

Enclosure to ST-96-0287

**Calculation Summary of Radiological Doses
for Steam Generator Tube Rupture with Loss of Offsite Power and
Stuck Open ADV**

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VERIFICATION STATUS: COMPLETE

The Safety-Related design information contained in this document has been verified to be correct by means of Design Review using the Other Design Document Checklist of QPM 101.

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Subject: Calculation of the Radiological Doses for the Steam Generator Tube Rupture with LOSS OF OFFSITE POWER and Stuck Open ADV event at 2% Stretch Power

SUMMARY

The following discussion summarizes selected methods and assumptions used in calculation of the radiological releases for the Steam Generator Tube Rupture with LOSS OF OFFSITE POWER and Stuck open ADV at 2% stretch power. In summary:

- 1) The 2 hour and 8 hour primary to secondary leakages and secondary steam releases remain the same as the original calculation. The primary to secondary leakage is a function of the RCS and steam generators pressures which are mostly controlled by the operator during the event and are not impacted by the 2% power increase or lower AFAS setpoint.

For the first two hours, the secondary steam releases are driven by the stuck open ADV on the affected steam generator which removes much more heat than the core generates as decay heat. For the 8 hour period, the total integrated decay heat generated by the stretch power core using the 1979 ANS decay heat curve is less than that assumed in the original analysis.

- 2) The additional radiological doses are due to the increased period of tube uncover during the event. The assumed period of uncover was increased from 887 seconds in the original calculation to 1230 seconds (effectively assuming a tube uncover period from 460 seconds to 1690 seconds) for the stretch power analysis.
- 3) A copy of the chronology of the event was marked up and is attached. The only markup is the time that the level in the faulted steam generator rises above the top of the U-tubes. This value has been increased from 1385 seconds (in the copy) to 1690 seconds. Even though the changes considered in the stretch power calculation would slightly impact the timing of the event, the increase in time of level recovery above the U-tubes is the only change needed to represent the conservative approach used for radiological dose calculation.

DISCUSSION

The radiological doses for this event are primarily due to the releases from the stuck open ADV on the affected steam generator. Most of the releases occur between the time that the affected steam generator ADV becomes stuck and the time that the level in the affected steam generator rises above the top of the tubes. During this period, the entire primary to secondary leakage is assumed to flash immediately and be released to atmosphere with a DF of 1.0. The original calculation of this event established this time to be from 460 seconds to 1347 seconds, for a total of 887 seconds (14.8 minutes). The 2% stretch power calculation increased this time period to 1230 seconds (20.5 minutes), effectively assuming a tube uncover period from 460 seconds to 1690 seconds. The additional 343 seconds are due to the following considerations:

- 1) 212 seconds resulting from reduction of the AFW rate from 750 GPM to 650 GPM.
- 2) 60 seconds to account for lower steam generator masses at initiation of the event and the time of AFAS initiation.
- 3) 71 seconds resulting from the reduction of AFAS initiation analytical setpoint from 25% to 21% of wide range span.

The 2% higher power does not affect the two hour or 8 hour steam releases and radiological doses. For the first two hours, the secondary steam releases are driven by the stuck open ADV on the affected steam generator which removes much more heat than the core generates as decay heat. For the 8 hour period, the total integrated decay heat generated by the stretch power core using the 1979 ANS decay heat curve is less than that assumed in the original analysis.

Based on the above discussion, the two hour and 8 hour PIS and GIS radiological doses were calculated as follows:

2 Hour PIS

From the original calculation, the radiological doses during the tube uncover period (460 to 1347 seconds) were 185.2 REM. The total two hour radiological doses were 206.6 REM.

The two hour PIS doses for stretch power are calculated by ratioing the original dose release in proportion to the increased time of tube uncover, as follows:

$$[(20.5/14.8) * 185.2] + (206.6 - 185.2) = 278 \text{ REM.}$$

The radiological doses were conservatively increased by another 5% to account for the expanded MSSV setpoint tolerances from 1% to 3%. This brings the 2 hour PIS dose to 292 REM (rounded up).

2 Hour GIS

From the original calculation, the radiological doses between 1337 and 1690 seconds (the additional period of tube uncover for stretch power) were recalculated, assuming that the entire primary to secondary leakage flashes immediately and becomes airborne with a DF of 1.0. The additional doses during this period were calculated to be 30.6 REM. The additional doses during this period were added to the 40.4 REM, the 2 hour doses from the original calculation. This resulted in a two hour GIS dose of 71 REM.

The increased MSSV tolerances do not significantly impact the overall GIS doses since the GIS spiking is small during the MSSV opening this period.

8 Hour PIS and GIS

The additional dose increases determined above for two hour PIS and GIS, resulting from the increased tube uncover period for stretch power were subsequently recalculated using the 8 hour to two hour dispersion factor ratio and then added to the respective 8 hour PIS and GIS doses of the original calculation.

Table 15.6.3-6
SEQUENCE OF EVENTS FOR A STEAM GENERATOR TUBE
RUPTURE WITH A LOSS OF OFFSITE POWER
AND FULLY STUCK OPEN ADV
(Sheet 1 of 5)

Time (sec)	Event	Setpoint or Value	Success Path or Comment
0.0	Tube rupture occurs	--	--
40	Third charging pump started, feet below program level	-0.75	Primary system integrity
40	Letdown control valve throttled back to minimum flow, feet below program level	-0.75	Primary system integrity
47	CPC hot leg saturation trip signal generated	--	Reactivity control
47.15	Trip breakers open	--	Reactivity control
48	Turbine/generator trip	--	Secondary system integrity
51	Loss of offsite power	--	--
52	LH main steam safety valves open, psia	1,265	Secondary system integrity
52	RH main steam safety valves open, psia	1,265	Secondary system integrity
56	Maximum steam generator pressures both steam generators, psia	1,330	--

Table 15.6.3-6
SEQUENCE OF EVENTS FOR A STEAM GENERATOR TUBE
RUPTURE WITH A LOSS OF OFFSITE POWER
AND FULLY STUCK OPEN ADV
(Sheet 2 of 5)

Time (sec)	Event	Setpoint or Value	Success Path or Comment
121	Steam generator water level reaches auxiliary feedwater actuation signal (AFAS) analysis setpoint in unaffected generator, percent wide range level	25*	Secondary system integrity
122	AFAS generated	--	--
131	Steam generator water level reaches AFAS analysis setpoint in the affected generator, percent wide range level	25*	Primary system integrity
132	AFAS generated	--	--
167.0	Auxiliary feedwater initiated to unaffected steam generator	--	Secondary system integrity
177.0	Auxiliary feedwater initiated to affected steam generator	--	Secondary system integrity

* The analysis used a setpoint of 21%. Even though this change would slightly impact the timing of the event, the only change needed to represent the conservative approach of the analysis is the time of level recovery above the u-tubes.

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Table 15.6.3-6

SEQUENCE OF EVENTS FOR A STEAM GENERATOR TUBE
RUPTURE WITH A LOSS OF OFFSITE POWER
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(Sheet 3 of 5)

Time (sec)	Event	Setpoint or Value	Success Path. or Comment
460	Operator initiates plant cooldown by opening one ADV on each SG - ADV of the affected SG instantane- ously opens fully	--	Reactor heat removal
484	Pressurizer empties	--	--
513	MSIS actuation secondary pressure, psia	919	Secondary system integrity
535	Automated isolation of AFW to affected SG, ΔP SGs, psi	185	Secondary system integrity
581	Pressurizer pressure reaches safety injection actuation signal (SIAS) analysis setpoint, psia	1,578	Reactivity control
581	Safety injection actuation signal generated	--	--

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SEQUENCE OF EVENTS FOR A STEAM GENERATOR TUBE
RUPTURE WITH A LOSS OF OFFSITE POWER
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(Sheet 4 of 5)

Time (sec)	Event	Setpoint or Value	Success Path or Comment
581	Safety injection flow initiated	--	Reactivity control
655	Operator overrides the AFW isolation signal and starts feeding the affected SG with AFW	--	--
775	Operator takes manual control of the AFW system, feeds affected SG with both AFW pumps	--	--
895	Operator shuts the ADV of the unaffected steam generator	--	--
1015	Operator initiates auxiliary spray to the pressurizer	--	--
1690 → 1385	Level in the affected SG above the top of U-tubes, percent wide range	71.5	--

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Table 15.6.3-6

SEQUENCE OF EVENTS FOR A STEAM GENERATOR TUBE
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(Sheet 5 of 5)

Time (sec)	Event	Setpoint or Value	Success Path or Comment
2040	Pressurizer level, percent	50	--
2400	Operator controls HPSI flow, backup pressur- izer heater output, and auxiliary spray flow to control RCS pressure and subcooling, °F	20	--
28,800	Shutdown cooling entry conditions are reached; RCS pressure, psia/ temp, °F	400/350	--
28,800	Operator activates shutdown cooling system	--	--