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Attention: Jim Wilson

SUBJECT: **INFC RMATION ON EPG/SAG RESPONSE FOR A SHORT-TERM STATION BLACKOUT STATION BLACKOUT SCENARIO**

As part of the NRC staff's review of the BWROG Emergency Procedure and Severe Accident Guidelines (EPG/SAG), the BWROG was requested to provide typical timelines for accident progression with operator actions for the Short-Term Station Blackout (SBO) scenario. In support of this request the staff provided time lines and parameter values from several NRC studies for use by the BWROG. Enclosure 1 describes the actions which would be taken in accordance with the BWROG EPG/SAG for a Short-Term SBO with ADS actuation at a BWR/4 (Browns Ferry/Peach Bottom). Enclosure 2 describes the actions which would be taken in accordance with the BWROG EPG/SAG at a BWR/6 (Grand Gulf).

This information is being provided for your use in understanding the response of BWRs to severe accidents such as the SBO. If you have any questions regarding this enclosed information, please contact Bill Williamson (TVA) at (205) 729-2455 or Wayne Russell (Entergy) at (601) 437-2717.

Best regards,

Kevin P. Donovan

Kevin P. Donovan, Chairman
BWR Owners' Group

Enclosure: 1. Information on EPG/SAG Response for a Short-Term Station Blackout Scenario for a BWR/4
2. Information on EPG/SAG Response for a Short-Term Station Blackout Scenario for a BWR/6

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x RD-10-1

INFORMATION ON EPG/SAG RESPONSE FOR A SHORT-TERM STATION BLACKOUT SCENARIO FOR A BWR/4

The following discussion describes the actions which would be taken in accordance with the BWROG EPG/SAG for a short-term Station Blackout (SBO) with ADS actuation at a BWR/4. The scenario data and time line was provided by ORNL through the NRC. The scenario is taken from NUREG/CR-5869, Identification and Assessment of BWR In-Vessel Severe Accident Mitigation Strategies, and from NUREG/CR-2182, Station Blackout at Browns Ferry Unit One-Accident Sequence Analysis. Since the scenario in NUREG /CR-5869 models the EPG actions from a previous revision of the EPGs, the scenario was utilized from the initiating time until the RPV water level reached the Minimum Steam Cooling RPV Water Level (MSCRWL) and then the Minimum Zero Injection RPV Water Level (MZIRWL) at which time Emergency RPV Depressurization is required. The scenario is picked back up at the time of the manual ADS. The hydrogen generation and concentration after the core heats up is estimated based upon the hydrogen generation reported in NUREG/CR-2182 for the TUB' (a transient event with failure to recover either offsite or onsite AC power within 1 to 4 hours and failure of both HPCI and RCIC) sequence.

The scenario as provided does not credit any RPV injection prior to RPV breach due to melted core. Due to this limitation, very little action can be taken by the ERO and plant staff. This scenario is useful in that it provides a worst case time line to determine when the ERO would be manned compared to when the SAG is entered. It also provides an opportunity to explain the transitions within the EPG/SAG as plant conditions change.

A more realistic scenario would be to credit the use of the fire system for RPV emergency injection. RPV injection from the fire system does not require electrical power. There is one installed diesel driven fire pump. This pump is capable of achieving the necessary RPV injection flow rate. Use of the fire system is proceduralized and only requires starting of the pump and manually opening several valves. This is expected to require 30-60 minutes to line up.

Both cases are evaluated to illustrate the symptomatic nature of the BWROG EPG/SAG. A single description is provided to the point where emergency RPV depressurization occurs. RPV emergency injection from the fire system cannot occur until the RPV is depressurized. Two discussions are provided from that point on to describe the strategy differences with and without injection from the fire system.

Time: 0 seconds

Loss of offsite power-initiated scram from 100% power.
Failure of on-site A/C power. Independent loss of turbine-driven HPCI and RCIC systems. Loss of instrumentation which is not powered from DC source (drywell temperature, hydrogen and oxygen monitors, drywell radiation monitors, wide range suppression pool level instruments).

The RPV Control EPG is entered due to RPV water level decreasing below the Low Level Scram Setpoint (LLSS) or due to RPV pressure increasing above the High Pressure Scram Setpoint (HPSS).

RC/Q guidance:

Place the mode switch in the shutdown position.
Verify all control rods are fully inserted.
Exit RC/Q and enter the scram procedure.

RC/P guidance:

Stabilize RPV pressure below 1045 psig with SRVs (the SRVs are used in a sequence to equalize the heat distribution to the suppression pool).
Depressurize the RPV and maintain cooldown rate less than 100 °F per hour (the shift crew is expected to minimize RPV cooldown due to lack of makeup capability).

RC/L guidance:

Note: Due to loss of all electric and steam driven injections sources, RPV water level decreases and cannot be restored and maintained above the LLSS.
The level control band lower limit expands from LLSS to the top of active fuel (TAF).

Emergency Classification:

ALERT classification is declared based on event in progress which involves substantial degradation in safety of the plant.

Time: 50 seconds

Drywell temperature exceeds the maximum normal operating temperature but due to the loss of indication, drywell temperature cannot be monitored by the shift crew.

Time: 130 seconds

The Primary Containment Control Guideline is entered based on suppression pool temperature reaching the most limiting suppression pool temperature LCO.

SP/T Guidance:

Due to lack of AC power, no suppression pool cooling is available. The shift will monitor the suppression pool temperature and RPV pressure to determine when the parameters cannot be maintained below the Heat Capacity Temperature Limit (HCTL) and EMERGENCY RPV DEPRESSURIZATION IS REQUIRED.

DW/T Guidance:

Due to lack of AC power, direct drywell temperature indication is not available. The shift crew is expected to determine that drywell temperature cannot be maintained below the maximum normal operating temperature. The shift crew could determine that drywell temperature cannot be maintained below the drywell design temperature, but it is expected that they would not under these conditions due to lack of makeup capability if the RPV is depressurized. At some point, it is expected that the shift crew would estimate drywell temperature based on the drywell pressure increase being due to adiabatic heatup of the drywell. Due to lack of AC power, no drywell cooling is available nor are drywell sprays available.

The shift will monitor drywell temperature indirectly to determine when it cannot maintained below the drywell design temperature and EMERGENCY RPV DEPRESSURIZATION IS REQUIRED.

PC/P Guidance:

Due to lack of AC power, containment pressure control systems and SBGT cannot be used to maintain primary containment pressure below the high drywell pressure scram setpoint (HDPSS). The shift will monitor primary containment pressures to determine when it exceeds the HDPSS.

SP/L Guidance:

The shift will monitor suppression pool level using the narrow range suppression pool level instruments to determine when it cannot be maintained below the SRV Tail Pipe Limit (SRVTPL) and EMERGENCY RPV DEPRESSURIZATION IS REQUIRED.

PC/G Guidance:

The shift will be unable to monitor directly hydrogen and oxygen concentrations in the suppression chamber and drywell. The shift crew is expected to determine that there is no hydrogen present based on RPV water level above TAF and that the primary containment remains inerted based upon drywell pressure and suppression chamber pressure remaining above atmospheric pressure. As long as the drywell and suppression chamber are inerted and no hydrogen is detected, no action is required.

Expected Priorities:

Establish RPV injection from any available source. At this point it would be expected that four areas would be pursued: (1) restoration of electrical power; (2) restoration of RCIC; (3) restoration of HPCI; and (4) lining up the fire system for emergency RPV injection.

Time: 4.5 minutes

The Primary Containment Control Guideline is re-entered based on primary containment pressure reaching the HDPSS.

PC/P Guidance:

PC/P-1, -2, and -3 are entered and executed simultaneously.
PC/P-1 directs the operator to monitor suppression chamber pressure to determine when SUPPRESSION POOL SPRAY IS REQUIRED. (With no AC power available, suppression pool sprays are inoperable).
PC/P-2 directs the operator to monitor the Pressure Suppression Pressure to determine when EMERGENCY RPV DEPRESSURIZATION IS REQUIRED.
PC/P-3 directs the operator to vent the primary containment before the suppression chamber pressure reaches the Primary Containment Pressure Limit A (PCPL A), defeating interlocks if necessary and irrespective of offsite radioactivity release rate. (This action can be accomplished using the hardened wetwell vent which are DC powered).
The other actions remain the same.

Expected Priorities:

Establish RPV injection from any available source. At this point it would be expected that four areas would be pursued: (1) restoration of electrical power; (2) restoration of RCIC; (3) restoration of HPCI; and (4) lining up the fire system for emergency RPV injection. Due to the low value of suppression chamber and drywell pressure (~1 psig, ~2.5 psig, respectively), it is expected the shift will not vent the primary containment at this time.

Time: 5.5 minutes

The Primary Containment Control Guideline is re-entered based on suppression pool water level reaching the maximum suppression pool water level LCO. The actions remain the same.

Time: 21 minutes

RPV downcomer water level decreases to the ADS setpoint; at this point the crew is likely to transfer from RC/L to Contingency 1 in the RPV Control EPG. However, the determination of when RPV water level cannot be maintained above the TAF is a judgment call. The SRO could make this determination as soon as it is determined that no injection is available or when RPV water level actually decreases to TAF.

Emergency Classification:

SITE AREA EMERGENCY classification declared based on determination that RPV water level cannot be maintained above TAF.

Time: 32.3 minutes

RPV downcomer water level decreases to the bottom of the wide range level instruments range. Transition to the Post Accident Water Level indicators. These instruments measure the collapsed in shroud RPV water level.

Time: 36 minutes

RPV collapsed water level decreases to TAF.

Note: At this time the shift must decide that RPV water level cannot be maintained above the TAF. This is a judgment call and could be made earlier; however, the timing is not critical for this event.

RC/L Guidance:

Exit RC/L and enter EPG Contingency #1.

C1 Guidance:

Prevent automatic operation of ADS.

RC/P Guidance:

Continue to control RPV pressure using SRVs. The SRVs are used in sequence to equalize the heat distribution to the suppression pool.

Primary Containment Control EPG Guidance:

Continue to monitor parameters for requirement to Emergency Depressurize.

Expected Priorities:

Shift priorities remain establishing RPV injection from any available source. If the fire system is available, it would be reasonable for the shift to place a higher priority on lining up the fire system for RPV injection by this time. If the Fire System is not available, priorities would be set based on perceived success paths.

Note: The fire system RPV injection requires manual opening of several large valves in the secondary containment. With two operators, lineup of the fire system for RPV injection requires at least 45 minutes. With more operators it could be lined up within 20-30 minutes. It can reasonably be expected that the fire system would receive high priority and more than minimum operators assigned to align it. The shutoff head for the fire system is 150 psig in the RPV. The fire system is capable of injecting up to 3700 gpm.

C1 Guidance:

When RPV collapsed water level drops to TAF, because no injection subsystem can be lined up for injection, specific guidance is provided to line up the fire system for injection, start the pumps, and increase injection flow to the maximum.

Expected Priorities:

Shift priorities remain establishing RPV injection from any source. If the fire system is available, it is reasonable that the shift would now consider lining up the fire system for RPV injection as the highest priority and reduce lineup time by utilizing additional personnel. If the fire system is not available, priorities would be set based perceived restoration success.

Emergency Classification:

A GENERAL EMERGENCY is declared based on determining that RPV water level cannot be restored and maintained above TAF (This is a judgment call and could occur earlier.)

Time: 38.5 minutes

RPV swollen water level (two-phase) reaches TAF. This cannot be monitored by the unit operator. Core uncovery begins.

Time: 44 minutes

RPV collapsed water level reaches the Minimum Steam Cooling RPV Water Level (MSCRWL).

C1 Guidance:

STEAM COOLING IS REQUIRED. This causes RC/P to be exited and Contingency 3 to be executed for RPV pressure control.

C3 Guidance:

Stabilize RPV pressure using the SRVs. The SRVs are used in sequence to equalize the heat distribution to the suppression pool.

Expected Priorities:

Shift priorities remain establishing RPV injection from any source. If the fire system is available, the shift most likely has placed the highest priority on lining up the fire system for RPV injection with the pump running before RPV collapsed water level reaches the Minimum Zero Injection RPV Water Level (MZIRWL). If the fire system is not available, priorities would be set based on perceived success paths.

Time: 45.2 minutes
RPV collapsed water level reaches MZIRWL

C3 Guidance:

When RPV water level drops to MZIRWL, EMERGENCY RPV DEPRESSURIZATION IS REQUIRED.
Exit C3 and enter Contingency 2, Emergency RPV Depressurization

C2 Guidance:

Rapidly depressurize the RPV, irrespective of the resulting cooldown rate, by opening all ADS valves.

C1 Guidance:

If no injection system is available, the shift must decide that RPV water level cannot be restored and maintained above the MSCRWL and PRIMARY CONTAINMENT FLOODING IS REQUIRED.

The entire EPG is exited and the SAG is entered.

The RPV and Primary Containment Flooding SAG is entered due to Primary Containment Flooding being required.

RC/F Guidance:

Step RC/F is used to determine the appropriate flooding step for existing plant conditions.
Step RC/F-3 is entered because:

RPV level cannot be restored and maintained above TAF; and it can be determined that core debris has not breached the vessel;

Restore and maintain RPV water level above BAF, maximizing injection into the RPV and primary containment from sources external to primary containment;

If venting the primary containment will facilitate primary containment flooding, vent the primary containment, defeating isolation interlocks if necessary and irrespective of offsite radioactivity release rate.

RC/P Guidance:

Rapidly depressurize the RPV by opening all the ADS valves.
Maintain RPV pressure less than the Minimum RPV Flooding Pressure (MFRP) above the suppression chamber. MFRP is 62 psi for the example plant.

Note: The RPV must be maintained in a depressurized state until adequate core cooling is assured to preclude high pressure melt ejection and direct containment heating. Section RC/P provides continued guidance to maintain the RPV depressurized.

RC/Q Guidance:

Inject boron with SLC until tank is empty or it is determined the RPV is breached. This action cannot be performed until AC power is restored.

The Containment and Radioactivity Release Control SAG is entered due to Primary Containment Flooding being required.

SP/T Guidance:

Due to lack of AC power, no suppression pool cooling is available.

DW/T Guidance:

Due to lack of AC power, no direct drywell temperature indication and no drywell cooling is available. Until AC power is restored drywell sprays are not available.

PC/P Guidance:

Monitor suppression chamber pressure to determine when Suppression pool sprays and drywell sprays are required.
Before the primary containment pressure reaches the Primary Containment Pressure Limit C (PCPL C), vent the primary containment, defeating interlocks if necessary and irrespective of offsite radioactivity release rate, to control primary containment pressure below PCPL C.

PC/R Guidance:

Monitor drywell radiation. Before drywell radiation reaches the drywell or suppression chamber radiation level which requires a General Emergency be declared, suppression pool spray and drywell spray are required. Until AC power is restored neither drywell radiation indication nor drywell sprays are available.

PC/G Guidance:

The shift crew will be unable to monitor directly hydrogen and oxygen concentrations in the suppression chamber and drywell. The shift crew is expected to determine that the primary containment remains inerted based upon drywell pressure and suppression chamber pressure above atmospheric pressure. With RPV water level below TAF, the shift crew is expected to determine that hydrogen concentration in the suppression chamber and drywell cannot be determined to be below 6%. PC/G-1 and PC/G-4 direct the operators to vent and purge the drywell and suppression chamber if the offsite radioactivity release limit is expected to remain below the technical specifications limit.

SC/T Guidance:

When an area temperature exceeds its maximum normal operating temperature, isolate all primary systems (systems that connect to RPV or attached piping) that are discharging into areas outside the primary and secondary containments except those systems required to be operated elsewhere in the SAG. Until AC power is restored, there are no indications of secondary containment area temperatures in the control room.

SC/R Guidance:

When an area radiation level exceeds its maximum normal operating radiation level, isolate all primary systems (systems that connect to RPV or attached piping) that are discharging into areas outside the primary and secondary containments except those systems required to be operated elsewhere in the SAG. Until AC power is restored, there are no indications of secondary containment area radiation levels in the control room.

SC/L Guidance:

If any floor drain sump or area water level cannot be restored and maintained below its maximum normal operating level, isolate all primary systems (systems that connect to RPV or attached piping) that are discharging into areas outside the primary and secondary containments except those systems required to be operated elsewhere in the SAG. Until AC power is restored, there are no indications of any floor drain sump levels in the control room.

RR Guidance:

Isolate all primary systems (systems that connect to RPV or attached piping) that are discharging into areas outside the primary and secondary containments except those systems required to be operated elsewhere in the SAG.

Expected Priorities:

RPV injection from any source; getting and maintaining the RPV in a depressurized state. Some primary containment flooding is taking place due to blowdown of the RPV through the SRVs. The SRO should determine that venting the primary containment will not facilitate primary containment flooding. It is expected that the SRO will determine that the offsite radioactivity release rate would be exceeded if the drywell or suppression chamber is vented.

Time: 45.7 minutes

Fuel zone level instruments go downscale

RC/F Guidance:

Based on all level indicators being downscale and no injection available, the SRO is likely to determine that RPV water level cannot be restored and maintained above BAF and enter step RC/F-5 because it injection into the RPV cannot be restored and maintained greater than the Minimum Debris Retention Injection Rate (MDRIR); and because suppression chamber pressure and primary containment water level are within the Pressure Suppression Pressure.

Maximize injection into the RPV from any available injection source.

If injection into the RPV will not be reduced, maximize injection into the primary containment from sources external to primary containment.
If venting the primary containment will facilitate primary containment flooding or RPV injection, vent the primary containment, defeating isolation interlocks and irrespective of offsite radioactivity release rates.

NOTE: Steps RC/P, RC/Q and the Containment and Radioactivity SAG remain in effect regardless of which flooding step is entered.

Expected priorities:

RPV injection from any source; maintaining the RPV depressurized. Some primary containment flooding is taking place due to blowdown of the RPV through the SRVs. The SRO should determine that venting the primary containment will not facilitate primary containment flooding.

Time: 45.8 minutes
If operations began lining up fire system at the beginning of the event, the fire system could be available for injection at this time.

Time: 47.8 minutes
Core heatup begins as RPV steam flow drops.

Time: 48.7 minutes

RPV pressure 150 psig; shutoff head for Fire system. (If the fire system has been lined up and is running injection would begin at this pressure.)

Time: 50 minutes
It is assumed that core plate dryout takes place at this time and the core begins to heat up. This cannot be observed by the operators and guidance remains the same.

Time: 56.6 minutes
Core temperature is high enough that hydrogen begins to be generated.

PC/G Guidance:

PC/G-1 and PC/G-4 would continue to be executed.

Other guidance remains the same.

Expected Priorities:

RPV injection from any source; maintaining the RPV depressurized; restoring AC power. The SRO should determine that venting the primary containment will not facilitate primary containment flooding. With RPV water level downscale, the SRO should recognize that some core damage is taking place and hydrogen is being generated. No radiological data is supplied for this scenario, but it is doubtful that projected release rates would be within Tech. Spec. limits; therefore, the suppression chamber would not be vented.

Time: 60 minutes
The ERO is manned and the Emergency Director function is transferred to the TSC.

Expected Priorities:

RPV injection from any source; maintaining the RPV depressurized; restoring AC power. The ERO will begin evaluating the event and plant conditions. The ERO will begin looking for evidence of the core conditions and for the core breach signature.

The ERO should determine that venting the primary containment will not facilitate primary containment flooding. With RPV water level downscale, the ERO should recognize that some core damage is taking place. No radiological data is supplied for this scenario, but it is doubtful that projected release rates would be within Tech. Spec. limits; therefore, the suppression chamber would not be vented

Time: 66 minutes
If the fire system is available, it should have been lined up by this time and injecting. It is estimated that hydrogen concentration in the suppression chamber would exceed 6% at this time. Because the suppression chamber remains inerted (<5% oxygen concentration), all SAG guidance remains the same.

Time: 101.1 minutes
Molten control blades and fuel channels begin to relocate.

Time: 102.4
First local failure of core plate due to molten control blades and fuel channels reaching core plate.

Time: 186.2 minutes
Fuel rods in central region of core relocating to core plate

Time: 216.1 minutes
RPV bottom head dryout. Failure of control rod guide tubes and collapse of remaining portions of intact core fall into bottom head.

Time: 226.2 minutes
RPV bottom head penetrations fail, resulting in equalization of RPV pressure and drywell pressure.

Step RC/F directs that step RC/F-5 be exited and step RC/F-2 be entered due to changing plant conditions.

Step RC/F-2 is entered when it is determined that core debris has breached the RPV.

NOTE: the ERO should determine that core debris has breached the RPV based upon the guidance in the TSG; .i.e., the RPV breach signature observed (increase in drywell pressure and decrease in RPV pressure).

RC/F-2 guidance:

Maximize injection into the RPV from sources external to the primary containment.

If injection into the RPV from sources external to primary containment will not be reduced, maximize injection into the primary containment from sources external to the primary containment.

If venting the primary containment will facilitate primary containment flooding, vent the primary containment , defeating isolation interlocks if necessary and irrespective of the offsite radioactivity limit.

Expected Priorities:

RPV injection from any source; restoration of AC power.

The ERO should determine that venting of the primary containment will not facilitate primary containment flooding.

The primary containment would not be vented since the containment remains inerted and the offsite radioactivity release rate would be expected to exceed the technical specification limit.

Time: 234.3 minutes

Pour of molten debris from RPV begins. Corium-concrete reaction begins.

NOTE: The provided scenario does not allow restoration of any RPV injection. As a result there is very little physical action that can be taken by the plant staff. The purpose of this description is to provide an overview of transfer guidance from section to section as plant conditions change.

A more realistic scenario would be to allow establishment of RPV injection from the fire system. The following description will illustrate how the availability of the fire system would change the outcome of the event.

Scenario Assuming Fire System can be lined up for injection

Time: 45.8 minutes
If operations began lining up fire system at the beginning of the event, the fire system could be available for injection at this time. If the fire system is lined up at this time and injecting step RC/F would direct that step RC/F-5 be exited and step RC/F-4 be entered since it could be determined that RPV injection can be restored and maintained above the MDRIR. The Fire system would begin restoring the RPV water level and possibly prevent the core from heating up significantly as soon as its shutoff head pressure was reached. However, for the purposes of this discussion, it is assumed that the fire system is not lined up and ready for injection at this point.

Time: 47.8 minutes
Core heatup begins as RPV steam flow drops.

Time: 48.7 minutes
RPV pressure 150 psig; shutoff head for Fire system.

If the fire system has been lined up and is running injection would begin at this pressure.

Time: 50 minutes
It is assumed that core plate dryout takes place at this time and the core continues to heat up. This cannot be observed by the operators and guidance remains the same.

Time: 56.6 minutes
Core temperature is high enough that hydrogen begins to be generated.

PC/G Guidance:

PC/G-1 and PC/G-4 would continue to be executed.

Other guidance remains the same.

Expected Priorities:

RPV injection from any source; maintaining the RPV depressurized, restoring AC power.

The SRO should determine that venting the primary containment will not facilitate primary containment flooding. With detection of hydrogen in primary containment, the SRO should recognize that some core damage is taking place. No radiological data is supplied for this scenario, but it is doubtful that projected release rates would be within Tech. Spec. limits; therefore, the suppression chamber would not be vented.

Time: 60 minutes
The ERO is manned and the Emergency Director function is transferred to the TSC.

Expected Priorities:

RPV injection from any source; maintaining the RPV depressurized; restoring AC power. The ERO will begin evaluating the event and plant conditions. The ERO will begin looking for evidence of the core conditions and for the core breach signature.
The ERO should determine that venting the primary containment will not facilitate primary containment flooding. With RPV water level downscale, the ERO should recognize that some core damage is taking place. No radiological data is supplied for this scenario, but it is doubtful that projected release rates would be within Tech. Spec. limits; therefore, the suppression chamber would not be vented.

Time: 66 minutes
RPV pressure is stable between 20 to 50 psig.
The fire system is lined up and injecting into the RPV at greater than MDRIR.
It is estimated that hydrogen concentration in the suppression chamber would exceed 6% at this time.

NOTE: When the RPV injection rate equals the MDRIR, there is sufficient injection to remove all the heat being generated from decay heat. Even if the core relocates to the RPV bottom head, there is sufficient injection to provide cooling of the debris, preventing RPV breach. When the injection flow exceeds the MDRIR, RPV water level must increase. Ultimately, RPV water level will come back on scale and rise above TAF.

Expected priorities:

RPV injection from any source; maintaining RPV depressurized, maintaining fire system injection. The ERO should determine that venting of the primary containment will not facilitate primary containment flooding.
No radiological data is supplied for this scenario, but it is doubtful that projected release rates would be within Tech. Spec. limits; therefore, the suppression chamber would not be vented.

Time: after 66 minutes

RPV water level rises above BAF and high enough to bring the post accident range instruments on scale.

Step RC/F directs that step RC/F-4 be exited and RC/F-3 be entered due to change in plant conditions.
Step RC/F-3 is entered because RPV water level can be restored and maintained above BAF.

RC/F-3 Guidance:

Maintain RPV water level greater than BAF, maximizing injection into the RPV from any available injection source.

If venting will facilitate primary containment flooding or RPV injection, vent the primary containment, defeating isolation interlocks if necessary and irrespective of the offsite radioactivity release rate.

Time: some time after

RPV water level rises above TAF.

Step RC/F directs that step RC/F-3 be exited and step RC/F-1 be entered due to change in plant conditions.

Step RC/F-1 is entered because RPV water level can be restored and maintained above TAF.

If venting will facilitate primary containment flooding or RPV injection, vent the primary containment, defeating isolation interlocks if necessary and irrespective of the offsite radioactivity release rate.

NOTE: Even though the RPV water level is restored above TAF and hydrogen generation is terminated, hydrogen control is still a priority due to the hydrogen concentration in the primary containment. When electrical power is eventually restored, the ERO will need to coordinate with state and local agencies to determine the optimum time to vent and purge the primary containment to reduce hydrogen concentration below the deflagration limit.

INFORMATION ON EPG/SAG RESPONSE FOR A SHORT-TERM STATION BLACKOUT SCENARIO FOR A BWR/6

The following discussion describes the actions that would be taken in accordance with the BWROG EPG/SAG for a Short-Term Station Blackout with ADS Actuation at the Grand Gulf Nuclear Station. The scenario data and time line was provided by ORNL through the NRC.

The scenario as provided does not credit any RPV injection prior to RPV breach due to melted core. Due to this limitation, very little action can be taken by the ERO and plant staff. This scenario is useful in that it provides a worst case time line to determine when the ERO would be manned compared to when the SAG is entered. It also provides an opportunity to explain the transitions within the EPG/SAG as plant conditions change.

A more realistic scenario would be to credit use of the fire system for RPV emergency injection. RPV emergency injection from the fire system does not require electrical power. There are two installed diesel driven fire pumps and one onsite pumper fire truck. Any of these three sources are capable of achieving the calculated RPV emergency injection flow rate. Use of the fire system under accident conditions is proceduralized and necessary hardware for fire hose connection is installed in the plant.

Both cases were evaluated to illustrate the symptomatic nature of the BWROG EPG/SAG. A single description is provided to the point where emergency RPV depressurization occurs. RPV emergency injection from the fire system cannot occur until after the RPV is depressurized. Two discussions are provided from that point on to describe the strategy differences with and without RPV injection from the fire system.

Grand Gulf Short-Term SBO With ADS Actuation:

T=0	SBO occurs, RCIC fails, Reactor scrams from 100%, MSIVs close	
	The EPG is entered:	
	The RPV Control EPG is entered due to RPV water level decreasing below the Low Level Scram Setpoint (LLSS).	
	RC/Q guidance:	
		Place the mode switch in the shutdown position.
		Verify all control rods are fully inserted.
		Exit RC/Q and enter the Scram Procedure.
	RC/L guidance:	
	NOTE: (Due to loss of all electric and steam driven injection sources, RPV water level decreases and cannot be restored and maintained above the LLSS).	
		Level control band lower limit expands from LLSS to TAF.
	RC/P guidance:	
		Stabilize RPV pressure below 1045 psig with SRVs.
		Depressurize the RPV and maintain cooldown rate below 100°F/hr (The shift is expected to minimize RPV cooldown rate at this time due to lack of RPV makeup capability.)
	The Containment Control EPG is entered due to High Suppression Pool Temperature.	
		All legs of the Containment Control EPG are entered concurrently but due to SBO very little if any containment control actions can be performed. The shift would monitor containment parameters to determine a need for RPV emergency depressurization.
	Emergency Classification:	
		An Alert is declared due to SBO.
	Expected Priorities:	
		Establish RPV injection from any available source. At this point it is be expected that three areas would be pursued; (1) Restoration of electrical power, (2) Restoration of RCIC, and (3) Lining up the fire system for emergency RPV injection.
T=15	Emergency Classification:	
		A Site Area Emergency is declared due to SBO greater than 15 minutes. (This is a judgment call and could occur earlier.)
T=24	RPV water level drops to TAF.	
	NOTE: (At this time the shift must decide that RPV water level cannot be maintained above TAF. This is a judgment call and which could occur earlier, however timing is not critical.)	
	RC/L guidance:	
		Exit RC/L and enter EPG Contingency #1 (C-1)
	C-1 guidance:	
		Prevent automatic operation of ADS
	Expected Priorities:	
		Shift priorities remain establishing RPV injection from any available source. If the fire system is available, it would not be unreasonable for the shift to have placed a higher priority on lining up of fire system for RPV emergency injection by this time. If the Fire System is not available, priorities would be set based on perceived success paths.

	NOTE: (The fire system RPV emergency injection requires manual connection of eight fire hoses in the secondary containment. It is estimated that this may take up to 60 minutes.)	
	C-1 guidance:	
		When RPV water level drops to TAF, because no injection subsystem can be lined up for injection, specific guidance is now provided to line up the fire system for injection, start the pumps and increase injection flow to the maximum.
T=24 (cont)	Expected Priorities:	
		Shift priorities remain establishing RPV injection from any available source. If the fire system is available, it is reasonable that the shift could now consider lining up of the fire system for RPV emergency injection as the highest priority and reduce lineup time by utilizing additional personnel. If the Fire System is not available, priorities would be set based on perceived restoration success.
T=40	RPV water level drops to Minimum Steam Cooling RPV Water Level (MSCRWL)	
	C-1 guidance:	
		STEAM COOLING IS REQUIRED
		Exit RC/P and enter EPG Contingency #3
	C-3 guidance:	
		Stabilize RPV pressure using the SRVs
	Expected Priorities:	
		Shift priorities remain establishing RPV injection from any available source. If the fire system is available, the shift has most likely placed the highest priority on lining up the fire system for RPV emergency injection with the pumps running before RPV water level reaches Minimum Zero Injection RPV Water Level. (MZIRWL) If the Fire System is not available, priorities would be set based on perceived success paths.
	Emergency Classification:	
		A General Emergency is declared due to loss of coolant greater than make up capability. (This is a judgment call and could occur earlier.)
T=57.5	RPV water level drops to MZIRWL	
	C-3 guidance:	
		EMERGENCY DEPRESSURIZATION IS REQUIRED
		Exit C-3 and enter C-2
	NOTE: (If the fire system was able to be lined up for RPV emergency injection with the pumps running before RPV water level dropped to MZIRWL, C-3 guidance would have required emergency depressurization at that time, however depressurization timing is not critical.)	
	C-2 guidance:	
		Rapidly depressurize the RPV, irrespective of the resulting cooldown rate by opening all ADS valves.
T=60	The ERO is manned and the Emergency Director function is transferred to the TSC.	
		NOTE: (When the ADS valves are opened, RPV water level initially swells to above MSCRWL. It then starts to decrease as inventory is lost through the SRVs.)
	RPV water level drops to MSCRWL.	

	C-1 guidance:
	When Emergency RPV Depressurization is required, if RPV water level cannot be restored and maintained above MSCRWL, PRIMARY CONTAINMENT FLOODING IS REQUIRED
	Exit the EPG and enter the SAG
	The RPV and Primary Containment SAG is entered.
	Step RC/F is used to determine the appropriate flooding step for existing plant conditions
	Step RC/F-3 is entered because RPV water level cannot be restored and maintained above TAF but it can be maintained above BAF and it has not been determined that core debris has breached the RPV.
	NOTE: (As long as RPV water level can be maintained above BAF, it is expected that any core debris that may relocate to the lower head will be submerged and will not breach the RPV.)
T=60 (cont)	RC/F-3 guidance:
	Restore and maintain RPV water level above BAF, maximizing injection into the RPV and primary containment from sources external to the primary containment.
	If venting the primary containment will facilitate primary containment flooding, vent the primary containment, defeating isolation interlocks in necessary and irrespective of the offsite radioactivity release rate.
	Step RC/P is entered any time the SAG is entered.
	NOTE: (The RPV must be maintained in a depressurized state until adequate core cooling is assured to preclude high pressure melt ejection and direct containment heating. Section RC/P provides continued guidance to maintain the RPV in a depressurized state.)
	RC/P guidance:
	Rapidly depressurize the RPV, irrespective of the resulting cooldown rate by opening all ADS valves.
	Maintain RPV pressure less than MRFP.
	Step RC/Q is entered any time the SAG is entered.
	NOTE: (In this event, EPG section RC/Q was exited after all control rods were verified inserted. Entry into the SAG raises criticality concerns regarding conditions that could lead to control rod melt prior to fuel rod degradation.)
	RC/Q guidance:
	Confirm or place the mode switch in SHUTDOWN.
	If ARI was not initiated, initiate ARI.
	Inject SLC until the SLC tank is empty or core debris has breached the RPV. (SLC is not available under these conditions.)
	The Containment and Radioactivity Release Control SAG is entered any time the SAG is entered.
	NOTE: (All legs of the Containment and Radioactivity Control SAG are entered concurrently but due to SBO very little if any containment control actions can be performed.)

	Expected Priorities:
	RPV injection form any source; maintaining the RPV depressurized; Some containment flooding is occurring due to steam discharging through the SRVs. The rate of SRV steam flow is a function of RPV pressure and containment pressure. Containment pressure is less than one psig at this time. Venting the primary containment would have little to no affect on SRV steam flow. The ERO should determine that venting of the primary containment will not facilitate primary containment flooding. It would not be unreasonable for the ERO and the state and local agencies to have started actions to determine the best time to vent the primary containment should venting become necessary.
	NOTE: (The availability of the fire system RPV emergency injection greatly affects the scenario from this point forward. Both cases will be evaluated by first evaluating without the fire system injection available, then returning to this point and evaluating with the fire system injection available)
First case: Fire system RPV emergency injection is not available:	
T=73	RPV water level drops below BAF.
	Step RC/F directs that Step RC/F-3 be exited and Step RC/F-5 be entered due to change in plant conditions.
	Step RC/F-5 is entered because RPV water level cannot be restored and maintained above BAF and RPV injection rate cannot be restored and maintained greater than the Minimum Debris Retention Injection Rate (MDRIR) and the suppression chamber pressure and primary containment water level are within the Pressure Suppression Pressure (PSP).
	RC/F-5 guidance:
	Maximize injection into the RPV from any available injection source.
	If injection into the RPV will not be reduced, maximize injection into the primary containment from sources external to the primary containment.
	If venting the primary containment will facilitate primary containment flooding or RPV injection, vent the primary containment, defeating isolation interlocks in necessary and irrespective of the offsite radioactivity release rate.
	NOTE: (Steps RC/P, RC/Q and the Containment and Radioactivity Release Control SAG remain in affect regardless of which flooding step is entered.)
	Expected Priorities:
	RPV injection form any source; maintaining the RPV depressurized; Some containment flooding is occurring due to steam discharging through the SRVs. The rate of SRV steam flow is a function of RPV pressure and containment pressure. Containment pressure is less than one psig at this time. Venting the primary containment would have little to no affect on SRV steam flow. The ERO should determine that venting of the primary containment will not facilitate primary containment flooding. It would not be unreasonable for the ERO and the state and local agencies to have started actions to determine the best time to vent the primary containment should venting become necessary.
T=75	Containment hydrogen concentration detected (comes on scale)
	PC/G guidance:
	Energize hydrogen igniters (Unable to energized due to SBO)

		If the offsite radioactivity release rate is expected to remain below the Tech. Spec. release rate limit, vent and purge the containment.
	Expected Priorities:	
		RPV injection form any source; maintaining the RPV depressurized; As stated above, the ERO should determine that venting of the primary containment will not facilitate primary containment flooding. With the detection of hydrogen in the primary containment, the ERO should recognize that some core damage is taking place. No radiological data is supplied for this scenario but it is doubtful that projected offsite release rates would be within Tech. Spec. release rate limits, therefore the primary containment would not be vented. The specified action of PC/G is to vent and purge the primary containment. Since the SBO prevents purging the primary containment, venting would not be performed even if projected radioactivity release rates permitted. The purpose of venting and purging is to reduce hydrogen concentration. Venting by itself would result in a higher hydrogen concentration than if the containment is not vented. Restoration of electrical power priority increases to provide primary containment purge capability.
T=100	Drywell hydrogen concentration detected (comes on scale)	
	PC/G guidance:	
		Operate the hydrogen mixing system (Unable to operate due to SBO)
	Expected Priorities:	
		RPV injection form any source; maintaining the RPV depressurized; Restoration of electrical power; As stated above, the ERO should determine that venting of the primary containment will not facilitate primary containment flooding. As stated above the primary containment would not be vented for hydrogen control because no purge is available.
T=150	Containment hydrogen concentration reaches HDOL (8.6%)	
	PC/G guidance:	
		Vent and purge the primary containment irrespective of the offsite radioactivity release rate.
		Because the hydrogen igniters are de-energized, prevent operation of the hydrogen igniters until containment and drywell hydrogen concentrations are below HDOL.
	Expected Priorities:	
		RPV injection form any source; maintaining the RPV depressurized; Restoration of electrical power; As stated above, the ERO should determine that venting of the primary containment will not facilitate primary containment flooding. As stated above the primary containment would not be vented for hydrogen control because no purge is available.
T=662	RPV breach due to molten core	
		Step RC/F directs that Step RC/F-5 be exited and Step RC/F-2 be entered due to change in plant conditions.
		Step RC/F-2 is entered when it is determined that core debris has breached the RPV.
	Note: (The ERO should determine that core debris has breached the RPV based on the guidance found in the TSG. RPV has been depressurized, Hydrogen has been observed and the RPV breach signature (sudden increase in drywell pressure) is observed.)	

	RC/F-2 guidance	
		Maximize injection into the RPV from sources external to the primary containment.
		If injection into the RPV from sources external to the primary containment will not be reduced, maximize injection into the primary containment from sources external to the primary containment.
		If venting the primary containment will facilitate primary containment, vent the primary containment, defeating isolation interlocks in necessary and irrespective of the offsite radioactivity release rate.
	Expected Priorities:	
		RPV injection form any source; Restoration of electrical power; As stated above, the ERO should determine that venting of the primary containment will not facilitate primary containment flooding. As stated above the primary containment would not be vented for hydrogen control because no purge is available.
NOTE: (The provided scenario does not allow restoration of any RPV injection. As a result there is very little physical action that can be taken by the plant staff. The purpose of this portion of the description is to provide an overview of transfer of guidance from section to section as plant conditions change. A more realistic scenario would be to at least allow the establishment of RPV injection from the fire system. The following description will illustrate how the availability of the fire system would change the outcome of the event.)		

Second case: Fire system RPV emergency injection is available:		
T=63	RPV pressure decreases to 125 psig. Fire system starts to inject.	
T=73	RPV pressure stable at 30 psig	
	Fire system injecting into the RPV at 215 gpm	
	RPV water level drops below BAF.	
		Step RC/F directs that Step RC/F-3 be exited and Step RC/F-5 be entered due to change in plant conditions.
		Step RC/F-5 is entered because RPV water level cannot be restored and maintained above BAF and RPV injection rate cannot be restored and maintained greater than the Minimum Debris Retention Injection Rate (MDRIR) and the suppression chamber pressure and primary containment water level are within the Pressure Suppression Pressure (PSP).
	RC/F-5 guidance:	
		Maximize injection into the RPV from any available injection source.
		If injection into the RPV will not be reduced, maximize injection into the primary containment from sources external to the primary containment.
		If venting the primary containment will facilitate primary containment flooding or RPV injection, vent the primary containment, defeating isolation interlocks in necessary and irrespective of the offsite radioactivity release rate.
	NOTE: (Steps RC/P, RC/Q and the Containment and Radioactivity Release Control SAG remain in affect regardless of which flooding step is entered.)	
	Expected Priorities:	
		RPV injection form any source; maintaining the RPV depressurized; Maintaining fire system injection Some containment flooding is occurring due to steam discharging through the SRVs. The rate of SRV steam flow is a function of RPV pressure and containment pressure. Containment pressure is less than one psig at this time. Venting the primary containment would have little to no affect on SRV steam flow. The ERO should determine that venting of the primary containment will not facilitate primary containment flooding. It would not be unreasonable for the ERO and the state and local agencies to have started actions to determine the best time to vent the primary containment should venting become necessary.
T=75	Containment hydrogen concentration detected (comes on scale)	
	PC/G guidance:	
		Energize hydrogen igniters (Unable to energized due to SBO)
		If the offsite radioactivity release rate is expected to remain below the Tech. Spec. release rate limit, vent and purge the containment.

T=75 (cont)	Expected Priorities:	
		RPV injection form any source; maintaining the RPV depressurized; maintaining fire system injection As stated above, the ERO should determine that venting of the primary containment will not facilitate primary containment flooding. With the detection of hydrogen in the primary containment, the ERO should recognize that some core damage is taking place. No radiological data is supplied for this scenario but it is doubtful that projected offsite release rates would be within Tech. Spec. release rate limits, therefore the primary containment would not be vented. The specified action of PC/G is to vent and purge the primary containment. Since the SBO prevents purging the primary containment, venting would not be performed even if projected radioactivity release rates permitted. The purpose of venting and purging is to reduce hydrogen concentration. Venting by itself would result in a higher hydrogen concentration than if the containment is not vented. Restoration of electrical power priority increases to provide primary containment purge capability.
T=100	Drywell hydrogen concentration detected (comes on scale)	
	PC/G guidance:	
		Operate the hydrogen mixing system (Unable to operate due to SBO)
	Expected Priorities:	
		RPV injection form any source; maintaining the RPV depressurized; Restoration of electrical power; As stated above, the ERO should determine that venting of the primary containment will not facilitate primary containment flooding. As stated above the primary containment would not be vented for hydrogen control because no purge is available.
T=120	Fire system injection rate exceeds MDRIR	
		Step RC/F directs that Step RC/F-5 be exited and Step RC/F-4 be entered due to change in plant conditions.
		Step RC/F-4 is entered because RPV water level cannot be restored and maintained above BAF and RPV injection rate can be restored and maintained greater than the Minimum Debris Retention Injection Rate (MDRIR).
	RC/F-4 guidance:	
		Maintain RPV injection greater than MDRIR, maximizing injection into the RPV from any available injection source.
		If venting the primary containment will facilitate primary containment flooding or RPV injection, vent the primary containment, defeating isolation interlocks in necessary and irrespective of the offsite radioactivity release rate.

NOTE: (When the RPV injection rate equals the MDRIR, there is enough injection to remove all the heat being generated from decay heat. Even if the core relocates to the RPV bottom head, there is now sufficient injection to provide cooling of the debris, preventing RPV breach.
Decay heat continues to decrease with time. If the fire system injection rate can be held constant, eventually the injection rate exceeds that required to remove decay heat and RPV water level must increase. Ultimately RPV water level will come back on scale and rise to above TAF.)

T=?	RPV water level rises above BAF	
		Step RC/F directs that Step RC/F-4 be exited and Step RC/F-3 be entered due to change in plant conditions.
		Step RC/F-3 is entered because RPV water level can be restored and maintained above BAF.
	RC/F-3 guidance:	
		Maintain RPV water level greater than BAF, maximizing injection into the RPV from any available injection source.
		If venting the primary containment will facilitate primary containment flooding or RPV injection, vent the primary containment, defeating isolation interlocks in necessary and irrespective of the offsite radioactivity release rate.
T=?	RPV water level rises above TAF	
		Step RC/F directs that Step RC/F-3 be exited and Step RC/F-1 be entered due to change in plant conditions.
		Step RC/F-1 is entered because RPV water level can be restored and maintained above TAF.
	RC/F-1 guidance:	
		Maintain RPV water level greater than TAF, maximizing injection into the RPV from any available injection source.
		If venting the primary containment will facilitate primary containment flooding or RPV injection, vent the primary containment, defeating isolation interlocks in necessary and irrespective of the offsite radioactivity release rate.
NOTE: (Even though the RPV water level is restored above TAF and hydrogen generation terminated, hydrogen control is still a high priority due to the hydrogen concentration in the primary containment. When electrical power is eventually restored, the ERO will need to coordinate with state and local agencies to determine the optimum time to vent and purge the primary containment to reduce hydrogen concentration to below HDOL. Once hydrogen concentration is reduce to below HDOL, the hydrogen igniters can then be energized to remove the remaining hydrogen and the containment vent and purge secured.)		