IAEA International Conference on Topical Issues in Nuclear Installation Safety

Guidance on the Implementation of Modifications to Mitigate Beyond Design Basis Accidents

Fred Dermarkar

Vice President Engineering Strategy

Ontario Power Generation

October 2013

Presentation Overview

- Canadian Utility Principles for Beyond Design Basis Events
  - Approach to achieve "practical elimination…."
- Guidance on Modifications for Beyond Design Basis Events and Accidents

Canadian Nuclear Utility Principles for Beyond Design Basis Events

- Developed and agreed to by the 3 Utilities
- Provide guidance for utility decision making to maintain consistency
- Clearly defines the end point
- Provides a vehicle for communication within the Nuclear industry, with the Public and Regulators

Canadian Nuclear Utility Principles for Beyond Design Basis Events

Recognizing the high level of public interest and concern following the accidents at Fukushima Dai-ichi on March 11, 2011, the Canadian nuclear utilities developed a set of Principles to guide their response and to reassure the public.

Three companies, Ontario Power Generation, Bruce Power and New Brunswick Power have agreed to these principles and are committed to their implementation.

The objective is to **practically eliminate the potential for societal disruption due to a nuclear incident by maintaining multiple and flexible barriers to severe event progression** through application of the following principles:

1. Actions and defences will focus on stopping accident progression prior to a severe accident.
2. Multiple barriers to event progression and multiple means to supply water or electricity will be used to ensure adequate defence.
3. Methods and actions to initiate heat transport system cooldown and maintain fuel cooling will be a primary and early priority.
4. Actions to maintain Containment integrity will be utilized to minimize radioactive releases.
5. Containment venting will be controlled through a filtered system.
6. Necessary systems, structures and components will be confirmed to survive rare yet credible conditions for external hazards.
7. Irradiated Fuel Bay (IFB) water levels will be maintained sufficiently above the top of the fuel to mitigate high radiation fields, hydrogen production, and fuel damage.
8. Emergency Mitigating Equipment will be robust, readily available, easily deployable within required timeframes, and have adequate redundancy.
9. Canadian utilities will utilize a common philosophy for the prevention of a Beyond Design Basis Accident (BDBA).

The Canadian industry responded with diligence and urgency to understand and address the lessons learned from the events of Fukushima. The response has quickly provided additional real physical barriers to a very low probability, high consequence event such as seen at Fukushima thereby reducing the risk of adverse affects to the public and the environment.

These Principles are voluntary but nevertheless reflect the genuine aspiration of the participants to apply them, to make every effort to achieve the overall objective, and to be held accountable for our decisions in this regard.

We demonstrate by the signatures below our committment to implementation these principles.

Wayne Robbins Chief Nuclear Officer Ontario Power Generation	Len Clewett Chief Nuclear Officer Bruce Power	Sean Granville Chief Nuclear Officer New Brunswick Power
Date: 13-08-2013	Date: 15-08-2013	Date: 16-08-2013.

ONTARIO POWER GENERATION Bruce Power Énergie NB Power

Objective of the Principles

Practically eliminate the potential for societal disruption due to a nuclear incident by maintaining multiple and flexible barriers to severe event progression

Principle 1 – Event Progression Defences

Actions and defences will focus on stopping accident progression prior to a severe accident.

- Maintaining adequate fuel cooling prevents fuel failures.
- Severity of consequences escalates with event progression.
- Mitigation should receive the majority of the actions and focus from the utilities.

ONTARIO POWER GENERATION Bruce Power Énergie NB Power

Principle 1 - Event Progression Defenses

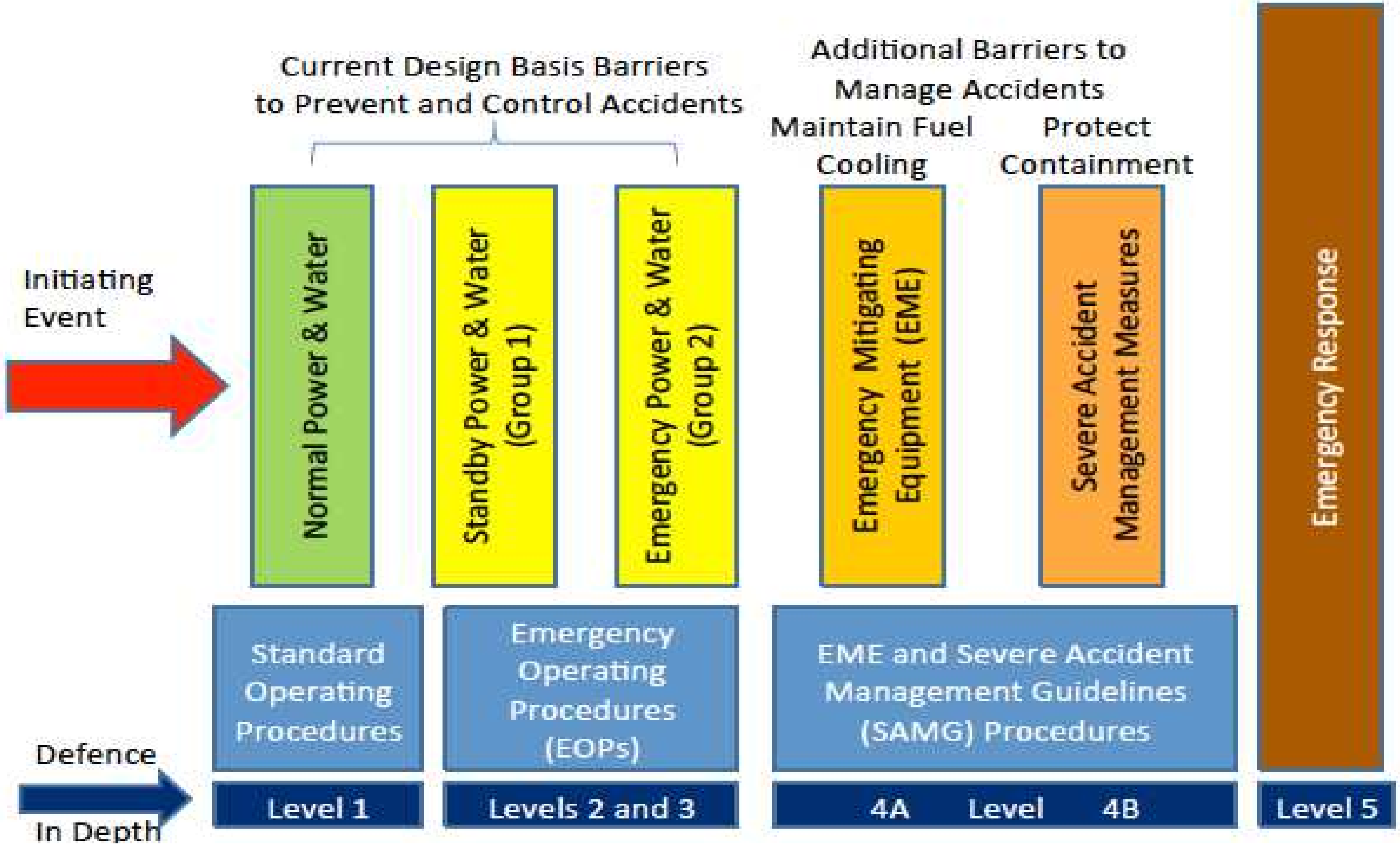
Quick connections for Steam Generator EME Supply

Flood barriers installed

ONTARIO POWER GENERATION Bruce Power Énergie NB Power

Principle 2 – Multiple Barriers

Multiple barriers to event progression and multiple means to supply water or electricity will be used to ensure adequate defence



ONTARIO POWER GENERATION · Bruce Power · Énergie NB Power

Principle 2 – Multiple Barrier Actions

Supply water to CANDU heat sinks with portable pumps

Heat Transport   Steam Generators   Moderator   Shield Tank

ONTARIO POWER GENERATION   Bruce Power   Énergie NB Power

Principle 3 – Early Fuel Cooling

Methods and actions to initiate heat transport system (HTS) cool-down and maintain fuel cooling will be a primary and early priority

- Cooldown is achieved by opening Steam Reject Valves (SRVs)
  - Increases margin to fuel failures (lower temperature).
  - Allows for EME to inject additional water into a depressurized steam generators.
- Actions to open SRVs need to be simple and reliable.

Principle 3 – Early Fuel Cooling Actions

- Cooldown of the Heat Transport can be achieved by opening boiler steam Reject Valves manually

- Air Supply connections installed to open and hold open valves
- Class II battery banks confirmed to be seismically robust

Principle 4 – Containment Integrity

Actions to maintain Containment integrity will be utilized to minimize radioactive releases

- Control pressure
  - Containment Cooling
  - Containment Venting (Principle 5)
- Control hydrogen
  - Minimize generation
  - Effective removal
- Control water inventory to minimize flooding
  - Water injection and control

ONTARIO POWER GENERATION Bruce Power Énergie NB Power

Principle 4 - Containment Integrity Actions

Containment ACUs supplied with water and electricity

1 MW Generators

Passive Autocatalytic Recombiners

Principle 5 – Filtered Venting

Containment venting will be controlled through a filtered system

- With a functional containment, decisions can be made when to vent and for how long.
- Controlled filtered venting will minimize radioactive releases and their potential impact on the environment.
- The ability to delay when containment will be vented allows for short lived material to be reduced through decay.

Principle 5 – Filtered Venting

Containment venting will be controlled through a filtered system

Principle 6 – Equipment Integrity

Necessary systems, structures and components will be confirmed to survive rare yet credible conditions for external hazards

- Existing Plant equipment will only be relied upon if shown available after Beyond Design Basis Event
- Review Level Conditions (RLCs) established for rare yet credible conditions.

  e.g., seismic Design Basis ~1,000 yr; RLC ~10,000 yr

- Provides assurance that the plants will meet the objective for BDBE

ONTARIO POWER GENERATION Bruce Power Énergie NB Power

Principle 6 –Equipment Integrity Actions

- Seismic Margin Assessments or Fragility analyses being completed:
  - Passive water supply to Steam Generators (Dearator)
  - Class II batteries and rack
- EME Quick connects designed to meet BDBE requirement.
- Seismic safety margin and vulnerabilities assessed as part of station PSAs.
- Seismically-induced internal fires and internal flooding assessments in progress.
- Credible external hazard magnitudes being updated (seismic, tsunami, wind)

Principle 7 – Spent Fuel Cooling

Irradiated Fuel Bay (IFB) water levels will be maintained sufficiently above the top of the fuel to mitigate high radiation fields, hydrogen production, and fuel damage

- The time required to respond to a loss of IFB cooling is typically quite long.
- The volume of water in the IFB should be maximized within normal water levels to the extent practicable.
- EME to supply water to account for leakage and steaming.

Principle 7 – Spent Fuel Cooling Actions

EME Water Supply piping to IFB

Principle 8 – Readily Deployed

Emergency Mitigating Equipment will be robust, readily available, easily deployable within required timeframes, and have adequate redundancy

- Stored at higher elevation, away from station, close enough for timely deployment and accessible following BDBE
  - Pre-staging is an option for predictable events (e.g., severe weather)
- Deployable by diverse work groups, supported by procedures, training and practice and validated by drills
- More than one method for deployment (trucks, tractors, security vehicles)
- Reliability of EME supported by using proven technology, preventative maintenance and routine testing
- On-site fuel supplies adequate for > 72 hour run time, with provisions for refueling in place.

Principle 8 – “Readily Deployed” Actions

ONTARIO POWER GENERATION   Bruce Power   Énergie NB Power

Principle 9 - Common Philosophy

Canadian utilities will utilize a common philosophy for the prevention of a Beyond Design Basis Accident (BDBA)

- Interaction between utilities gives a larger perspective and experience base
  - Encourages challenging and learning
  - Improves capability to respond and to provide mutual assistance
  - Provides credibility
  - Facilitates regulatory concurrence.

ONTARIO POWER GENERATION Bruce Power Énergie NB Power

Principle 9 -Common Philosophy Actions

- COG Severe Accident Joint Project Technical Reports
  - Shutdown and Low Power, Multi-unit Station, Technical Basis Document and SAMG Update, Containment Integrity, In-Vessel Retention, Instrument Survivability, Habitability
- COG Emergency Preparedness Work Shop III June 3&4,
  - Diverse participation including CNSC, Health Canada and provincial agencies.
- WANO SOER 13-2 corrective action plans
  - Developed cooperatively
- Mutual Aid Agreement in effect
- Regional Emergency Response Support Centre
  - Site selection complete

ONTARIO POWER GENERATION Bruce Power Énergie NB Power

Designing for Beyond Design Basis

- Objective
  - Deliver functionality to prevent or mitigate significant adverse consequences with reasonable assurance
    - Maintain fuel cooling
    - Arrest core damage
    - Protect containment integrity
  - Ensure functionality for design basis conditions is not compromised
- Graded approach
- Recognized as providing interim direction

Graded Approach

- Four categories of Systems, Structures & Components (SSCs):

1. Existing engineered SSCs called upon to manage BDBAs

Steam Reject Valves to depressurize Steam Generators

2. Equipment upgrades installed on existing engineered SSCs to manage BDBAs.

Additional Air supply to hold Steam Reject Valves open

Graded Approach

Containment venting will be controlled through a filtered system

3. New engineered SSCs for the sole purpose of managing BDBAs

4. Portable SSCs to be attached to existing SSC to manage BDBAs

Application to Design

- For all Categories:
  - Analysis based on more realistic initiating conditions
  - Interfacing components designed to requirements of the parent system
  - Robustness demonstrated for Review Level Conditions (RLCs)
    - RLC: appropriate estimate of the intensity of a rare, yet credible external hazard to confirm adequate safety margin for beyond design basis events

Application to Design

- For Category 4:
  - Design process documented, approved by the Design Authority.
  - Codes / standards appropriate for portable equipment to be used
  - Equipment to be designed for two tie-in points, at least one of which is an engineered tie-in point

Application to Procurement

- For Categories 1,2:
  - Full procurement rigour as applied to nuclear components
- For Category 3:
  - As above, but typical commercial / industrial process may apply beyond system isolation tie-in points. Deviations approved by Design Authority.

Quick connect: commercial
Piping to isolation point: nuclear

Application to Procurement

- For Category 4:
  - Commercial/industrial processes apply and manufacturer's standards apply.
  - Equipment to be stored in a manner to make it resilient to BDBEs

- Spare parts:
  - Appropriately considered in the procurement process.
  - For Category 4, provide for N+1 running spares, per FLEX.

Application to Installation, Commissioning and Testing

- For Category 1, 2:
  - Process for installation, testing, commissioning same as for normal engineering change control process
- For Category 3, 4:
  - Commercial/industrial processes apply for installation, testing and commissioning
  - Demonstration that functional performance requirements have been met

Application to Operations and Maintenance

- For all categories:
  - Operator Routines and Testing are performed regularly to ensure reliability and availability of SSCs.
  - Allowable outage times as defined in Operational Safety Requirements, which are part of the design and licensing basis
- For Category 4:
  - Where equipment redundancy exists, equipment can be taken out of service for maintenance for up to 90 days.
  - Where no equipment redundancy exists, equipment can be taken out of service for up to 14 days for maintenance.
  - A longer restoration period requires approval of the Operations and Maintenance Director.

ONTARIO POWER GENERATION Bruce Power Énergie NB Power

Principles for Sustainability

- The technical basis for BDBA Response Capability (BDBA RC) shall be formally documented and periodically reviewed to ensure that it remains current.
- Regular maintenance and testing of BDBA RC shall be controlled through a predefined process consistent with regular station equipment; it shall be documented and periodically audited.
- The maintenance of BDBA RC shall be routinely self-assessed and independently audited
- BDBA RC shall be revisited when new safety analysis is performed

Principles for Sustainability

- Station modification control processes shall ensure that BDBA RC is not inadvertently altered.
- BDBA RC functional requirements shall be documented in a manner similar to the Operational Safety Requirements for design basis credits.
- Station transient material processes shall include controls to ensure that access to tie-in points and staging locations for BDBA RC are accessible.
- Maintenance and Outage Management processes shall account for capability to implement BDBA RC.

Conclusion

- Recent applications at OPG:
  - Flood barrier protection at Pickering
  - Emergency Mitigating Equipment at Pickering and Darlington
  - Containment Filtered Venting System at Darlington
- The application of the process has confirmed that it is sound and provides required flexibility.
- Communication between project staff, nuclear safety staff and design organizations is key to ensure the correct balance and rigour is applied.

SUMMARY

- Canada is committed to the objective to "Practically Eliminate the Potential for Societal Disruption"
- We have defined the steps and processes to meet and sustain this objective
- We are well advanced
- We are willing to learn and improve

ONTARIO POWER GENERATION Bruce Power Énergie NB Power