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July 7, 2003

Document Control Desk
U. S. Nuclear Regulatory Commission
Washington D. C. 20555-0001

ATTENTION: Chief, Information Management Branch
Division of Program Management
Policy Development and Analysis Staff

Subject: Duke Energy Corporation
Oconee Nuclear Station - Units 1, 2, and 3
Docket Nos. 50-269, 50-270, and 50-287

Revisions to Topical Report DPC-NE-3003 In Support of Steam Generator Replacement
Response to NRC Staff Request for Additional Information

Reference: Duke Submittal Dated June 13, 2002

Enclosed herein, please find the Duke Energy Corporation (Duke) response to the May 12, 2003 NRC staff's request for additional information concerning topical report DPC-NE-3003, Revision 1, "Mass and Energy Release and Containment Response Methodology."

Attachment 1 to this letter constitutes Duke's response to questions 1 - 12, and 14 - 17. Duke's response to question 13 will be submitted by July 31, 2003.

During the preparation of the responses, two (2) additional revisions to the methodology were identified as necessary. These new revisions are detailed in Attachment 2. Duke requests that the NRC include these revisions within the scope of review of the original June 13, 2002 submittal.

If there are any questions or if additional information is needed on this matter, please call J. A. Effinger at (704) 382-8688.

A001

Very truly yours,

K. S. Canady

xc:

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ATTACHMENT 1

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Attachment 1

**Duke Power Response To
Request For Additional Information**

**DPC-NE-3003 Revision 1
"Mass and Energy Release and Containment Response Methodology"**

<u>General Questions</u>

1. Discuss the major differences between FATHOMS and GOTHIC 7.0 and the effect these differences will have on the containment analyses.

Response: FATHOMS Version 2.4 was released in April of 1989. Shortly thereafter, FATHOMS became the GOTHIC code under EPRI sponsorship. Since then there have been many versions of GOTHIC released as part of the ongoing GOTHIC Enhancement Project. Each new version of GOTHIC adds new modeling features, user conveniences and improves and extends existing modeling capabilities. The list of differences between FATHOMS 2.4 and GOTHIC 7.0 is extensive but only a few of the differences are of significance for Duke's application for the analysis of the temperature and pressure response in containment for the Oconee Nuclear Station. These differences are described below.

<u>Drop Energy Equation</u>
FATHOMS 2.4 solves one energy equation for the vapor phase (air and steam) and a second energy equation for the combined drop and liquid phases. This means that within each computational control volume the drops and the liquid phases are at the same temperature. One of the first modifications under the GOTHIC project was the addition of a separate energy equation for the drop field. With this improvement, the drops and liquid phases within a computational control volume can be at different temperatures. If drops are present, the combined drop/liquid energy equation in FATHOMS 2.4 generally tends to promote thermal equilibrium in the liquid and vapor phases. The large interface area of the drops effectively extends the interface area for the water pool or films, enhancing the interphase heat and mass transfer.

<u>Drop Deposition</u>
Both FATHOMS 2.4 and GOTHIC 7.0 include models for the drop deposition. However, for the Oconee applications, the FATHOMS model is limited to gravitational settling using a constant drag coefficient appropriate for large drops. This makes the settling rate independent of the drop size. The drop deposition model in GOTHIC 7.0 includes gravitational settling and impaction. Deposition due to impaction is small for this application because the bulk average containment velocity is low. The settling deposition in GOTHIC 7.0 depends on the drop diameter because the drag coefficient is a function of the drop size. Small drops, typical of the size created by a LOCA, will fall slower in GOTHIC 7.0 due to the larger drag coefficient. Therefore, the water retained as drops in the atmosphere will typically be larger with GOTHIC 7.0 than with FATHOMS 2.4. GOTHIC 7.0 also includes a drop agglomeration model whereby smaller drops combine to form larger drops that are subject to higher fall out rates.

Drop Entrainment

Both FATHOMS 2.4 and GOTHIC 7.0 include models for drop entrainment. Typically drop entrainment occurs at high vapor velocity across a liquid surface. The bulk average velocities calculated for Oconee applications are not high enough to result in significant entrainment. However, GOTHIC 7.0 includes another entrainment mechanism that is not in FATHOMS. In GOTHIC 7.0, a portion ($1/6^{th}$) of the condensation rate is assumed to be converted to drops to simulate dripping from ceilings and equipment. The model was incorporated to improve comparison with experimental results from HDR and other large-scale facilities. The drops created by this mechanism are large and quickly fall from the atmosphere but they do provide the potential for increased interface heat and mass transfer.

Interphase Heat and Mass Transfer

In FATHOMS 2.4, the interface heat and mass transfer at the drop and liquid surfaces is calculated using effective heat transfer coefficients for each side of the interface that incorporates mass transfer as appropriate. The particular correlation used for the effective heat transfer coefficients depends on whether the phase is superheated or subcooled relative to the local saturation temperature. The energy balance at the interface used to calculate the rate of phase change is

$$\Gamma\Delta h_{\Gamma} = A_I H_{l,eff}(T_l - T_s) + A_I H_{v,eff}(T_v - T_s)$$

where Γ is the rate of phase change, Δh_{Γ} is the heat of vaporization, A_I is the interface area, $H_{l,eff}$ and $H_{v,eff}$ are the heat transfer coefficients, including phase change effects, for the liquid and vapor sides of the interface respectively. T_l, T_v and T_s are the liquid, vapor and saturation temperatures, respectively.

In GOTHIC 7.0, the interfacial heat and mass transfer are calculated using a heat and mass transfer analogy. The energy balance for the interface is

$$\Gamma\Delta h_{\Gamma} = A_I H_l(T_l - T_I) + A_I H_v(T_v - T_I)$$

where H_l and H_v are the sensible heat transfer coefficients for the liquid and vapor sides of the interface respectively and T_I is the interface temperature. The unknown interface temperature is obtained by simultaneously solving the interface energy balance with the mass transfer equation

$$\Gamma = -A_I H_m(\varphi_v - \varphi_I)$$

and the assumption that the steam pressure at the interface is the saturation pressure at the interface temperature. H_m is the mass transfer coefficient and φ_v and φ_I are the steam concentrations in the vapor phase and at the interface, respectively.

The heat transfer coefficients are from correlations for free and forced convection as appropriate for the local conditions. The mass transfer coefficient is obtained from the heat transfer correlations using a heat and mass transfer analogy. The formulation for the interface heat and mass transfer in FATHOMS tends to keep the phases closer to thermal equilibrium than the GOTHIC formulation. The interface area is largely dependent on the flow regime that the code determines is appropriate for the given situation. Although there have been changes to the flow regime selection logic in GOTHIC, for this application the interface area would be based on an assumed film regime configuration and should be approximately the same for the two codes.

Observed Differences in Code Predictions

A comparison of the code results from FATHOMS 2.4 and GOTHIC 7.0 for the Oconee cases shows that for LOCA:

1. GOTHIC 7.0 predicts peak pressures that are generally slightly lower (~0.5 psia)
2. GOTHIC 7.0 predicts peak temperatures that are generally slightly lower (~0.5° F)

For MSLB:

1. GOTHIC 7.0 predicts peak pressures that are generally slightly higher (~0.5 psia)
2. GOTHIC 7.0 predicts peak temperatures that are generally lower (~10° F)

For MSLB and LOCA:

1. GOTHIC 7.0 predicts sump water volumes that are generally lower.
2. GOTHIC 7.0 predicts sump water temperatures that are generally lower.

These differences are consistent with the code differences. For the LOCA events both codes predict a saturated containment atmosphere due to the large amount of drops injected. The slightly lower pressure and temperature from GOTHIC 7.0 may be attributed to additional drop hold up in the atmosphere. This effectively increases the heat capacity of the atmosphere and reduces the temperature rise for a given energy addition.

For the MSLB events, the higher pressure predicted by GOTHIC 7.0 may be attributed to additional steam generation from the improved interface heat and mass transfer models and from the drops that are generated due to dripping. The additional vaporization takes heat from the atmosphere and reduces the atmosphere temperature.

The lower sump liquid volume predicted by GOTHIC 7.0 may be attributed to higher drop concentrations in the atmosphere due to larger drag on small drops and drops generated by the dripping model. The lower sump temperature predicted by GOTHIC 7.0 may be attributed to the addition of the second energy equation for the drops and the improved heat and mass transfer models in GOTHIC 7.0.

The code changes discussed above were all directed toward providing a more realistic and physically based solution for accident events. All of the model improvements were made in conjunction with code and model validation. The validation base for GOTHIC 7.0 is significantly greater than for FATHOMS 2.4 and code results are generally in good agreement with experimental data.

2. How is the nitrogen released from the accumulators accounted for in the containment LOCA calculations?

Response: The nitrogen cover gas injection boundary condition in the long-term large-break LOCA containment response is described on pg. 6-20. A constant nitrogen flow rate of 356 lbm/sec is assumed from t=37.6 to 44.5 seconds for the injection of this gas. This boundary condition is also included in the peak containment pressure analyses. Because the peak containment pressure is reached prior to the time at which this gas is injected into containment for all cases analyzed, it has no impact on the calculated peak containment pressure.

The determination of the core flood tank initial conditions to maximize the containment pressure is discussed on pgs. 3-5 and 3-6.

3. Please provide the results using the GOTHIC 7.0 code of peak pressure and temperature calculations for the sensitivity cases listed in Table 3.1-1 of DPC-NE-3003 in tabular and graphical form. If the results or conclusions are significantly different from those presented in DPC-NE-3003P, explain the difference.

Response: Table 3.1-1 of DPC-NE-3003 describes a spectrum of LOCA peak pressure cases including a range of break locations and sensitivity analyses for several important modeling assumptions. The staff's request is understood to focus on the difference in the predicted results from the FATHOMS and GOTHIC 7.0 code versions. Rather than show the comparison for the cases in Table 3.1-1, a different set of cases has been selected which is more focused on the current knowledge of the key sensitivity parameters. Also, the results presented are for the ROTSGs, which is the subject of Revision 1 to the topical report.

The results of the 14 code comparison analyses are shown in Table 3-1 below and in the figures that follow. In general, the pressure and vapor temperature response predictions were very similar in both magnitude and trend. GOTHIC 7.0 predictions for peak pressures and vapor temperature were slightly lower (~0.5 psig and 0.5°F). These differences are consistent with the code model differences described in the response to Question #1. Both codes predict a saturated containment atmosphere due to the large amount of drops injected. The slightly lower pressure, vapor temperature, and liquid temperature from GOTHIC 7.0 may be attributed to additional drop hold up in the atmosphere. This effectively increases the heat capacity of the atmosphere and reduces the temperature rise for a given energy addition. A comparison of the total liquid and drop masses, and liquid temperatures, show the predictions of the two codes to be essentially the same. This is consistent with the changes in the drop deposition and entrainment models discussed in Question #1. These results show that the two code versions give essentially similar results for the same break location and initial and boundary conditions.

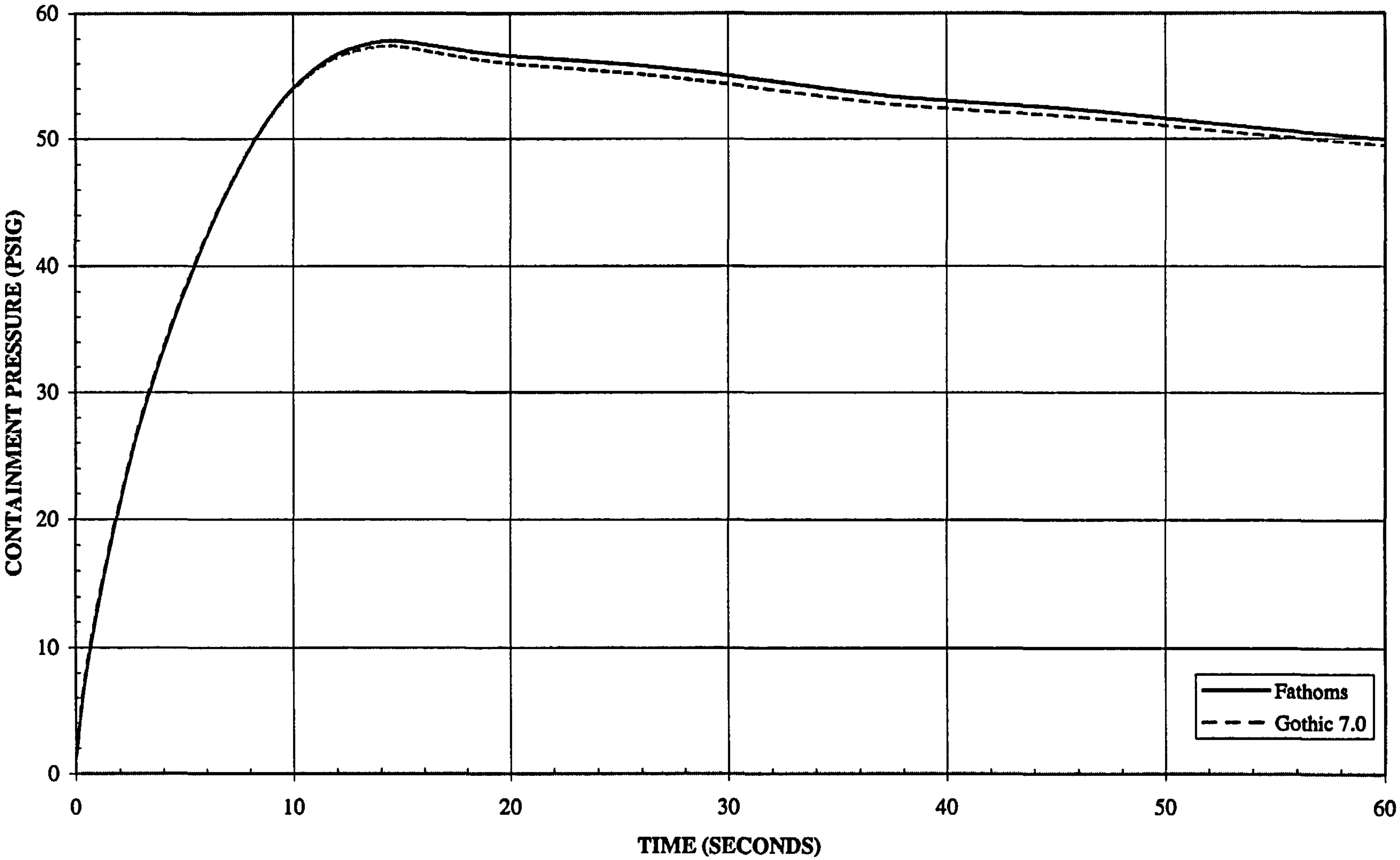
Table 3-1

ROTSG Case Description	Peak Containment Pressure (psig)		Peak Containment Temperature (°F)	
	Fathoms	Gothic 7.0	Fathoms	Gothic 7.0
Hot Leg SG Inlet Break w/ High RCS Flow Cases				
14.1 ft^2 Hot Leg Break w/ M1 Pump Degradation Model	57.83	57.41	282.77	282.41
14.1 ft^2 Hot Leg Break w/ M3 Pump Degradation Model	58.03	57.63	283.02	282.67
14.1 ft^2 Hot Leg Break w/ Sensitivity to Steamline Superheat	57.99	57.60	282.98	282.64
14.1 ft^2 Hot Leg Break w/ Sensitivity to Main Feedwater	58.48	58.09	283.56	283.22
Hot Leg SG Inlet Break on a 5° ΔTcold Loop Cases				
14.1 ft^2 Hot Leg Break 5° ΔTcold Loop Case 1	57.68	57.28	282.60	282.25
14.1 ft^2 Hot Leg Break 5° ΔTcold Loop Case 2	57.88	57.48	282.84	282.49
Hot Leg SG Inlet Break w/ Low RCS Flow Cases				
14.1 ft^2 Hot Leg Break w/ M1 Pump Degradation Model	58.02	57.59	282.99	282.62
14.1 ft^2 Hot Leg Break w/ M3 Pump Degradation Model	57.76	57.37	282.70	282.35
Hot Leg RV Outlet Break w/ Low RCS Flow Cases				
14.1 ft^2 Hot Leg Break w/ M1 Pump Degradation Model	57.14	56.84	281.97	281.71
14.1 ft^2 Hot Leg Break w/ M3 Pump Degradation Model	56.85	56.58	281.64	281.40
Hot Leg RV Outlet Break w/ High RCS Flow Cases				
14.1 ft^2 Hot Leg Break w/ M1 Pump Degradation Model	57.16	56.87	282.00	281.75
14.1 ft^2 Hot Leg Break w/ M3 Pump Degradation Model	56.87	56.59	281.65	281.41
Cold Leg Pump Discharge Break w/ High RCS Flow Case				
8.55 ft^2 Cold Leg Break @ Pump Discharge	53.03	52.44	276.68	276.15
Cold Leg Pump Suction Break w/ High RCS Flow Case				
8.55 ft^2 Cold Leg Break @ Pump Suction	54.30	53.45	278.26	277.46

GOTHIC 7.0 - FATHOMS COMPARISON

ROTSG LARGE BREAK LOCA

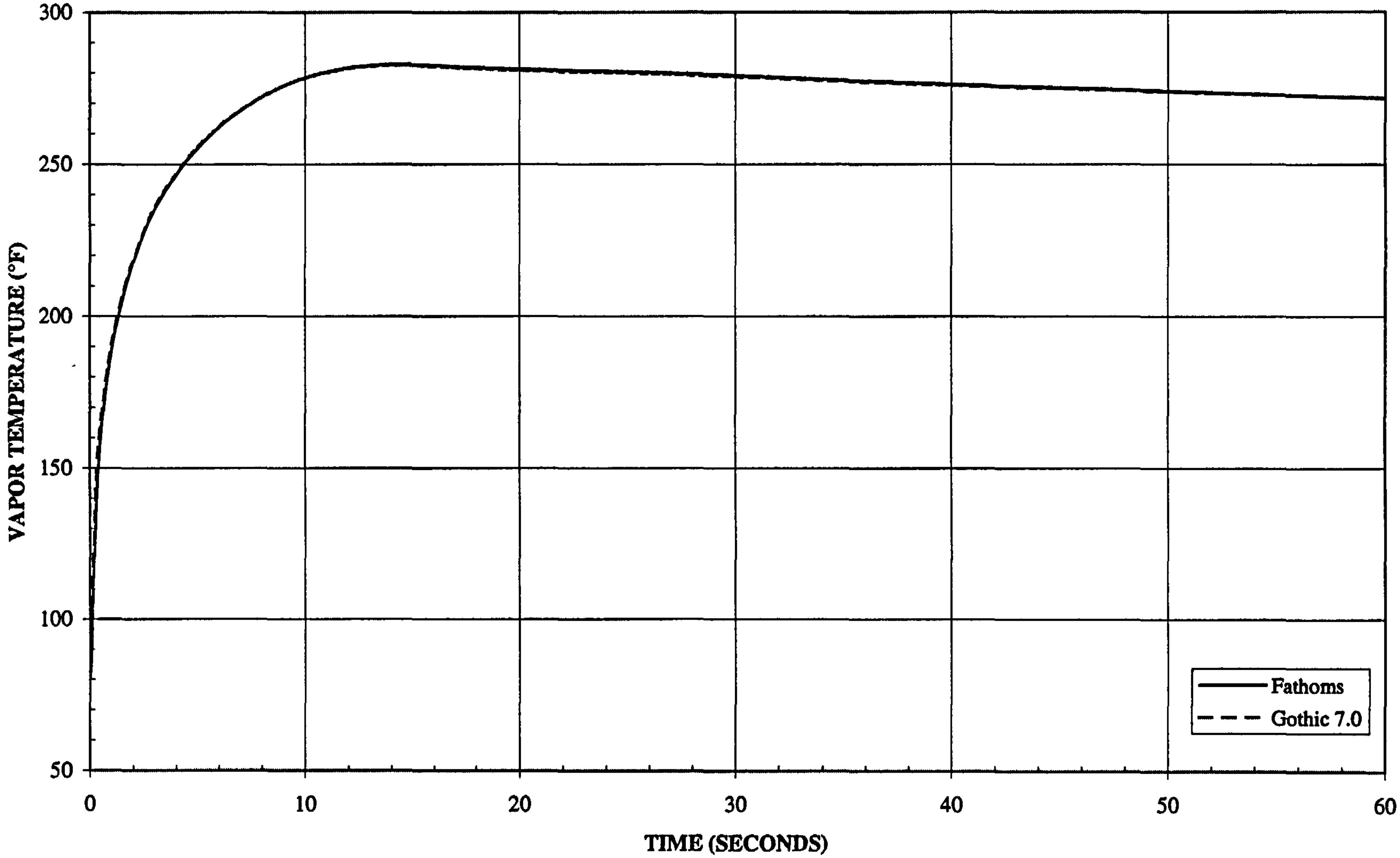
(14.1 ft^2 Break - SG Inlet - High Initial RCS Flow w/ M1 Pump Degradation Model)



GOTHIC 7.0 - FATHOMS COMPARISON

ROTSG LARGE BREAK LOCA

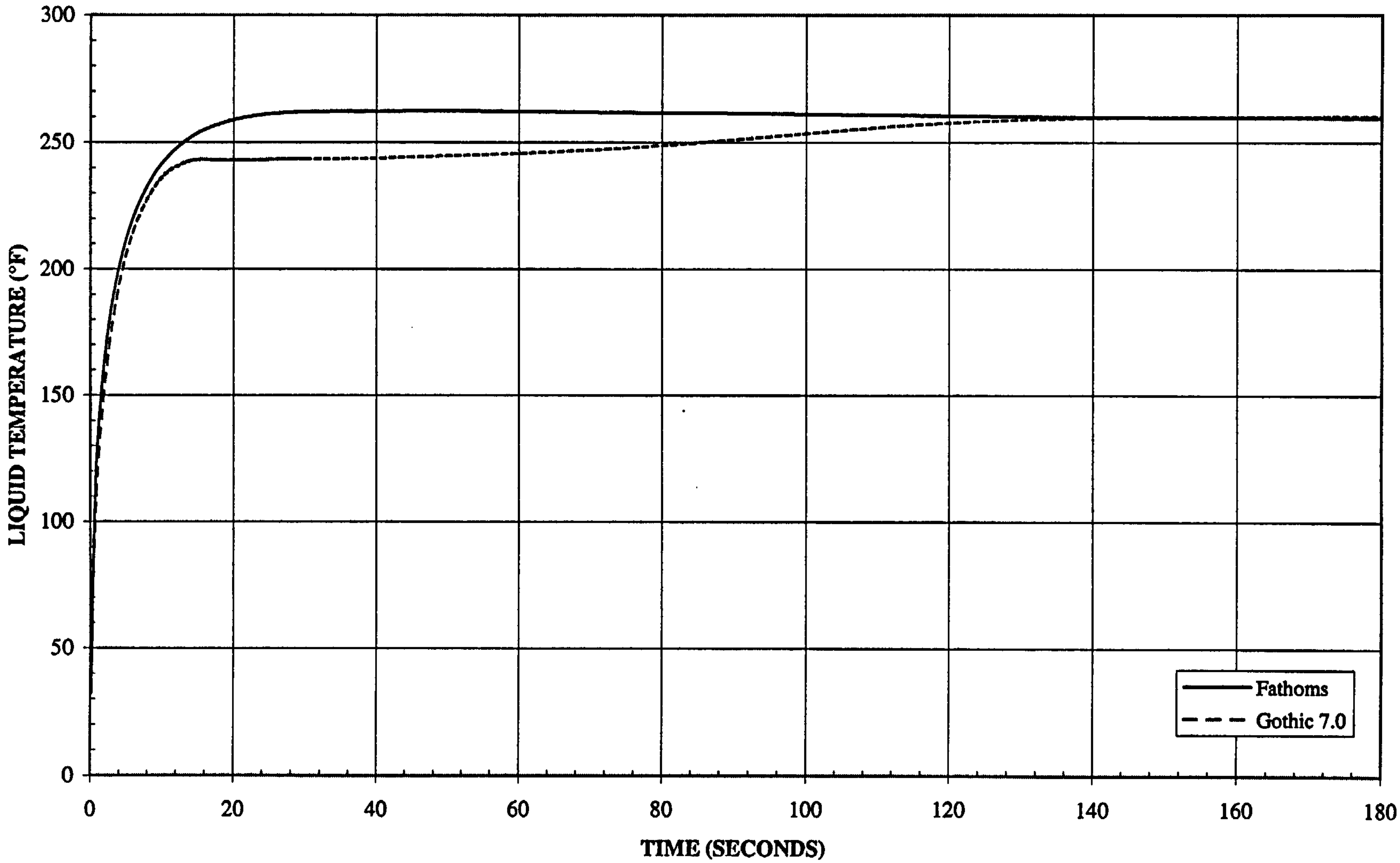
(14.1 ft^2 Break - SG Inlet - High Initial RCS Flow w/ M1 Pump Degradation Model)



GOTHIC 7.0 - FATHOMS COMPARISON

ROTSG LARGE BREAK LOCA

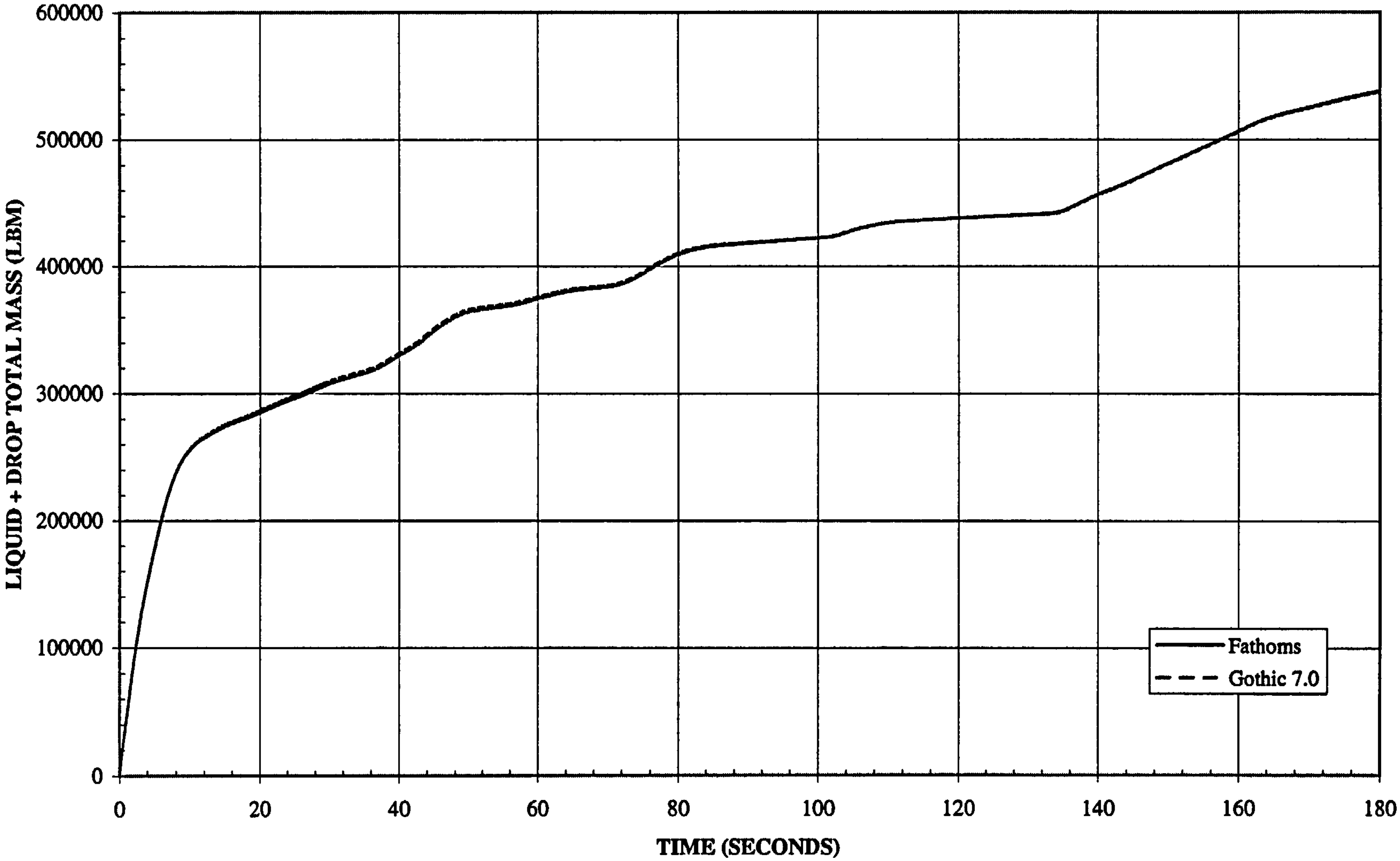
(14.1 ft^2 Break - SG Inlet - High Initial RCS Flow w/ M1 Pump Degradation Model)



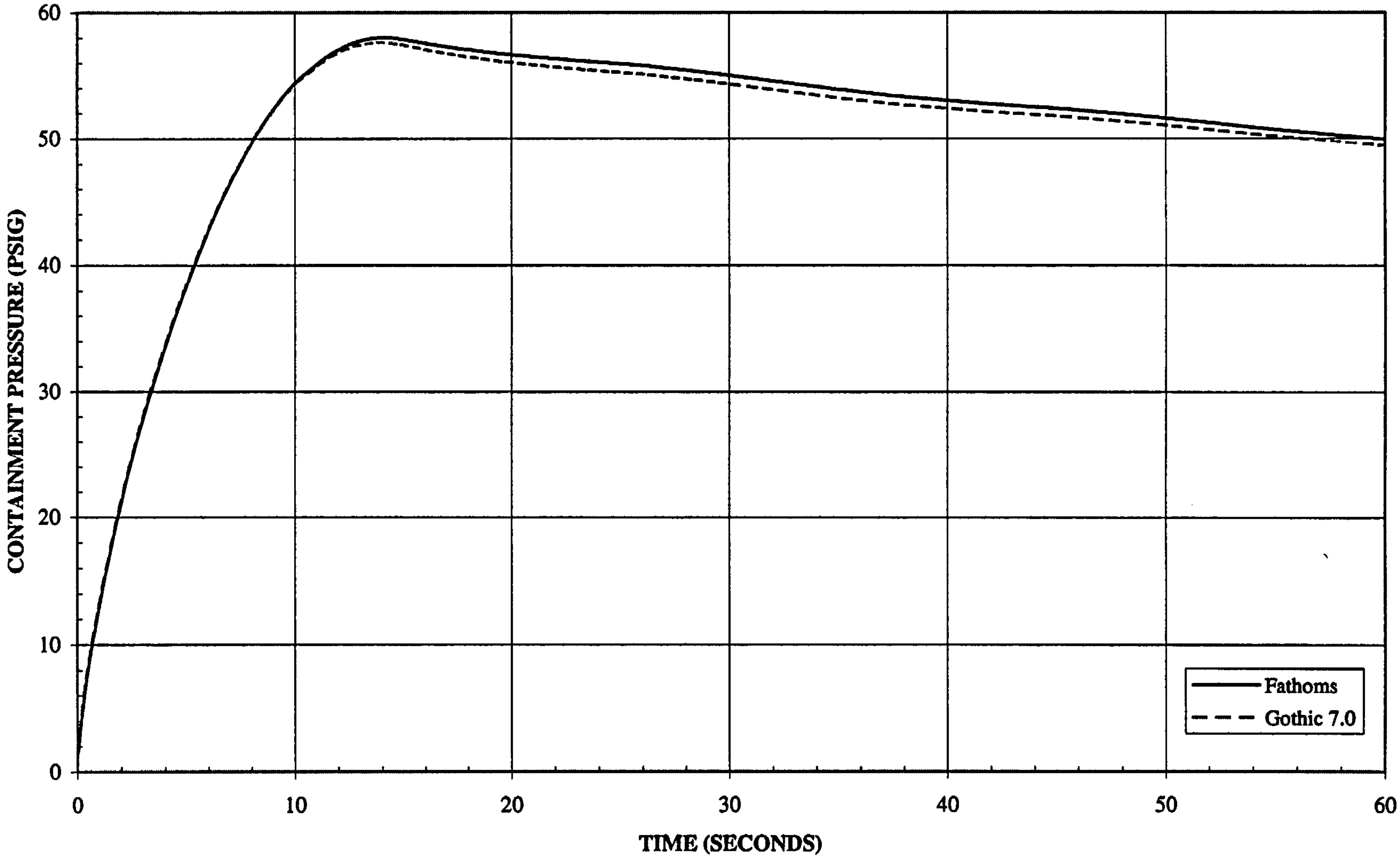
GOTHIC 7.0 - FATHOMS COMPARISON

ROTSG LARGE BREAK LOCA

(14.1 ft^2 Break - SG Inlet - High Initial RCS Flow w/ M1 Pump Degradation Model)



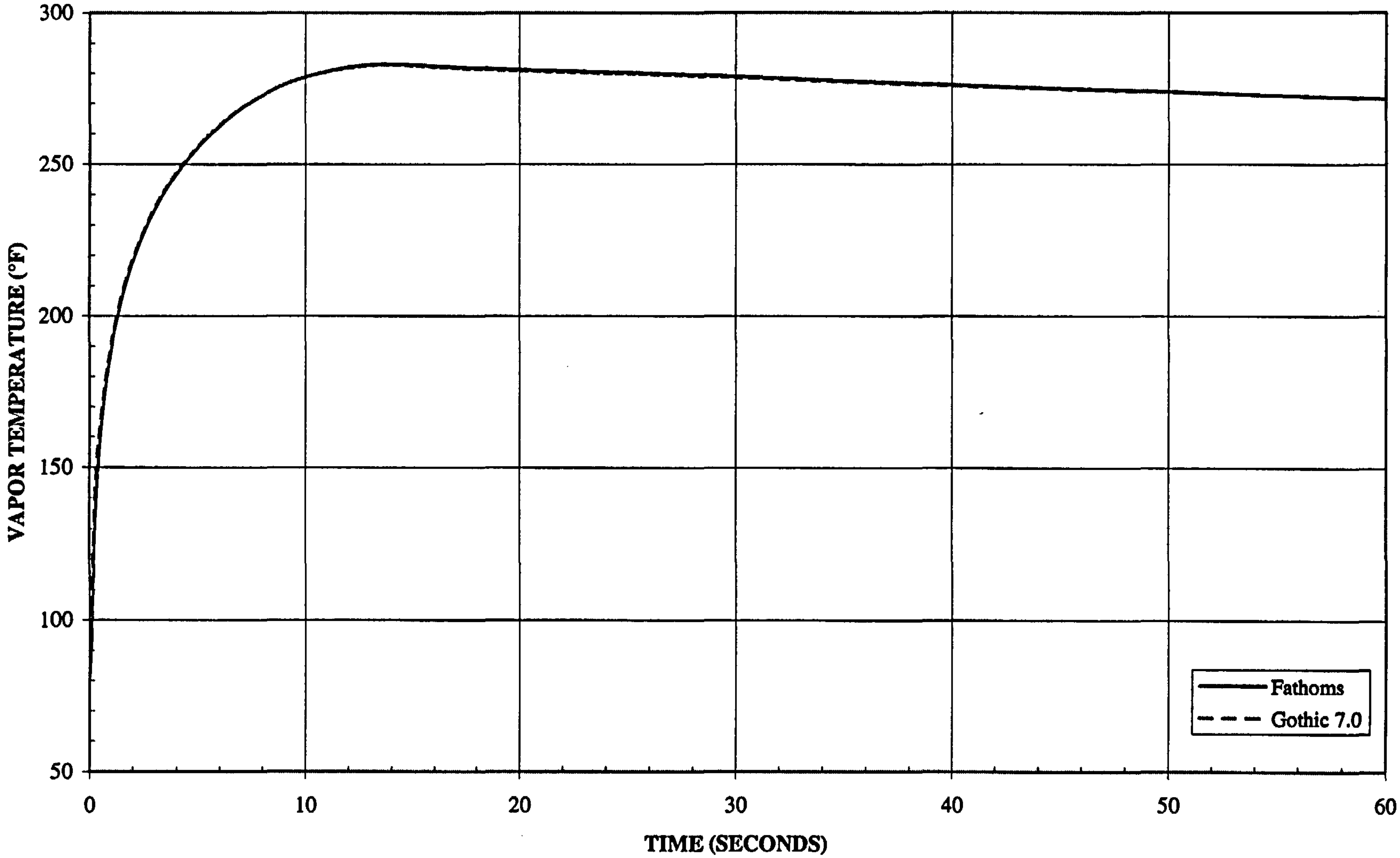
GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(14.1 ft^2 Break - SG Inlet - High Initial RCS Flow w/ M3 Pump Degradation Model)



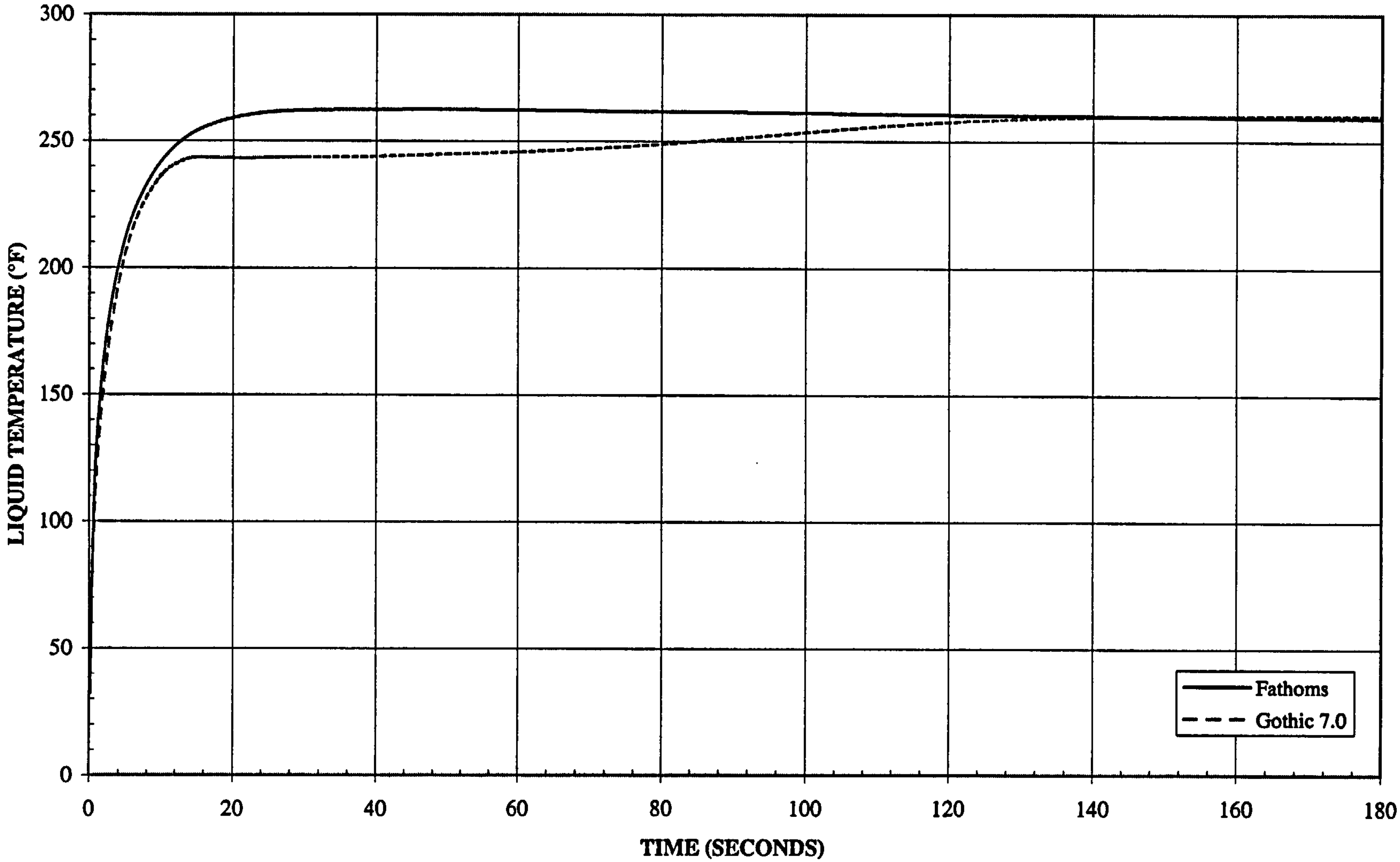
GOTHIC 7.0 - FATHOMS COMPARISON

ROTSG LARGE BREAK LOCA

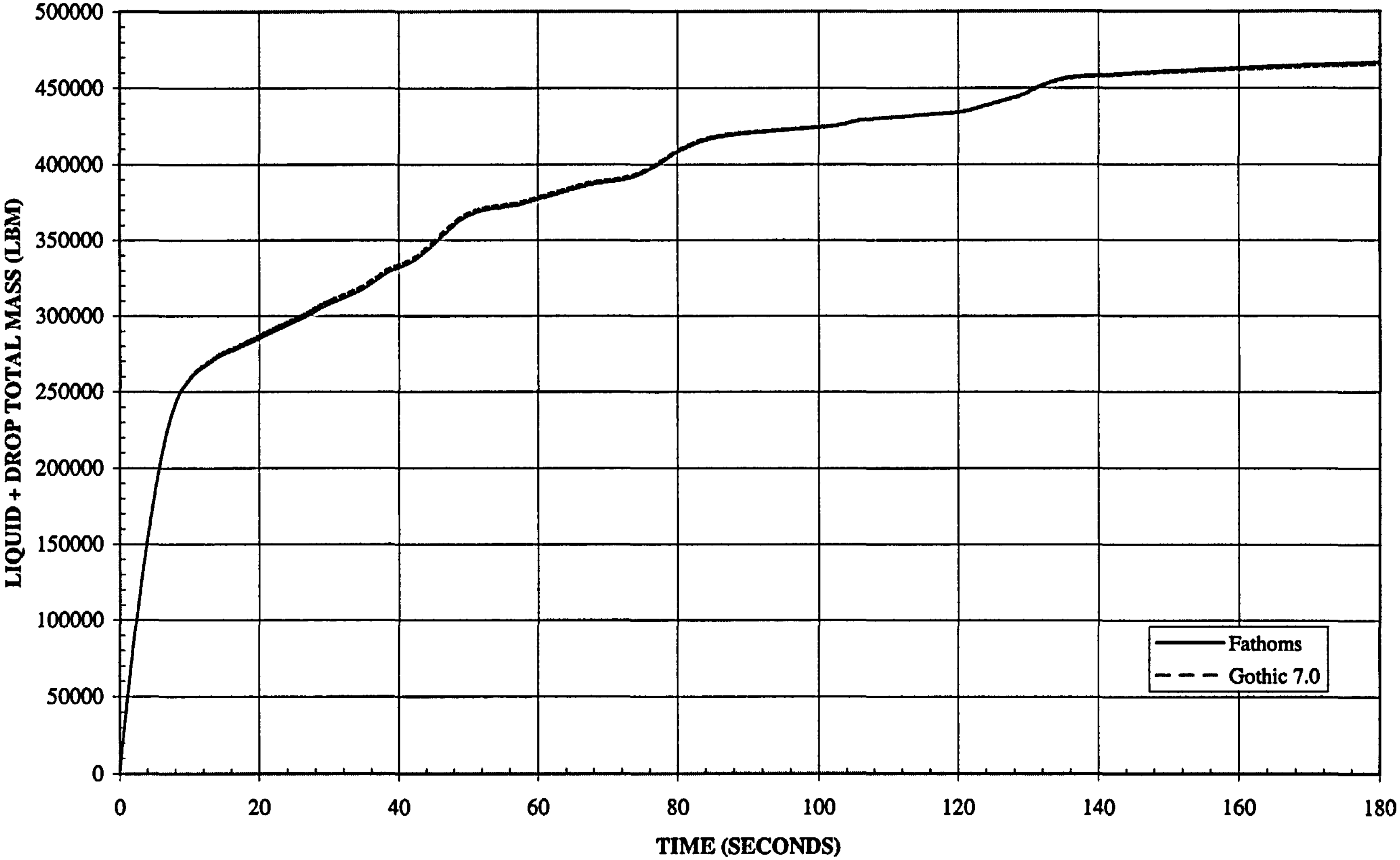
(14.1 ft^2 Break - SG Inlet - High Initial RCS Flow w/ M3 Pump Degradation Model)



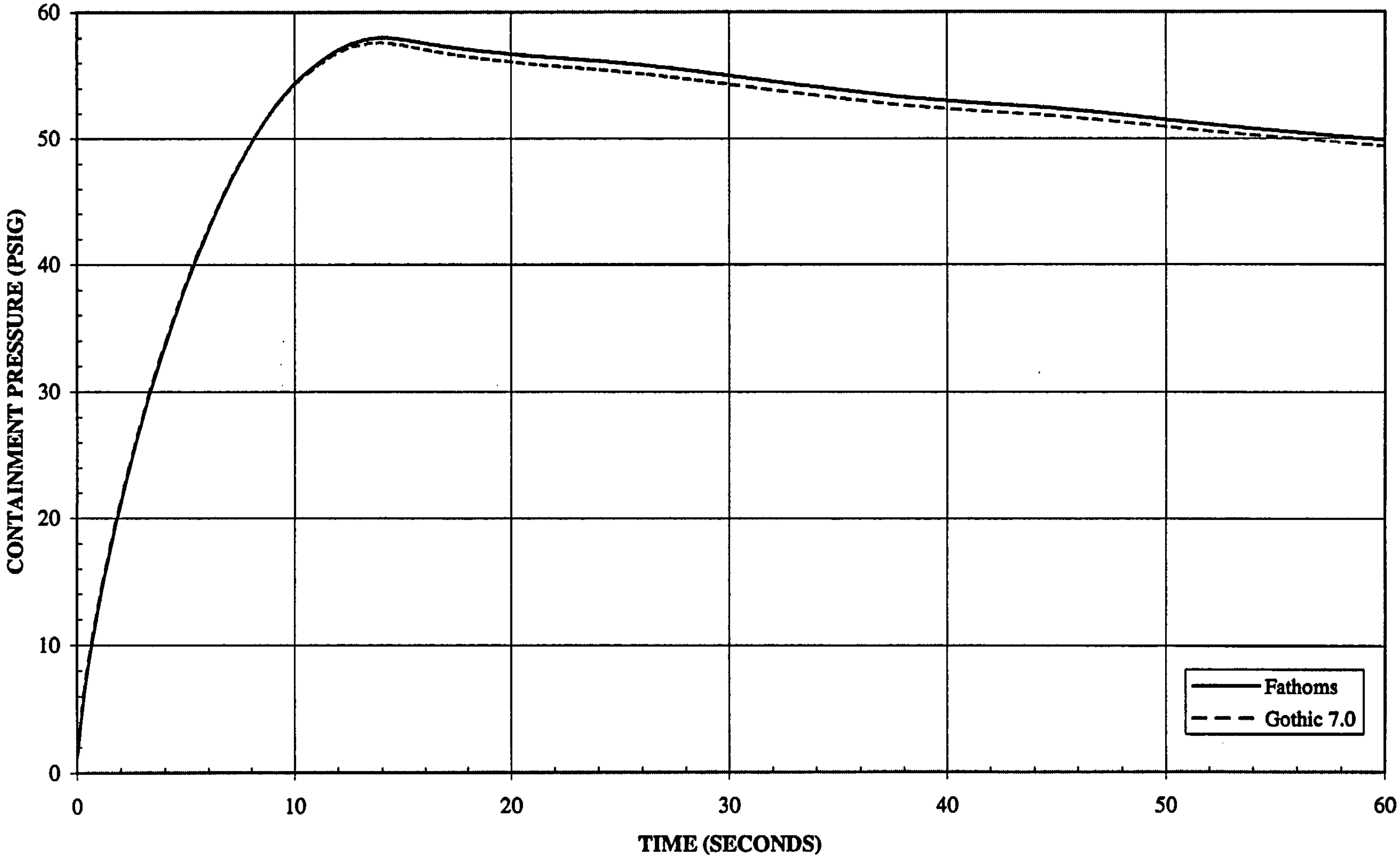
GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(14.1 ft^2 Break - SG Inlet - High Initial RCS Flow w/ M3 Pump Degradation Model)



GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(14.1 ft^2 Break - SG Inlet - High Initial RCS Flow w/ M3 Pump Degradation Model)



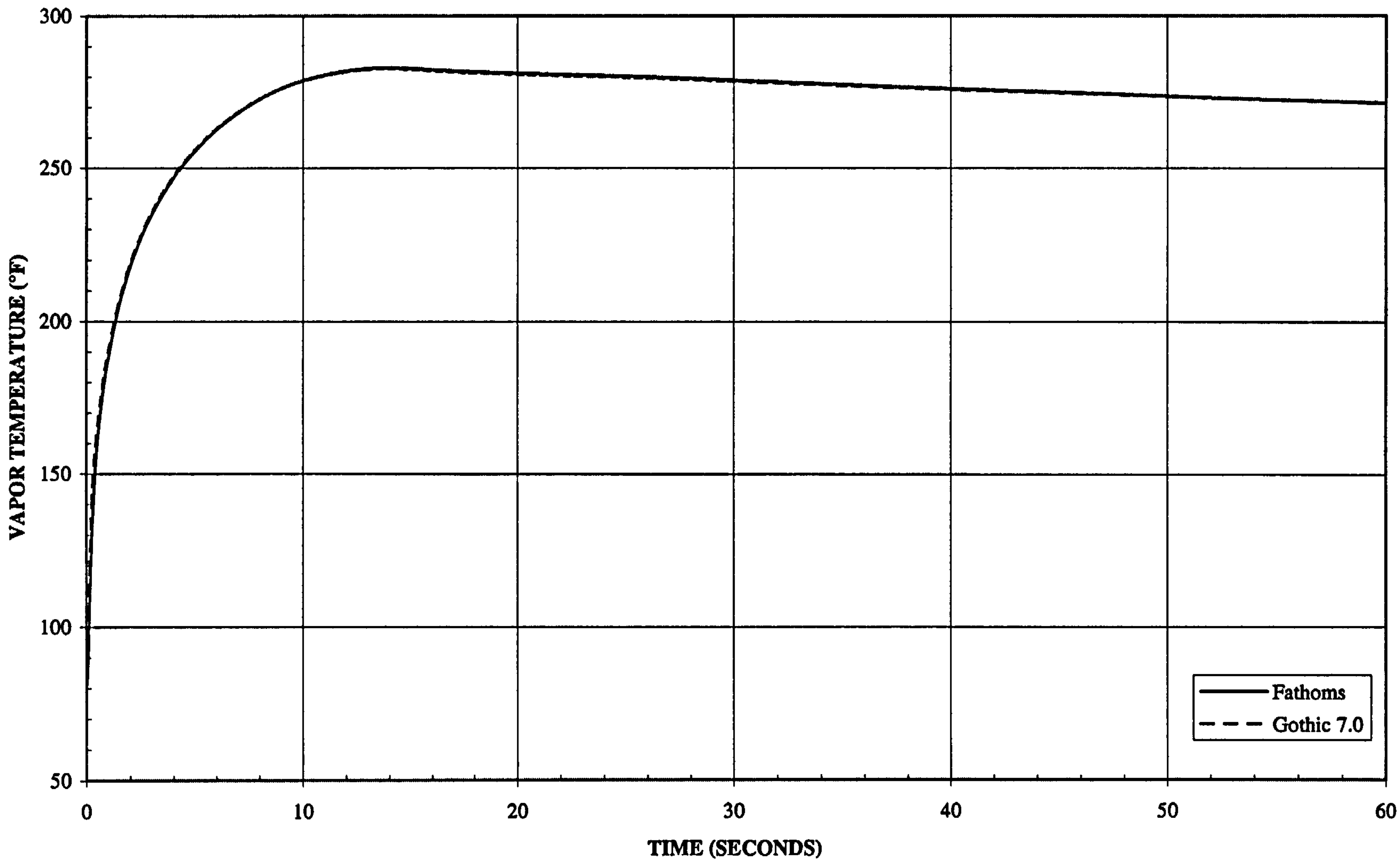
GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(14.1 ft^2 Break - SG Inlet - High Initial RCS Flow w/ Sensitivity to Steamline Superheat)

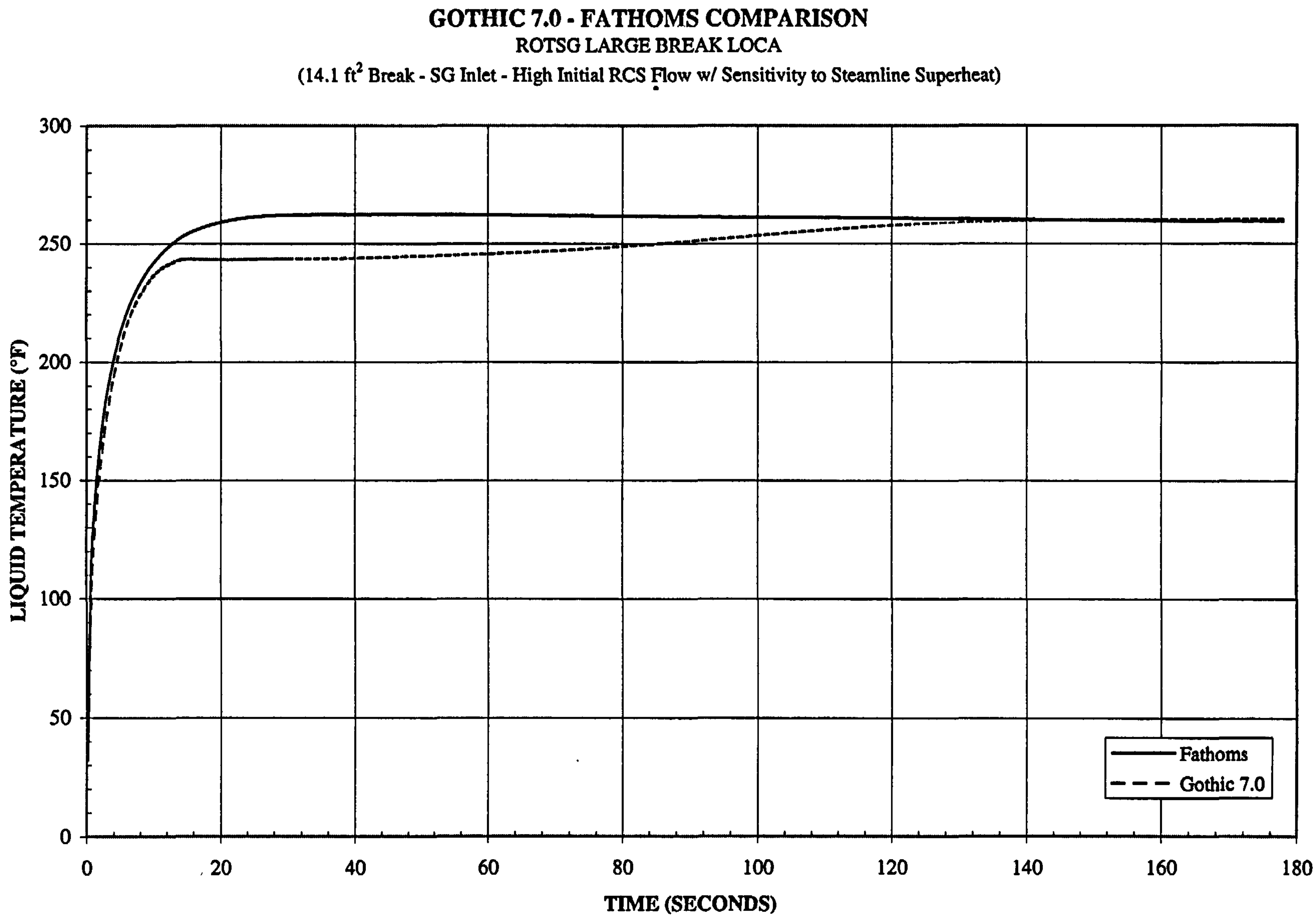


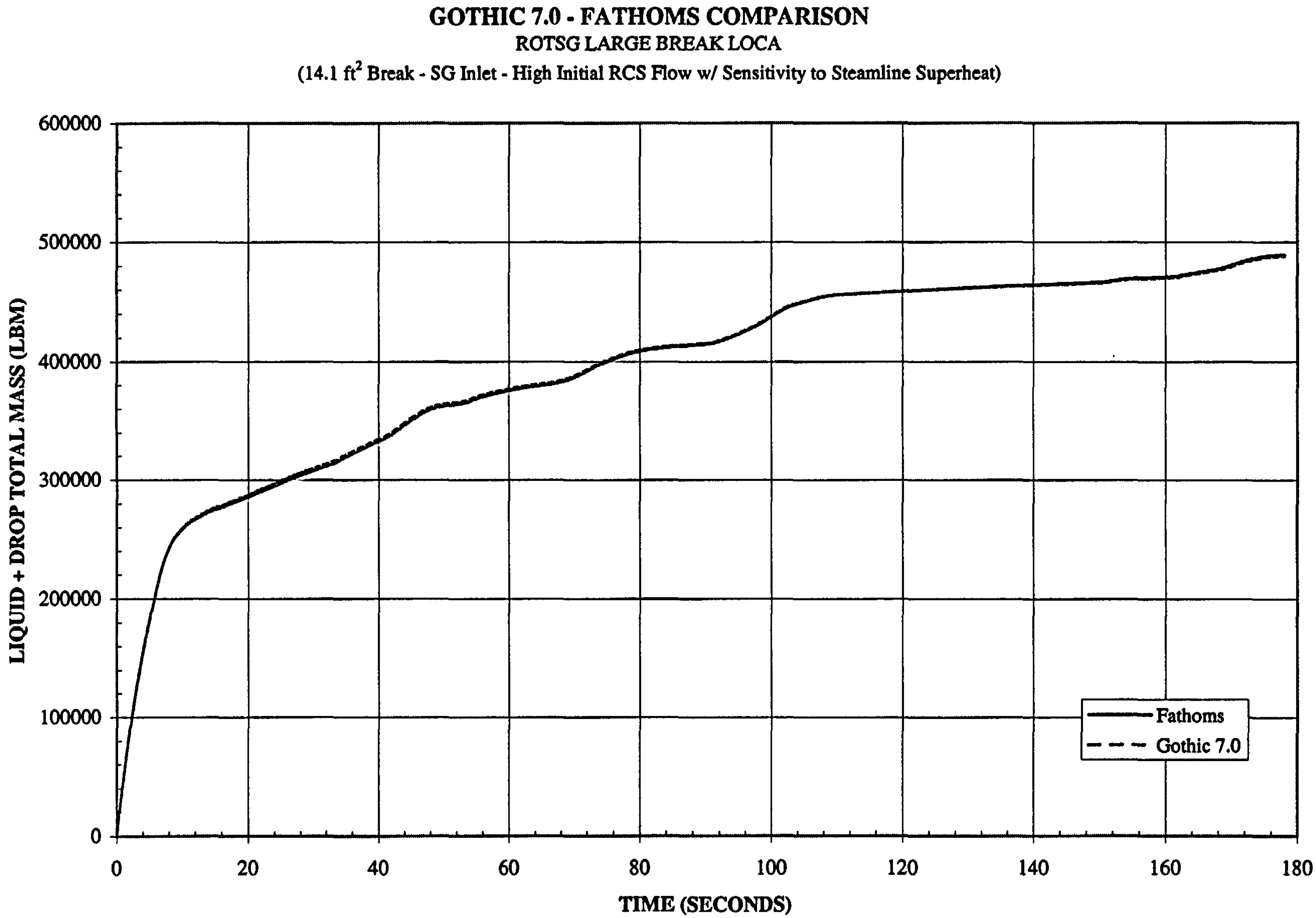
GOTHIC 7.0 - FATHOMS COMPARISON

ROTSG LARGE BREAK LOCA

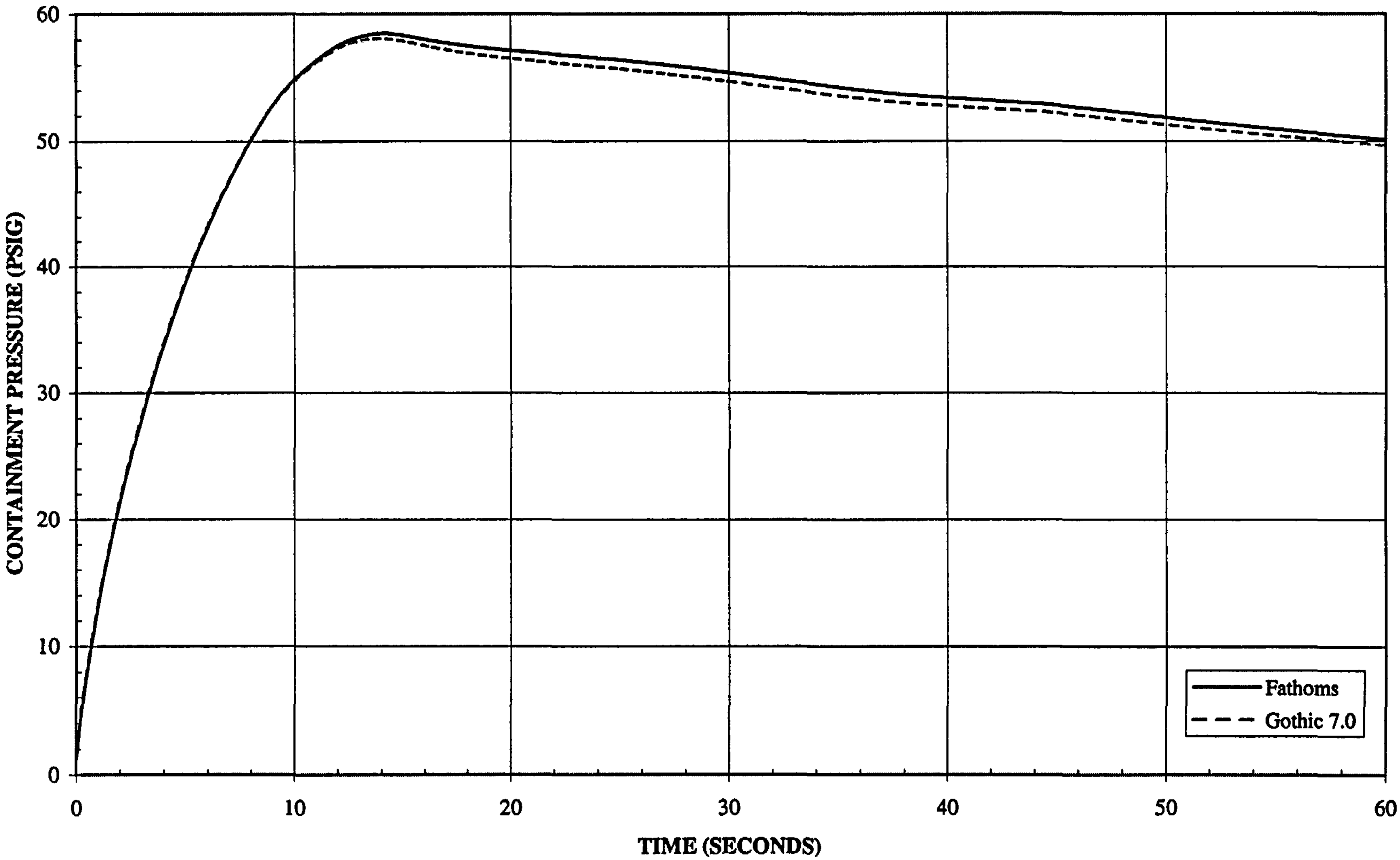
(14.1 ft^2 Break - SG Inlet - High Initial RCS Flow w/ Sensitivity to Steamline Superheat)




GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(14.1 ft2 Break - SG Inlet - High Initial RCS Flow w/ Sensitivity to Steamline Superheat)
LIQUID TEMPERATURE (°F)
300
250
200
150
100
50
0
0
20
40
60
80
100
120
140
160
180
TIME (SECONDS)
Fathoms
Gothic 7.0


GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(14.1 ft^2 Break - SG Inlet - High Initial RCS Flow w/ Sensitivity to Steamline Superheat)
LIQUID + DROP TOTAL MASS (LBM)
600000
500000
400000
300000
200000
100000
0
0
20
40
60
80
100
120
140
160
180
TIME (SECONDS)
Fathoms
Gothic 7.0

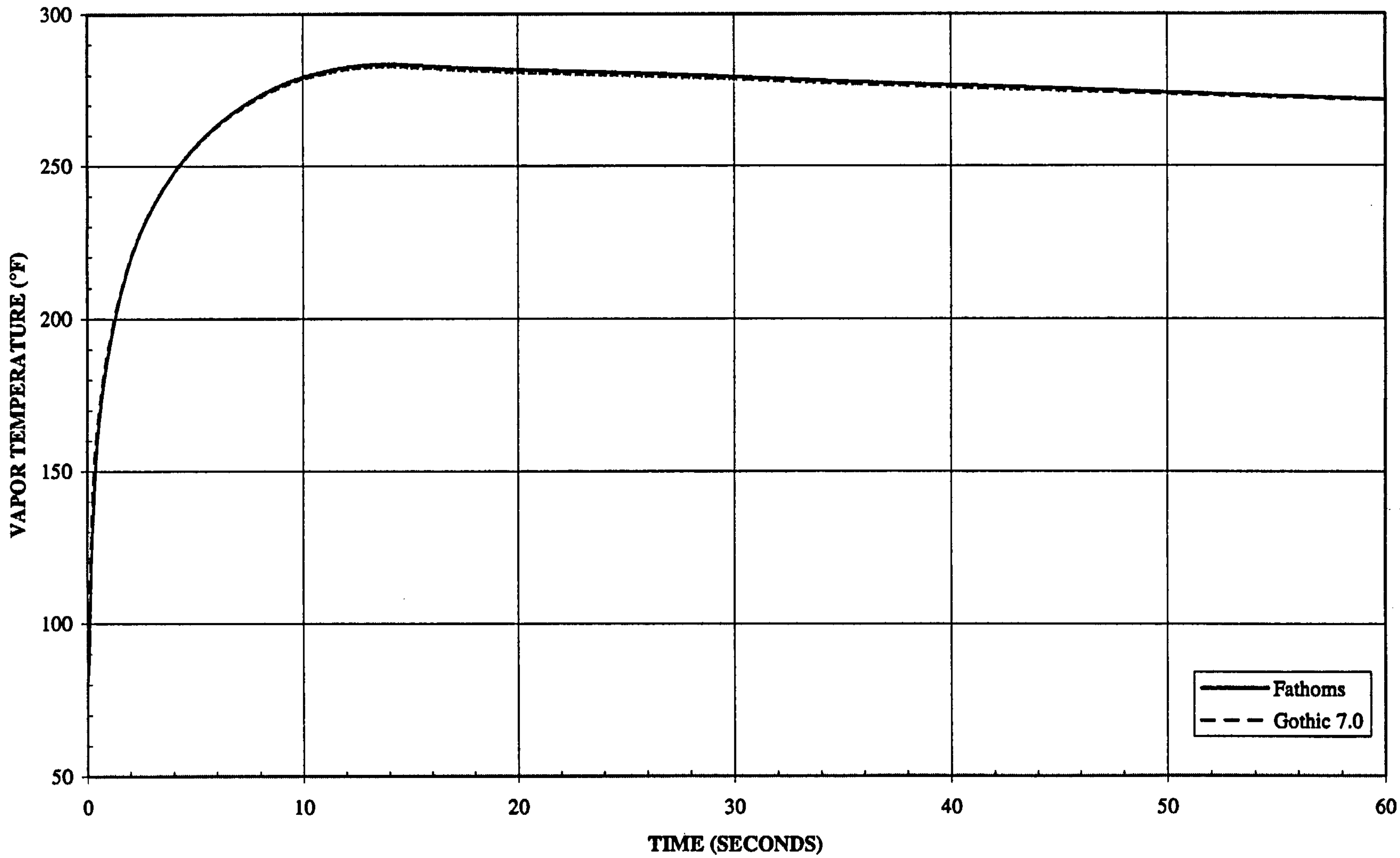
GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(14.1 ft^2 Break - SG Inlet - High Initial RCS Flow w/ Sensitivity to Main Feedwater)

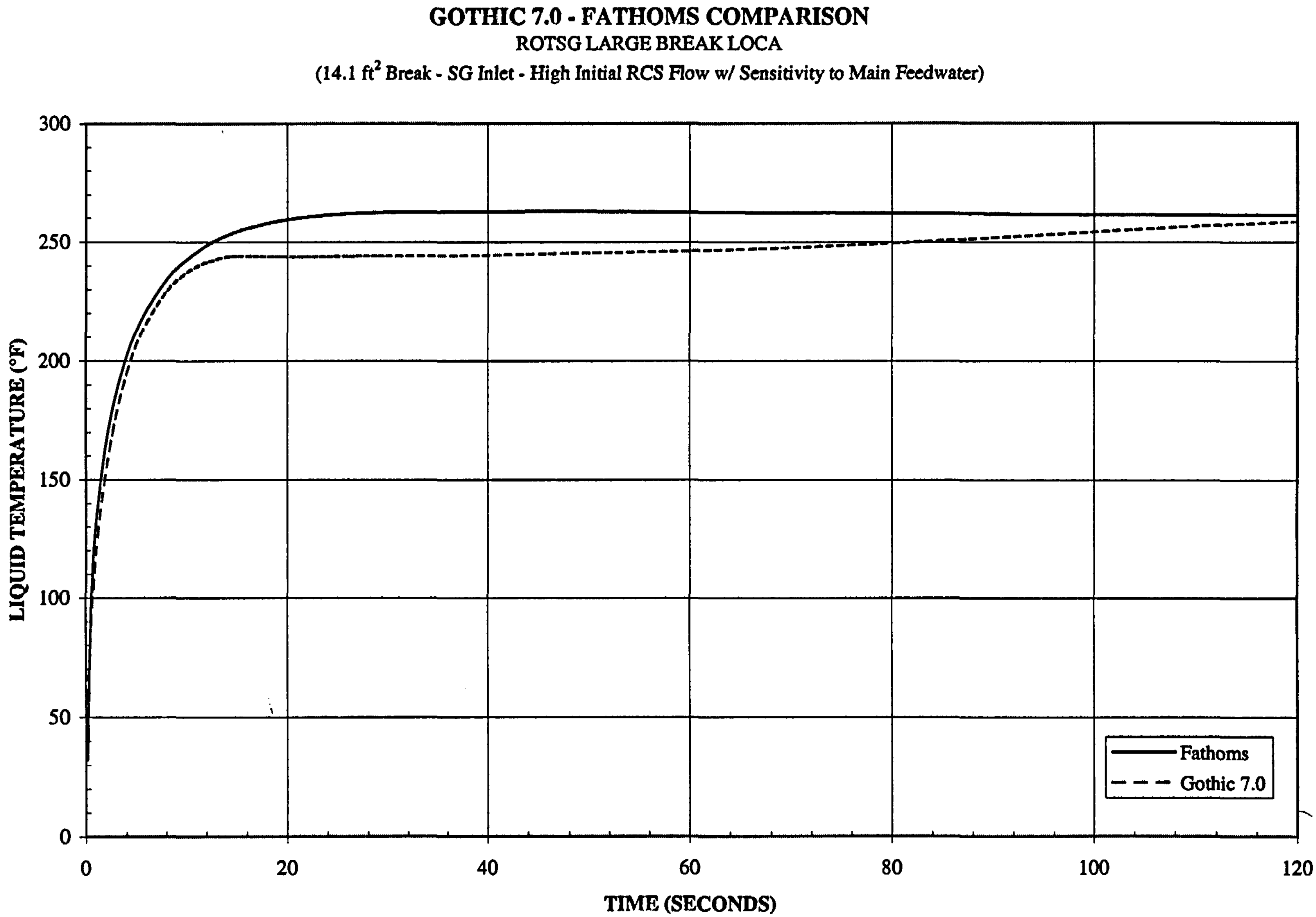


GOTHIC 7.0 - FATHOMS COMPARISON

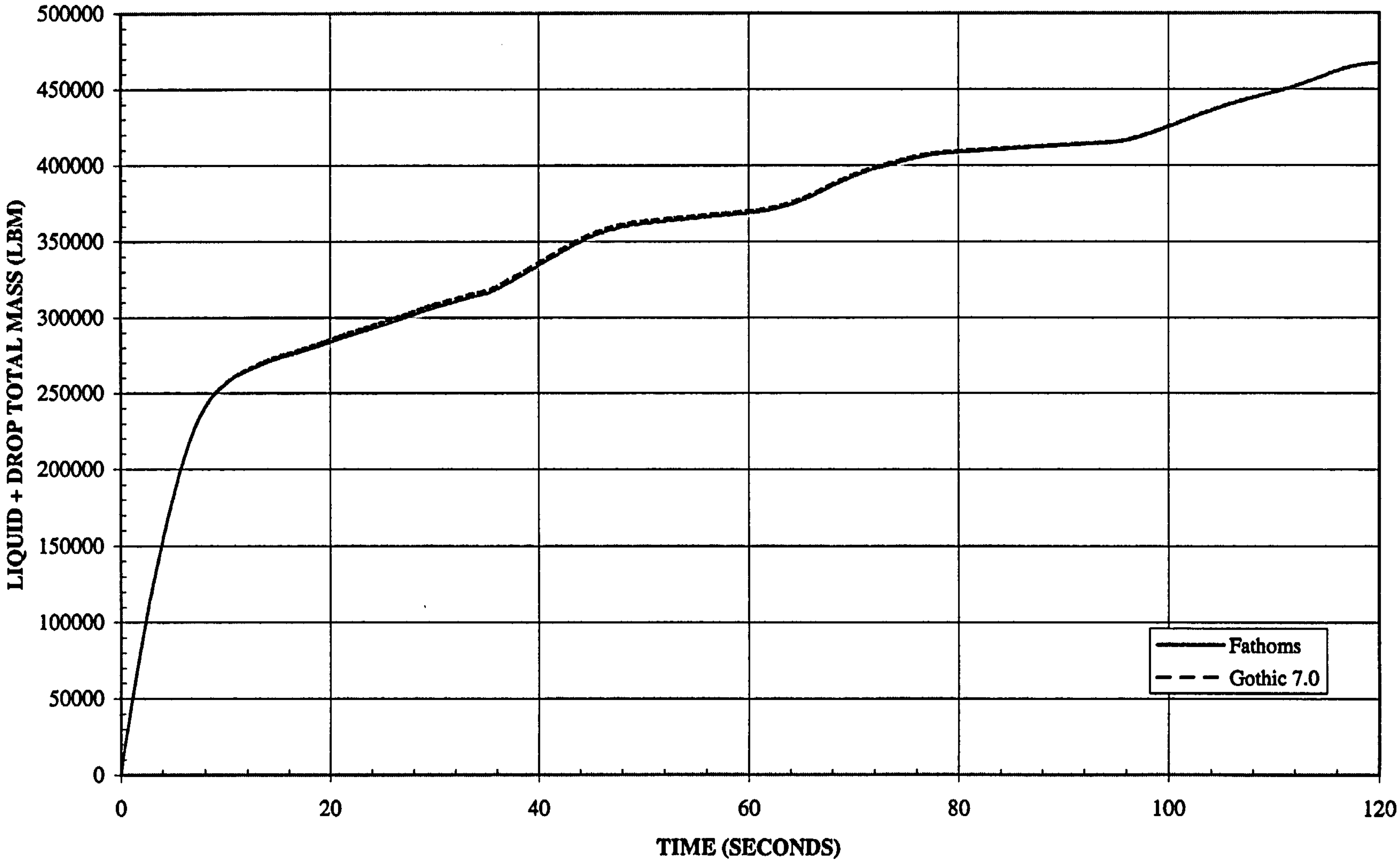
ROTSG LARGE BREAK LOCA

(14.1 ft^2 Break - SG Inlet - High Initial RCS Flow w/ Sensitivity to Main Feedwater)




GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(14.1 ft2 Break - SG Inlet - High Initial RCS Flow w/ Sensitivity to Main Feedwater)
LIQUID TEMPERATURE (°F)
300
250
200
150
100
50
0
0
20
40
60
80
100
120
TIME (SECONDS)
Fathoms
Gothic 7.0

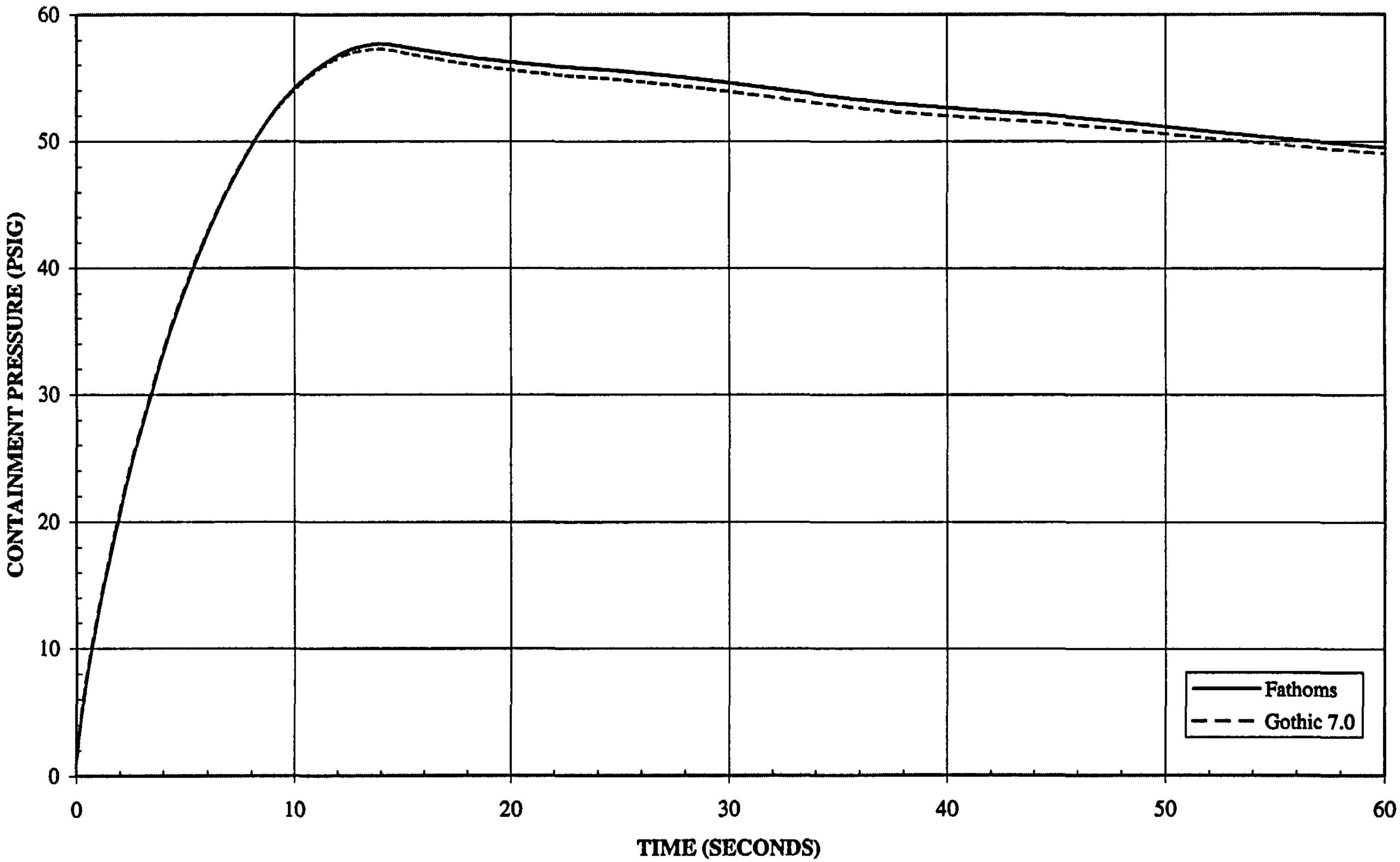
GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(14.1 ft^2 Break - SG Inlet - High Initial RCS Flow w/ Sensitivity to Main Feedwater)

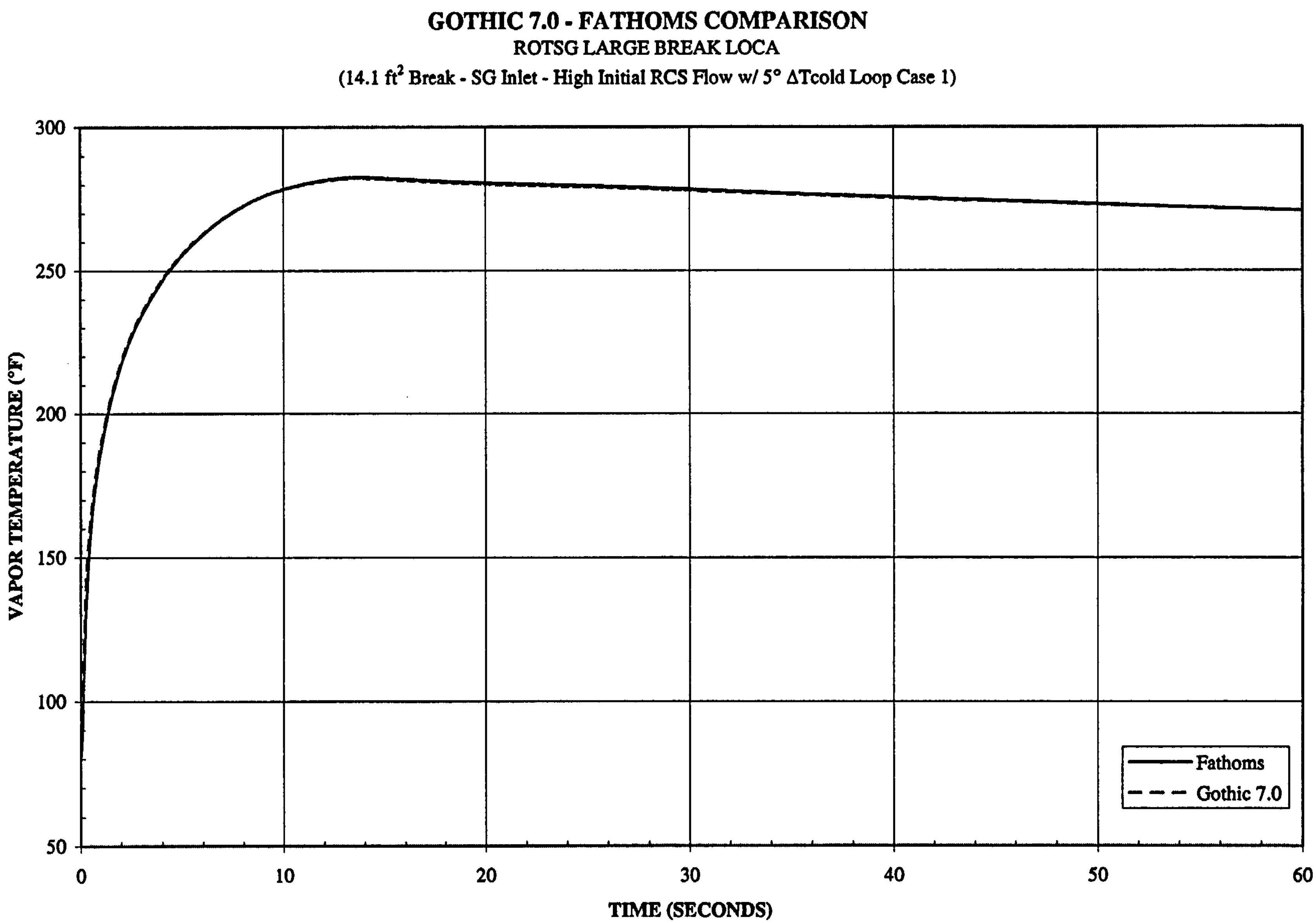


GOTHIC 7.0 - FATHOMS COMPARISON

ROTSG LARGE BREAK LOCA

(14.1 ft^2 Break - SG Inlet - High Initial RCS Flow w/ 5° ΔTcold Loop Case 1)

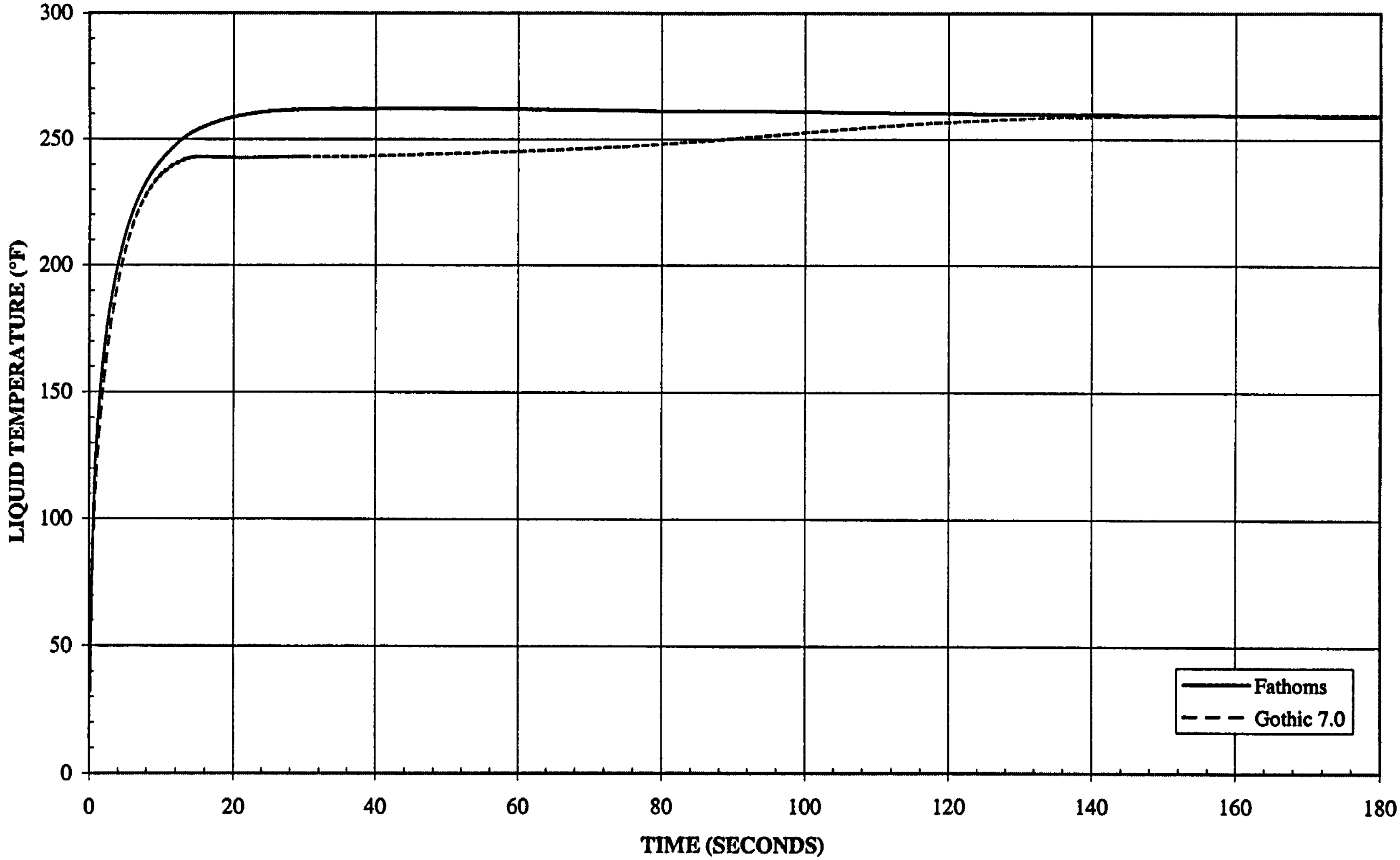



GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(14.1 ft² Break - SG Inlet - High Initial RCS Flow w/ 5° ΔTcold Loop Case 1)
VAPOR TEMPERATURE (°F)
300
250
200
150
100
50
0
10
20
30
40
50
60
TIME (SECONDS)
Fathoms
Gothic 7.0

GOTHIC 7.0 - FATHOMS COMPARISON

ROTSG LARGE BREAK LOCA

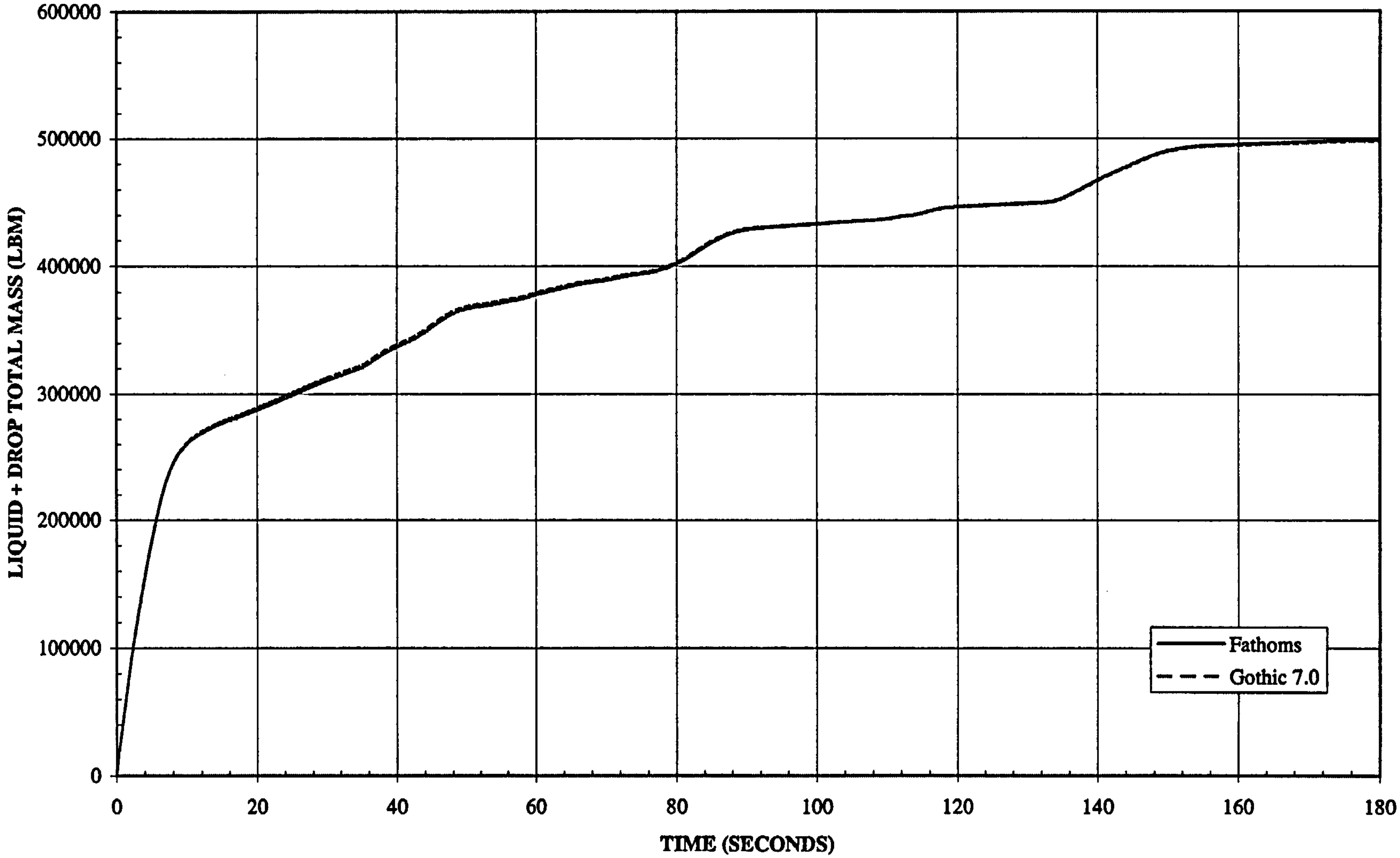
(14.1 ft^2 Break - SG Inlet - High Initial RCS Flow w/ 5° ΔTcold Loop Case 1)



GOTHIC 7.0 - FATHOMS COMPARISON

ROTSG LARGE BREAK LOCA

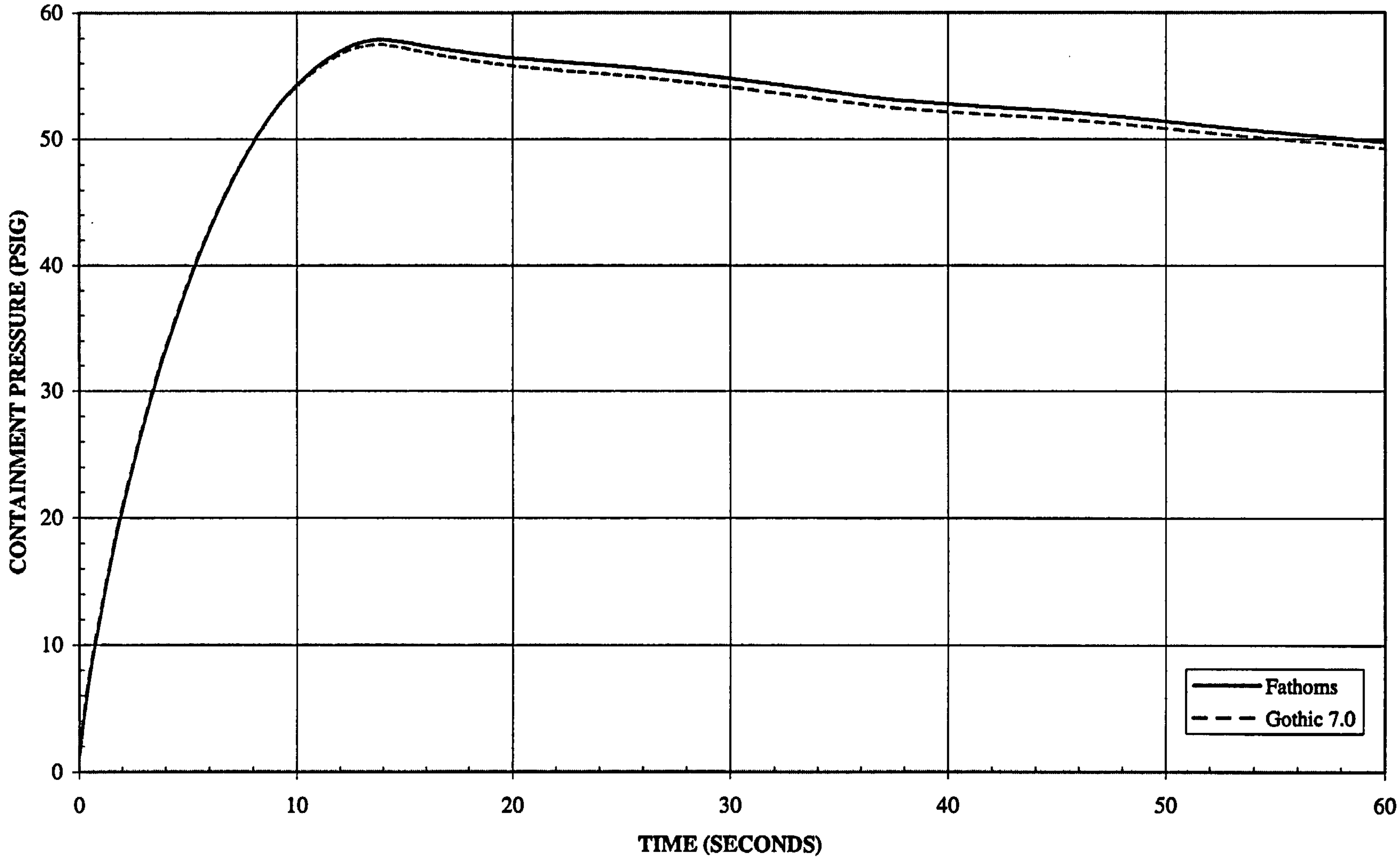
(14.1 ft^2 Break - SG Inlet - High Initial RCS Flow w/ 5° ΔTcold Loop Case 1)



GOTHIC 7.0 - FATHOMS COMPARISON

ROTSG LARGE BREAK LOCA

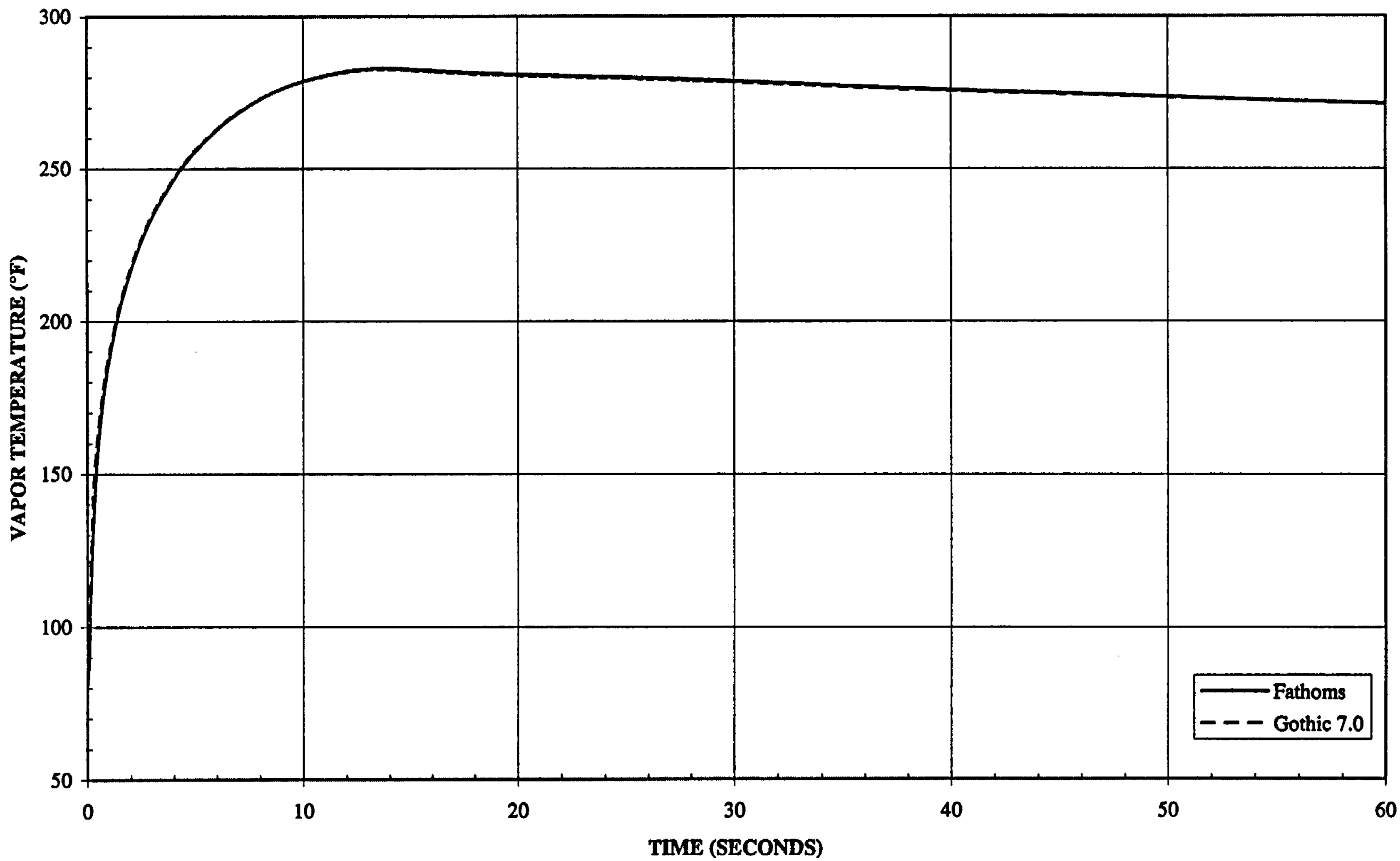
(14.1 ft^2 Break - SG Inlet - High Initial RCS Flow w/ 5° ΔTcold Loop Case 2)



GOTHIC 7.0 - FATHOMS COMPARISON

ROTSG LARGE BREAK LOCA

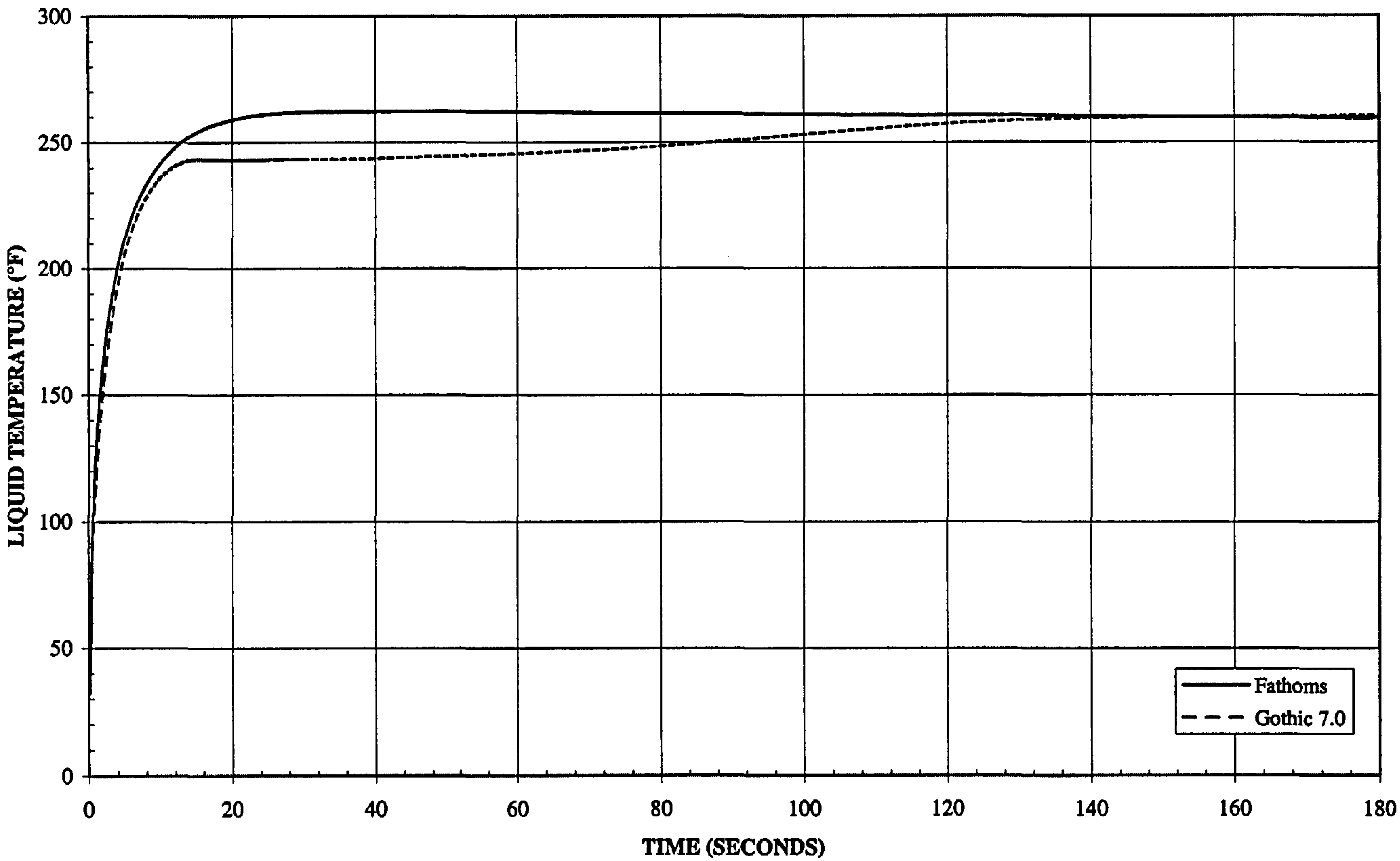
(14.1 ft^2 Break - SG Inlet - High Initial RCS Flow w/ 5° ΔTcold Loop Case 2)



GOTHIC 7.0 - FATHOMS COMPARISON

ROTSG LARGE BREAK LOCA

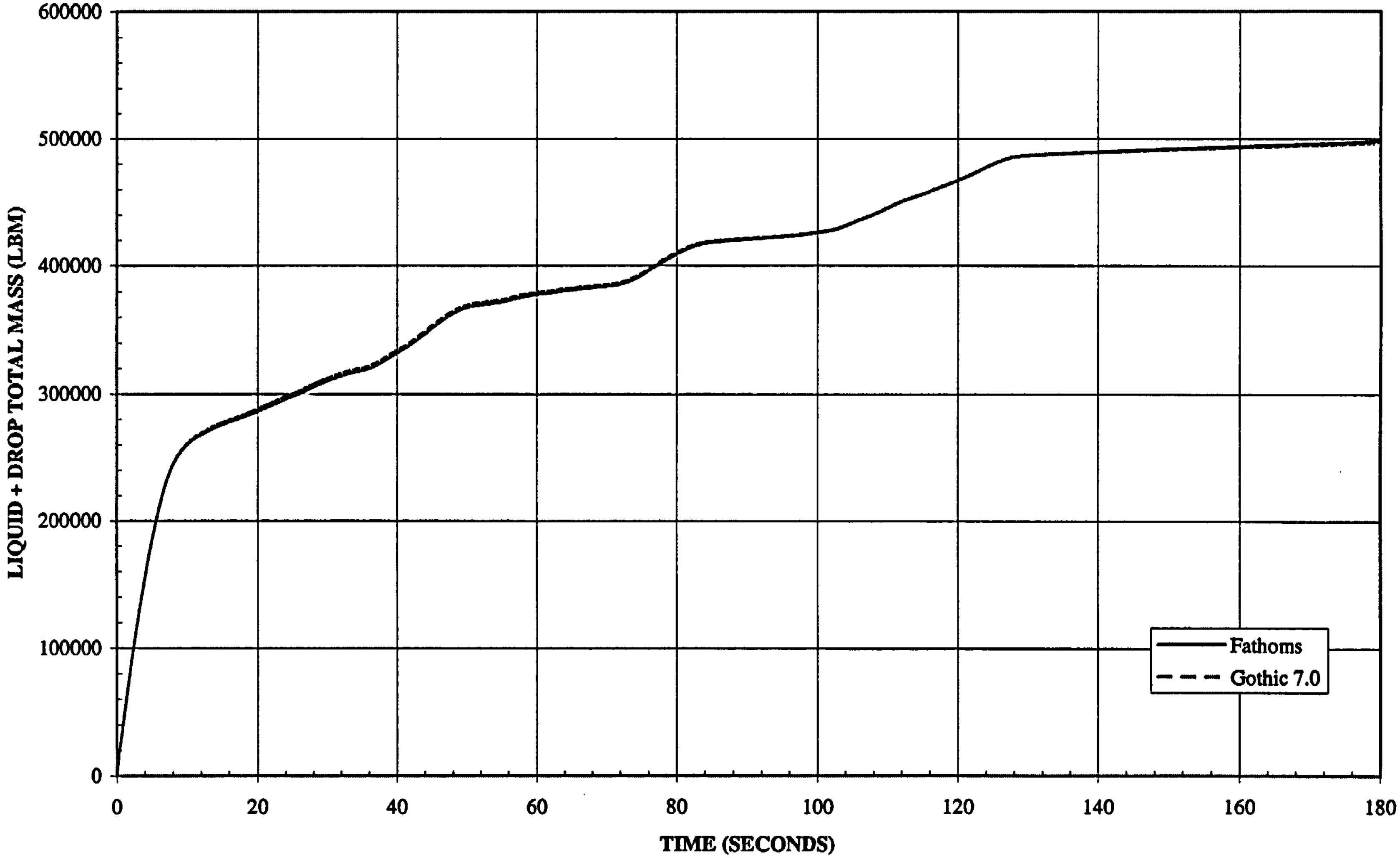
(14.1 ft^2 Break - SG Inlet - High Initial RCS Flow w/ 5° ΔTcold Loop Case 2)

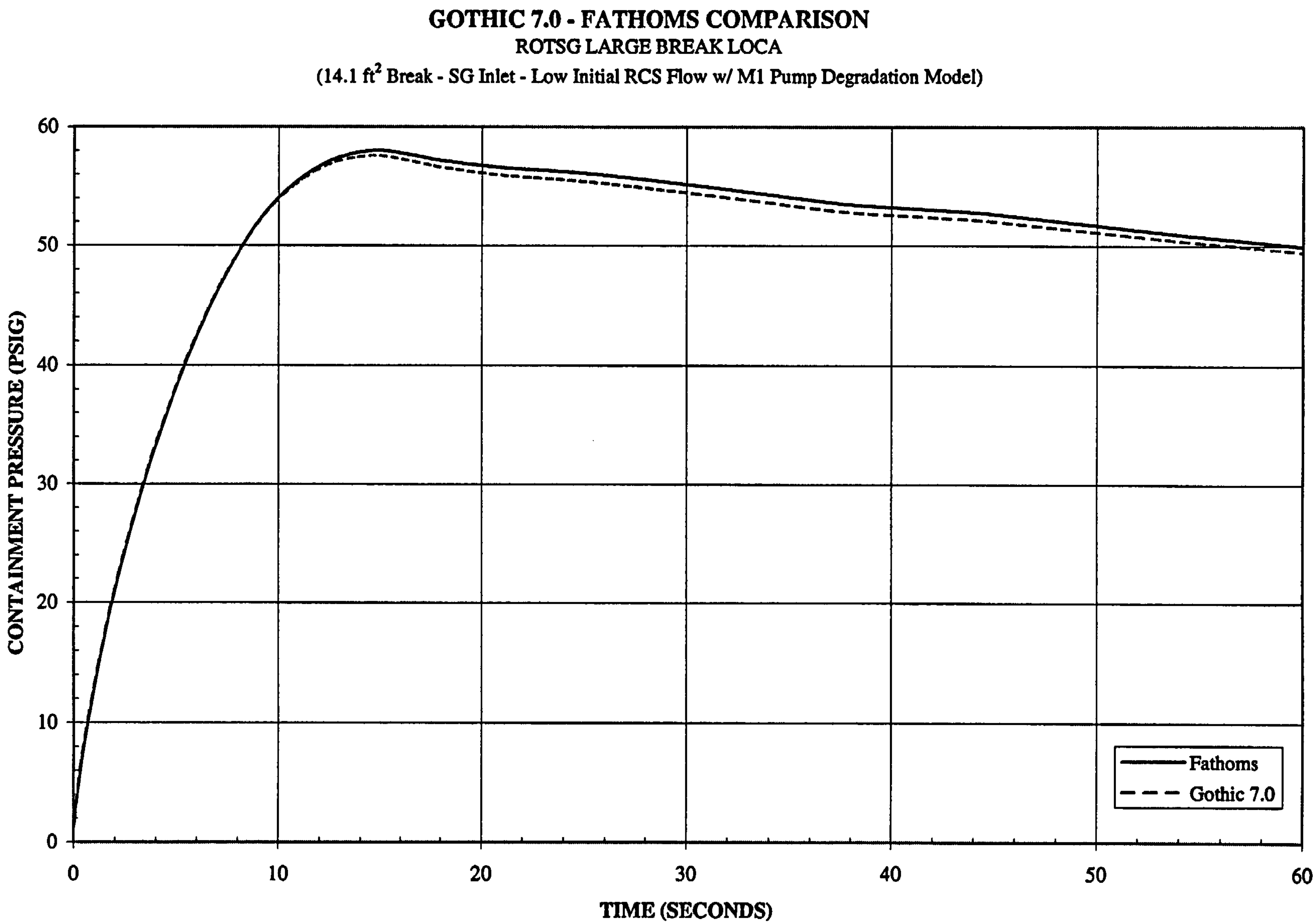


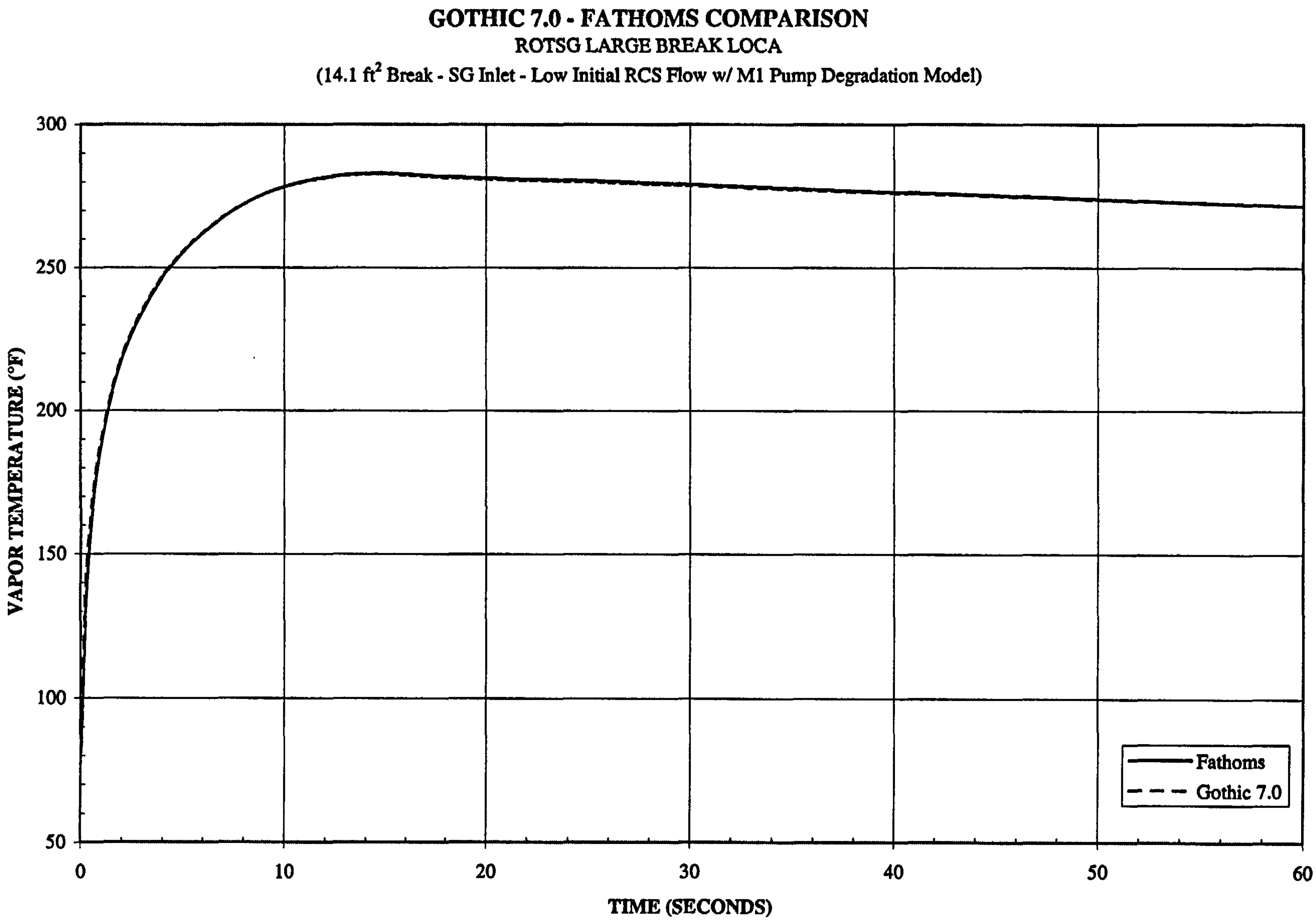
GOTHIC 7.0 - FATHOMS COMPARISON

ROTSG LARGE BREAK LOCA

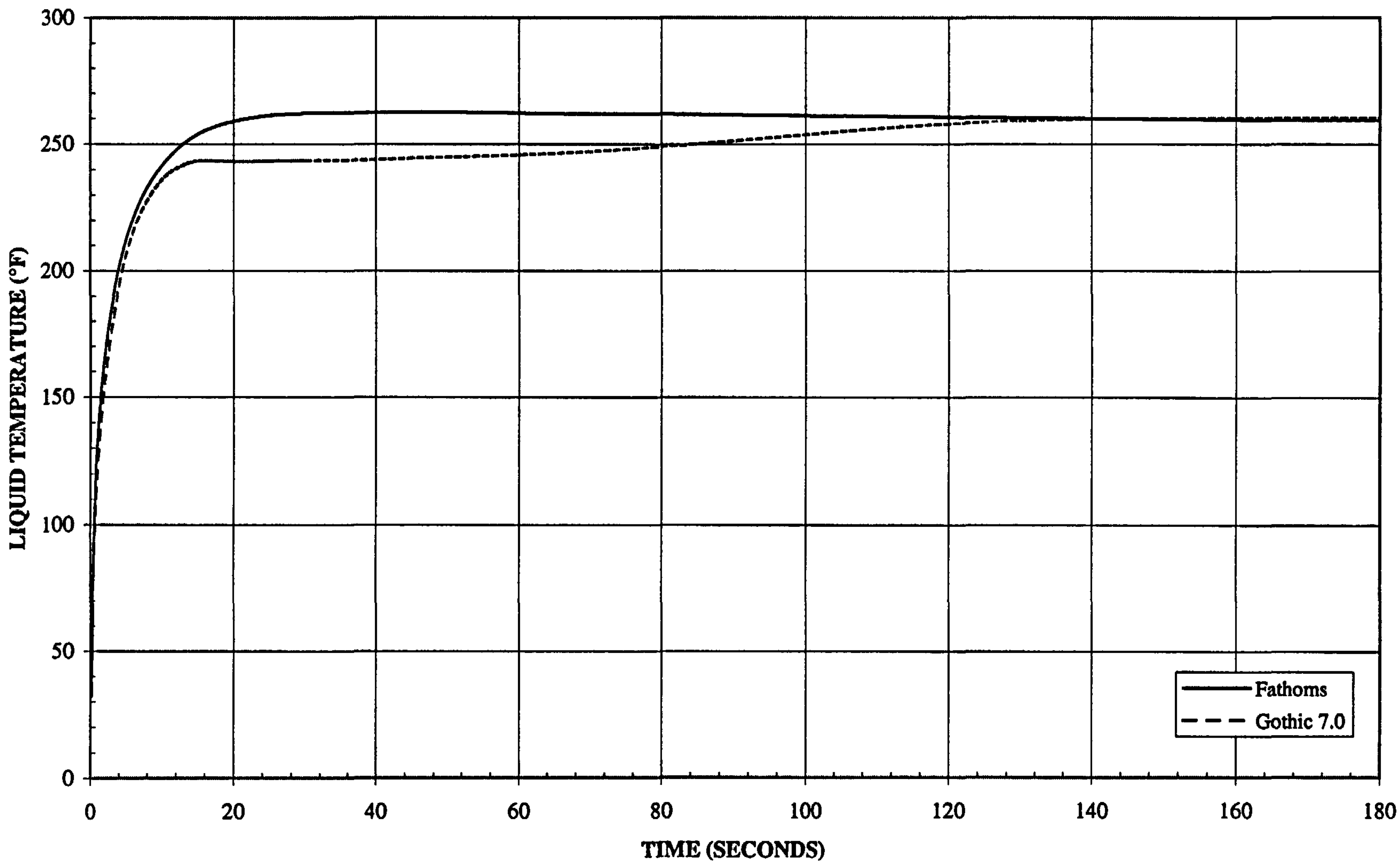
(14.1 ft^2 Break - SG Inlet - High Initial RCS Flow w/ 5° ΔTcold Loop Case 2)



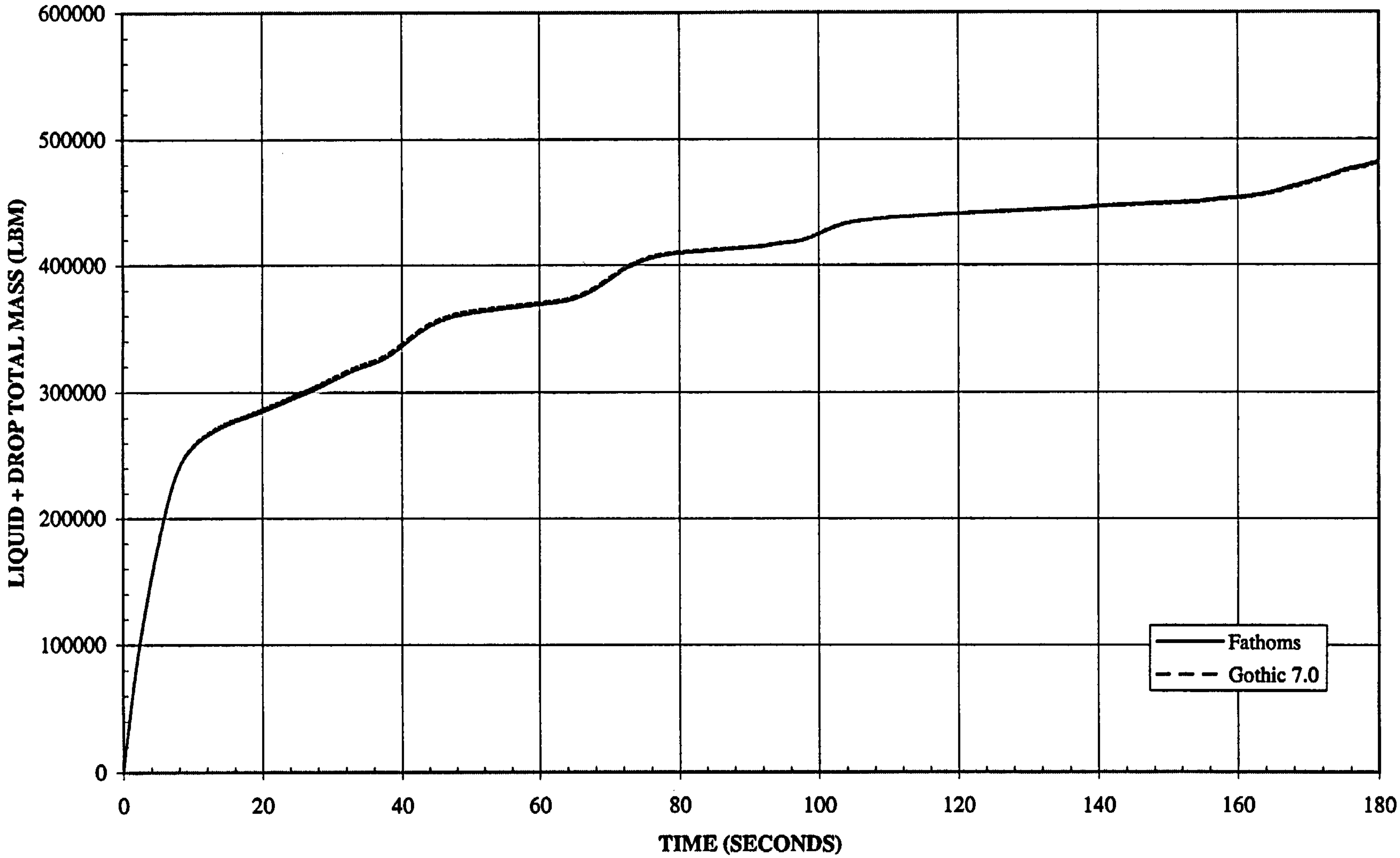

GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(14.1 ft² Break - SG Inlet - Low Initial RCS Flow w/ M1 Pump Degradation Model)
CONTAINMENT PRESSURE (PSIG)
TIME (SECONDS)
0
10
20
30
40
50
60
Fathoms
Gothic 7.0

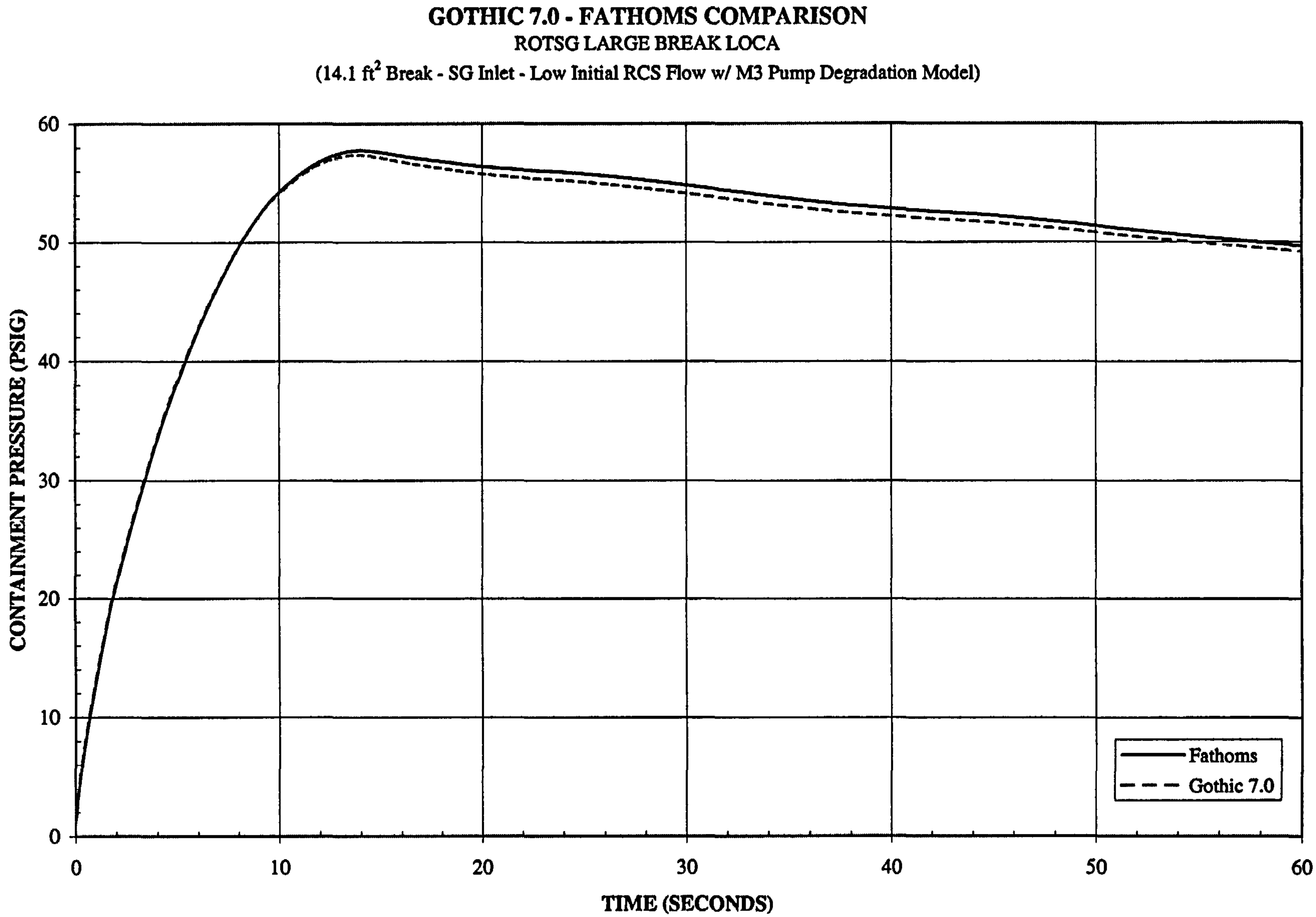

GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(14.1 ft² Break - SG Inlet - Low Initial RCS Flow w/ M1 Pump Degradation Model)
VAPOR TEMPERATURE (°F)
300
250
200
150
100
50
0
10
20
30
40
50
60
TIME (SECONDS)
Fathoms
Gothic 7.0

GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(14.1 ft^2 Break - SG Inlet - Low Initial RCS Flow w/ M1 Pump Degradation Model)

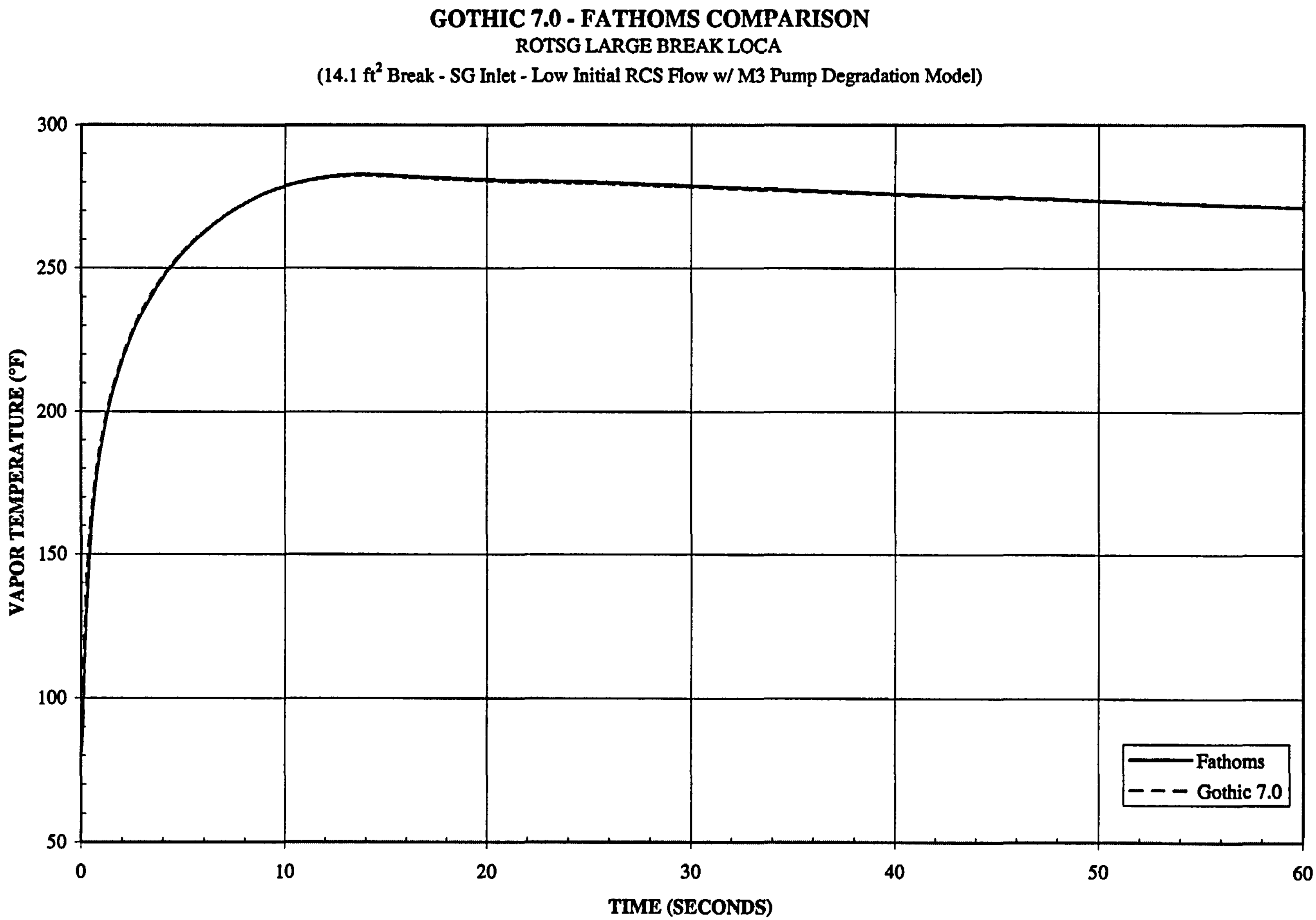


GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(14.1 ft^2 Break - SG Inlet - Low Initial RCS Flow w/ M1 Pump Degradation Model)

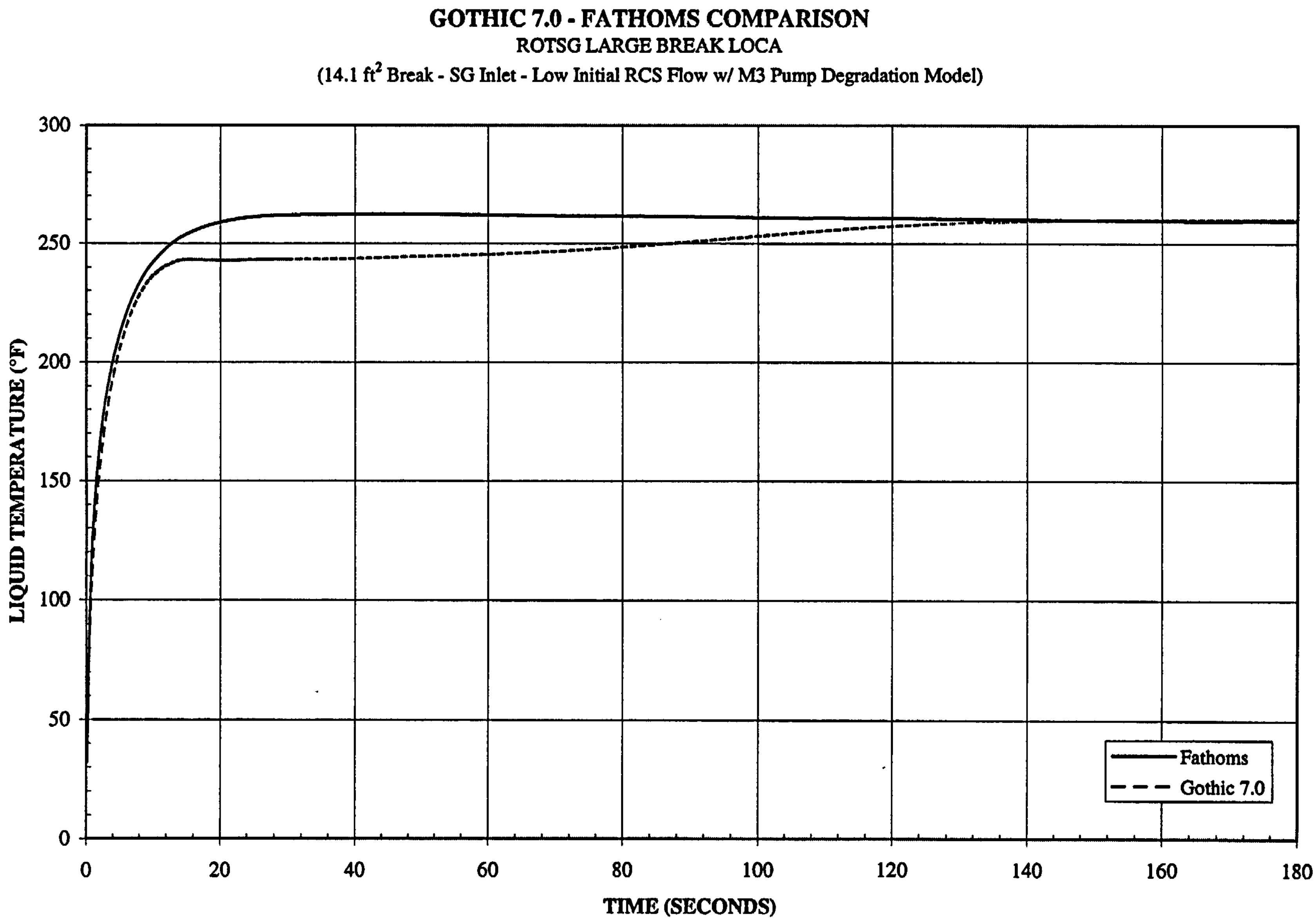




GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(14.1 ft² Break - SG Inlet - Low Initial RCS Flow w/ M3 Pump Degradation Model)
CONTAINMENT PRESSURE (PSIG)
TIME (SECONDS)
0
10
20
30
40
50
60
Fathoms
Gothic 7.0



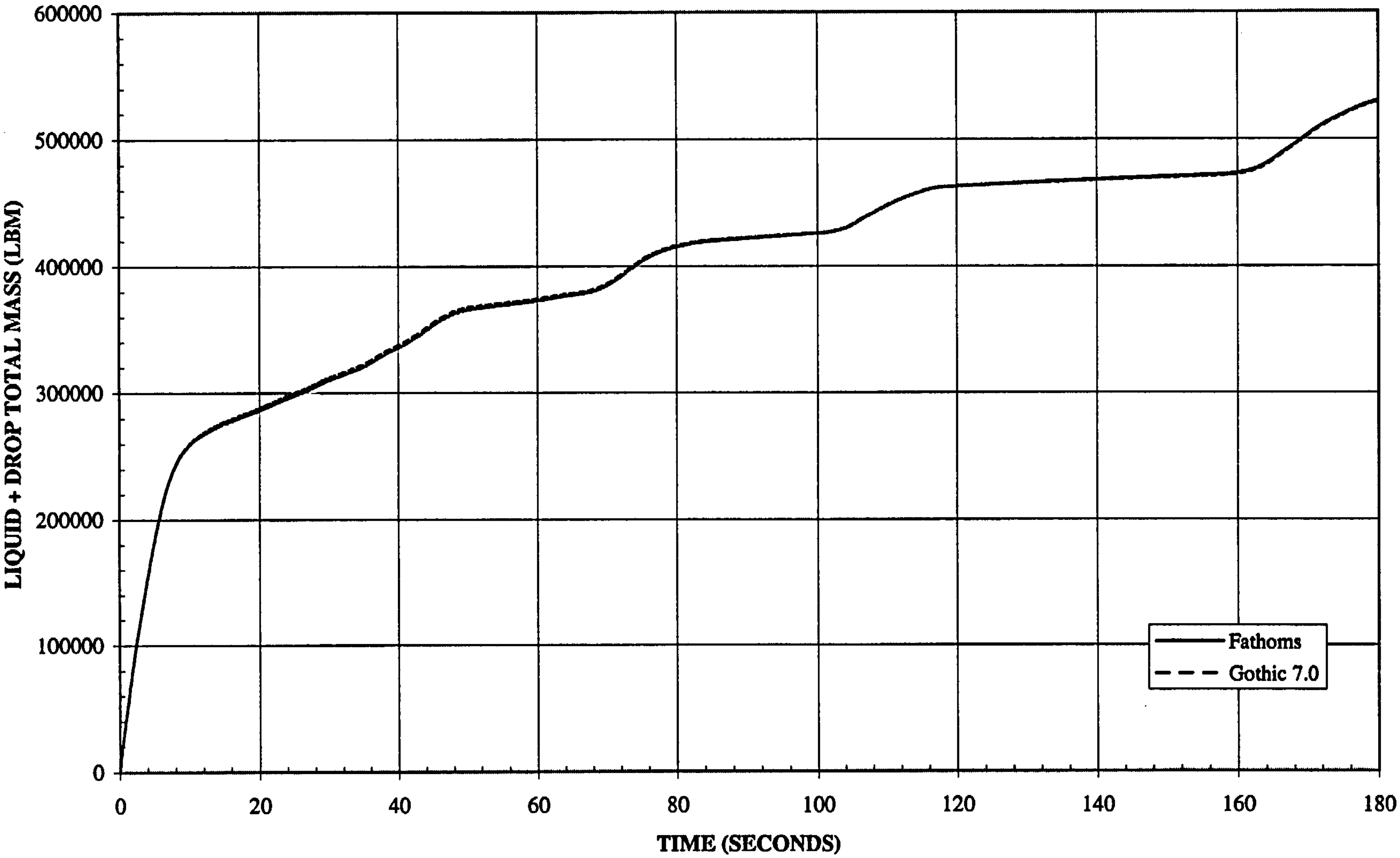
GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(14.1 ft² Break - SG Inlet - Low Initial RCS Flow w/ M3 Pump Degradation Model)
VAPOR TEMPERATURE (°F)
300
250
200
150
100
50
0
10
20
30
40
50
60
TIME (SECONDS)
Fathoms
Gothic 7.0


GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(14.1 ft² Break - SG Inlet - Low Initial RCS Flow w/ M3 Pump Degradation Model)
LIQUID TEMPERATURE (°F)
300
250
200
150
100
50
0
0
20
40
60
80
100
120
140
160
180
TIME (SECONDS)
Fathoms
Gothic 7.0

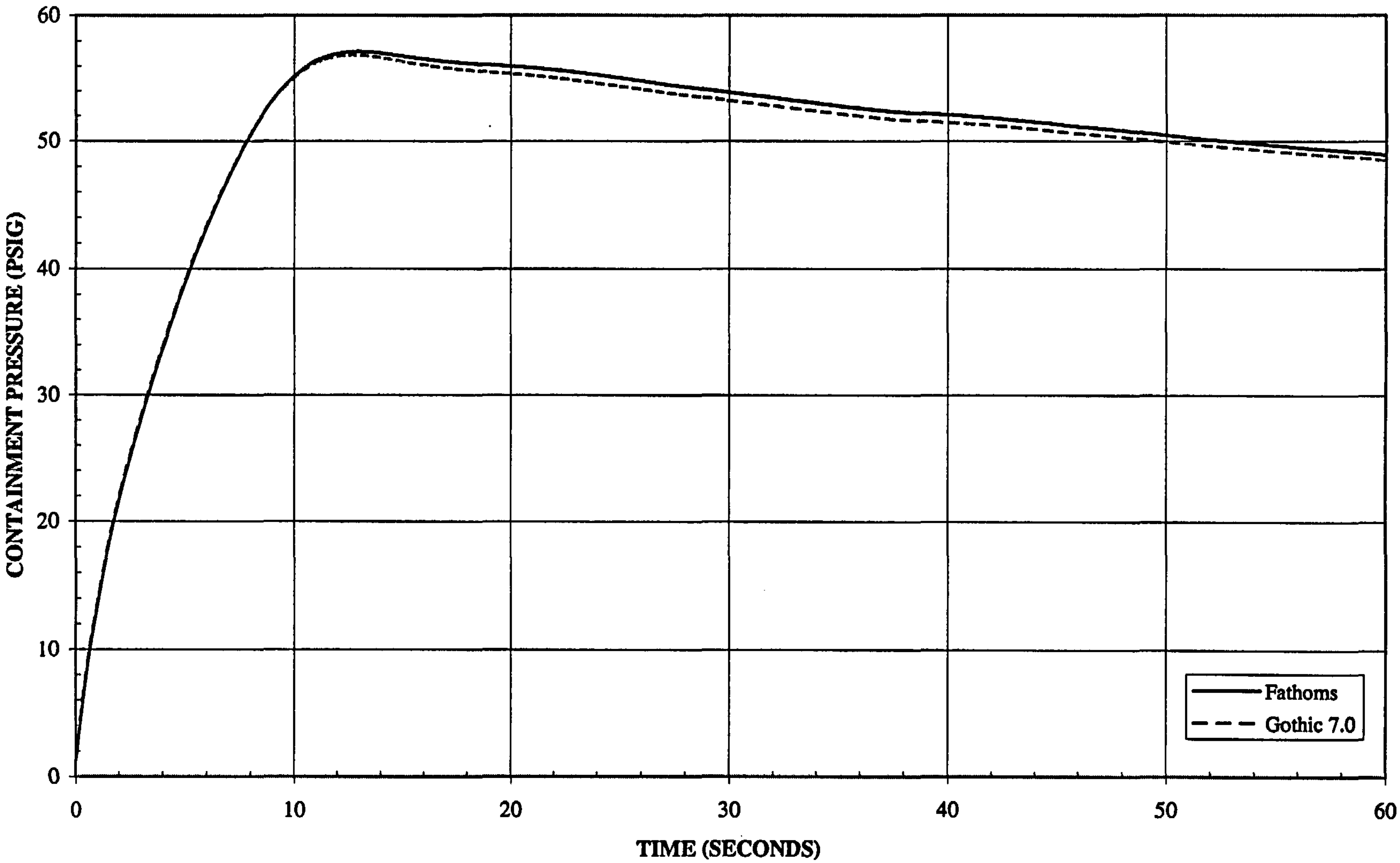
GOTHIC 7.0 - FATHOMS COMPARISON

ROTSG LARGE BREAK LOCA

(14.1 ft^2 Break - SG Inlet - Low Initial RCS Flow w/ M3 Pump Degradation Model)



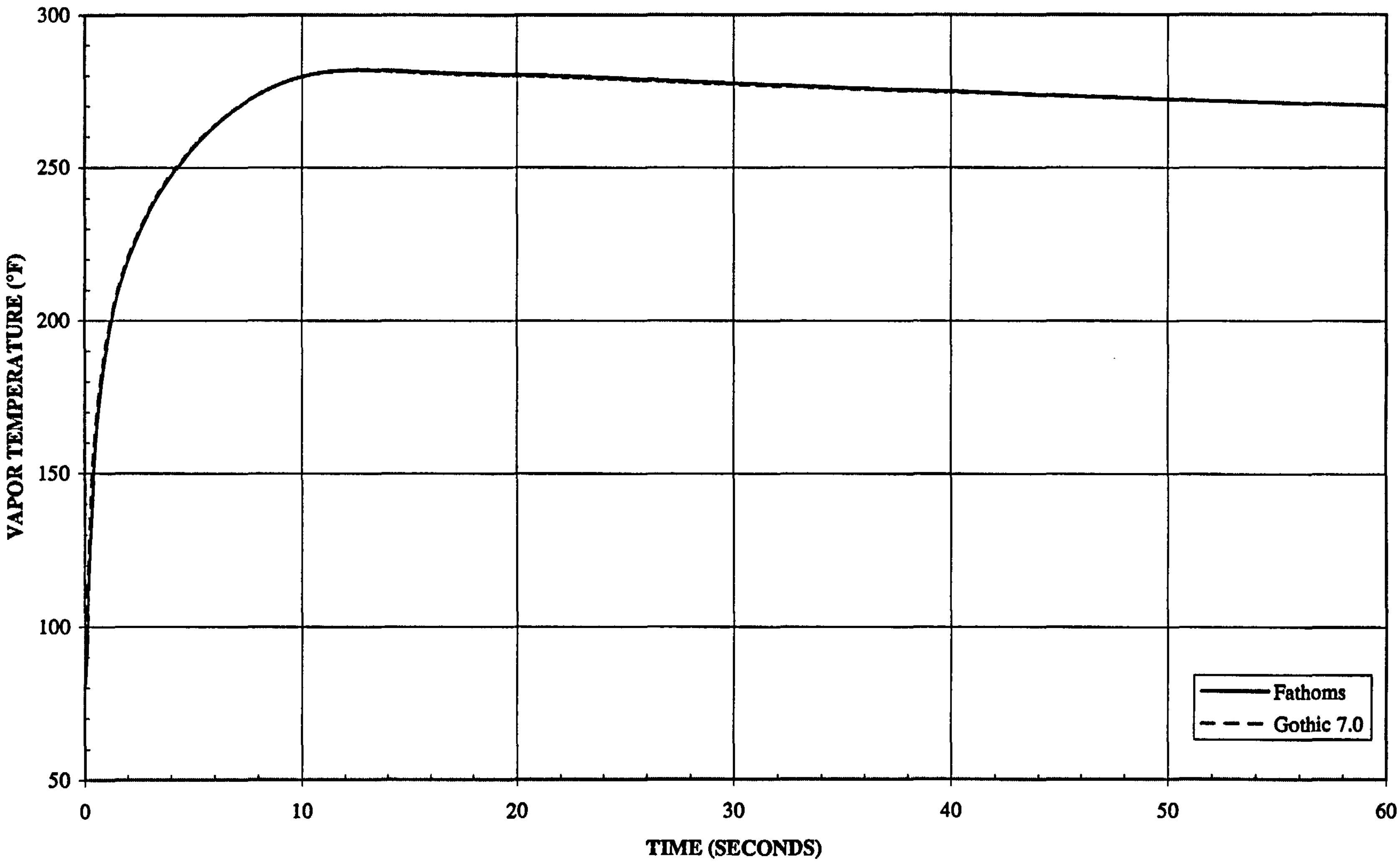
GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(14.1 ft^2 Break - RV Outlet - Low Initial RCS Flow w/ M1 Pump Degradation Model)

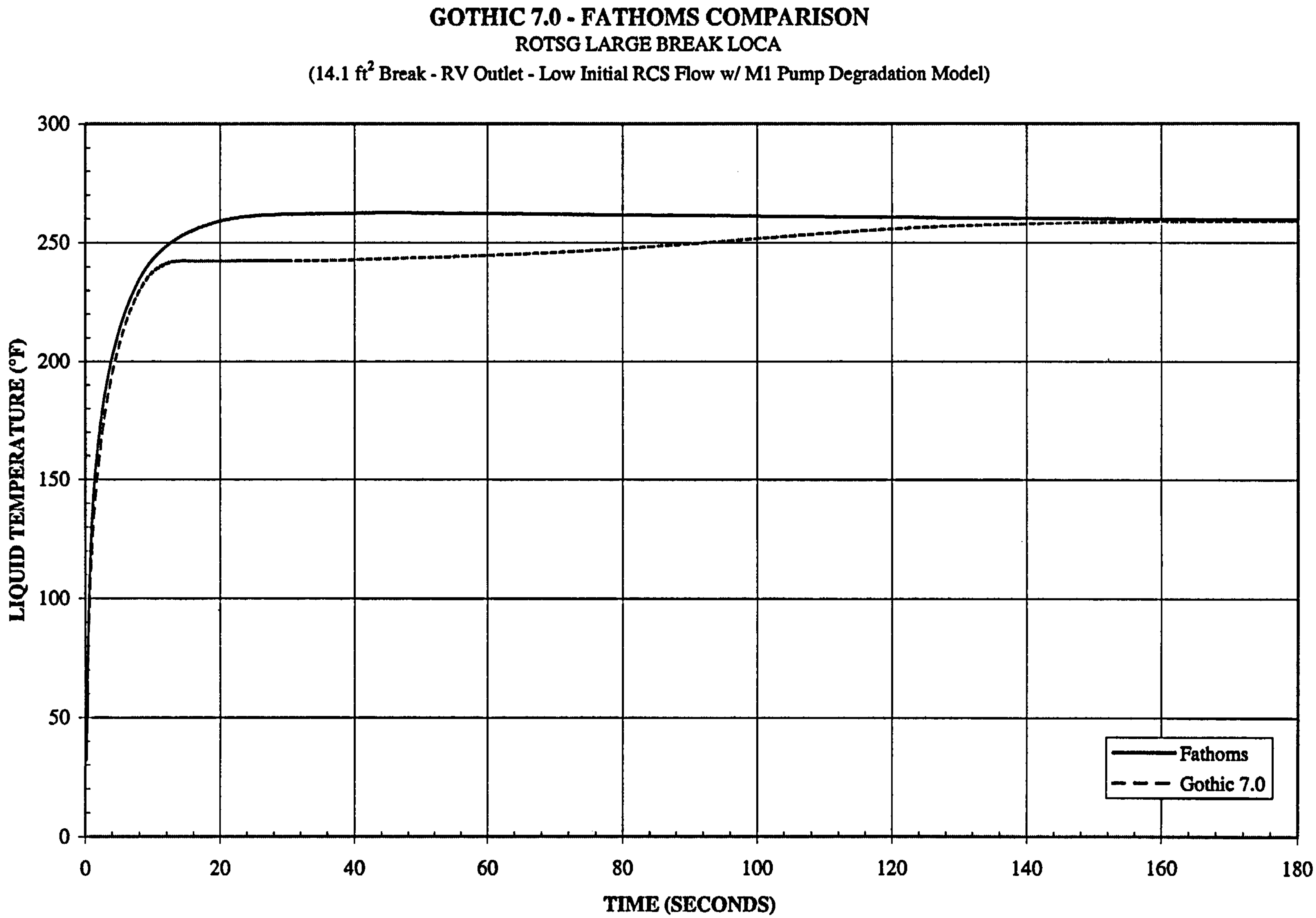


GOTHIC 7.0 - FATHOMS COMPARISON

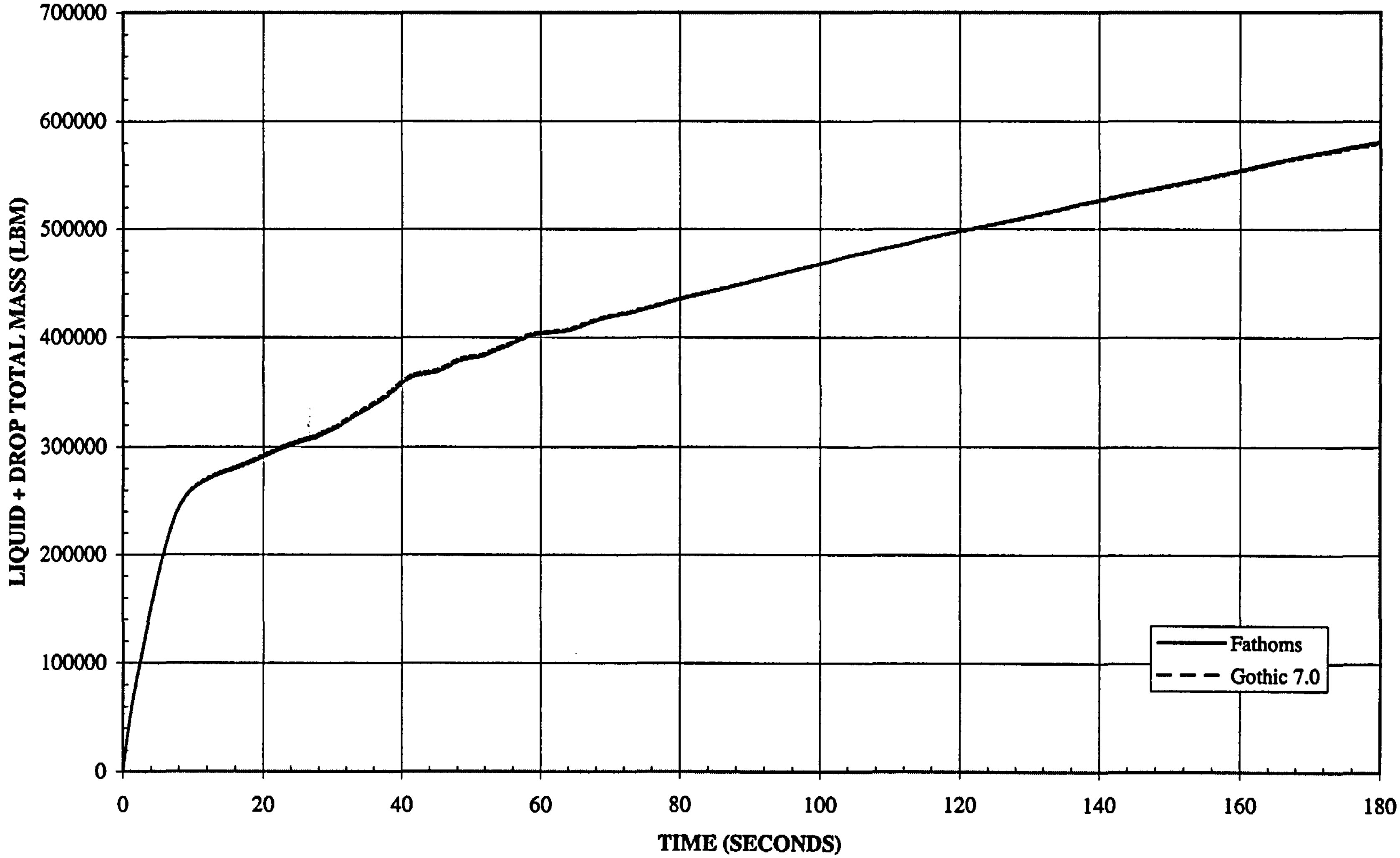
ROTSG LARGE BREAK LOCA

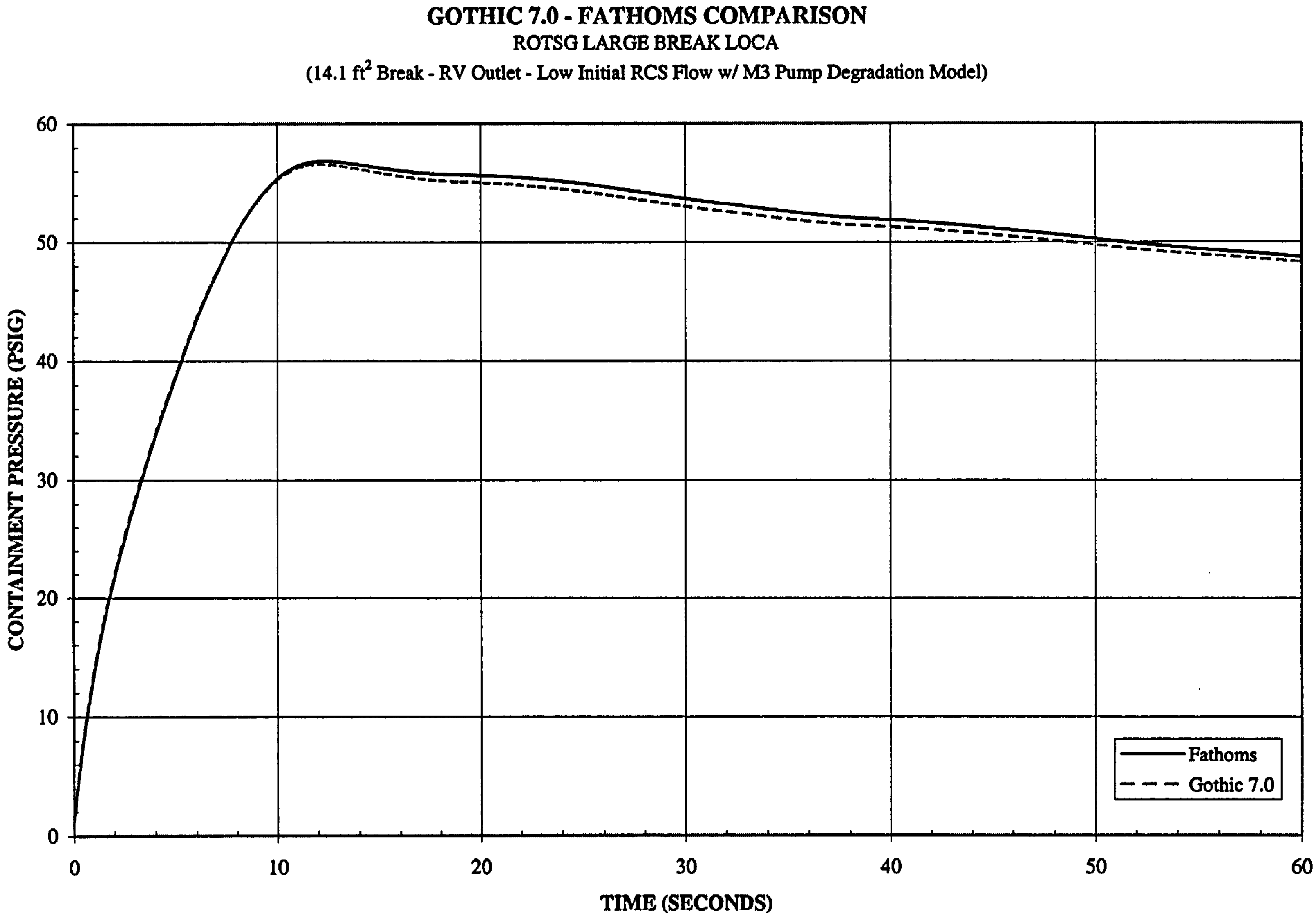
(14.1 ft^2 Break - RV Outlet - Low Initial RCS Flow w/ M1 Pump Degradation Model)



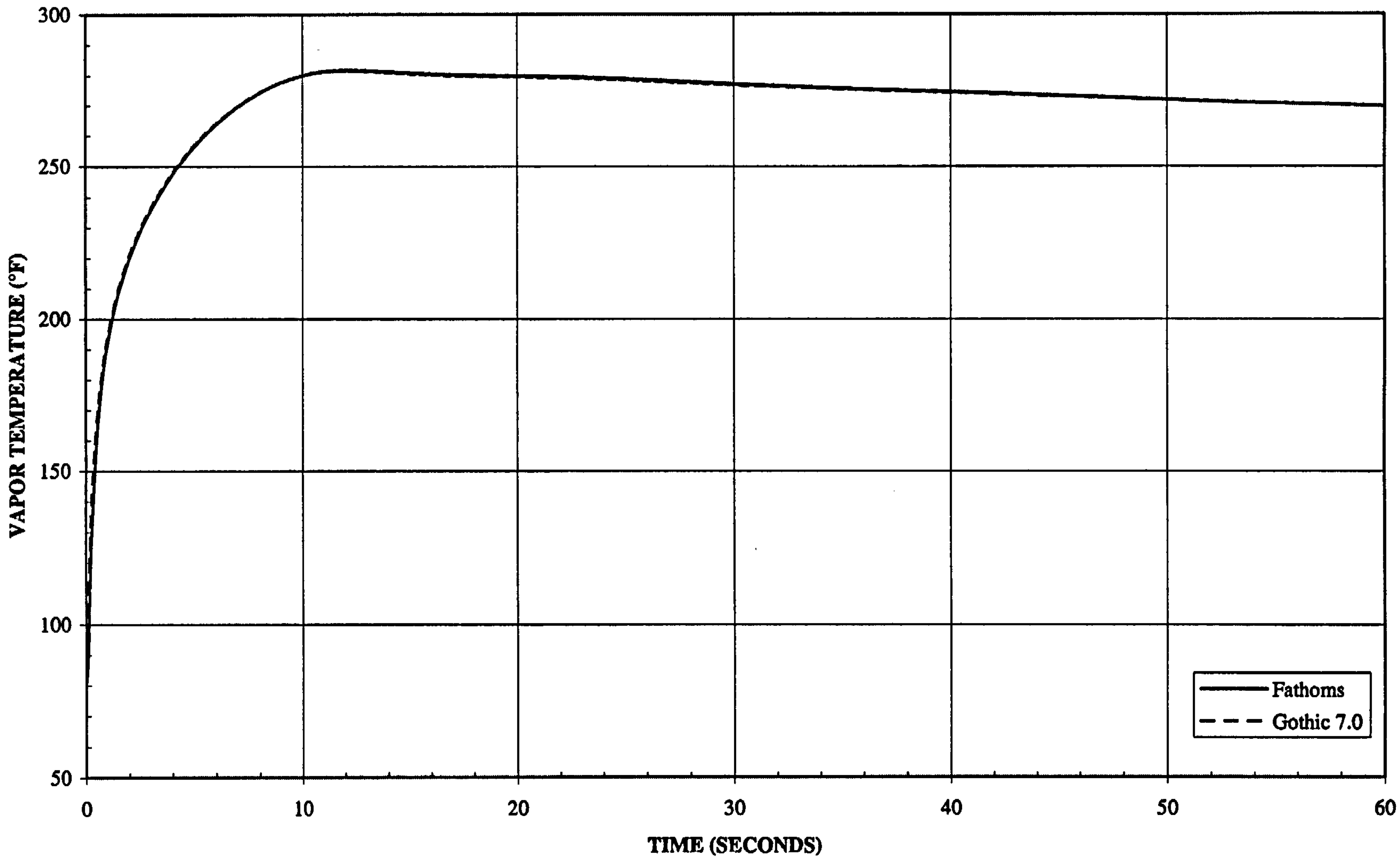

GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(14.1 ft² Break - RV Outlet - Low Initial RCS Flow w/ M1 Pump Degradation Model)
LIQUID TEMPERATURE (°F)
TIME (SECONDS)
300
250
200
150
100
50
0
0
20
40
60
80
100
120
140
160
180
Fathoms
Gothic 7.0

GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(14.1 ft^2 Break - RV Outlet - Low Initial RCS Flow w/ M1 Pump Degradation Model)




GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(14.1 ft² Break - RV Outlet - Low Initial RCS Flow w/ M3 Pump Degradation Model)
CONTAINMENT PRESSURE (PSIG)
TIME (SECONDS)
0
10
20
30
40
50
60
Fathoms
Gothic 7.0

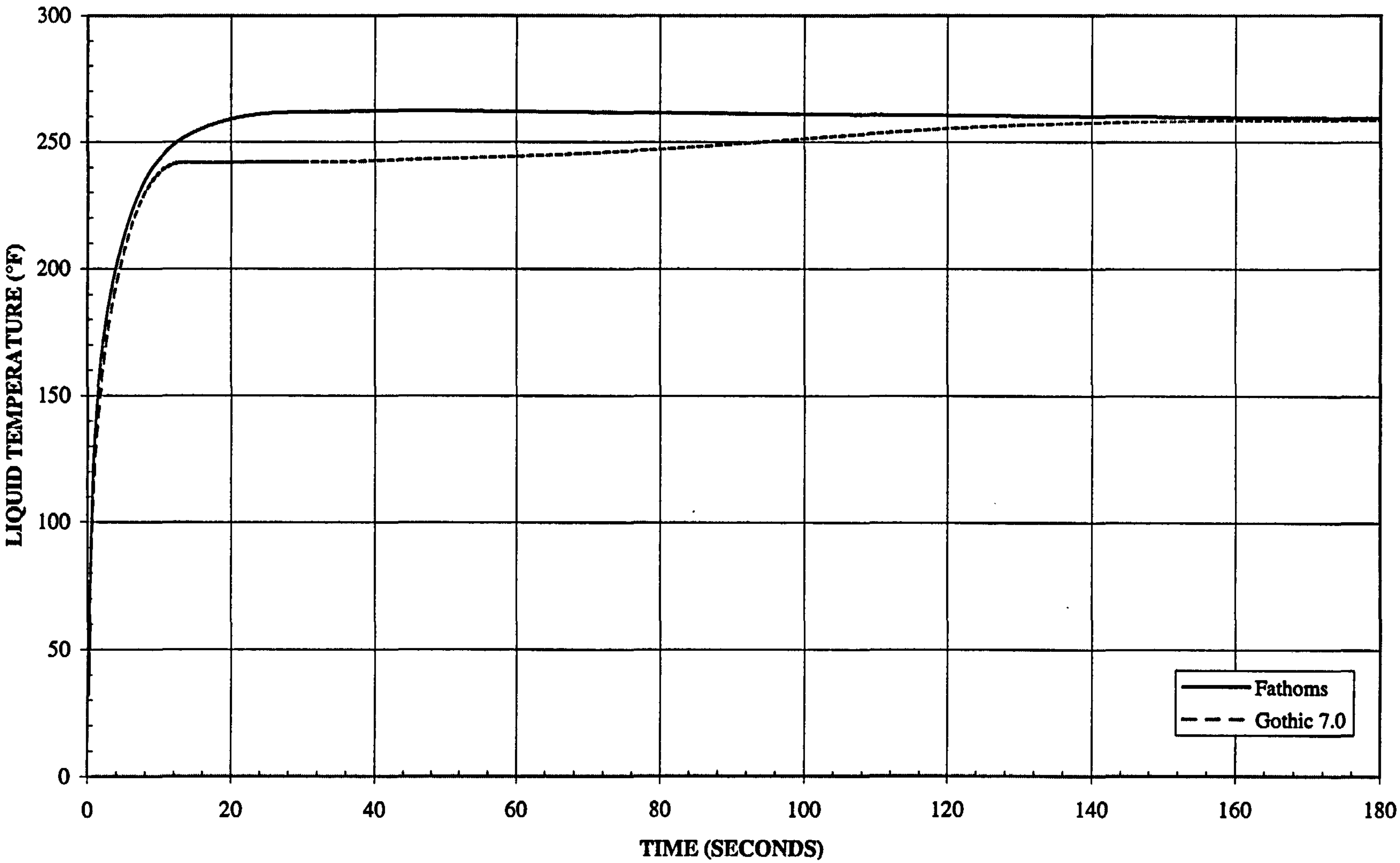
GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(14.1 ft^2 Break - RV Outlet - Low Initial RCS Flow w/ M3 Pump Degradation Model)

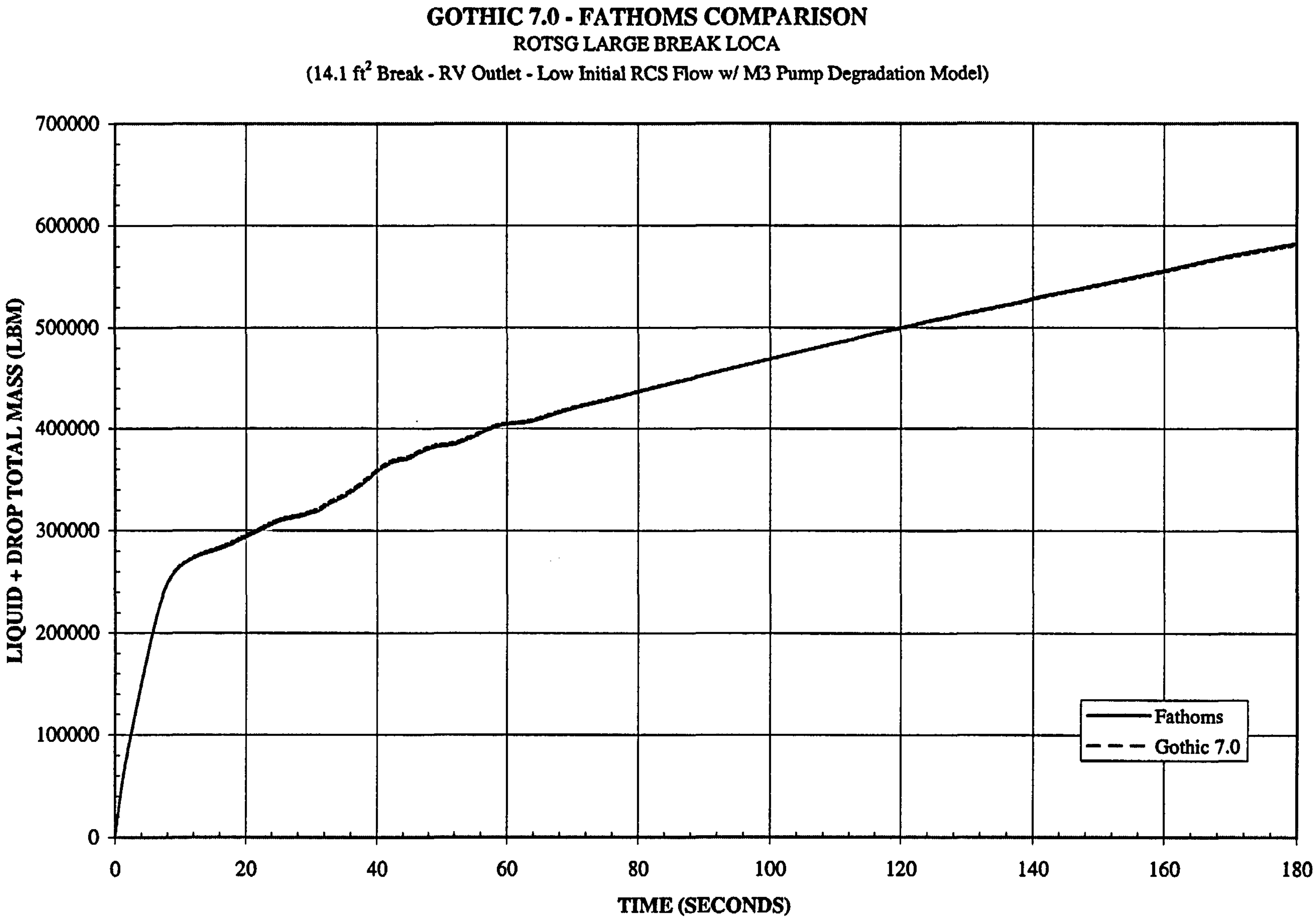


GOTHIC 7.0 - FATHOMS COMPARISON

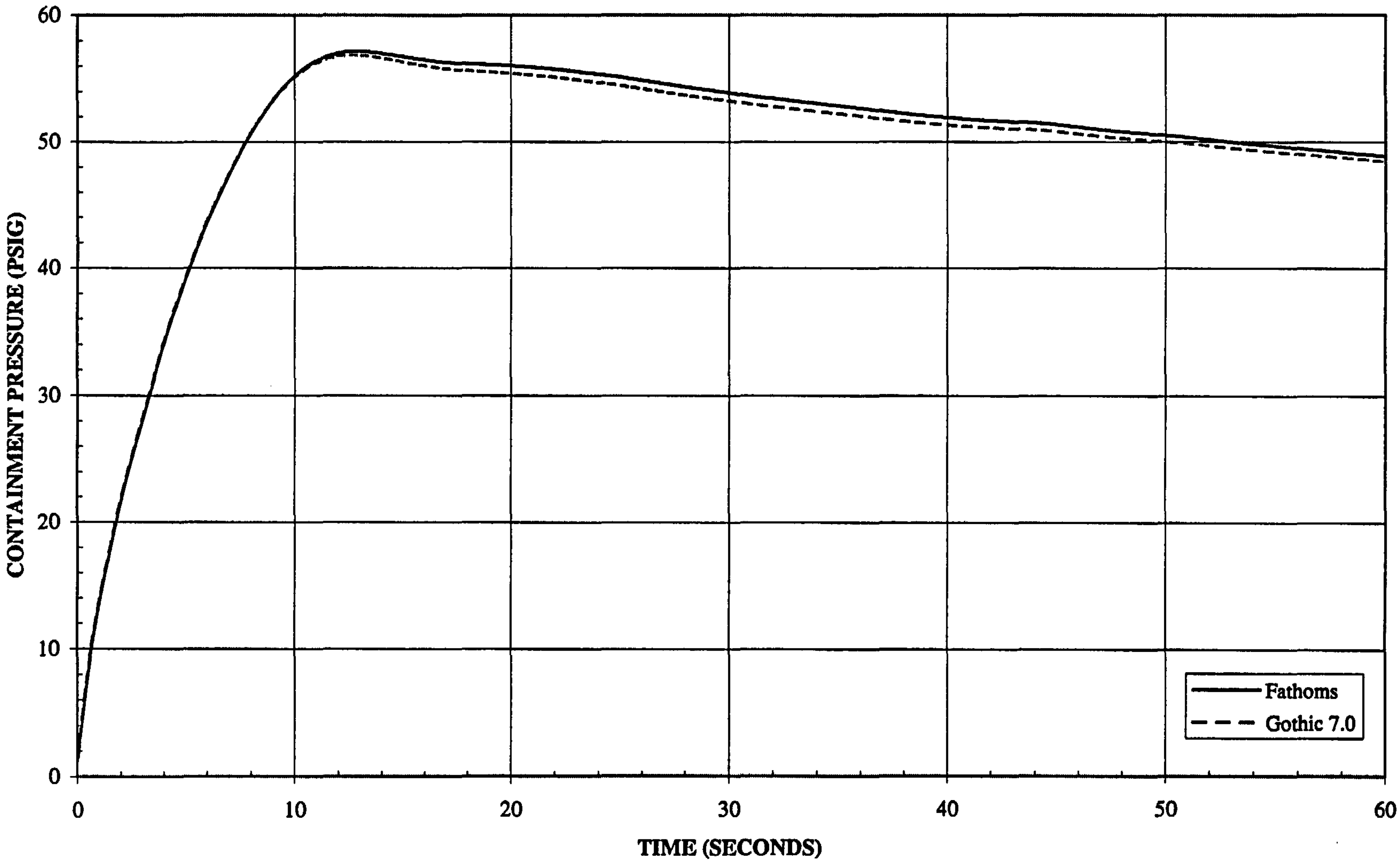
ROTSG LARGE BREAK LOCA

(14.1 ft^2 Break - RV Outlet - Low Initial RCS Flow w/ M3 Pump Degradation Model)




GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(14.1 ft² Break - RV Outlet - Low Initial RCS Flow w/ M3 Pump Degradation Model)
LIQUID + DROP TOTAL MASS (LBM)
700000
600000
500000
400000
300000
200000
100000
0
0
20
40
60
80
100
120
140
160
180
TIME (SECONDS)
Fathoms
Gothic 7.0

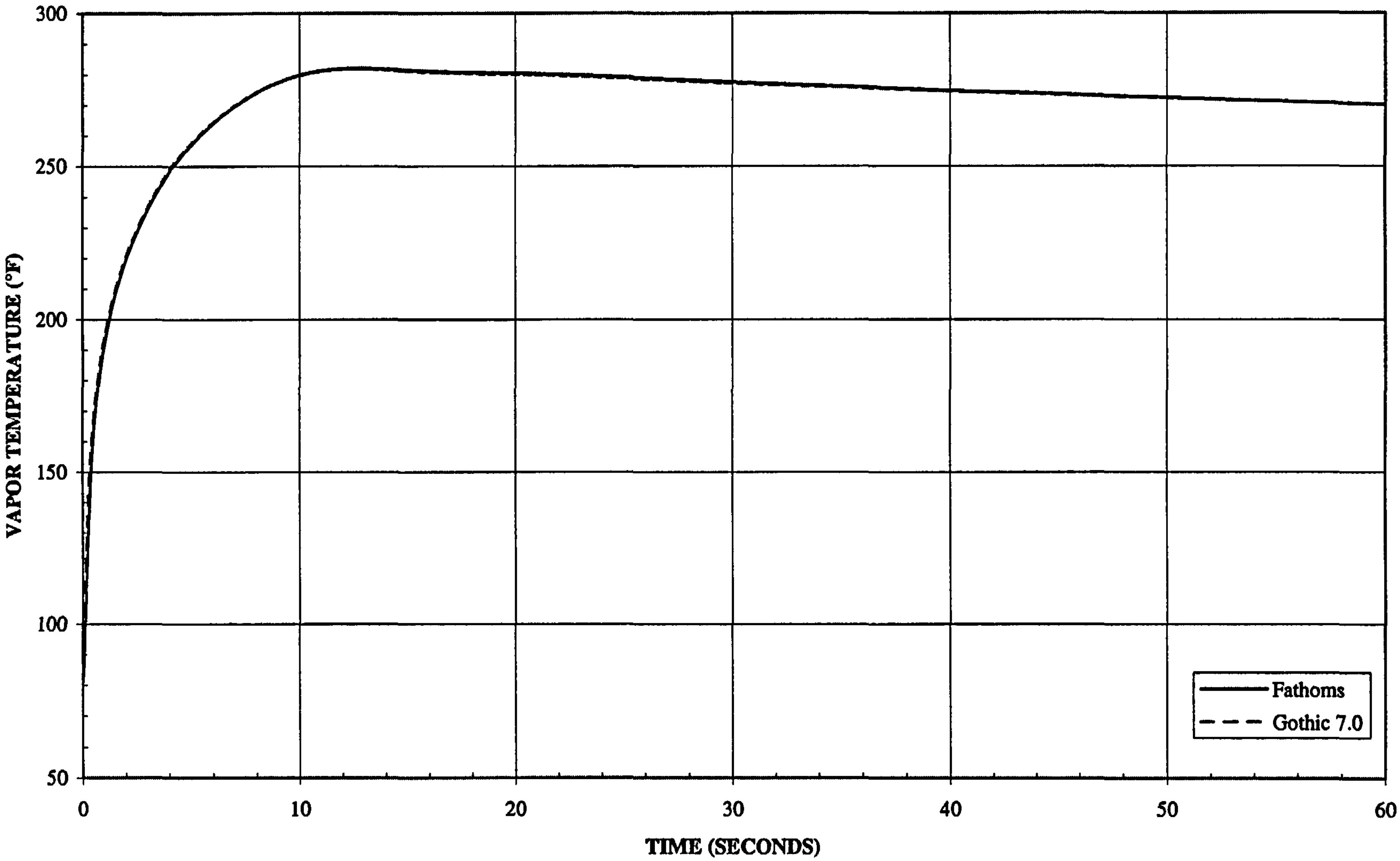
GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(14.1 ft^2 Break - RV Outlet - High Initial RCS Flow w/ M1 Pump Degradation Model)

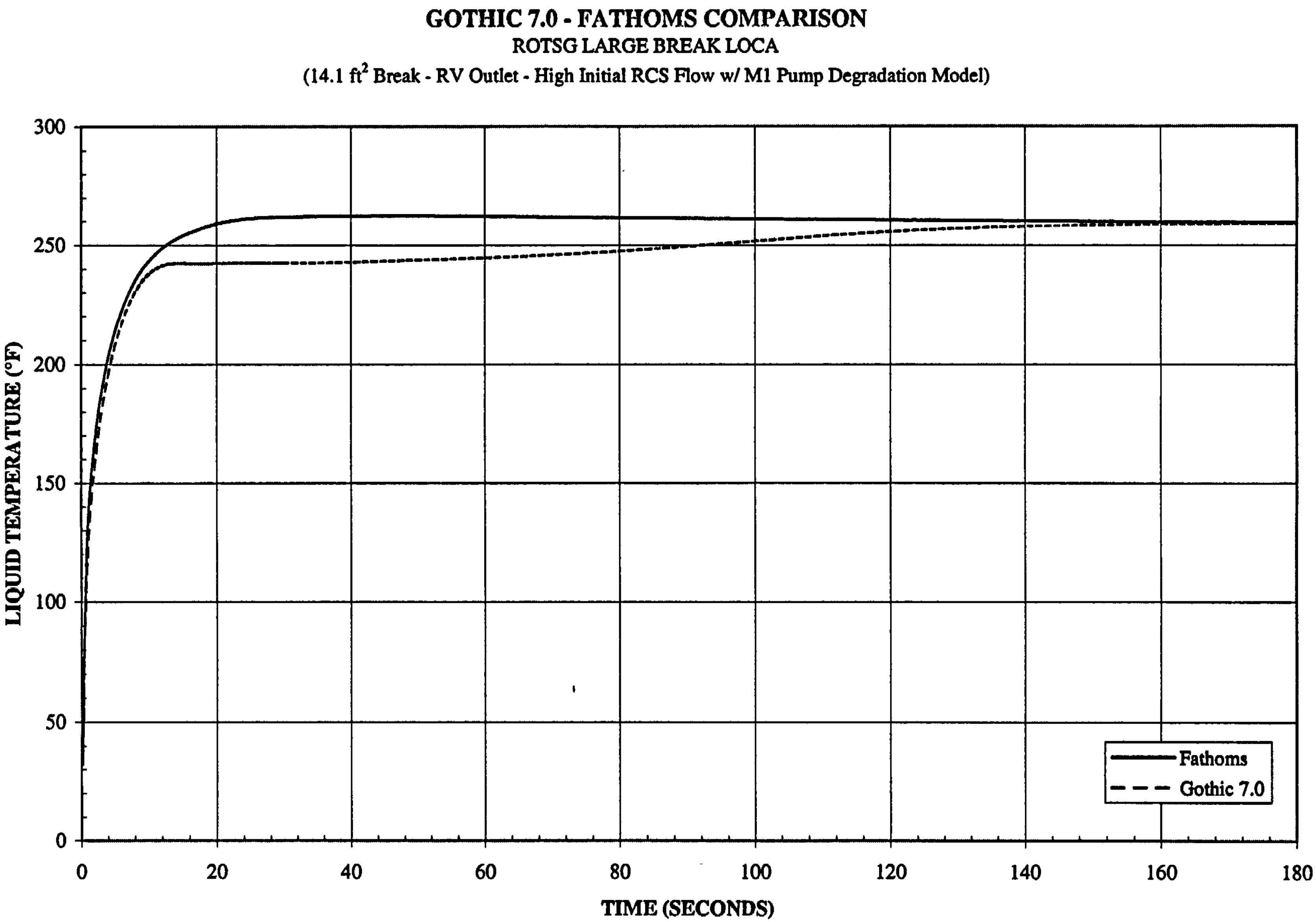


GOTHIC 7.0 - FATHOMS COMPARISON

ROTSG LARGE BREAK LOCA

(14.1 ft^2 Break - RV Outlet - High Initial RCS Flow w/ M1 Pump Degradation Model)

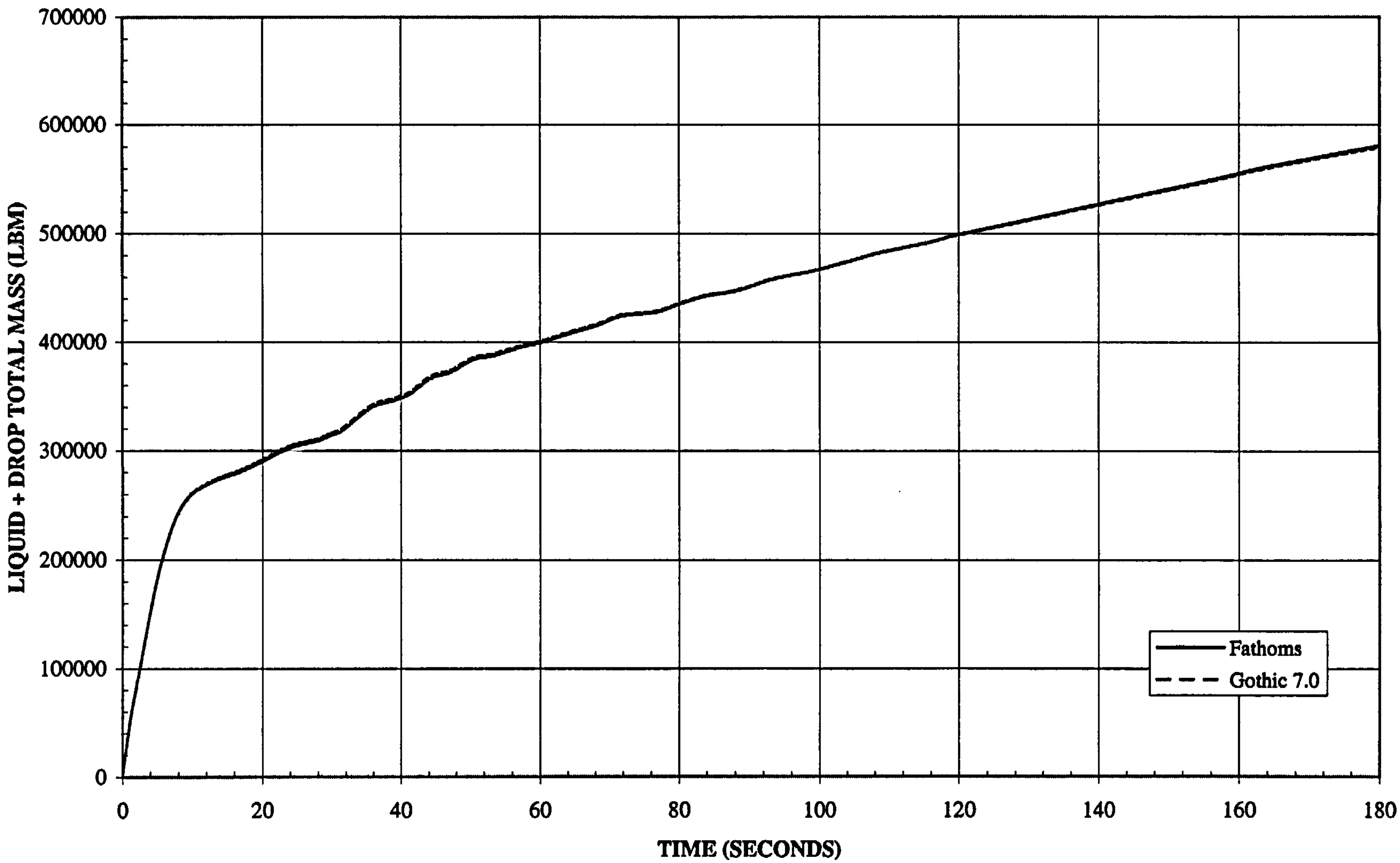


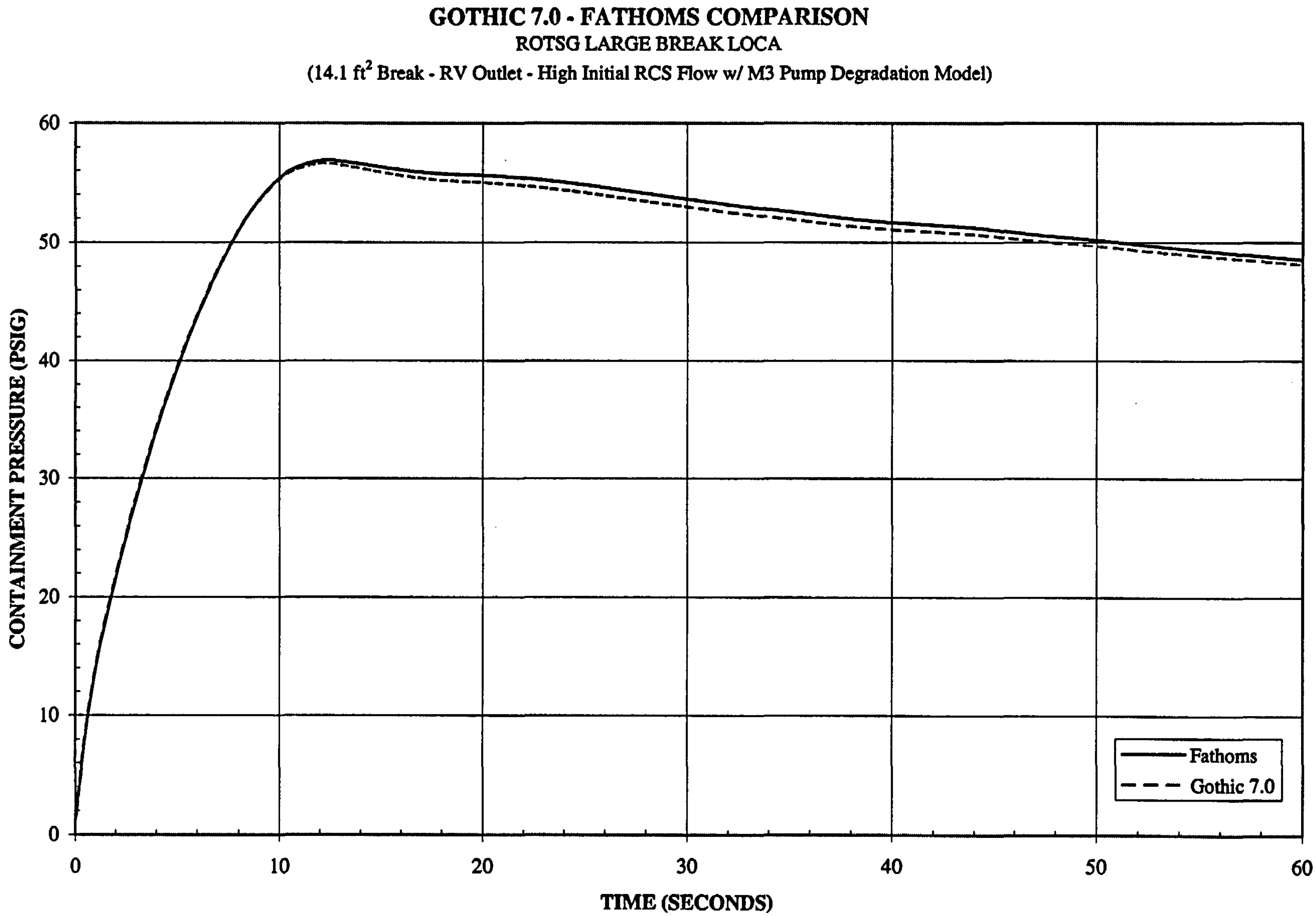

GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(14.1 ft² Break - RV Outlet - High Initial RCS Flow w/ M1 Pump Degradation Model)
LIQUID TEMPERATURE (°F)
TIME (SECONDS)
300
250
200
150
100
50
0
0
20
40
60
80
100
120
140
160
180
Fathoms
Gothic 7.0

GOTHIC 7.0 - FATHOMS COMPARISON

ROTSG LARGE BREAK LOCA

(14.1 ft^2 Break - RV Outlet - High Initial RCS Flow w/ M1 Pump Degradation Model)

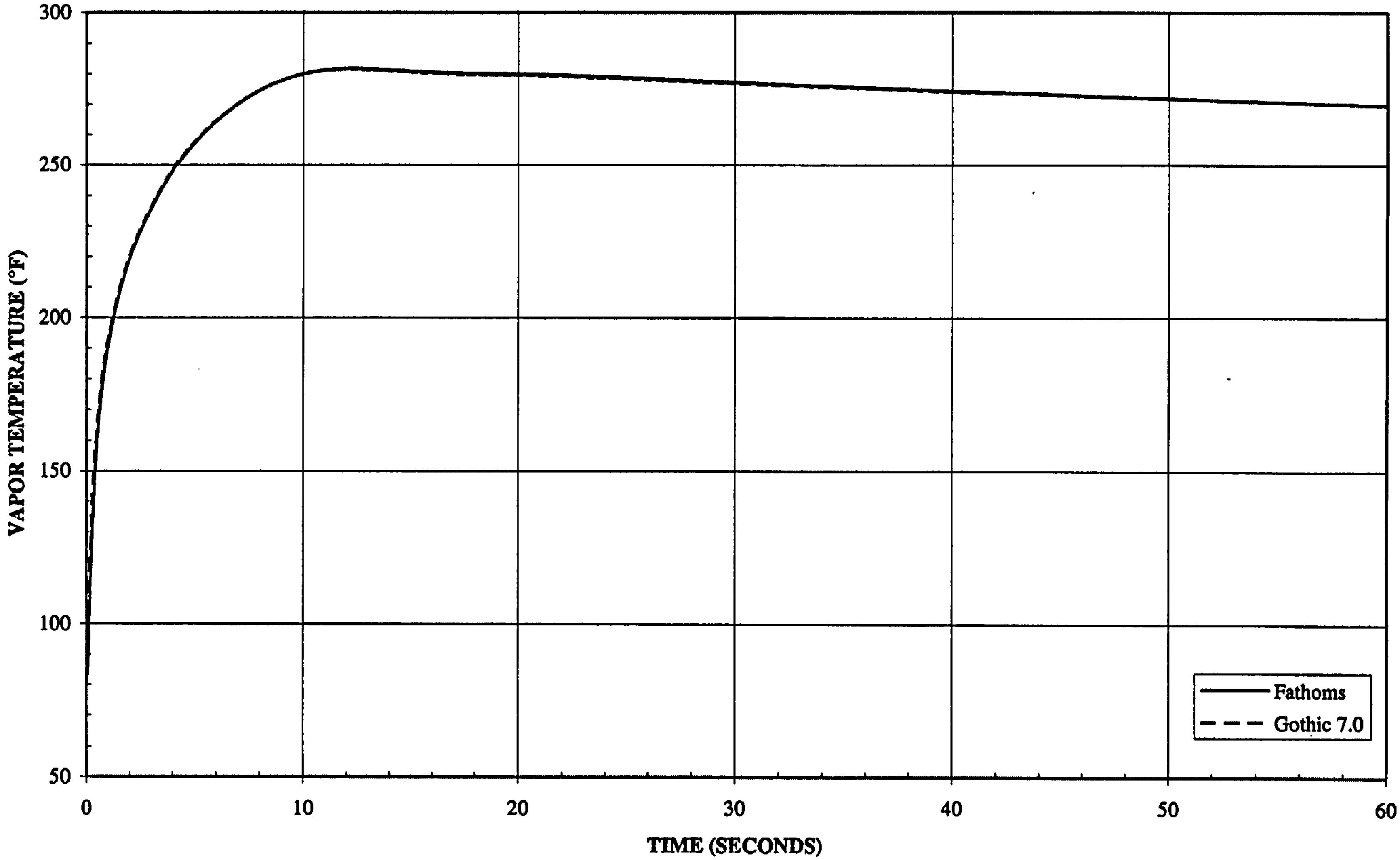



GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(14.1 ft² Break - RV Outlet - High Initial RCS Flow w/ M3 Pump Degradation Model)
CONTAINMENT PRESSURE (PSIG)
TIME (SECONDS)
Fathoms
Gothic 7.0

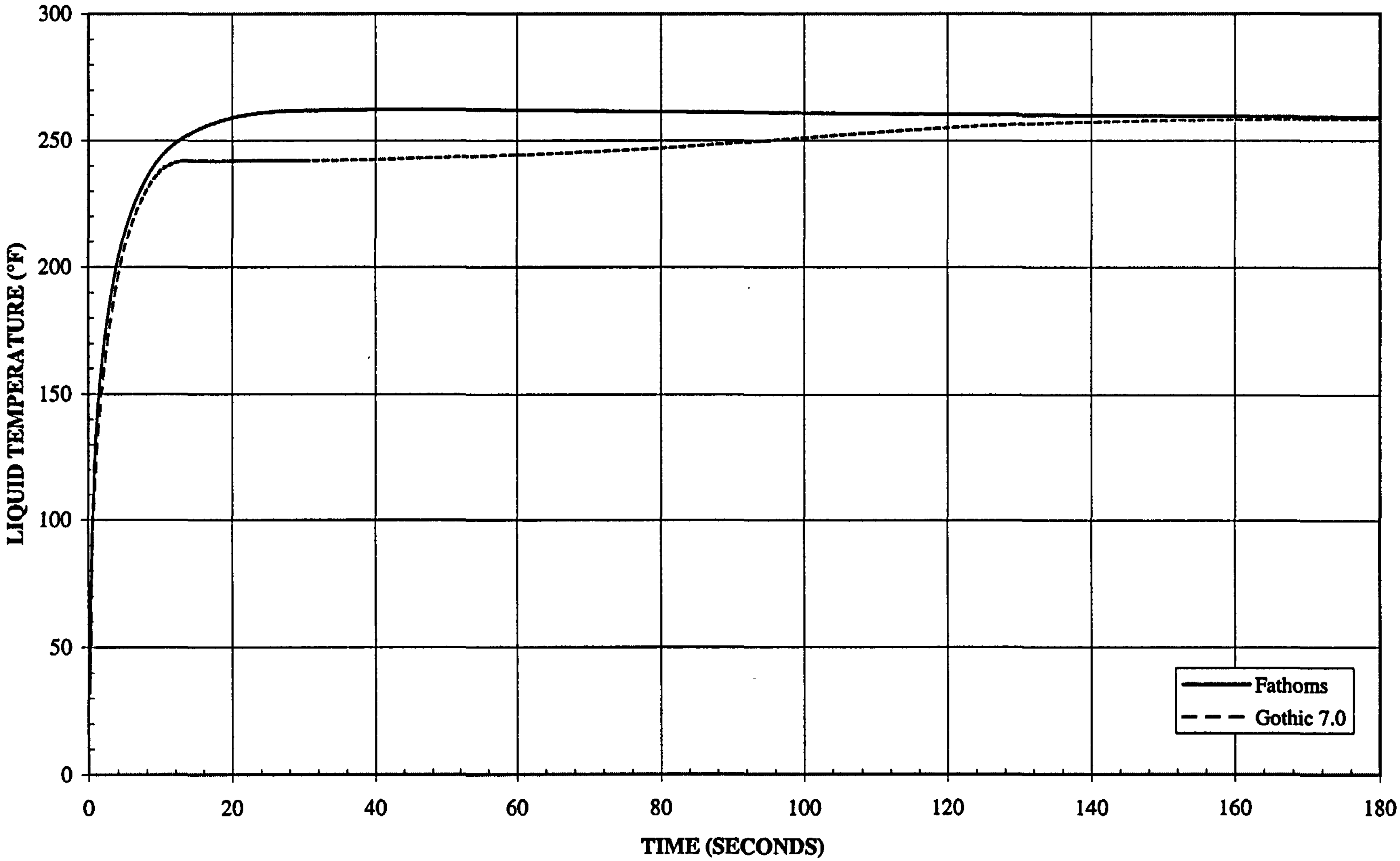
GOTHIC 7.0 - FATHOMS COMPARISON

ROTSG LARGE BREAK LOCA

(14.1 ft^2 Break - RV Outlet - High Initial RCS Flow w/ M3 Pump Degradation Model)



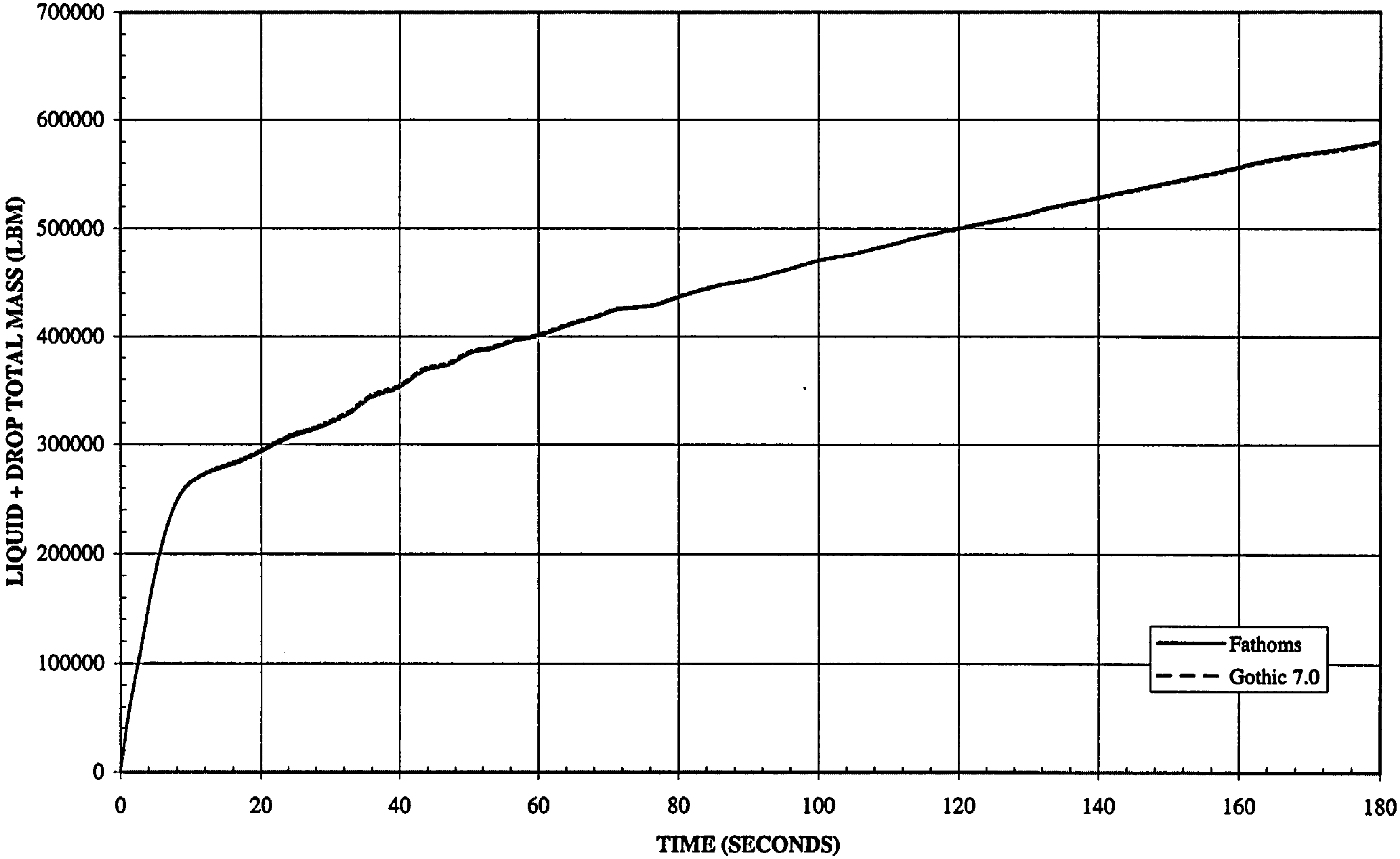
GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(14.1 ft^2 Break - RV Outlet - High Initial RCS Flow w/ M3 Pump Degradation Model)

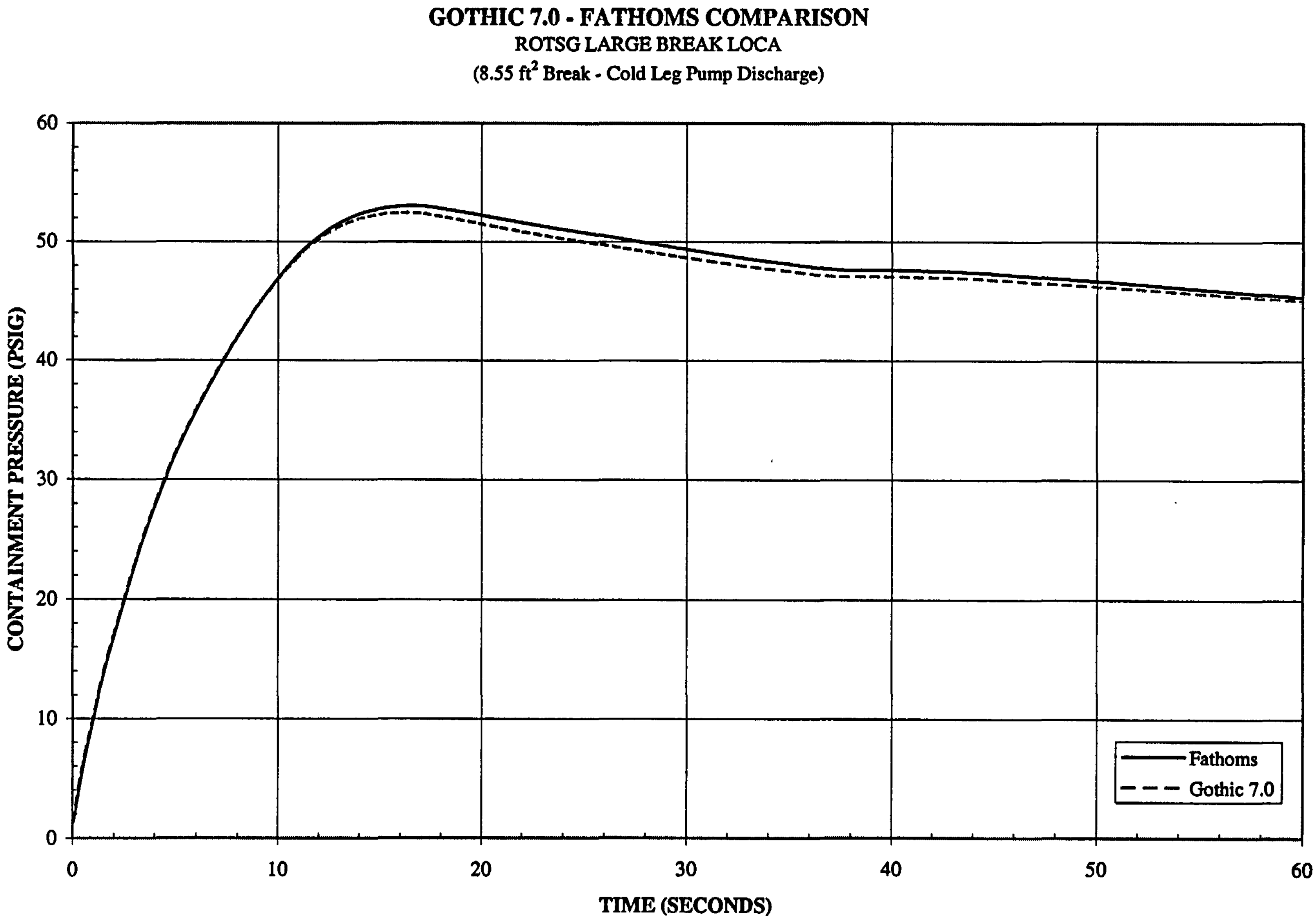


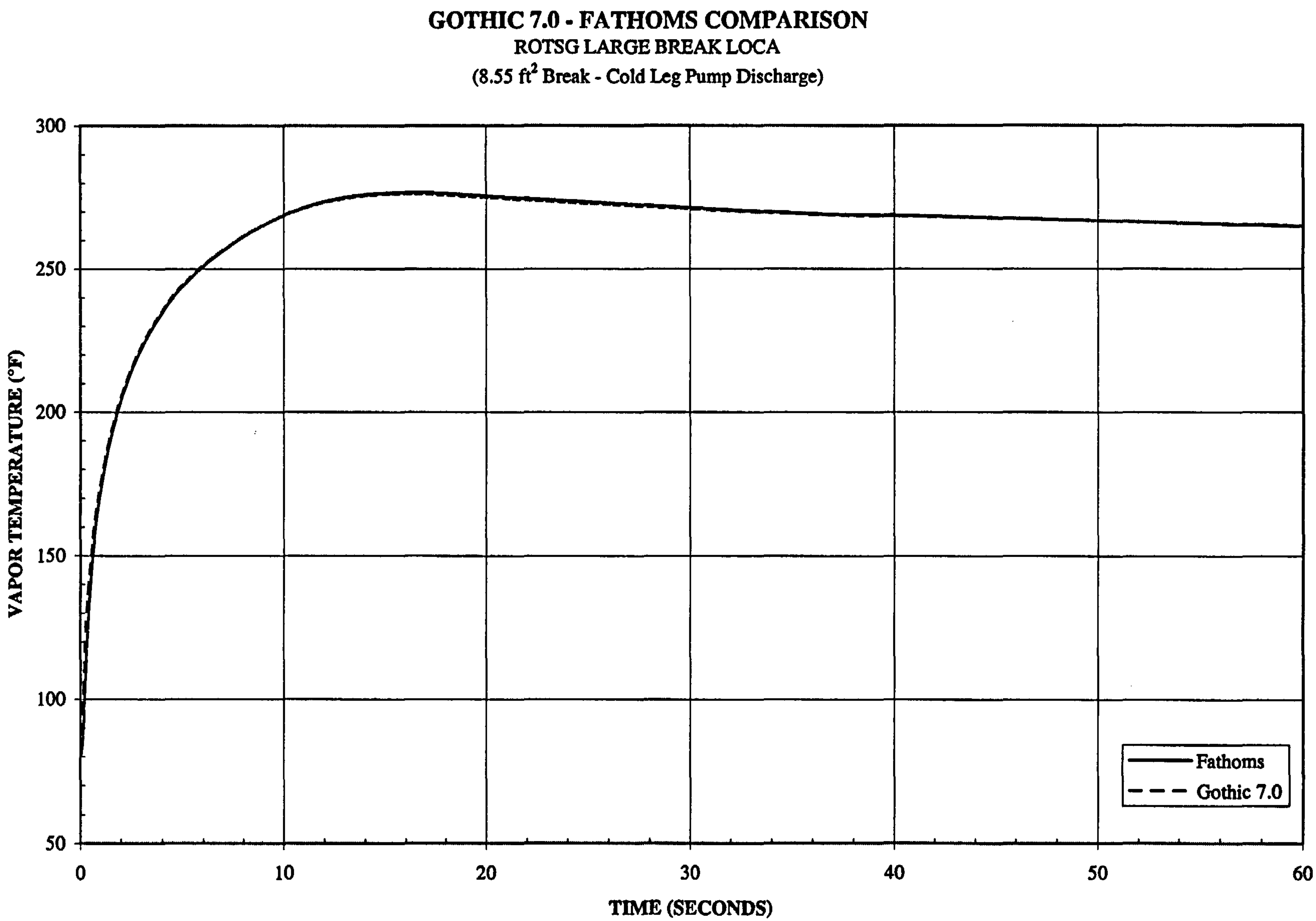
GOTHIC 7.0 - FATHOMS COMPARISON

ROTSG LARGE BREAK LOCA

(14.1 ft^2 Break - RV Outlet - High Initial RCS Flow w/ M3 Pump Degradation Model)

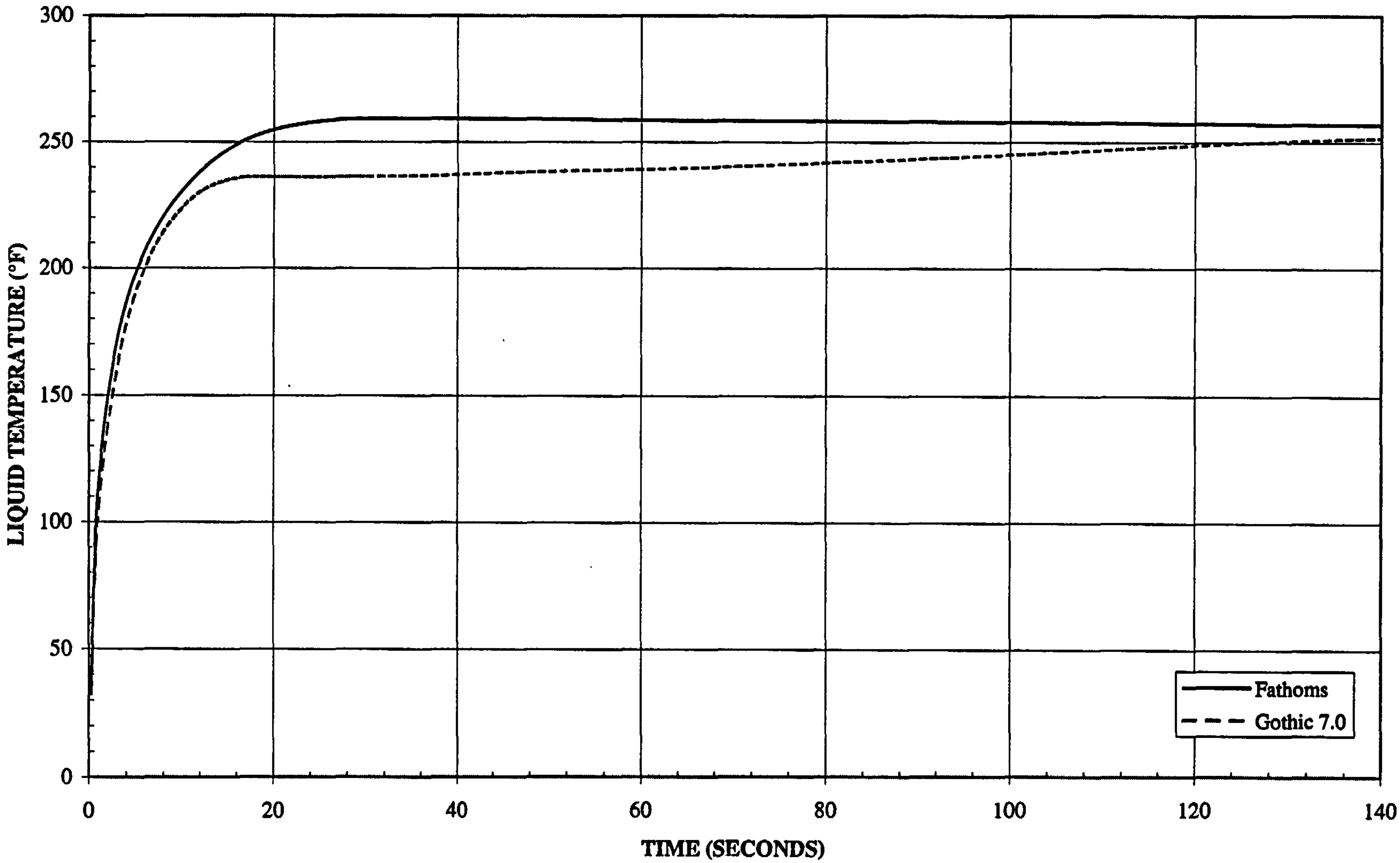


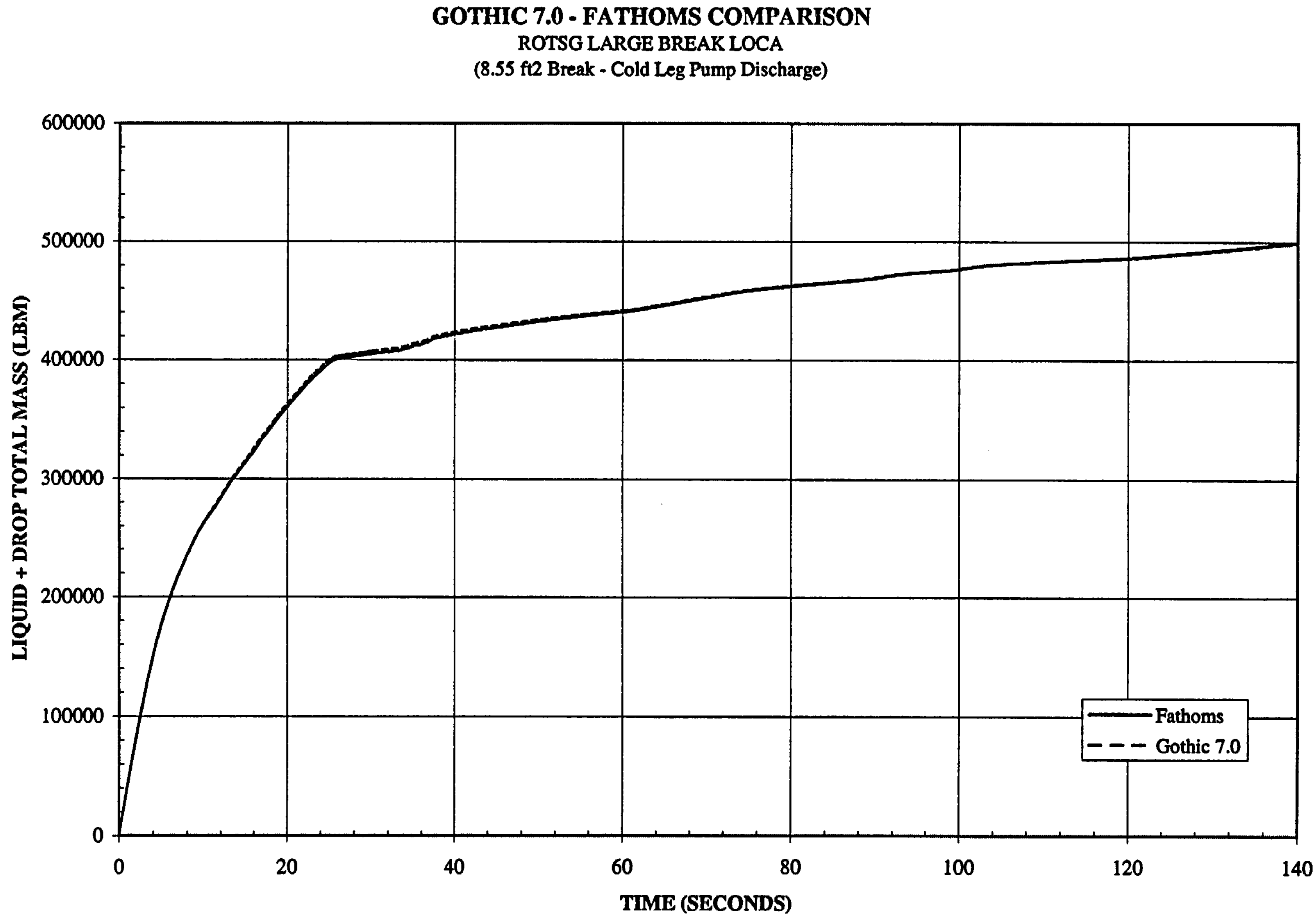

GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(8.55 ft² Break - Cold Leg Pump Discharge)
CONTAINMENT PRESSURE (PSIG)
60
50
40
30
20
10
0
0
10
20
30
40
50
60
TIME (SECONDS)
Fathoms
Gothic 7.0



GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(8.55 ft2 Break - Cold Leg Pump Discharge)
VAPOR TEMPERATURE (°F)
300
250
200
150
100
50
0
10
20
30
40
50
60
TIME (SECONDS)
Fathoms
Gothic 7.0

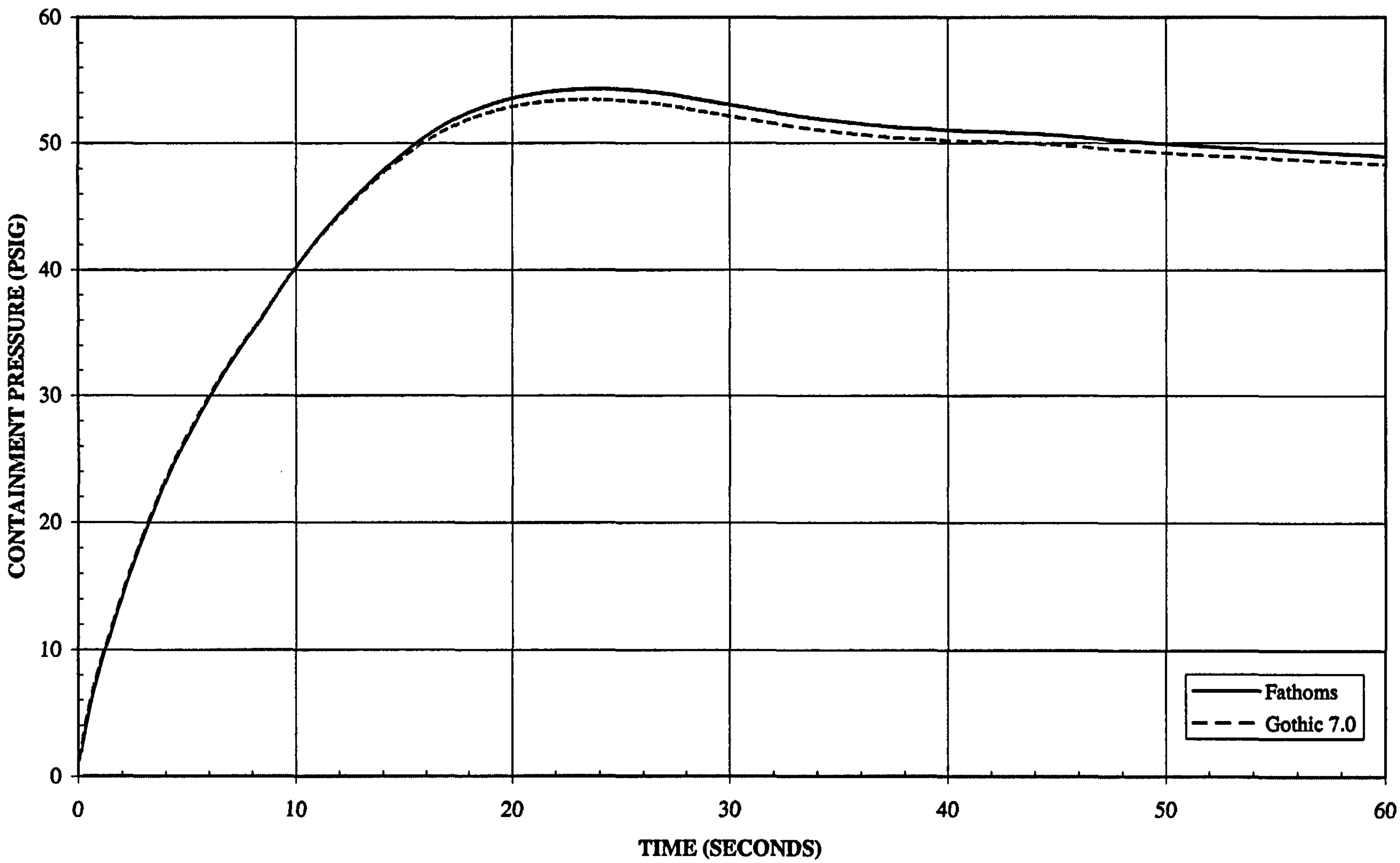
GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(8.55 ft2 Break - Cold Leg Pump Discharge)

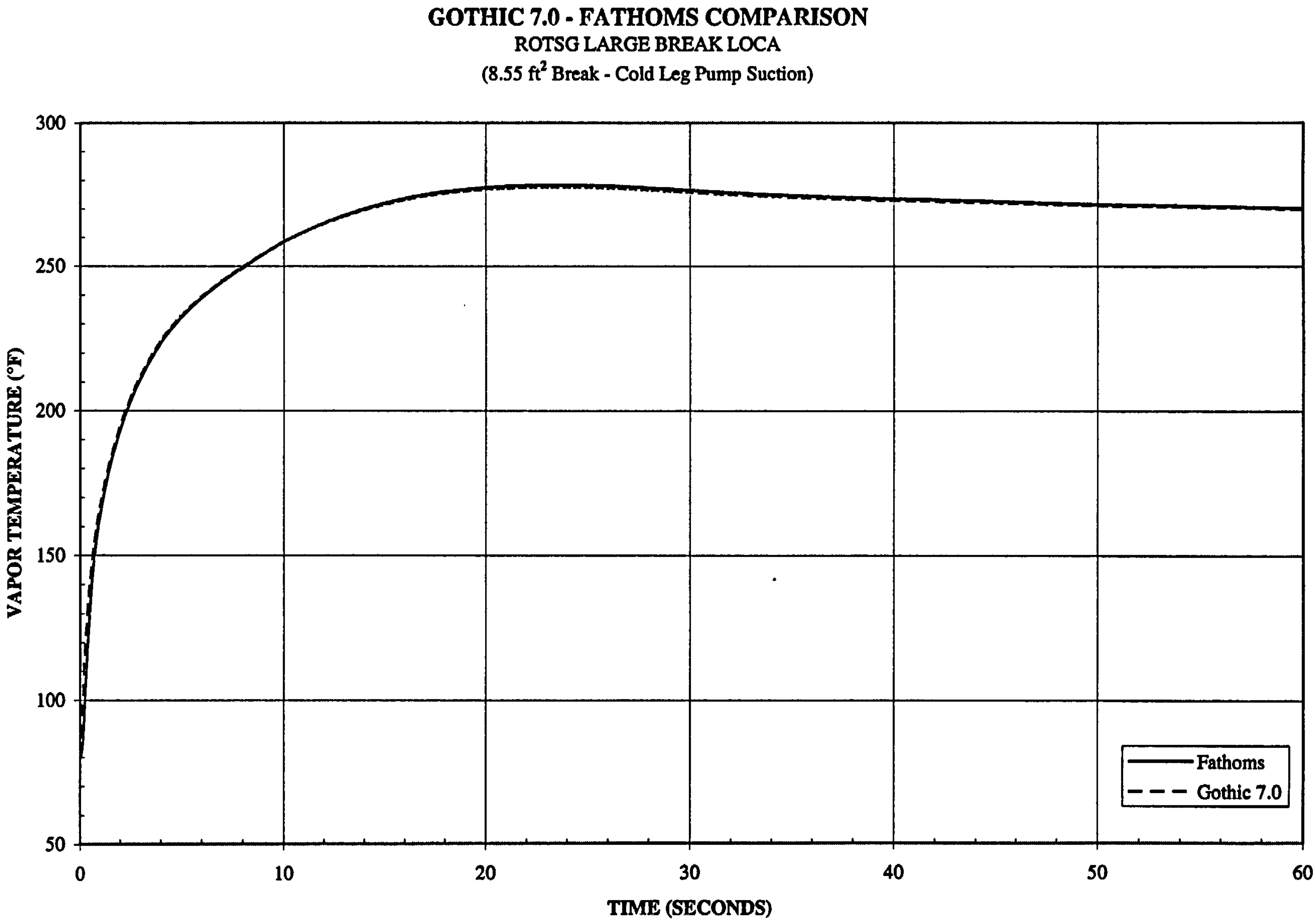




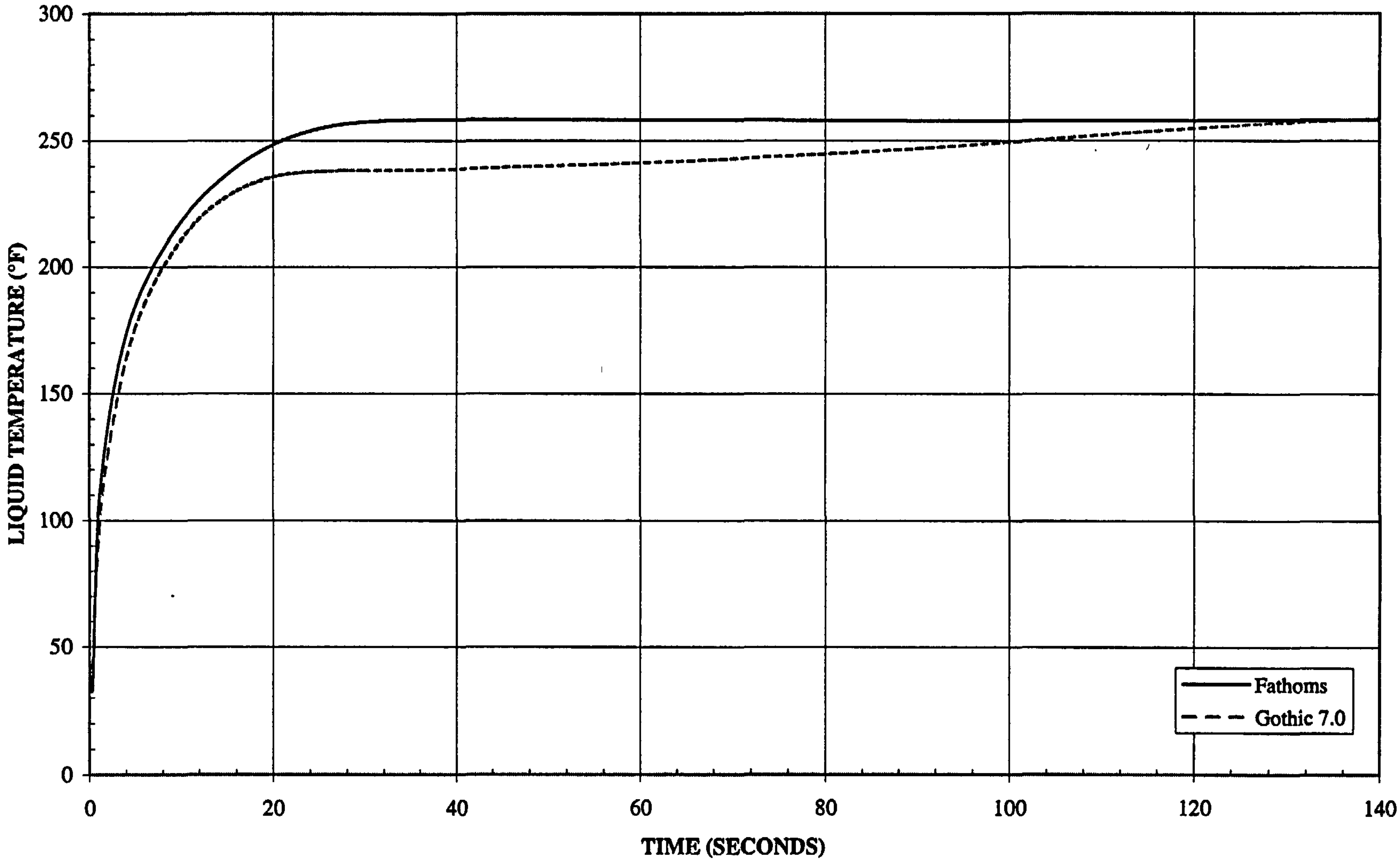
GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(8.55 ft2 Break - Cold Leg Pump Discharge)
LIQUID + DROP TOTAL MASS (LBM)
600000
500000
400000
300000
200000
100000
0
0
20
40
60
80
100
120
140
TIME (SECONDS)
Fathoms
Gothic 7.0

GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(8.55 ft^2 Break - Cold Leg Pump Discharge)

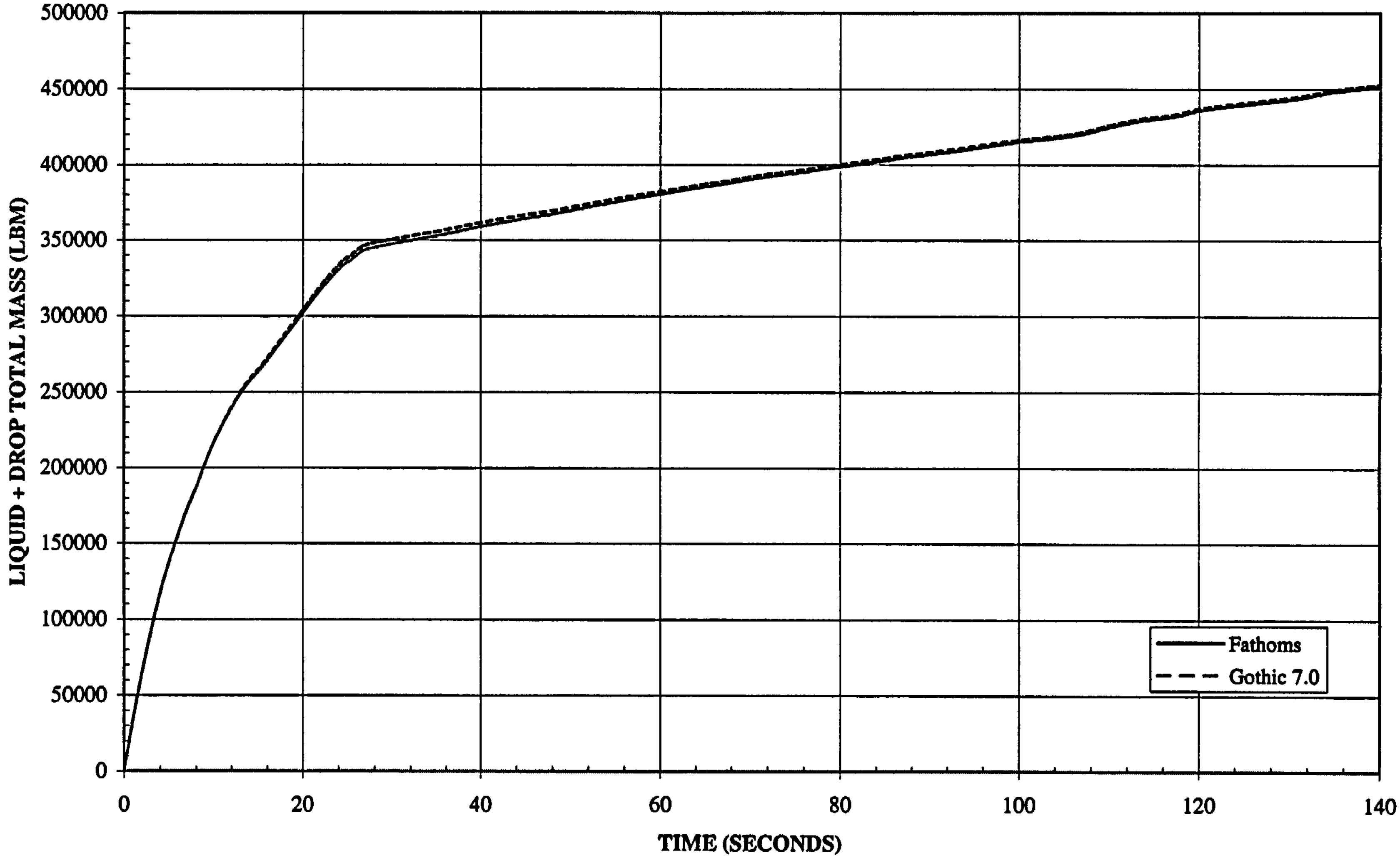



GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(8.55 ft² Break - Cold Leg Pump Suction)
VAPOR TEMPERATURE (°F)
300
250
200
150
100
50
0
10
20
30
40
50
60
TIME (SECONDS)
Fathoms
Gothic 7.0

GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(8.55 ft2 Break - Cold Leg Pump Suction)



GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG LARGE BREAK LOCA
(8.55 ft2 Break - Cold Leg Pump Suction)



Questions On DPC-NE-3003-P and DPC-NE-3003-P Revision 1

Chapter 1

4. Page 1-2 of DPC-NE-3003-P: The last paragraph discusses the FATHOMS code. This should be modified to include discussion of the GOTHIC code.

Response: Revision 4 on p. 3-4 of Attachment 3 to the June 13, 2002 submittal includes a new sentence on p. 1-3 of the topical report that mentions the new Appendix C for the GOTHIC 7.0 code. This is the preferred text to include referral to the GOTHIC 7.0 content in Chapter 1 of the report. Also, Revision 10 on p. 3-6 includes more discussion of GOTHIC 7.0 in Chapter 2.

5. Page 1-3: (a) Why was NRC review of Supplement 1, the November 1997 version of DPC-NE-3003-P not required? (b) Please provide Supplement 2 of DPC-NE-3003-P.

Response: (a) Supplement 1 is a revised application of the NRC-approved methodology for the steam line break mass and energy release and containment response methodology. The main difference in the Supplement 1 application compared to the Chapters 5 & 6 application is crediting main feedwater isolation via the Main Steam Line Break Detection and Main Feedwater Isolation System. The Main Steam Line Break Detection and Main Feedwater Isolation System is a station modification that was installed subsequent to the submittal of the topical report. This station modification and associated analyses were reviewed and approved by the NRC by letter dated December 7, 1998 (License Amendments 234, 234, and 233). Supplement 1, the current UFSAR Chapter 6 analysis, was added since it replaced the analysis in Chapters 5 & 6 as the licensing basis analysis. The intent was to avoid future use of the superceded analysis results in Chapters 5 & 6. The Chapters 5 & 6 analyses were retained for historical purposes. No new methodology was included in Supplement 1, and so submittal for NRC review was not required.

(b) Supplement 2 of DPC-NE-3003-P is already included at the back of the November 1997 published version.

Chapter 3

6. Pages 3-9 and 3-10: Conservative mass and energy calculations depend not only on bounding high fuel stored energy but the rapid transfer of this energy to the coolant. Please describe the modeling of this energy transfer and why it is conservative.

Response: The gap thermal conductivity required to obtain the desired conservative initial fuel temperature is held constant during the peak containment pressure analysis. The time of peak containment pressure roughly corresponds with the end of the primary coolant system blowdown as the mass release is the primary driving factor for the containment pressure response.

During the blowdown the core average fuel temperature decreases from an initial value of approximately 1390°F, to approximately 590°F. At the end of blowdown the volume average core fluid temperature is about 310°F with an average vapor void fraction exceeding 98%. With the current modeling approach, approximately three quarters of the core stored energy and all of the heat generated in the fuel is released during the primary coolant system blowdown. This modeling approach is conservative since the gap thermal conductivity is held constant. As the fuel cools during blowdown, the gap would actually open causing the gap thermal conductivity to decrease. This phenomenon is not credited in the methodology.

7. Page 3-13: (a) Please explain why the sump water temperature and the EQ temperatures are bounding for different break sizes. (b) It appears that the report is stating that a double-ended guillotine break at the same location (reactor vessel outlet nozzle) has two different values (8.55 ft^2 and 14.1 ft^2). Please clarify.

Response: The double-ended guillotine flow area for a cold leg pump discharge break is 8.55 ft^2. The double-ended guillotine flow area for a hot leg break is 14.1 ft^2. The cold leg pump discharge break is the limiting break location for the EQ response. A typographical error is included in this change. The sentence that includes the 8.55 ft^2 flow area should have identified the break location as "*reactor vessel inlet nozzle*" instead of "*reactor vessel outlet nozzle*".

8. Page 3-15: Why was it necessary to change the RBS flow rate assumptions in the BWST depletion and the FATHOMS analysis to be consistent when they were previously conservative? What is the effect of this loss of conservatism in terms of peak containment pressure and temperature, and EQ temperatures?

Response: The original topical report text included specific flow values which are changing due to modifications being made to the reactor building spray headers. Specifically, some of the spray nozzles are being plugged and flow orifices are being installed to reduce the total spray flow. Previously RBS flow was manually throttled to a setpoint. The modifications described will eliminate the need for throttling. The spray values assumed in the analysis are conservative for the plant following the modifications.

There is no impact to the short-term LOCA peak containment pressure analysis as RBS operation is not credited. The assumed spray flowrates assumed in the long-term LOCA analysis and the steam line break analysis are conservative values. Use of conservative values for inputs to the methodology is considered appropriate. The reduction is spray flow is offset in the steam line break analysis that determines the EQ temperature profile by increasing the required capacity of the RBCUs (the fan coolers).

Chapter 4

9. Page 3-16: (a) Rather than using a simple containment model built into the RELAP5 calculation, input to RELAP5 from the FATHOMS code is used. (a) Is there a feedback to ensure consistency between the RELAP5 and the FATHOMS calculations? (b) The description of this phase of the calculation says that "similar break sizes" are used. What criteria are used to determine that the break sizes are "similar" and why do calculations from "similar" break sizes give results that are better than those from a simple model of (presumably) the same break size? (c) Provide results from sensitivity calculations to

demonstrate that the start times for the RBCUs and the RBS are close enough to each other and that the containment peak conditions are acceptably close.

Response: (a) There is no feedback between the FATHOMS and RELAP5 calculations. However, it should be noted that for all SBLOCA cases the break remains choked and therefore the containment pressure does not directly impact the RELAP5 calculation. There are two FATHOMS results that do impact the RELAP5 calculation 1) the RBS actuation time (actuates on high containment pressure), which effects the timing of the swap to sump recirculation and 2) the containment sump water temperature, which affects the injection water temperature during sump recirculation. Iterations are performed until the results converge or conservative agreement is achieved between the FATHOMS calculation and the RELAP5 assumptions. These parameters are compared in the answer to item (c) below.

(b) The wording in the technical justification could be modified to be more precise. For all of the cases that were reanalyzed for the ROTSG, the FATHOMS results used in each of the RELAP5 calculations were taken from the cases with the same size break. In general a larger break could be used as a conservative boundary condition for a smaller break since spray actuation will occur earlier and the sump temperature will generally be hotter. The wording should have stated "for a similar case" instead of "for a similar break size" since there are other assumption in the FATHOMS analysis (i.e. RBCU performance, cooling water temperature, initial conditions) which can impact the containment results.

(c) The RBCUs are not modeled in the RELAP5 calculation. The same RBS actuation time is assumed in the RELAP5 and the FATHOMS calculations. The assumed actuation time was determined from preliminary calculations. In the final FATHOMS calculation, a check is made of the predicted FATHOMS containment pressure at RBS actuation and the analysis setpoint (20 psig). The assumed actuation times and the FATHOMS calculated pressures at the time of RBS actuation are provided in Table 9-1. The containment sump water temperatures calculated by FATHOMS and assumed in the RELAP5 calculation are also provided in Table 9-1.

Table 9-1
Comparison of FATHOMS calculated parameters with the RELAP5 assumptions

Parameter	Break Size		
	0.01 ft^2	0.025 ft^2	0.05 ft^2
RBCU actuation - FATHOMS	1895 sec	898 sec	573 sec
RBCU actuation - RELAP5	not modeled	not modeled	not modeled
RBS actuation - FATHOMS	9000 sec	4000 sec	1200 sec
RBS actuation - RELAP5 (for BWST depletion only)	9000 sec	4000 sec	1200 sec
FATHOMS calculated containment pressure at RBS actuation	21 psig	25 psig	22 psig
FATHOMS calculated sump temperature - At start of sump recirculation - Peak	 184 °F 201 °F	 190 °F 200 °F	 200 °F 215 °F
RELAP5 assumed sump water temperature - At start of sump recirculation - Peak	 185 °F 205 °F	 200 °F 200 °F	recirculation phase not modeled

10. Page 3-16 to 3-17: In the transition from RELAP5 to FATHOMS for small break calculations the heat structures will be modeled as heaters with a prescribed heat flux. They were previously modeled as heat slabs. (a) What is the advantage of this change? (b) How is the heat flux of the heater component determined as a function of time? (c) Provide a sensitivity study of the effect of the heat flux vs. heat structure on the long- term containment response.

Response: The original version of DPC-NE-3003-PA contained a discrepancy between the RELAP5 and FATHOMS treatments of the primary and secondary system fluid and metal energy content and the manner in which it was passed from RELAP5 to FATHOMS. In Section 4.1, Long-Term Mass and Energy Release, first paragraph on p.4-3, the original documentation discussed the RELAP5 heat structures being collapsed into heat slabs consistent with the simplified FATHOMS node boundaries. In Section 6.4.3, pg. 6-31, the original documentation stated that the RCS heat structures are modeled with the FATHOMS heater model. The changes to Section 4.1 of DPC-NE-3003 were made to remove this discrepancy in the documentation, and represent no changes to the mass and energy release or containment response methodology.

The technical justification to Change #35 in the DPC-NE-3003, Revision 1 change package incorrectly stated that there was a change in the stored energy modeling for the FATHOMS small break LOCA containment analyses. The FATHOMS heater component model has always been used for the small beak LOCA analyses; there were no changes to this methodology introduced, other than the inclusion of the stored energy in the secondary system fluid and structural metal (which had been left out in the original analyses). The final sentence in the Technical Justification to Change #35 also incorrectly discusses the impact of a modeling change from the heat slab to heater component model in the FATHOMS small break LOCA analyses.

In summary, there was no change to the methodology used to transfer the energy from the primary and secondary system fluid/metal from the RELAP5 to the FATHOMS small break LOCA analyses (other than the inclusion of the secondary system energy content). The discussion in the Technical Justification to Change #35 regarding such a change was in error. The heat flux is calculated by dividing the total energy content of each component at the end of the RELAP5 analysis by the remaining transient time in the FATHOMS analysis (a constant heat flux is assumed for each component for the duration of the FATHOMS analysis).

11. Section 6.1 Page 6-1 of DPC-NE-3003-P: Some words are missing between the last sentence on page 6-1 and the first words on page 6-2 of the original report. The proposed revision did not fix this. Please provide the missing words.

Response: The November 1997 version added the missing paragraph to the bottom of p. 6-1.

12. Section 6.2.1 Page 6-9 First paragraph: If Case 3B is considered the worst case LOCA for containment peak pressure, isn't the loss of offsite power, rather than loss of a 4160-V bus, the more limiting case? Please explain.

Response: The with or without offsite power assumption, as discussed on pp. 3-2 and 3-21, is mainly of interest for the LOCA peak pressure analyses relative to the continued operation of the reactor coolant pumps. Both with offsite power (RCPs continue to run) and without offsite power (RCPs trip at time zero) cases are analyzed. The limiting single failure assumption, as discussed beginning on p. 3-12, involves the loss of emergency power to a 4160V bus, which causes a loss of one train of safeguards. This single failure is irrelevant for the peak pressure cases since the peak containment pressure is reached prior to the actuation of any of the safeguards powered by the 4160V bus regardless of whether or not the single failure is assumed. The loss of offsite power assumption has only a minor impact on the peak pressure results as discussed in the first paragraph on p. 6-9.

<u>Questions Concerning GOTHIC</u>

13. Provide a temperature envelope curve for EQ purposes calculated with GOTHIC and with FATHOMS. Discuss the differences in EQ envelopes calculated with FATHOMS and GOTHIC due to the use of different models in the two codes, especially those models which affect moisture in the atmosphere.

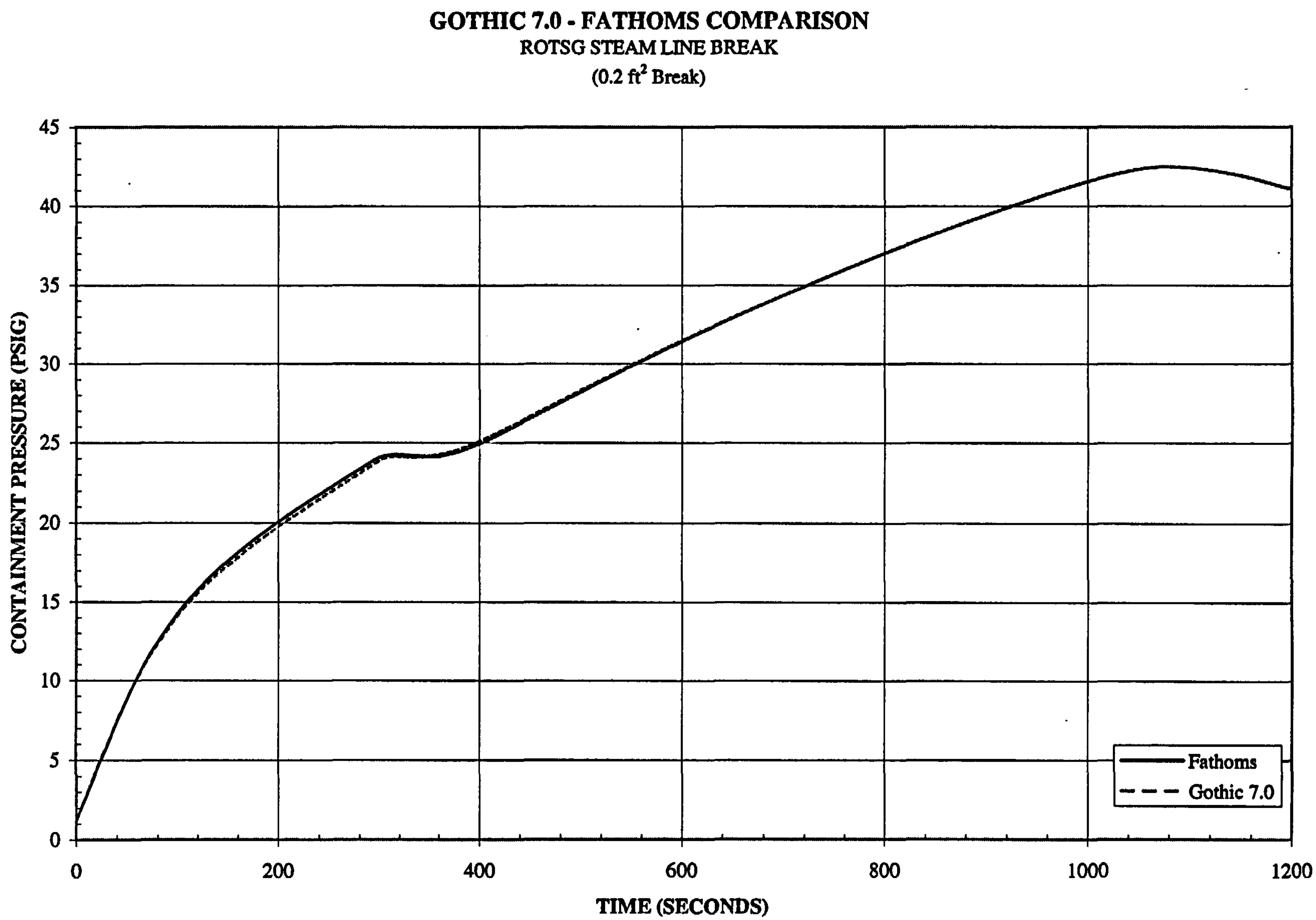
Response: To be provided at a later date.

14. Show that GOTHIC and FATHOMS calculations result in the same pressures, temperatures, sump temperatures, etc. for the design basis LOCA and main steam line break events. If they do not, explain differences in terms of the differences in models between the two codes. (See Question 1.)

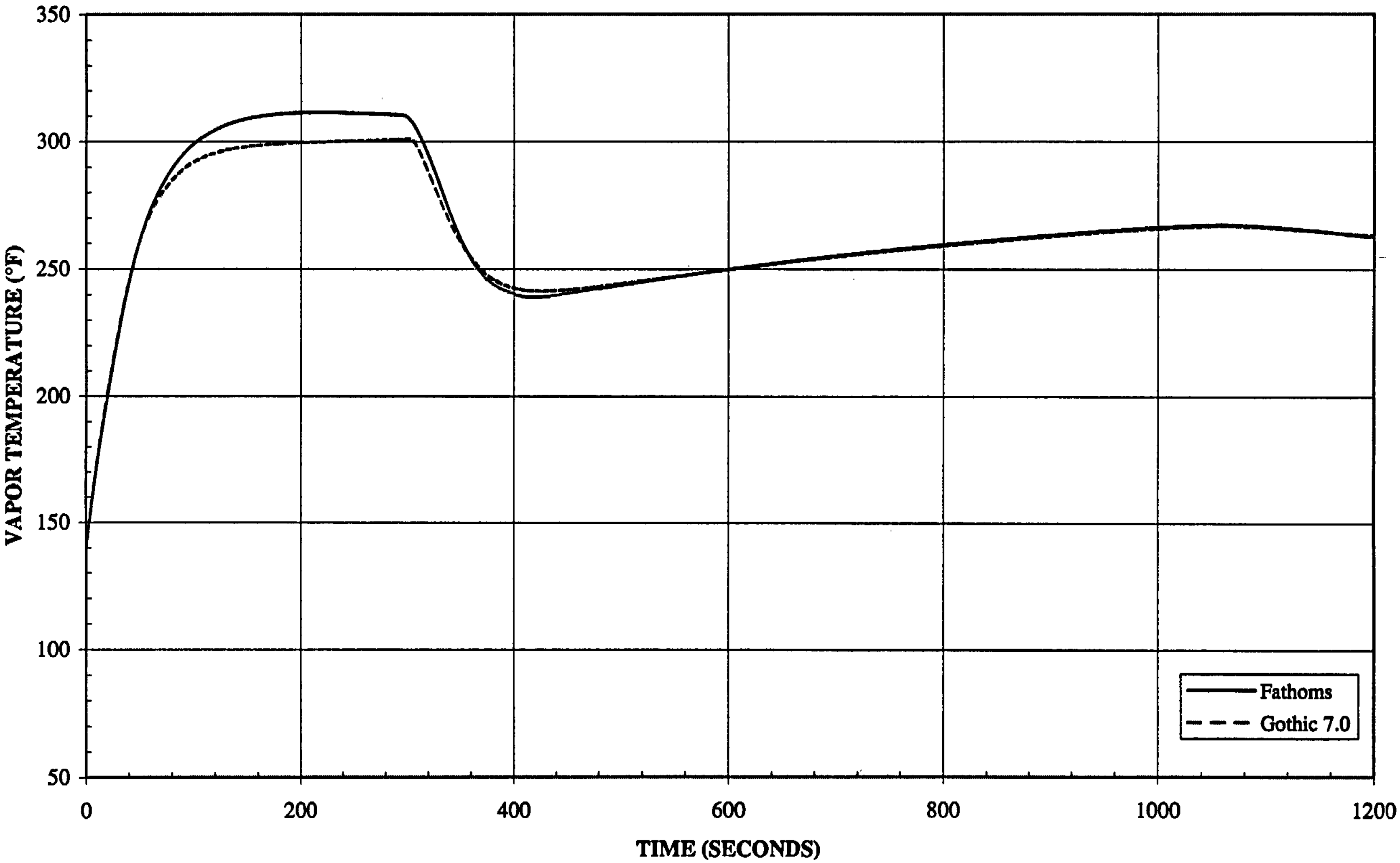
Response: Refer to the response to Question #3 for LOCA. The results of the 6 code comparison analyses for the main steam line break are given in Table 14-1 and the figures that follow. The containment response following a main steam line break event for the ROTSG was performed to compare the results from FATHOMS 2.4 and GOTHIC 7.0. In general, the pressure and vapor temperature responses are very similar. GOTHIC 7.0 predictions for peak pressures are slightly lower on the smaller break sizes (~0.3 psi) and slightly higher for larger break sizes (~0.95 psi). The peak vapor temperature responses predicted by GOTHIC 7.0 overall are slightly lower (~12°F). For larger break sizes, the higher pressure predicted by GOTHIC 7.0 may be attributed to additional steam generation from the improved interface heat and mass transfer models and from the drops that are generated due to dripping. The slightly lower pressure for smaller break sizes may be attributed to additional droplets in the atmosphere. The slightly lower vapor temperature and liquid temperature in GOTHIC 7.0 for all break sizes may be attributed to additional droplets in the atmosphere also. This effectively increases the heat capacity of the atmosphere and reduces the temperature rise for a given energy addition. As discussed in the responses to Questions #1 and #3, more liquid is predicted to remain in droplet form in GOTHIC 7.0 which results in less liquid mass in the sump. In addition, the lower sump temperature predicted by GOTHIC 7.0 may be attributed to the addition of the second energy equation for the drops and the improved heat and mass transfer models in GOTHIC 7.0.

Table 14-1

ROTSG Case Description	Peak Containment Pressure (psig)		Peak Containment Temperature (°F)	
	Fathoms	Gothic 7.0	Fathoms	Gothic 7.0
0.2 ft^2 Steam Line Break	42.48	42.48	311.38	301.04
0.6 ft^2 Steam Line Break	54.76	54.53	384.69	372.05
1.0 ft^2 Steam Line Break	56.60	56.32	417.82	405.07
1.0 ft^2 Steam Line Break with 90" SG Level	43.57	43.74	417.23	404.63
1.4 ft^2 Steam Line Break	52.23	53.18	438.80	426.02
Double Ended Guillotine Steam Line Break	55.23	55.63	463.08	450.11


GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG STEAM LINE BREAK
(0.2 ft² Break)
CONTAINMENT PRESSURE (PSIG)
45
40
35
30
25
20
15
10
5
0
0
200
400
600
800
1000
1200
TIME (SECONDS)
Fathoms
Gothic 7.0

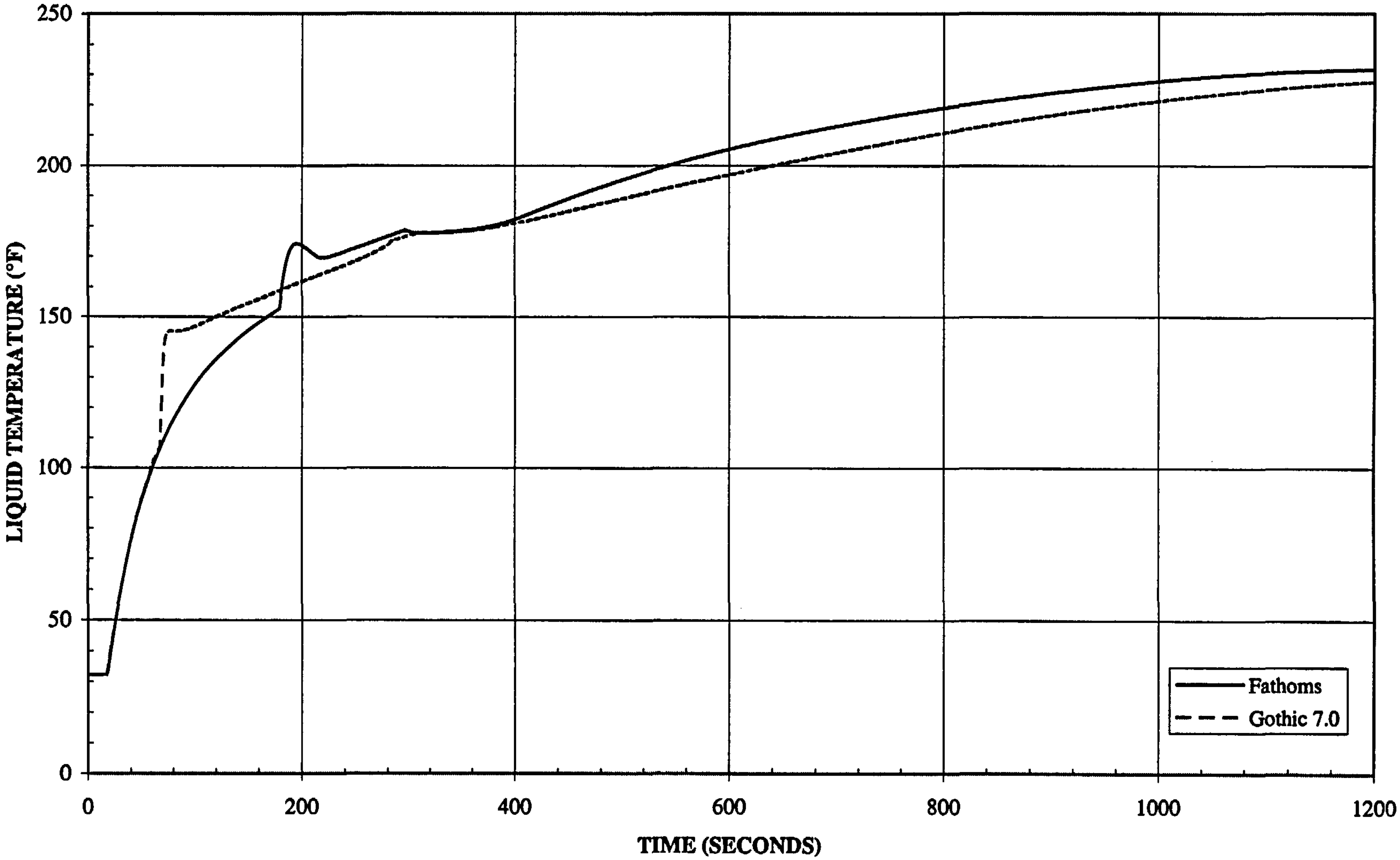
GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG STEAM LINE BREAK
(0.2 ft^2 Break)



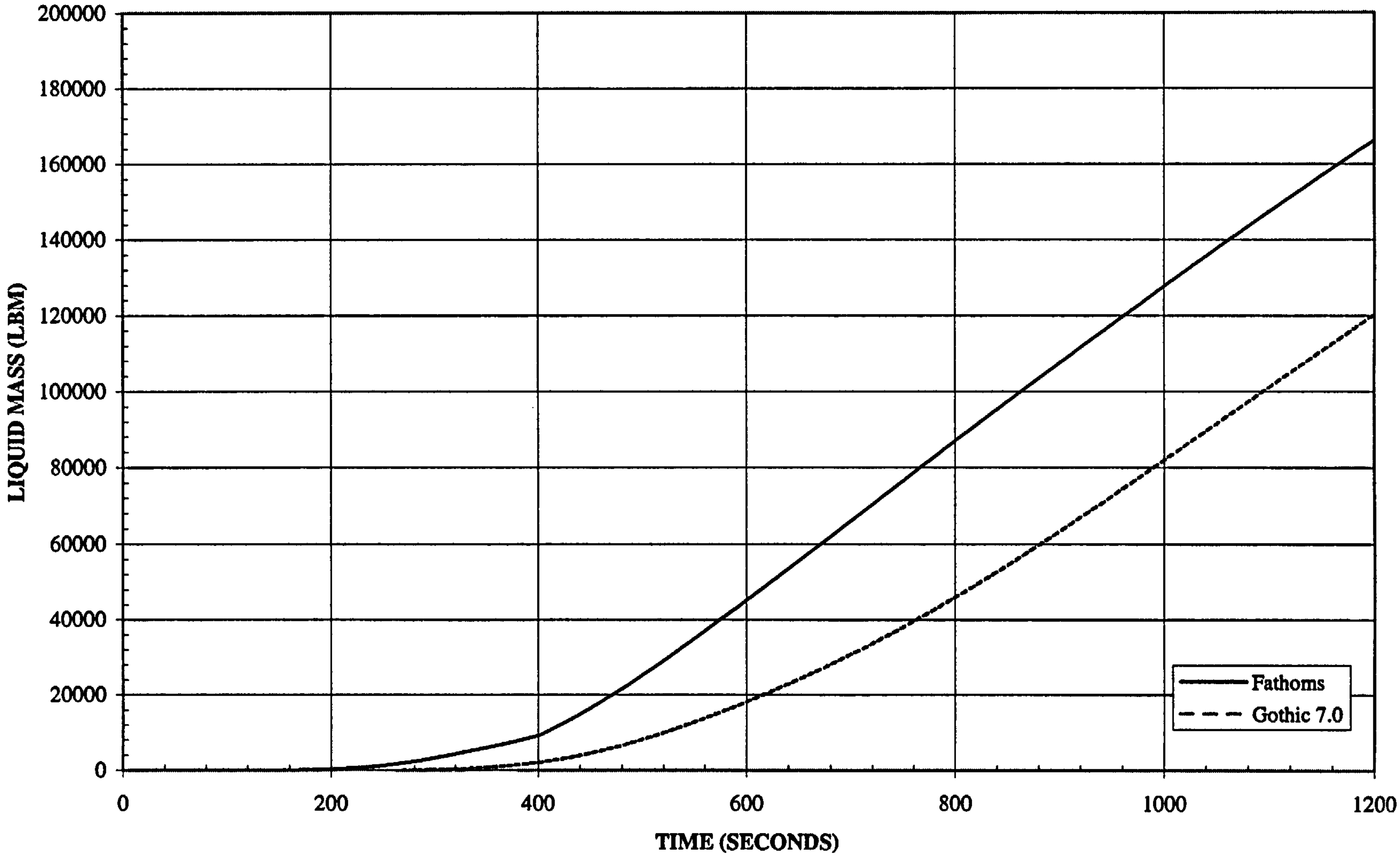
GOTHIC 7.0 - FATHOMS COMPARISON

ROTSG STEAM LINE BREAK

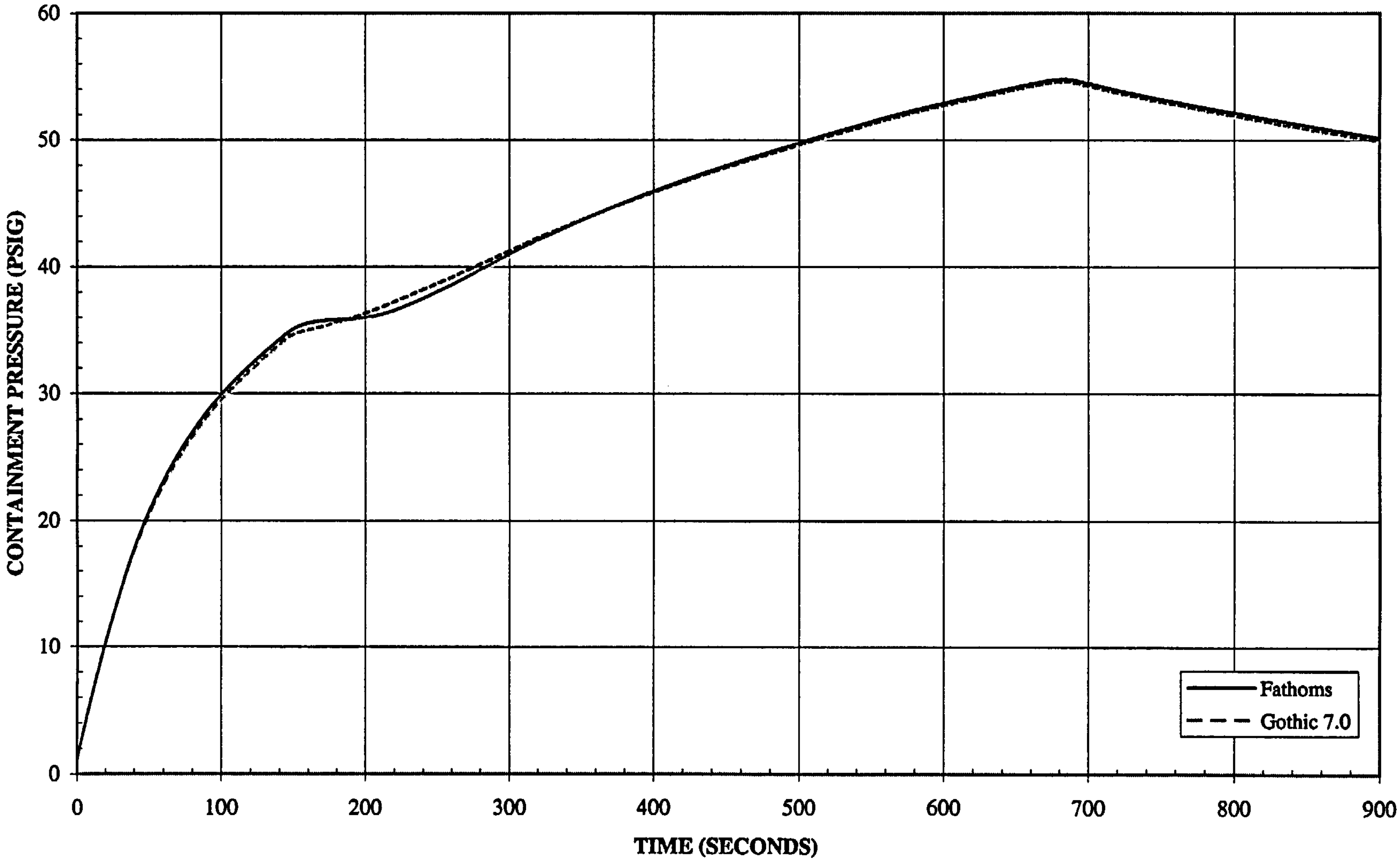
(0.2 ft^2 Break)



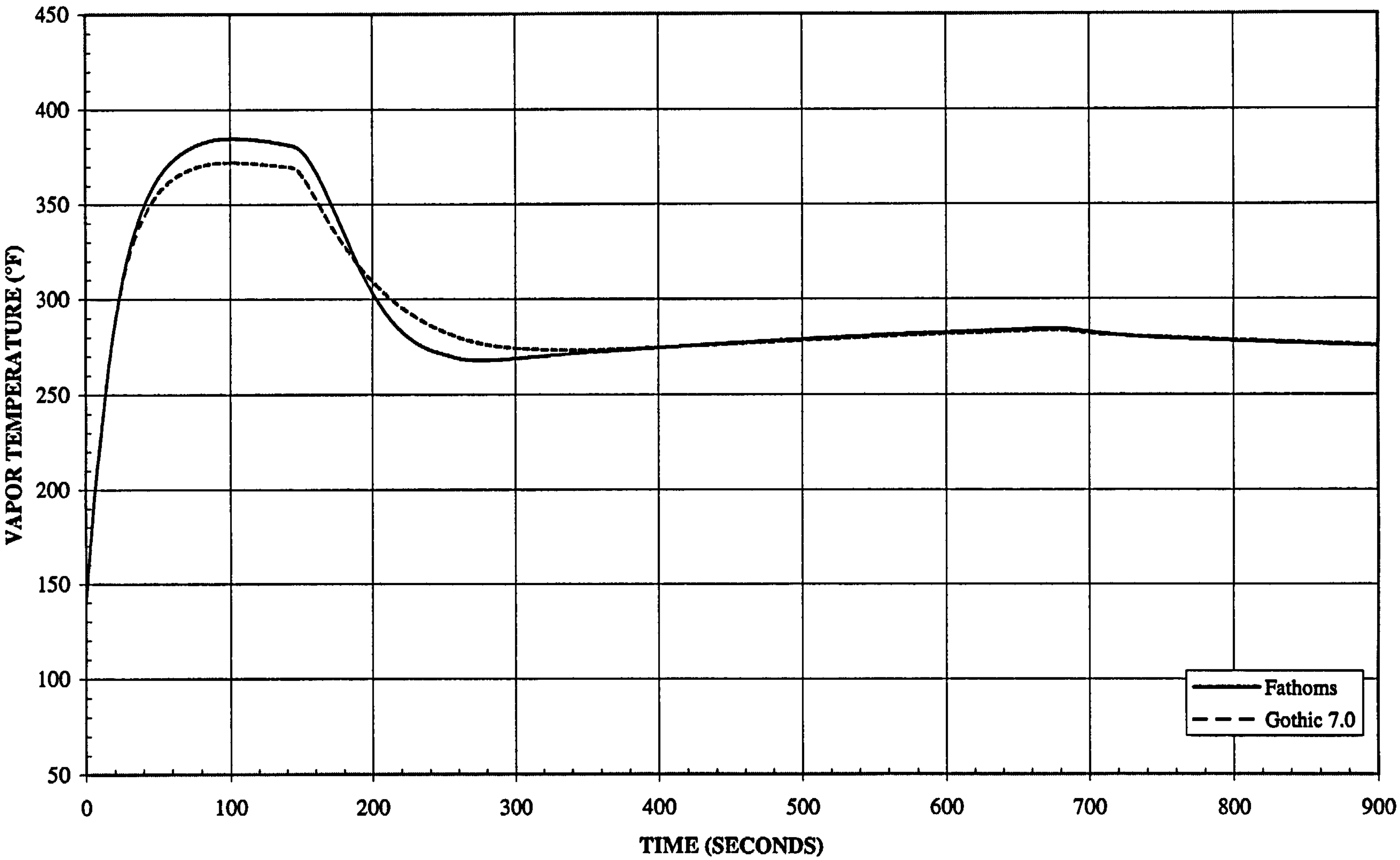
GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG STEAM LINE BREAK
(0.2 ft^2 Break)



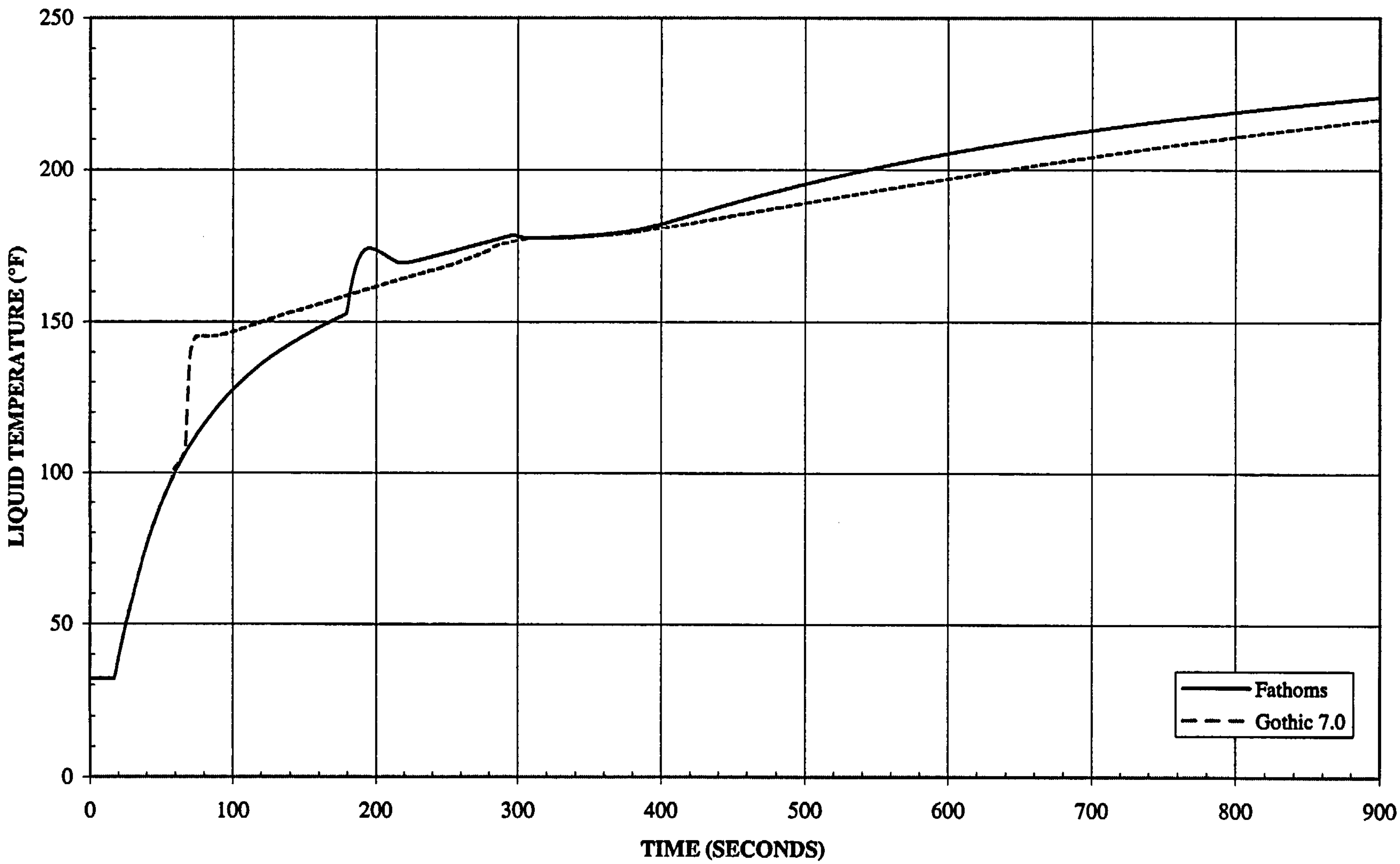
GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG STEAM LINE BREAK
(0.6 ft^2 Break)



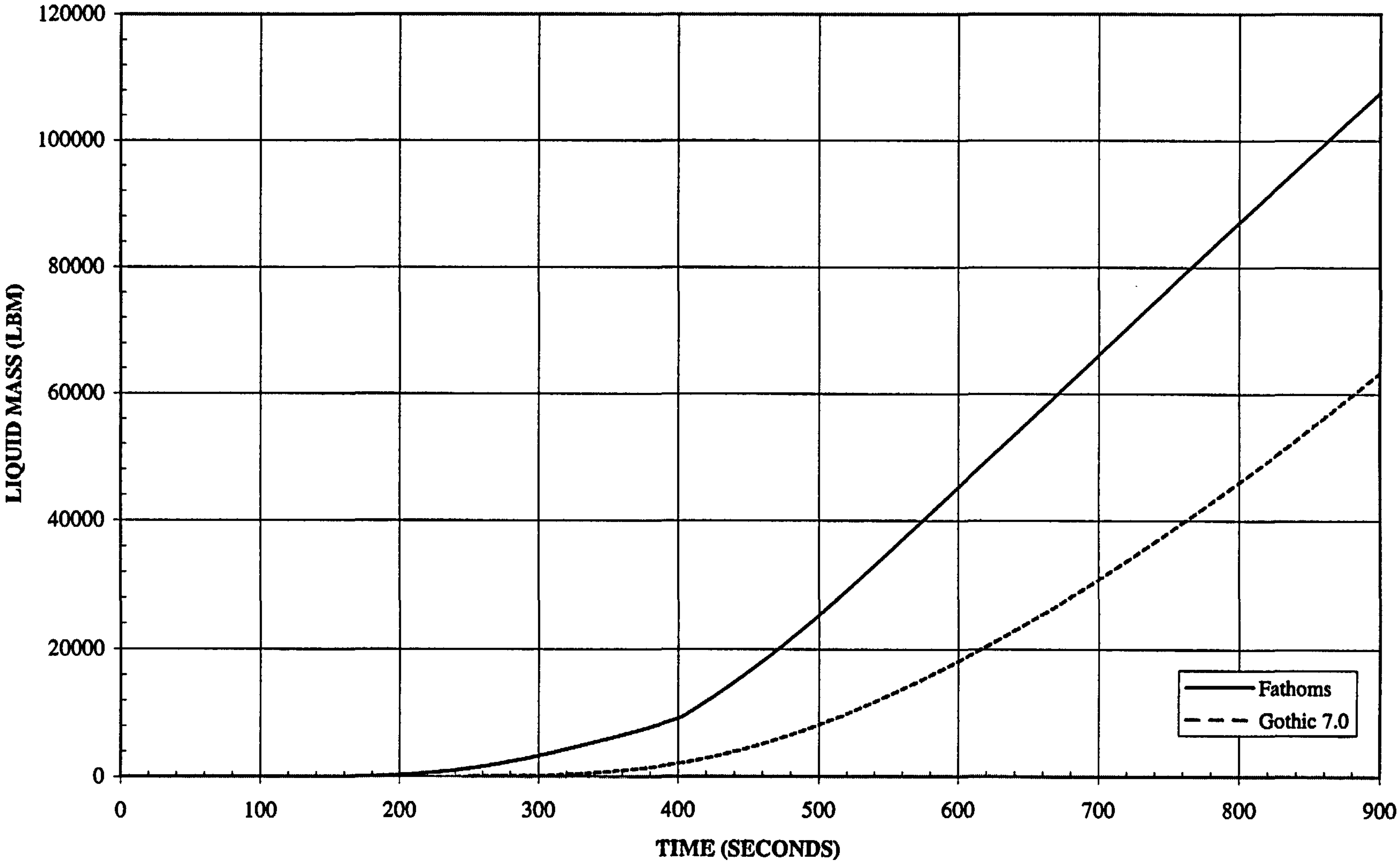
GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG STEAM LINE BREAK
(0.6 ft^2 Break)



GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG STEAM LINE BREAK
(0.6 ft^2 Break)



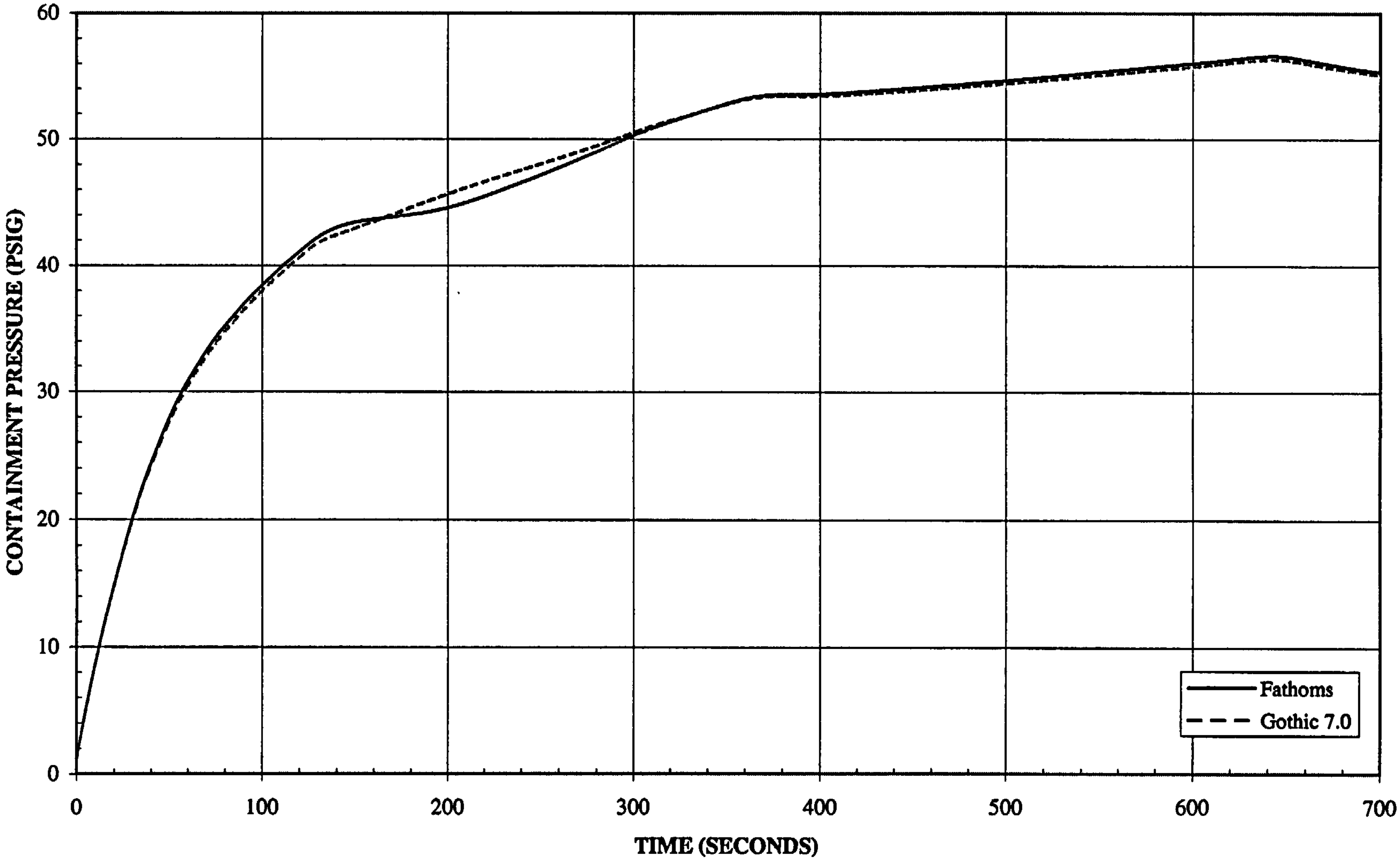
GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG STEAM LINE BREAK
(0.6 ft^2 Break)



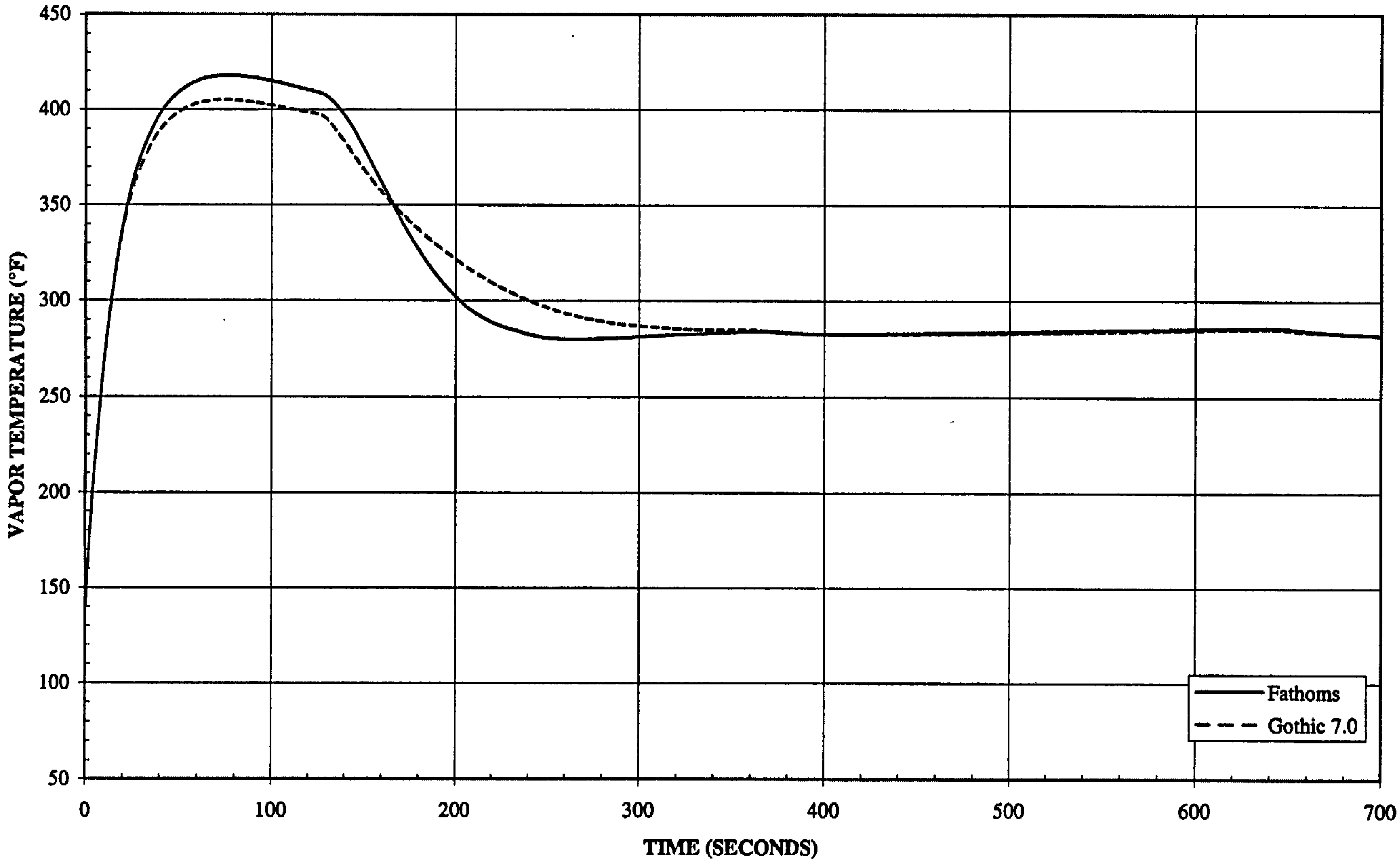
GOTHIC 7.0 - FATHOMS COMPARISON

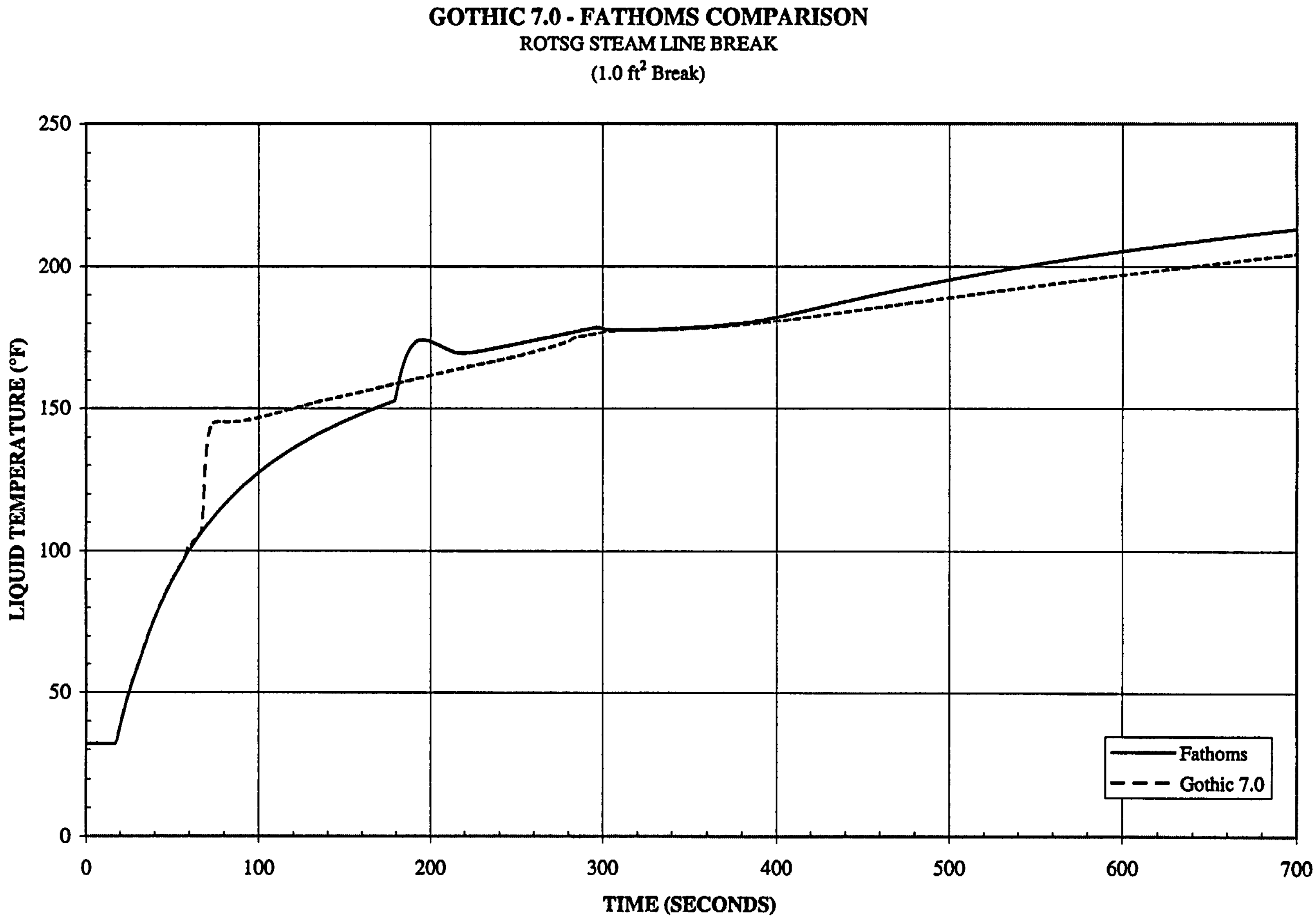
ROTSG STEAM LINE BREAK

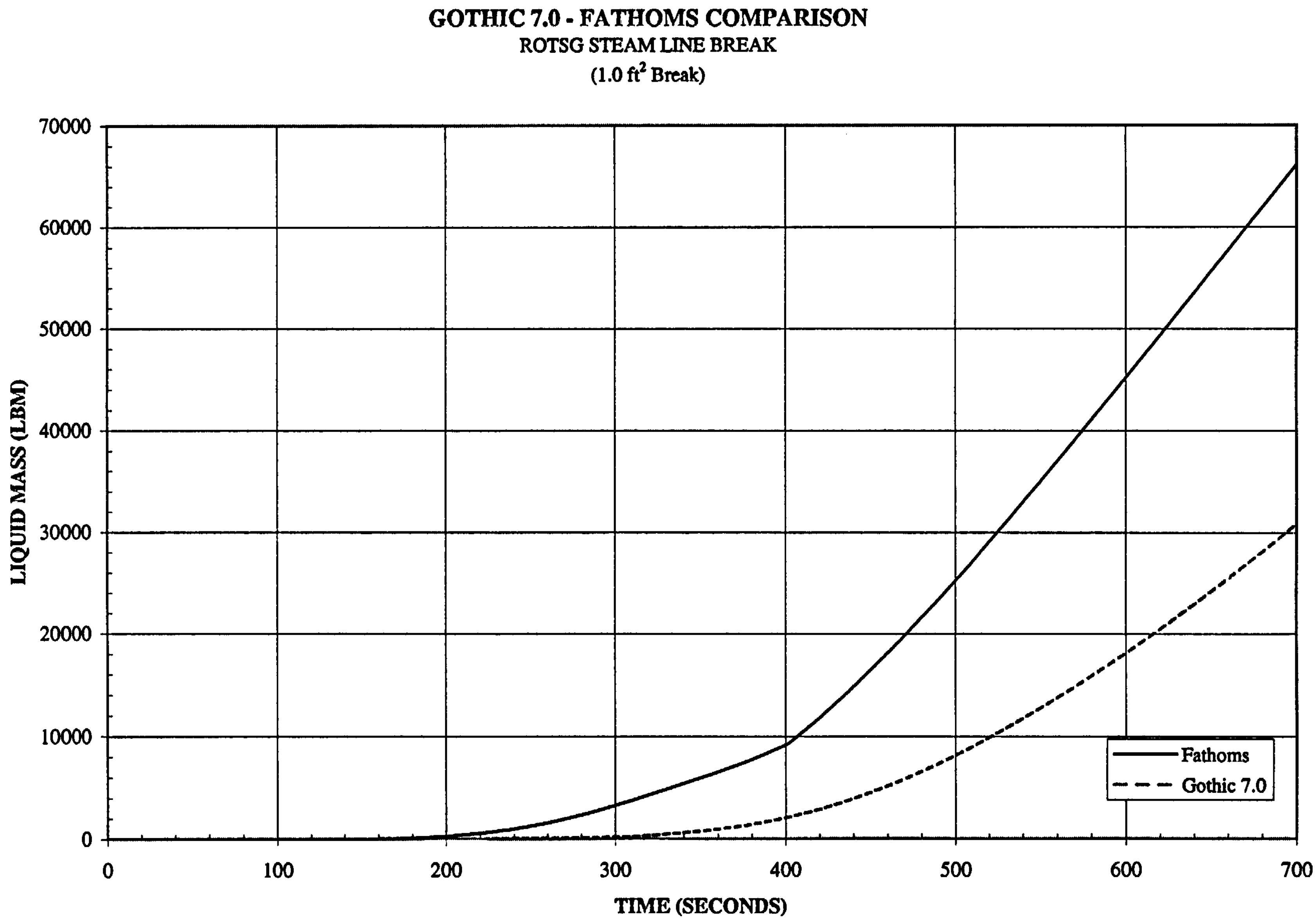
(1.0 ft^2 Break)



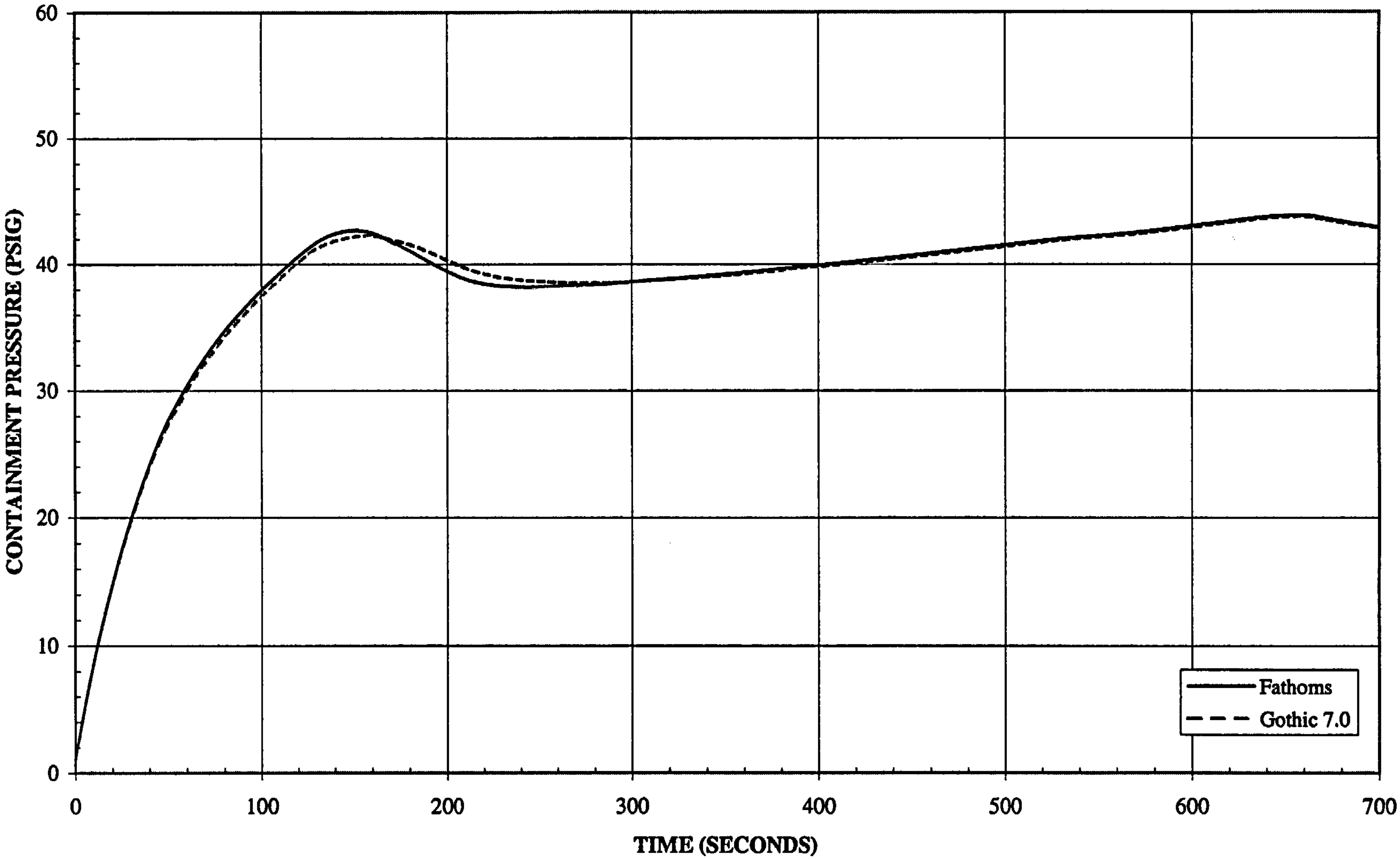
GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG STEAM LINE BREAK
(1.0 ft^2 Break)

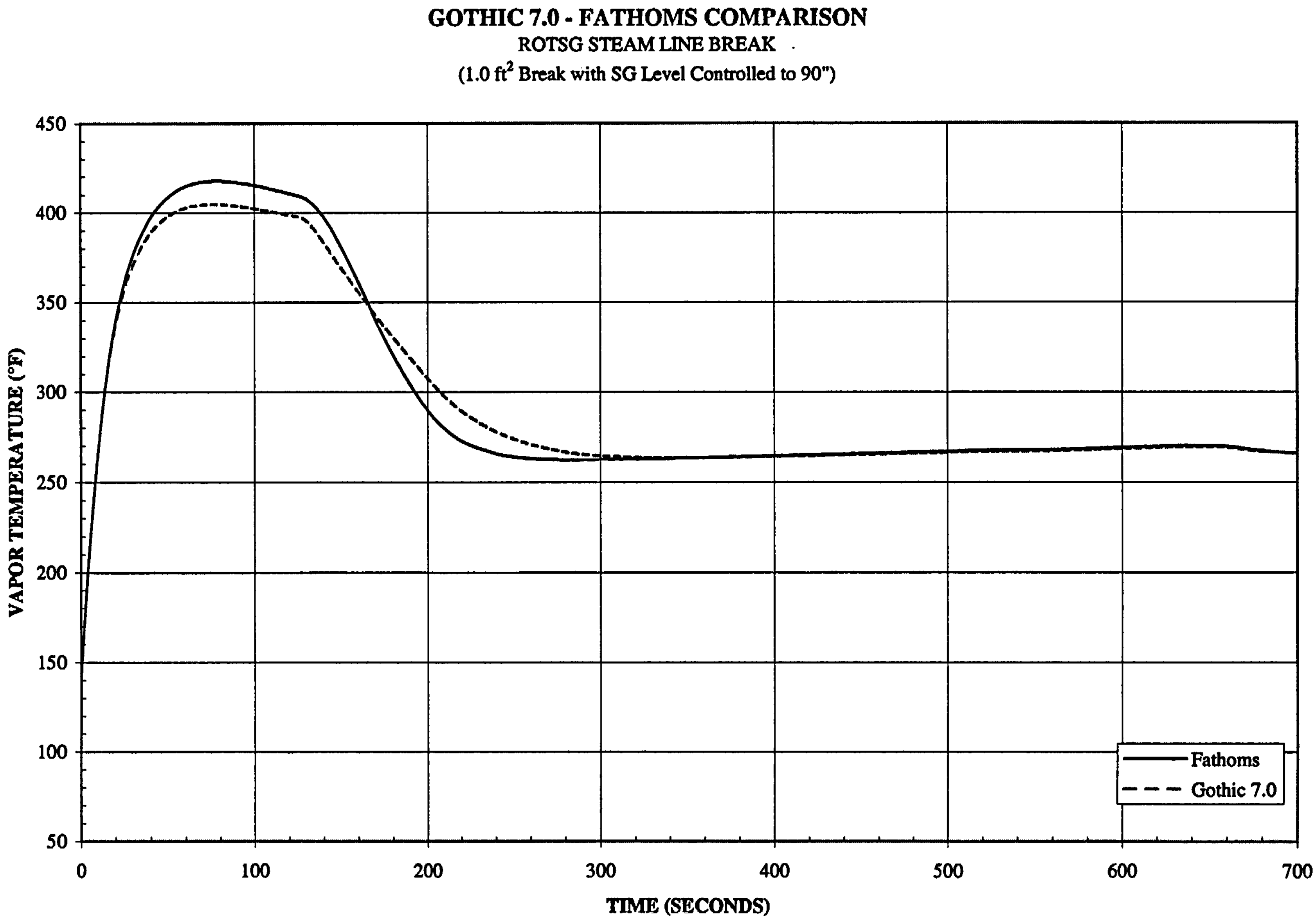



GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG STEAM LINE BREAK
(1.0 ft² Break)
LIQUID TEMPERATURE (°F)
TIME (SECONDS)
Fathoms
Gothic 7.0
0
50
100
150
200
250
0
100
200
300
400
500
600
700


GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG STEAM LINE BREAK
(1.0 ft^2 Break)
LIQUID MASS (LBM)
70000
60000
50000
40000
30000
20000
10000
0
0
100
200
300
400
500
600
700
TIME (SECONDS)
Fathoms
Gothic 7.0

GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG STEAM LINE BREAK
(1.0 ft^2 Break with SG Level Controlled to 90")



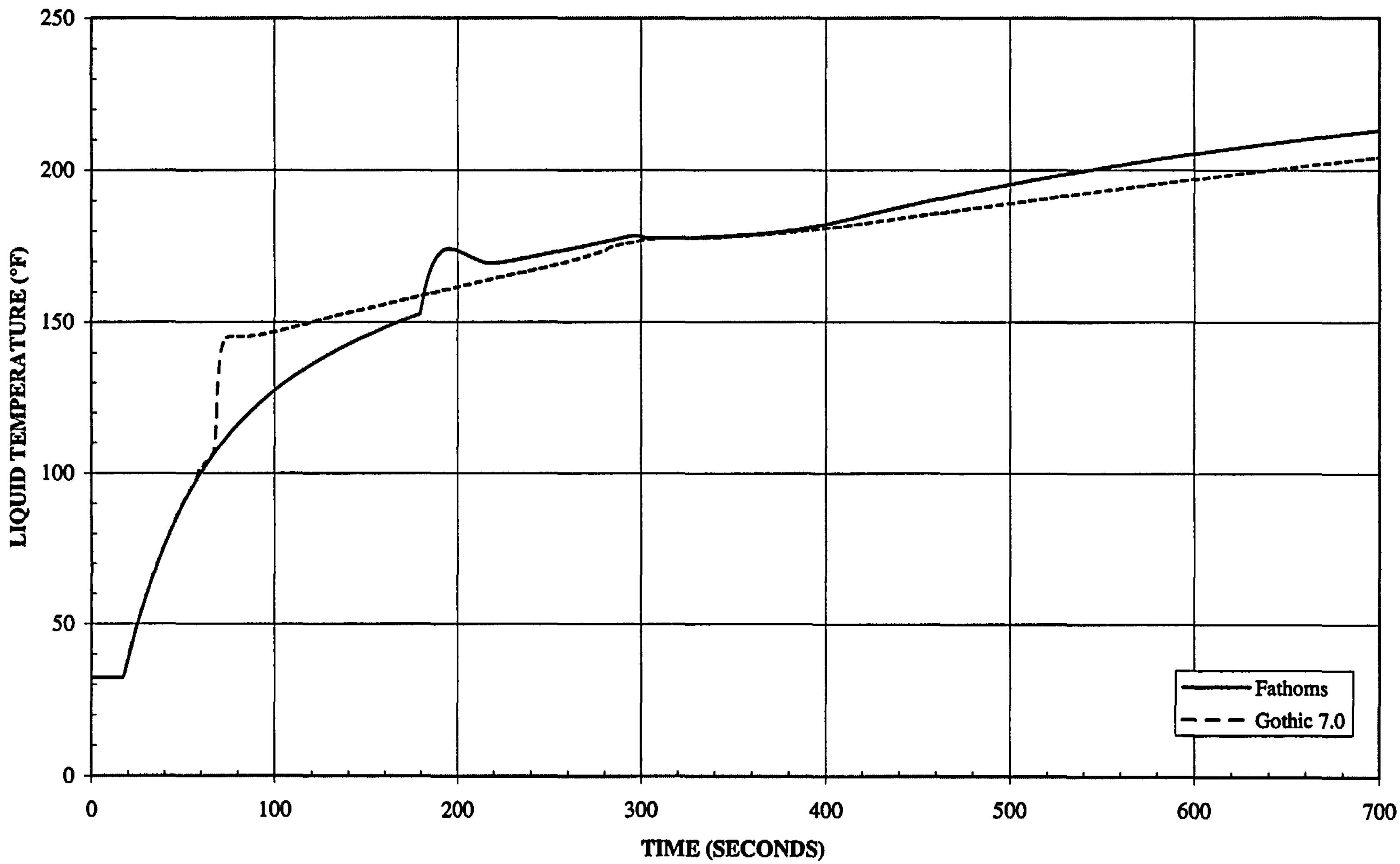


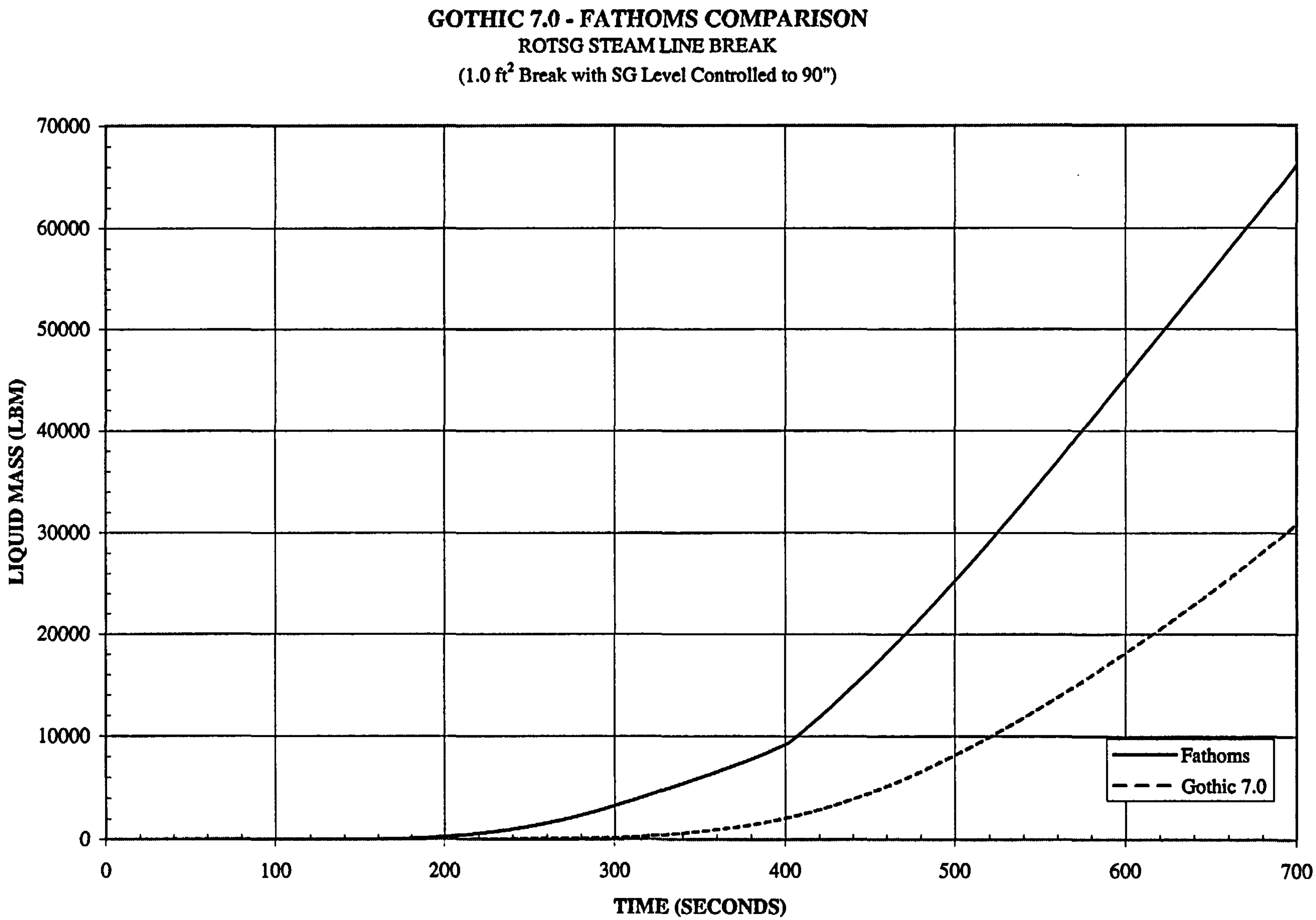
GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG STEAM LINE BREAK
(1.0 ft² Break with SG Level Controlled to 90")
VAPOR TEMPERATURE (°F)
TIME (SECONDS)
450
400
350
300
250
200
150
100
50
0
100
200
300
400
500
600
700
Fathoms
Gothic 7.0

GOTHIC 7.0 - FATHOMS COMPARISON

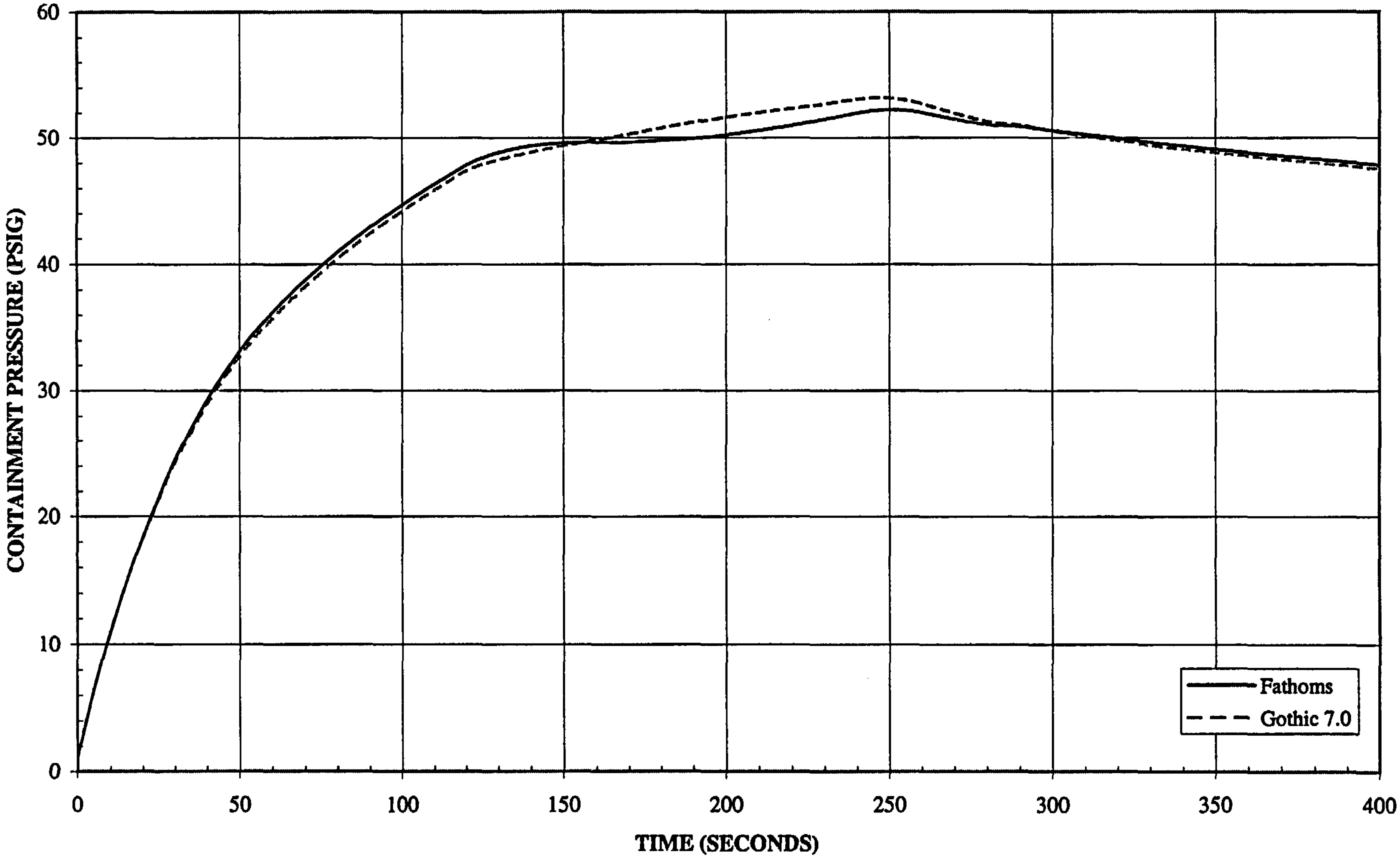
ROTSG STEAM LINE BREAK

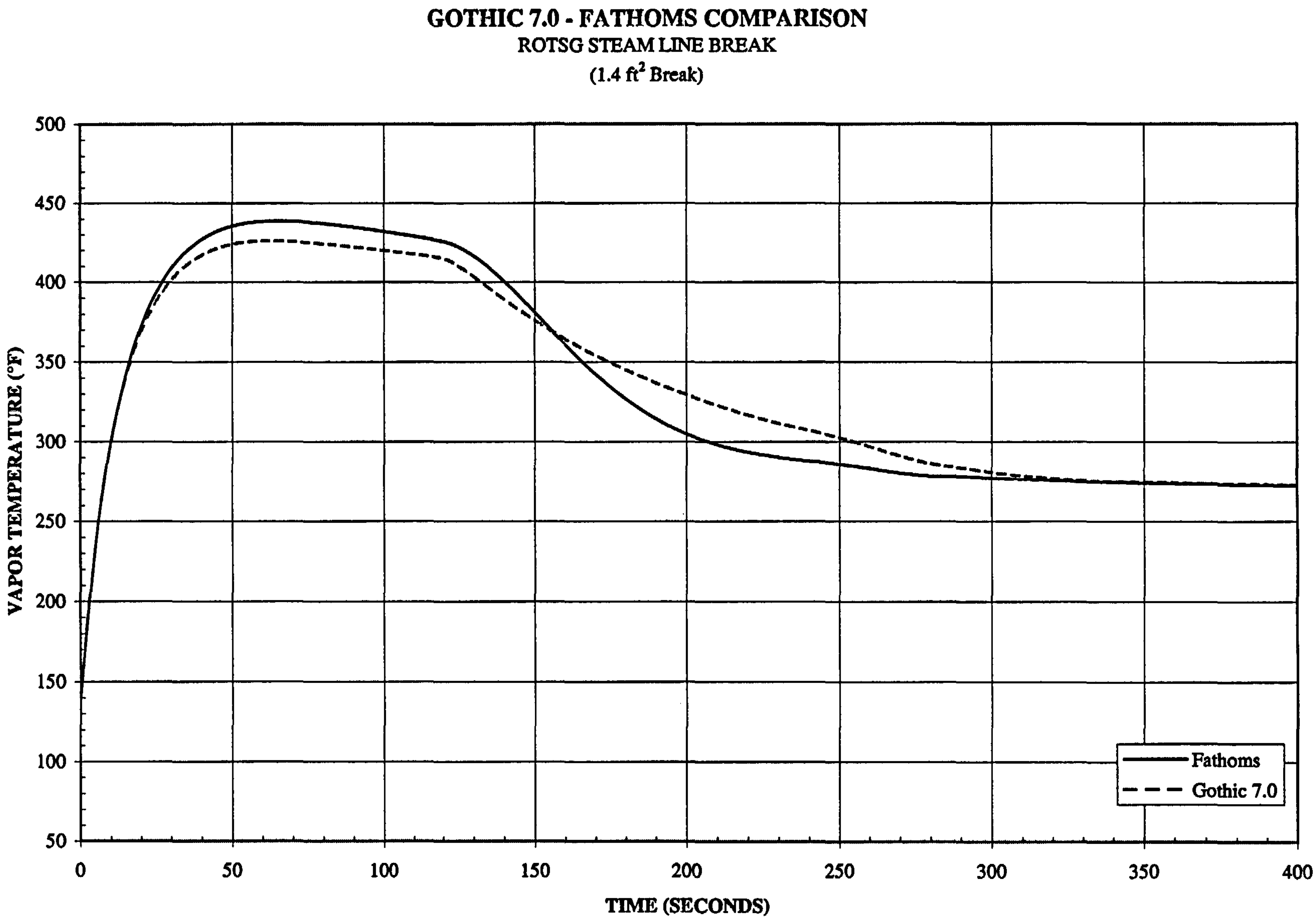
(1.0 ft^2 Break with SG Level Controlled to 90")



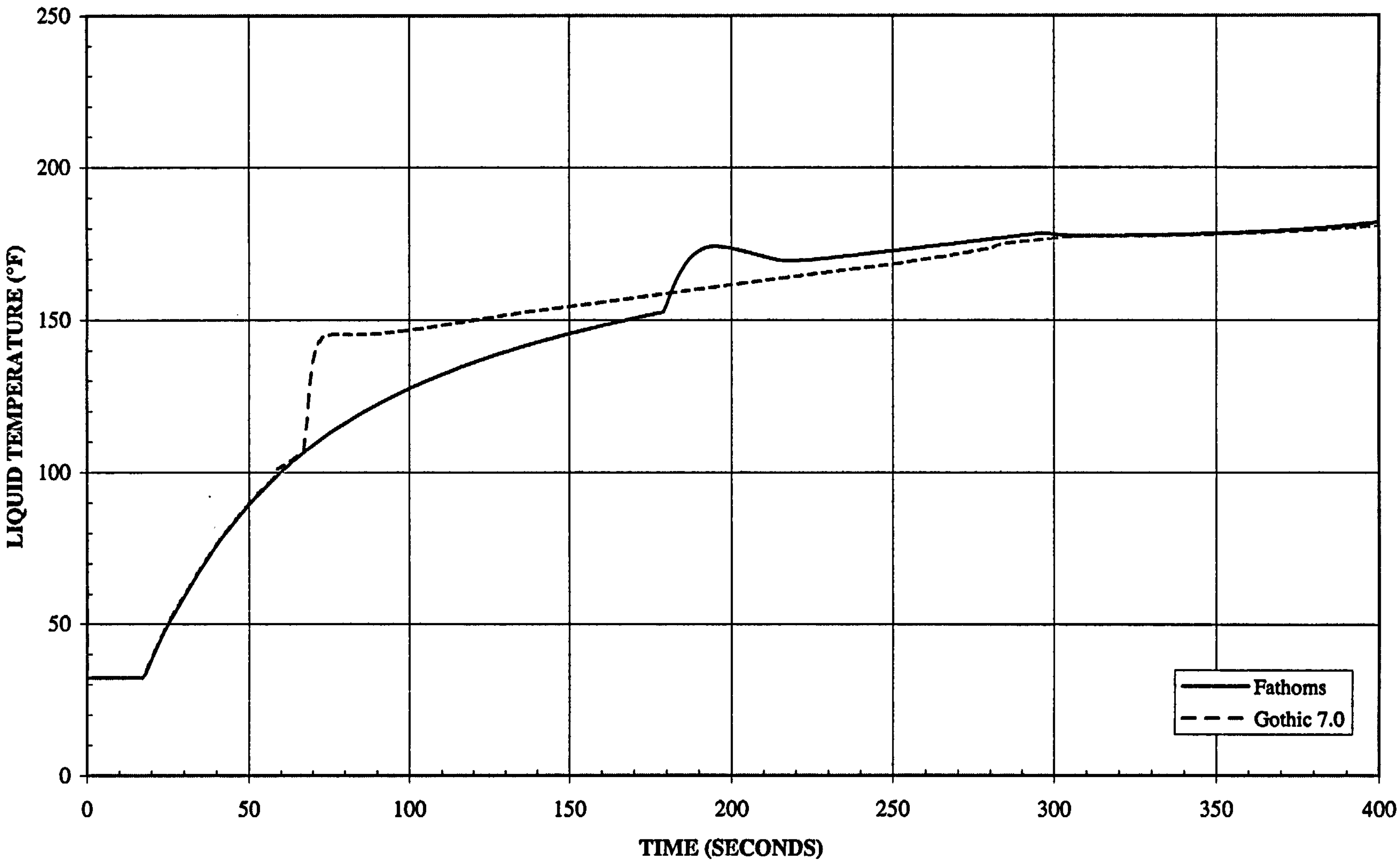

GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG STEAM LINE BREAK
(1.0 ft² Break with SG Level Controlled to 90")
LIQUID MASS (LBM)
70000
60000
50000
40000
30000
20000
10000
0
0
100
200
300
400
500
600
700
TIME (SECONDS)
Fathoms
Gothic 7.0

GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG STEAM LINE BREAK
($1.4\ ft^2$ Break)




GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG STEAM LINE BREAK
(1.4 ft² Break)
VAPOR TEMPERATURE (°F)
500
450
400
350
300
250
200
150
100
50
0
50
100
150
200
250
300
350
400
TIME (SECONDS)
Fathoms
Gothic 7.0

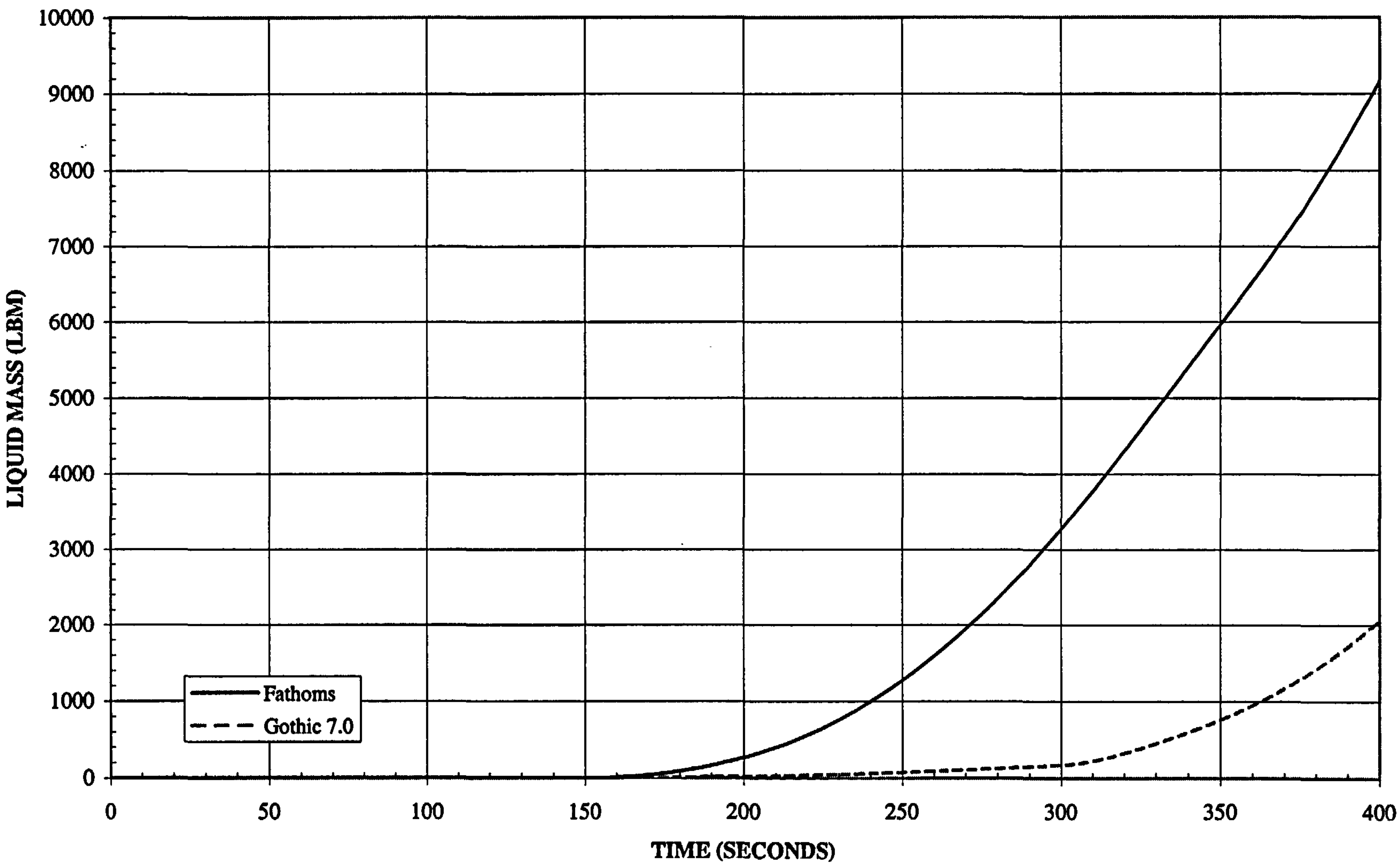
GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG STEAM LINE BREAK
(1.4 ft^2 Break)

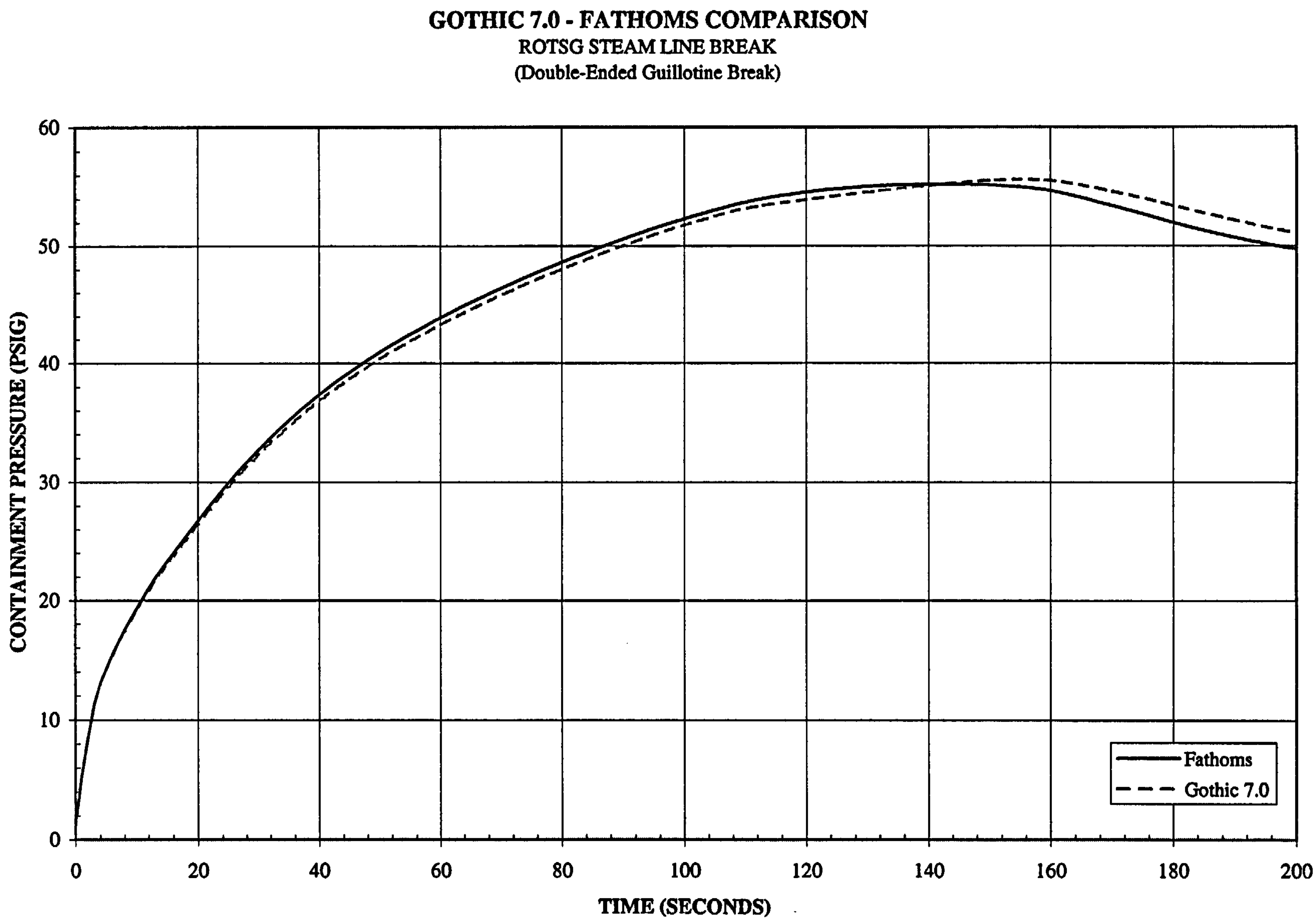


GOTHIC 7.0 - FATHOMS COMPARISON

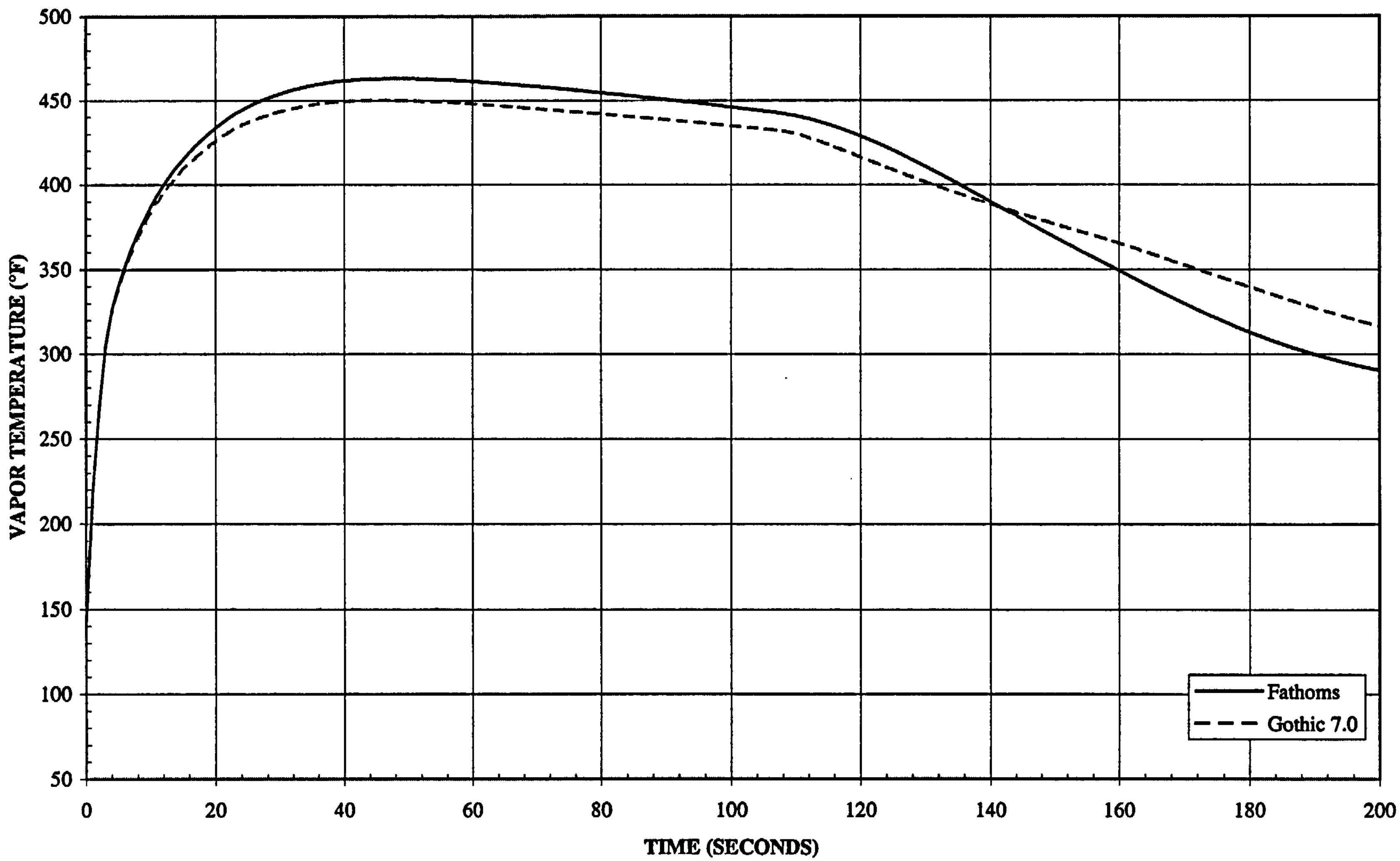
ROTSG STEAM LINE BREAK

($1.4\ ft^2$ Break)

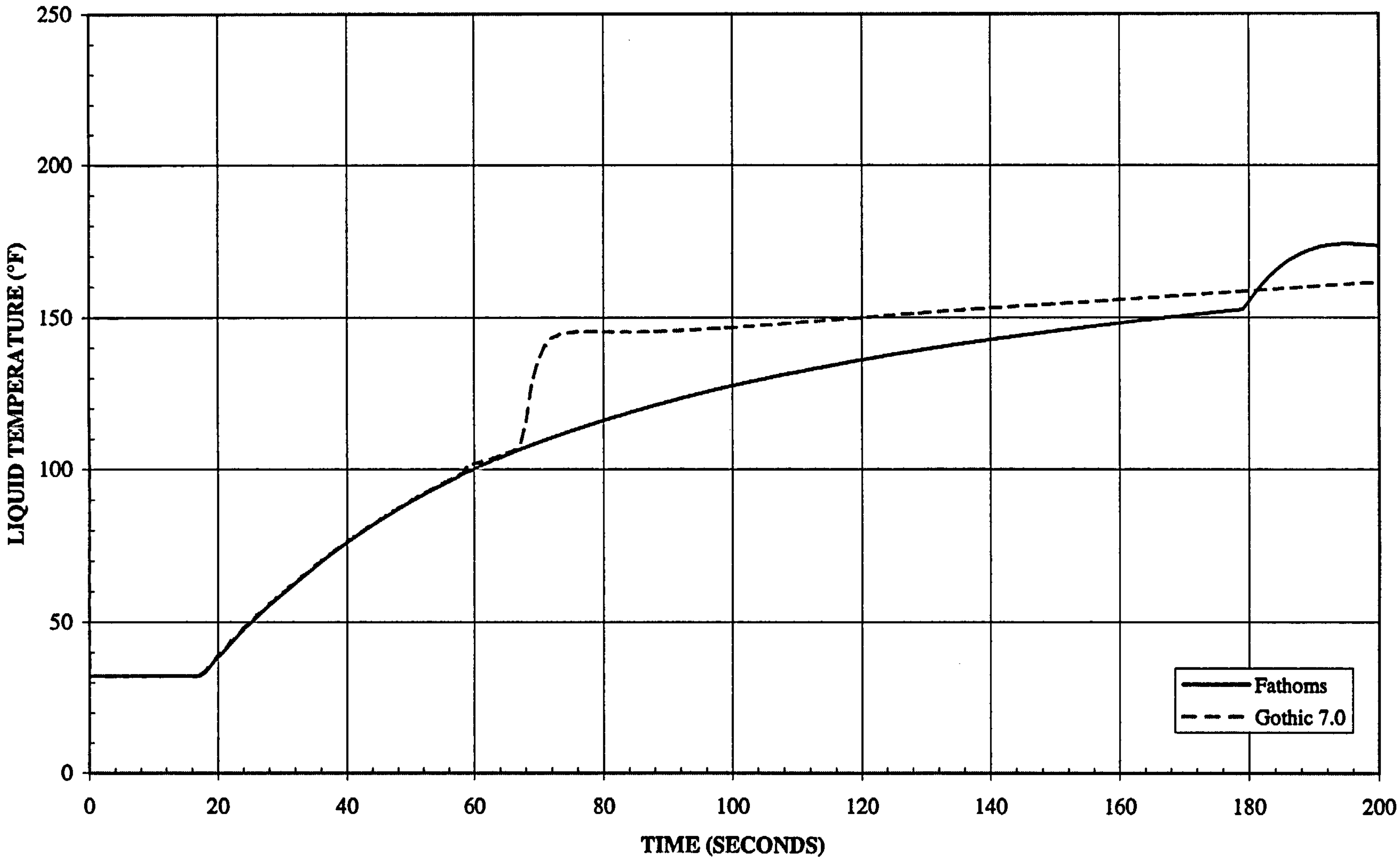



GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG STEAM LINE BREAK
(Double-Ended Guillotine Break)
CONTAINMENT PRESSURE (PSIG)
0
10
20
30
40
50
60
TIME (SECONDS)
0
20
40
60
80
100
120
140
160
180
200
Fathoms
Gothic 7.0

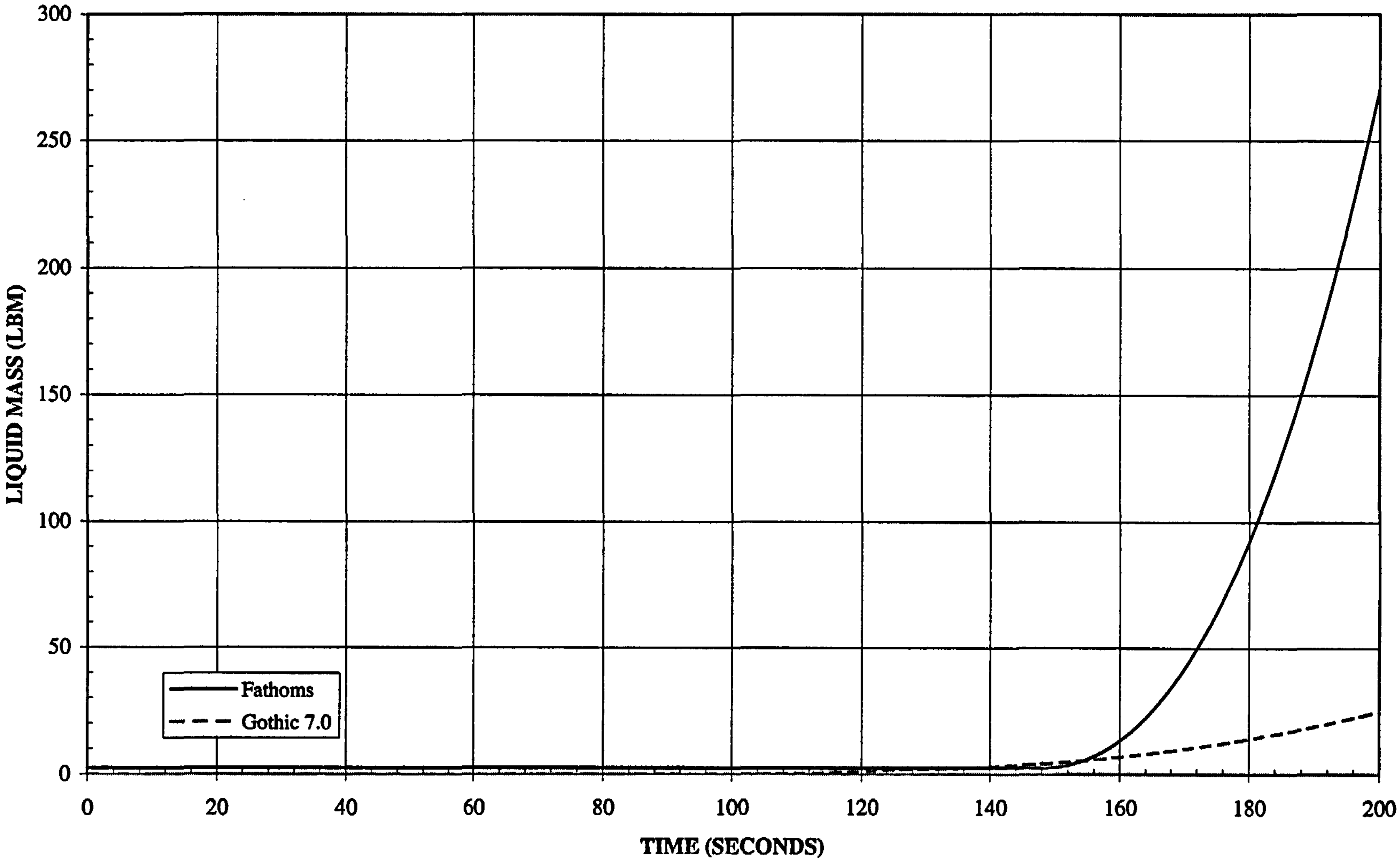
GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG STEAM LINE BREAK
(Double-Ended Guillotine Break)



GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG STEAM LINE BREAK
(Double-Ended Guillotine Break)



GOTHIC 7.0 - FATHOMS COMPARISON
ROTSG STEAM LINE BREAK
(Double-Ended Guillotine Break)



15. Will the Mist Diffusion Layer (MDL) model be used in GOTHIC calculations? If so, please provide curves of a main steam line break calculation with and without this model. All other input and assumptions should be as proposed for licensing basis calculations.

Response: The Uchida Condensation Option will be utilized for all heat slabs in the GOTHIC calculations. This is consistent with the guidance in ANSI/ANS 56.4-1983. This represents no change in the containment analysis methodology (consistent with FATHOMS).

16. Will GOTHIC calculations be performed with a pressure flash or temperature flash assumption concerning the distribution of vapor in the containment atmosphere?

Response: The GOTHIC boundary conditions representing LOCA mass and energy releases will partition the flow by phase. Separate flowrates and enthalpies for the steam and liquid phases of the blowdown are calculated in the RELAP5 code and passed to GOTHIC as separate boundary conditions. All liquid flow is entered as droplets when the RCS pressure exceeds the containment pressures. Subsequently the distribution of the droplets is determined by GOTHIC's heat and mass transfer equations. When the RCS pressure has decreased to the containment pressure the liquid flow is entered in the continuous liquid phase, and spills onto the containment floor with little energy transfer. This liquid phase will not flash into steam, as is permitted in the 'pressure flash' model from CONTEMPT4. The steam phase break flow from the RELAP5 blowdown analysis is added directly to the containment atmosphere.

For main steam line break mass and energy releases, the boundary condition is single phase steam, and so the question is not applicable.

17. Will the Drop Liquid Conversion Option be used in GOTHIC calculations? If so, please provide curves of a 14.1 ft^2 hot leg beak at the vessel outlet calculation with and without this model. All other input and assumptions should be as proposed for licensing basis calculations.

Response: The Drop Liquid Conversion Option, which signals the use of the GOTHIC default models for drop phase entrainment, agglomeration, and deposition, will be used in the GOTHIC calculations. This is consistent with the selection of code-calculated de-entrainment fractions, rather than a user-specified value, in previous FATHOMS analyses.

When the 14.1 ft^2 hot leg break at the vessel outlet from the set of GOTHIC runs in response to Question #3 above is re-run with the Drop Liquid Conversion Option set to IGNORE, the GOTHIC peak pressure calculation is identical to the original case with the INCLUDE option. The selection of this option has no impact on the calculated peak pressure. Since the results with this option removed are identical to the base case, no curve is provided.

ATTACHMENT 2

ADDITIONAL REVISIONS TO DPC-NE-3003, REVISION 1

"Mass and Energy Release and Containment Response Methodology"

Attachment 2

Additional Revisions To

DPC-NE-3003, Revision 1
"Mass and Energy Release and Containment Response Methodology"

The following two items are additional revisions that were not included in the scope of the original Revision 1 submitted for NRC review by letter dated June 13, 2002.

1. Appendix C, "GOTHIC Version 7.0 Code", of Revision 1 of DPC-NE-3003 (Attachments 3 & 4 of the June 13, 2002 submittal) describes Duke's proposed use of the GOTHIC 7.0 code for the containment response analysis. The following paragraph is from pp. 3-62 and 4-62 of Attachments 3 and 4, respectively.

> *"GOTHIC 7.0 features the use of control variables that are not available in FATHOMS. The control variables provide enhanced capability and flexibility to input boundary conditions or forcing functions into the code. For instance, the output of the BFLOW code to determine the quality of water exiting a cold leg break for long-term mass and energy releases can be input via control variables. This capability was not available for FATHOMS and specific code changes were implemented in order to input the BFLOW code results (Section 2.4.1.2)."*

Subsequent to the submittal of Revision 1, Duke has decided not to use the GOTHIC 7.0 control variables for input of the output of the BFLOW code. Rather, GOTHIC 7.0 has been modified similar to the modifications previously made to FATHOMS to input the results of the BFLOW methodology. Therefore, the GOTHIC 7.0 and FATHOMS methodology will be the same with regard to how the results of BFLOW are input. The above paragraph will be revised as follows to indicate this similarity:

> *"GOTHIC 7.0 features the use of control variables that are not available in FATHOMS. The control variables provide enhanced capability and flexibility to input boundary conditions or forcing functions into the code. These are essentially user convenience features and do not constitute elements of the methodology.*
>
> *The long-term mass and energy release boundary condition modeling in FATHOMS has been similarly installed in GOTHIC 7.0. This modeling approach, which enables interpolation of the BFLOW code results as an input boundary condition, are described in Sections 2.2.1.1, 2.4.1.2, and 6.3 of DPC-NE-3003."*

2. Due to the code modification to GOTHIC Version 7.0 described in Item #1 above, the code version must be uniquely identified. This Duke-specific version will be designated GOTHIC 7.0/DUKE in the published version of the report.