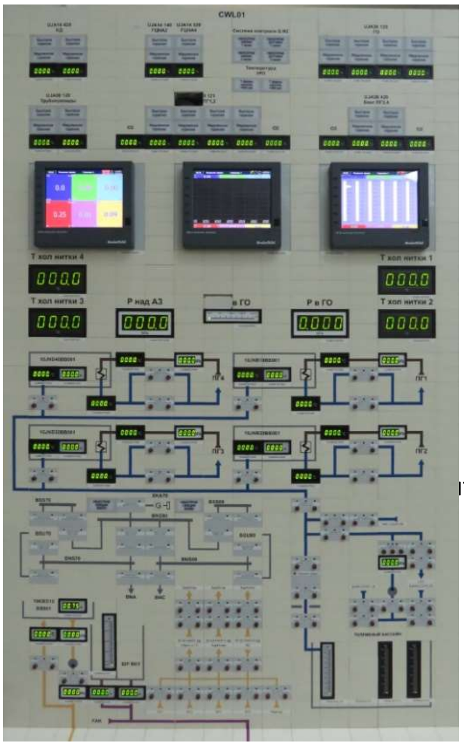
The BDBA panel includes following:

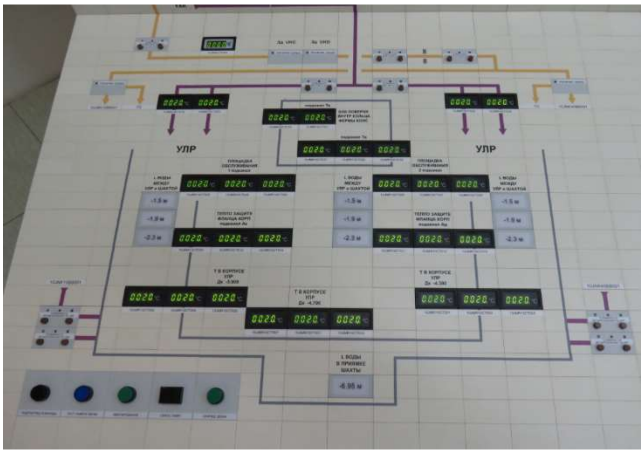
- Plant control trains
- Digital information trains
- Analogue information trains
- Sound alarm trains

Instrumentation and controls required for accident management, including the post-Fukushima measures (Mobile-D /G, Alternative feed water pump), are provided with all in one panel, which is also available under the condition of the complete loss of auxiliary power supply.

The information on the panel will be shared with the Accident management group established at the protected emergency response control points of the nuclear power plant (PERCP).

The panel enhances timely and consistent monitoring of the operations under accident status and improves the flow of information between the technical support centre and the control room.





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<Overveiw of the BDBA management panel>

Paluel, France

Mission Date; 20 Sep. - 7 Oct., 2021

Use of lessons learned from OE on availability of mobile compressors for supplementing safety related needs (pneumatic actuators, regulation, etc) in extreme external hazard scenarios.

To take into account lessons learned from the earthquake and tsunami devastation at Fukushima Daiichi nuclear power plant, the robustness of the plant has been increased by making mobile equipment available in a timely manner in case of station blackout, loss of ultimate heat sink or more generally when the existing plant safety systems are jeopardized by an unexpected scenario.

This mobile equipment is stored at a safe distance from the plant, and can be transported on site in a short time, by road, flat bottom boat or helicopter. The plant is going beyond the provision of mobile water supply and emergency generators which is rather widespread worldwide, by additionally having mobile air compressors available.

The goal of these mobile compressors is to re-pressurize the safety-related compressed air system at the plant in case of accident. This system enables actuation of key pneumatic valves, and will avoid having to actuate them manually in a radioactive environment (which could lead to a significant dose to workers). It would allow the use of the compressed air system even if electrical power cannot be timely restored.

Standard cables of a comfortable length are available with the compressors and would allow the quick connection points installed on site to be reached. Frequent exercises have been conducted both at the plant and in a dismantled facility used as a training centre, to test deployment, connection and operation.

The equipment weights 770 kg, and is about 2 x 1.1 x 1.8 m wide. It delivers a pressure of 7 bar with an air flow capacity of 48 m3/h and can operate at full power with an autonomous fuel tank for 10 hours, after which it would be refilled from a larger tank.

Belleville, France

Mission Date; 15 Nov. - 2 Dec., 2021

Identification of essential equipment with fluorescent tags

On the loss of all AC and DC power, lighting is very limited which impedes local actions to re-establish core cooling, such as manually supplying Auxiliary Feedwater to the Steam Generators and manually controlling steam dump to atmosphere. On critical components necessary to re-establish core cooling in this difficult situation, the plant has installed fluorescent tags to aid the field operators quickly identify the correct equipment. This improves the reliability of these local actions and aids the prompt recovery of core cooling.

Benefits:

- Time saved by identifying equipment more readily,
- Reduced stress when applying emergency documents, and
- Reduced exposure to ionizing radiation.

Fluorescent tag

Fluorescent tag on steam dump valve

Belleville, France

Mission Date; 15 Nov. - 2 Dec., 2021

The plant has installed a backup system that, in the event of a loss of all AC and DC power, can be used to depressurize the primary circuit to avoid the vessel failing at high pressures. This is critical to preserving the last fission product barrier (Containment). If the primary circuit vessel fails at high pressure then High Pressure Melt Ejection (HPME) occurs leading to Direct Containment Heating (DCH) with the potential of a simultaneous hydrogen burn. The resultant pressure spike can challenge the final fission product barrier.

The backup system consists of a light battery pack stored by the Main Control Room (MCR) which connects into an installed electrical cabinet. Sufficient charge is available to open and maintain open all of the primary circuit pressurizer relief valves. The system is easy to use which is essential in the challenging conditions experienced by loss of all AC and DC power.

Benefits:

- An easy and effective means of depressurizing the primary circuit on loss of all AC and DC power,
- Ensuring the injection of water from accumulators attached to the primary circuit, delaying the progression of the accident, and
- The preservation of the final fission product barrier (Containment) on loss of all AC and DC power.

Portable Battery Pack

Installed Electrical Cabinet for opening of the pressurizer relief valves.

Saeul (Shin-Kori 3&4), Korea, Rep. of

Mission Date; 31 Oct. - 17 Nov., 2022

Mobile water purification system for accident management

The plant has a mobile water purification system that can filter raw water, including sea water, for use in prolonged beyond design basis accidents.

The system consists of three vehicles. The first vehicle is a mobile pumping unit, the second vehicle contains the ultra-filtration filter units and the third vehicle is used to store and discharge the filtered water. The filtration system has a nominal production capacity of 500 gallons of filtered water per minute and can store up to 10 tons of filtered water.

Benefits:
Since the plant is located on the coast, filtered seawater can be used to inject into the reactor coolant system or spent fuel pool to cool the fuel if there are no alternative water sources available during a prolonged beyond design basis accident. Designated plant personnel are trained on the deployment and operation of this system.

Tricastin, France

Mission Date; 28 Nov. -15 Dec., 2022

‘TABATA’ board in the main control room for keeping track of in-field tasks being carried out during emergency situations

Description

The ‘TABATA’ board comprises three columns in which the control room operators, the supervisor or field operators retrieve instructions for work to be carried out on plant.

Emergency operating procedures (EOP) and severe accident management guidelines (SAMG) refer to instructions for use on plant: RFLL (line-ups), RFLE (electrical work instructions) and RFAG (instructions to be applied in severe accident conditions).

Before ‘TABATA’, there was no specific system for shelving ‘pending’ instructions and having a concise overview of results and of the ongoing situation. Instructions are placed in three ‘TABATA’ columns:

- Pending: instructions are called up by procedures, but personnel are not available to respond to the request.
- In progress: control room operators, supervisors and personnel in charge of overseeing the application of EOPs or SAMGs can see, which instructions are being applied on plant.
- Result: Once an instruction has been completed, it is placed in the ‘result’ column, regardless of whether the task was successfully completed or not. This makes it easier for operators and supervisors to identify failed tasks.
-

Benefits

Pending instructions are classified by plant area (RCA, turbine hall, electrical building) and the type (RFLL or RFLE). Operations personnel don’t need to search for instructions in the pile of documents and the control room operators obtain a quicker overview of line-up tasks in progress. ‘TABATA’ saves time in starting tasks on plant and in processing the outcomes.

The control room personnel involved in the application of EOPs have an immediate overview of tasks (pending, in progress or completed) making it easier for them to have a clear idea of plant status. The system makes it easier to fill the emergency/SAM management register and provides a more comprehensive record for shift crews, including hand-over periods.

Borssele, Netherlands

Mission Date; 23 Jan. - 9 Feb., 2023

The implementation of a passive Reactor Coolant Pump (RCP) seal isolation valve.

Purpose
The passive valve will isolate the RCP seals automatically in the early stages of a plant Black Out event. Early isolation of the RCP seals will lead to a smaller temperature increase rate after failure of the seal cooling. Therefore, automatic isolation of the seals reduces the risk of RCP seal failure and subsequent primary coolant loss in situations when the Emergency Core Cooling System (ECCS) is not available.

Description
In an Extended Loss of AC Power event (ELAP), the strategy will be to isolate the RCP cooling manually and to cool down the primary system in order to reduce the risk of RCP seal failure. The plant implemented an ELAP procedure containing this strategy, including manual isolation of the seal cooling. The plant also implemented passive RCP isolation valves to reduce the risk of RCP seal failure even further. The rationale behind this is that the isolation should be carried out very early into an event but could be delayed due to possible electrical faults or task overload.

Benefits
- Passive isolation reduces the temperature increase rate of the seals. This delays the time to reach critical temperatures where the seals could fail by more than 10 hours. Failure of the RCP seals will lead to a loss of coolant accident.
- It reduces the potential requirement to exchange RCP seals.

Penly, France

Mission Date; 4 - 21 Sep., 2023

The accident mitigation strategies implemented on the plant have been timed in exercises and these times are included in the guidelines for their implementation. This facilitates resource allocation and strategy prioritization.

The aim is to assist the overall implementation of accident management strategies by including the likely implementation times on all strategies implemented on the plant.

These strategies could either be implemented by Field Operators such as the manual opening of the Steam Generator atmospheric dump valves or it could be the deployment and installation of portable equipment by maintenance technicians.

The Field Operator procedures for actions on the plant have a documented expected time to complete the procedure. An example is that it is indicated that it takes one Field Operator 15 minutes to refine the alignment of the space between the double Containment Building walls to the Containment Filtered Vent System.

The guidance for the Maintenance Technicians for deploying and installing portable equipment also have documented expected time for completion. An example is that it is indicated that it will take 4 hours for two Maintenance Technicians to align the demineralized water system to provide make-up to the Spent Fuel Pool.

Benefits

1. Decreased stress in the Technical Support Centre by knowing when to expect implementation of an accident mitigation strategy.
2. Decreased stress of Field Operators and Maintenance Technicians by knowing they have a reasonable amount of time to accomplish a given task.
3. Aid the choice and prioritization of accident management strategies by appreciating which are likely to be faster.
4. Aid the management of limited resources in each discipline when numerous strategies on the plant may be required.

HEYSHAM 2, United Kingdom

Mission Date; 2 - 19 Oct., 2023

Monitoring of Key Plant Parameters Following a BDB Accident

Following a Beyond Design Basis (BDB) event causing loss of normal indications, the Continuous Emergency Monitoring System (CEMS) provides live display of key plant parameters in multiple locations both on and off-site to facilitate severe accident management decision making. CEMS records 8 hours of plant data leading up to and 24 hours after the event utilizing resilient station-based power. It consists of permanently installed response equipment and, when deployed, the CEMS Repair Kit can replace the functionality of key station-based system components. CEMS also provides an interface to the Deployable Communication and Information System (DCIS) so that plant status can continue to be monitored beyond the initial 24-hour period that CEMS supports.

The CEMS cubicle acts as the central hub of the CEMS system capturing data and making it available for users (CCR, Reactor Building, ECC) to view or download locally or from remote locations. A single CEMS cubicle is capable of monitoring two reactors. If the site is required to be evacuated, a mobile command centre is established at an appropriate staging post and the system can transmit data to this command centre, the CESC, and other organizations as required.
Parameters provided to monitor Critical Safety Functions (CSFs):

- Reactor bottom temp, T1 (2 Quadrants) - Circulator Outlet Gas Temp;
- Reactor top temp, T2 (2 Quadrants) - T2 Temperature;
- Reactor Pressure - Reactor Gas Pressure;
- Boiler Conditions - Boiler Outlet Pressure (4 Quadrants).

Key Benefits Provided by CEMS:

- Permits transfer of parameters key to monitor critical safety functions in a BDB event;
- Permanently installed in the plant;
- Continuously monitoring to record an additional 8 hours of data preceding the event;
- Provides parameters for 24 hours independently, which can be extended by DCIS from DBUE;
- Provides indications to multiple locations for flexibility:
    - Fixed PC in the Emergency Control Centre (ECC);
    - Satellite PC stored on site to allow mobile access;
    - Interfaces with the DCIS supplied as part of the DBUE;
    - Can transmit data to mobile and fixed offsite Command and Control locations;

Accessible by the Corporate Central Emergency Support Centre (CESC) for support.

Paks, Hungary

Mission Date; 4-21 Nov., 2024

The plant has developed software that accurately and reliably predicts the initiating event, the timing of important events (such as core damage, reactor vessel failure and large early releases) as well as the evolution of the severe accident parameters that are monitored in the TSC (Technical Support Center).

Purpose

The purpose of the predictive tool is to provide information about the possible initiating event and the corresponding accident progression. It predicts the behaviour of parameters and allows the plant sufficient time to facilitate the strategies to mitigate the consequences of a severe accident. With the use of this tool, the analysts can alert the TSC and Emergency Response Organization (ERO) personnel of the future status of the plant and expected time of significant events such as core damage and possible large releases. The ultimate goal is to improve the management of a severe accident in the TSC.

Description

The development of the predictive tool, BUTA (Baleset Utáni Támogató Alkalmazás - Post-Accident Support Application) was a collaborative effort between NUBIKI and the Accident Management team at Paks NPP. BUTA predicts the time progression of accident scenarios to provide future indication of the status of the plant. The data has been successfully verified and validated against MAAP and ASTEC simulations, as well as available measured data recorded during operational transients.

The details of the predictive tool are as follows:

- BUTA uses a database of over 320 pre-calculated scenarios for accident sequence identification. It uses MAAP5.03-VVER for predicting the progression of the scenario.
- Some examples of initiators currently in the software are LOCAs, SLB, Total Loss of Feed Water, Primary to Secondary leakages (SGTR), SBO, Reactivity Initiated Accidents.
- The behavior of all parameters measured by the Severe Accident Measurement System (SAMS) and needed for the Severe Accident Guideline are predicted by BUTA.
- The tool has the capability to plot the results of these parameters against time.
- The interface of the tool is user-friendly and intuitive.
- The software has 2 separate modes: one for training and the other for live operation. For live operation the software will be connected to the SAMS (this is an ongoing project with a deadline of December 2025). Based on detected parameter changes measured by SAMS, the software will be able to automatically predict the occurred initiating event.
- The analysts at the TSC have received training on use of the predictive software tool and will continue to receive refresher training annually.
- The tool has been used during all severe accident drills since 2023.

Benefits

- The analyst in the TSC will be aware of the initiating event as well as the behavior of all parameters that are monitored in the Diagnostic Flow Chart (DFC) and in the Severe Challenge Status Trees (SCST).
- Each of the four severe accident monitoring systems (SAMS) in the TSC can run a different simulation independently.
- The analyst will be able to alert the TSC leader and the Unit Supervisor responsible for SAMGs of the prediction of the parameters and the timing of important events such as reactor vessel failure, core damage, large early releases and fuel melt in the spent fuel pool.
- The TSC team will have sufficient time to address the results and prepare a strategy in advance to mitigate the consequences of the accident progression.
- The training module of BUTA has proven to be very useful for educating personnel on the

expectations of trends and failures during a severe accident.

- Use of BUTA reduces stress levels in the TSC since trends are being forecast and strategies can be implemented to manage adverse trends.

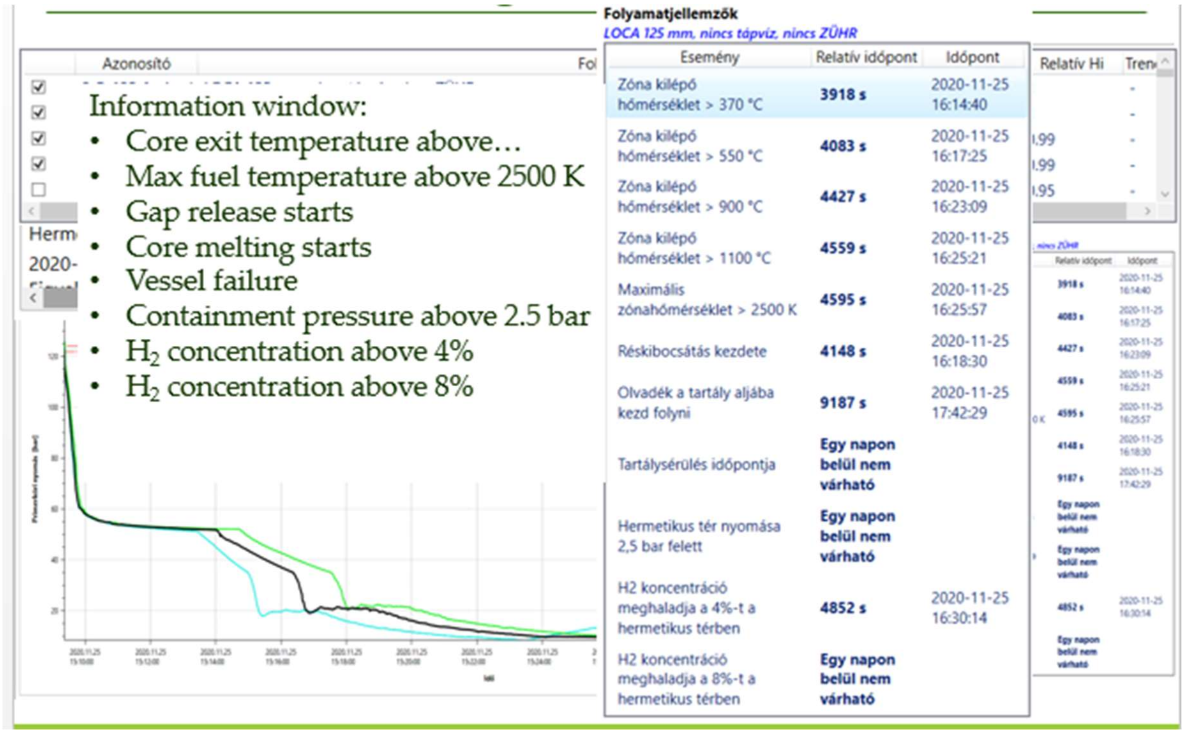

Fig 1: Detection of the Initiating Event

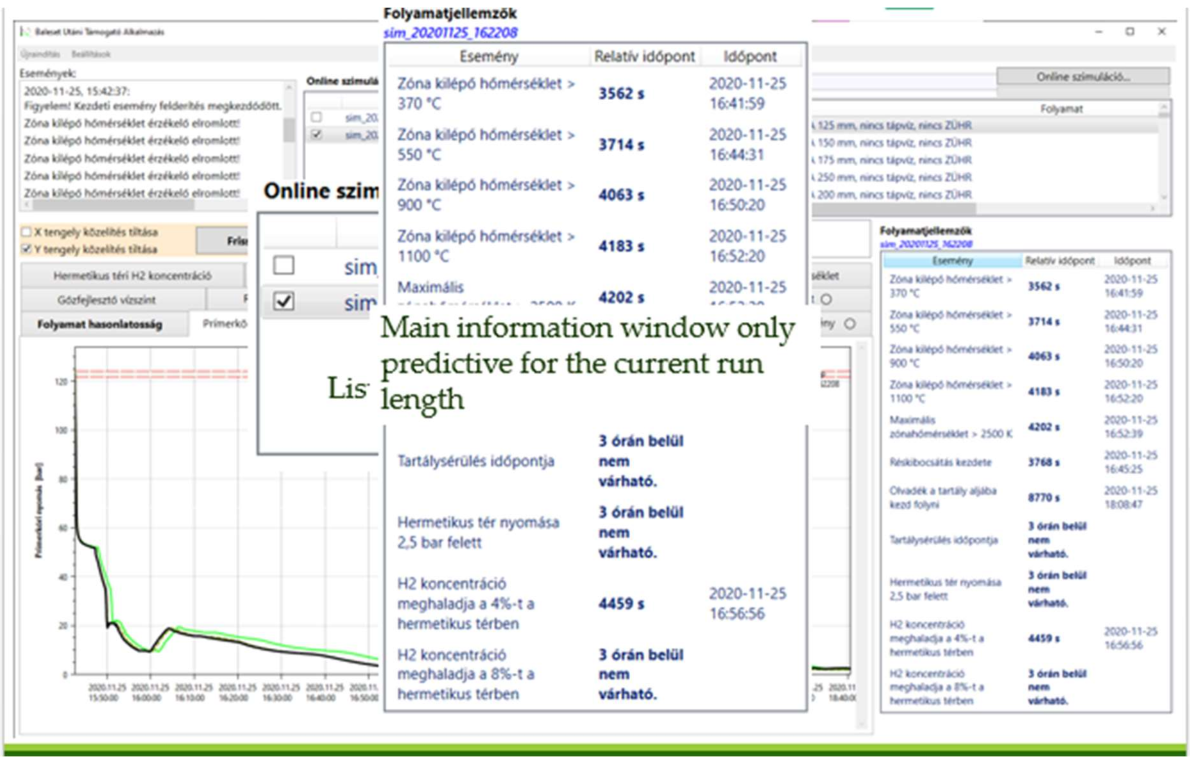

Fig 2: Online simulation results