NFSR-0114
REV. 0

Revised Steam Generator Tube Rupture Analysis for Byron/Braidwood

November, 1996

By

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Abstract

The plant specific analysis required by the NRC to resolve the Steam Generator Tube Rupture (SGTR) licensing issues for the Byron/Braidwood plants was provided in Reference 1. The NRC approved the Reference 1 ComEd methodology by issuing an SER for the Byron/Braidwood SGTR transient analysis in Reference 2.

The Byron Unit 1 and Braidwood Unit 1 Generating Stations steam generators are being replaced with BWI replacement steam generators (RSGs). The SGTR event is being reanalyzed to support the Byron/Braidwood steam generator replacement project. This reanalysis, which is based on the previously NRC approved methodology (References 1 and 2), is necessary to verify that the RSGs meet the same acceptance criteria as the D-4 and D-5 steam generators (OSGs) which are currently in place at the Byron and Braidwood stations.

This analysis includes the following changes to the Reference 1 analysis' assumptions:

1. addition of a RSG model,
2. revised average Reactor Coolant System (RCS) temperature (T_{AVG}) to 575 °F,
3. revised operator response times,
4. added uncertainty for initial values for power, T_{AVG} and Steam Generator (SG) level,
5. revised turbine runback power to 70%, and
6. added OTDT case to verify most conservative approach is utilized.

In the Reference 1 analysis, a bounding case was performed for the D-4 and D-5 steam generators. This OSG case is reanalyzed to the same set of assumptions as the RSGs. Prior to RSG installation, the OSG reanalysis bounds all four Byron and Braidwood Units. After RSG installation, the OSG reanalysis bounds Byron Unit 2 and Braidwood Unit 2 and the RSG analysis bounds Byron Unit 1 and Braidwood Unit 1.

The results of this reanalysis show that the steam generators do not overfill and that the Offsite Dose (OD) cases have adequate margin to the 10 CFR 100 requirements.

Table of Contents

List of Tables

List of Figures

1. Introduction

Following the 1982 Ginna SGTR event, the NRC expressed concerns over traditional FSAR assumptions and methodology used for this transient. In response to the NRC's concerns, the Westinghouse Owners Group (WOG) addressed the SGTR licensing issues on a generic basis by issuing WCAP-10698 and Supplement 1 to WCAP-10698 (References 3 and 4, respectively). Subsequently, ComEd submitted plant specific SGTR analysis for Byron and Braidwood (Reference 1) in accordance with the NRC SER requirements for the referenced WCAPs. The NRC approved the ComEd methodology by issuing an SER for the Byron/Braidwood SGTR transient analysis (Reference 2).

Currently, Byron Unit 1 and Braidwood Unit 1 have Westinghouse model D-4 SGs while Byron Unit 2 and Braidwood Unit 2 have Westinghouse model D-5 SGs. The Reference 1 analysis bounds both D-4 and D-5 SGs (OSGs). Since the Byron Unit 1 and Braidwood Unit 1 D-4 SGs are being replaced with BWI replacement steam generators (RSGs), the SGTR event is being reanalyzed. This revised analysis, which is based on the previously NRC approved methodology (References 1 and 2), is necessary since the OSGs and RSGs have different physical characteristics which impact the previous SGTR analysis results.

The differences between OSGs and RSGs that impact the SGTR analysis are summarized in Table 1. The smaller RSG tube diameter leads to reduction in break flow, which increases the Margin to Overfill (MTO) and lowers the rate of transfer of primary coolant activity to the secondary. The larger heat transfer area increases the steam generator pressure for the same T_{AVG}. This increase in secondary pressure also leads to a reduction in break flow. But the RSGs have more moisture separators in the generator which reduces secondary side volume which in turn reduces the MTO. To assess the impact of these differences, the SGTR event has been reanalyzed.

Some of the assumptions used in the Reference 1 analysis have been revised for this analysis. The bounding case performed for the OSGs in Reference 1 has been reanalyzed in this analysis in order to use a single and consistent set of assumptions for both OSGs and RSGs. Prior to RSG installation, the OSG reanalysis bounds all four Byron and Braidwood Units. After RSG installation, the OSG reanalysis bounds Byron Unit 2 and Braidwood Unit 2 and the RSG analysis bounds Byron Unit 1 and Braidwood Unit 1. Section 2 describes the changes from the Reference 1 analysis. Section 3 presents the results of this reanalysis. Section 4 presents the conclusions of this revised SGTR analysis.

2. Model/Assumption Changes

The following subsections provide detailed descriptions of the differences between the Reference 1 SGTR analysis and this revised SGTR analysis. Table 2 is a summary of these differences. Figure 1 is a noding diagram of the RETRAN model used in this reanalysis.

2.1 Updates to Reference 1

The Reference 1 analysis has previously been updated due to an increase in OSG tube plugging level, reduction in Thermal Design Flow (TDF) and use of RETRAN-02 MOD 5.1. These minor changes were performed under the 10 CFR 50.59 process. The most recent analysis documented in Reference 5 is used as the base case for this reanalysis.

The Reference 1 analysis was performed at 0% tube plugging level for the OSGs and supplemented by an analysis which supported a 10% tube plugging level (Reference 6). The tube plugging level was increased to 30% in the Reference 5 model. This change involved reduction in heat transfer area and decrease in SG pressure. The 30% tube plugging model is used in the OSG cases for this analysis.

The reduction in TDF for the OSGs in Reference 5 is part of the OSG tube plugging increase program. This analysis uses the Reference 5 TDF for both RSGs and OSGs since the RCS flow requirement remains the same for Unit 1 and Unit 2 after RSG installation.

The Reference 1 analysis was performed using RETRAN-02 MOD 3. The Reference 5 analysis used RETRAN-02 MOD 5.1. For the use of RETRAN-02 MOD5.1, benchmark cases were performed in Reference 5. The conclusion was there were no significant differences between RETRAN-02 MOD3 and RETRAN-02 MOD5.1 and the model developed for MOD3 can be used for MOD5.1.

2.2 RSG Model

The physical characteristics of the RSGs have been incorporated into the Reference 1 RETRAN model for the RSG analysis. The same modeling techniques and RETRAN options used for the OSG model in Reference 1 are used for the RSG model in this analysis.

2.3 Additional Case

An additional MTO case which trips on OTDT instead of low pressurizer pressure is included in this analysis to verify that the most conservative approach is utilized. As the primary side depressurizes after a steam generator tube ruptures, the OTDT reactor trip setpoint is reached earlier than the low pressurizer pressure reactor trip setpoint. Since

the time from tube rupture to AFW isolation is an assumed operator response time, an early reactor trip results in AFW going into the ruptured generator for a longer period of time which leads to a reduction in MTO. However, the amount of turbine runback is less if a OTDT reactor trip is assumed instead of a low pressurizer pressure reactor trip. Both cases are analyzed to ensure the most conservative approach is utilized .

For the OTDT trip scenario, this analysis uses turbine runback to 95% power. This amount of runback is based on the difference in time between the first runback and the OTDT reactor trip.

2.4 Assumption Changes

2.4.1 Uncertainties

The Reference 1 analysis included 30 psi uncertainty in RCS pressure. This reanalysis uses an updated pressure uncertainty of 43 psi and includes uncertainties on initial values for T_{AVG} , SG level and power. The uncertainties used are consistent with those used for the OSG tube plugging increase program (Reference 7).

A T_{AVG} uncertainty of -8 °F is used since lower T_{AVG} leads to lower SG pressure. The reduced SG pressure results in higher break flow, which is conservative for both MTO and OD cases. The model is initialized at 567 °F, corresponding to a nominal T_{AVG} of 575 °F. The SG pressure at a nominal T_{AVG} of 575 °F is then lowered by a pressure uncertainty of 43 psi.

The SG level uncertainty applied is 5%. For the MTO case, the nominal SG level is increased by 5% to reduce the initial MTO. For the OD cases, the nominal SG level is reduced by 5% to increase the release of offsite dose activity.

The power level uncertainty applied is +2%. The initial power of 100% is increased to 102% for all cases since higher core heat flux leads to higher primary pressure and higher break flow.

2.4.2 Initial Conditions

The following initial conditions are changed:

1. The nominal T_{AVG} is revised from 569.1°F to 575 °F. Byron and Braidwood has been analyzed for a T_{AVG} window of 569.1 °F to 588.4 °F as part of the T-HOT reduction program. The Reference 1 analysis used the nominal T_{AVG} (low end of the T_{AVG} window) as the analysis T_{AVG}. For this analysis, the analysis T_{AVG} includes a -8°F uncertainty to the nominal T_{AVG}. The net impact is that the analysis T_{AVG} decreased by 2 °F for this analysis. The use of a lower T_{AVG} is a more conservative assumption.

2. The initial steam generator pressure and mass are revised to correspond to the revised nominal T_{AVG}. The revised pressure and mass are more conservative than the Reference 1 analysis.
3. The steam generator tube plugging level of 20% is used for the RSGs. The steam generator tube plugging level for the OSGs remains at 30%.

2.4.3 Operator Response Times

The operator response times have been changed based on demonstrated performance to draft revised Emergency Operating Procedures (EOPs). In the E-0 procedure, draft revisions were made to allow the operators to isolate the ruptured SG earlier once a tube rupture is suspected. The draft revised procedure was tested on two licensed reactor operator crews from Byron and two licensed reactor operator crews from Braidwood. The draft revisions are scheduled to be approved in early 1997. It should be noted that only the MTO scenario is exercised at the simulator. The OD case uses the same assumed time for initiating RCS cooldown and depressurization as the MTO case.

The analysis response time used in the MTO and OD cases, along with the observed operator response time at the simulator, are summarized in Tables 3 and 4, respectively. The analysis response time to isolate AFW to the ruptured SG is more than 200 seconds longer than the average operator response time observed at the simulator. This is a conservative assumption since the time to isolate AFW has the most significant impact on the MTO case. The remainder of the response times used in the analysis are closer to the average times observed at the simulator. This is acceptable since the AFW isolation and the total overall response times are conservative.

The analysis response time for AFW isolation is shorter than the Reference 1 analysis by 5 minutes. This is supported by the proposed revisions to the EOPs which allowed the operators to isolate AFW earlier once the accident is identified. This shortened response time is also met by the simulator demonstrations performed for the Reference 1 analysis (see Reference 2). The total analysis response time for the remainder of the operator actions is longer than the Reference 1 analysis by 10 minutes. These two time requirements are more conservative than the Reference 3 WOG analysis assumptions.

2.4.4 Turbine Runback

In the Reference 1 analysis, the amount of turbine runback used is 60%. This assumption was based on the reactor trips on low pressurizer pressure approximately 300 seconds after a tube rupture. This analysis changes the turbine runback assumption to 70% for the low pressurizer pressure reactor trip case to be consistent with the Reference 3 WOG analysis. The observation at the simulator is that the reactor is tripped manually by the operators <u>without any</u> turbine runback. The operators are expected to trip the reactor if a trip setpoint is exceeded. Therefore, it is justified to

limit turbine runback to zero. However, to be conservative, this analysis uses runback to 70% power for the low pressurizer pressure reactor trip case.

3. Results

This section describes the results of the revised SGTR analysis.

3.1 MTO Case

3.1.1 OSG Results

The sequence of events for the OSG MTO cases are shown in Table 5. Figures 2 to 4 are plots of key parameters for the OSG low pressurizer pressure reactor trip case. The results from the Reference 1 analysis are included for comparison purposes. Since the isolation of the ruptured SG is earlier in this analysis than the Reference 1 analysis, the rate of increase in ruptured SG liquid volume is less (Figure 4). The gain in MTO is maintained through the end of the event. The operator response time to initiate RCS cooldown is longer in this analysis than the Reference 1 analysis. Figures 2 and 3 show the RCS pressure and break flow remain higher during this part of the event.

For the OTDT case, the time of the first turbine runback is compared to the time of the OTDT reactor trip. The OTDT reactor trip occurs later than the first turbine runback by less than 30 seconds. Since power decreases by 5% for each 30 second interval after the runback setpoint is reached, it is appropriate to use runback to 95% power for the OTDT case.

Figures 5 to 7 are plots of key parameters for the OSG OTDT reactor trip case. The results from the OSG low pressurizer pressure reactor trip case are included for comparison purposes. Since the OTDT reactor trip occurs much earlier than the low pressurizer pressure trip, the SI initiation is much later after reactor trip for the OTDT reactor trip case. Figures 5 to 7 show that, except for the earlier reactor trip for the OTDT case, the results of the two cases follow the same trend.

The SGTR transient ends when charging and letdown is established and break flow is terminated. At the time the SGTR transient is terminated, the ruptured SG contains 290 cubic feet of gas volume as the MTO for the low pressurizer pressure reactor trip case and 293 cubic feet of gas volume as the MTO for the OTDT reactor trip case.

3.1.2 RSG Results

The sequence of events for the RSG MTO cases are shown in Table 6. Figures 8 to 10 are plots of key parameters for the RSG low pressurizer pressure reactor trip case. The results from the OSG low pressurizer pressure reactor trip analysis are included for comparison purposes. Since the RSGs have smaller tube diameter, the initial break flow is smaller than the OSGs (Figure 9) and the depressurization of the RCS is also slower for the RSGs. Figure 8 shows that the low pressurizer pressure reactor trip occurs about 100 seconds later for the RSGs than the OSGs. This results in less AFW

going into the ruptured RSG than into the ruptured OSG. At the time of AFW isolation, the amount of liquid in the ruptured generators is about the same for the RSG and the OSG (Figure 10). After the AFW isolation, the ruptured OSG is filled at a faster rate due to the higher break flow rate. However, since the RSG has a smaller secondary side volume, the final MTO for the RSG is smaller than the OSG.

For the OTDT case, the time of the first turbine runback is compared to the time of the OTDT reactor trip. The OTDT reactor trip occurs later than the first turbine runback by less than 30 seconds. Since power reduces by 5% for each 30 second interval after the runback setpoint is reached, it is appropriate to use runback to 95% power for the OTDT case.

Figures 11 to 13 are plots of key parameters for the RSG OTDT reactor trip case. The results from the OSG OTDT reactor trip analysis are included for comparison purposes. Similar to the low pressurizer pressure reactor trip case, the RSG case reached the OTDT reactor trip setpoint later than the OSG case. The difference in reactor trip time is around 50 seconds. At the time of AFW isolation, the ruptured RSG has more liquid. After the AFW isolation, the ruptured OSG is filled at a faster rate due to the higher break flow rate. However, since the RSG has a smaller secondary side volume, the final MTO for the RSG is smaller than the OSG. Figure 11 shows the RSG case RCS pressure rises between AFW isolation and initiation of RCS cooldown while the OSG case shows a falling trend. This is due to the smaller break flow for the RSG case.

At the time the SGTR transient is terminated, the ruptured SG contains 226 cubic feet of gas volume as the MTO for the low pressurizer pressure reactor trip case and 60 cubic feet of gas volume as the MTO for the OTDT reactor trip case. Therefore, the limiting case is the OTDT case with 60 cubic feet of MTO.

3.2 OD Cases

3.2.1 OSG Results

The sequence of events for the OD cases is show in Table 7. Figures 14 to 17 are plots of key parameters for this event. The results from the Reference 1 analysis are included in the plots for comparison purposes. This analysis uses a longer response time to initiate RCS cooldown. The impact is higher pressure and break flow as shown in Figures 14 and 15.

3.2.2 RSG Results

The sequence of events for the OD cases is shown in Table 7. Figures 18 to 21 are plots of key parameters for this event. The results from the OSG reanalysis are included in the plots for comparison purposes. For the RSGs, because the break flow is smaller than the OSGs, the reactor trip occurs later than the OSGs (Figure 18).

3.2.3 Dose Calculation

The release of offsite dose activity occurs mainly when the SG PORV on the ruptured SG fails open and during the release of steam through the intact SG PORVs. Consistent with Reference 1, the release during the time the ruptured SG PORV fails open is reported. The amount of release during the RCS cooldown period is insignificant compared to the margin available to the acceptance criteria in SRP 15.6.3. The offsite doses are calculated using the same methodology as in the Reference 1 analysis.

The offsite dose results are shown in Tables 8 and 9. The OSG analysis resulted in slightly higher dose than the Reference 1 analysis due to a slightly delayed reactor trip and revised initial OSG conditions. The slight increase in dose release is considered insignificant when compared to the acceptance criteria in SRP 15.6.3. Although the reactor trip occurs later for the RSGs, smaller break flow and higher initial SG mass for the RSGs combined to result in lower dose release than the OSGs and the Reference 1 analysis.

4. Conclusions

The rupture of a single steam generator tube for the OSGs and for the RSGs at the B/B plant has been evaluated. Some of the assumptions used in the Reference 1 analysis are modified in this analysis . The initial conditions which are revised for this analysis include initial RCS T_{AVG}, and initial SG pressure and mass. An additional case crediting OTDT reactor trip for the MTO case is included. The amount of turbine runback for the low pressurizer pressure trip case is revised to 70%. The appropriate uncertainties are added to the initial values for T_{AVG}, SG level and power. The operator response times are revised to reflect the draft revised EOPs. The critical time requirement established in Reference 8 is revised to: isolating the ruptured SG within 11 minutes and completing the remaining mitigation actions within an additional 31 minutes.

The results of this reanalysis show that the offsite doses do not exceed 10 CFR 100 limits or the acceptance criteria of SRP 15.6.3 and that margin to SG overfill is available.

In accordance with the NRC acceptance letter of WCAP 10698-P-A and Supplement 1 to WCAP 10698-P-A, the following plant specific submittal requirements for this analysis were completed:

1. Licensed operators utilizing the Byron simulator and Braidwood simulator performed comparable SGTR runs demonstrating the operator response times used in this analysis for both the MTO and OD cases were realistic. The operator response times used in this analysis are discussed in Section 2.

2. A site specific SGTR offsite radiation consequence analysis was performed using the Reference 1 methodology, consistent with WCAP 10698-P-A Supplement 1 methodology. The offsite dose was calculated based on the Standard Review Plan (SRP) 15.6.3 guidelines and it was determined that the offsite dose does not exceed the 10 CFR 100 limits and meets the SRP 15.6.3 acceptance criteria. The offsite dose results are discussed in Section 3.

3. An evaluation of the main steam line and associated piping supports has been performed for the OSGs as part of the submittal for Reference 1. Since the main steam line and associated piping supports are not changed as part of the RSG installation, the Reference 1 evaluation is applicable to the RSGs. The structural adequacy under water filled conditions should a SGTR occur has been verified.

4. A list of systems, components and instrumentation which the analyses assume are necessary for SGTR mitigation has been compiled in Reference 1. The list includes the safety/non-safety related classification of the equipment and the source of power for the required PORVs and control valves. Since this analysis did not change any assumptions for the systems, components and instrumentation assumed in the Reference 1 analysis, this list is applicable for this analysis.

5. The compatibility of the Byron/Braidwood systems with WCAP 10698-P-A bounding plant analysis has been evaluated in Reference 1. The conclusion that no major design differences affecting the MTO exist and the use of the same limiting single failures as identified in WCAP 10698-P-A and Supplement 1 of WCAP 10698-P-A are applicable for this analysis.

Therefore, based on the results presented in this report, it is concluded that the Byron/Braidwood plants demonstrate compliance with the licensing requirements established by the NRC for the mitigation of a SGTR event.

5. References

1) ComEd Report, "Steam Generator Tube Rupture Analysis for Byron and Braidwood Plants, Revision 1", February 1990.

2) NRC Safety Evaluation Report for Byron Units 1 and 2 and Braidwood Units 1 and 2 Steam Generator Tube Rupture (SGTR), Docket Nos. STN 50-454, 50-455, 50-456 and 50-457, dated April 23, 1992.

3) WCAP-10698-P-A, "SGTR Analysis Methodology to Determine the Margin to Steam Generator Overfill", August 1987.

4) Supplement 1 to WCAP-10698-P-A, "Evaluation of Offsite Radiation Doses for a Steam Generator Tube Rupture Accident", March 1986.

5) ComEd Nuclear Fuel Services Calcnote PSA-B-95-09, "B/B Steam Generator Tube Rupture Analysis to Support 30% Tube Plugging", Rev. 1, dated 10/1/95.

6) ComEd Nuclear Fuel Services Calcnote RSA-B-90-02, "Byron and Braidwood Steam Generator Tube Rupture Analysis with 10% SG Tube Plugging", Rev. 0, dated May 18, 1990.

7) ComEd memo NFS:PSS:93-305, "Byron/Braidwood RTDP Uncertainties," dated October 29, 1993.

8) ComEd Memo, "Response to Request for Additional Information on Byron/Braidwood SGTR Analysis, TAC Nos. M57080/63247 and M64026/64053, NRC Docket Nos. 50-454/455 and 50-456/457", dated January 17, 1992.

Table 1 - Key Physical Differences between OSG and RSG

Parameter	OSG	RSG	Impact on SGTR Analysis
Tube Inside Diameter (in)	0.664	0.605	increase MTO decrease dose
Heat Transfer Area (ft^2)	48300	79800	increase MTO decrease dose
Secondary Side Volume (ft^3)	5949	5221	decrease MTO

Table 2 - Model/Assumption Differences

Item	Reference 1 Analysis	Revised Analysis	
	OSG	OSG	RSG
SG Tube Plugging Level (%)	10*	30	20
Thermal Design Flow (lbm/hr)	144.2×10^6	137.3×10^6	137.3×10^6
Computer Code Version	RETRAN-02 MOD3	RETRAN-02 MOD5.1	RETRAN-02 MOD5.1
SG Model	OSG Model (bounds D4 and D5 SGs)	OSG Model (bounds D4 and D5 SGs)	RSG Model
MTO OTDT Reactor Trip Case	n/a	included	included
Initial T_{AVG} (°F)	569.1	567 (575 nominal)	567 (575 nominal)
Initial SG Level	nominal	nominal +/- 5%	nominal +/- 5%
Initial Power (%)	100	102	102
Operator Response Times	see Tables 3 and 4	see Tables 3 and 4	see Tables 3 and 4
Turbine Runback - MTO Low Pzr. Press. Reactor Trip Case (% power)	60	70	70
Turbine Runback - MTO OTDT Reactor Trip Case (% power)	n/a	95	95

* as supplemented by Reference 6.

Table 3 - Analysis Operator Response Times (MTO Case)

Operator Action	Reference 1 Analysis Response Time (sec)	Revised Analysis Response Time (sec)	Observed Average Response Time (sec)
Isolate AFW to Ruptured SG	960	660	430
Initiate RCS Cooldown	540	1080	1084
Initiate RCS Depressurization	240	120	99
Terminate ECCS Flow (except 1 Centrifugal Charging Pump)	60	120	112
Establish Charging	60	120	121
Establish Letdown	240	180	181
Reopen Pressurizer PORV	120	240	237

Table 4 - Analysis Operator Response Times (OD Case)

Operator Action	Reference 1 Analysis Response Time (sec)	Revised Analysis Response Time (sec)	Observed Average Response Time (sec)
Isolate Ruptured SG PORV	1200 (after SG PORV opens)	1200 (after SG PORV opens)	n/a
Initiate RCS Cooldown	540	1080	1084
Initiate RCS Depressurization	240	120	99
Terminate ECCS Flow	not modeled	not modeled	n/a

Table 5 - Sequence of Events (OSG MTO Cases)

System Response/Operator Action	Reference 1 OSG low pzr press. trip Time (sec)	Revised OSG low pzr press. trip Time (sec)	Revised OSG OTDT trip Time (sec)
SG Tube Rupture Occurs	0	0	0
Reactor Trip	314	306	171
Auxiliary FW Injection	324	315	171
Safety Injection	324	315	418
Ruptured SG AFW Isolated	960	660	660
RCS Cooldown Initiated	1500	1740	1740
RCS Cooldown Terminated	2457	2629	2616
RCS Depressurization Initiated	2697	2749	2736
RCS Depressurization Terminated	2810	2854	2842
ECCS Flow Terminated	2870	2974	2962
70 GPM Charging Flow Established	2930	3094	3082
RCS Letdown Established	3170	3274	3262
Reopen Pressurizer PORV	3290	3515	3502
Reclose Pressurizer PORV	3315	3547	3534

Table 6 - Sequence of Events (RSG MTO Cases)

System Response/Operator Action	RSG low pzr. press. trip Time (sec)	RSG OTDT trip Time (sec)
SG Tube Rupture Occurs	0	0
Reactor Trip	410	228
Auxiliary FW Injection	421	228
Safety Injection	421	642
Ruptured SG AFW Isolated	660	660
RCS Cooldown Initiated	1740	1740
RCS Cooldown Terminated	2690	2679
RCS Depressurization Initiated	2810	2799
RCS Depressurization Terminated	2940	2928
ECCS Flow Terminated	3061	3048
70 GPM Charging Flow Established	3181	3168
RCS Letdown Established	3361	3348
Reopen Pressurizer PORV	3602	3589
Reclose Pressurizer PORV	3638	3625

Table 7 - Sequence of Events (OD Cases)

System Response/Operator Action	Reference 1 OSG Time (sec)	Revised OSG Time (sec)	RSG Time (sec)
SG Tube Rupture Occurs	0	0	0
Reactor Trip	466	482	666
Safety Injection	471	487	671
Ruptured SG PORV opens	497	515	681
Auxiliary FW Injection	557	575	741
Ruptured SG PORV Isolated	1697	1715	1881
Auxiliary FW Isolated	1757	1775	1941
RCS Cooldown Initiated	2247	2795	2961
RCS Cooldown Terminated	2991	3534	3658
RCS Depressurization Initiated	3231	3654	3778
RCS Depressurization Terminated	3393	3763	3881

Table 8 - Offsite Dose Results (Thyroid)

Case	Reference 1 OSG (rem)	Revised OSG (rem)	RSG (rem)	SRP 15.6.3 Acceptance Criteria (rem)
Byron Preaccident Iodine Spike - EAB	19.11	19.72	14.71	300.0
Byron Preaccident Iodine Spike - LPZ	0.57	0.59	0.44	300.0
Byron Concurrent Iodine Spike - EAB	18.11	18.46	13.82	30.0
Byron Concurrent Iodine Spike - LPZ	0.54	0.55	0.41	30.0
Braidwood Preaccident Iodine Spike - EAB	25.81	26.64	19.87	300.0
Braidwood Preaccident Iodine Spike - LPZ	2.38	2.46	1.83	300.0
Braidwood Concurrent Iodine Spike - EAB	24.46	24.93	18.67	30.0
Braidwood Concurrent Iodine Spike - LPZ	2.26	2.30	1.72	30.0

Table 9 - Offsite Dose Results (Whole Body)

Case	Reference 1 OSG (rem)	Revised OSG (rem)	RSG (rem)	SRP 15.6.3 Acceptance Criteria (rem)
Byron Preaccident Iodine Spike - EAB	0.2100	0.2111	0.1797	25
Byron Preaccident Iodine Spike - LPZ	0.0063	0.0063	0.0054	25
Byron Concurrent Iodine Spike - EAB	0.2079	0.2094	0.1729	2.5
Byron Concurrent Iodine Spike - LPZ	0.0062	0.0062	0.0052	2.5
Braidwood Preaccident Iodine Spike - EAB	0.2837	0.2852	0.2428	25
Braidwood Preaccident Iodine Spike - LPZ	0.0262	0.0263	0.0024	25
Braidwood Concurrent Iodine Spike - EAB	0.2808	0.2829	0.2336	2.5
Braidwood Concurrent Iodine Spike - LPZ	0.0259	0.0261	0.0215	2.5

Figure 1 - SGTR Analysis Noding Diagram

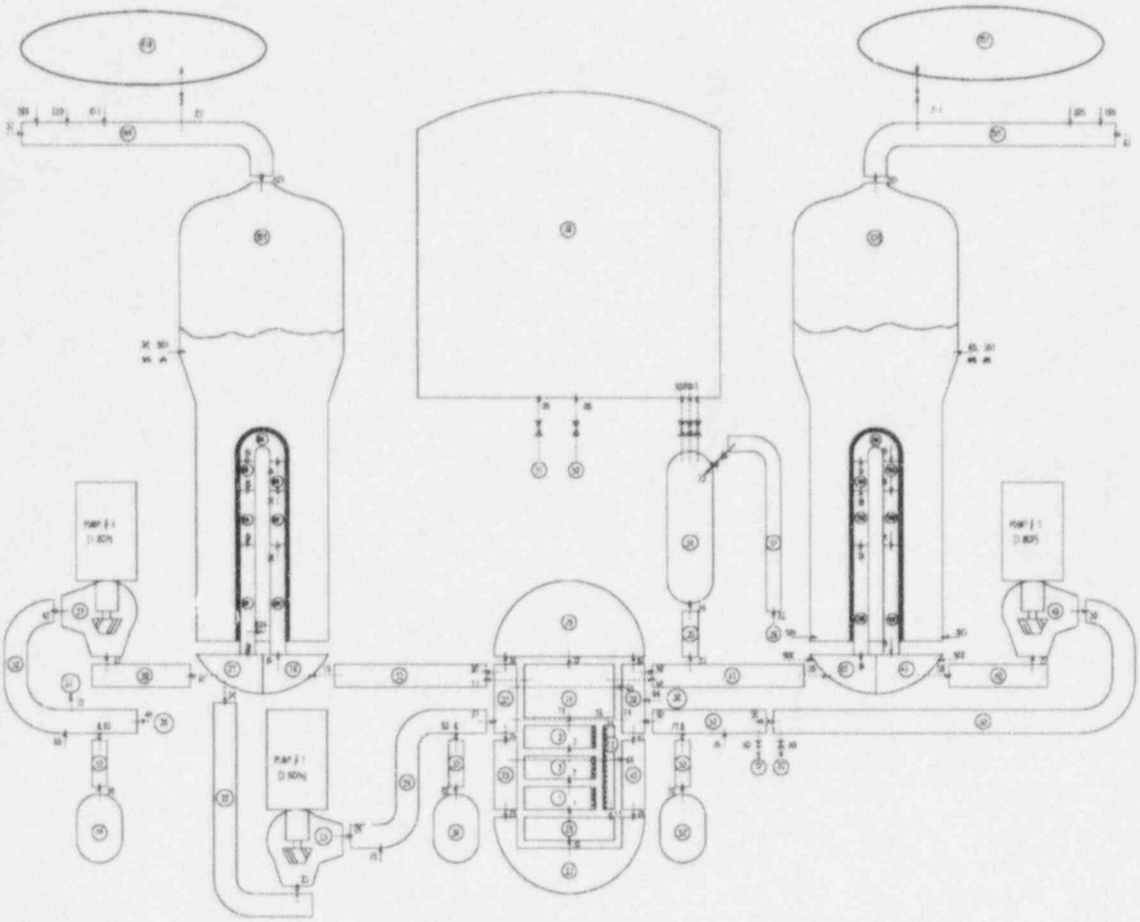

Figure 2 - Pressurizer/Ruptured SG Pressure **(OSG MTO Low Pzr. Pressure Case)**

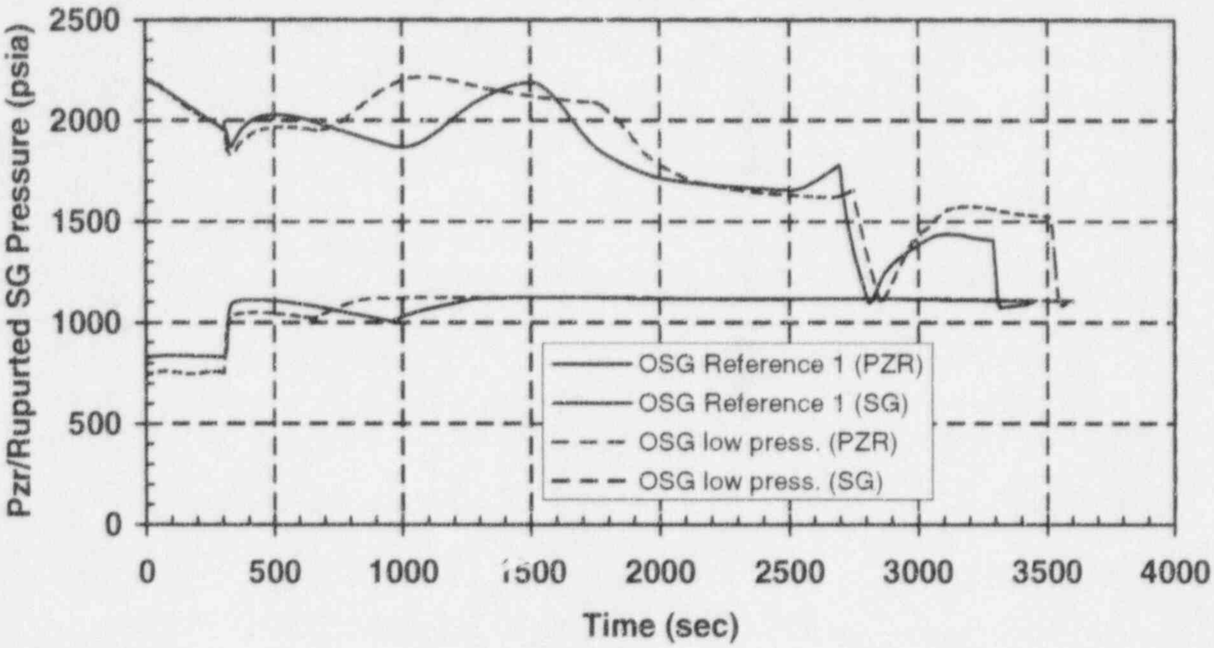

Figure 3 - Ruptured Tube Flow **(OSG MTO Low Pzr. Pressure Case)**

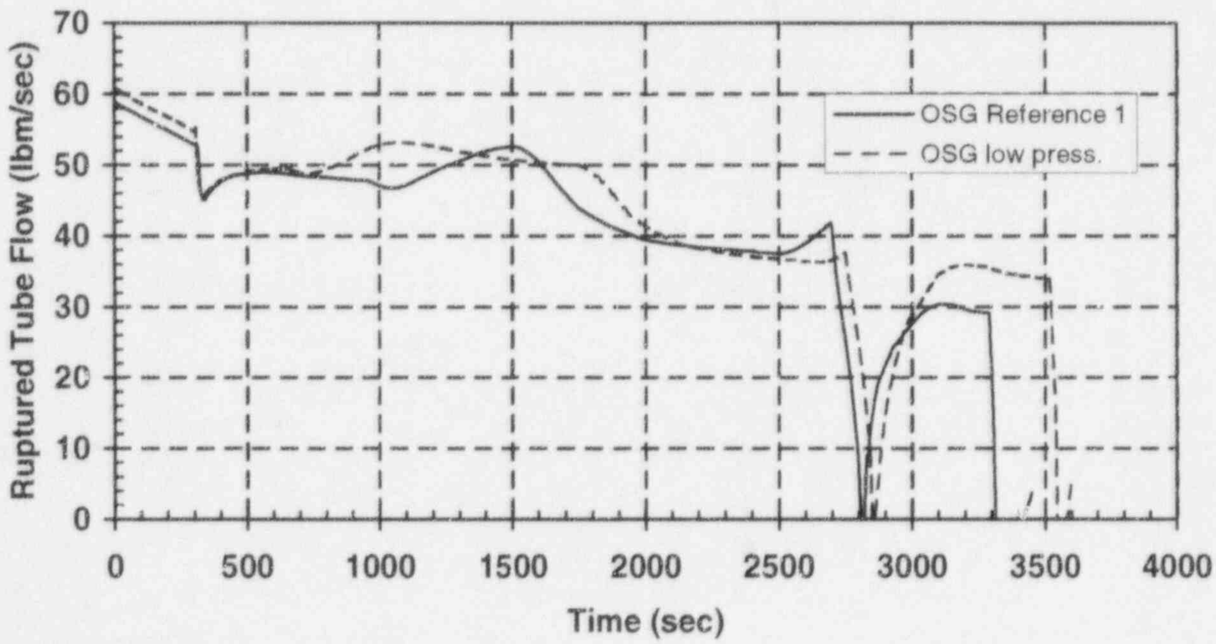

Figure 4 - Ruptured SG Liquid Volume __(OSG MTO Low Pzr. Pressure Case)__

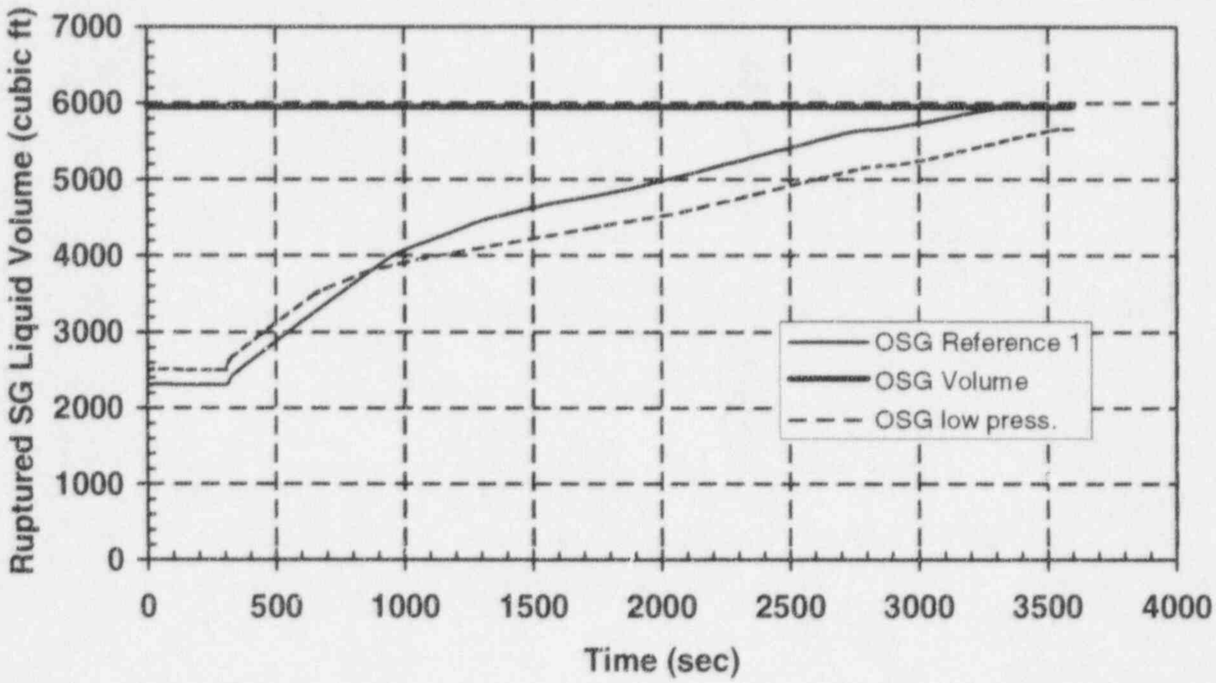

Figure 5 - Pressurizer/Ruptured SG Pressure <u>(OSG MTO OTDT Case)</u>

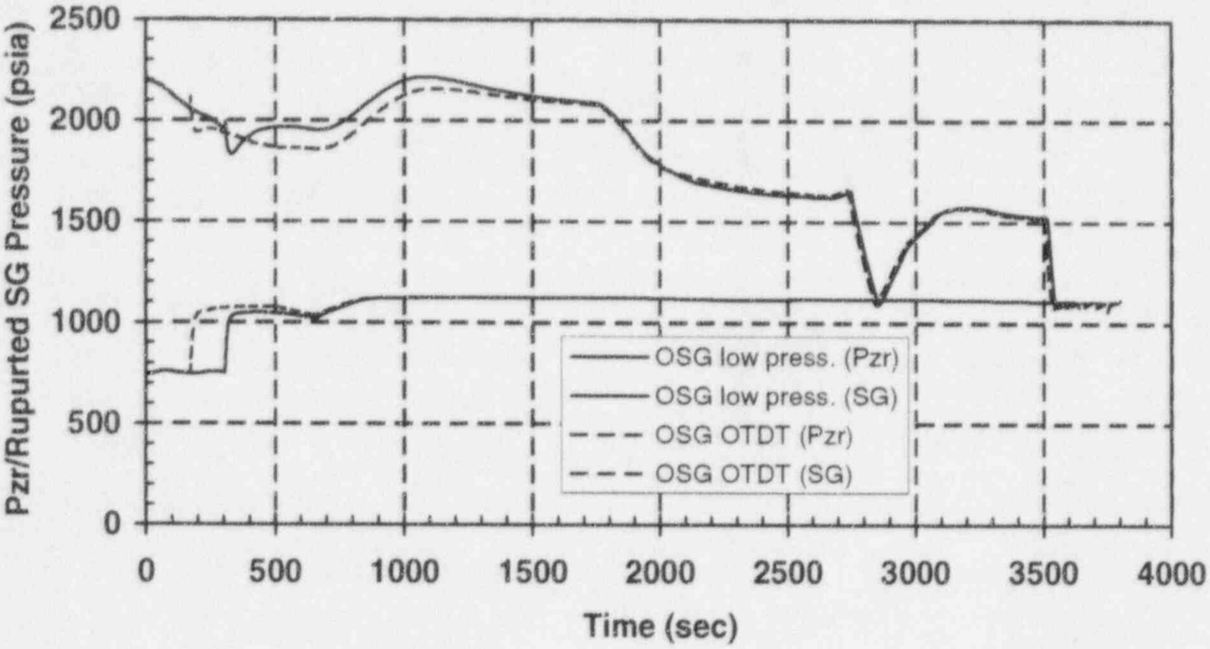

Figure 6 - Ruptured Tube Flow <u>(OSG MTO OTDT Case)</u>

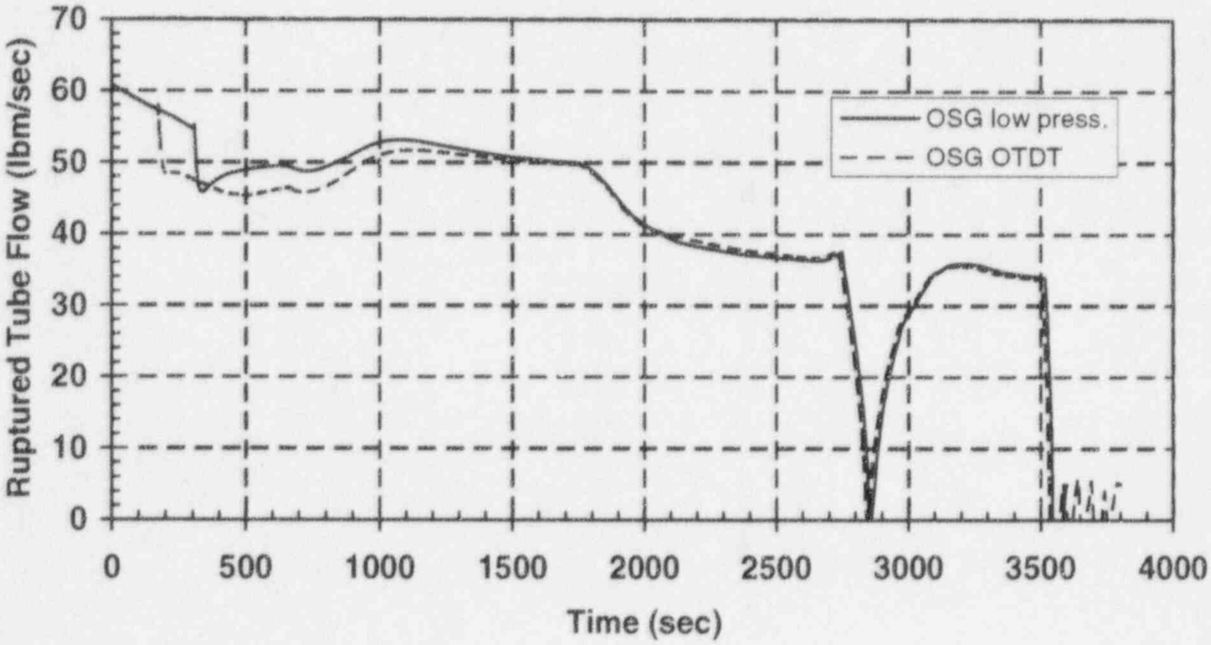

Figure 7 - Ruptured SG Liquid Volume **<u>(OSG MTO OTDT Case)</u>**

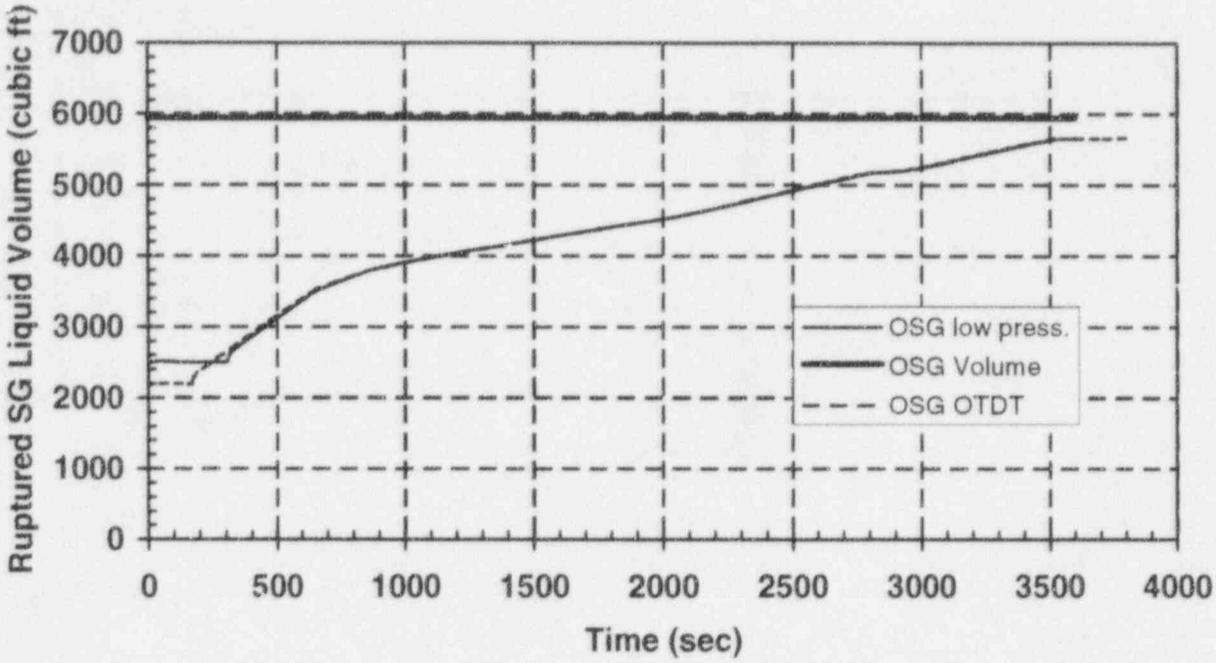

Figure 8 - Pressurizer/Ruptured SG Pressure (RSG MTO Low Pzr. Pressure Case)

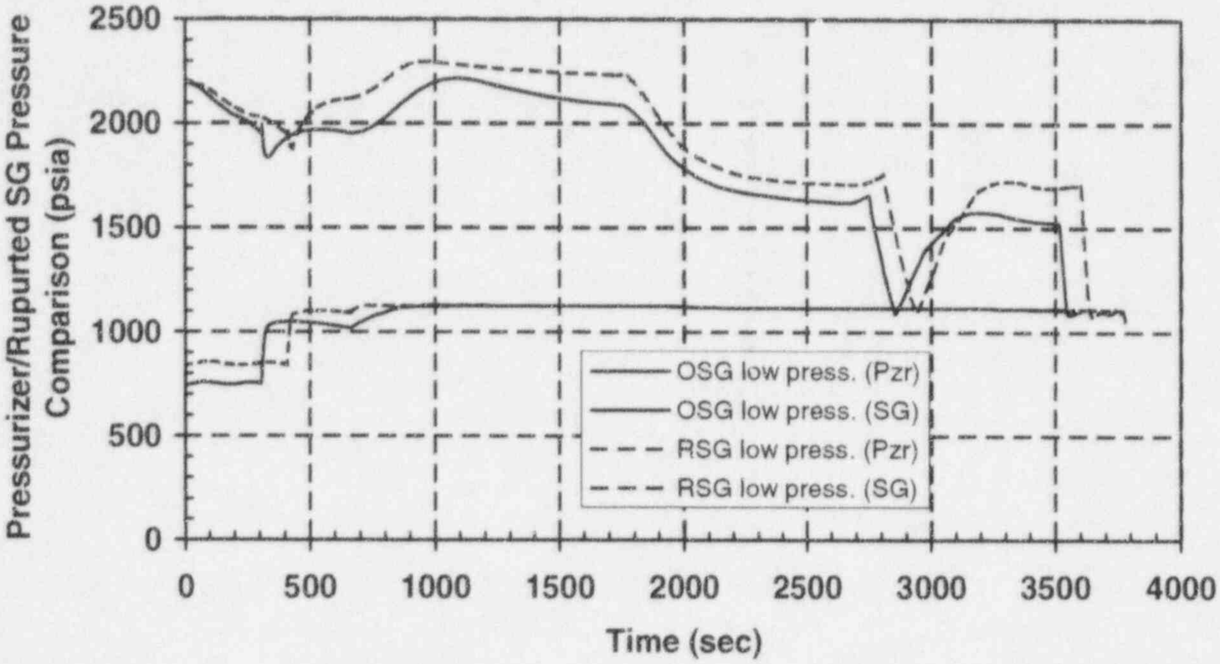

Figure 9 - Ruptured Tube Flow (RSG MTO Low Pzr. Pressure Case)

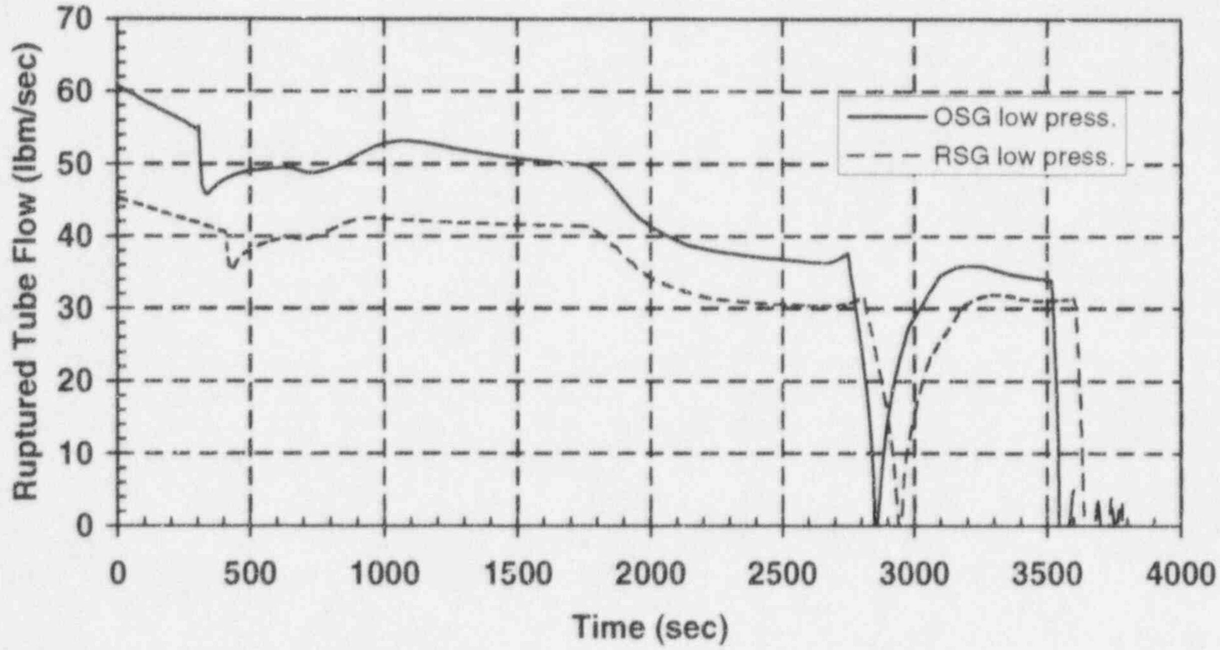

Figure 10 - Ruptured SG Liquid Volume <u>(RSG MTO Low Pzr. Pressure Case)</u>

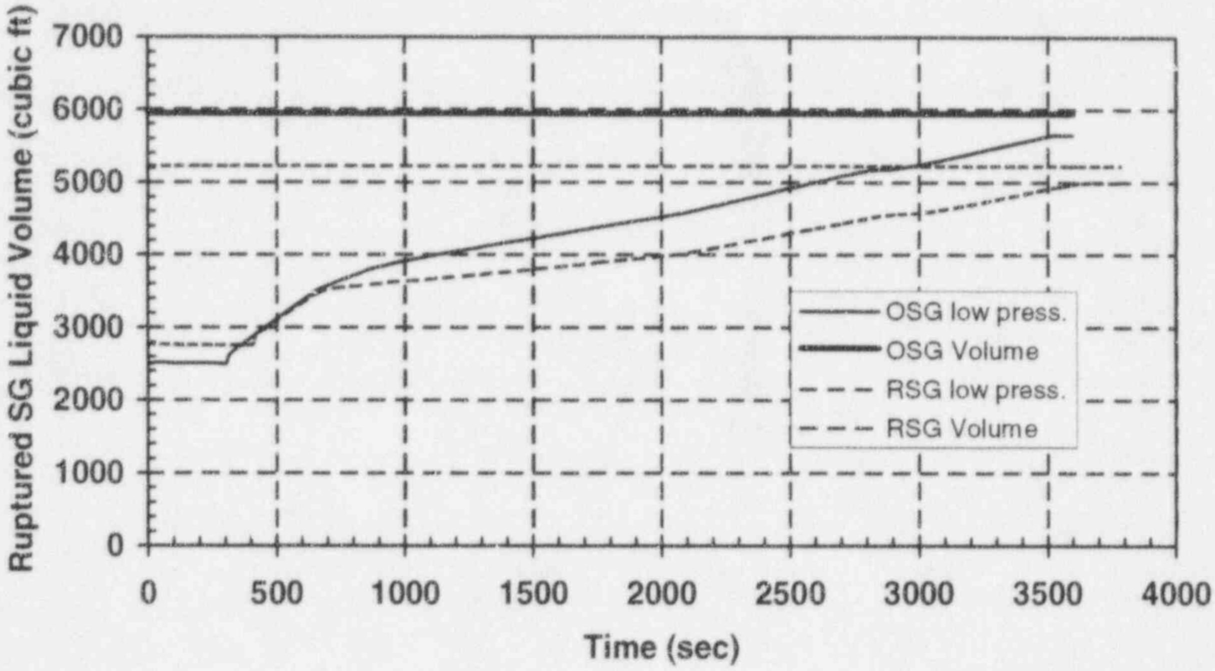

Figure 11 - Pressurizer/Ruptured SG Pressure (RSG MTO OTDT Case)

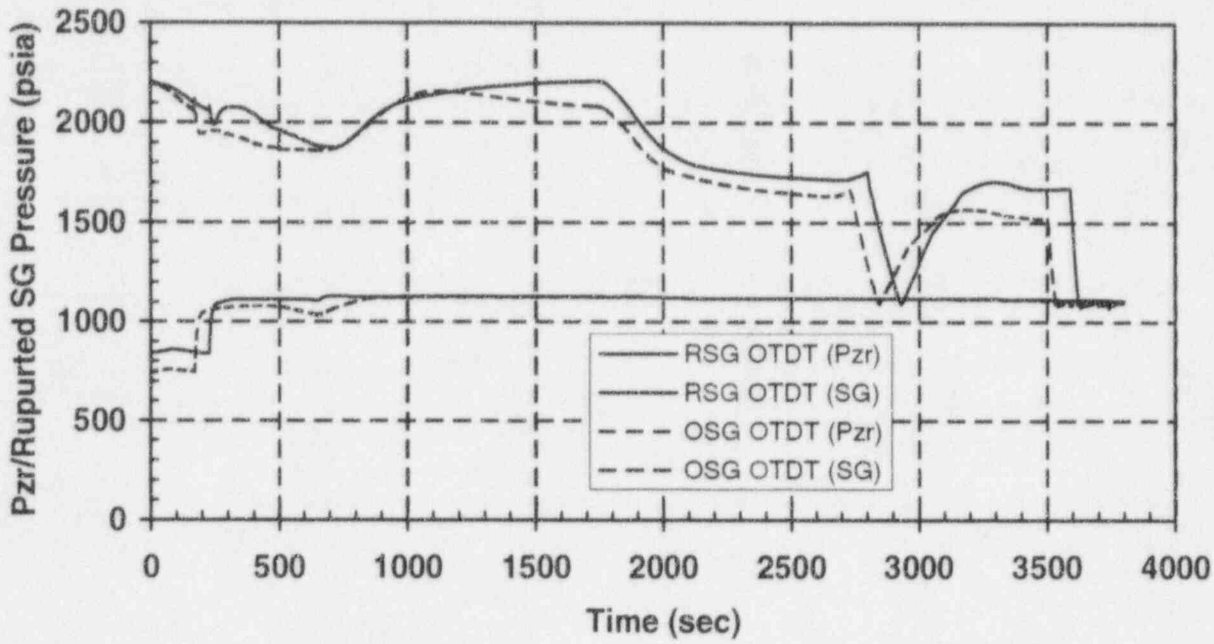

Figure 12 - Ruptured Tube Flow (RSG MTO OTDT Case)

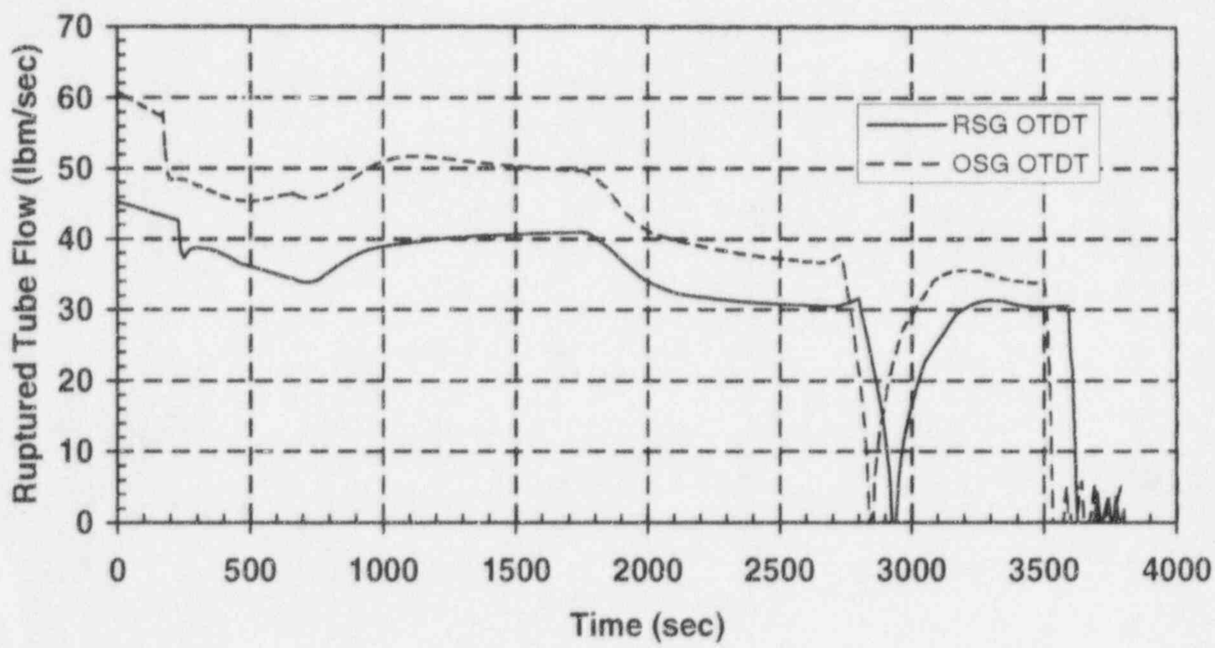

Figure 13 - Ruptured SG Liquid Volume <u>(RSG MTO OTDT Case)</u>

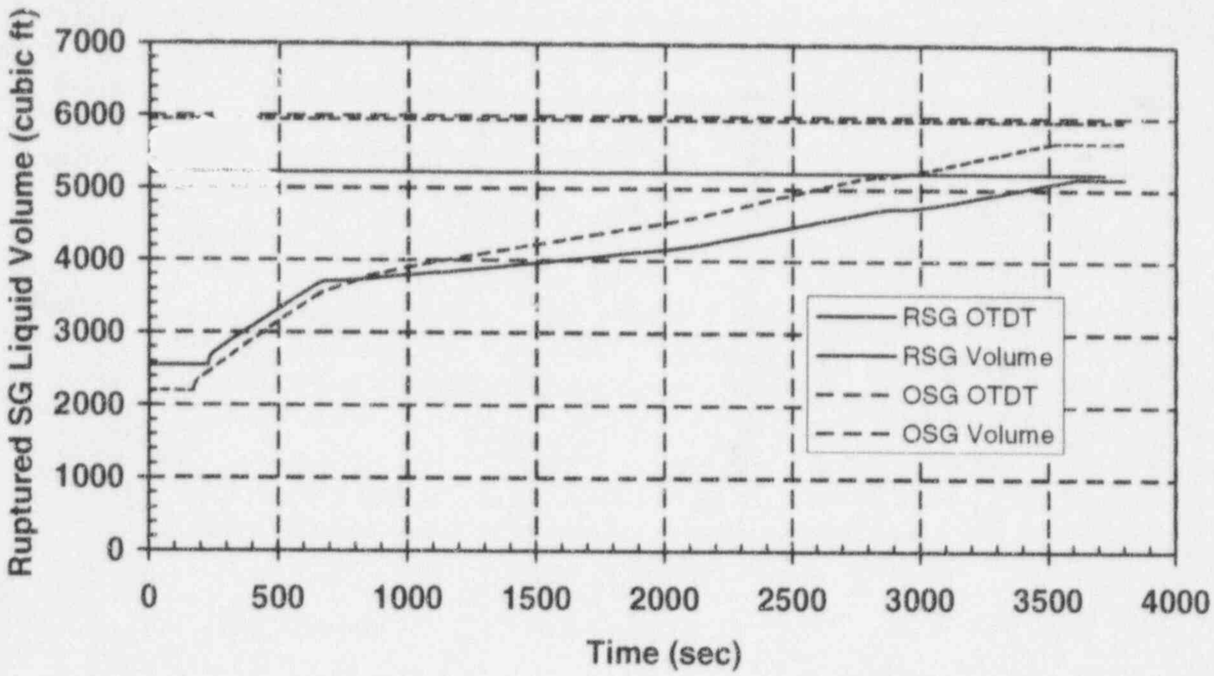

Figure 14 - Pressurizer/Ruptured SG Pressure <u>(OSG OD Case)</u>

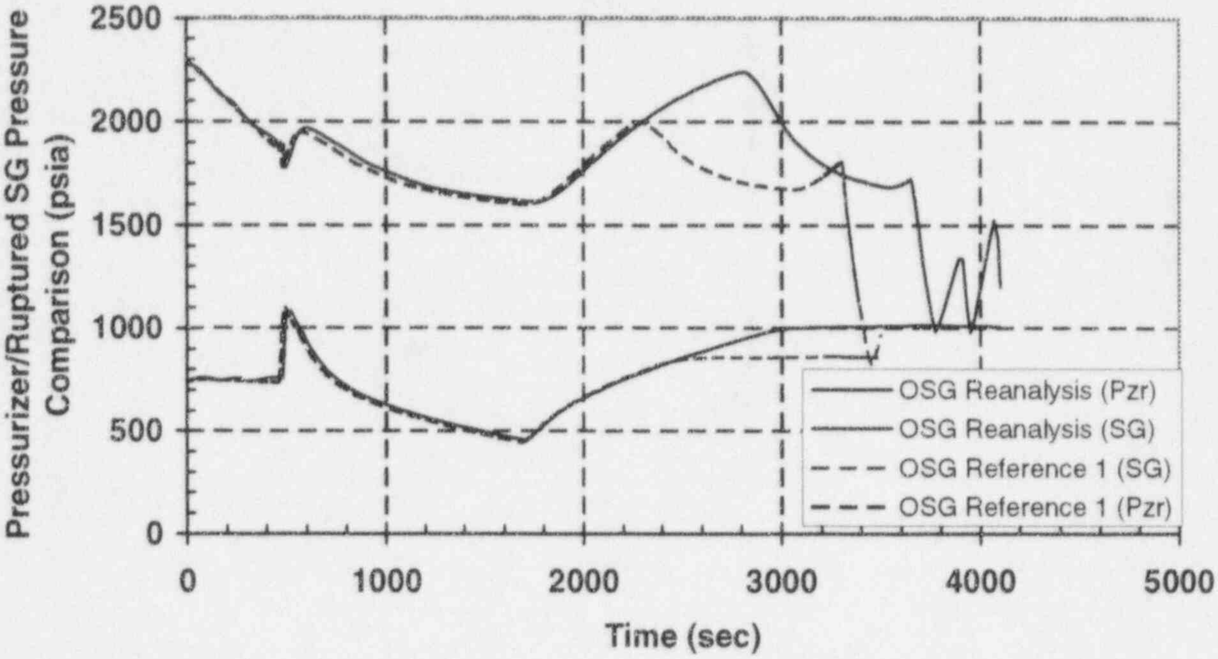

Figure 15 - Ruptured Tube Flow <u>(OSG OD Case)</u>

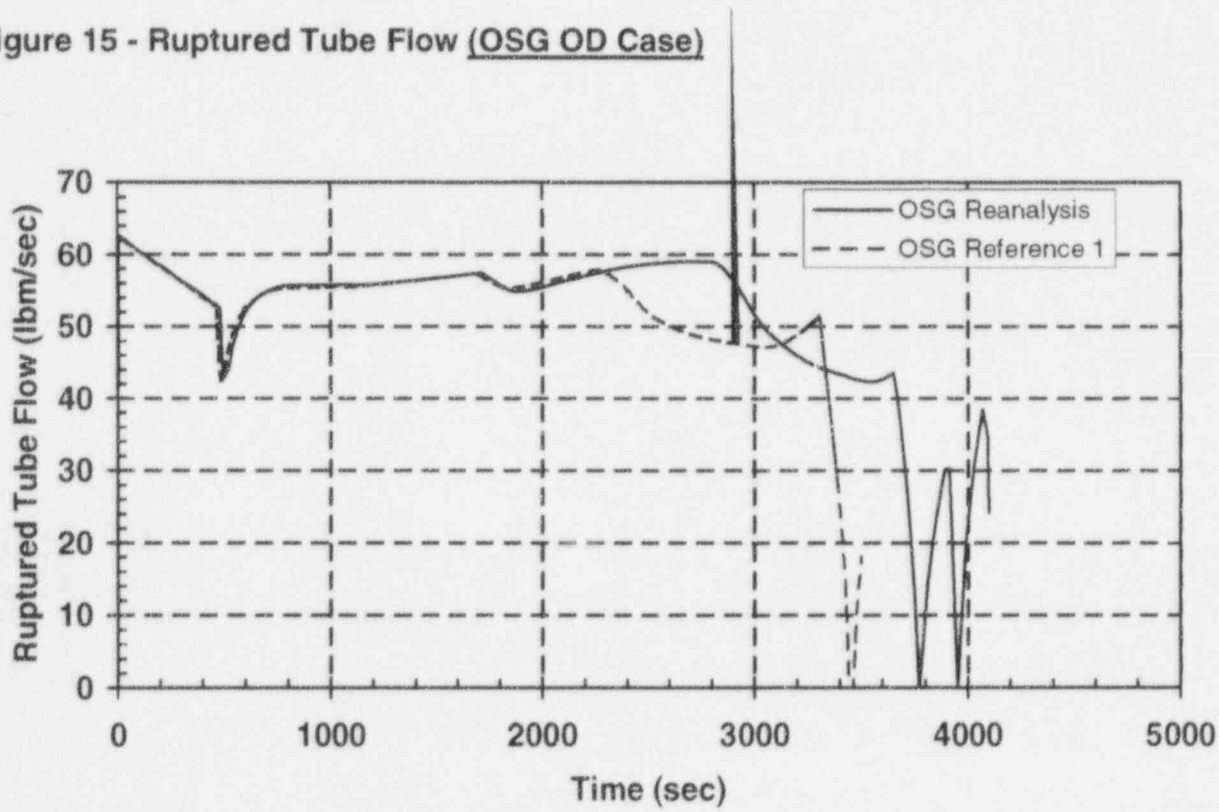

Figure 16 - Ruptured SG Steam Release Rate (OSG OD Case)

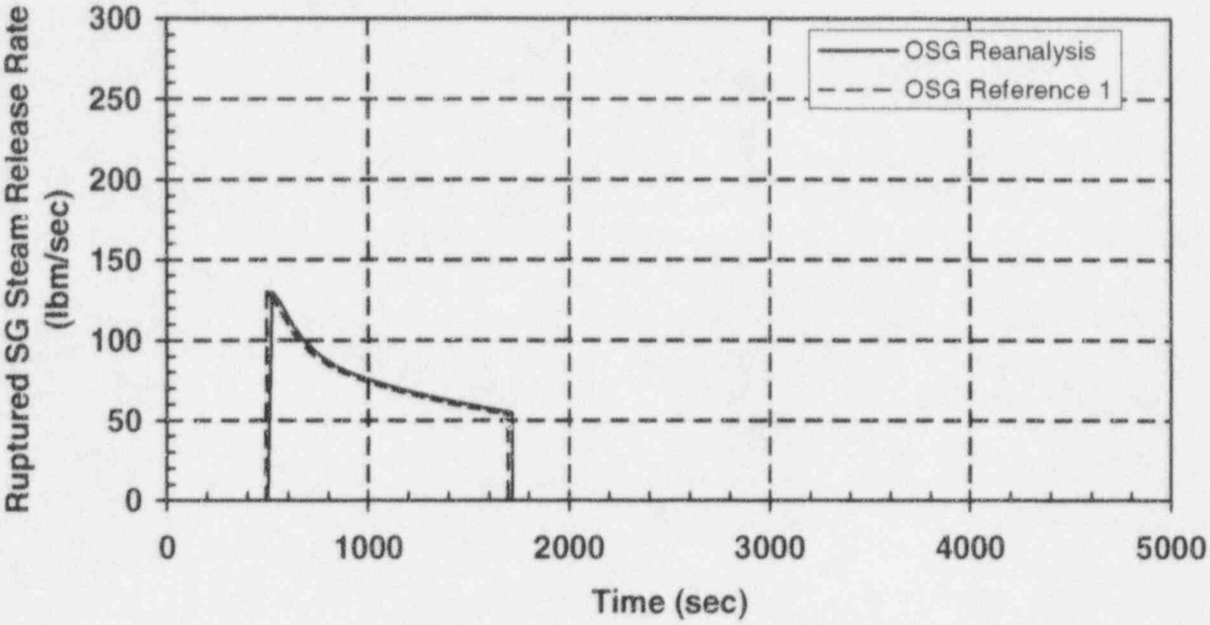

Figure 17 - Intact SG Steam Release Rate (OSG OD Case)

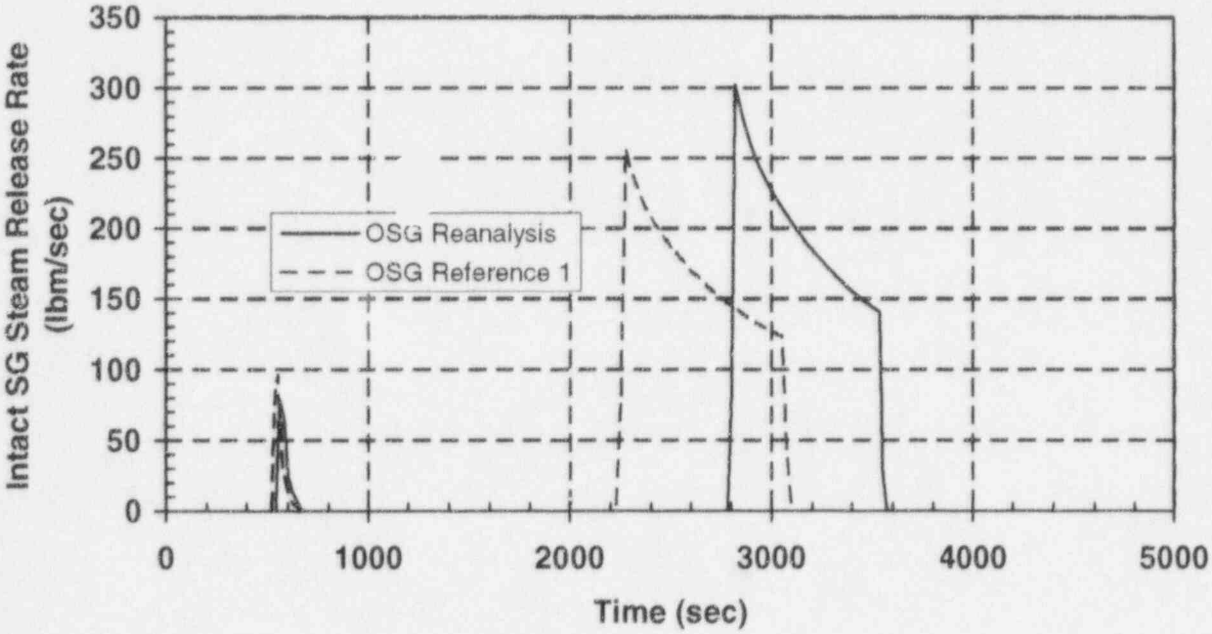

Figure 18 - Pressurizer/Ruptured SG Pressure (RSG OD Case)

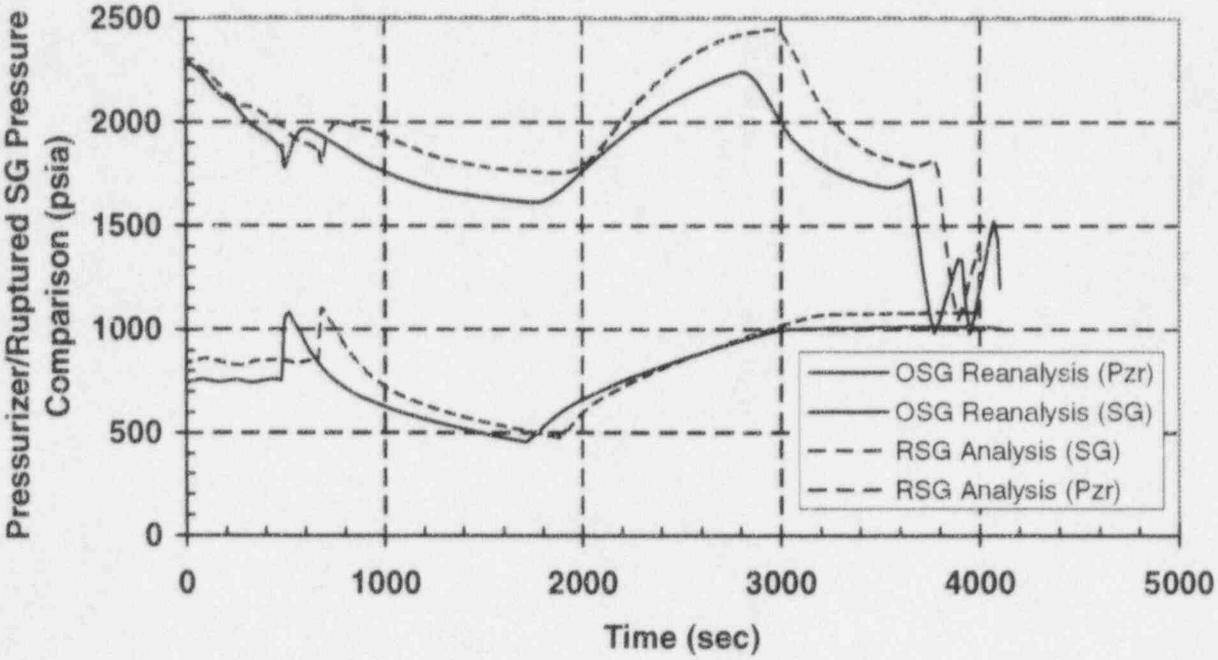

Figure 19 - Ruptured Tube Flow (RSG OD Case)

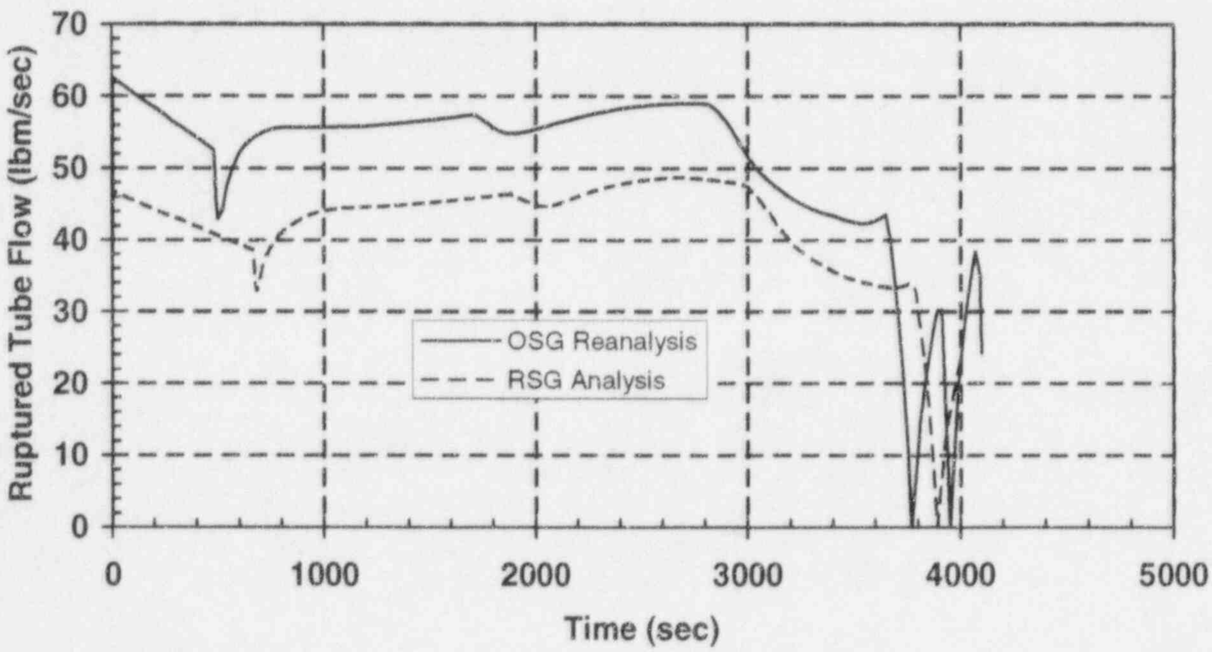

Figure 20 - Ruptured SG Steam Release Rate (RSG OD Case)

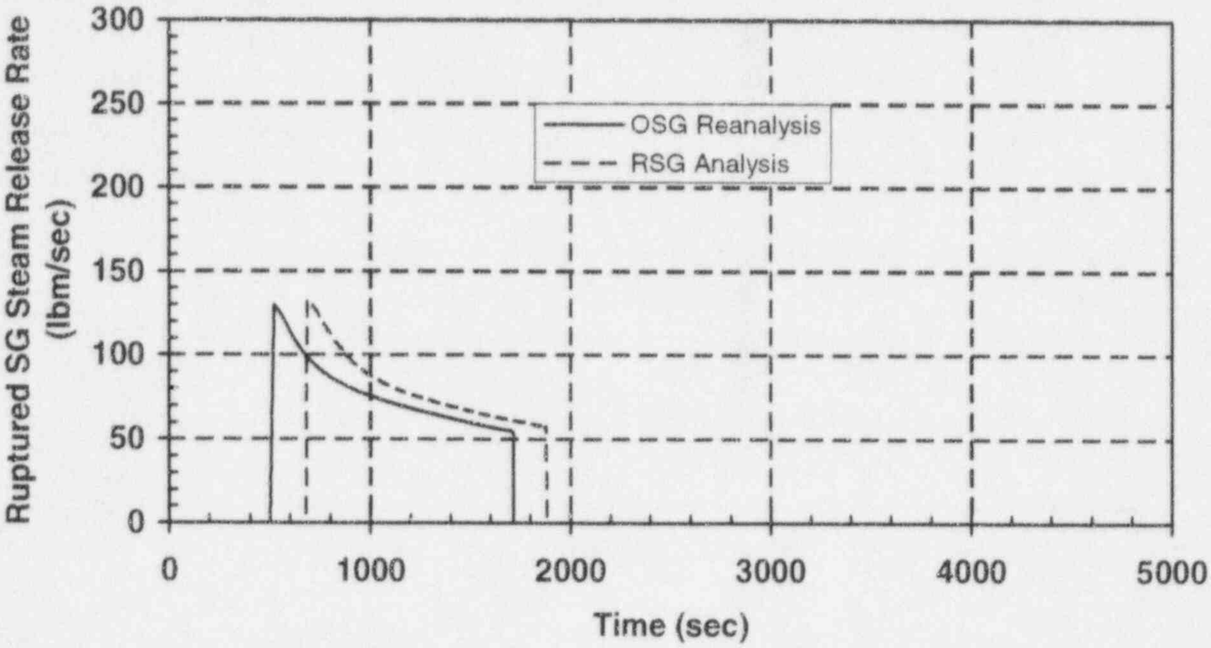

Figure 21 - Intact SG Steam Release Rate (RSG OD Case)