Structure of SAMGs


Presented by Ivica Basic APoSS d.o.o.
Overview

• Introduction
• Examples
  – Generic SAMG Implementation
  – Plant specific SAMG
  – IPE Background
  – Background Documents – Strategies/Setpoints
  – Procedures
  – Conclusions
• Potential Issues from Regulator
• References
The operating organization shall establish, and shall periodically review and as necessary revise, an accident management programme.

**IAEA SSR-2/1, rev.1, para#2.10: „... the establishment of accident management procedures..”**
For AM development, it is important to understand the challenges to Fission Product (FP) barriers.

Mitigating strategies may compete for resources, therefore, it is important to establish priorities.

An understanding of severe accident phenomena is critical to AM.
Core Damage States

**OX**
- Degraded fuel conditions
- Cladding oxidation significant
- Fuel degradation sufficient to lead to appreciable fuel debris relocation
- Potential for critical fuel configurations

**BD**
- Degraded fuel conditions with RCS/RPV challenged
- Significant fuel relocation
- Coolability of the fuel geometry degraded

**EX**
- Degraded fuel conditions with RCS/RPV lower head breached
- Core debris relocation into containment occurred
- Direct attack of the concrete containment can occur

Ref: EPRI Technical Basis Report, 2012, courtesy J. Gabor, ERIN Engineering

\[ OX = \text{Oxidized Fuel} \]

\[ BD = \text{Badly Damaged core} \]

\[ EX = \text{core Ex-vessel} \]
Spent Fuel Pool Damage States

**SFP-OX**
- Degraded conditions
- Cladding oxidation significant
- Fuel degradation sufficient to lead to appreciable fuel debris relocation
- Potential for critical fuel configurations

**SFP-BD**
- Degraded conditions with challenge to SFP structure
- Significant material relocation
- Coolability of the fuel assembly geometry degraded

Ref: EPRI Technical Basis Report, 2012, courtesy J. Gabor, ERIN Engineering
Containment Damage States

CC = closed and cooled

- Containment intact and cooled

CH = challenged

- Containment challenged
- Appreciable buildup of energy
- Presence of flammable gases in containment

B = Bypassed

- Containment bypass
- Direct pathway from RCS/RPV out of containment (e.g. SGTR, ISLOCA)

I = Impaired

- Containment impaired
- Containment isolation failure or some other breach
- Direct pathway out of containment exists

Ref: EPRI Technical Basis Report, 2012, courtesy J. Gabor, ERIN Engineering
Vulnerabilities?

- Design?
- Procedure?
- Human failure?
• 1985: US NRC issued “Policy Statement on Severe Accidents Regarding Future Designs and Existing Plants” - formulated an approach for systematic safety examination of existing plants

• To implement this approach, GL 88-20 issued, requesting that all licensees perform an IPE in order “to identify plant-specific vulnerabilities to severe accidents”

• Internal events + internal floods

• Submittal guidance: NUREG-1335
PSA Level 1 and 2

- Plant specific analysis (IPE – Individual Plant Examination) - plant response on Severe accident
  - PSA Level 1:
    - Event Trees and Fault Tree,
    - Core Damage State Evaluation
  - PSA Level 2
    - Containment Event Trees (PDS evaluation)
    - Deterministic analysis capability to simulate severe accidents (MAAP, MELCOR,..)
Link Level 1 Results to Level 2

**Level-1 Sequence Event Tree**

- Initiating Event A
  - OK
  - CD
    - OK
    - CD
      - OK
      - Source Terms (Release Categories)

- Initiating Event B
  - CD
    - OK
    - Resolve status of ignored systems
      - PDS_i
        - PDS_j
  - CD
    - Add containment systems
      - PDS_1
      - PDS_2
      - PDS_n
Timing and severity of challenges to the barriers against releases of radioactive material - generic

- The initiating events were selected based on the dominant core melt sequences of a number of IPEs. The time sequence information was obtained from the IPE source term analyses which were performed with MAAP 3.0B, Revision 17.
Plant-specific Severe Accident Management insights were developed based on the following:

**Dominant core damage sequences from Level 1 study** have been grouped and assessed following the criteria set out in NUMARC 91-04, Severe Accident Issue Closure Guideline.

For **beyond 24 hour sequence** (loss of SW, loss of CCW, station blackout), insights were developed based on the accident scenarios.

The **Level 2 results** have been grouped into release categories and insights have been derived based on these categories. Also, the phenomenological evaluations have been reviewed to gather additional insights.

**IPE – Individual Plant Examination**

**Level 1 PSA**

**Sequences that lead to core damage after 24 hours**

**Level 2 PSA**
NEK IPE / IPEEE Insights

• Internal events
  • CDF comparable to US plants
  • Risk profile - no outliers
  • Insights - generic for PWR plants (switchover to recirculation, heat sink - AWF / feed & bleed, SGTR - RCS cooldown & depressurization)

• Internal flood
  • Flood zones with dominant risk contribution identified
  • Contribution to Total CDF small
The overall capability of the plant to respond to and recover from an accident situation

Accident Management measures or strategies may be **PREVENTIVE or MITIGATIVE (or BOTH)**
Westinghouse Severe Accident Management

Accident Severity

- Normal Operation
- Transient
- Reactor Trip
- Safety Injection
- Core Uncovery
- Core Damage
- Vessel Failure
- Containment Failure/Vent

Main Control Room:
- Abnormal Operating Procedures

Technical Support Center:
- Emergency Operating Procedures
- Technical Support to Control Room
- Severe Accident Management Guidelines

Emergency Operations Facility:
- Site Emergency Plan

Severe Accident Management Guidelines

Purpose:
- Protect fission product boundaries
- Mitigate releases
- Mitigate severe accident phenomena
- Restore controlled stable condition

Features:
- Implemented by TSC
- Separate from EOPs
- Symptom based
Mitigative actions
- *mitigate core damage and protect fission product boundaries*
- are included in the *Severe Accident Management Guidelines (SAMG)*

Examples of Mitigative Actions:
- Vent containment (protect containment boundary integrity) (SCG-2)
- Establish feed to steam generators (protect SG tube integrity, scrub releases) (SAG-1)
- Depressurize reactor system (prevent high pressure vessel failure) (SAG-2)

The effectiveness of mitigative measures can be quantified using Level 2 PSA (quantification of fission product release frequency and magnitude)
## Accident Management Overview

<table>
<thead>
<tr>
<th>EVENT</th>
<th>Design basis accident</th>
<th>Beyond design basis accident</th>
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</thead>
<tbody>
<tr>
<td>OBJECTIVE</td>
<td>Prevent damage to core</td>
<td>Mitigate effects of core damage</td>
</tr>
<tr>
<td>AM TYPE</td>
<td>PREVENTIVE</td>
<td>MITIGATIVE</td>
</tr>
<tr>
<td>Procedure/guideline</td>
<td>Emergency Operating Procedures</td>
<td>Severe Accident Management Guidelines</td>
</tr>
<tr>
<td>Optimal Recovery</td>
<td></td>
<td>Critical Safety Function Restoration</td>
</tr>
</tbody>
</table>
WOG SAMG Structure Interface with ERGs

Core Damage Conditions Observed

Site Emergency Plan

TSC not functional

WOG ERGs

SACRG-1

SACRG-2

DFC SAGs and SAEG1

SCST and SCGs

TSC functional

SAEG-2

CSS
Critical Safety Functions Tree

GOAL
No Fission Product Release

BOUNDARY
Fuel
RCS
CONT
Dist

FUNCTION
Subcriticality
Core Cooling
Heat Sink

Subcriticality
Core Cooling
Heat Sink
Integrity

Containment

CSF PRIORITY
Subcriticality (S)
Core Cooling (C)
Heat Sink (H)
Integrity (P)
Containment (Z)
Inventory (I)
Emergency Response Guidelines Network

Normal Operation

Alarm?

Yes

Rx Trip Required?

Yes

E-0

No

SI Required?

Yes

Event Diagnosed?

No

Rx Trip Recovery

Yes

ORG Recovery

No

Other Procedures

Repair

Monitor CSFST in parallel

CSF Satisfied?

No

FRG for CSF Restoration

Yes

Enter at E-0 (ECA-0.0)

Directed to ORG

Exit to normal procedure

Enter if CSF not satisfied

Return to ORG when CSF satisfied
Emergency Response Guidelines Network

1. Normal Operation
   - Alarm?
     - No
     - Yes
       - Rx Trip Required?
         - No
           - Other Procedures
           - Repair
         - Yes
           - E-0
             - SI Required?
               - No
               - Yes
                 - Event Diagnosed?
                   - No
                     - Rx Trip Recovery
                   - Yes
                     - ORG Recovery
   - Yes
     - ORGs

2. Transition
   - CSF Satisfied?
     - No
     - FRG or CSF Restoration

3. FRGs
   - ORG Network
SAMG Interface With Emergency Procedures

Base criterion: ERGs are terminated and SAMGs are entered at onset of core damage
- SAMG is a separate document from the ERGs
- No simultaneous usage of ERGs and SAMG

EOP in effect at the onset of core damage must be:
- FR-C.1 (most sequences)
- ECA-0.0 (only accidents with no ac power)
- FR-S.1 (some ATWS events)
Transition to SAMGs based on:

- FR-C.1: Core exit temperature > 650 °C, AND all recovery actions have failed
- ECA-0.0: Core exit temperature > 650 °C
- FR-S.1: Core exit temperature > 650 °C
SAMG Reference Decision Making Process

Enter SAMG

Determine plant conditions

Are any F.P. boundaries challenged?

Prioritize challenges

Identify strategies

Implement optimal strategy

Are all challenges mitigated?

Is the plant in a controlled stable state?

Prioritize challenges

Identify strategies

Implement optimal strategy

Exit
SAMG Overview of Components

Control Room

Severe Accident Control Room Guideline (SACRG-1)
Initial Response

Severe Accident Control Room Guideline (SACRG-2)
for Transients after the TSC is Functional

Technical Support Center

Diagnostic Flow Chart (DFC)

Severe Accident Guidelines
SAG-1 Inject into the Steam Generators
SAG-2 Depressurize the RCS
SAG-3 Inject into the RCS
SAG-4 Inject into Containment
SAG-5 Reduce Fission Product Releases
SAG-6 Control Containment Conditions
SAG-7 Reduce Containment Hydrogen
SAG-8 Flood Containment

Graphical Computation Aids

SAEG-1
TSC Long Term Monitoring Activities

SAEG-2
SAMG Termination

Severe Challenge Status Tree (SCST)

Severe Challenge Guidelines
SCG-1 Mitigate Fission Product Releases
SCG-2 Depressurize Containment
SCG-3 Control Hydrogen Flammability
SCG-4 Control Containment Vacuum

CA-1 RCS Injection to Recover Core
CA-2 Injection Rate for Long Term Decay Heat Removal
CA-3 Hydrogen Flammability in Containment
CA-4 Volumetric Release Rate from Vent
CA-5 Containment Water Level and Volume
CA-6 RWST Gravity Drain
CA-7 Hydrogen Impact when Depressurizing Containment
Identify available equipment to perform strategy

Identify capability of available equipment

Identify and evaluate negative impacts

Identify means to mitigate negative impacts

Evaluate consequences of NOT performing strategy

Should strategy be performed?

Identify preferred equipment lineup

Identify any limitations

Advise control room of recommended strategy

Verify strategy implementation

Identify long term concerns

Return to DFC
TSC Diagnostic Flow Chart

Enter TSC severe accident guidance

Begin monitoring severe challenge status tree

Water level in all SGs > 32% narrow range

Yes

Go to SAG-1
Inject into steam generators

No

RCS pressure < 22.2 kp/cm^2

Yes

Go to SAG-2
Depressurize RCS

No

Core temperature < 354 deg. C

Yes

Go to SAG-3
Inject into RCS

No

Containment water level > 3 m wide range

Yes

Go to SAG-4
Inject into containment

No

Site releases < Site Emergency Levels

Yes

Reduce fission product releases

No
Development of plant specific SAMG can be based on Owner Groups (e.g. PWROG) generic guidelines:

- Generic Strategies defined (an action /set of actions) to be taken; a challenge that is to be mitigated, and the equipment that will be used);
- Many steps needed to developed plant specific procedures (development of plant specific background documentation, procedures, implement required changes in EP,..)
WOG Generic SAMG Implementation

- Review of WOG Generic SAMG applicability;
- Development of plant-specific SAMG setpoint;
- Development of plant-specific computational aids;
- Review of EOPs to incorporate transitions to SAMG;
- Writing of plant-specific control room SACRGs;
- Writing of plant-specific TSC guidance, including SAGs, SCGs, DFC, SCST, and SAEGs;
Purposes were:

- Identify if all **generic strategies** are applicable to NEK - can successfully be applied; Accident Management measures or strategies may be PREVENTIVE (delay or prevent core damage) or **MITIGATIVE** (mitigate core damage and protect fission product boundaries) or BOTH

- Verify if **IPE insights** are adequately **addressed** in generic strategies;

- Identify the plant **specific capabilities** (equipment that will be used), action to be taken to mitigate the challenge
Implementation of NEI 12-06 (FLEX)

(a) Existing View of Typical Operating Procedure Hierarchy

Support Procedures

- SAMGs
- EOPs
- AOPs
- ARPs
- GOPs

EDMG

50.54(hh)(2)

Revision of SAMGs

(b) Future View of Typical Operating Procedure Hierarchy

Support Procedures

- FLEX Support Guidelines

EDMG

Added as EOPs
Attachments (37 !!!)
which are referenced to
SAMGs if needed
The Pressurized Water Reactor Owner’s Group (PWROG) is in the process of upgrading the generic Severe Accident Management Guidelines (SAMGs)

- Phase I (completed 2013): Each vendor generic SAMG was upgraded to include key Fukushima lessons learned that could be included without unnecessary delay

- Phase II (completed 2015): Integration of the three vendor generic SAMGs into one generic Pressurized Water Reactor (PWR) SAMG
Insights from Development of the Combined PWR SAMG

- Phase I Scope: Update the three individual vendor generic SAMGs to include updates from the Electric Power Research Institute (EPRI) Technical Basis Report (TBR) update
  - Addition of Spent Fuel Pool (SFP) SAMG
  - Addition of Aux. Building Ventilation Strategies
  - Guidance related to the use of Raw Water (e.g., saltwater, river water, dirty water, etc.)
  - Guidance related to containment venting
Insights from Development of the Combined PWR SAMG

- Phase II Scope: Develop a common generic PWR SAMG includes the best features of the three individual SAMG products
  - Provides consistency for Nuclear Regulatory Commission (NRC) oversight
  - Provides efficiency for future updates
  - Provides effective basis for sharing plant-to-plant experience and assistance

- Phase II scope includes
  - Generic Guidelines
  - Generic Training
  - Generic Validation
  - Generic Scenario Templates
Insights from Development of the Combined PWR SAMG

- The generic PWR SAMG includes a number of enhancements not in the Phase I generic SAMGs
  - Enhanced integration with other procedures and guidance
    - Transitions between Emergency Operating Procedures (EOPs), Extensive Damage Mitigation Guidelines (EDMGs), FLEX Support Guides (FSGs)
    - Common handbook of accident management capabilities
  - Review of Boiling Water Reactor Owner’s Group Severe Accident Management products
    - Instrumentation guidance
  - Attention to NRC identified deficiencies
    - Multi-unit events
    - Decision-maker guidance
  - Feedback from drills and exercises based on the existing SAMGs, including:
    - Additional guidance for delayed Technical Support Center (TSC)
    - Simplification of some knowledge based decisions to prevent paralysis
  - Guidance for a severe accident originating from plant shutdown conditions
Insights from Development of the Combined PWR SAMG

- Transition of SAMG authority from MCR to TSC upon completion of priority actions and activation of the TSC
- Communication between MCR and TSC

Diagram:
- Enter SAMG
- MCR SAG-1
- MCR SAG-2
- DPG
- TSC SAGs
- Exit SAMG
Insights from Development of the Combined PWR SAMG

- Additional Main Control Room (MCR) guidance was added to the SAMGs to include priority actions that should be done for all severe accidents
  - Inject water into the steam generators
  - Depressurize the Reactor Coolant System (RCS)
  - Inject water into the RCS
  - Inject water into containment

- Once the priority actions are performed, the MCR will determine if the TSC has been activated

- Additional MCR guidance was added for the time period after the TSC has been activated
  - Provide feedback to TSC on knowledge from MCR
Some of the major changes to the TSC guidance include:

- A Diagnostic Process Guideline (DPG) that directs the TSC to a specific guideline for each critical plant parameter.
  - Multiple color-coded thresholds for each parameter allows for a prioritization of actions based on plant conditions.
- Step-wise guidance in each guideline.
  - Identify evaluation and implementation price.
  - Rule-based priorities and preferred methods where appropriate.
  - Increased evaluation bases.
  - Simplified Computational Aid usage.
## Insights from Development of the Combined PWR SAMG

<table>
<thead>
<tr>
<th>Date: ___________________</th>
<th>RED</th>
<th>ORANGE</th>
<th>YELLOW</th>
<th>GREEN</th>
<th>TREND (Circle One)</th>
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<td>Time: ___________________</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### SG Level
- **Setpoint**: RED - LESS THAN LO1, GREEN - GREATER THAN LO1
- **Actual**: GREATER THAN LO1, STABLE, LESS THAN LO1, STABLE

### RCS Pressure
- **Setpoint**: RED - GREATER THAN PO2, GREEN - LESS THAN PO2
- **Actual**: GREATER THAN PO2, STABLE, LESS THAN PO2, STABLE

### Core Temperature
- **Setpoint**: RED - GREATER THAN T01, GREEN - LESS THAN T01
- **Actual**: GREATER THAN T01, STABLE, LESS THAN T01, STABLE

### Containment Water Level
- **Setpoint**: RED - LESS THAN LO2, GREEN - GREATER THAN LO4
- **Actual**: GREATER THAN LO4, STABLE, LESS THAN LO4, STABLE

### Containment Pressure
- **Setpoint**: RED - GREATER THAN P01, GREEN - LESS THAN P04
- **Actual**: GREATER THAN P01, STABLE, LESS THAN P04, STABLE

### Containment Hydrogen Concentration
- **Setpoint**: RED - GREATER THAN HO1, GREEN - LESS THAN HO2
- **Actual**: GREATER THAN HO1, STABLE, LESS THAN HO2, STABLE

### Site Release Level
- **Setpoint**: RED - GREATER THAN RO1, GREEN - LESS THAN RO2
- **Actual**: GREATER THAN RO1, STABLE, LESS THAN RO2, STABLE

### SFP Water Level
- **Setpoint**: RED - LESS THAN LO3, GREEN - GREATER THAN LO5
- **Actual**: LESS THAN LO3, STABLE, GREATER THAN LO5, STABLE
Insights from Development of the Combined PWR SAMG

• To ensure a systematic and logical method of severe accident mitigation, the basic format of the Westinghouse Severe Accident Guides (SAGs) has been chosen for the PWR SAMG

• To facilitate rapid response, a set of immediate priority actions are executed at the onset of a severe accident

• The evaluation bases scope and level of detail are being increased
  – Various tools are being developed to facilitate rapid decision making
Insights from Development of the Combined PWR SAMG

• The Phase I SAMG update incorporated Fukushima lessons learned into the three vendor specific SAMGs without significant modification to their format.

• The Phase II product, i.e., the PWR SAMG, combines the three PWR vendor’s generic SAMGs into a single generic SA mitigation methodology that will further improve SA management.
Conclusions

Development of plant specific SAMG should cover:

- The current worldwide state of the art in severe accident research including experimental and analytical efforts;
- Plant specific capabilities (structures, systems, components) and strategies assessment including FLEX capability NEI 06-12;
- Generic and specific PSA insights assessment;
- However, even that certain changes and revision of SAMGs and SEOPs were introduced by post Fukushima WENRA stress tests evaluations
  - PARs, PCFV, new ECR, additional LP SIS pump, mobile RHR HX (MHX), etc
Option without PSA Level 2 and Deterministic Severe Accident Analyses
Option without PSA Level 2 and Deterministic Severe Accident Analyses

- There is no need to cope with generic format (AREVA, Westinghouse, GE, etc.)
  - SAMGs are guidelines not procedures
  - Guidelines could be given in the format of logical symptom oriented diagrams with associated tables (advantages vs. disadvantages of mitigative measures)

- Evaluation of already identified and documented generic severe accident management candidate high level actions (CHLA) strategies and mitigate system/structure/component (SSCs) (based on OECD, IAEA and EPRI Severe Accident Management Guidance Technical Basis Reports (TBR) in comparison with subjected NPP design, available SSCs and its applicability
Definition of transition

- SAMG for MCR (should be similar to FR-C1)
- SAMG for Spent Fuel Pool (not available in generic SAMG, important issue from Fukushima point of view)
- SAMG for shutdown (e.g. loss of SRH on mid-loop operation)

Alternative means (mobile equipment FLEX) usage:
- Different fire protection pumps
- Fast connections to the systems (e.g. injection into SGs)
- Source of waters (e.g. amount for flooding the containment to protect cavity floor from MCCI OR even flooding the Rx cavity to the top of active fuel to establish external cooling)
Supporting Accident Analysis (generic & plant specific)

- Generic Severe Accident evaluation were performed for pilot (reference) plant not directly applicable for every plant (usually no sensitivity runs and modeled actions). The WOG SAMG reference plant is basically a 4-loop HP plant with system design features similar to current Westinghouse-design plants (mainly SNUPPS).

- E.g. in determining the actions which should be taken in generic SACRG-1, the consideration is limited to those actions in the first "hour" after core damage has begun for large LOCA events and ATWS events. Information from IPEs and generic severe accident analyses for large LOCA and ATWS core damage accident sequences provides the basis for defining the challenges to the containment fission product boundaries during this time frame.
Supporting Accident Analysis (generic & plant specific)

- **Generic Severe Accident evaluation** (e.g. WOG Background for SAG1 „Inject to SG”) is often just referred to analysis documented in EPRI TBR: „2.2.3 Creep Rupture of SG Tubes”, „The TBR contains an appendix (Volume II, Appendix I) discussing the creep rupture of RCS components during a severe accident. Figure I.2 of this appendix provides the relationship between tube temperature, RCS-SG differential pressure, and the time until tube rupture for Inconel 600 SG tubes in an as-fabricated state. Plant Specific analyses (either by MAAP or MELCOR, etc.) provide the flexibility for sensitivity cases:
  - Changing the input file the parameters related to the creep failure (either for SG u-tubes, RPV or HL pipe) can be changes and analysis profile and time sequence compared
MAAP 4.0.5 Creep Failure Model

MAAP 4.0.5 model of creep failure is based on observation of Larson-Miller parameter:

\[ \text{LMP} = T_R(A + \log_{10} x t_{rh}) \]

Where:
- \( \text{LMP} \) = Larson-Miller parameter
- \( T_R \) = temperature (K)
- \( t_{rh} \) = rupture time (hours), and
- \( A \) = best fit parameter, different for each material
## Deterministic Analysis of Severe Accidents Phenomena – example CREEP failure and influence on SAMG

<table>
<thead>
<tr>
<th>Analysis</th>
<th>HL pipe</th>
<th>SG Pipe</th>
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<tbody>
<tr>
<td></td>
<td>HL temperature &gt; 1100K</td>
<td>Time with T &gt; 850K</td>
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<tr>
<td><strong>Seabrook</strong></td>
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<tr>
<td>Base Case</td>
<td>N/A</td>
<td>&lt; 10 min</td>
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<tr>
<td>No core blockage</td>
<td>&gt; 30 min</td>
<td>&gt; 40 min</td>
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<tr>
<td>Loop seal clear</td>
<td>N/A</td>
<td>&lt; 10 min</td>
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<tr>
<td><strong>Ringhals</strong></td>
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<td></td>
</tr>
<tr>
<td>Base Case</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>No core blockage</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Delayed RV failure</td>
<td>&gt; 10 min</td>
<td>N/A</td>
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</table>
Deterministic Analysis of Severe Accidents Phenomena – example CREEP failure and influence on SAMG

Analyses of 3 LOAF cases:
- LPI recover just before HLs creep failure (CREEP1)
- HLs creep failures prevented by user intervention (CREEP2)
- User intervention to favorize SG tubes creep failure, recovery of AFW (CREEP3)
Deterministic Analysis of Severe Accidents Phenomena – example CREEP failure and influence on SAMG
Availability of important support functions as well as possibility of their restoration

- AC/DC capability for essential SSCs and critical safety function should be assessed together with possible alternatives (existing alternative sources + portable devices + FLEX connection)
  - Special attention to diagnostic instrumentation

- Water sources for makeup of SG and RCS should be evaluated together with alternative paths and sources for prolonged severe time window (4h, 24h, 72h...)
  - Special attention for long term cooling of RCS and containment

- Compressed Air for essential valves necessary for establishment of critical safety function
  - Special attention for containment isolation valve or PRZR PORV and SG PORVs
Plant initial operating mode, as accidents can develop in operating modes where one or more fission product barriers could already be lost at the beginning of the accident;

- At beginning of transient MCR is, due to degraded fission barriers, is in SEOP FRPs (typically FR C-1 and with CET above 650degC transferred to SACRG)
- When TCS become operable – switch to SAMG
- SAMGs are guidelines not procedures – few SAMGs can be executed in parallel
  - DFC and SCST should be monitored: when one of fission product barrier is lost one prioritized SCG is executed according to User Guide
Adequacy of a strategy in the given domain; Some strategies can be adequate in the preventive domain, but not as relevant in the mitigatory domain due to changing priorities

- SAMGs are guidelines not procedures and for each strategy the positive and negative aspects should be carefully assessed but decision making process should be assured not to stuck in the long assessment (limiting time during severe accident before corium degradation and Rx vessel failure)

- Adequacy of proposed HCLA could be evaluated during validation process
The difficulty of developing executing several strategies in parallel

- SAMGs are not procedures – guidelines:
  - Few SAGs strategies can be executed simultaneously (but prioritization should be performed based on time & staff & SSC available) observing and monitoring the critical safety function parameters
  - Only one SCG strategy can be executed alone
- User Guide should be developed
- This is important issue for the verification/validation and training
Long-term implications or concerns of implementing the strategies (e.g. unavailability of coolant for later use)

- Should be addressed in strategy for the establishing the necessary support systems
  - AC/DC capability for essential SSCs and critical safety function should be assessed together with possible alternatives (existing alternative sources + portable devices + FLEX connection)
  - Water sources for makeup of SG and RCS should be evaluated together with alternative paths and sources for prolonged severe time window (4h, 24h, 72h...)
  - Compressed Air for essential valves necessary for establishment of critical safety function
Regulator Review Role

Regulator Options

- Development of specific Regulatory Review Guide (RRG) based on IAEA guides (NS-G-2.15, SRS32(SAMG), SRS48(SEOP), Services Series No.9, etc.)
  - Review the SAMG development and maintenance process, documentation, update, implementation of findings after drills and excercise,...

- Organizing the IAEA RAMP mission or other kind of independent review

- Participate in execution of drills and excercise

- Do not forget: Responsibility of safety during DBA and SA is in NPPs, Regulatory Body approval of SAMG is not recommended due to sharing responsibility if something is wrong.
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[1] "Krško Source Term Analysis"; paper presented at the 2nd Regional Meeting "Nuclear Energy in Central Europe"; Portorož, Slovenia, September 11-14, 1995. I. Basic, B. Krajnc (NEK);


[3] “Development of Krško Severe Accident Management Database (SAMD); paper presented at the international conference “Nuclear Option In Countries With Small And Medium Electricity Grids”, Opatija, Croatia, October 7-9, 1996., I. Basic, R. Kocnar (NEK);


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Questions?
Comments?

Thanks for your attention!