UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

June 30, 2000

LICENSEE: Duke Energy Corporation

FACILITIES: McGuire Nuclear Station, Units 1 and 2
Catawba Nuclear Station, Units 1 and 2

SUBJECT: MEETING SUMMARY - MEETING OF JUNE 12, 2000, REGARDING WESTINGHOUSE BEST-ESTIMATE LARGE BREAK LOCA METHODOLOGY

REFERENCE: Meeting Notice by F. Rinaldi, dated May 26, 2000,

On June 12, 2000, the staff met with Duke Energy Corporation (DEC) and Westinghouse Electric Company (W) personnel to discuss information related to a proposed License Amendment to implement Westinghouse's Best-Estimate Large Break Loss-of-Coolant Accident (LOCA) methodology for the McGuire and Catawba plants. The proposed change in LOCA methodology would gain margin in the calculated large break LOCA peak cladding temperature, thus allowing more operational and core design margin. The meeting was planned to discuss the proposed schedule and the specific information required for Nuclear Regulatory Commission (NRC) review and approval.

The licensee and its contractor presented information related to their model development strategy. Specifically, they elaborated on their decision to perform a bounding analysis for the four units. Their strategy considered steam generator, accumulator, and vessel designs. Further, the licensee requested approval by September 1, 2000.

The NRC staff expressed their understanding of the proposed composite model for the four units, but indicated that the staff could not commit to a completion date until the actual Technical Specifications pages and the data supporting the licensee's initial request are received. Further, the staff indicated that the minimum time for review and approval, excluding time to address any requests for additional information, would be 2 months from receipt of all of the required submittals.

Enclosure 1 lists the meeting participants. Enclosure 2 is the handout provided by DEC/W.

Frank Rinaldi, Project Manager
Project Directorate II-1
Division of Project Licensing Management
Office of Nuclear Reactor Regulation

Docket Nos. 50-369, 50-370, 50-413, and 50-414

Enclosures: 1. Meeting Attendees
2. DEC/W Handout

cc w/encls: See next page

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/RA/

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Meeting summary dated June 30, 2000

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Catawba Nuclear Station

cc:

Mr. Gary Gilbert
Regulatory Compliance Manager
Duke Energy Corporation
4800 Concord Road
York, South Carolina 29745

Ms. Lisa F. Vaughn
Legal Department (PB05E)
Duke Energy Corporation
422 South Church Street
Charlotte, North Carolina 28201-1006

Anne Cottingham, Esquire
Winston and Strawn
1400 L Street, NW
Washington, DC 20005

North Carolina Municipal Power
Agency Number 1
1427 Meadowwood Boulevard
P. O. Box 29513
Raleigh, North Carolina 27626

County Manager of York County
York County Courthouse
York, South Carolina 29745

Piedmont Municipal Power Agency
121 Village Drive
Greer, South Carolina 29651

Ms. Karen E. Long
Assistant Attorney General
North Carolina Department of Justice
P. O. Box 629
Raleigh, North Carolina 27602

Elaine Wathen, Lead REP Planner
Division of Emergency Management
116 West Jones Street
Raleigh, North Carolina 27603-1335

North Carolina Electric Membership
Corporation
P. O. Box 27306
Raleigh, North Carolina 27611

Senior Resident Inspector
U.S. Nuclear Regulatory Commission
4830 Concord Road
York, South Carolina 29745

Virgil R. Autry, Director
Division of Radioactive Waste Management
Bureau of Land and Waste Management
Department of Health and Environmental
Control
2600 Bull Street
Columbia, South Carolina 29201-1708

Mr. C. Jeffrey Thomas
Manager - Nuclear Regulatory
Licensing
Duke Energy Corporation
526 South Church Street
Charlotte, North Carolina 28201-1006

Saluda River Electric
P. O. Box 929
Laurens, South Carolina 29360

Mr. Steven P. Shaver
Senior Sales Engineer
Westinghouse Electric Company
5929 Carnegie Blvd.
Suite 500
Charlotte, North Carolina 28209

Mr. G. R. Peterson
Site Vice President
Catawba Nuclear Station
Duke Energy Corporation
4800 Concord Road
York, South Carolina 29745-9635

Catawba Nuclear Station

cc:

Mr. T. Richard Puryear
Owners Group (NCEMC)
Duke Energy Corporation
4800 Concord Road
York, South Carolina 29745

Richard M. Fry, Director
Division of Radiation Protection
North Carolina Department of
Environment, Health, and
Natural Resources
3825 Barrett Drive
Raleigh, North Carolina 27609-7721

cc:
Ms. Lisa F. Vaughn
Legal Department (PBO5E)
Duke Energy Corporation
422 South Church Street
Charlotte, North Carolina 28201-1006

County Manager of
Mecklenburg County
720 East Fourth Street
Charlotte, North Carolina 28202

Michael T. Cash
Regulatory Compliance Manager
Duke Energy Corporation
McGuire Nuclear Site
12700 Hagers Ferry Road
Huntersville, North Carolina 28078

Anne Cottingham, Esquire
Winston and Strawn
1400 L Street, NW.
Washington, DC 20005

Senior Resident Inspector
c/o U.S. Nuclear Regulatory Commission
12700 Hagers Ferry Road
Huntersville, North Carolina 28078

Dr. John M. Barry
Mecklenberg County
Department of Environmental
Protection
700 N. Tryon Street
Charlotte, North Carolina 28202

Mr. Steven P. Shaver
Senior Sales Engineer
Westinshouse Electric Company
5929 Carnegie Blvd.
Suite 500
Charlotte, North Carolina 28209

Mr. H. B. Barron
Vice President, McGuire Site
Duke Energy Corporation
12700 Hagers Ferry Road
Huntersville, NC 28078-8985

Ms. Karen E. Long
Assistant Attorney General
North Carolina Department of
Justice
P. O. Box 629
Raleigh, North Carolina 27602

Mr. C. Jeffrey Thomas
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526 South Church Street
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Raleigh, North Carolina 27609-7721

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Duke Energy Corporation
4800 Concord Road
York, South Carolina 29745

LIST OF PARTICIPANTS

MEETING WITH DUKE ENERGY CORPORATION

AND

WESINGHOUSE ELECTRIC COMPANY

JUNE 12, 2000

NAME	AFFILIATION
Gregg B. Swindlehurst	Duke Energy Corporation
Charles J. Thomas	Duke Energy Corporation
Bob Harvey	Duke Energy Corporation
Mitch Nissley	Westinghouse Electric Company
Dan Golden	Westinghouse Electric Company
Sue Dederer	Westinghouse Electric Company
Frank Akstulewicz	NRC/NRR/SRXB
Frank Orr	NRC/NRR/SRXB
Joseph Staudenmeier	NRC/NRR/SRXB
Ralph Landry	NRC/NRR/SRXB
Chandu Patel	NRC/NRR/PD II-1
Frank Rinaldi	NRC/NRR/PD II-1

Enclosure 1

BEST-ESTIMATE LARGE BREAK LOCA

ANALYSIS PROGRAM FOR

DUKE POWER'S MCGUIRE & CATAWBA UNITS

NRC/DUKE/WESTINGHOUSE MEETING
ROCKVILLE MD
JUNE 12, 2000

M. NISSLEY
WESTINGHOUSE ELECTRIC COMPANY

Enclosure 2

BACKGROUND

WESTINGHOUSE AWARDED CONTRACT TO DELIVER FUEL TO MCGUIRE/CATAWBA UNITS BEGINNING WITH CATAWBA 2 CYCLE 11 (04/00)

PEAKING FACTORS REQUIRED BY CONTRACT COULD NOT BE MET WITH BASH EM (APPENDIX K)

CORE DESIGN FLEXIBILITY/FUEL CYCLE COSTS NEGATIVELY IMPACTED

- ⇨ **BELOCA ANALYSIS INITIATED TO FULFILL CONTRACT, REGAIN MARGIN, MINIMIZE FINANCIAL IMPACTS ON DUKE AND WESTINGHOUSE**
- ⇨ **FIRST IMPLEMENTATION DESIRED FOR MCGUIRE 2 CYCLE 14 (09/01/00 APPROVAL REQUESTED)**

WCOBRA/TRAC MODEL DEVELOPMENT STRATEGY

PERFORMED A DETAILED REVIEW OF MCGUIRE/CATAWBA AND WATTS BAR PLANT CONFIGURATIONS (PREVIOUSLY ANALYZED WITH BELOCA)

"BIG PICTURE" SIMILARITIES

- 4-LOOP, 17X17 FUEL
- INTERNALS DESIGNED FOR UPPER HEAD INJECTION
  - ⇨ ENHANCED BLOWDOWN COOLING RELATIVE TO OTHER INTERNAL DESIGNS
- UPFLOW IN BARREL-BAFFLE REGION
- ICE CONDENSER CONTAINMENT DESIGN
  - ⇨ EXTENDED REFLOOD DUE TO BOILING IN THE DOWNCOMER (STRUCTURAL HT, LOW Tsat)

DECISION TO PERFORM BOUNDING ANALYSIS FOR ALL FOUR UNITS

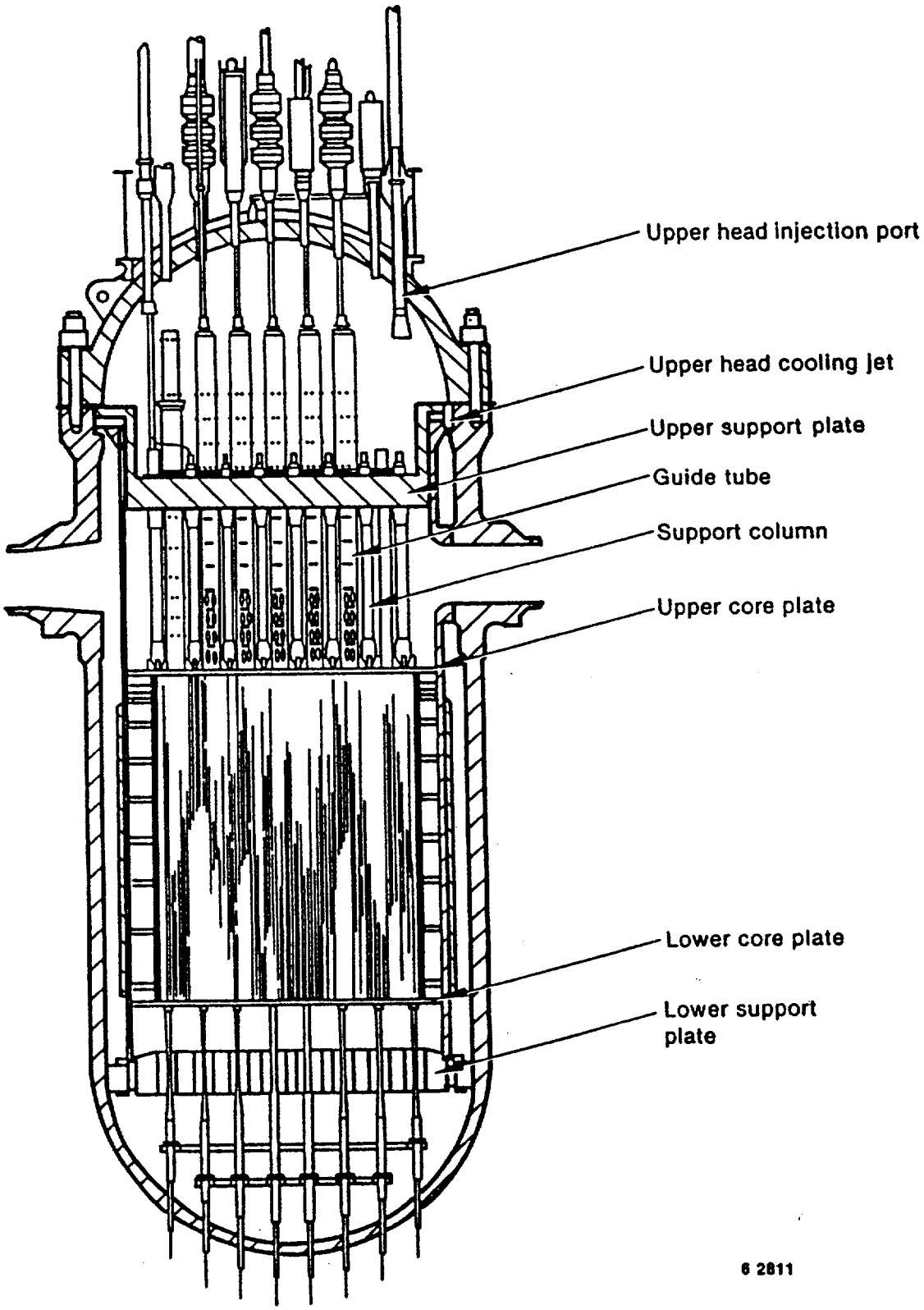


Figure 6.7-2. Sketch of PWR vessel with upper head injection (UHI).

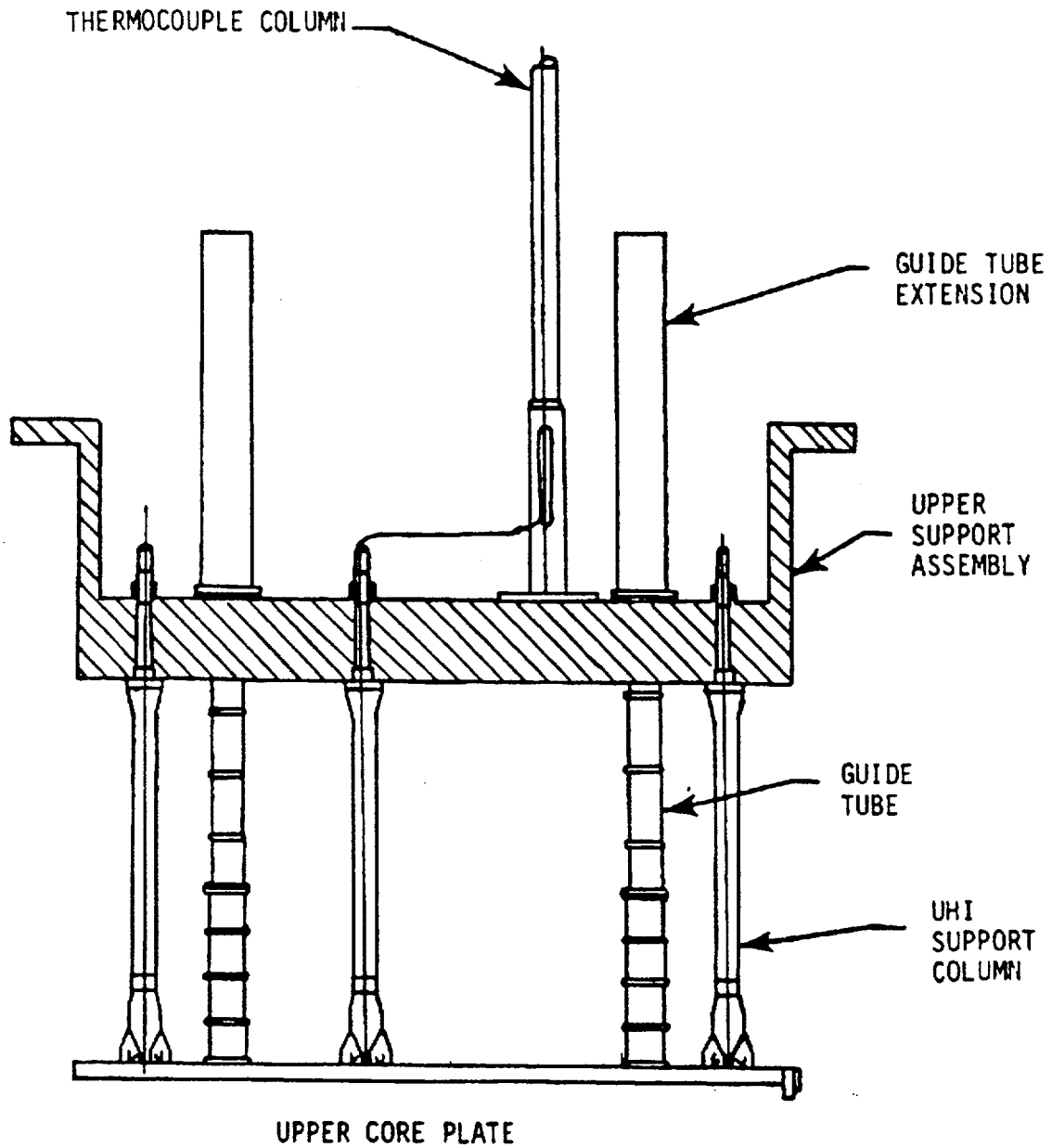


Figure 4-11.
Upper Core Support Structure

STRATEGY FOR ADDRESSING MCGUIRE/CATAWBA DIFFERENCES

LOOPS

STEAM GENERATOR DESIGN

M1/M2/C1 HAVE BWI SG, C2 HAS W D5 SG

	BWI	D5
NUMBER OF TUBES	6301	4113
AVE. LENGTH (ft)	81.6	67.6
TUBE I.D. (in)	0.608	0.664
FLOW AREA (ft2)	12.7	9.9
PRIMARY VOL. (ft3)	1258	881
PRESSURE DROP (psi)	37.4	43.6

(BWI @ 5% SGTP, D5 @ 10% SGTP)

⇨ C2 CONFIGURATION EXPECTED TO BE LIMITING, CONFIRM BY ANALYSIS

ACCUMULATOR LINE RESISTANCE

	M1	M2	C1	C2
EQUIV. L/D	705	384	427	427

MINIMUM LINE RESISTANCE LIMITING FOR WATTS BAR

⇨ M2 CONFIGURATION EXPECTED TO BE LIMITING, CONFIRM BY ANALYSIS

ACCUMULATOR WATER VOLUME

	M1/M2	C1/C2
VOLUME (gal)	6790-7422	7550-8159

MINIMUM WATER VOLUME LIMITING FOR WATTS BAR

⇨ M1/M2 CONFIGURATION EXPECTED TO BE LIMITING, CONFIRM BY ANALYSIS

ACCUMULATOR PRESSURE

	M1/M2	C1/C2
PRESSURE (psig)	565-659	555-708

⇨ C1/C2 RANGE BOUNDS ALL UNITS, USE IN UNCERTAINTY CALCULATIONS

VESSEL

UPPER INTERNALS COMPONENTS

COMPONENT	M1	M2/C1/C2
17X17 GT	65	65
15X15 GT	14	6
SC	106	114

⇨ DETERMINE LIMITING CONFIGURATION BY ANALYSIS

BARREL/BAFFLE (UPFLOW)

M1/M2 HAVE THICKER BAFFLE AND FORMER PLATES

MASS DIFFERENCE = 8900 lb

VOLUME DIFFERENCE = 18 ft3 (8% OF BARREL/BAFFLE WATER VOLUME)

⇨ MODEL MAXIMUM BARREL/BAFFLE WATER VOLUME TO DECREASE WATER AVAILABLE FOR CORE REFLOOD

⇨ MODEL THICKER PLATES TO INCREASE STEAM GENERATION

LIMITING CONFIGURATION ANALYSIS & RESULTS

1) DETERMINE LIMITING VESSEL CONFIGURATION USING CONSISTENT LOOP MODEL ("REFERENCE TRANSIENT" CONDITIONS, NOMINAL CD=1.0, RESULTING IN A PCT ~ $PCT^{75\%}$ FOR WATTS BAR)

   RESULTS: MCGUIRE 1 CONFIGURATION LIMITING

2) USING LIMITING VESSEL MODEL, CONFIRM THAT LOOP CONFIGURATION IS LIMITING (SINGLE EFFECT STUDIES)

   RESULTS: EXPECTATIONS CONFIRMED

3) REPEAT STEPS 1 AND 2 FOR A CASE FROM THE GLOBAL MODEL RUN MATRIX WHICH GIVES PCT ~ $PCT^{95\%}$ FOR WATTS BAR (CD = 1.4, WHICH BOUNDS THE MEASURED/PREDICTED CRITICAL FLOW RATES FOR ALL MARVIKEN ASSESSMENTS)

   RESULTS: CHOICE OF LIMITING CONFIGURATION CONFIRMED

OVERVIEW OF REFERENCE TRANSIENT

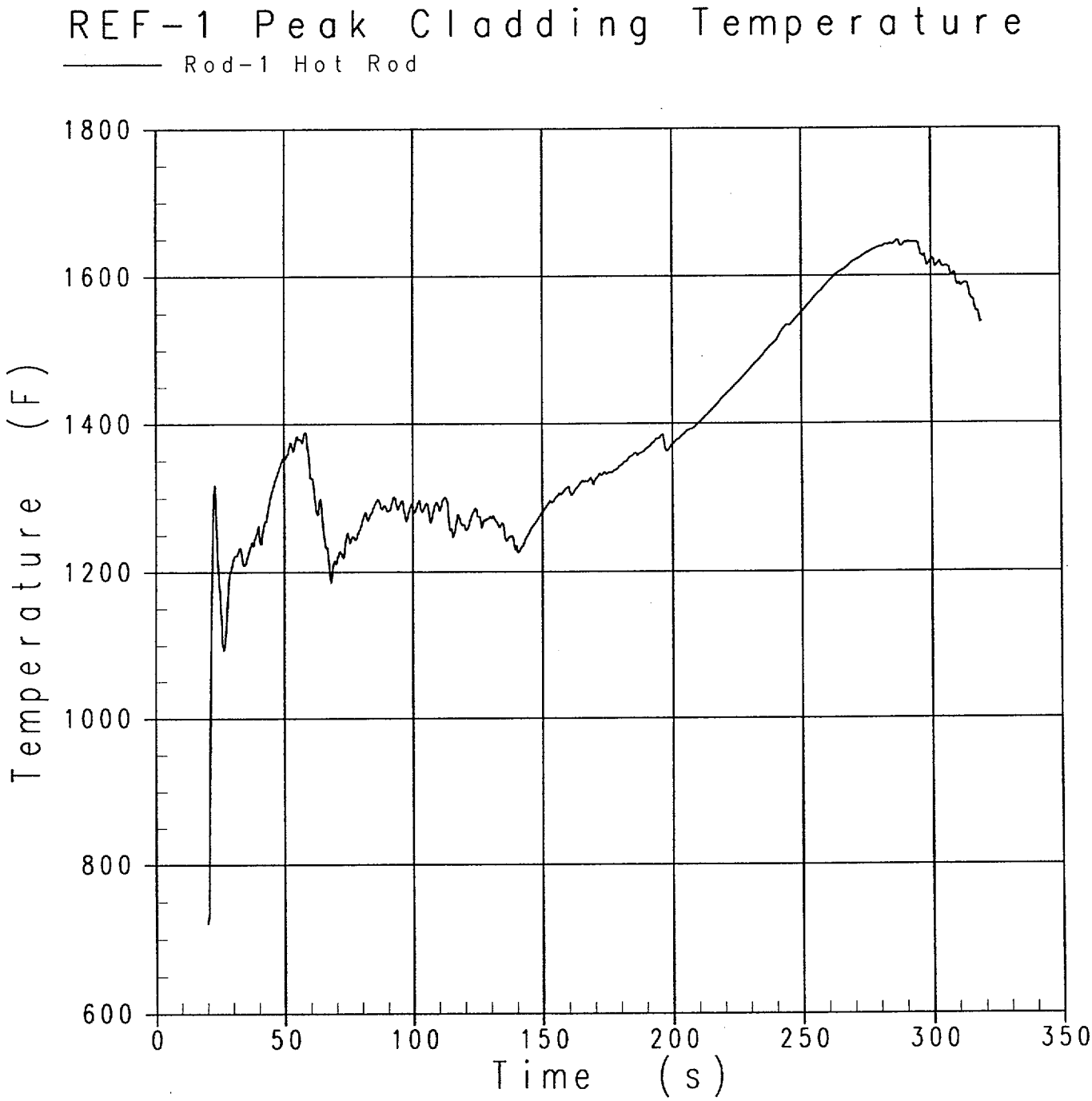
BLOWDOWN HEATUP TURNED AROUND BY UPFLOW COOLING, FOLLOWING FLASHING IN LOWER PLENUM

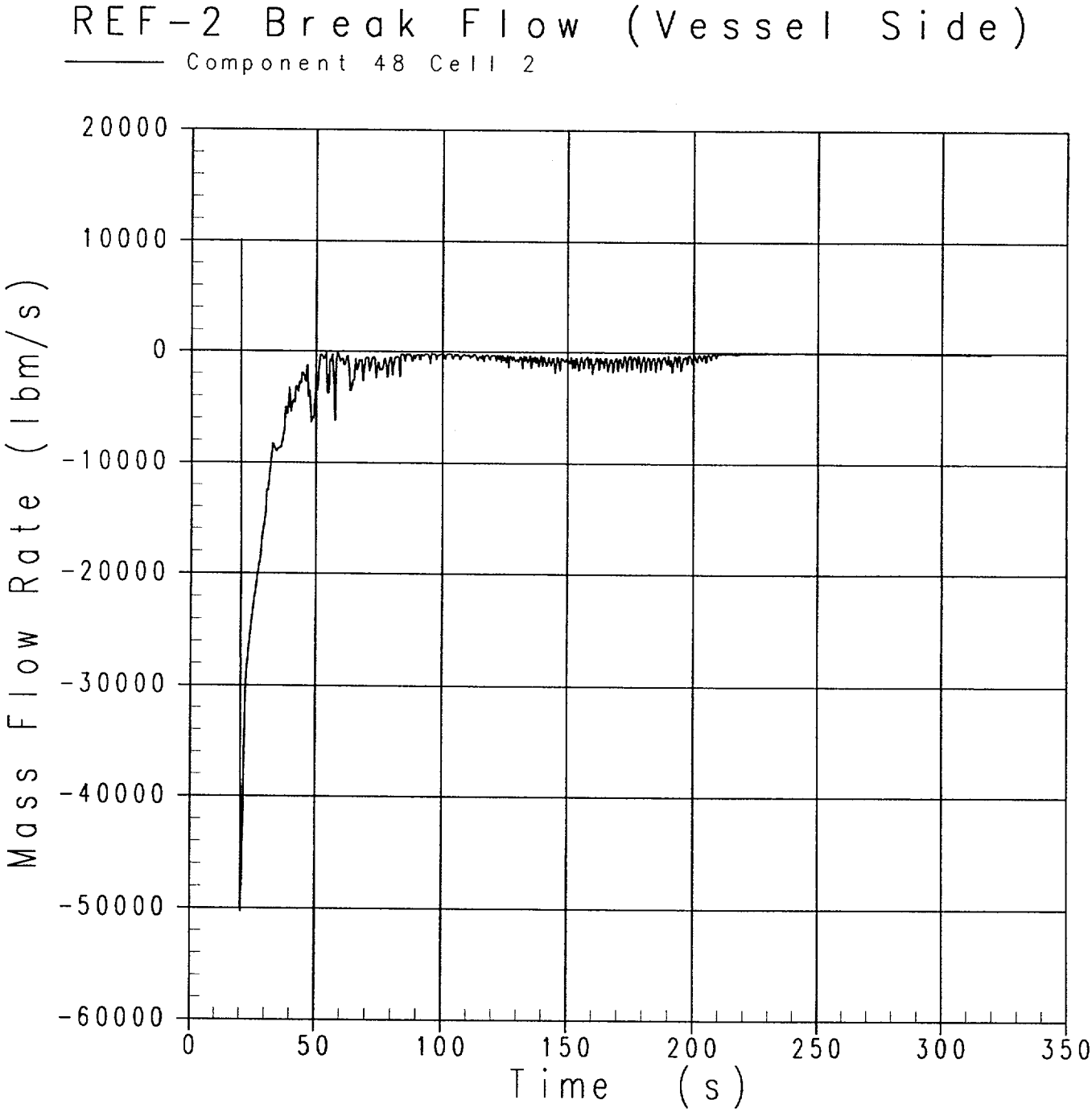
UPPER HEAD FLASHING SUBSEQUENTLY ENHANCES DOWNFLOW COOLING, LEADING TO RELATIVELY LOW TEMPERATURES AT END OF BLOWDOWN

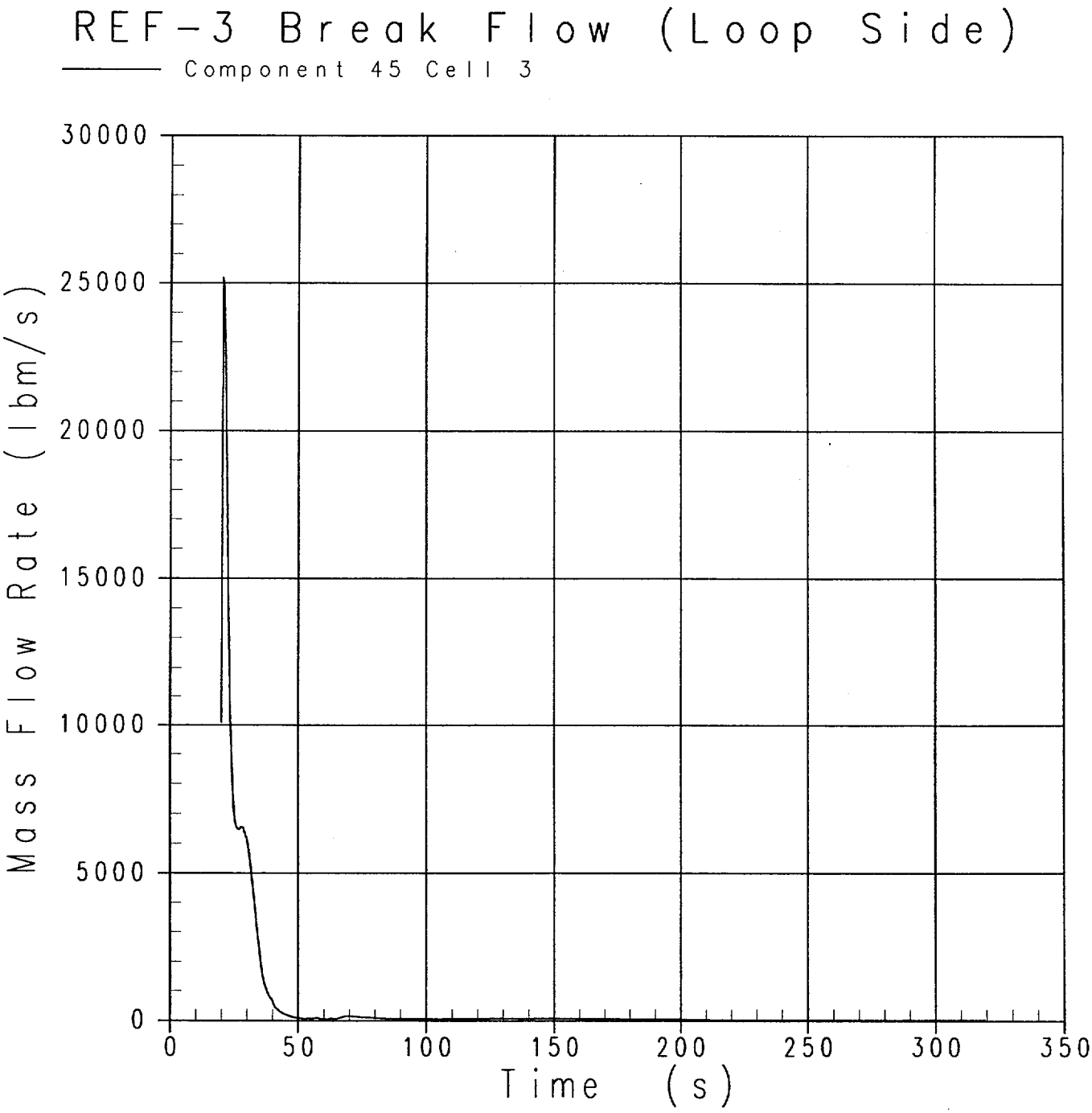
TEMPERATURES REMAIN LOW IN EARLY REFLOOD, DUE TO HIGH DOWNCOMER WATER LEVELS

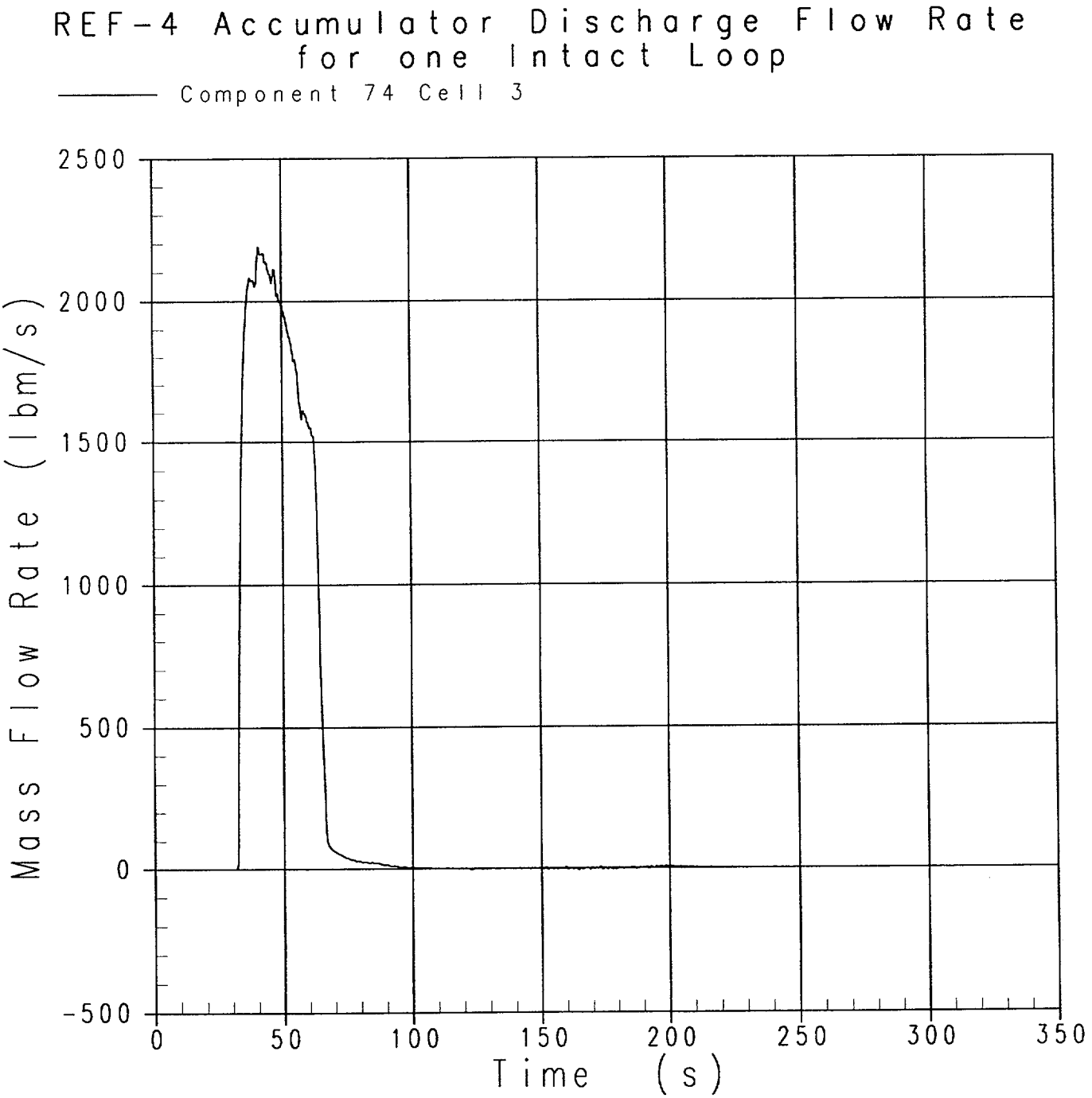
DOWNCOMER DRIVING HEAD SUBSEQUENTLY REDUCED DUE TO BOILING (STRUCTURAL HEAT TRANSFER AND LOW SATURATION TEMPERATURE, DUE TO ICE CONDENSER CONTAINMENT DESIGN)

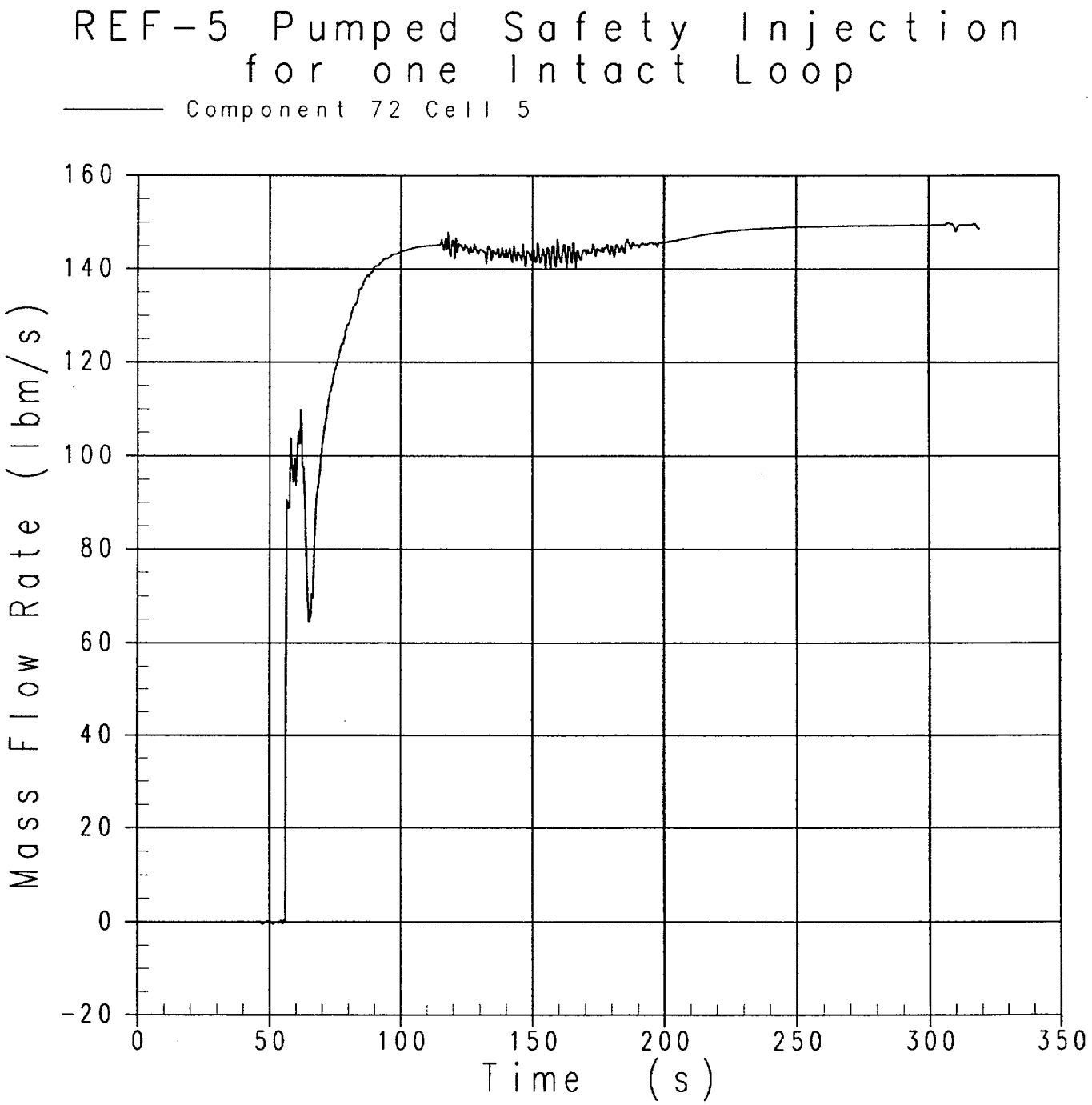
PUMPED SAFETY INJECTION RESTORES DRIVING HEAT, AND TERMINATES FUEL ROD HEATUP

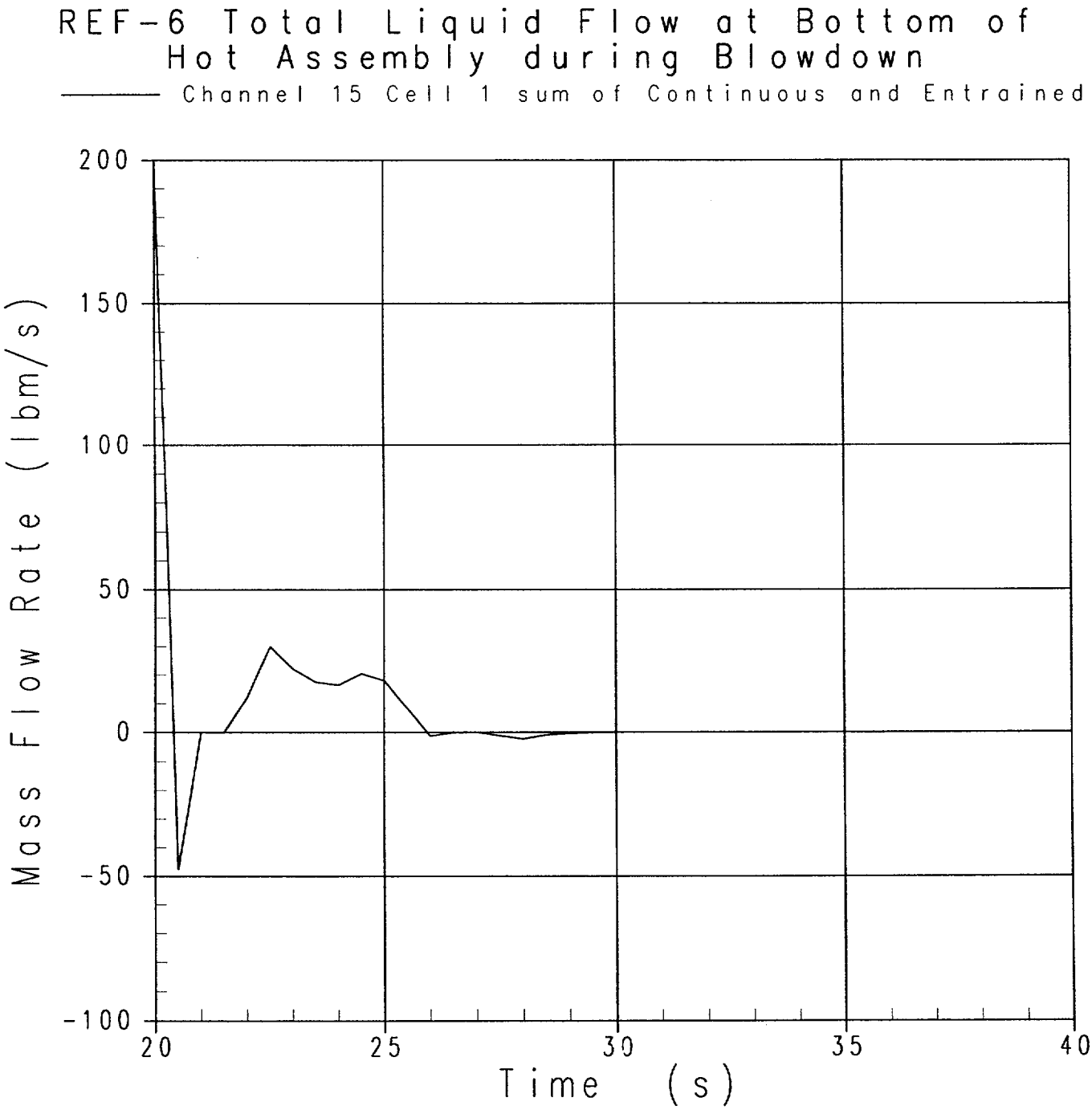

REF-1 Peak Cladding Temperature
Rod-1 Hot Rod
1800
1600
1400
1200
1000
800
600
Temperature (F)
0
50
100
150
200
250
300
350
Time (s)


REF-2 Break Flow (Vessel Side)
Component 48 Cell 2
20000
10000
0
-10000
-20000
-30000
-40000
-50000
-60000
Mass Flow Rate (lbm/s)
0
50
100
150
200
250
300
350
Time (s)

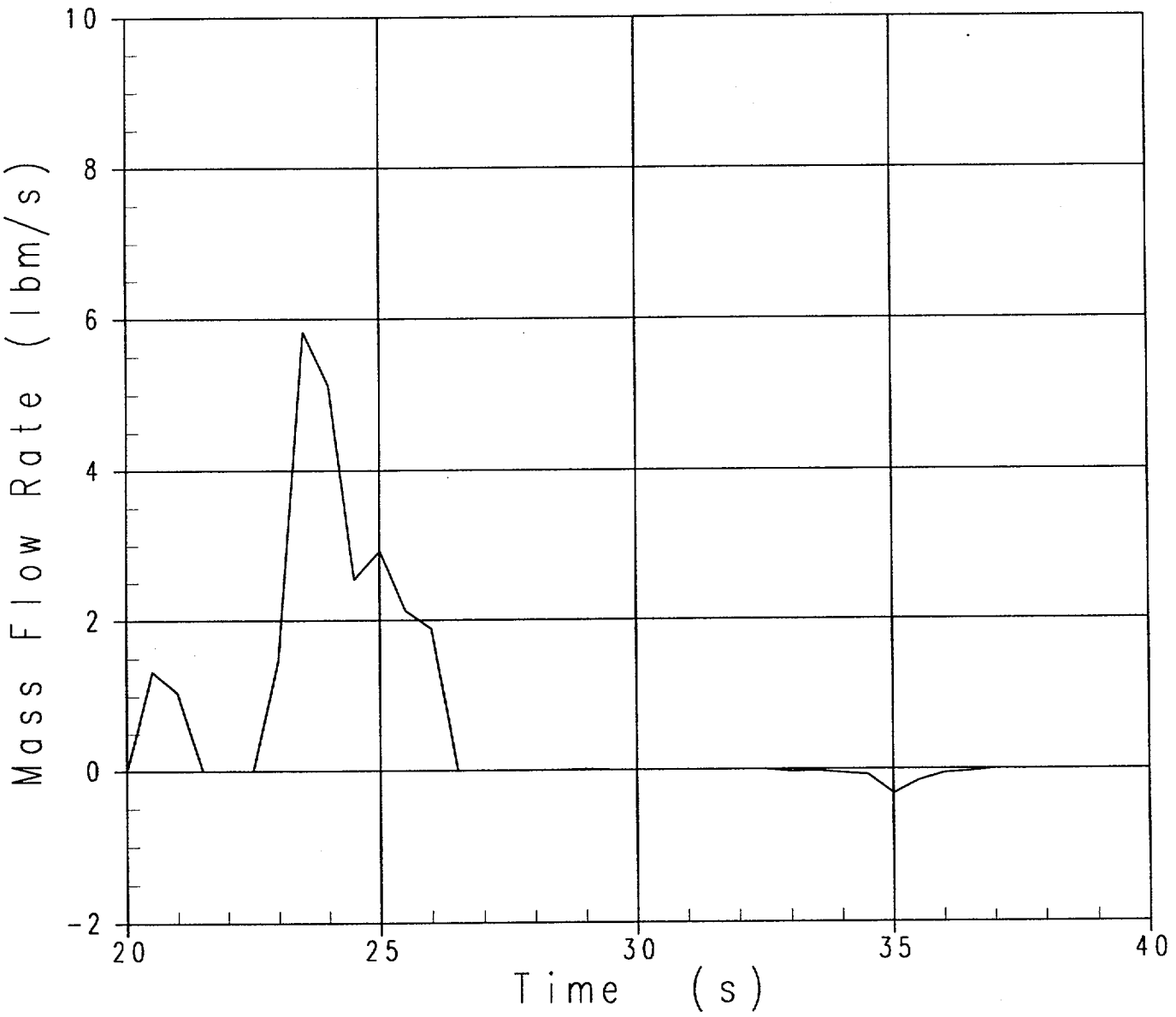

REF-3 Break Flow (Loop Side)
Component 45 Cell 3
Mass Flow Rate (lbm/s)
30000
25000
20000
15000
10000
5000
0
0
50
100
150
200
250
300
350
Time (s)

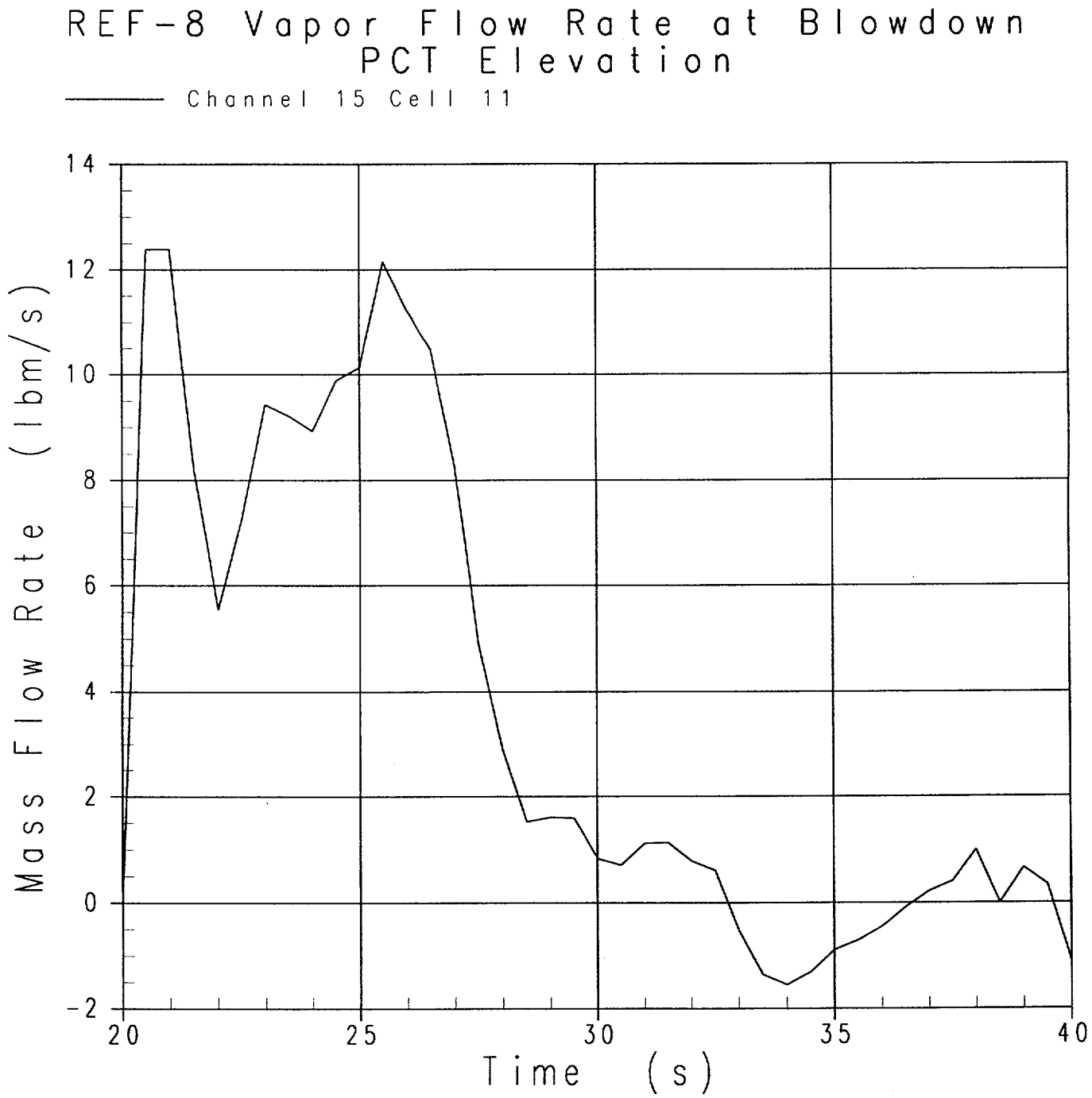

REF-4 Accumulator Discharge Flow Rate
for one Intact Loop
Component 74 Cell 3
Mass Flow Rate (lbm/s)
2500
2000
1500
1000
500
0
-500
0
50
100
150
200
250
300
350
Time (s)

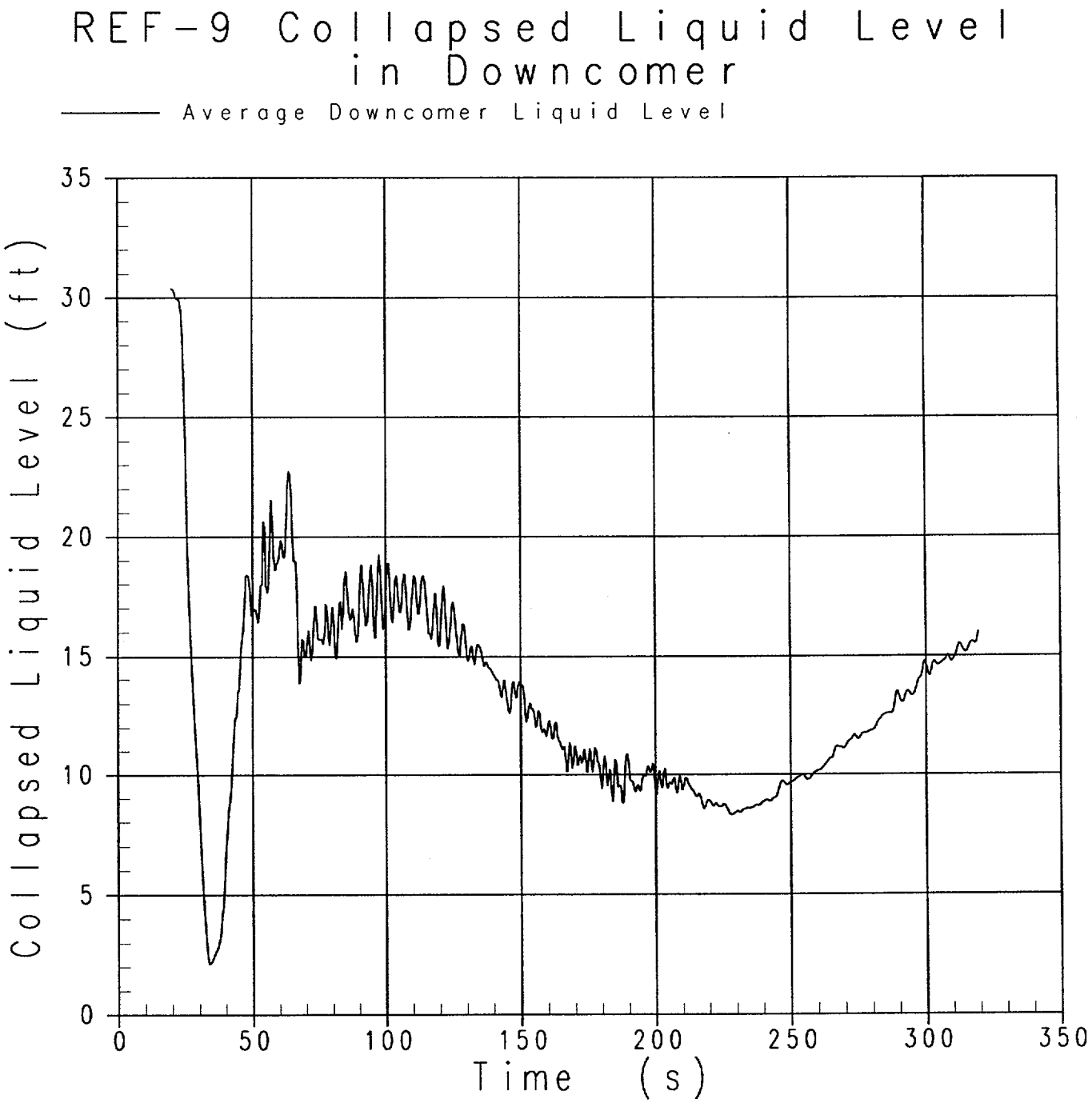

REF-5 Pumped Safety Injection
for one Intact Loop
Component 72 Cell 5
Mass Flow Rate (lbm/s)
160
140
120
100
80
60
40
20
0
-20
0
50
100
150
200
250
300
350
Time (s)

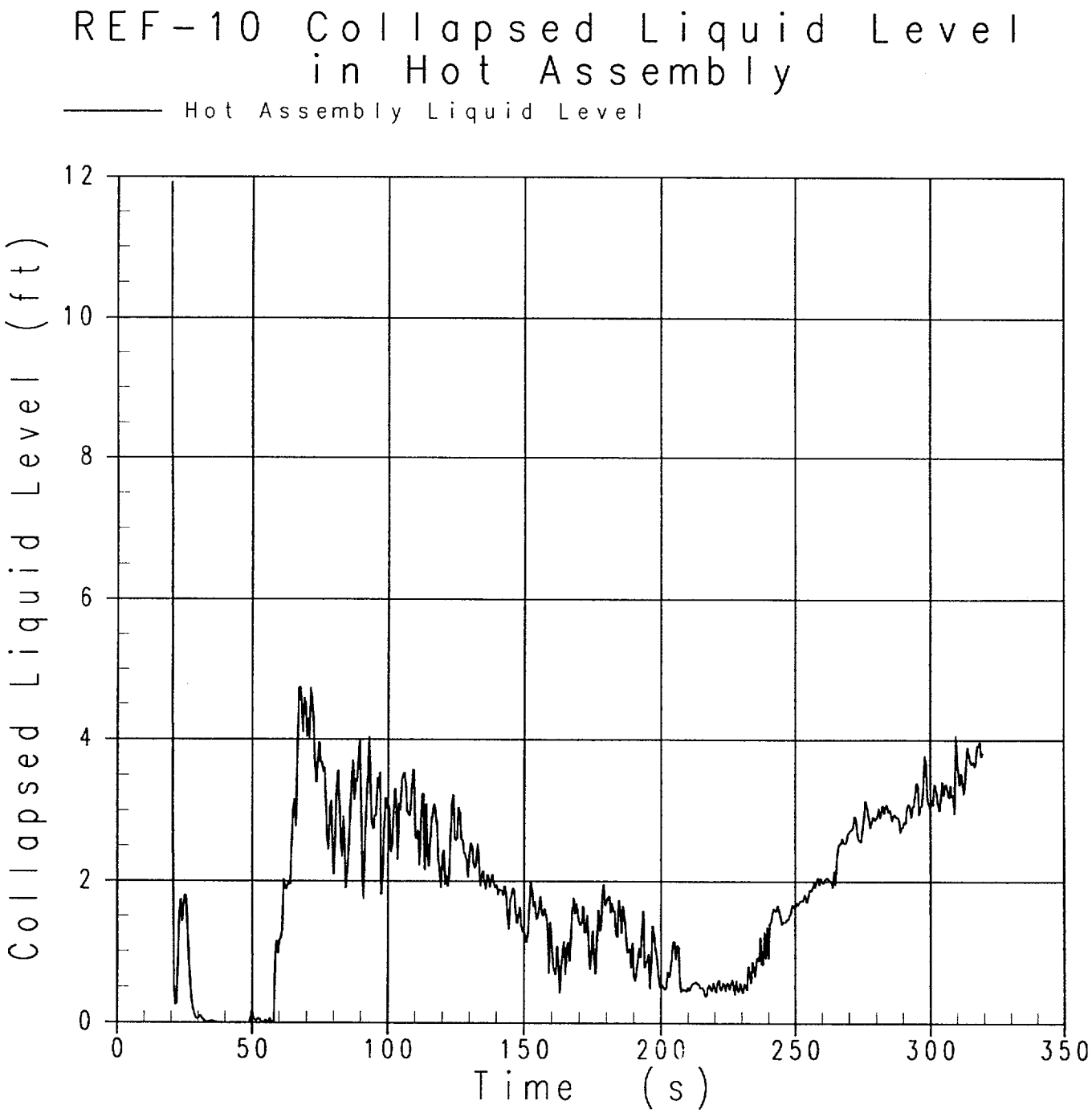

REF-6 Total Liquid Flow at Bottom of Hot Assembly during Blowdown
Channel 15 Cell 1 sum of Continuous and Entrained
200
150
100
50
0
-50
-100
Mass Flow Rate (lbm/s)
20
25
30
35
40
Time (s)

REF-7 Entrained Liquid Flow Rate at Blowdown PCT Elevation




REF-8 Vapor Flow Rate at Blowdown
PCT Elevation
Channel 15 Cell 11
Mass Flow Rate (lbm/s)
14
12
10
8
6
4
2
0
-2
20
25
30
35
40
Time (s)


REF-9 Collapsed Liquid Level in Downcomer
Average Downcomer Liquid Level
Collapsed Liquid Level (ft)
35
30
25
20
15
10
5
0
0
50
100
150
200
250
300
350
Time (s)


REF-10 Collapsed Liquid Level in Hot Assembly
Hot Assembly Liquid Level
Collapsed Liquid Level (ft)
0
2
4
6
8
10
12
0
50
100
150
200
250
300
350
Time (s)

STEAM GENERATOR DESIGN STUDY

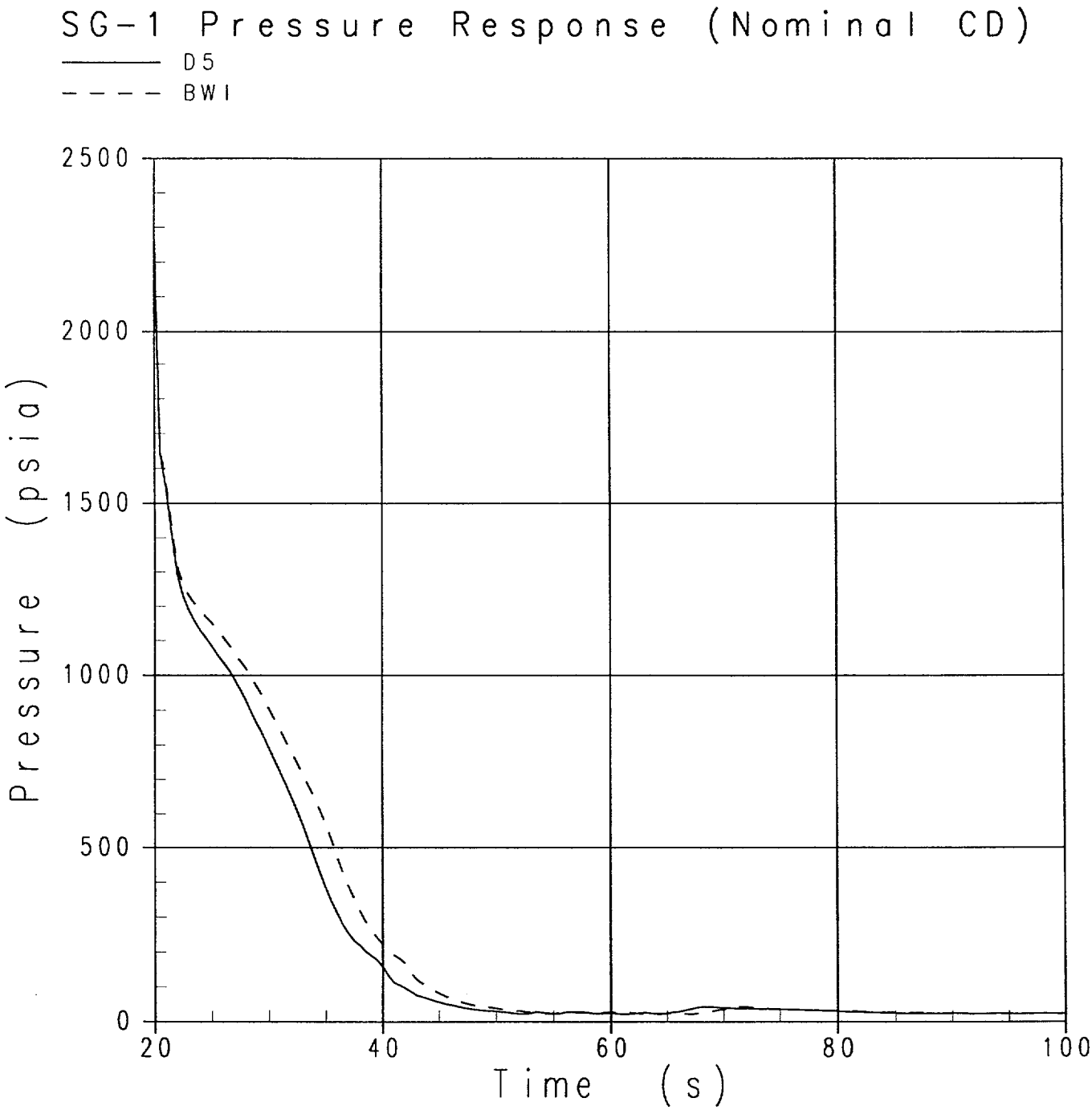
LARGER VOLUME FOR BWI SG RESULTS IN PROLONGED BLOWDOWN, DELAY IN REFLOOD (FIGURES SG-1 TO SG-3)

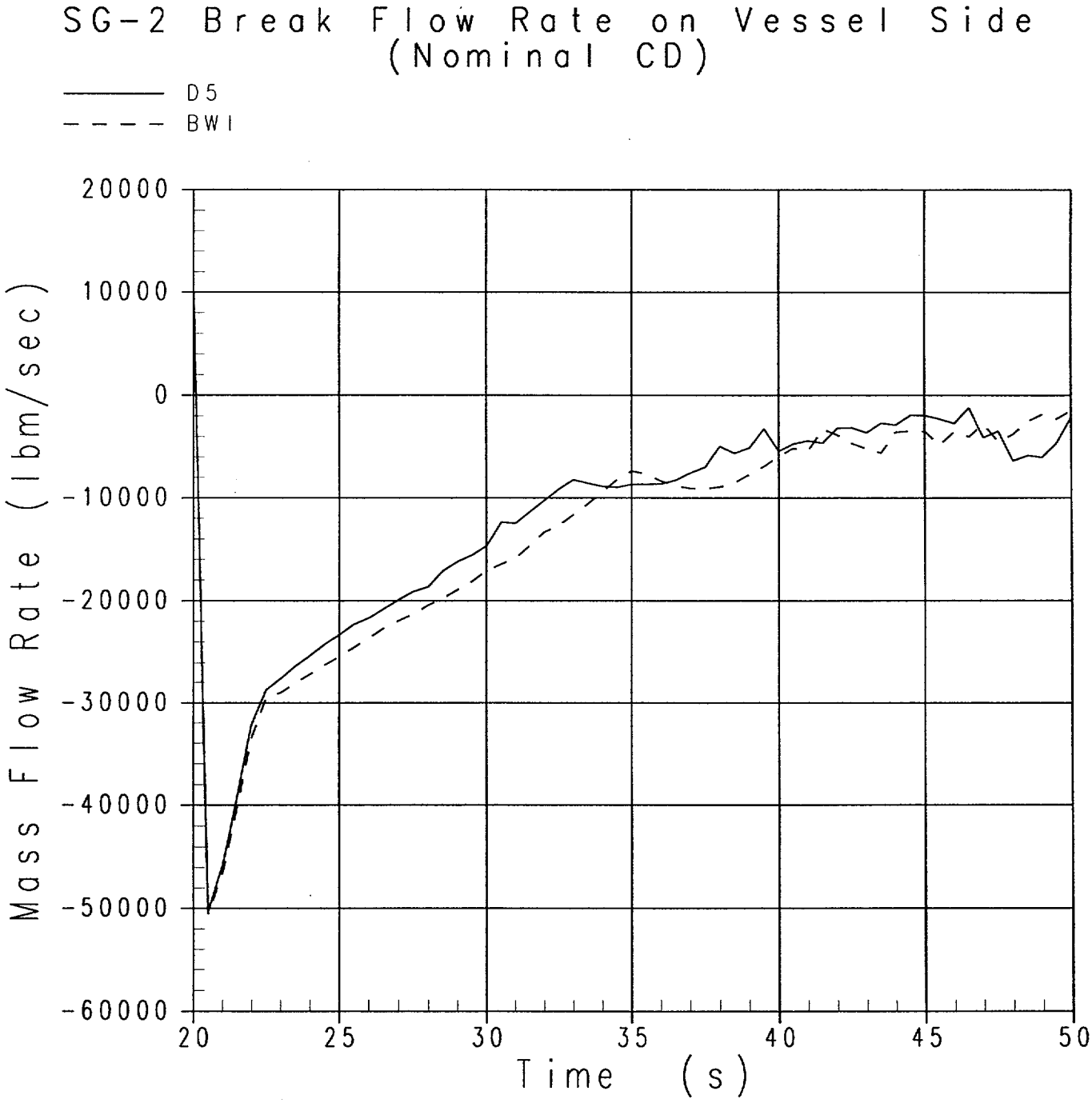
LOWER PLENUM FLASHING IS DELAYED, RESULTING IN SLIGHTLY HIGHER BLOWDOWN PCT (FIGURES SG-4 & SG-5)

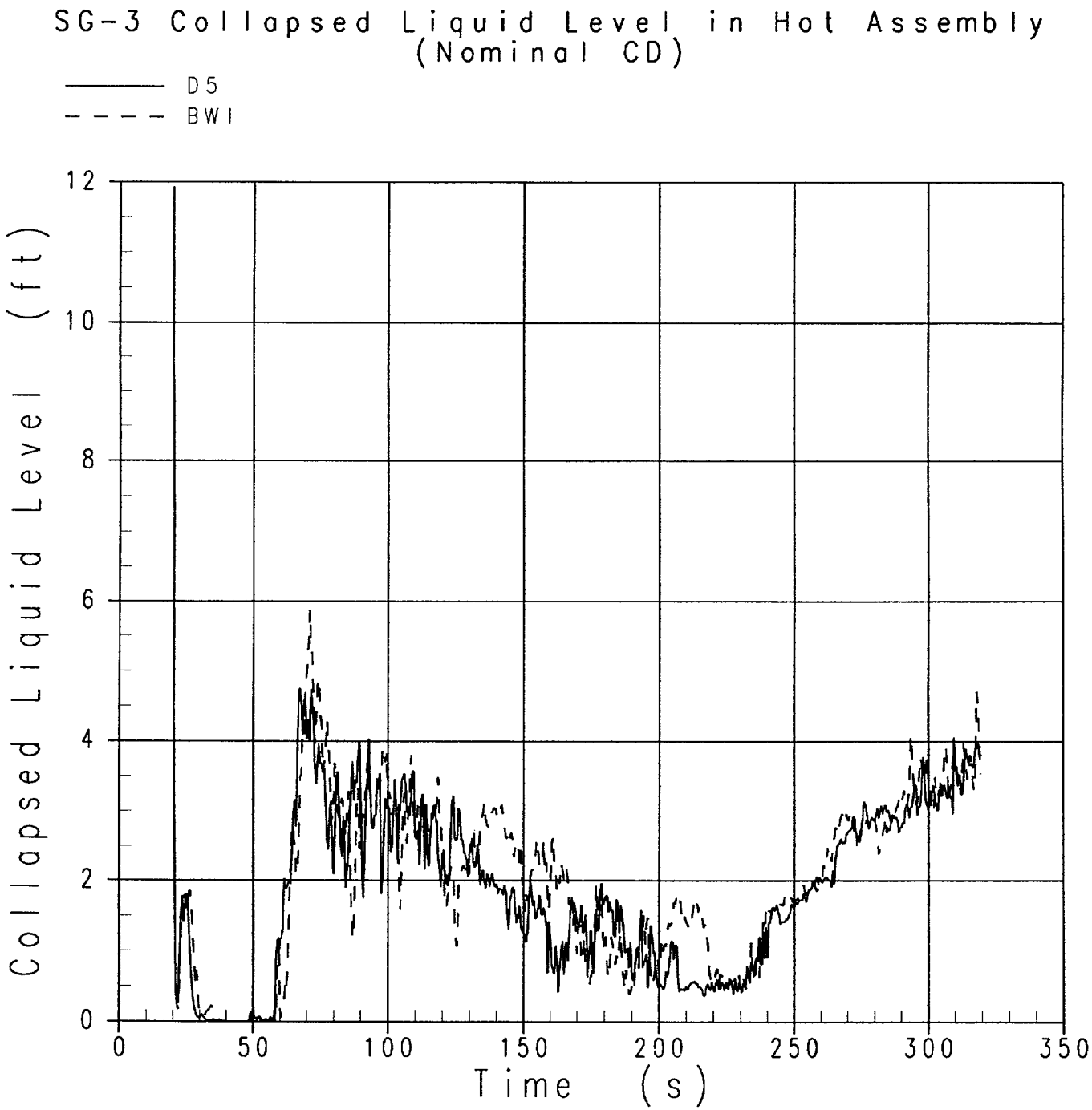
LESS UPPER PLENUM INVENTORY DELIVERED TO BROKEN LOOP HOT LEG, RESULTING IN BETTER DOWNFLOW COOLING (FIGURES SG-6 & SG-7)

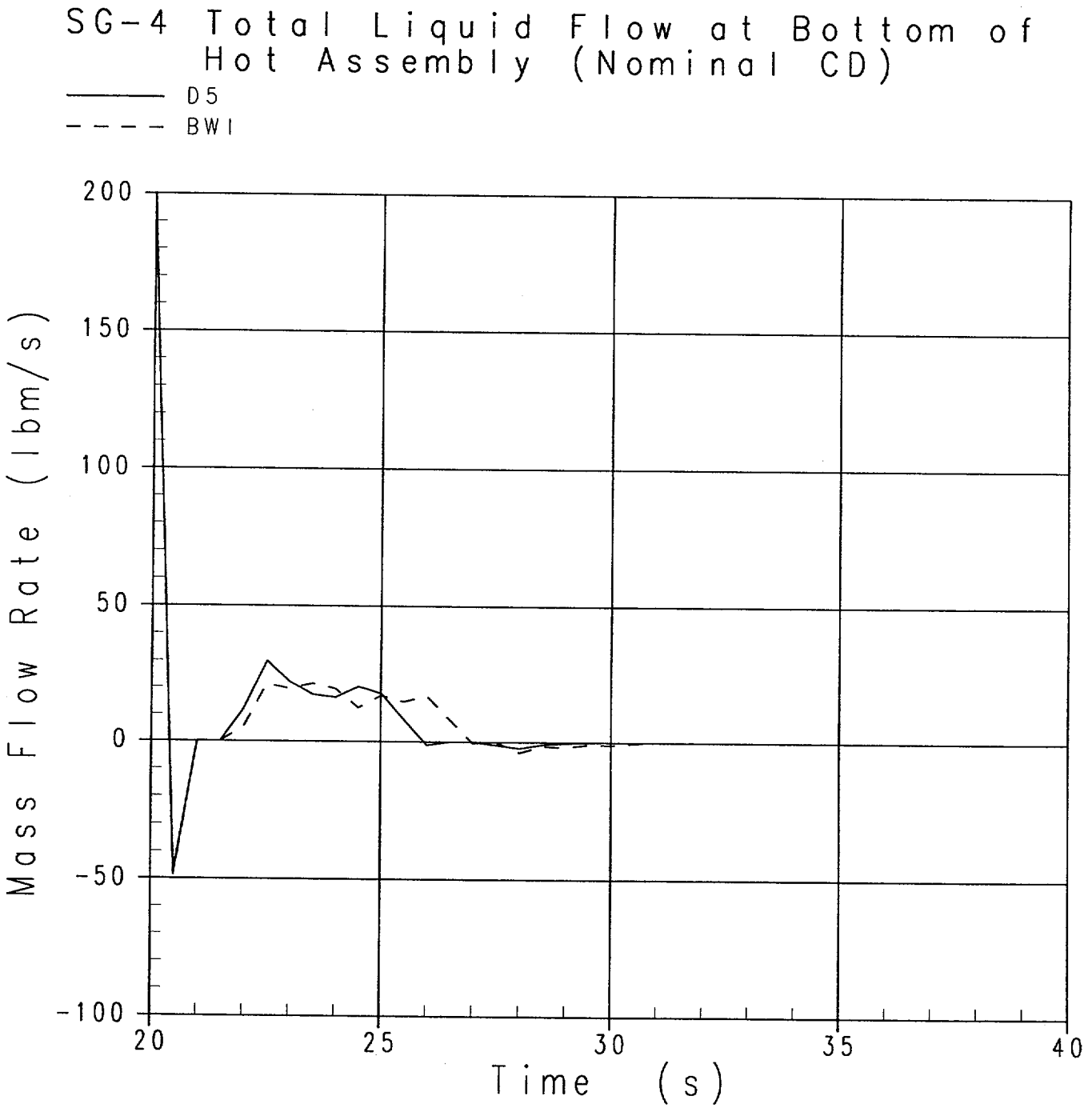
CONSISTENT RESPONSE SEEN FOR REFERENCE TRANSIENT AND CD=1.4 CASE (FIGURES SG-8 TO SG-11)

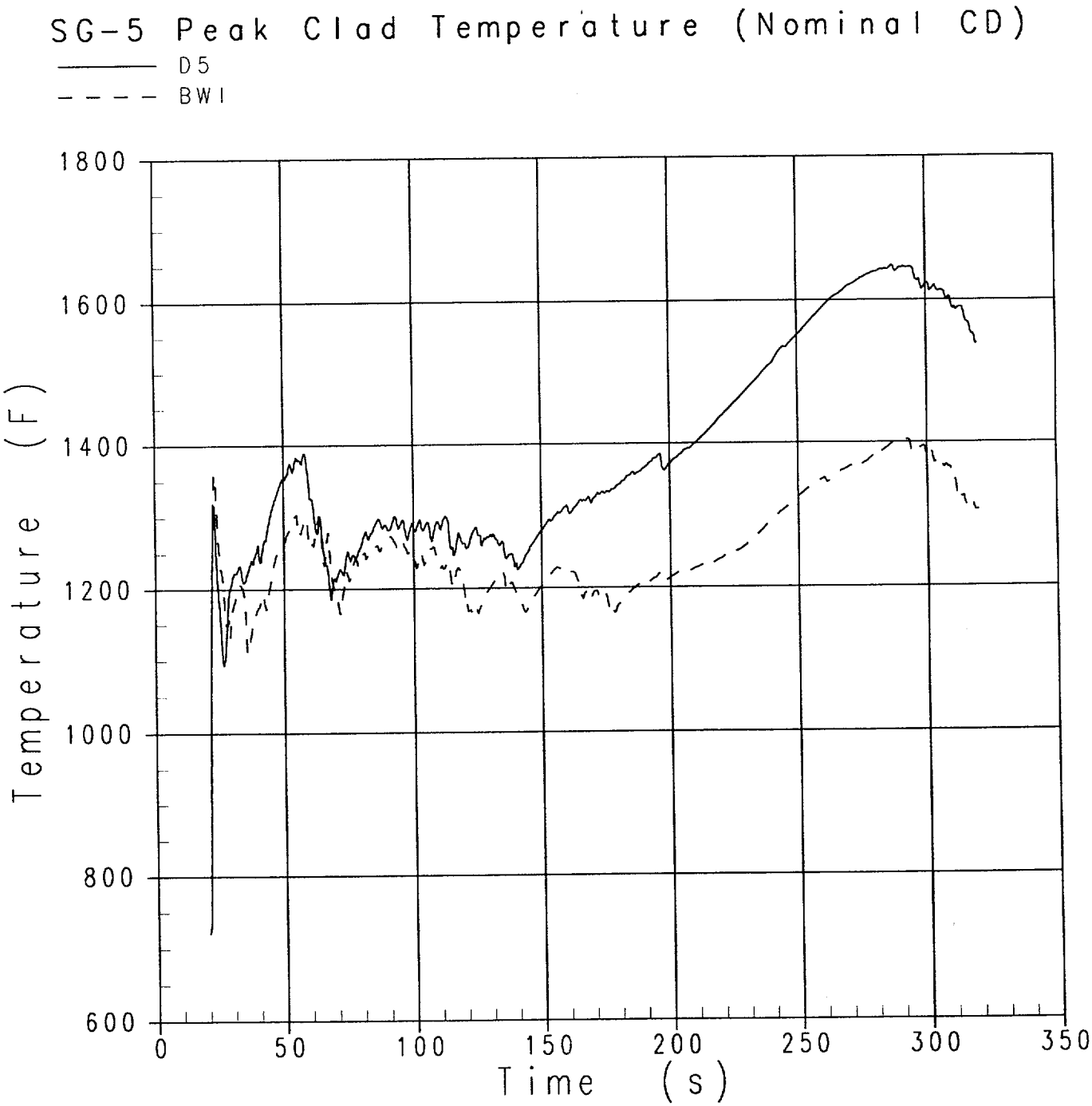
- ⇨ **D5 STEAM GENERATOR (CATAWBA 2) CONFIRMED AS APPROPRIATE FOR BOUNDING CONFIGURATION**

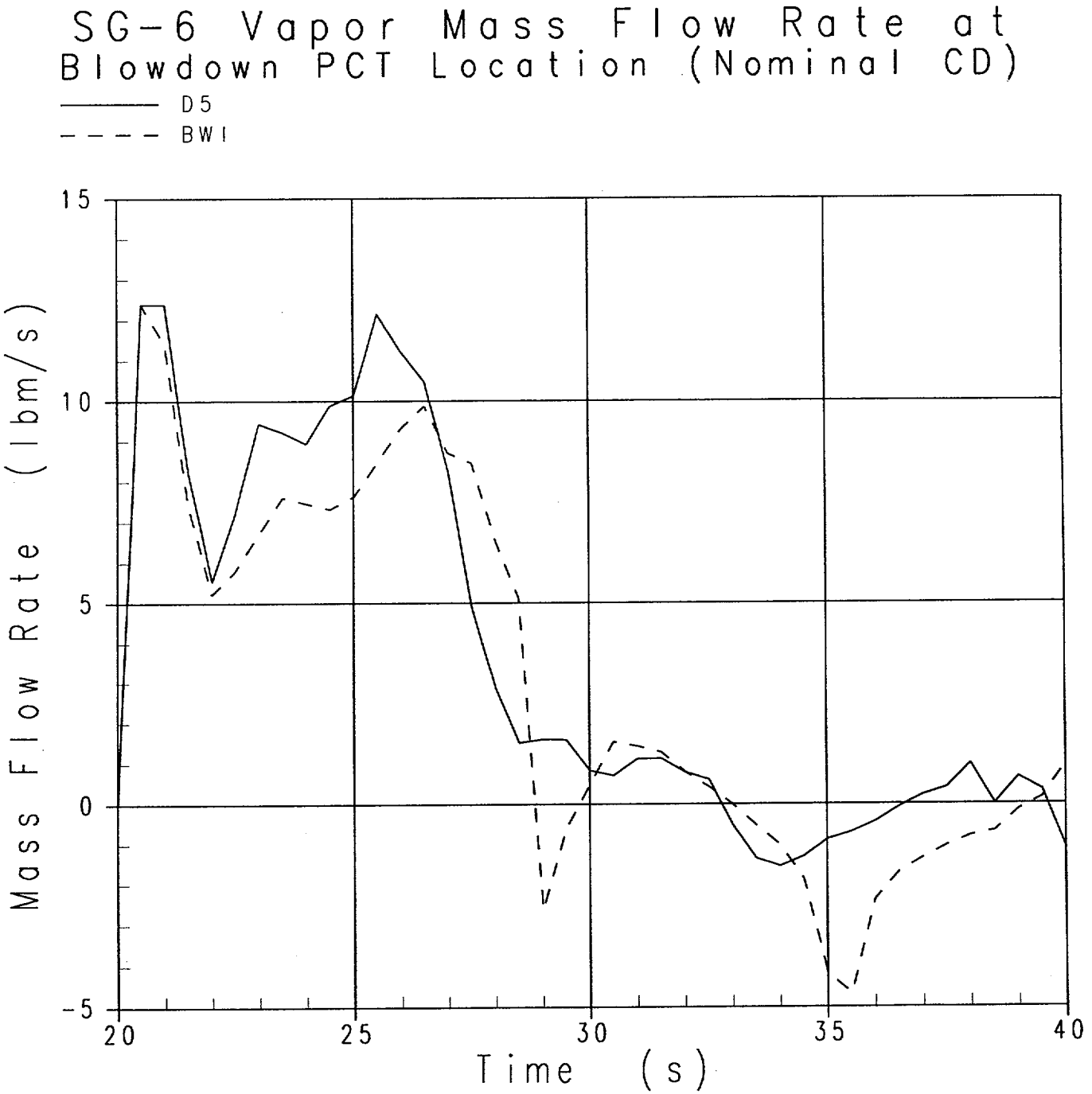

SG-1 Pressure Response (Nominal CD)
D5
BWI
2500
2000
1500
1000
500
0
Pressure (psia)
20
40
60
80
100
Time (s)


SG-2 Break Flow Rate on Vessel Side
(Nominal CD)
D5
BWI
20000
10000
0
-10000
-20000
-30000
-40000
-50000
-60000
Mass Flow Rate (lbm/sec)
20
25
30
35
40
45
50
Time (s)

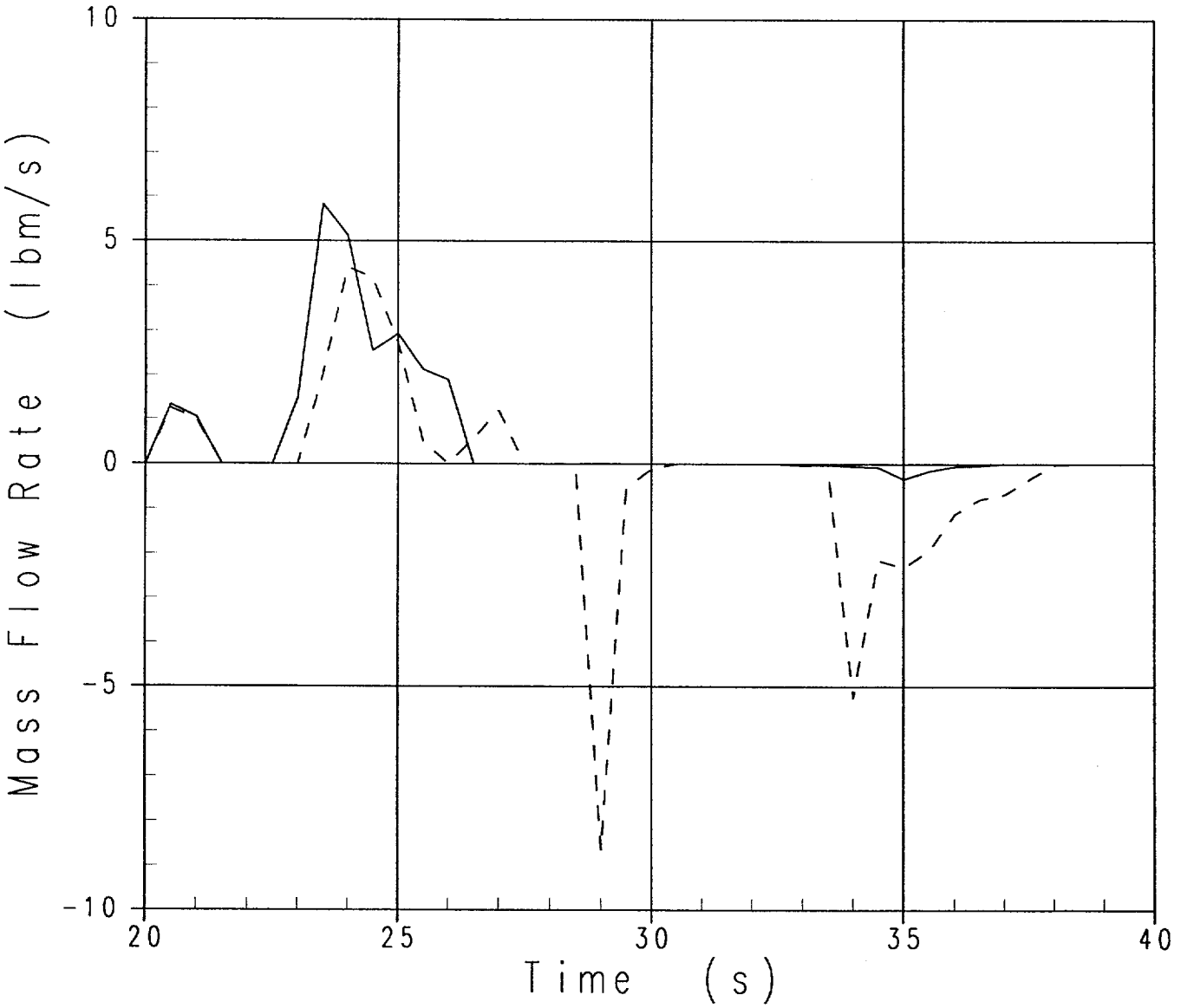

SG-3 Collapsed Liquid Level in Hot Assembly
(Nominal CD)
D5
BWI
Collapsed Liquid Level (ft)
0
2
4
6
8
10
12
0
50
100
150
200
250
300
350
Time (s)

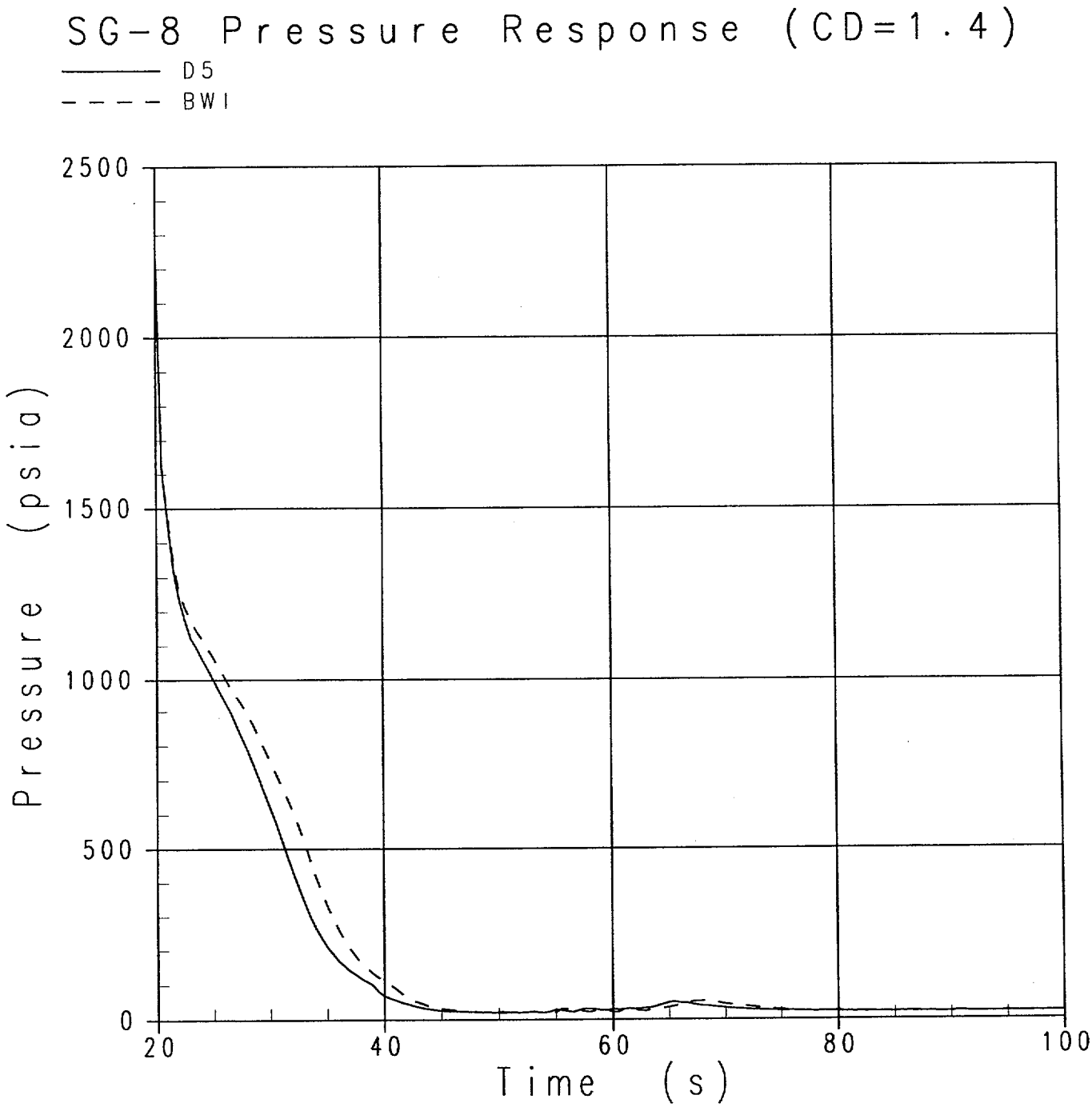

SG-4 Total Liquid Flow at Bottom of Hot Assembly (Nominal CD)
D5
BWI
200
150
100
50
0
-50
-100
Mass Flow Rate (lbm/s)
20
25
30
35
40
Time (s)

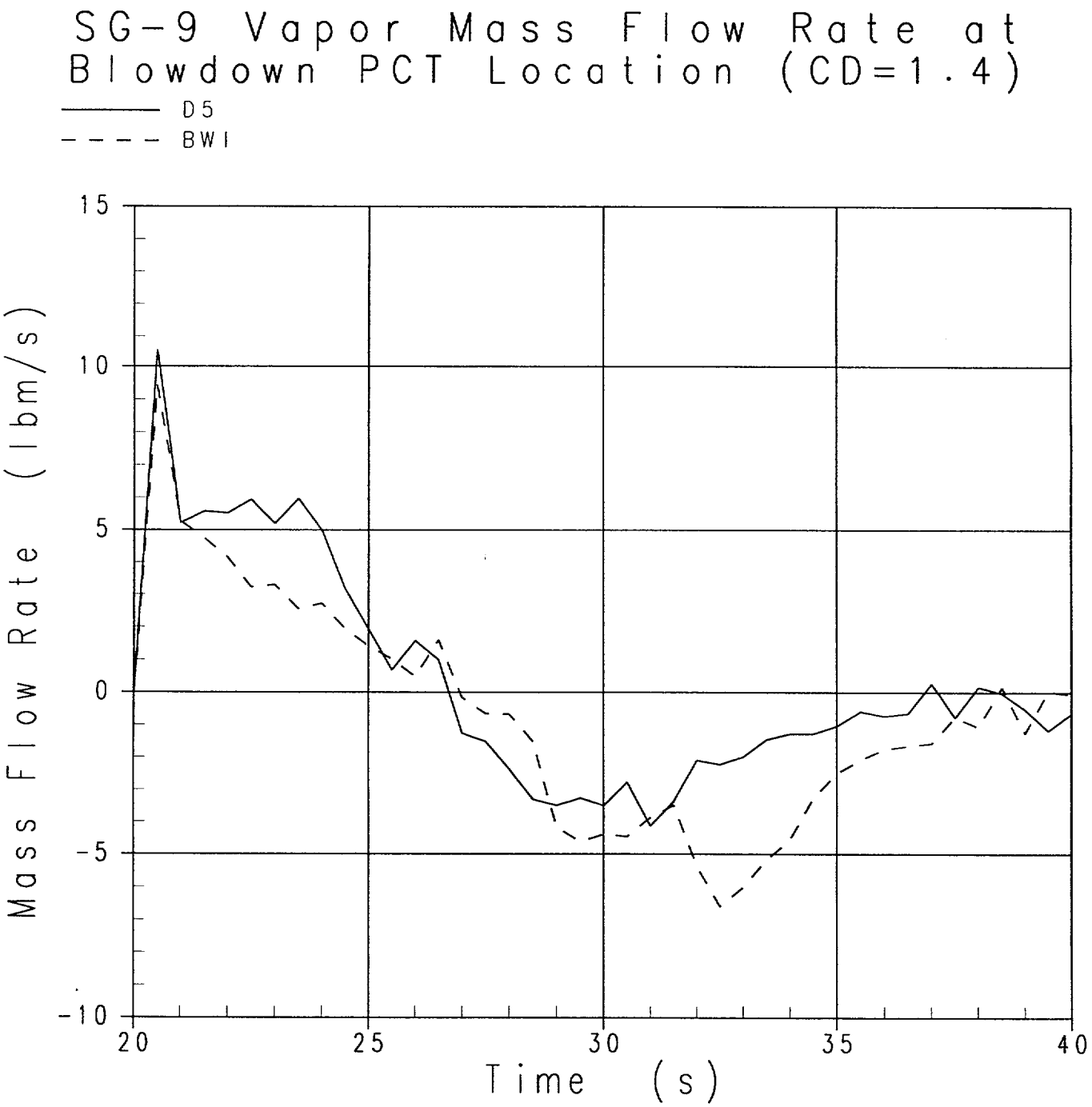

SG-5 Peak Clad Temperature (Nominal CD)
D5
BWI
1800
1600
1400
1200
1000
800
600
Temperature (F)
0
50
100
150
200
250
300
350
Time (s)


SG-6 Vapor Mass Flow Rate at
Blowdown PCT Location (Nominal CD)
D5
BWI
15
10
5
0
-5
Mass Flow Rate (lbm/s)
20
25
30
35
40
Time (s)

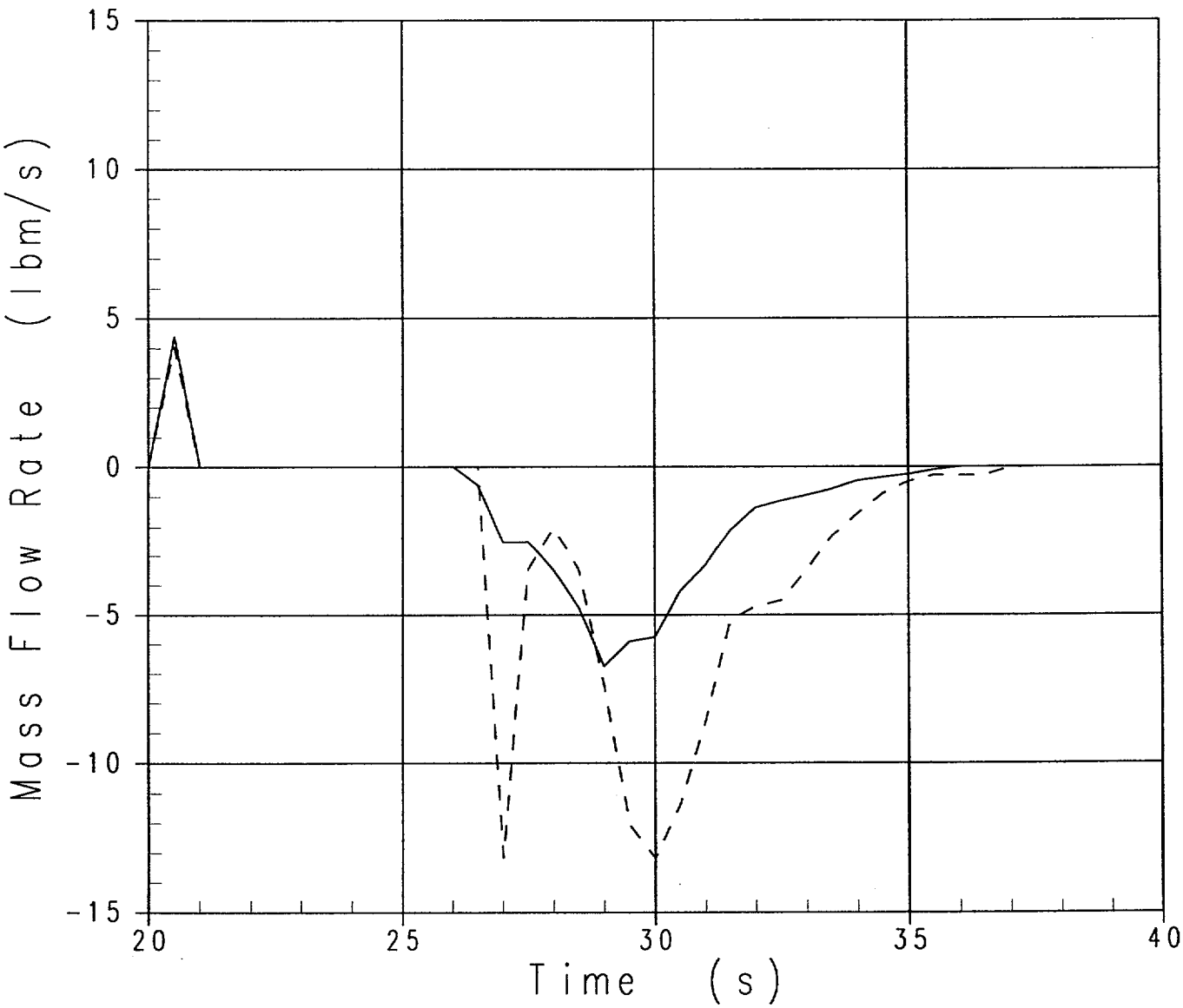
SG-7 Entrained Liquid Flow Rate at Blowdown PCT Location (Nominal CD)

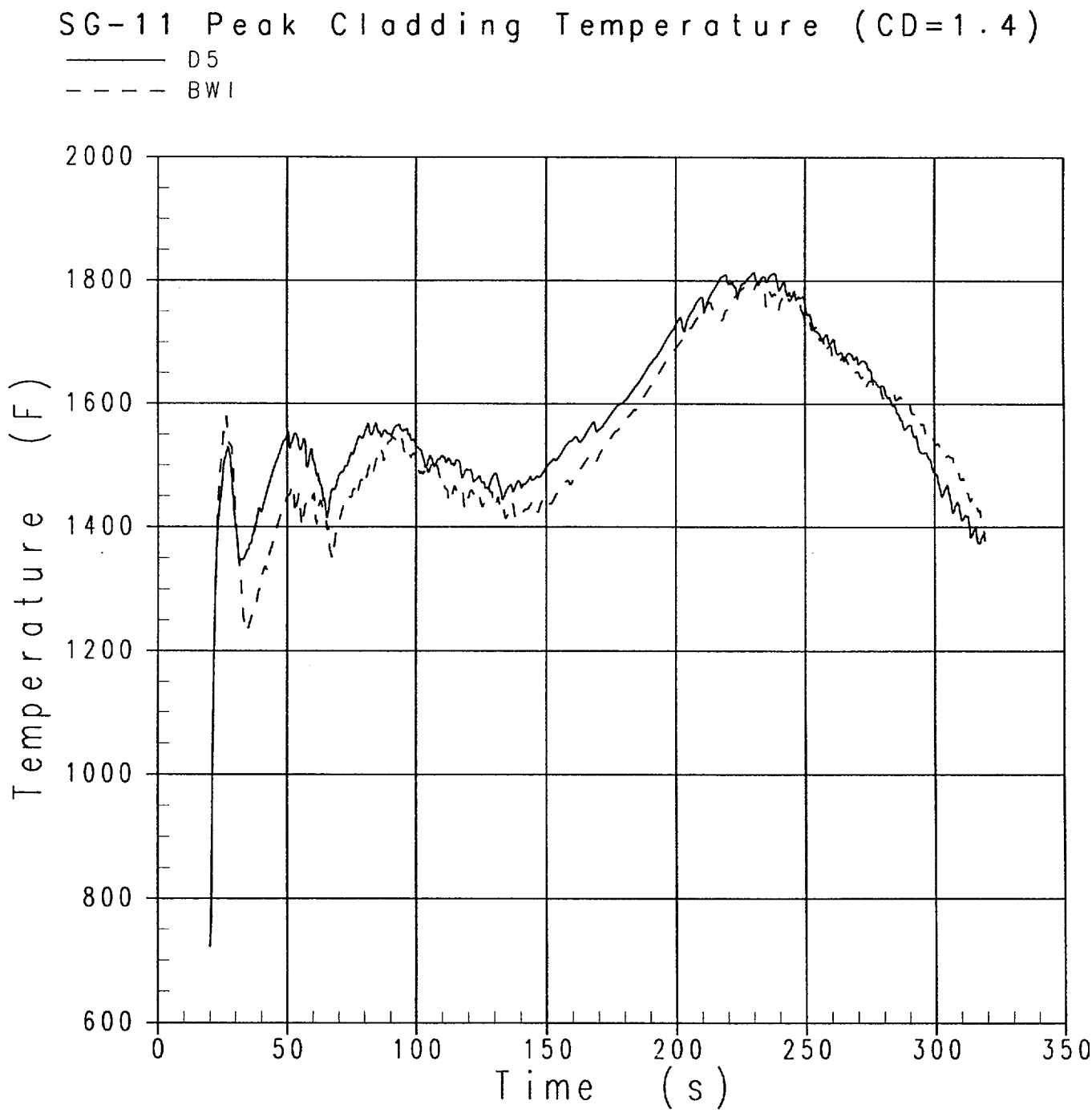



SG-8 Pressure Response (CD=1.4)
D5
BWI
2500
2000
1500
1000
500
0
Pressure (psia)
20
40
60
80
100
Time (s)


SG-9 Vapor Mass Flow Rate at Blowdown PCT Location (CD=1.4)
D5
BWI
15
10
5
0
-5
-10
Mass Flow Rate (lbm/s)
20
25
30
35
40
Time (s)

SG-10 Entrained Liquid Flow Rate at Blowdown PCT Location (CD=1.4)




SG-11 Peak Cladding Temperature (CD=1.4)
D5
BWI
2000
1800
1600
1400
1200
1000
800
600
Temperature (F)
0
50
100
150
200
250
300
350
Time (s)

ACCUMULATOR LINE RESISTANCE STUDY

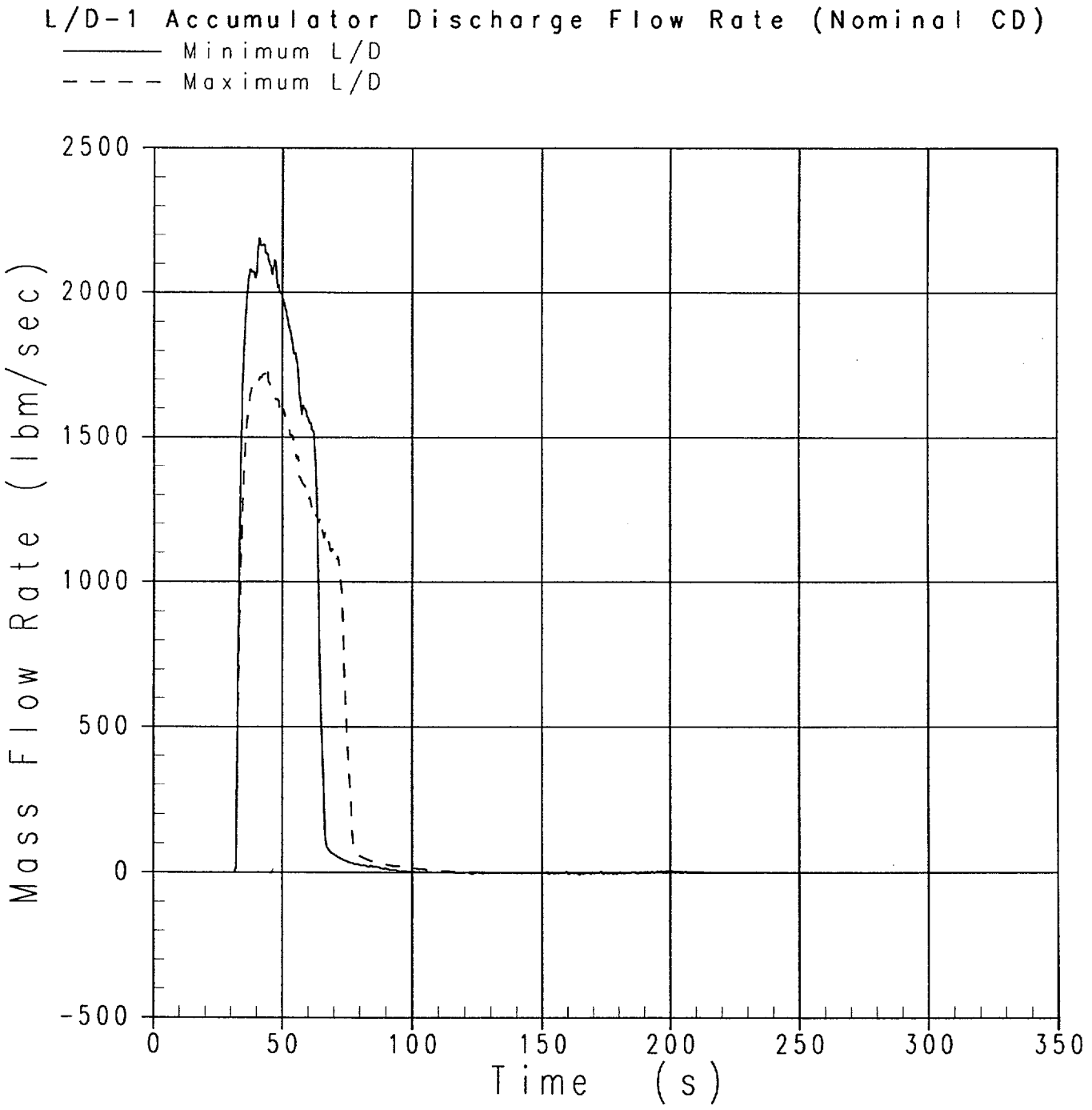
INCREASED RESISTANCE PROLONGS INJECTION (FIGURE L/D-1)

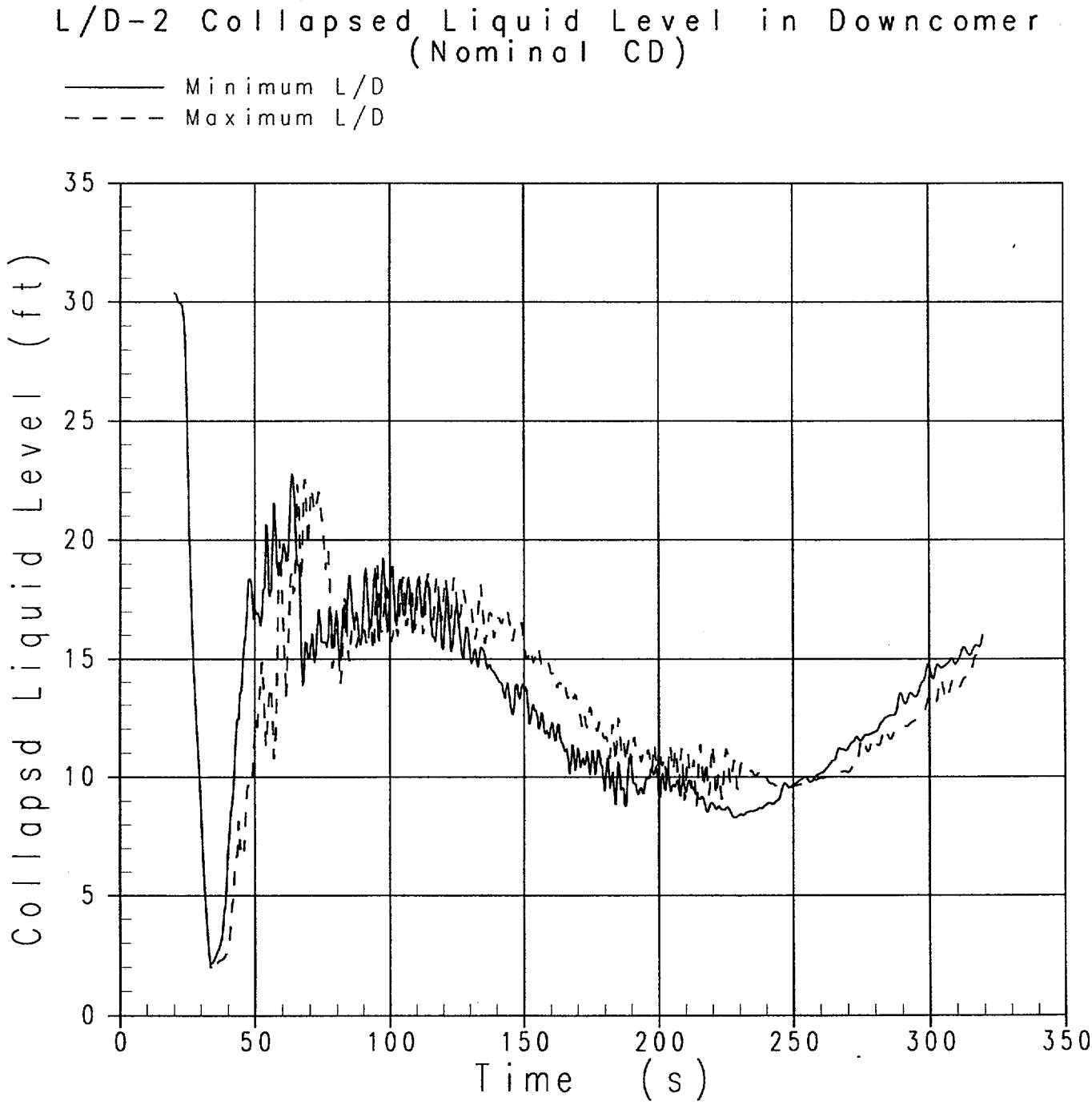
DELAY IN ONSET OF REFLOOD RESULTS IN PCT PENALTY IN EARLY REFLOOD (FIGURES L/D-2 TO L/D-4)

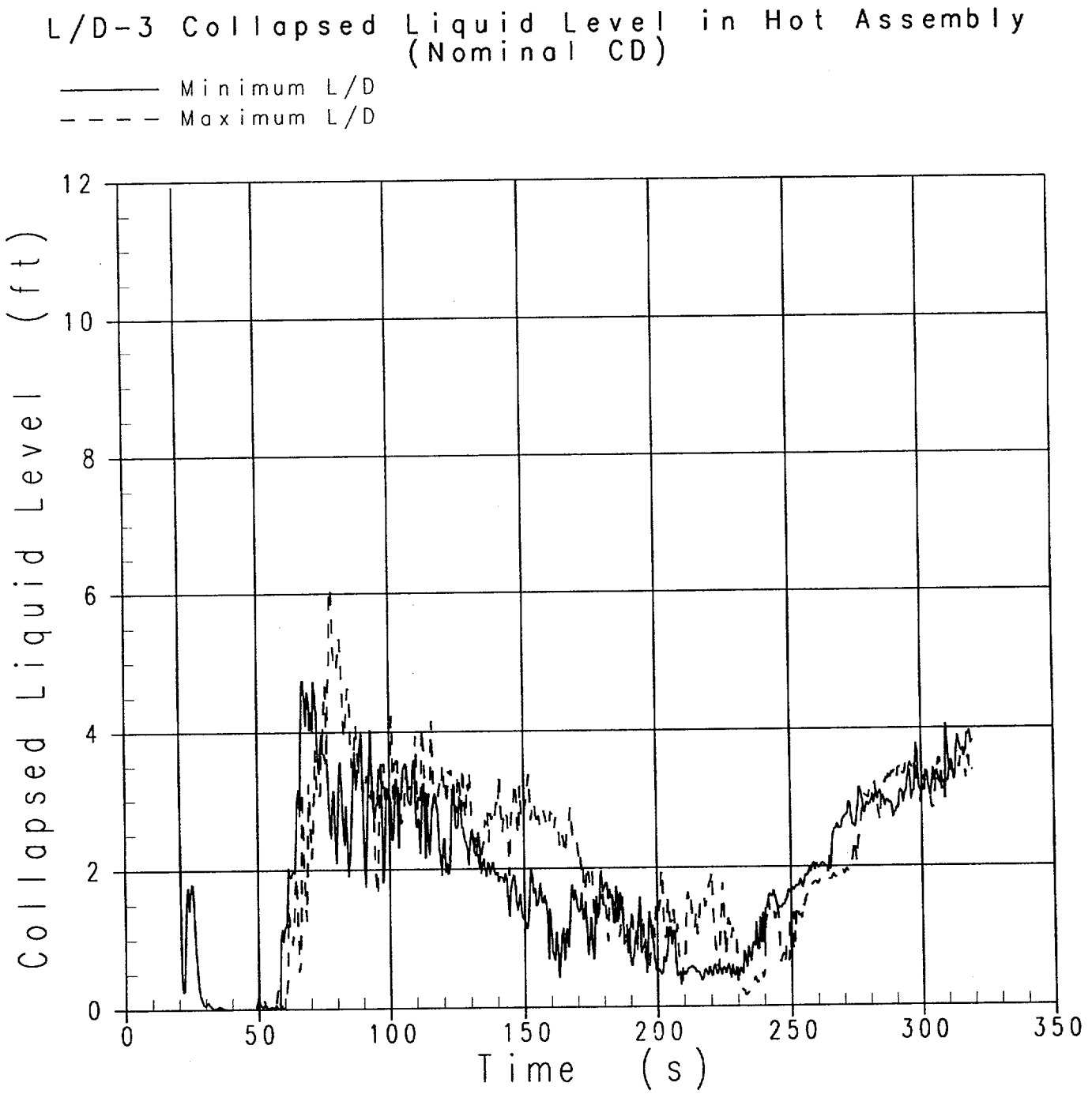
CORRESPONDING DELAY IN DOWNCOMER BOILING RESULTS IN PCT BENEFIT IN LATE REFLOOD

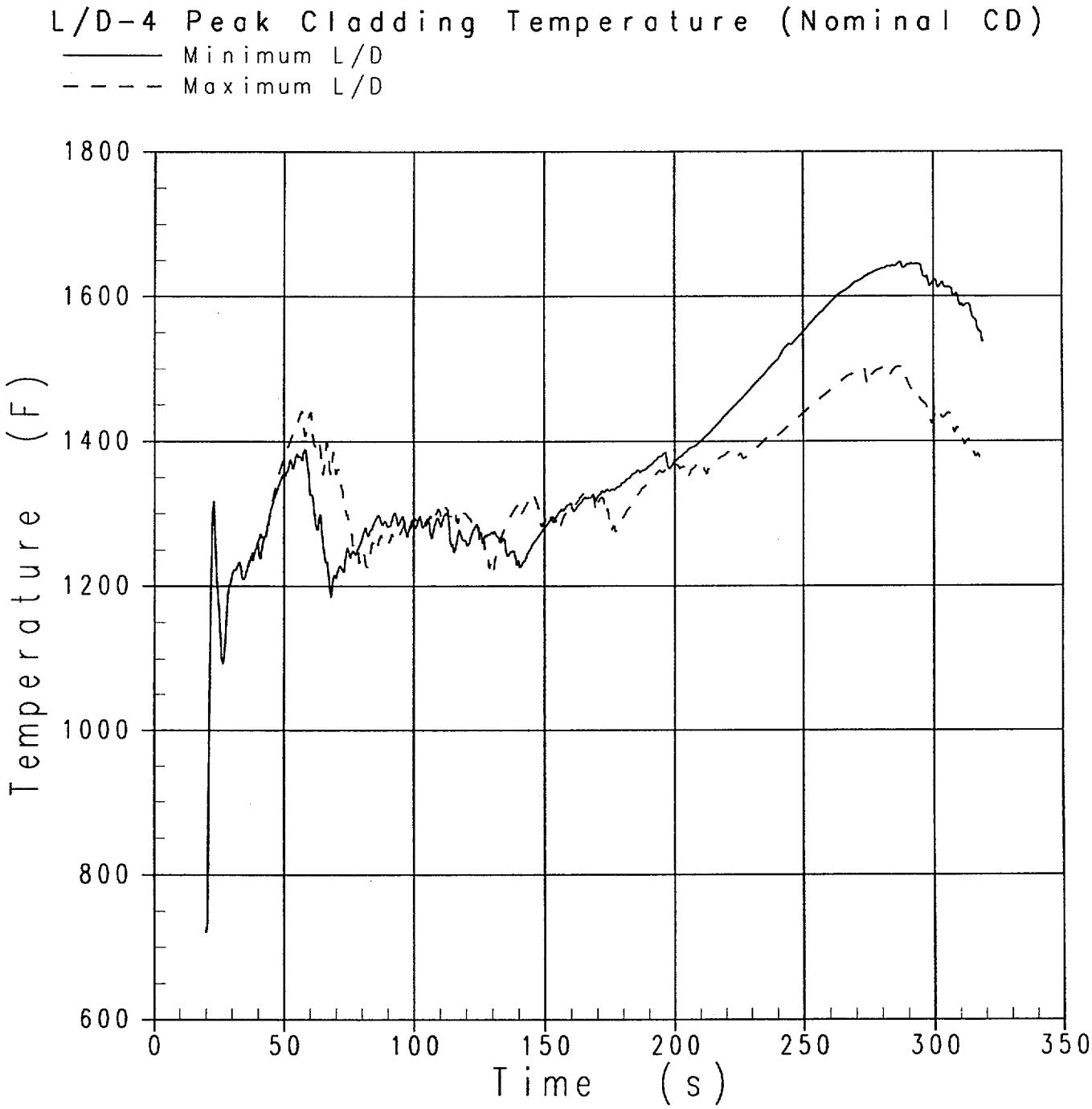
CONSISTENT RESPONSE SEEN FOR REFERENCE TRANSIENT AND CD=1.4 CASE (FIGURES L/D-5 TO L/D-8)

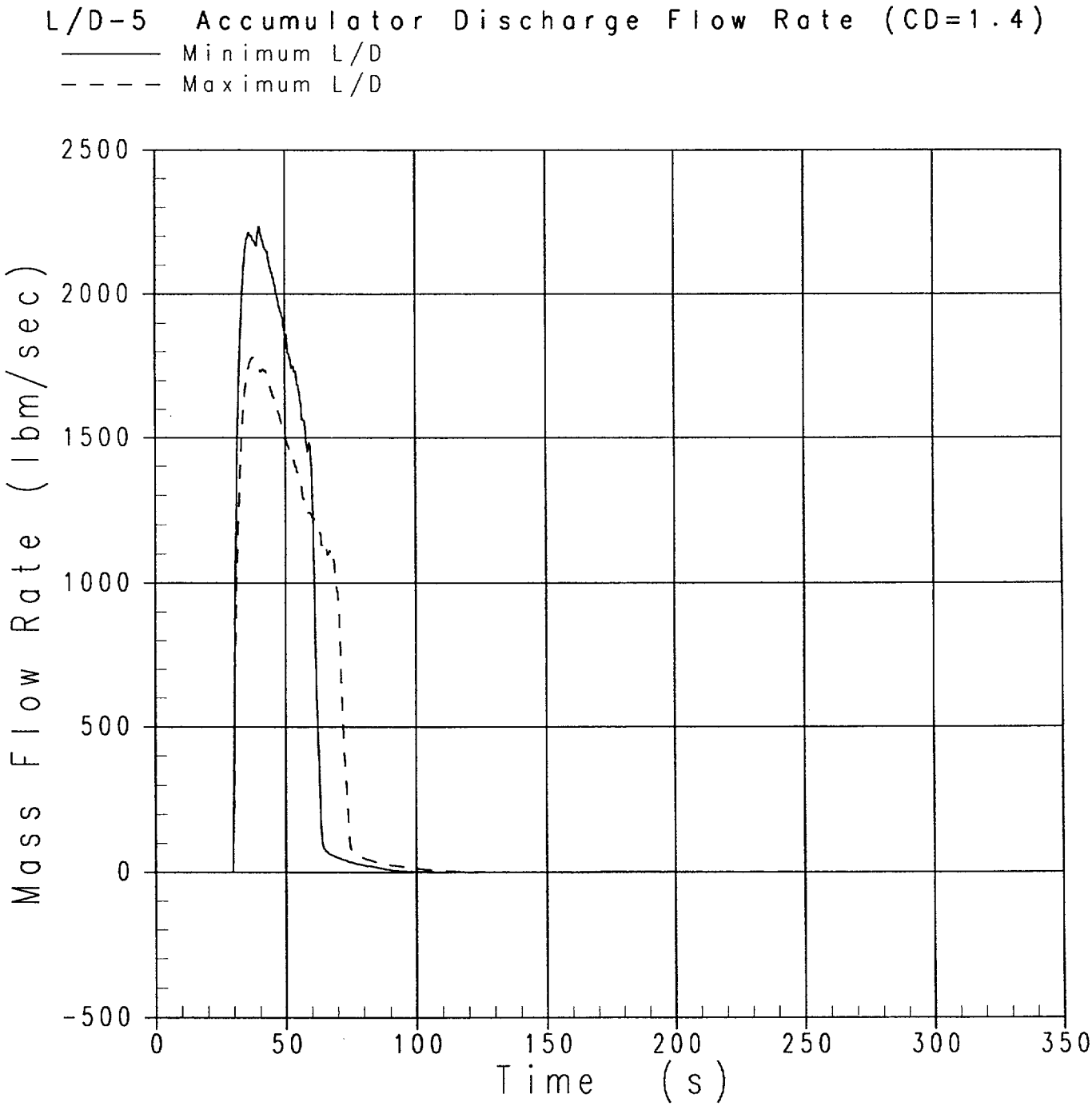
- ⇨ **MINIMUM LINE RESISTANCE (MCGUIRE 2) CONFIRMED AS APPROPRIATE FOR BOUNDING CONFIGURATION**

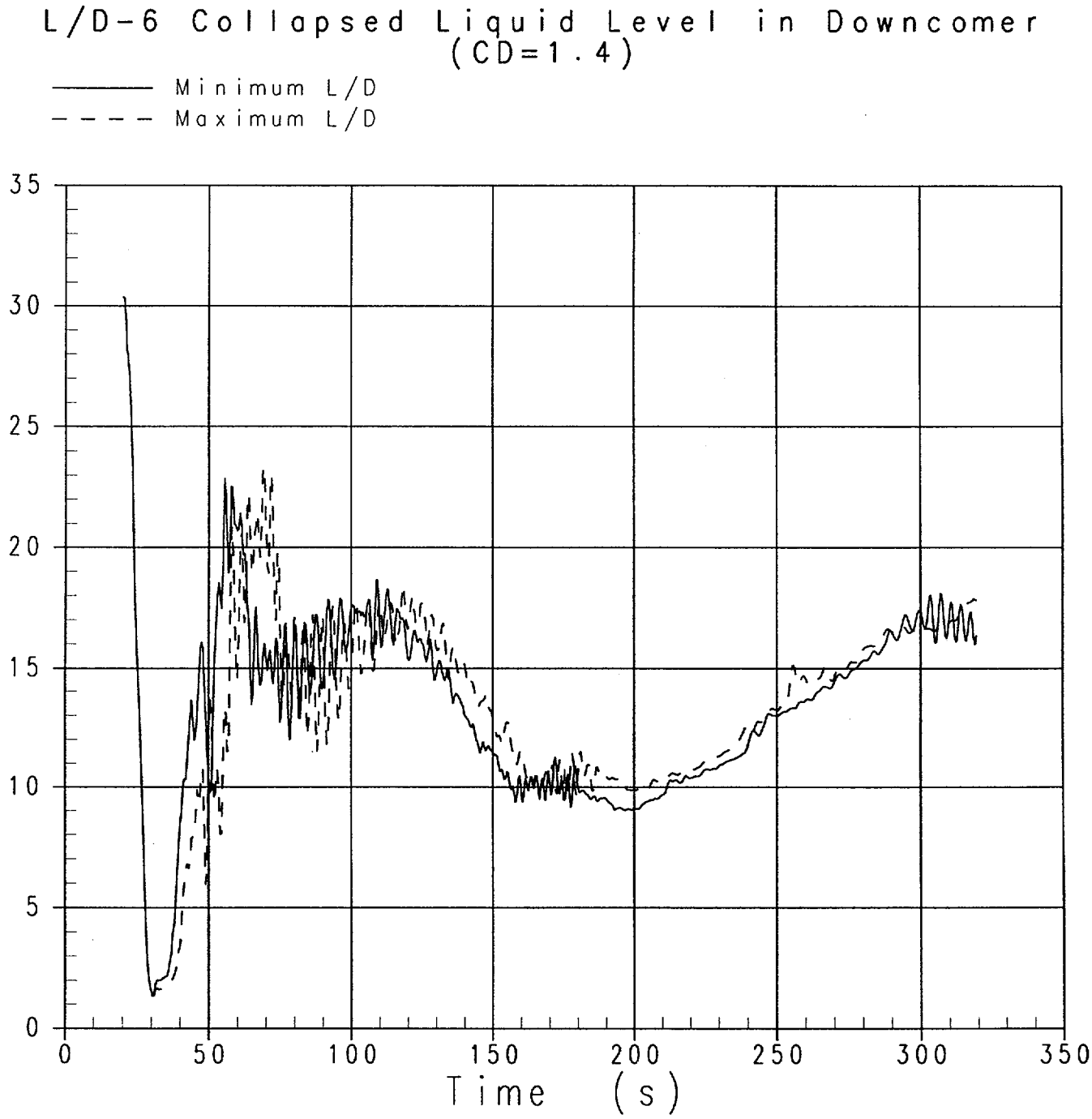

L/D-1 Accumulator Discharge Flow Rate (Nominal CD)
Minimum L/D
Maximum L/D
Mass Flow Rate (lbm/sec)
2500
2000
1500
1000
500
0
-500
0
50
100
150
200
250
300
350
Time (s)

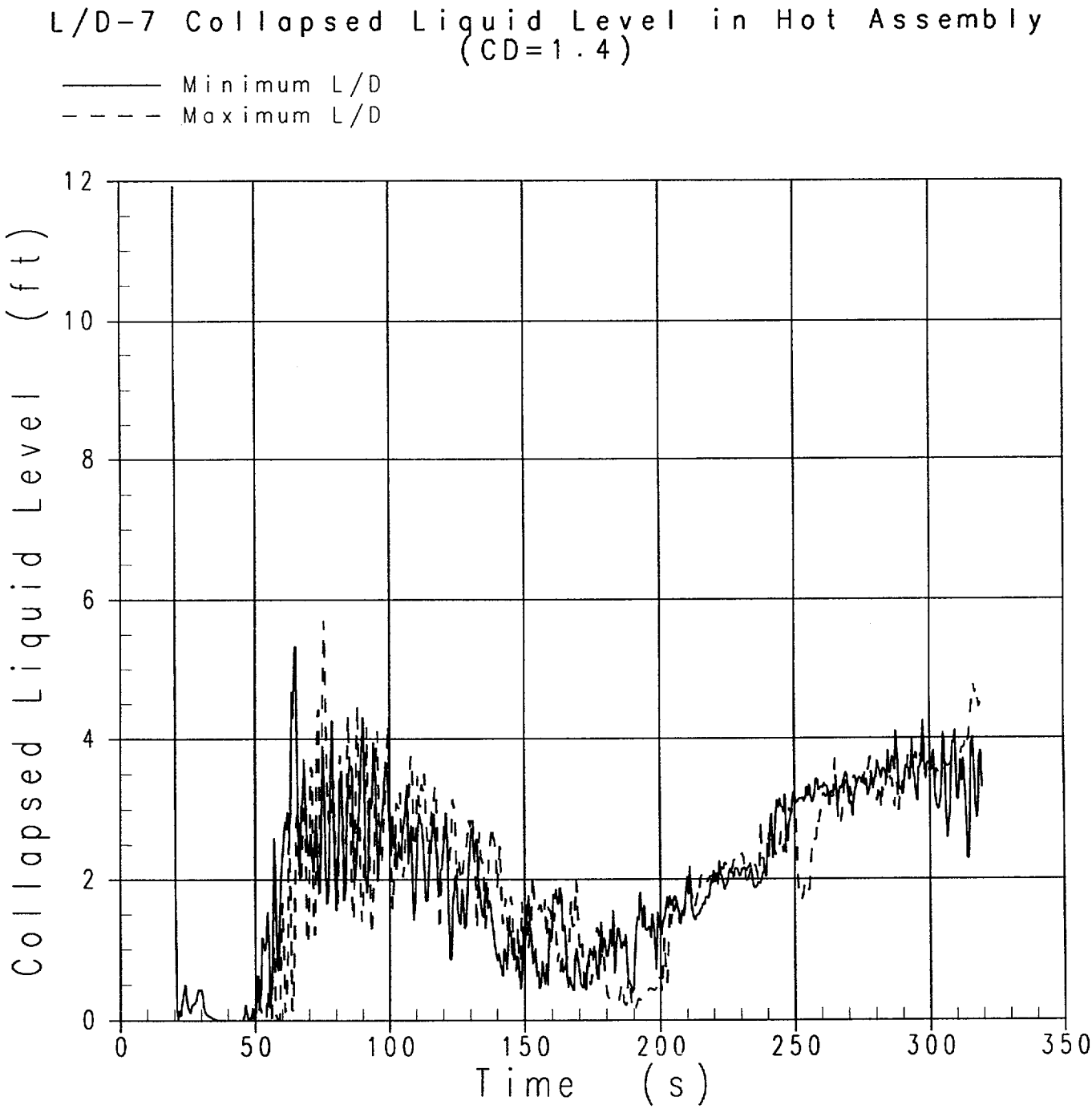

L/D-2 Collapsed Liquid Level in Downcomer
(Nominal CD)
Minimum L/D
Maximum L/D
Collapsd Liquid Level (ft)
35
30
25
20
15
10
5
0
0
50
100
150
200
250
300
350
Time (s)

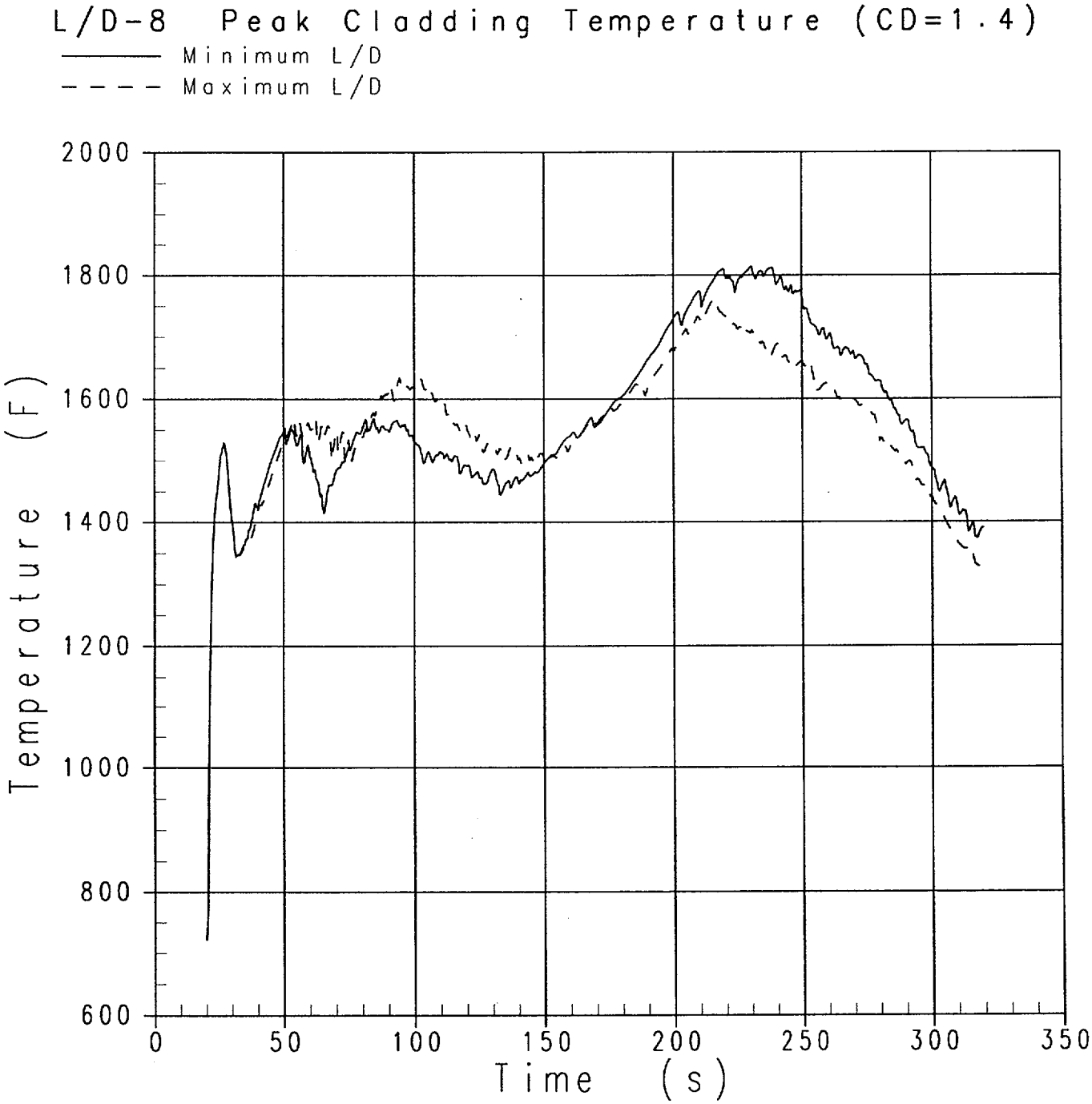

L/D-3 Collapsed Liquid Level in Hot Assembly
(Nominal CD)
Minimum L/D
Maximum L/D
Collapsed Liquid Level (ft)
0
2
4
6
8
10
12
0
50
100
150
200
250
300
350
Time (s)


L/D-4 Peak Cladding Temperature (Nominal CD)
Minimum L/D
Maximum L/D
1800
1600
1400
1200
1000
800
600
Temperature (F)
0
50
100
150
200
250
300
350
Time (s)


L/D-5 Accumulator Discharge Flow Rate (CD=1.4)
Minimum L/D
Maximum L/D
Mass Flow Rate (lbm/sec)
2500
2000
1500
1000
500
0
-500
0
50
100
150
200
250
300
350
Time (s)


L/D-6 Collapsed Liquid Level in Downcomer
(CD=1.4)
Minimum L/D
Maximum L/D
35
30
25
20
15
10
5
0
0
50
100
150
200
250
300
350
Time (s)


L/D-7 Collapsed Liquid Level in Hot Assembly
(CD=1.4)
Minimum L/D
Maximum L/D
Collapsed Liquid Level (ft)
0
2
4
6
8
10
12
0
50
100
150
200
250
300
350
Time (s)


L/D-8 Peak Cladding Temperature (CD=1.4)
Minimum L/D
Maximum L/D
2000
1800
1600
1400
1200
1000
800
600
Temperature (F)
0
50
100
150
200
250
300
350
Time (s)

ACCUMULATOR WATER VOLUME STUDY

INCREASED WATER VOLUME (DECREASED GAS VOLUME) PROLONGS INJECTION (FIGURE VOL-1)

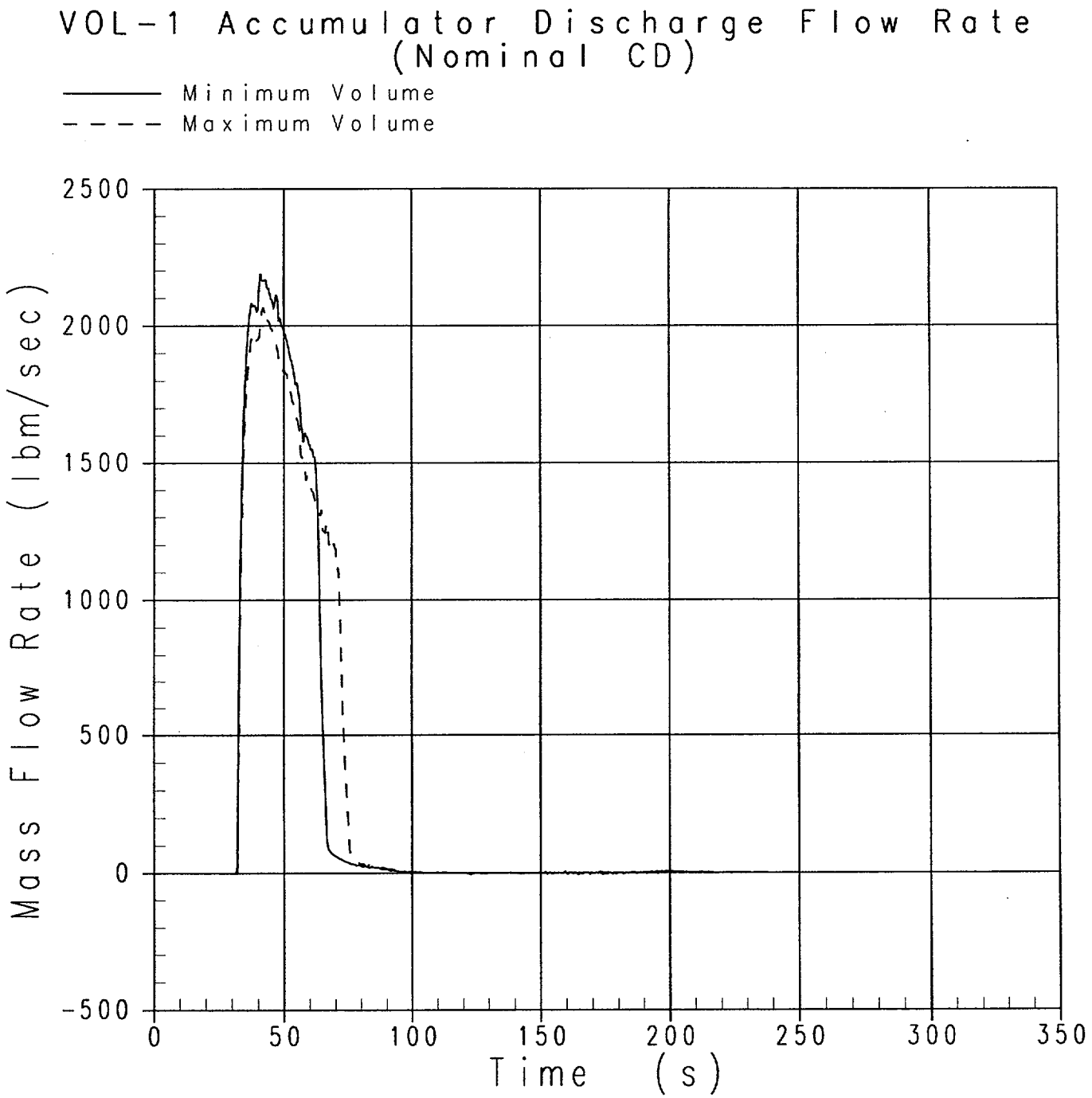
REFERENCE TRANSIENT RESPONSE COMPARABLE TO ACCUMULATOR LINE RESISTANCE STUDY (FIGURES VOL-2 TO VOL-4)

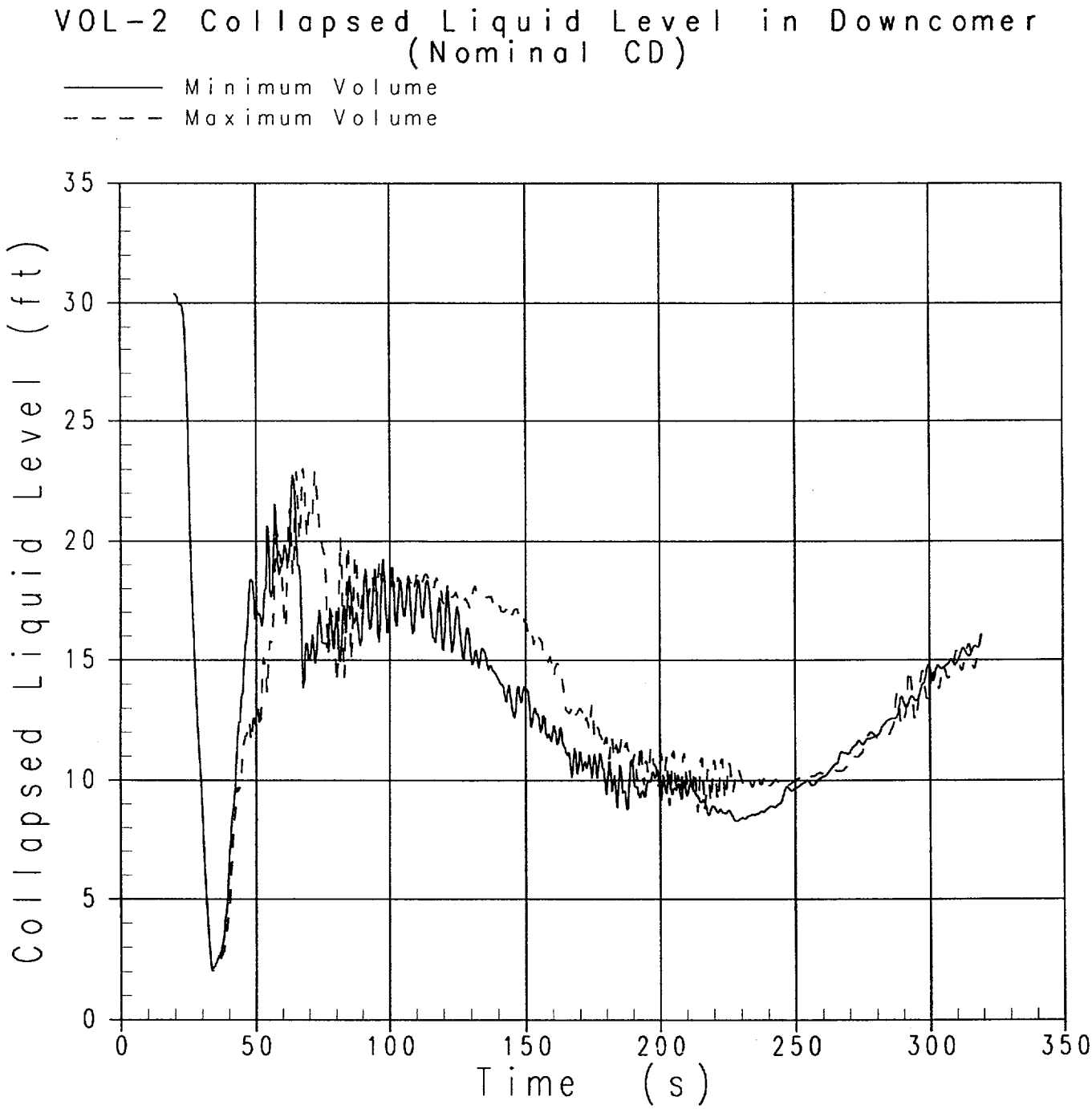
- DELAY IN ONSET OF REFLOOD RESULTS IN PCT PENALTY IN EARLY REFLOOD
- CORRESPONDING DELAY IN DOWNCOMER BOILING RESULTS IN PCT BENEFIT IN LATE REFLOOD

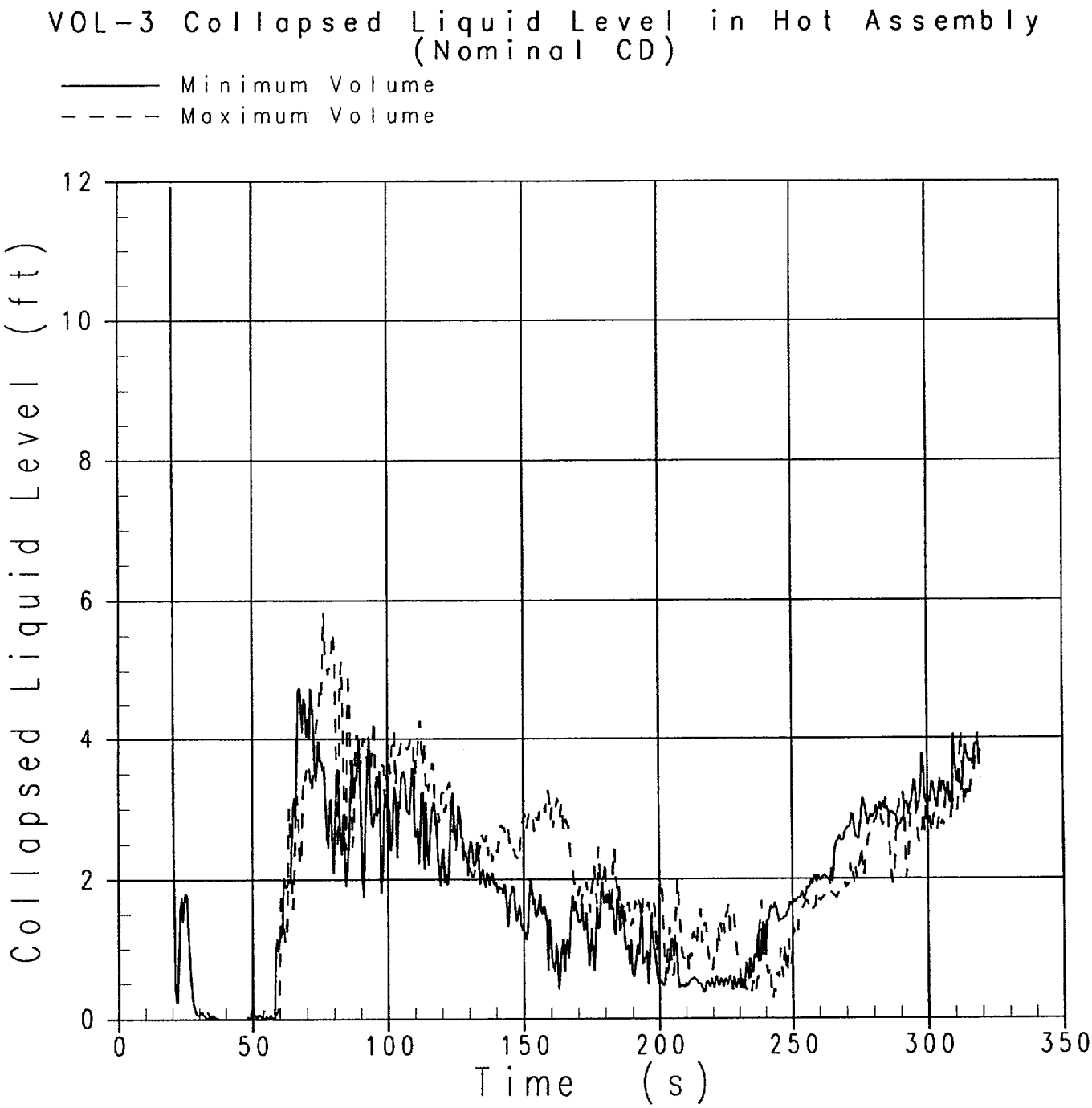
WATER IN DOWNCOMER ENTRAINED OUT OF BROKEN COLD LEG NOZZLE MORE EASILY FOR CD=1.4 CASE, RESULTING IN LITTLE CHANGE FOR REFLOOD BEHAVIOR (FIGURES VOL-5 TO VOL-8)

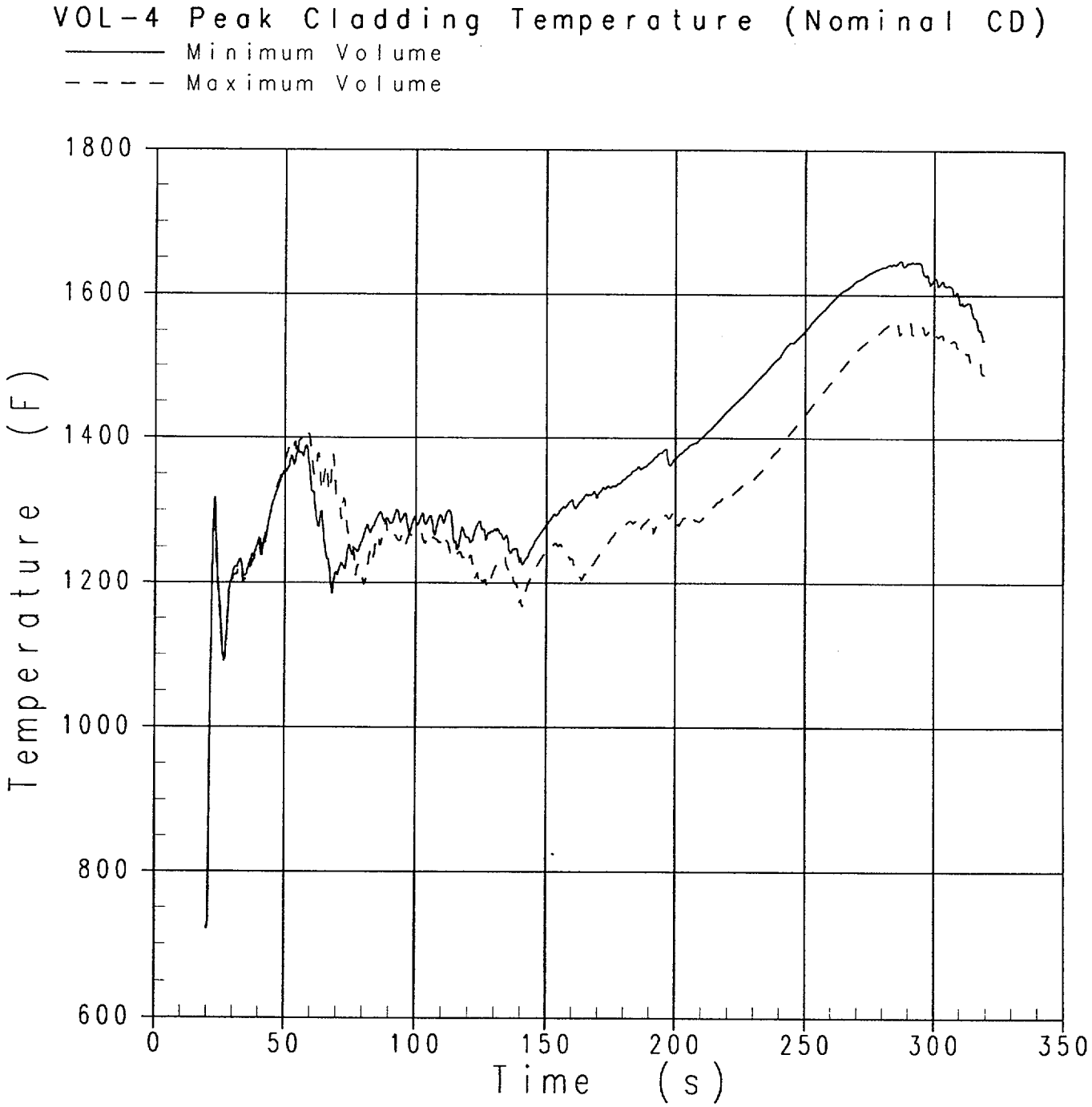
⇨ MINIMUM ACCUMULATOR WATER VOLUME CONFIRMED AS CONSERVATIVE FOR NOMINAL BREAK FLOWS, LITTLE EFFECT FOR MAXIMUM BREAK SIZE

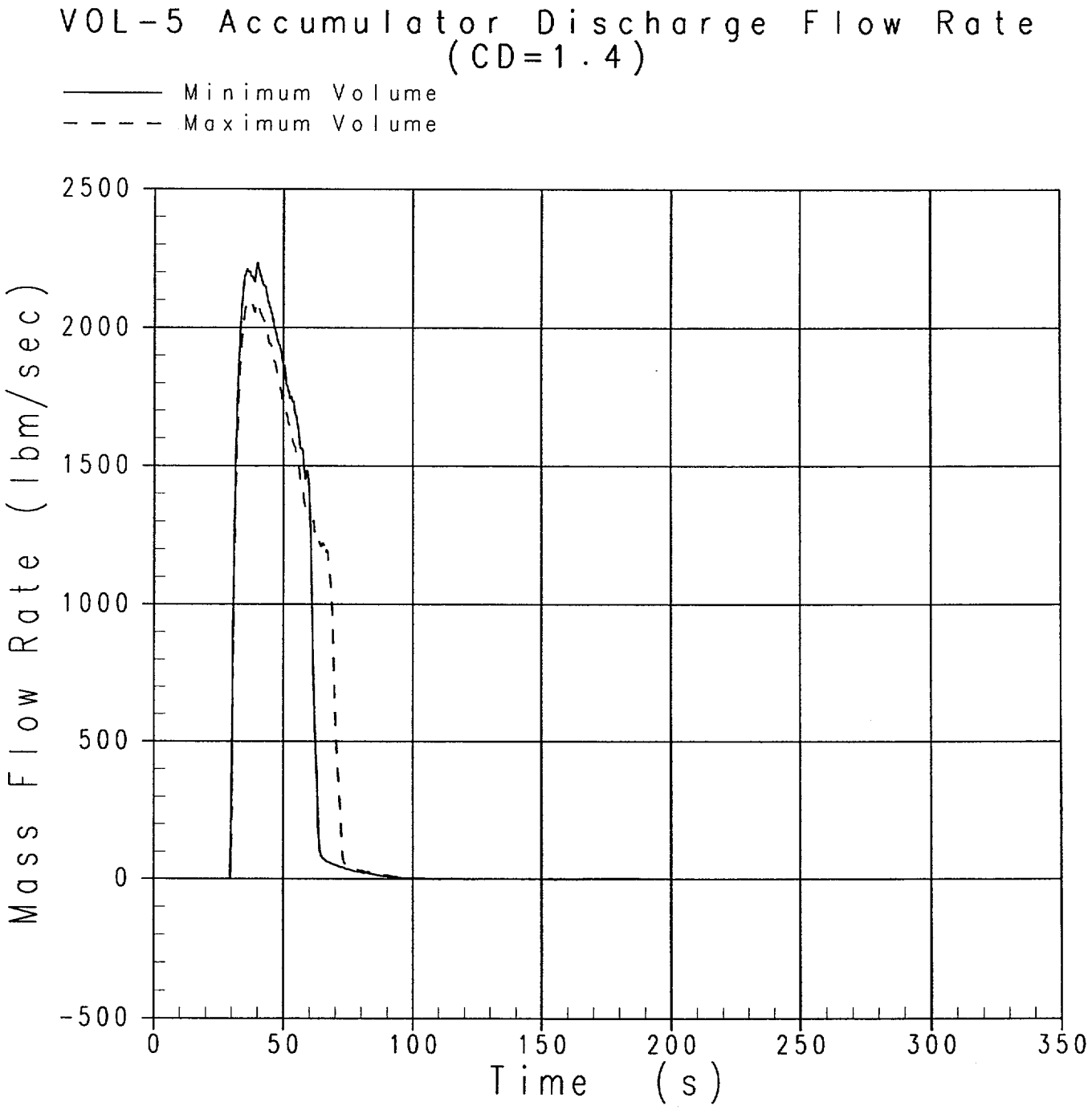
⇨ MINIMUM NOMINAL WATER VOLUME (M1/M2) WILL BE USED IN ANALYSIS, WITH VARIATIONS OVER M1/M2 RANGE CONSIDERED IN UNCERTAINTY ANALYSIS

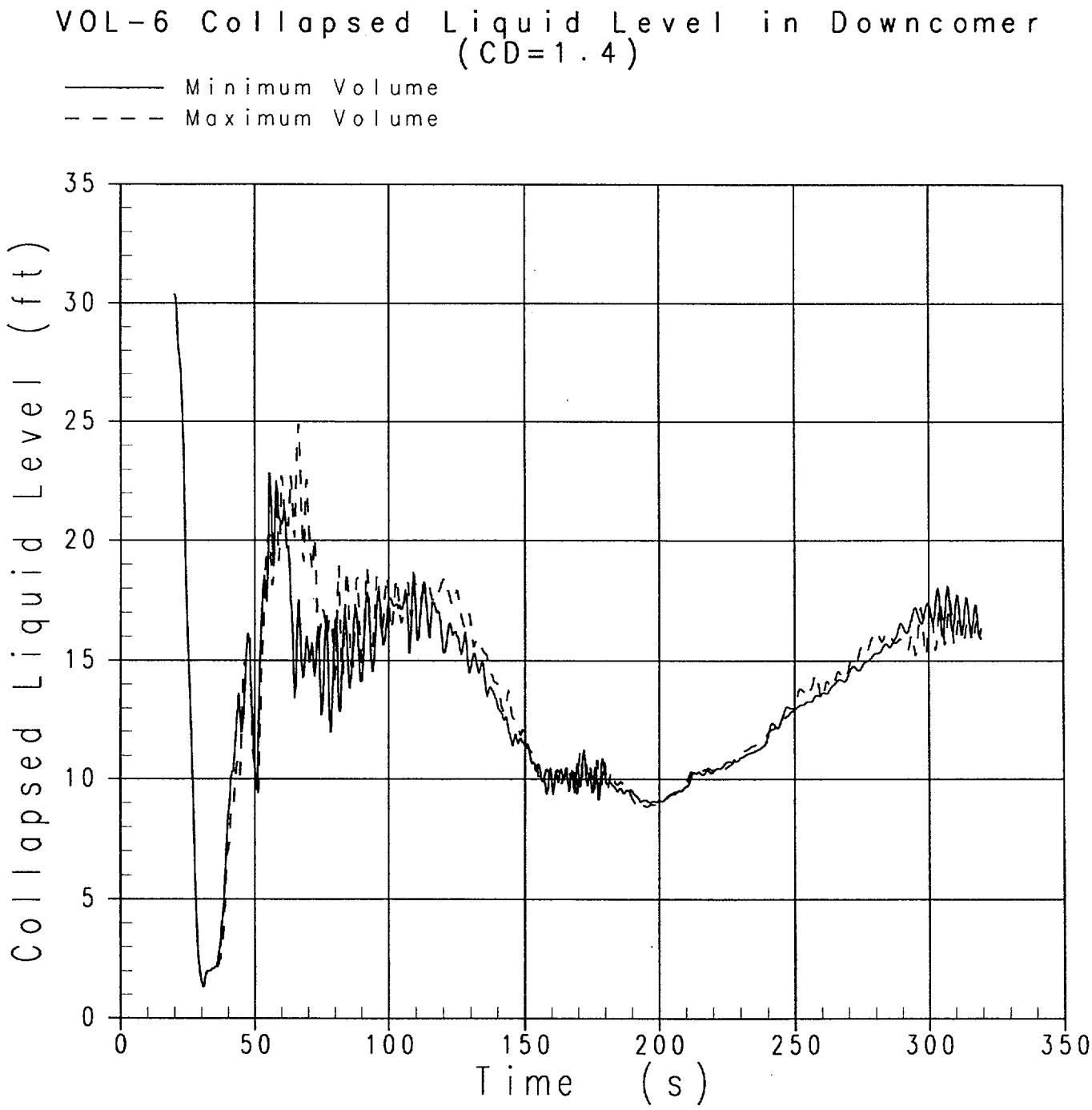

VOL-1 Accumulator Discharge Flow Rate
(Nominal CD)
Minimum Volume
Maximum Volume
Mass Flow Rate (lbm/sec)
2500
2000
1500
1000
500
0
-500
0
50
100
150
200
250
300
350
Time (s)

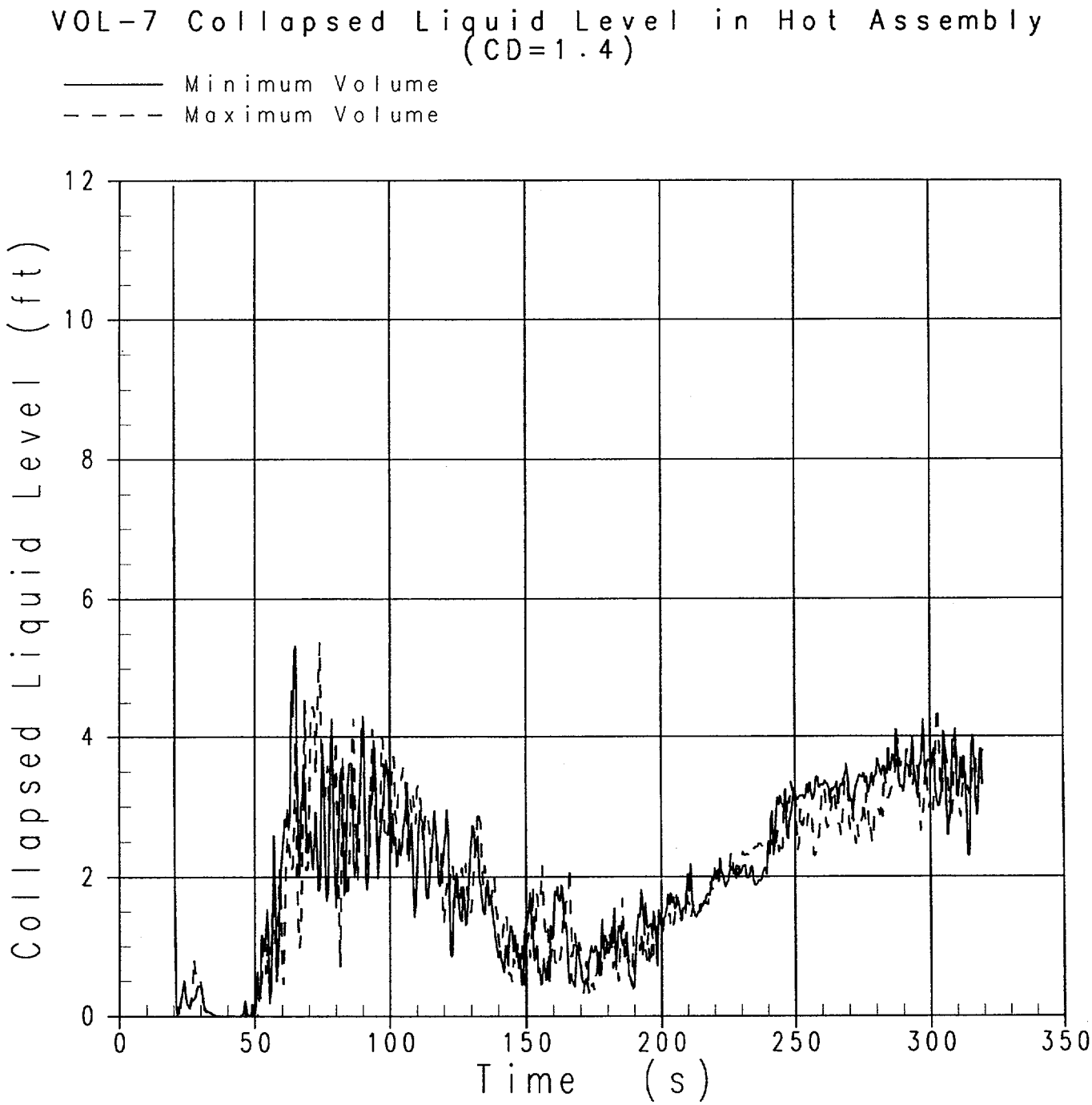

VOL-2 Collapsed Liquid Level in Downcomer
(Nominal CD)
Minimum Volume
Maximum Volume
Collapsed Liquid Level (ft)
35
30
25
20
15
10
5
0
0
50
100
150
200
250
300
350
Time (s)

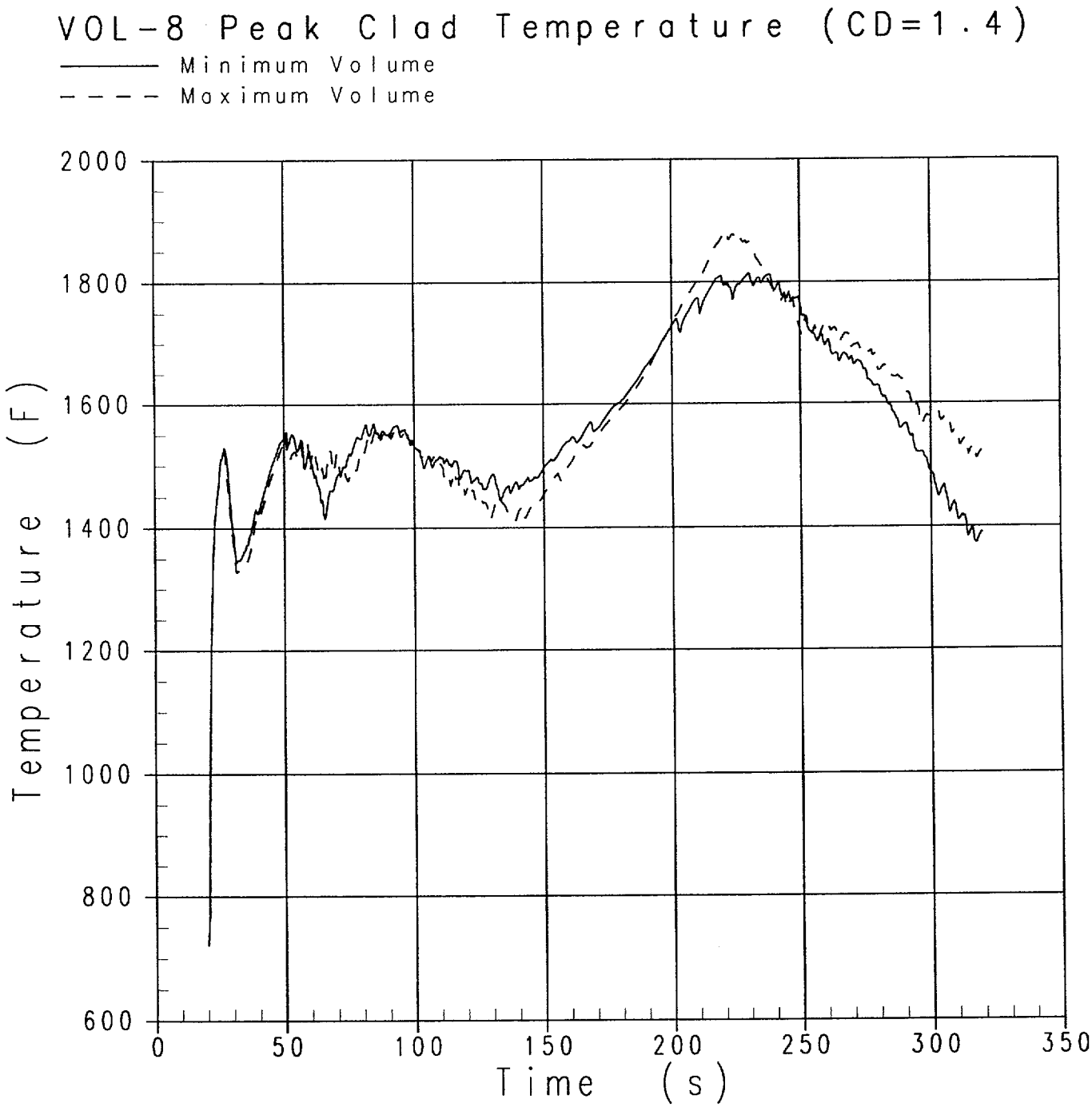

VOL-3 Collapsed Liquid Level in Hot Assembly
(Nominal CD)
Minimum Volume
Maximum Volume
Collapsed Liquid Level (ft)
0
2
4
6
8
10
12
0
50
100
150
200
250
300
350
Time (s)


VOL-4 Peak Cladding Temperature (Nominal CD)
Minimum Volume
Maximum Volume
1800
1600
1400
1200
1000
800
600
Temperature (F)
0
50
100
150
200
250
300
350
Time (s)


VOL-5 Accumulator Discharge Flow Rate
(CD=1.4)
Minimum Volume
Maximum Volume
Mass Flow Rate (lbm/sec)
2500
2000
1500
1000
500
0
-500
0
50
100
150
200
250
300
350
Time (s)


VOL-6 Collapsed Liquid Level in Downcomer
(CD=1.4)
Minimum Volume
Maximum Volume
Collapsed Liquid Level (ft)
35
30
25
20
15
10
5
0
0
50
100
150
200
250
300
350
Time (s)


VOL-7 Collapsed Liquid Level in Hot Assembly
(CD=1.4)
Minimum Volume
Maximum Volume
Collapsed Liquid Level (ft)
0
2
4
6
8
10
12
0
50
100
150
200
250
300
350
Time (s)


VOL-8 Peak Clad Temperature (CD=1.4)
Minimum Volume
Maximum Volume
2000
1800
1600
1400
1200
1000
800
600
Temperature (F)
0
50
100
150
200
250
300
350
Time (s)

VESSEL DESIGN STUDY

OVERALL SYSTEM BEHAVIOR VIRTUALLY IDENTICAL (FIGURES VES-1 & VES-2)

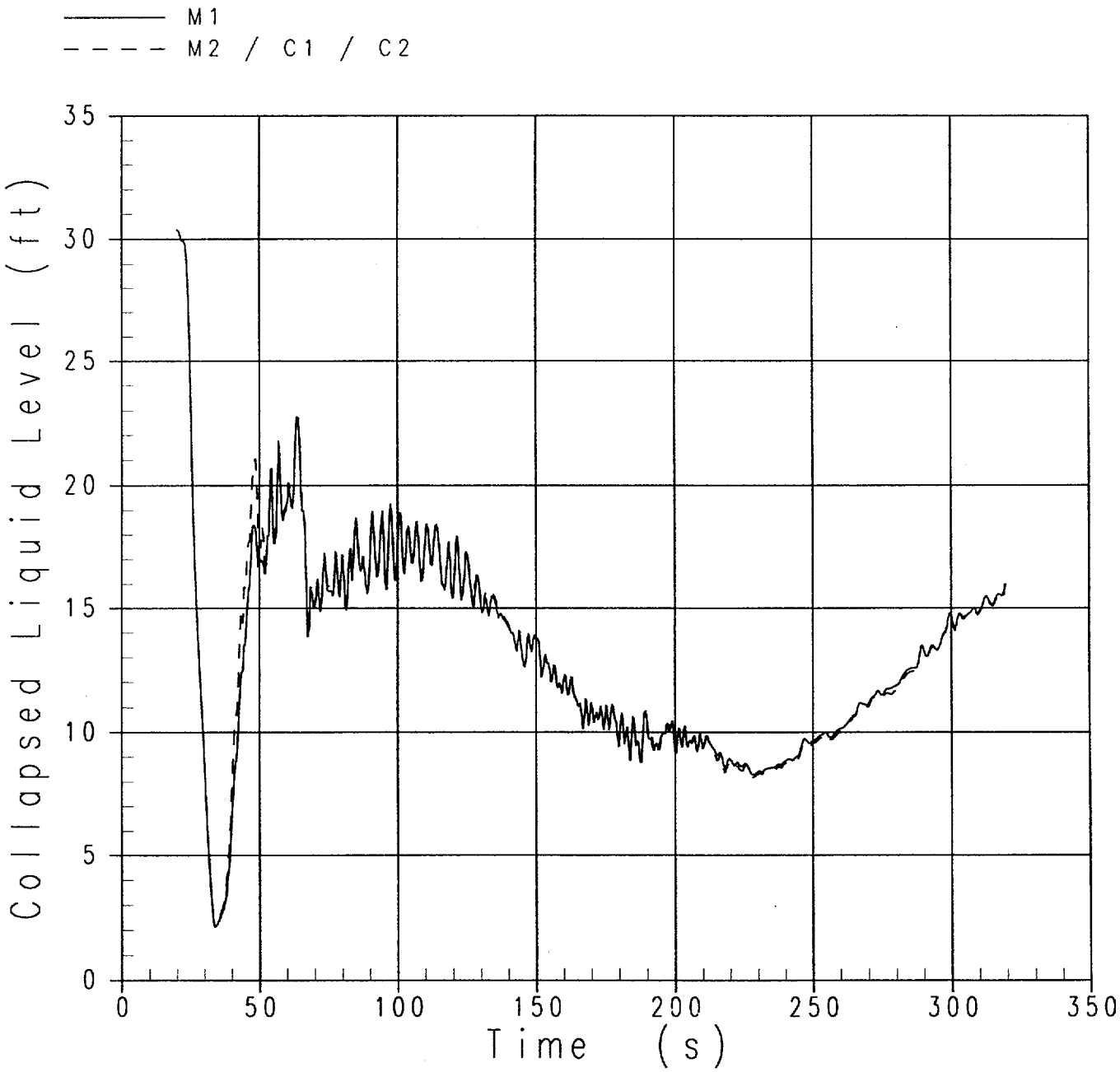
TEMPORARY INCREASE IN UPFLOW COOLING IN M2/C1/C2 VESSEL MODEL INTRODUCES PCT BENEFIT IN FIRST 5 SEC WHICH IS MAINTAINED THROUGHOUT TRANSIENT (FIGURES VES-3 TO VES-5)

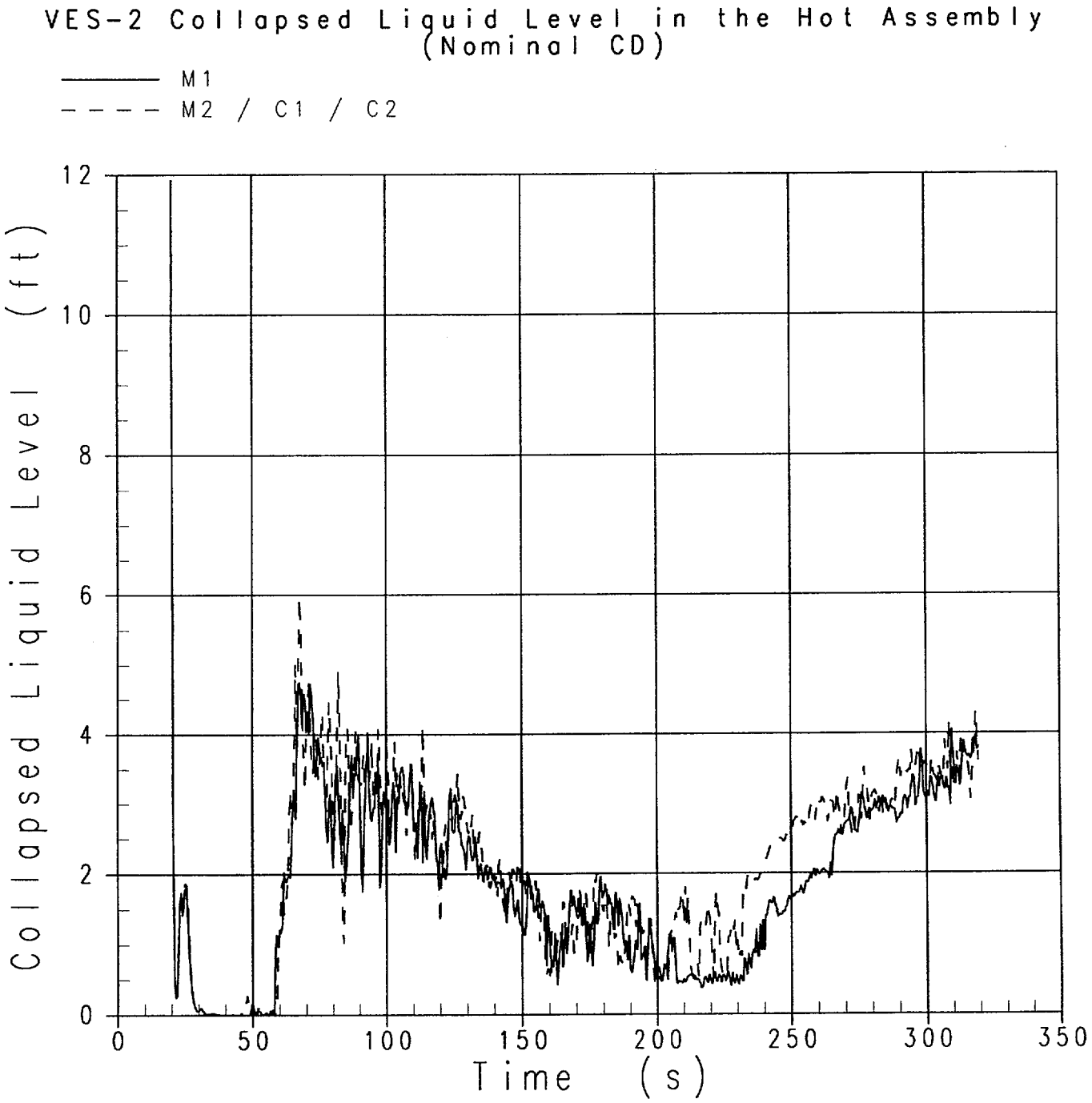
CONSISTENT RESPONSE SEEN FOR REFERENCE TRANSIENT AND CD=1.4 CASE (FIGURES VES-6 TO VES-9)

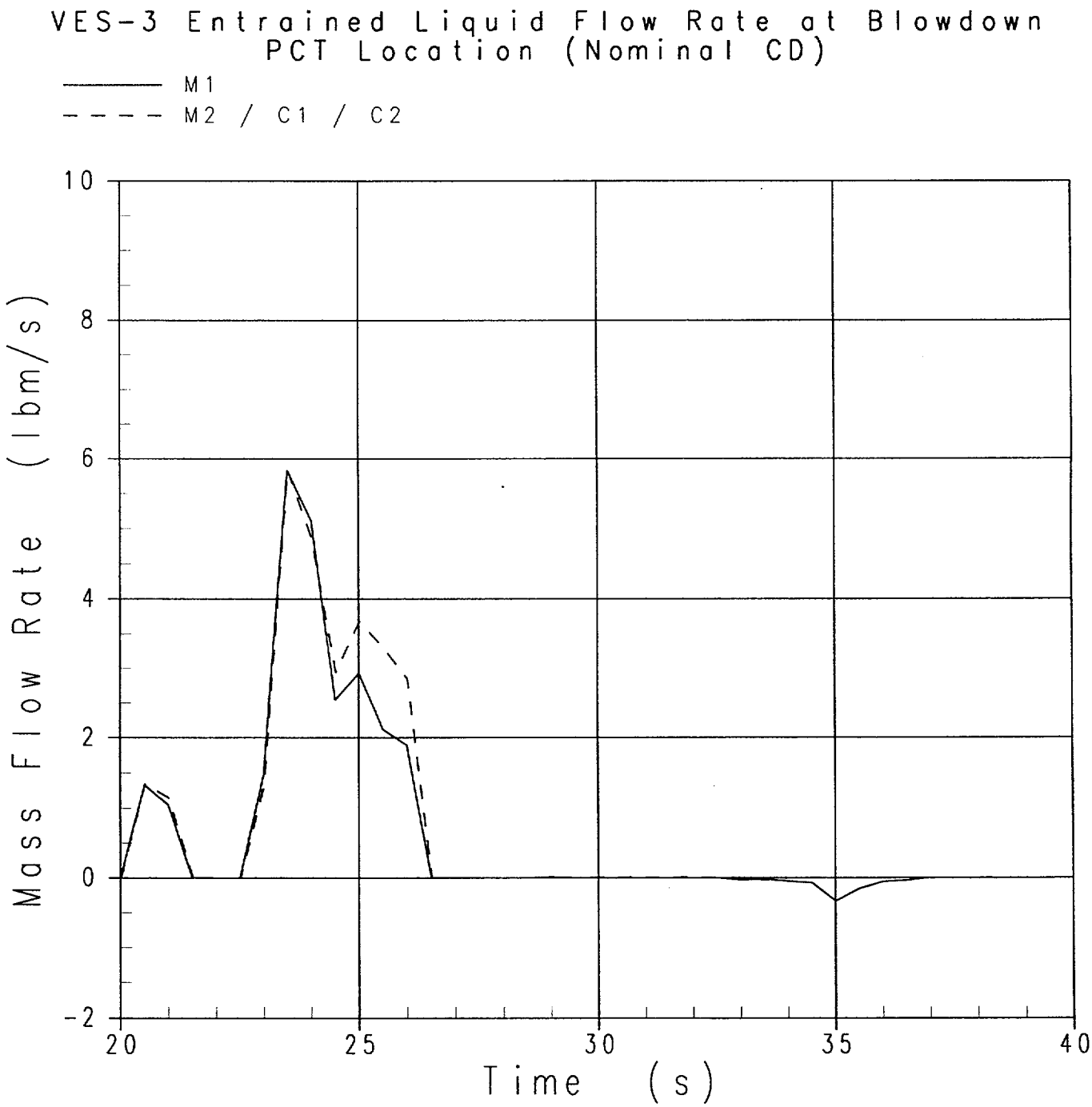
TRANSIENT DIFFERENCES TOO SMALL TO CLAIM THAT M1 VESSEL WOULD ALWAYS BE LIMITING

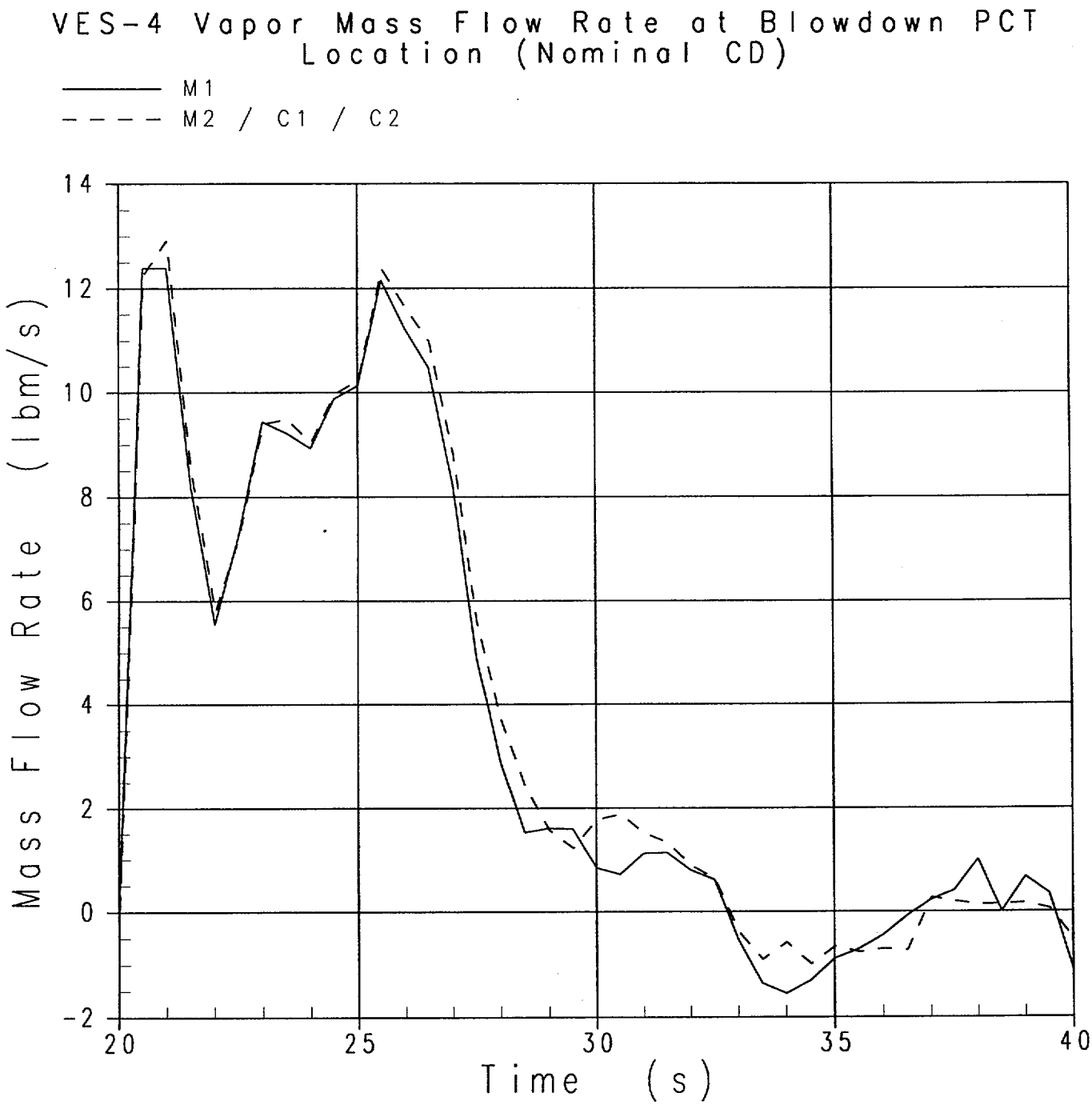
- ⇨ COMBINATION OF M1 VESSEL DESIGN AND BOUNDING LOOP CONFIGURATION CONSIDERED TO BE THE APPROPRIATE COMPOSITE PLANT CONFIGURATION

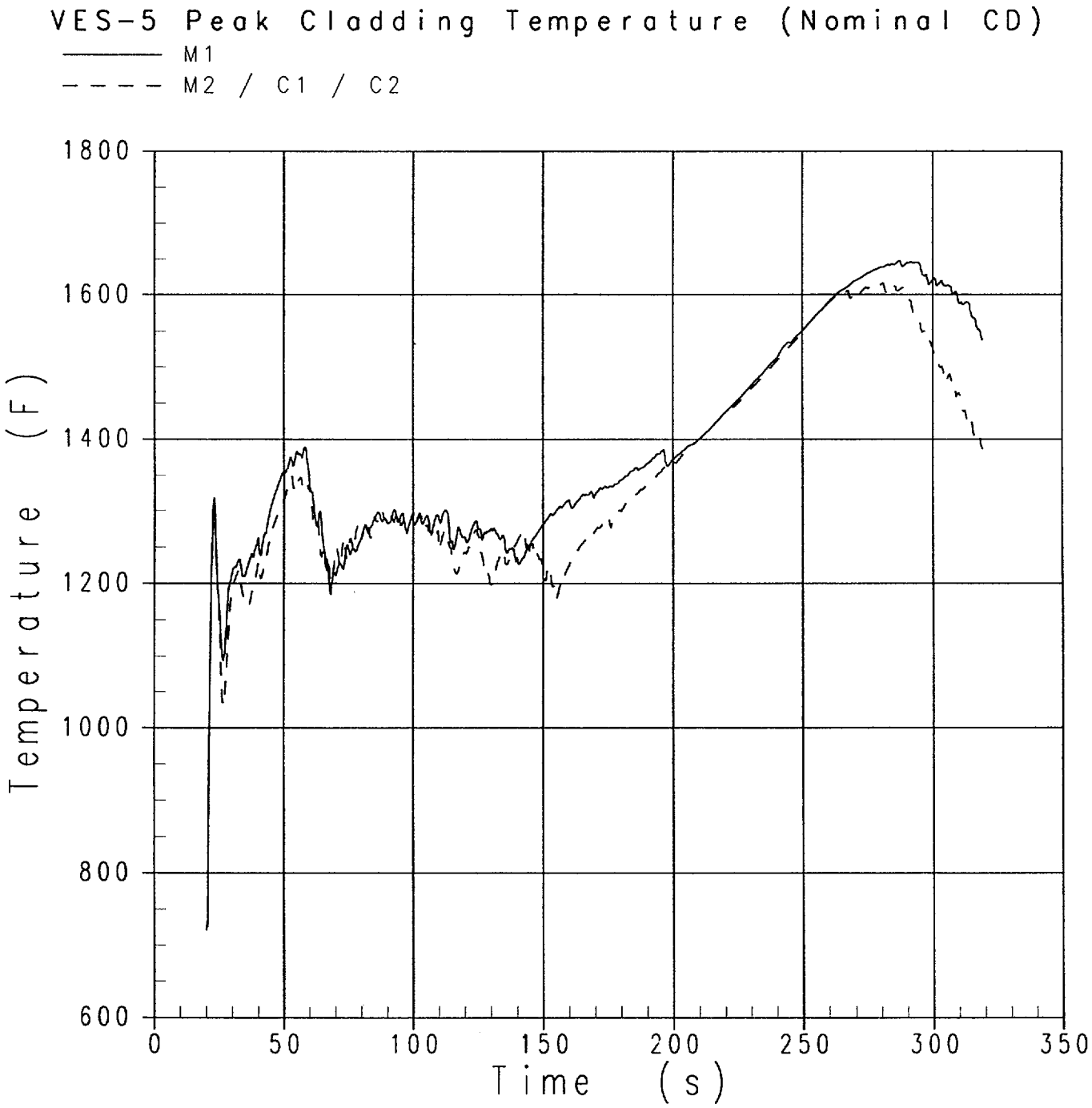
VES-1 Collapsed Liquid Level in the Downcomer
(Nominal CD)

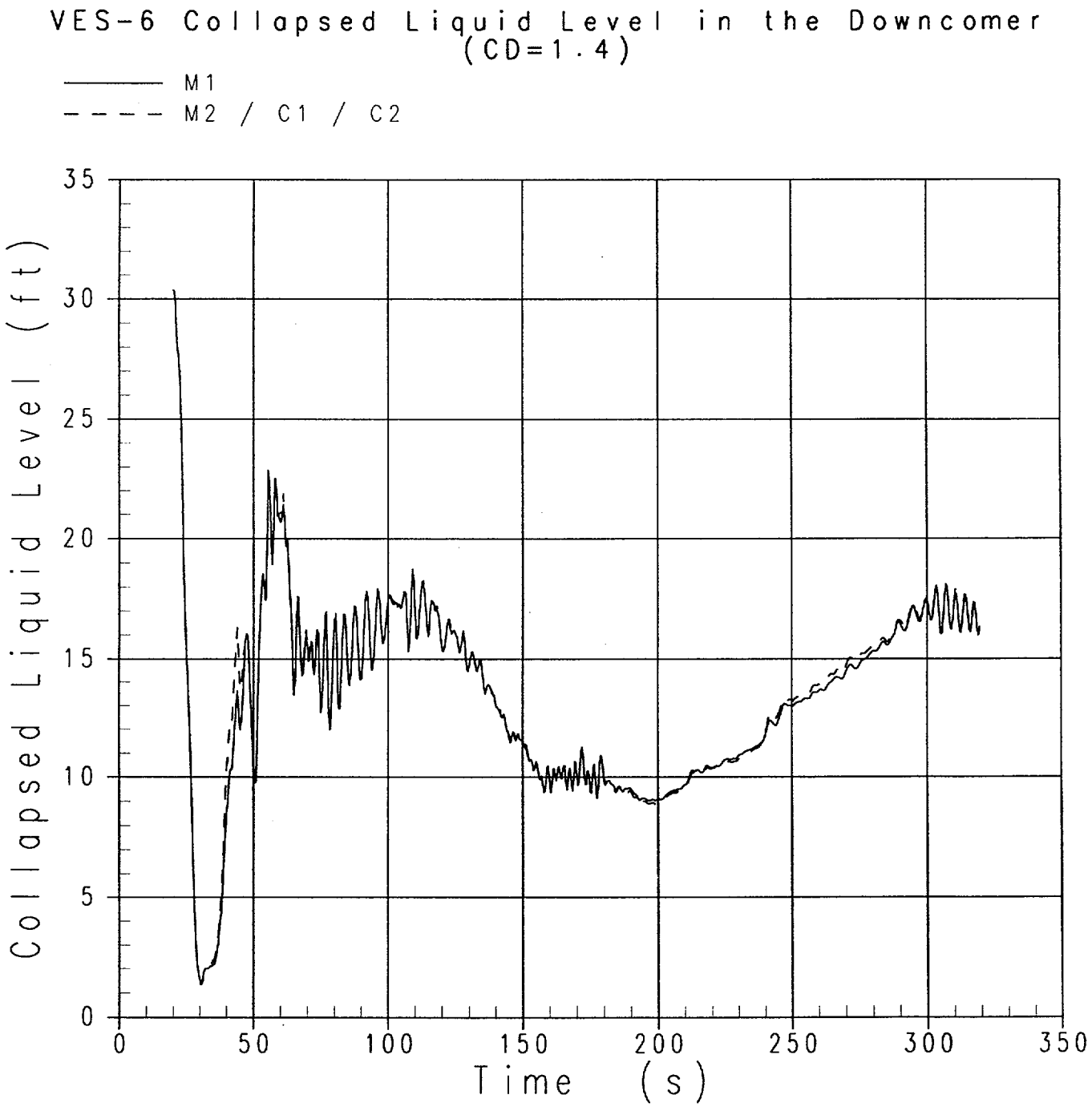


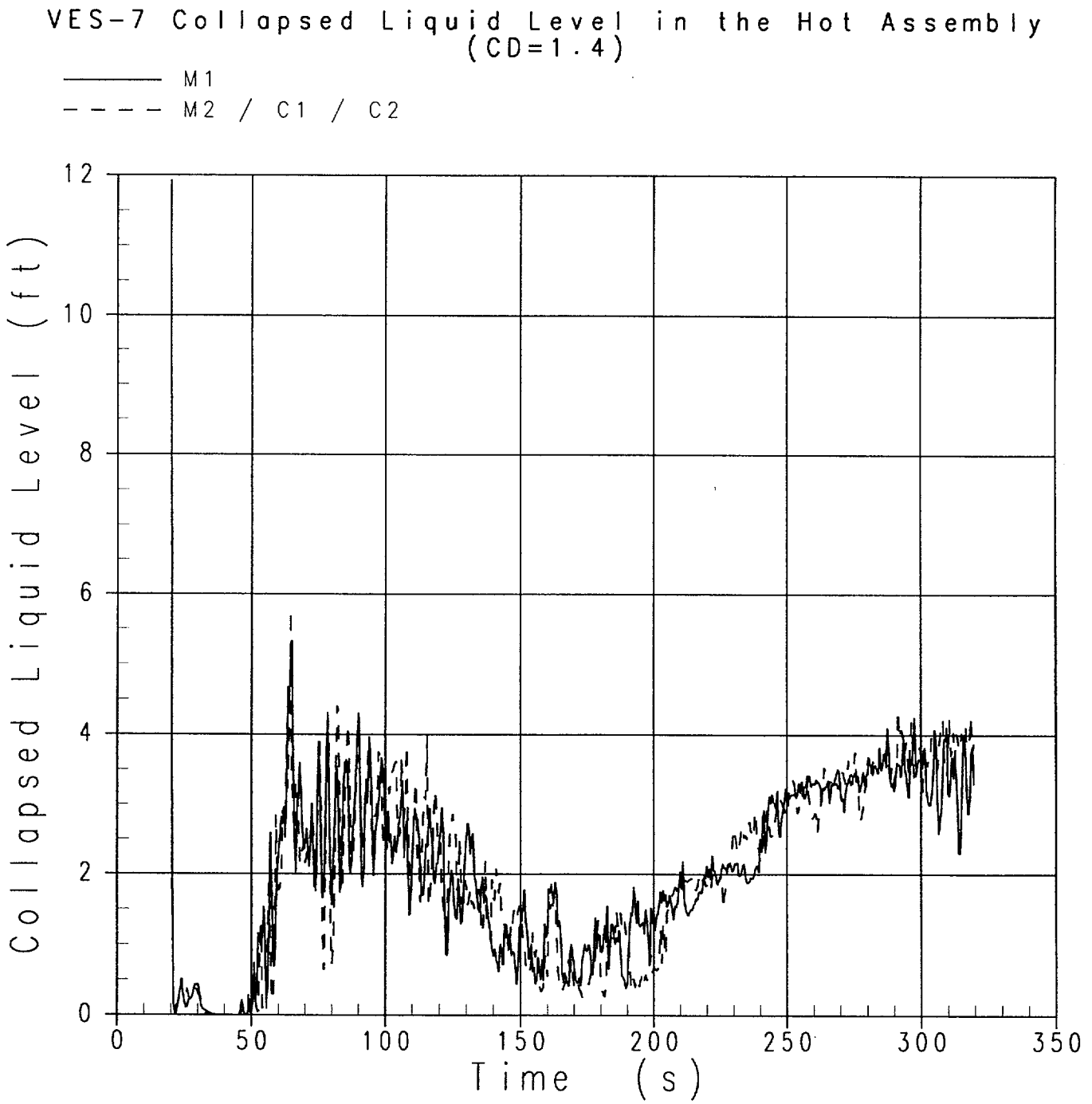

VES-2 Collapsed Liquid Level in the Hot Assembly
(Nominal CD)
M1
M2 / C1 / C2
Collapsed Liquid Level (ft)
0
2
4
6
8
10
12
0
50
100
150
200
250
300
350
Time (s)

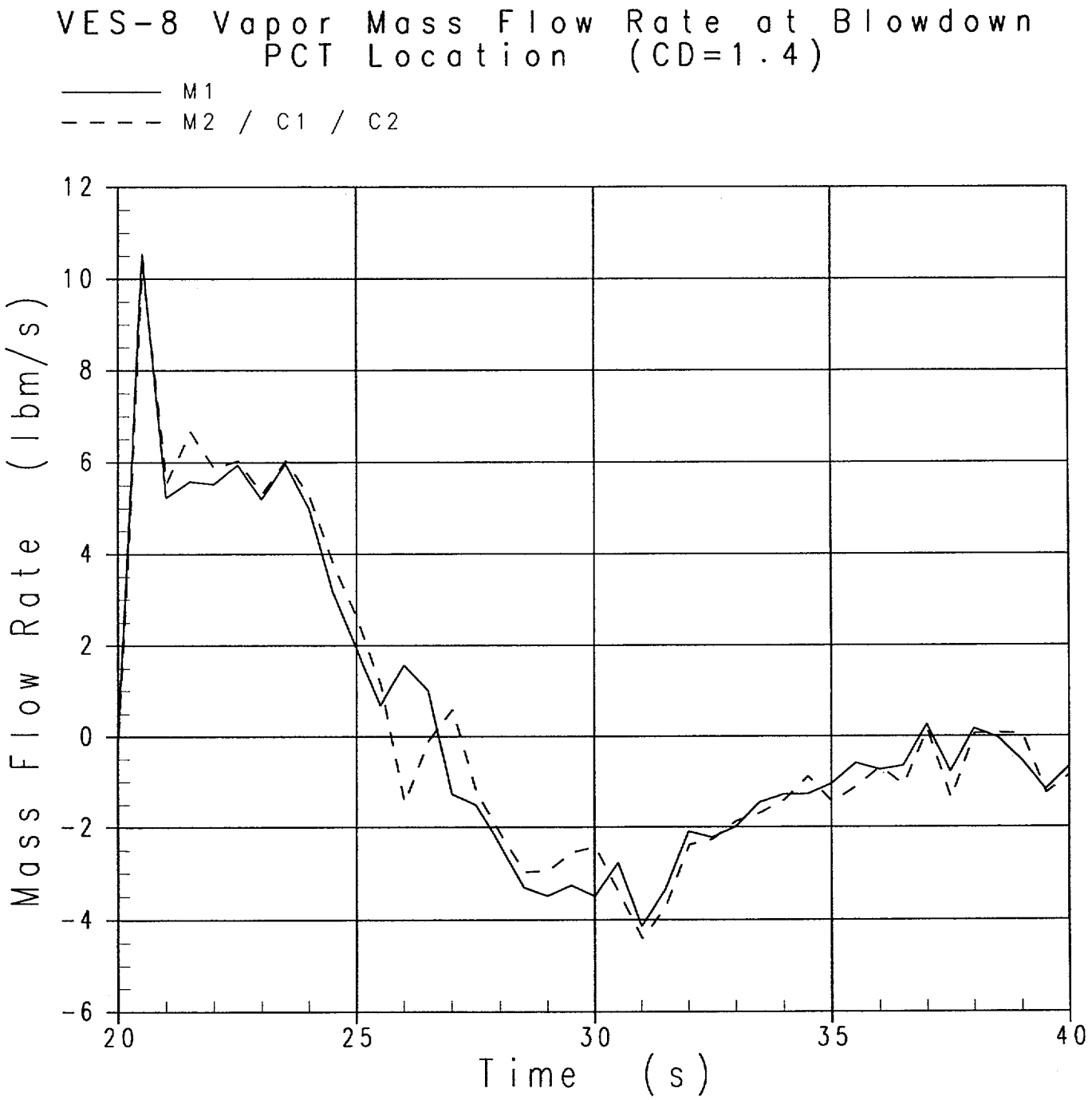

VES-3 Entrained Liquid Flow Rate at Blowdown
PCT Location (Nominal CD)
M1
M2 / C1 / C2
Mass Flow Rate (lbm/s)
10
8
6
4
2
0
-2
20
25
30
35
40
Time (s)

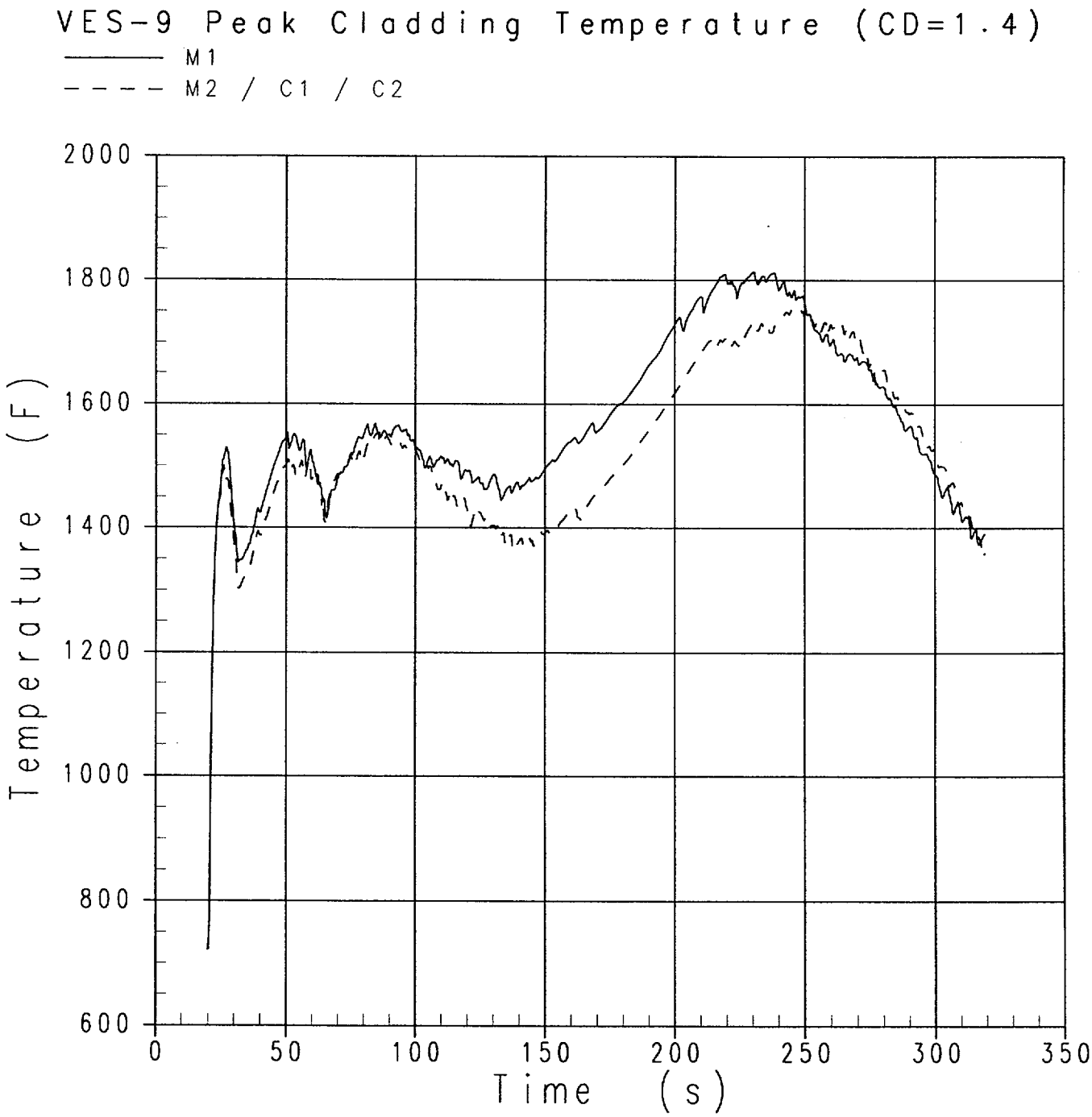

VES-4 Vapor Mass Flow Rate at Blowdown PCT Location (Nominal CD)
M1
M2 / C1 / C2
Mass Flow Rate (lbm/s)
14
12
10
8
6
4
2
0
-2
20
25
30
35
40
Time (s)


VES-5 Peak Cladding Temperature (Nominal CD)
M1
M2 / C1 / C2
1800
1600
1400
1200
1000
800
600
Temperature (F)
0
50
100
150
200
250
300
350
Time (s)


VES-6 Collapsed Liquid Level in the Downcomer
(CD=1.4)
M1
M2 / C1 / C2
Collapsed Liquid Level (ft)
35
30
25
20
15
10
5
0
0
50
100
150
200
250
300
350
Time (s)


VES-7 Collapsed Liquid Level in the Hot Assembly
(CD=1.4)
M1
M2 / C1 / C2
Collapsed Liquid Level (ft)
0
2
4
6
8
10
12
0
50
100
150
200
250
300
350
Time (s)


VES-8 Vapor Mass Flow Rate at Blowdown
PCT Location (CD=1.4)
M1
M2 / C1 / C2
Mass Flow Rate (lbm/s)
12
10
8
6
4
2
0
-2
-4
-6
20
25
30
35
40
Time (s)


VES-9 Peak Cladding Temperature (CD=1.4)
M1
M2 / C1 / C2
2000
1800
1600
1400
1200
1000
800
600
Temperature (F)
0
50
100
150
200
250
300
350
Time (s)

CONCLUSIONS

1) OVERALL SYSTEM RESPONSE IS DICTATED BY UPPER INTERNALS DESIGN FEATURES (PROMOTES GOOD BLOWDOWN COOLING) AND ICE CONDENSER CONTAINMENT DESIGN (PROLONGS REFLOOD)

2) LOOP CONFIGURATION DIFFERENCES ARE MORE SIGNIFICANT THAN VESSEL DIFFERENCES

3) LIMITING COMPOSITE PLANT CONFIGURATION DEFINED FOR REFERENCE TRANSIENT CONDITIONS (~ $PCT^{75\%}$) SHOWN TO ALSO BE APPROPRIATE FOR CONDITIONS ~$PCT^{95\%}$ (CD=1.4)

4) EACH VESSEL/LOOP MODEL USED TO DETERMINE CONFIGURATION TO BE ANALYZED WILL BE RETAINED TO ADDRESS FUTURE PLANT CHANGES, IF NEEDED

5) NRC CONCURRENCE WITH ANALYSIS STRATEGY AND REQUESTED APPROVAL SCHEDULE IS REQUESTED