IAEA 60 Years
Atoms for Peace and Development

Practical Examples of SAMG from PWROG, Including Rules of Usage/TSC Guidelines

SAMG-D Toolkit, Module 3, Chapter 12

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This presentation contains publicly available information related to the WOG and PWROG SAMG.

The WOG SAMG package is proprietary to the Westinghouse Owners Group.

The PWROG SAMG package is proprietary to the Pressurized Water Reactor Owners Group.

Agenda

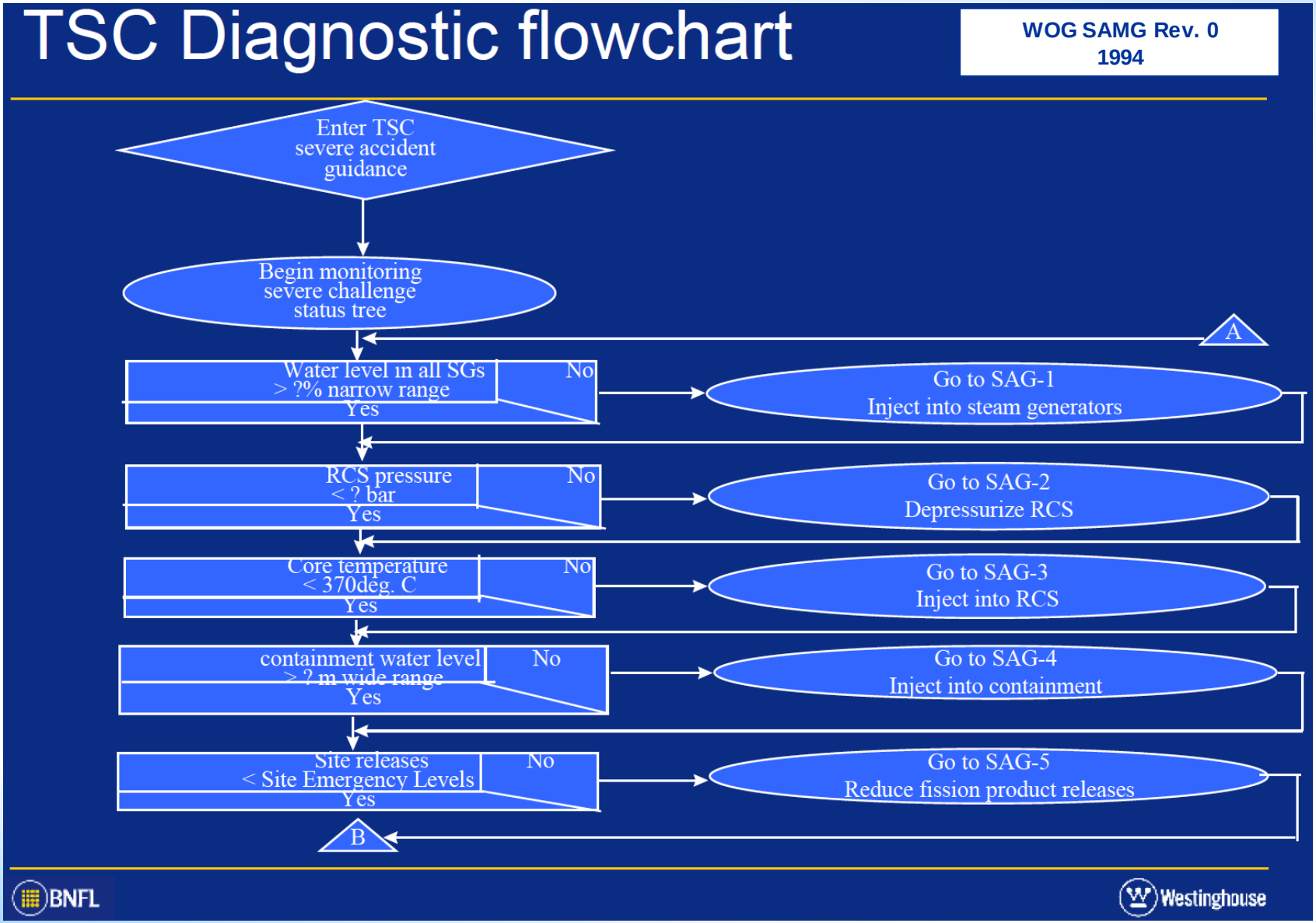
- WOG SAMGs
- PWROG SAMGs
- Example of PWR plant-specific SAMGs
- Conclusions
- References

WOG SAMG Oveview (1/7)

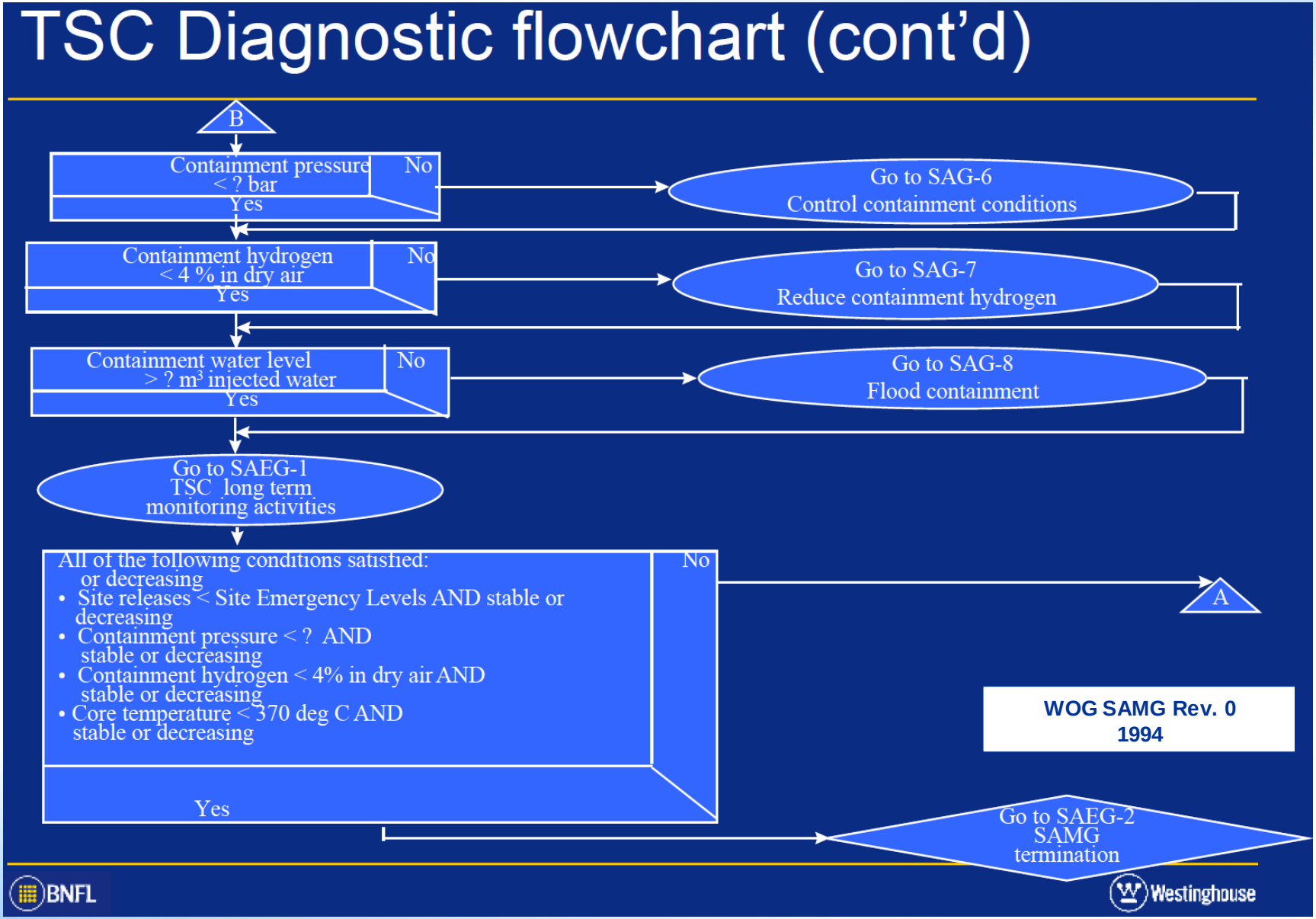
SACRGs	**Severe Accident Control Room Guidelines**		
SACRG-1	Severe Accident Control Room Guideline Initial Response		
SACRG-2	Severe Accident Control Room Guideline for Transients After the TSC is Functional		
DFC	**TSC Diagnostic Flow Chart**		
SAGs	**Severe Accident Guidelines**	SAG-1	Inject into 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
SCST	**TSC Severe Challenge Status Tree**		
SCGs	Severe Challenge Guidelines	SCG-1	Mitigate Fission Product Releases
		SCG-2	Depressurize Containment
		SCG-3	Control Hydrogen Flammability
		SCG-4	Control Containment Vacuum
SAEGs	**Severe Accident Exit Guidelines**	SAEG-1	TSC Long Term Monitoring Activities
		SAEG-2	SAMG Termination
CAs	**Computational Aids**	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

WOG SAMG Rev. 0
1994

WOG SAMG Oveview (2/7)



WOG SAMG Oveview (3/7)



WOG SAMG Overview (4/7)

- DFC Content - Severe Accident Guidelines (SAGs):
  - **SAG-1** Inject into 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

WOG SAMG Overview (5/7)

- SCST Content - Severe Challenge Guidelines (SCGs):
  - **SCG-1** Mitigate Fission Product Releases
  - **SCG-2** Depressurize Containment
  - **SCG-3** Control Hydrogen Flammability
  - **SCG-4** Control Containment Vacuum

WOG SAMG Overview (6/7)

- SAEGs - Severe Accident Exit Guidelines:
  - **SAEG-1** TSC Long Term Monitoring Activities
  - **SAEG-2** SAMG Termination

WOG SAMG Overview (7/7)

- CAs – Computational Aids:
  - **CA-1** RCS Injectino to Recover Core
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  - **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

WOG SAMG Rules of Usage (1/3)

- Base criterion: **EOPs are terminated** and SAMGs are entered at the onset of core damage.
- SAMGs are **separate documents** from the EOPs.
- **No simultaneous usage** of EOPs and SAMGs
- EOP in in effect at time 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)

WOG SAMG Rules of Usage (2/3)

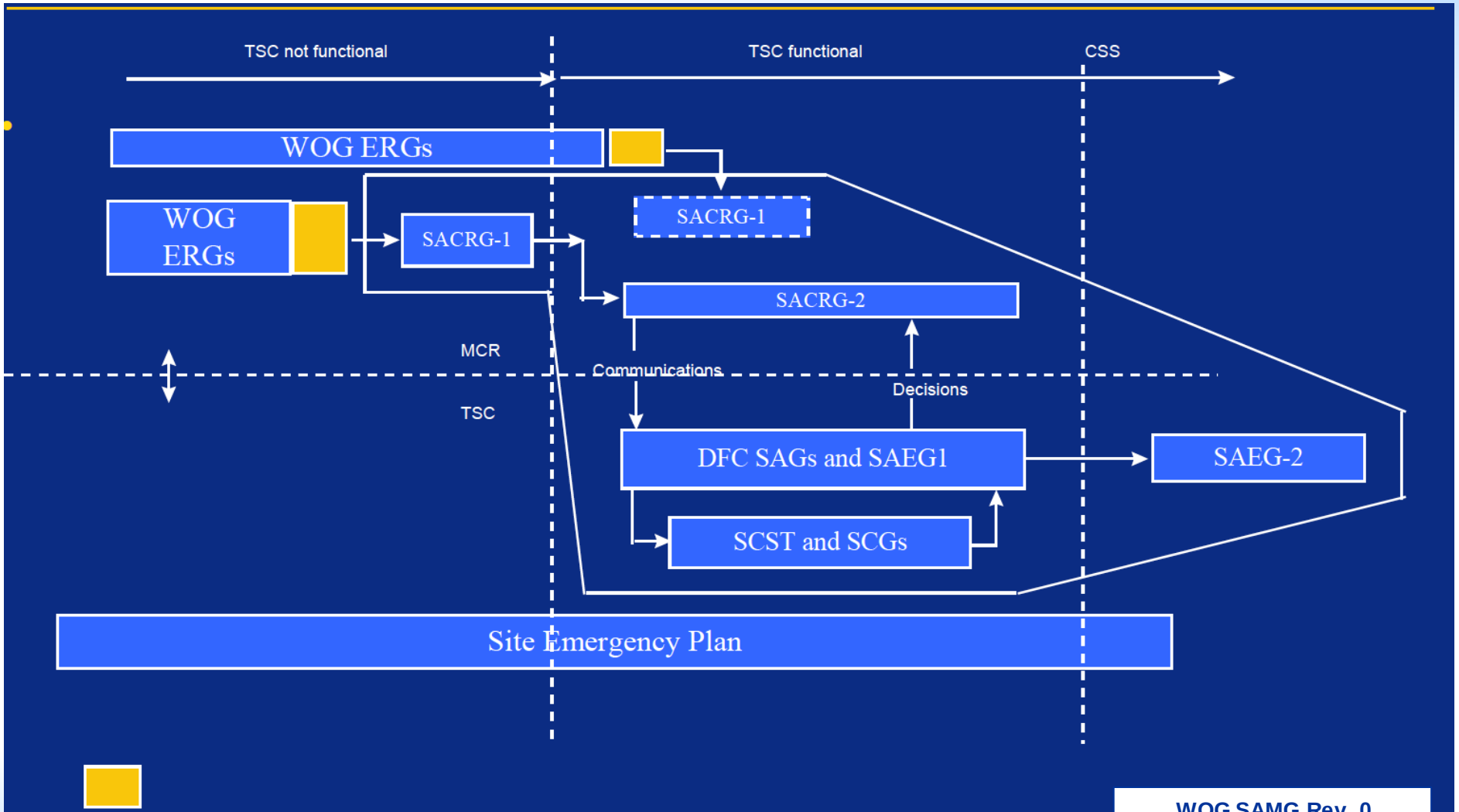
EVALUATORS : the team responsible for performing the evaluation (using the SAMGs) and recommending the appropriate recovery actions.

DECISION MAKER : Authorizes implementation of the actions recommended by the evaluation team, and has a broader understanding of the status of other aspects of the emergency response.

IMPLEMENTERS : This group performs the actions in the control room to implement the chosen strategy.

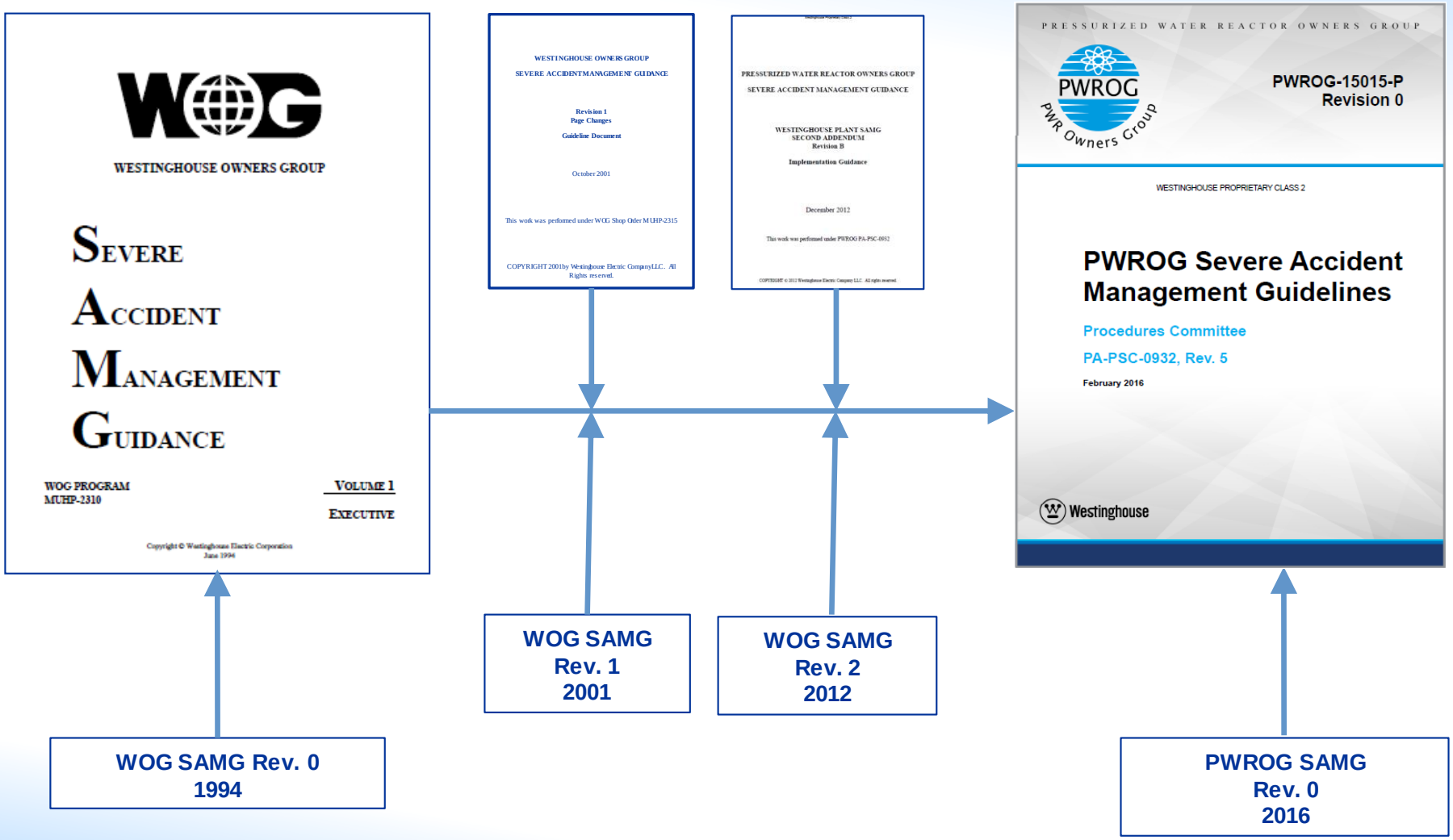
Responsibility	Evaluation	Decision	Implementation
Transition from EOPs to SAMG	Operation shift unit	Shift Supervisor	Operations shift unit (control room team)
Use of SACRGs by the control room	Operations shift unit	Shift Supervisor	Operations shift unit
SAMG evaluations, recommendations and implementation of strategy	SAMG evaluation team (TSC)	Emergency Director for decision affecting off-site response Shift Supervisor or Emergency Director for decision affecting on-site response	Operations shift unit, local action teams and External radiological monitoring team
Containment venting	SAMG evaluation team (TSC)	Emergency Director	Operations shift unit, local action teams and External radiological monitoring team
Terminate use of SAMG	SAMG evaluation team (TSC)	Emergency Director	Operations shift unit, local action teams and External radiological monitoring team
Long Term Recovery	TSC and ECC as already in the E-Plan for Recovery Actions	Emergency Director	Operations shift unit, local action teams and External radiological monitoring team

WOG SAMG Rules of Usage (3/3)



WOG SAMG Rev. 0
1994

WOG/PWROG SAMG Development



PWROG SAMG Overview (1/7)

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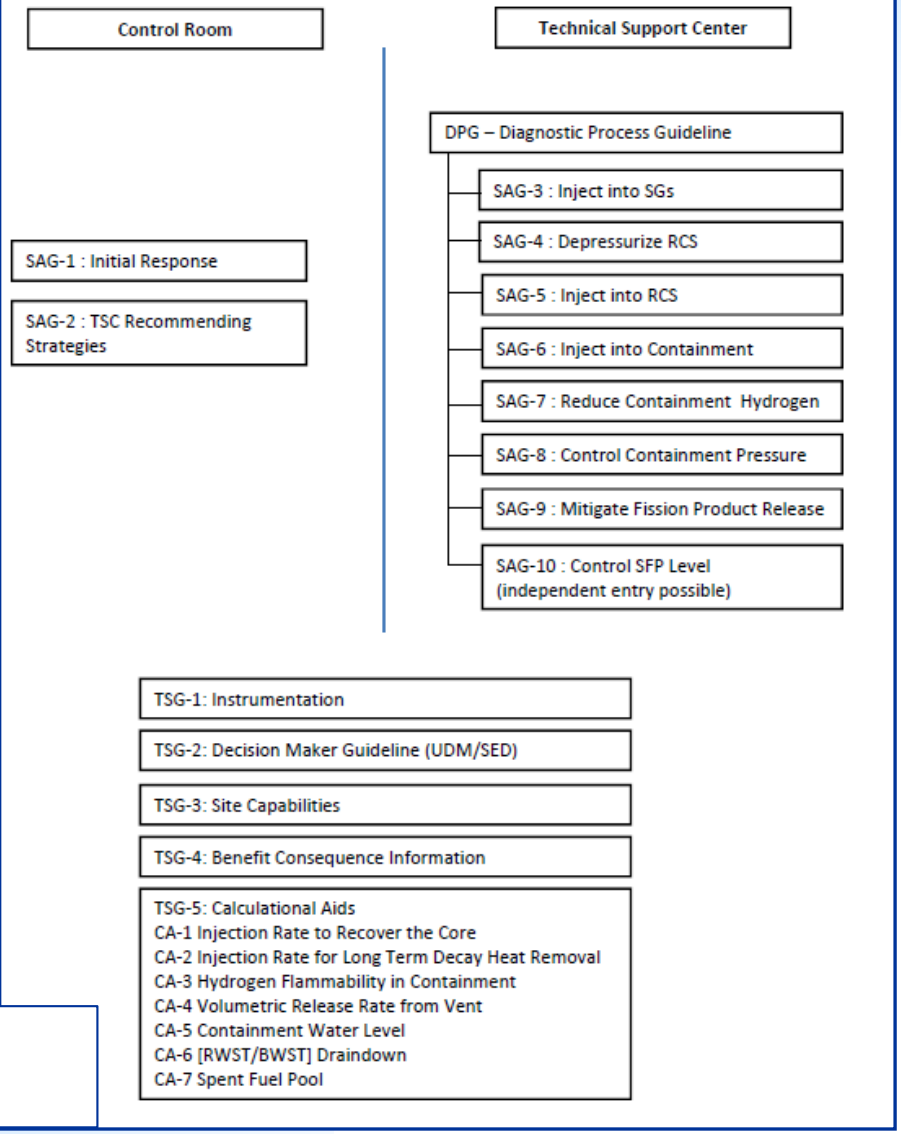
WOG SAMG Rev. 0
1994

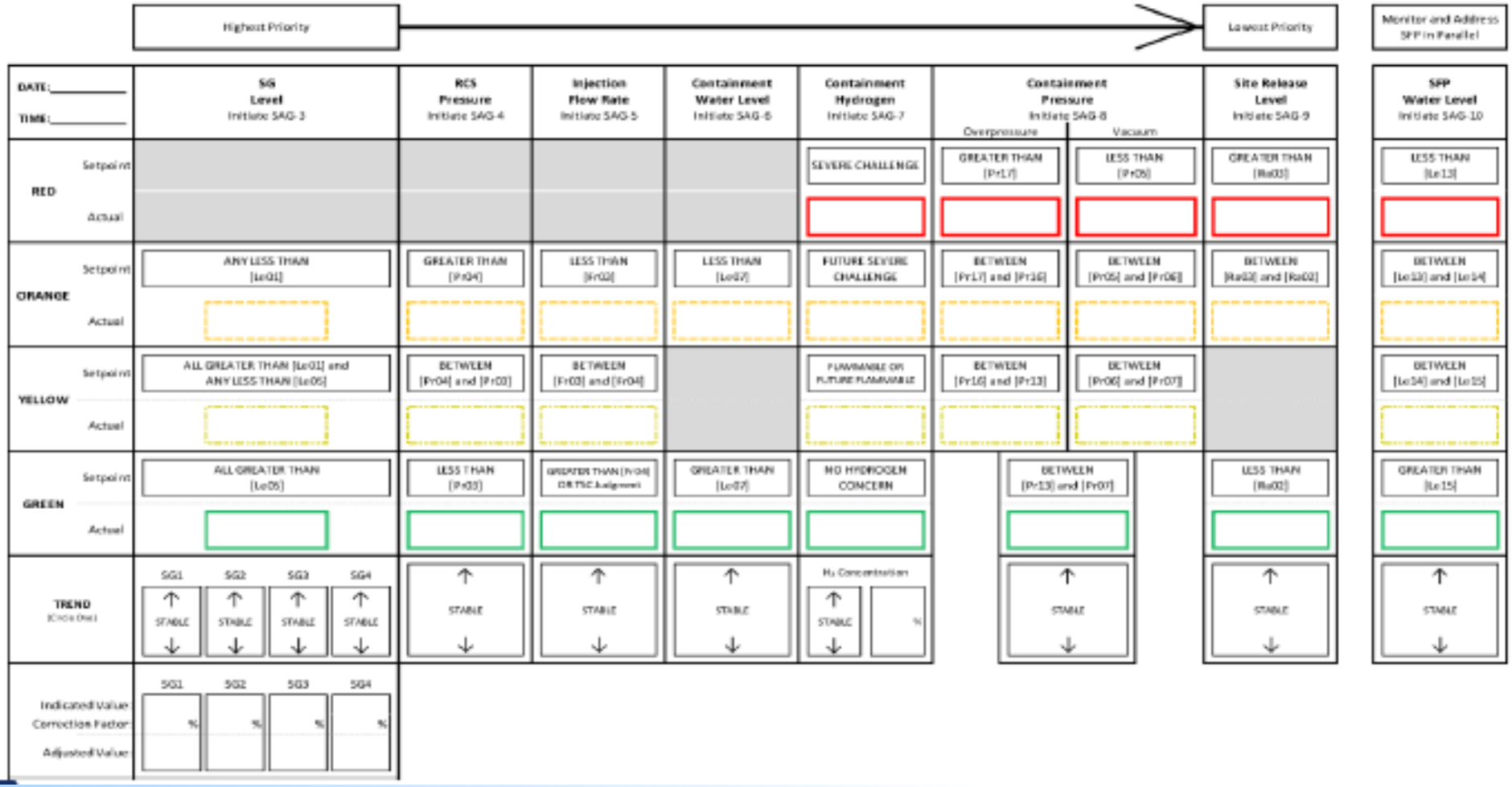
Figure 1: Main Components of the PWROG SAMG (DRAFT)



PWROG SAMG
Rev. 0
2016

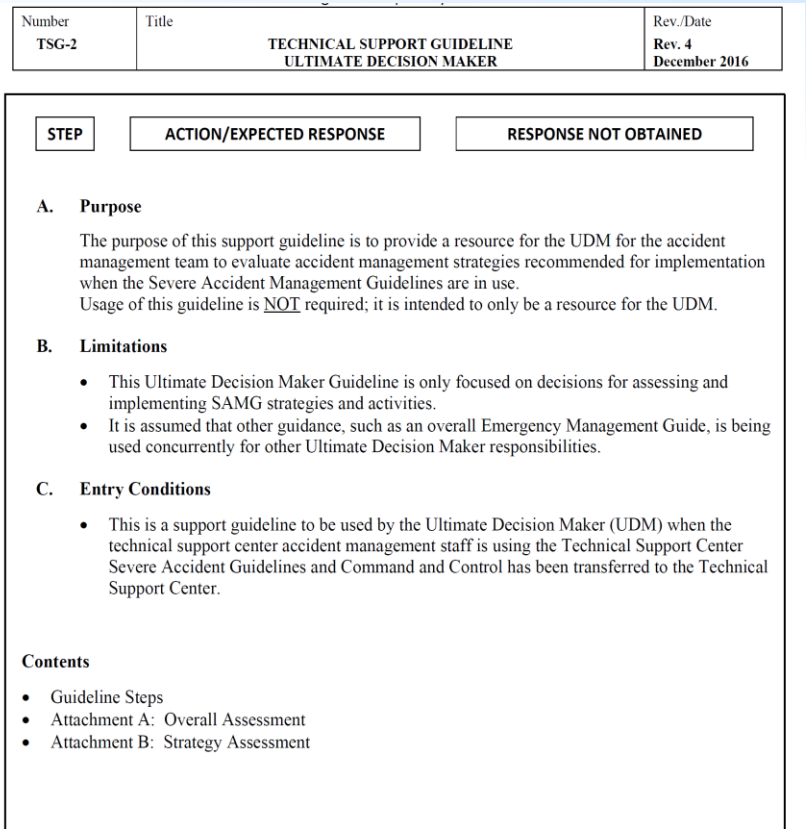
PWROG SAMG Overview (2/7)

- Diagnostic Process Guideline



PWROG SAMG Overview (3/7)

- TSGs are a new feature of the PWROG SAMG.
- "TSG" is consistent with the BWROG terminology for additional SAMG tools used by the TSC.
- TSGs provide additional information for TSC/MCR evaluations
  - TSG-1 Instrumentation Guideline
  - TSG-2 Decision Maker Guideline
  - TSG-3 Site Capabilities Guideline
  - TSG-4 Benefits and Consequences
  - TSG-5 Calculational Aids



Number	Title	Rev./Date
TSG-2	TECHNICAL SUPPORT GUIDELINE ULTIMATE DECISION MAKER	Rev. 4 December 2016

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED

A. Purpose

The purpose of this support guideline is to provide a resource for the UDM for the accident management team to evaluate accident management strategies recommended for implementation when the Severe Accident Management Guidelines are in use.
Usage of this guideline is NOT required; it is intended to only be a resource for the UDM.

B. Limitations

- This Ultimate Decision Maker Guideline is only focused on decisions for assessing and implementing SAMG strategies and activities.
- It is assumed that other guidance, such as an overall Emergency Management Guide, is being used concurrently for other Ultimate Decision Maker responsibilities.

C. Entry Conditions

- This is a support guideline to be used by the Ultimate Decision Maker (UDM) when the technical support center accident management staff is using the Technical Support Center Severe Accident Guidelines and Command and Control has been transferred to the Technical Support Center.

Contents

- Guideline Steps
- Attachment A: Overall Assessment
- Attachment B: Strategy Assessment

PWROG SAMG Overview (4/7)

- TSG-1: Instrumentation
  - This TSG provides guidance for evaluating the accuracy and reliability of plant instrumentation, contains instrumentation information (design limits, calibration details, operation details, calculated biases), guidance on cross-checking of indications with other instruments, obtaining local readings. It covers loss of all DC as well as loss of individual instrumentation.
- TSG-3: Site Capabilities
  - This TSG contains details of site mitigation equipment, both installed and portable equipment (e.g. air compressors, electrical generators and d.c. power sources). Details are pre-filled by the plant for equipment availability and location, capacity, operating requirements, etc. Site water resources and fuel resources are also be tracked.

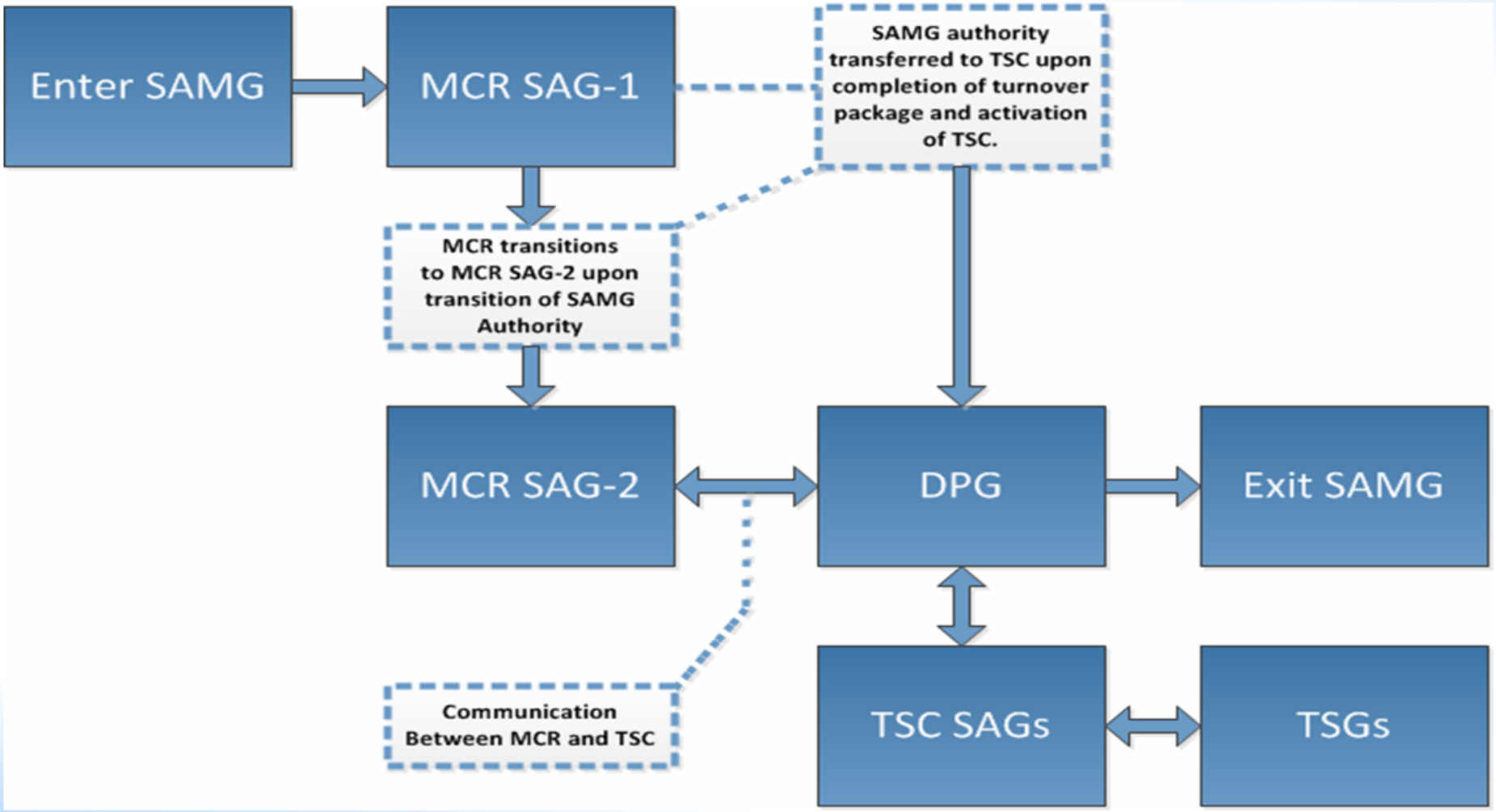
PWROG SAMG Overview (5/7)

- TSG-2: Decision Maker Guideline (UDM/SED)
  - This TSG provides the ERO Ultimate Decision Maker with guidance related to SAMG actions and potential conflicts.
  - This TSG provides the ultimate decision maker (the SED) with a tool that helps him to evaluate the appropriateness of proposed strategies in the context of:
    - personnel safety
    - physical plant damage
    - site resources
    - nuclear safety (single and multi-unit decisions)
    - regional impacts
    - regaining mitigation capability

PWROG SAMG Overview (6/7)

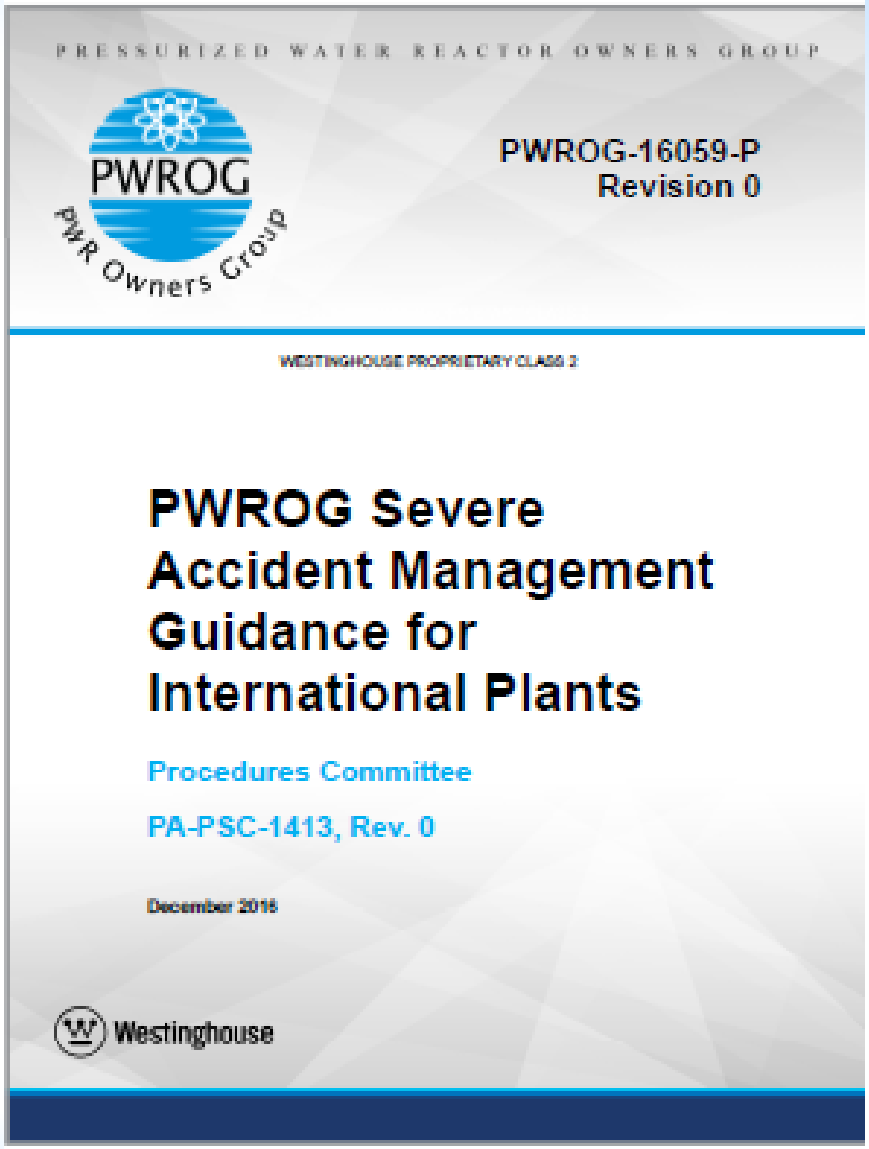
- TSG-4: Benefit Consequence Information
  - Benefit consequence evaluation has been simplified in the new SAMG by including the recommended action for most likely plant conditions directly in the SAGs. This TSG provides additional information regarding benefit/consequences of strategies.
- TSG-5: Calculation Aids
  - Calculational aids are grouped together in TSG-5.

PWROG SAMG Overview (7/7)

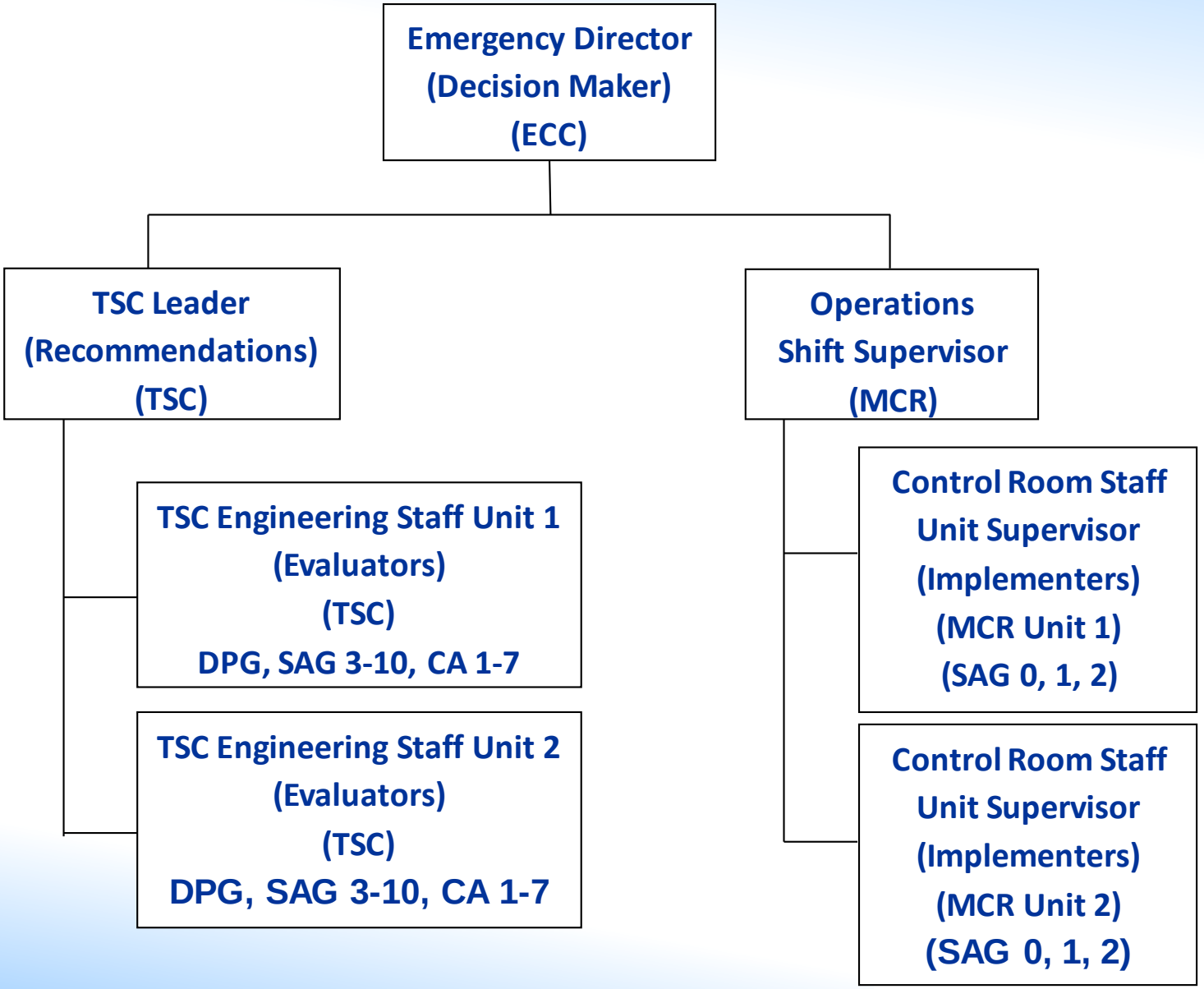


PWROG International Projects

- PWROG project PSC-1081:
  - Containment hydrogen control with PARs
  - Filtered vent system
  - Guideline for loss of all DC/ instrumentation
  - Pre- and post-vessel failure strategies and vessel failure detection
  - SAM at shutdown – alternate entry condition, diagnostics, priorities, etc.
  - Complete
- PWROG project PSC-1413:
  - Generic guideline package for international plants
  - Includes all 1081 upgrades
  - Includes selected PWROG SAMG upgrades
  - Complete



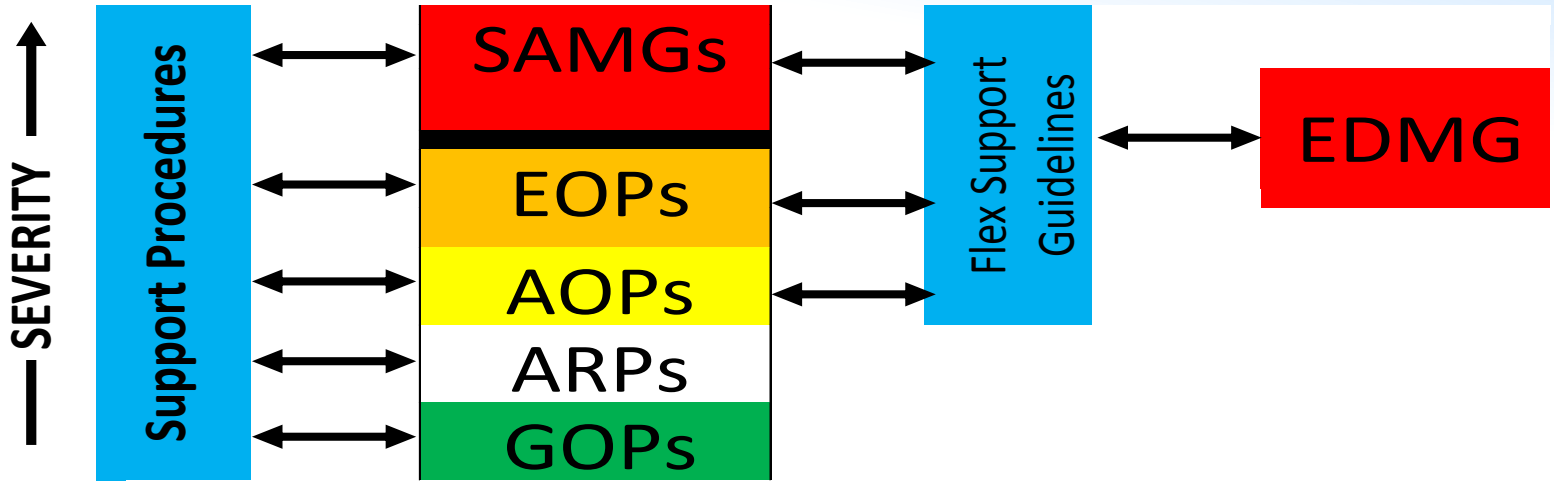
PWROG SAMG Roles and Responsibilities



PWROG SAMG Features and Comparison

	Original WOG	PWROG 15015 Consolidated US Owners Group SAMG	PWROG 16059 Updated SAMG for International Reference Plant
Reference plant	4 loop PWR	4 loop PWR	3 loop PWR
Diagnostic tools	DFC, SCST	DPG (new)	DPG (new)
Technical support guidelines	No	Included (5)	Included (3) (Other two are related to revised format below)
Modified SAG format	No	Included	Not included (existing WOG format retained)
Extended control room actions	No	Included	Included
Spent fuel pool	No	Full	Full
Shutdown (inc. modified entry)	No	Partial	Full (per PSC-1081) Containment radiation entry criterion
PARs	No	No	Included
Filtered vent	No	No	Included
Loss of d.c. guideline	No	No	Included (SAG-0)

Integration of Procedures and Guidelines



- Modified Emergency Operating Procedures (e.g., ECA-0.0, Station Blackout)
- FLEX Support Guidelines for use of mobile equipment
- Integrated PWROG Severe Accident Management Guidelines
- Generic SAMG for International Plants

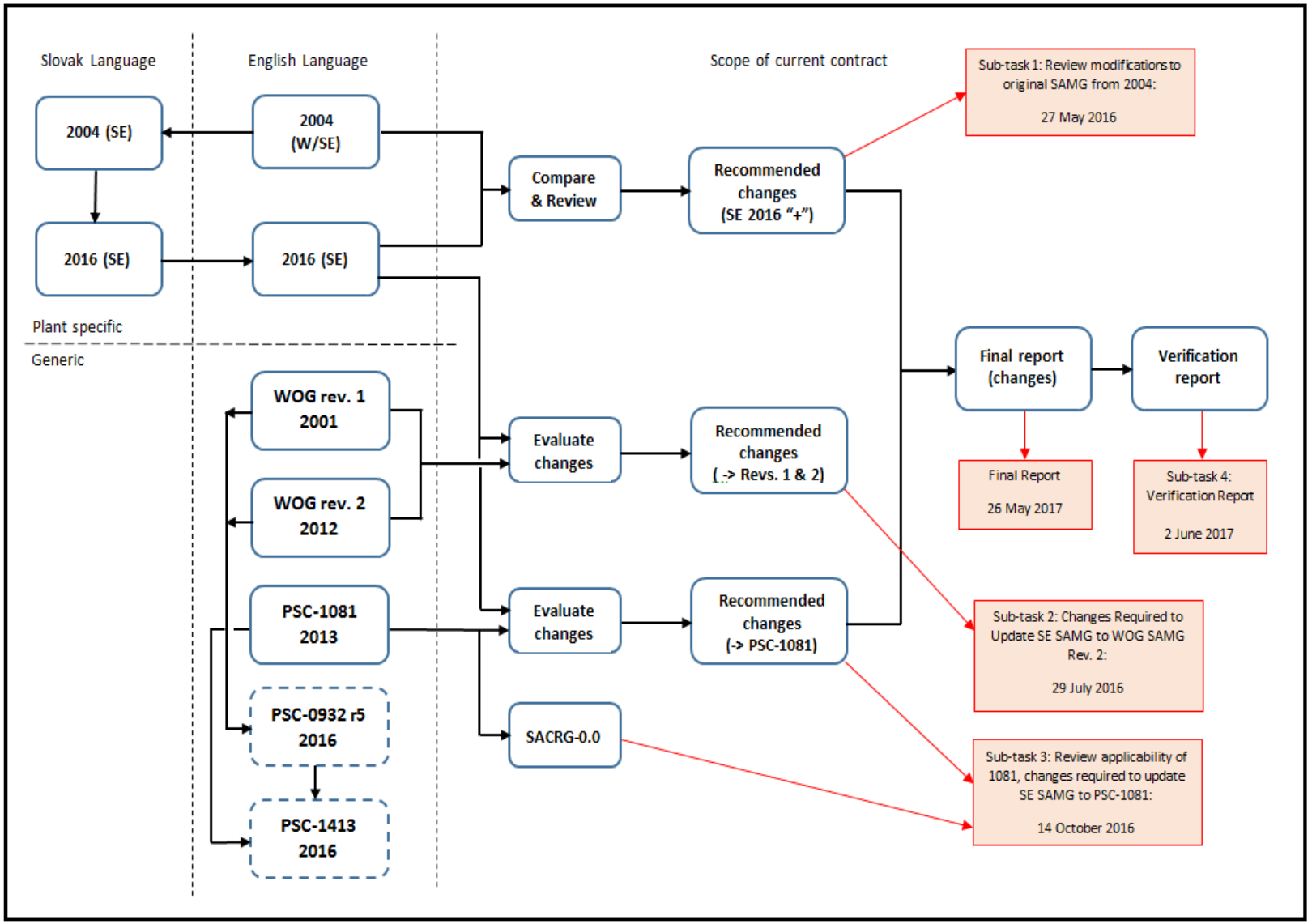
Addressing Fukushima Lessons Learned (1/2)

- Extended Station Blackout
  - Implementation of FLEX and corresponding FLEX Support Guidelines (FSG)
- Loss of instrumentation and control
  - FSG-7 and SACRG-0.0 for loss of d.c.
- One unit was in shutdown – no SAMG for shutdown
  - Extension of generic SAMG to cover shutdown states (PSC-1081/1413)
- Spent Fuel Pool cooling was lost – no SAMG for SFP cooling
  - FSG and FLEX equipment to makeup to SFP
  - Extension of generic SAMG to cover spent fuel pool accidents

Addressing Fukushima Lessons Learned (2/2)

- Use of seawater – potential precipitation issues
  - EPRI TBR update and WOG SAMG rev. 2 guidance
- Multi-unit accident
  - TSGs for Decision Maker
  - N+1 FLEX equipment
- Site disruption – TSC unavailable/late
  - Restructuring of control room SAGs – some actions systematic by operators
  - EDMG for loss of command and control

Example: Bohunice NPP SAMGs (1/4)



Example: Bohunice NPP SAMGs (2/4)

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Control Room

SACRG-0:
Severe Accident Control Room Guideline
Loss of DC and/or Instrumentation

SACRG-1:
Severe Accident Control Room Guideline
Initial Response

SACRG-2:
Severe Accident Control Room Guideline
TSC Functional

SACRG-3:
Severe Accident Control Room Guideline
Shutdown Modes Initial Response

SACRG-4:
Severe Accident Control Room Guideline
Shutdown Modes TSC Functional

Technical Support Center

Diagnostic Flow Chart (DFC)

Severe Challenge Status Tree (SCST)

Severe Accident Guidelines:

SAG-1: Depressurize the RCS
SAG-2: Inject into RCS
SAG-3: Inject into Containment and Cavity Flooding
SAG-4: Reduce Fission Product Releases
SAG-5: Inject into Steam Generators
SAG-6: Control Containment Conditions
SAG-7: Refill the Spent Fuel Pool

Severe Challenge Guidelines:

SCG-1: Mitigate Fission Product Releases
SCG-2: Depressurize Containment
SCG-3: Reduce Containment Hydrogen
SCG-4: Control Containment Vacuum
SCG-5: Recover Spent Fuel Pool Level

Computational Aids CA-1 to 9

CA-1: RCS Injection to Recover the Core
CA-2: Injection Rate for Long Term Decay Heat Removal
CA-4: Vent Mass Flow
CA-5: Containment Water Level and Volume
CA-6: Potential Containment Vacuum Severe Challenge
CA-7: Hydrogen Concentration in Long Term Stable Condition
CA-8: Radiation Level as a function of Time after Shutdown
CA-9: Coolant Flow needed for SFP Residual Heat Removal

SAEG-1
TSC Long Term Monitoring Activities

SAEG-2
SAMG Termination

Example: Bohunice NPP SAMGs (3/4)

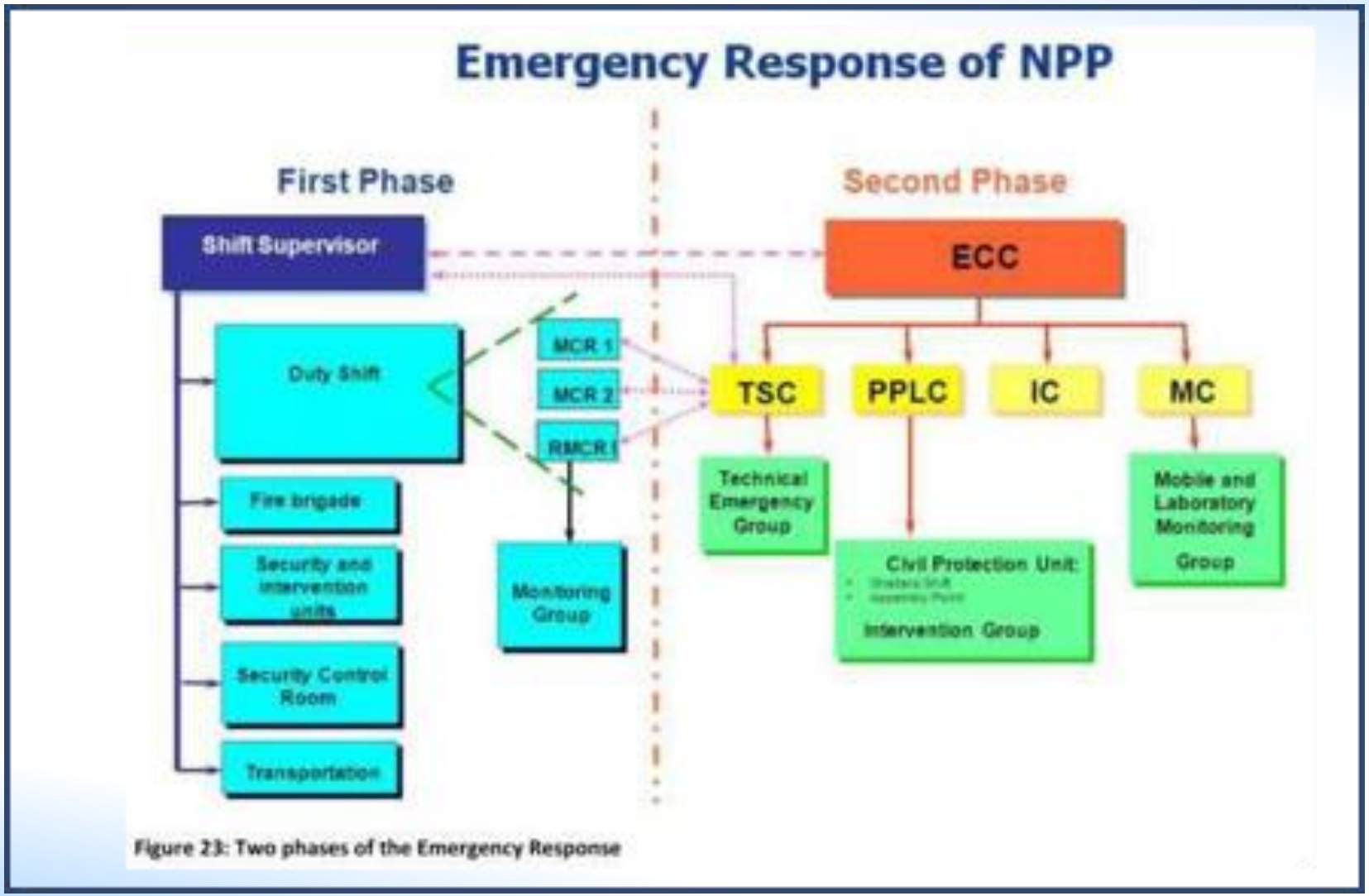
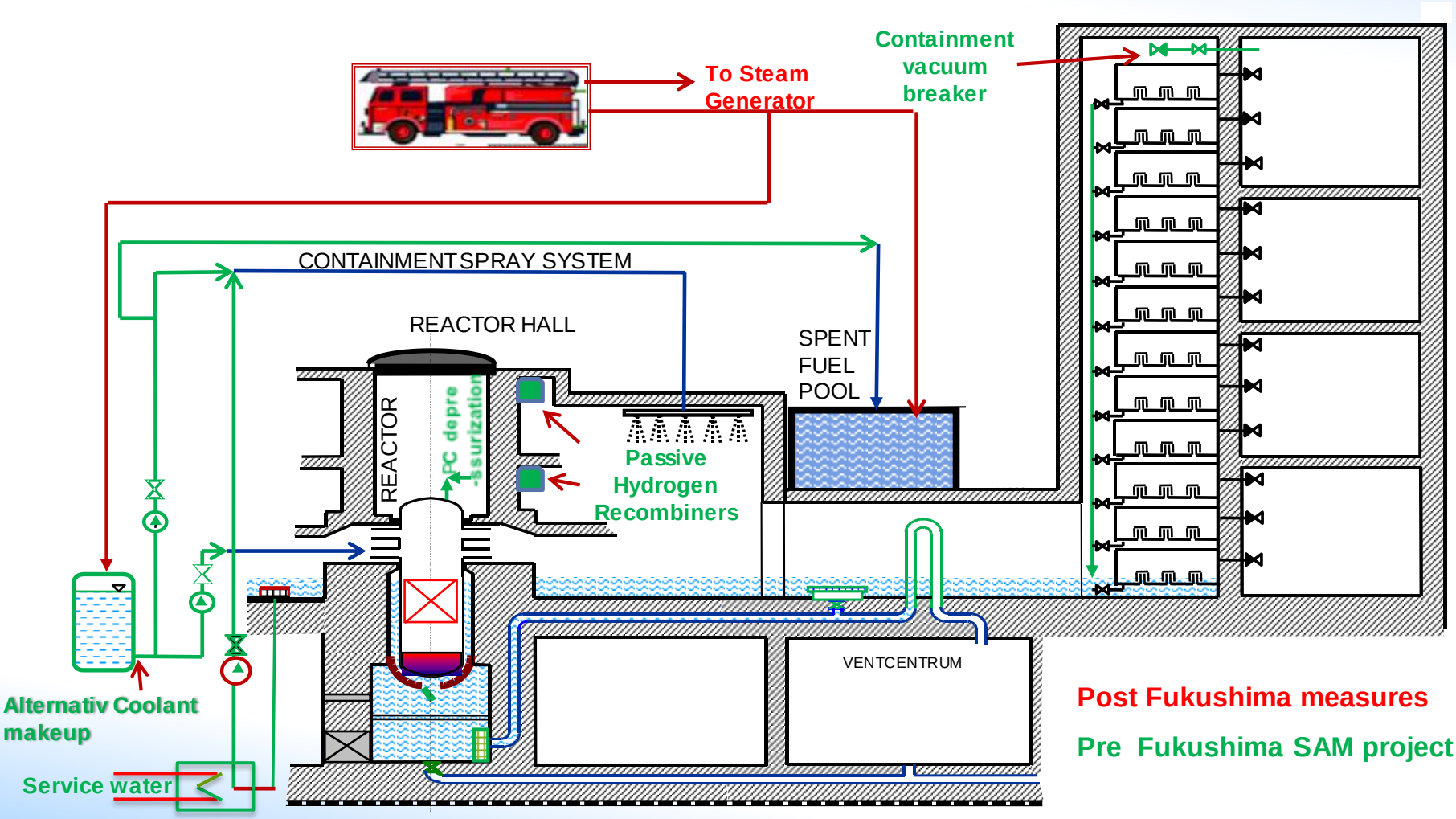


Figure 23: Two phases of the Emergency Response

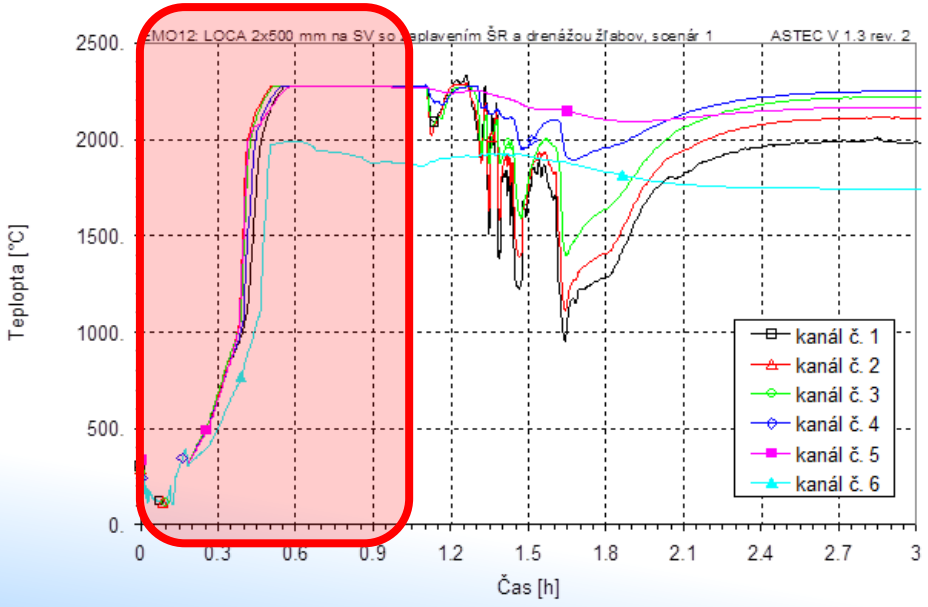
Example: Bohunice NPP SAMGs (4/4)



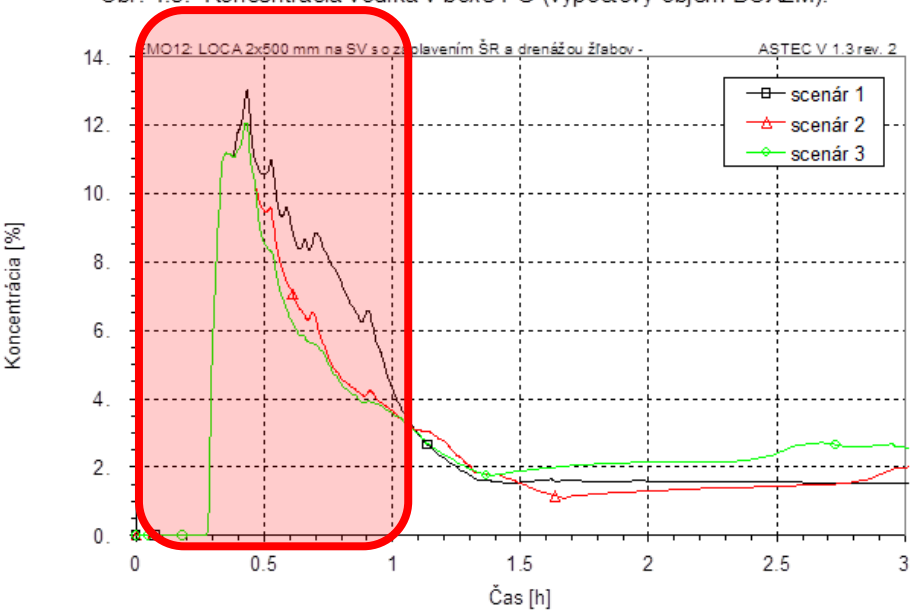
Example: Bohunice NPP SAMGs – LB LOCA w/o ECCS (1/5)

- EOP – SAMG transition based on CET > 1000°C
  - E-0 -> E-1 -> FR-C.1 -> SACRG-1

Obr. 1.9. Teplota na výstupe z AZ.



Obr. 4.9. Koncentrácia vodíka v boxe PG (výpočtový objem BOX2M).



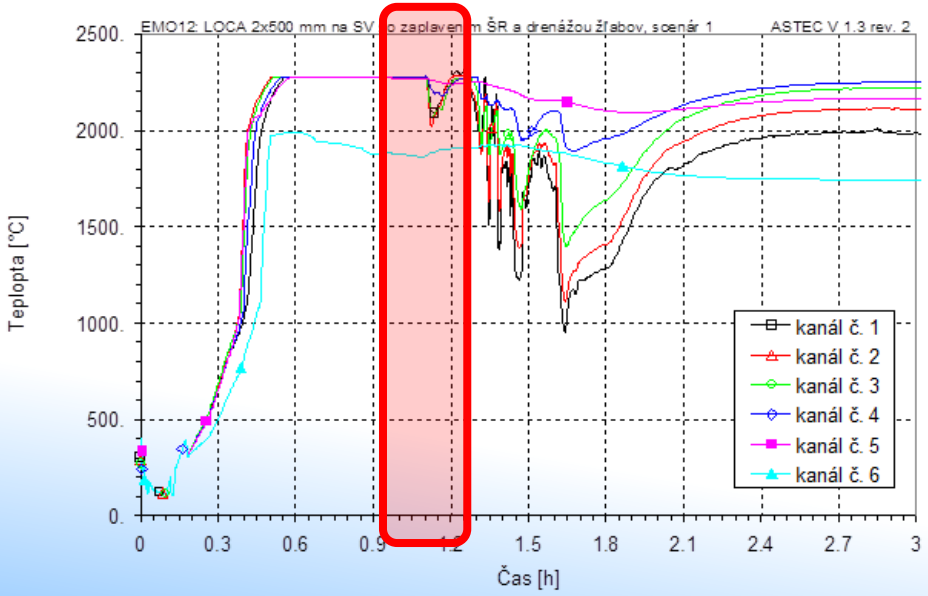
Example: Bohunice NPP SAMGs – LB LOCA w/o ECCS (2/5)

- SACRG-1 MCR actions:
  - RCS depressurization: via LB LOCA event
  - Containment flooding: via LB LOCA event
  - Reactor cavity floding: performed by MCR
  - Containment spray trip: performed by MCR
  - Inject into the RCS: performed by MCR using diverse SA dedicated RCS make-up
  - Inject into SGs: performed by MCR using EFW or firetruck

Example: Bohunice NPP SAMGs – LB LOCA w/o ECCS (3/5)

- State at the MCR – TSC turnover
  - Reactor cavity flooded, IVR ongoing, contrainment spray tripped, injection into RCS and SGs established
  - Core relocation ongoing, hydrogen concentration decreasing and below 6%
  - TSC starts to monitor DFC/SCST

Obr. 1.9. Teplota na výstupe z AZ.



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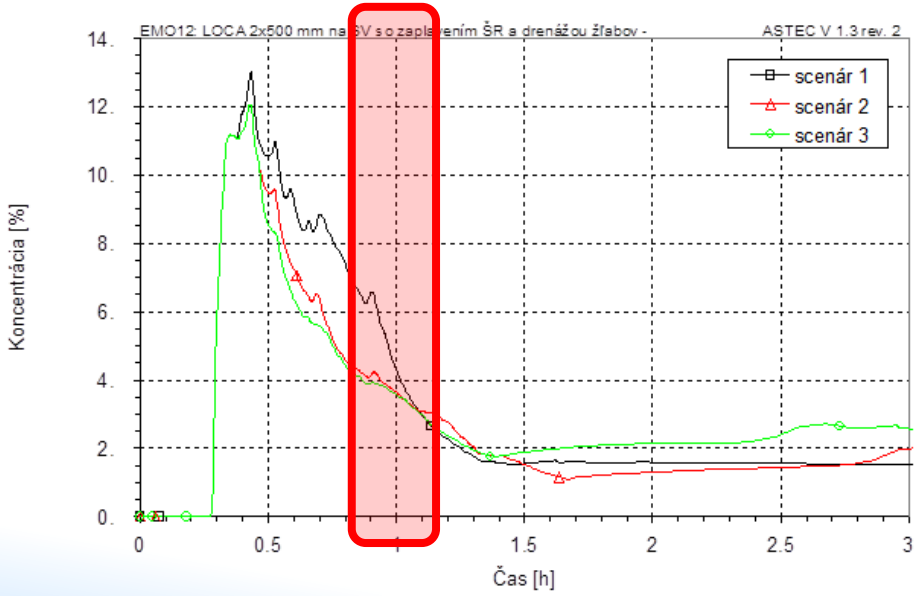
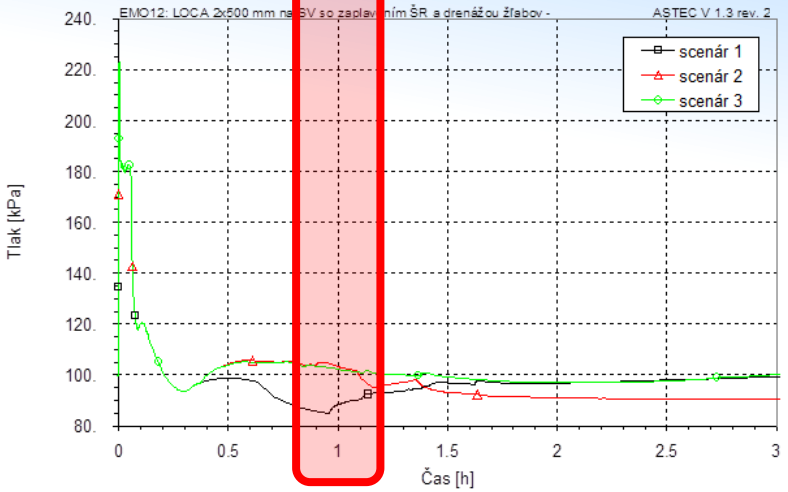


Example: Bohunice NPP SAMGs – LB LOCA w/o ECCS (4/5)

- TSC Diagnostics
  - DFC: Inject into the RCS as per SAG-2
  - The rest of the DFC/SCST entry setpoints clear

Obr. 4.1. Tlaky v boxe PG.



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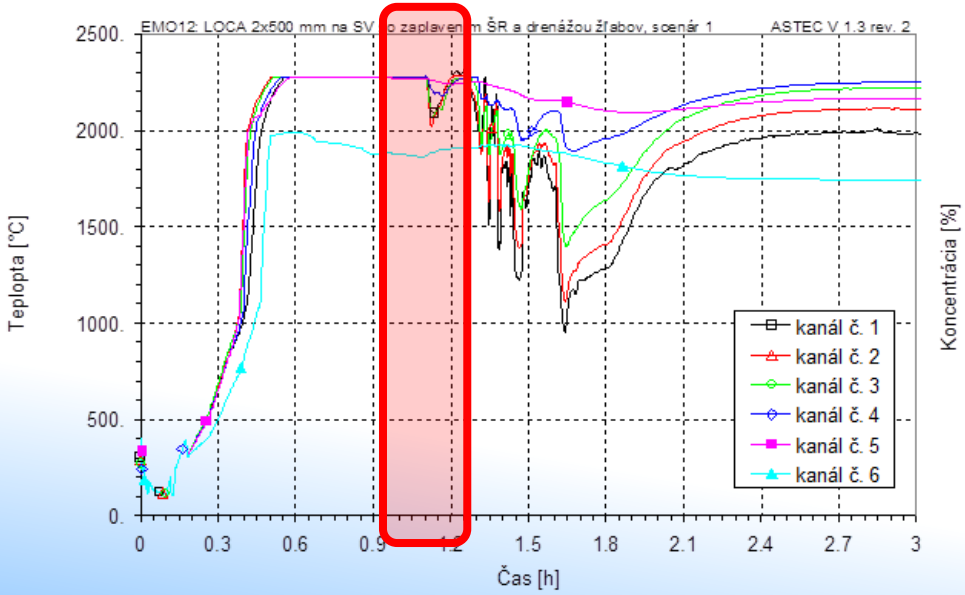

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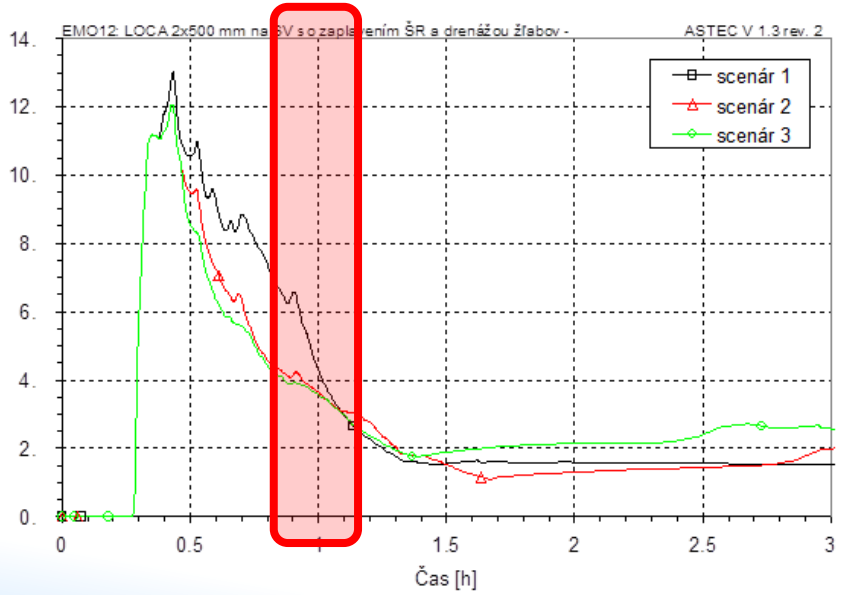
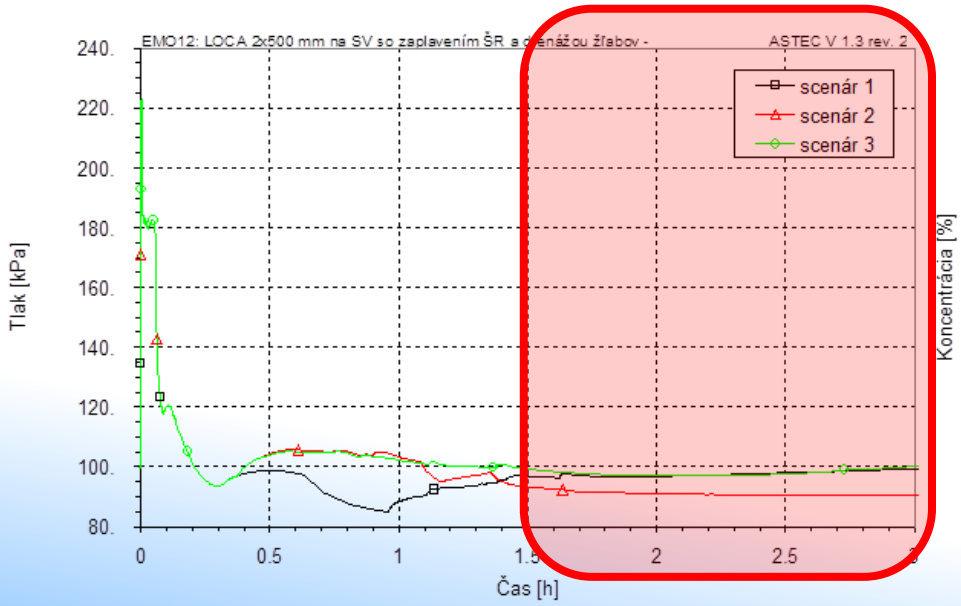


Example: Bohunice NPP SAMGs – LB LOCA w/o ECCS (5/5)

- SAMG termination
  - Reactor cavity flooded, IVR ongoing
  - Contrainment spray periodicaly operated to maintain containment pressure
  - Injection into RCS and SGs established
  - Long-term heat removal from containment established

Obr. 4.1. Tlaky v boxe PG.



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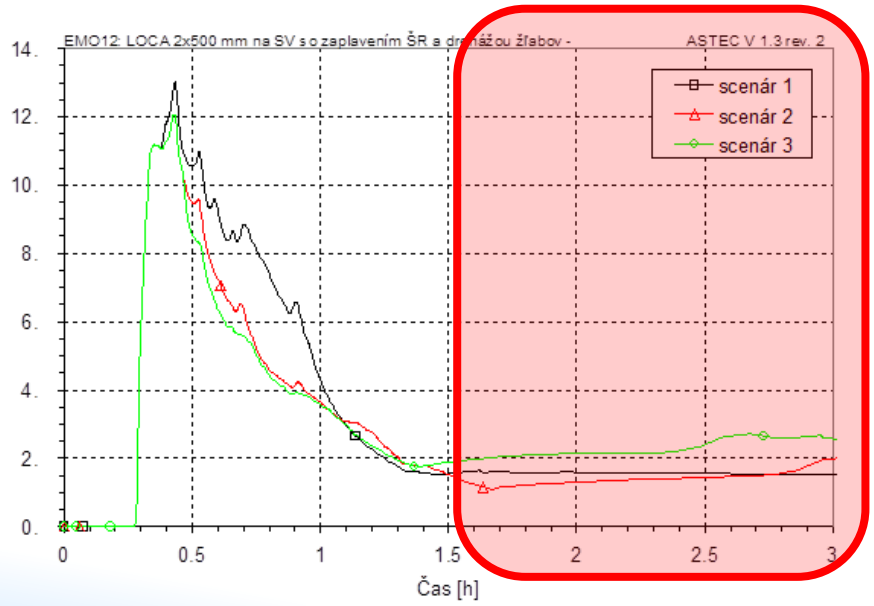

Conclusions

- Wide experience in implementing plant specific SAMG based on the original WOG guidelines
- While generic SAMG were revised periodically, the Fukushima accident revealed additional areas requiring attention
- Following Fukushima, PWROG programs were launched to address these areas, to integrate PWR SAMG (in US) and to provide specific guidance for International Plants
- Numerous improvements, including additional guidance for the Emergency Director
- Integrating revised SAMG with other plant specific guidance and procedures provides for a comprehensive accident management capability

References (1/2)

- ”The WOG SAMG approach and its plant-specific adaptation”, N. Dessars, Westinghouse Electric Europe, Workshop on Severe Accidents Related Issues, Prague, Czech Republic, June 17-18, 2003.
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Questions?