Appendix C.2 Palisades Thermal-Hydraulic Results

This appendix presents an overview of the RELAP5 modeling details and the results of the 65 cases evaluated for the Palisades plant. For Palisades, 27 cases in the LOCA category, 26 cases in the reactor/turbine trip category and 12 cases in the MSLB category were evaluated.

The RELAP5 model of the Palisades plant was developed, starting from an existing RELAP5 model originally developed for Palisades loss of external load licensing analysis by Siemens Power Corporation as discussed in Section 5.2 of this report. The original model was modified as appropriate for performing PTS analyses and updated to reflect the current Palisades plant configuration and operating procedures. The model modifications are described in References C.2-1 to C.2-3. Nodalization diagrams of the reactor vessel, coolant loops and main steam system regions of the Palisades PTS RELAP5 model are provided in Figures C.2-1, C.2-2 and C.2-3, respectively.

Results for each of the 65 cases analyzed are presented below as Figures C.2-4 through C.2-68. For each case, the following information is given in tabular format:

Case Category	LOCA, RT/TT, MSLB, etc.
Primary Failures	Description of the primary side failure
Secondary Failures	Description of the secondary side failure
Operator Actions	Description of any operator actions
Min DC Temp	The minimum average downcomer fluid temperature and associated time that minimum occurred
Comments	Any comments specific to the event

In addition to the information described above, plots of average downcomer fluid temperature, primary system pressure, and downcomer wall heat transfer coefficient are presented. Any analytical assumptions used in each case are also presented. To facilitate comparisons among cases, each figure presents summary information for the minimum downcomer temperature in the reactor vessel and the time during the event sequence when that minimum is reached. The results shown in these figures are used in the FAVOR probabilistic fracture mechanics analysis.

In Palisades, emergency operating instructions direct the operators to trip one of the two reactor coolant pumps in each of the two primary coolant loops if the pressurizer pressure falls below 8.96 MPa (1300 psia) after an SIAS signal has been generated. The operators also are to trip all reactor coolant pumps should the minimum RCS fluid subcooling fall below 14 K (25^{o}F) or if a containment high pressure signal is generated. Unless otherwise noted, the operators are always assumed to immediately trip the reactor coolant pumps according to these criteria. No other operator actions are assumed, except as listed under operator actions in each figure. For some cases, operator throttling of the HPI flow is assumed based on satisfaction of pressurizer level and RCS subcooling criteria.

Unless otherwise indicated in the modeling notes included with each figure, cases are assumed to be initiated from hot full power (HFP) conditions. The reactor thermal power corresponding to HFP conditions is 2530 MWth. When a hot zero power (HZP) case is indicated, the event is assumed to be initiated from a core power of 5.06 MW, which is 0.2% of the full core power.

All LOCA category case calculations were performed using large reverse flow loss coefficients in the pump-suction cold leg regions of the RELAP5 model as indicated in the modeling notes included with each figure. These coefficients are used to preclude setting up non-physical flow recirculation between the two common cold legs on each coolant loop. Certain calculations were performed without this assumption to judge its effect on the results and these are identified as such in the modeling notes.

For certain LOCA cases, a non-physical circulation within the reactor vessel downcomer and lower plenum region was also observed. This circulation was eliminated by disabling momentum flux (via user option selection) in the junctions of the downcomer region for those cases. The affected cases are identified in the modeling notes with each figure.

All MSLB cases are assumed to be initiated by the double-ended rupture of the steam line connected to one SG. The rupture is assumed to be downstream of the flow restrictor and inside the containment. Steam line breaks outside containment are not of PTS concern for Palisades because the early and automatic closure of the main steam isolation valves effectively terminates the transient event.

Certain unique features of the Palisades plant affecting its thermal-hydraulic response pertinent for PTS are described as follows.

The maximum rate at which auxiliary feedwater can be delivered to each SG in the Palisades plant is limited to a moderate value by an automatic controller. Further, additional auxiliary feedwater pumps can only be brought on line through operator action. These two features tend to limit the PTS risk of MSLB and SG overfeed events for Palisades because the flow to the affected steam generators is quite limited unless additional hardware and/or operator failures (and their attendant probabilities) are assumed. As identified in the modeling notes, certain of the cases were run assuming controller hardware and/or aggravating operator failures related to auxiliary feedwater control.

The pressurizer PORVs in Palisades have a very large flow capacity (as compared with other plants) but these valves are blocked closed during normal plant operation. Therefore, the effects of stuck-open pressurizer valves evaluated are limited to those caused by the smaller (and less likely to fail open) safety relief valves.

The Safety Injection Refueling Water Tank (SIRWT) is the initial source of water for the HPI system, the LPI system and (after draining of the boric acid storage tank) for the charging system. The available volume of the SIRWT is 889 m^3 (234,700 gallons). The SIRWT is also the source of water for the containment spray system. Although flow through all of these systems depletes the SIRWT inventory, the containment spray system dominates the depletion process. As the SIRWT approaches the empty condition, the

Recirculation Actuation Signal (RAS) is generated. The RAS results in the automatic termination of the LPI pump power and a switching of the HPI system suction from the SIRWT to the containment sump (where water has collected from the break effluent). The RAS, which typically occurs 1 to 2 hours following initiation of LOCA, stuck open pressurizer valve and MSLB events, significantly affects the PTS response of the plant. The PTS response is affected because the flow of cold LPI fluid into cold legs and downcomer is terminated and because the temperature of the HPI flow rises from the SIRWT temperature to the containment sump temperature. In the RELAP5 calculations reported here, the SIRWT level is tracked using a control variable which integrates the flows through the systems that drain the tank. When the integrated flow indicates that the low SIRWT level has been reached, RAS is generated in the model and the LPI flow is terminated. Then, the HPI fluid temperature is changed to reflect the containment sump temperature (which is defined as a function of break size from separate containment analyses provided by Palisades). The ECCS water injection temperature ranges from 307 to 343 K (93 to 158^{o}F).

Detailed information regarding the modeling assumptions and calculated plant responses for each of the Palisades cases is found in Reference C.2-1 to C.2-3.

References:

C.2-1 Fletcher, C.D. et al., Palisades RELAP5 Model Revisions for Pressurized Thermal Shock Calculations, Revision 1, June 3, 2002 (in preparation).

C.2-2 Fletcher, C.D and Palazov, V., Palisades RELAP5 PTS Calculation Transient Results, Revision 1, (in preparation)

C.2-3 Fletcher, C.D. and Arcieri, W.C., Palisades RELAP5 PTS Calculations for Rerun and Additional Cases, Revision 2 (in preparation)

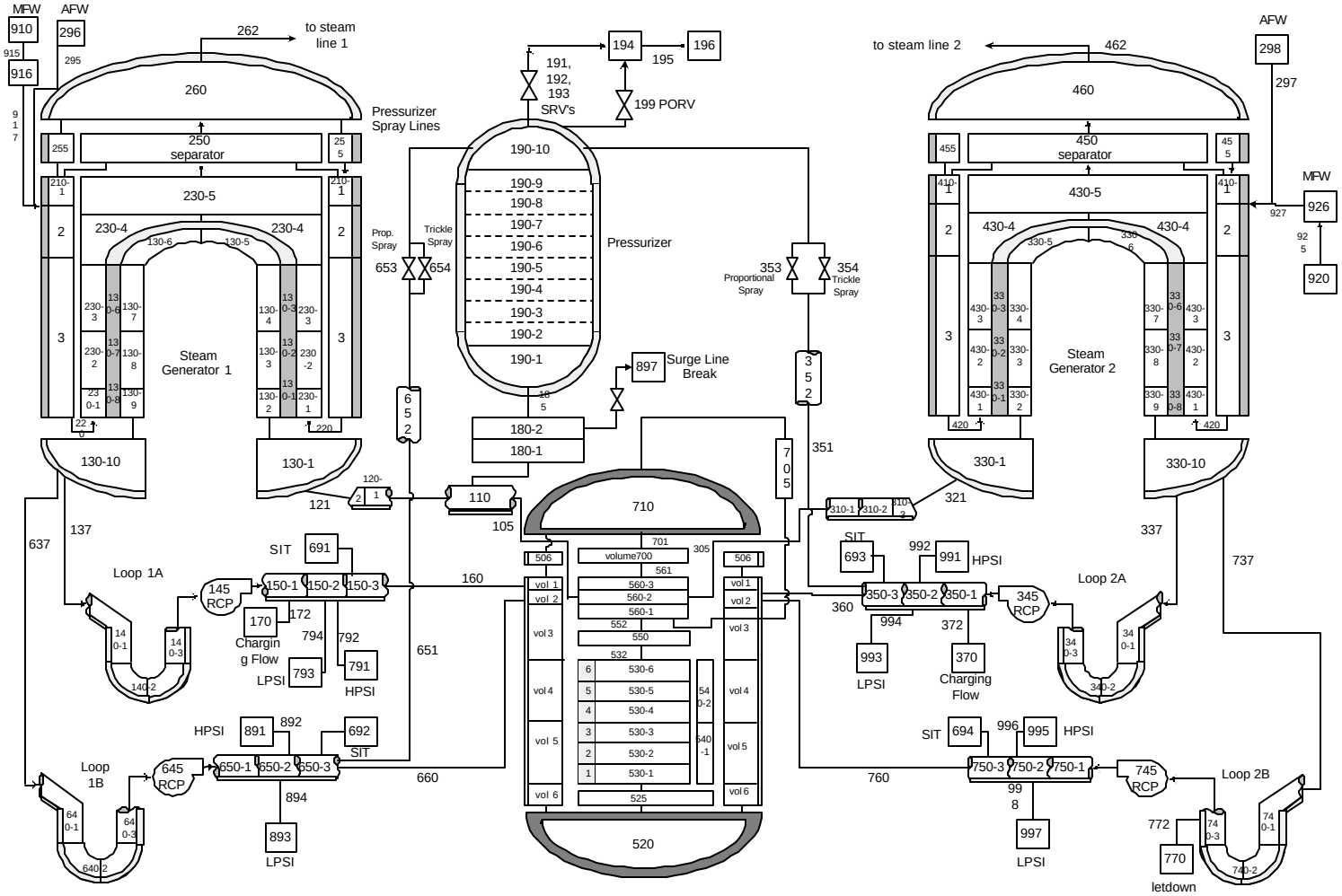

Figure C.2-1: RELAP5 Nodalization of the Palisades Reactor Coolant System

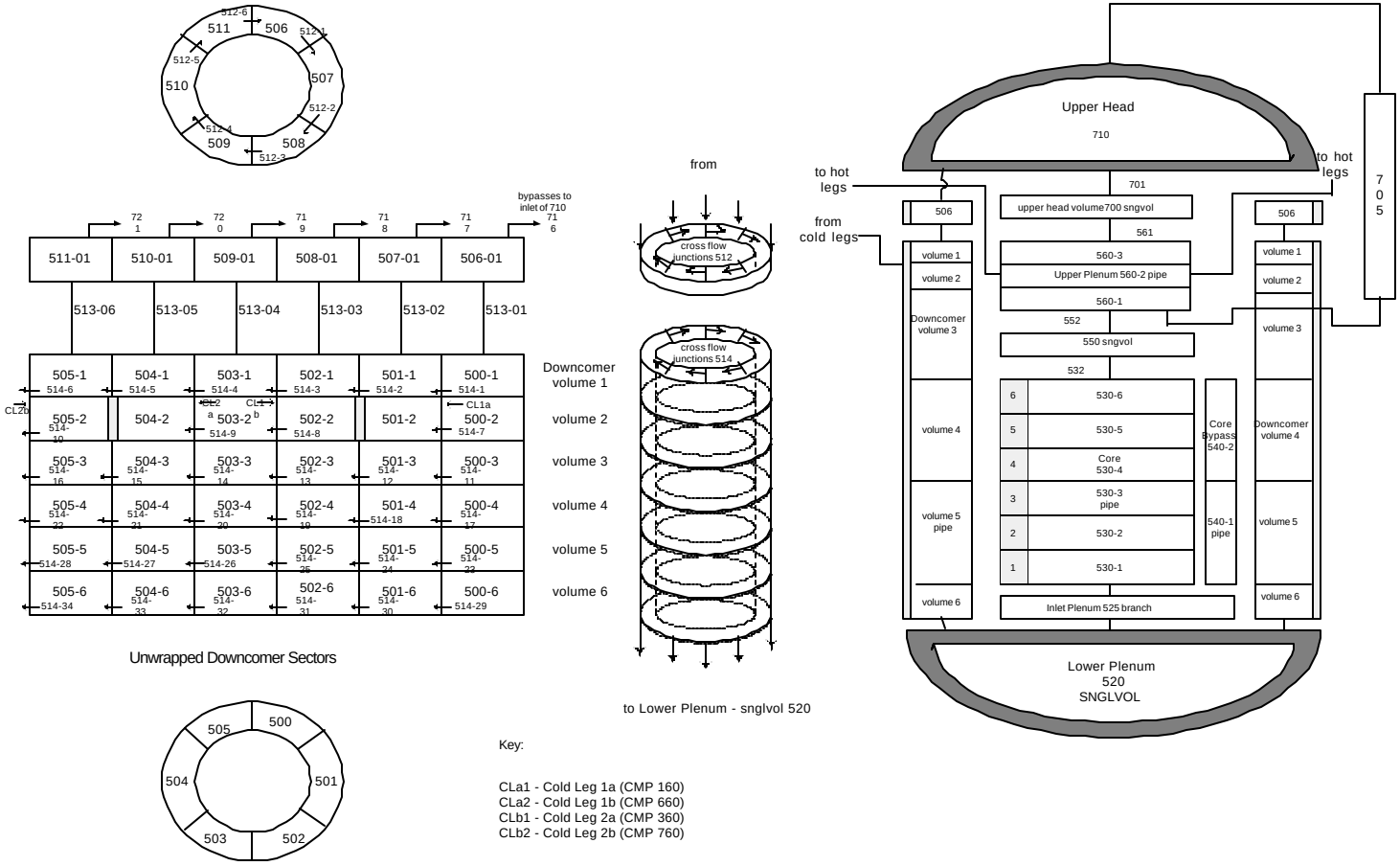

Figure C.2-2: RELAP5 Nodalization of the Palisades Reactor Vessel

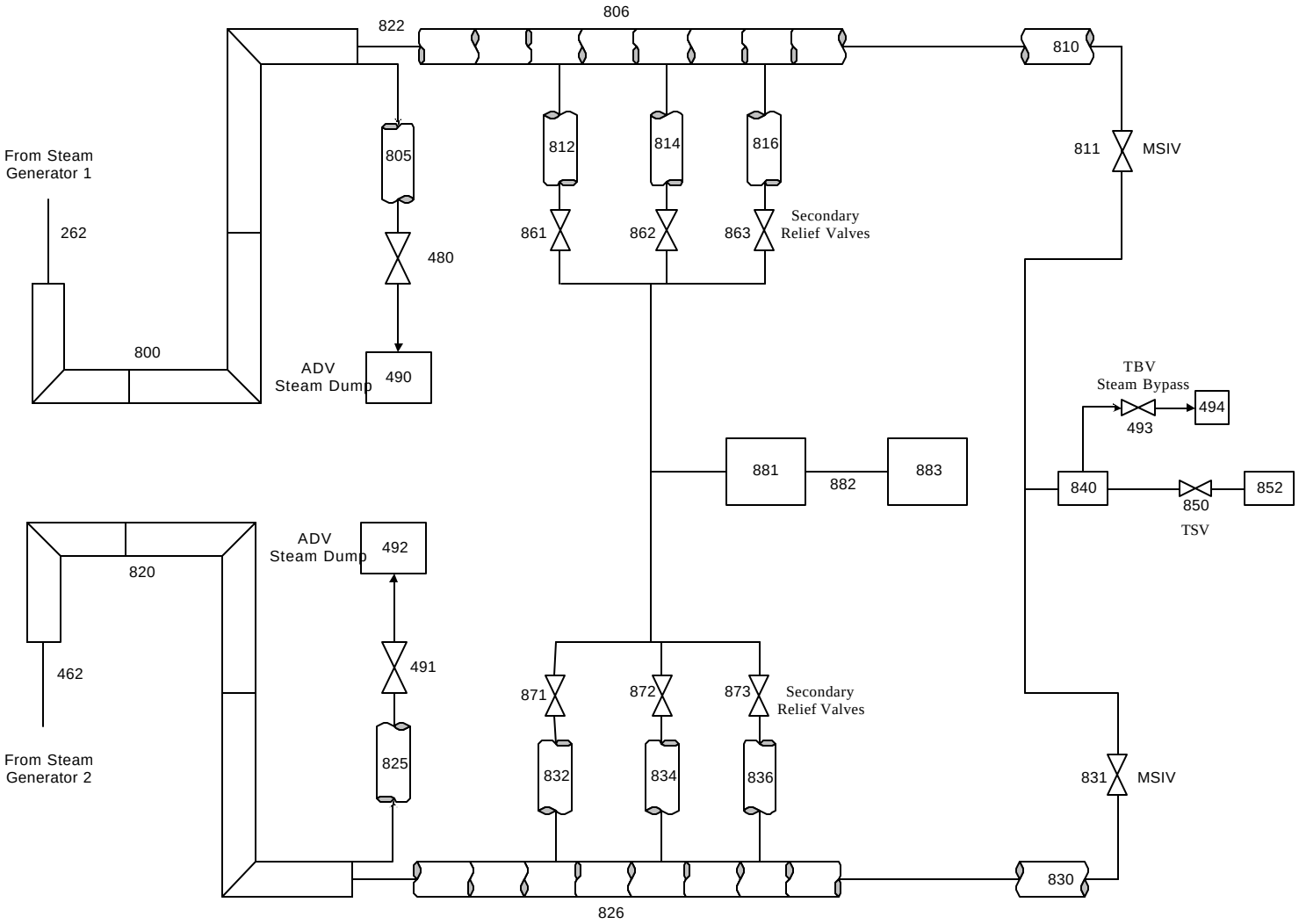

Figure C.2-3: RELAP5 Nodalization of the Palisades Secondary Side

Case Category	LOCA
Primary Failures	2.54 cm (1 inch) surge line break. Containment sump recirculation included in the analysis.
Secondary Failures	None.
Operator Actions	None.
Min DC Temp	500.8 K (441.7°F) at 15000 s
Comments	None.

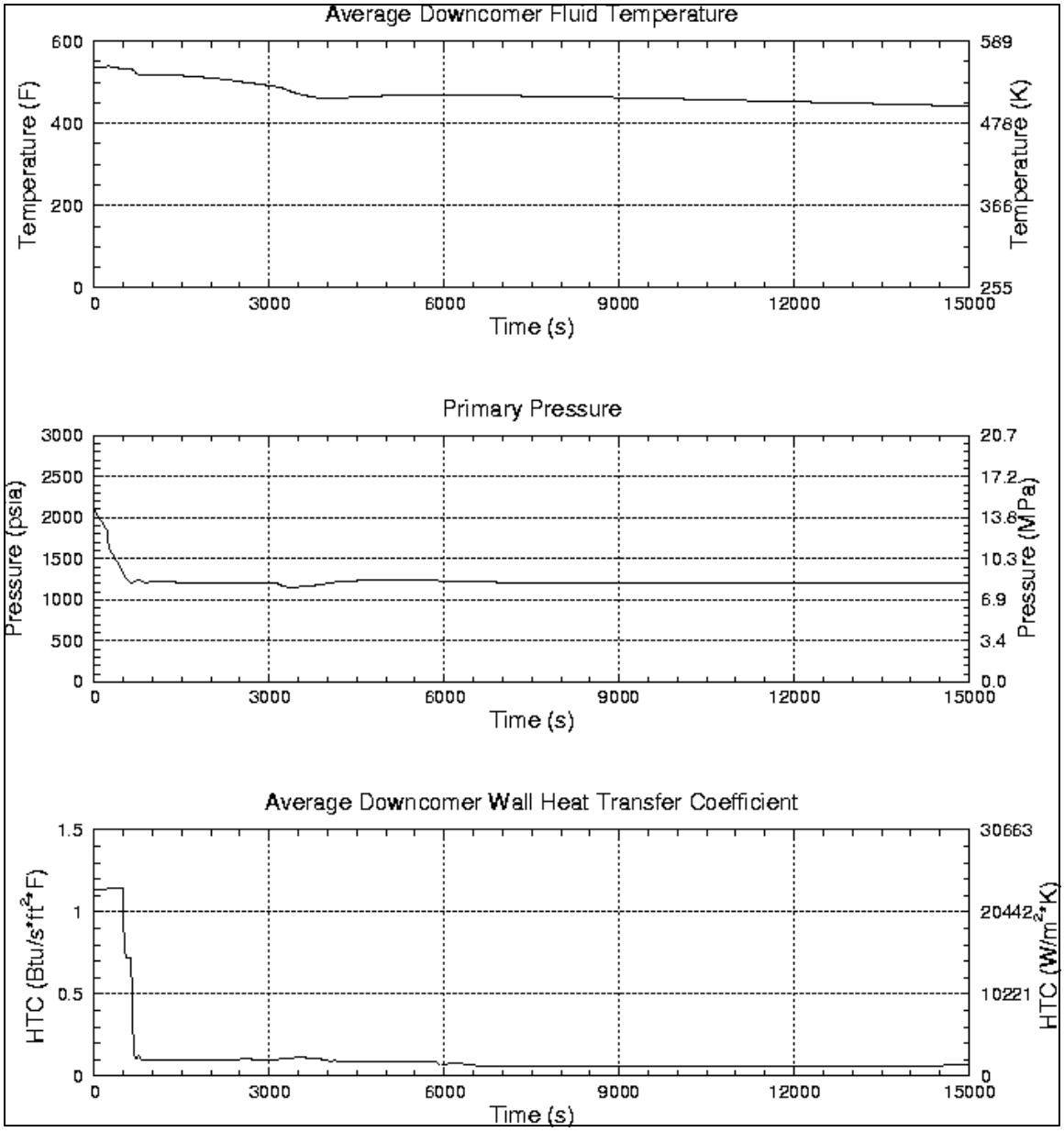

Figure C.2-4: Palisades PTS Results for Case 001

Case Category	LOCA
Primary Failures	3.59 cm (1.414 in) surge line break. Containment sump recirculation included in the analysis.
Secondary Failures	None.
Operator Actions	None.
Min DC Temp	436.5 K (326.0°F) at 15000 s
Comments	None.

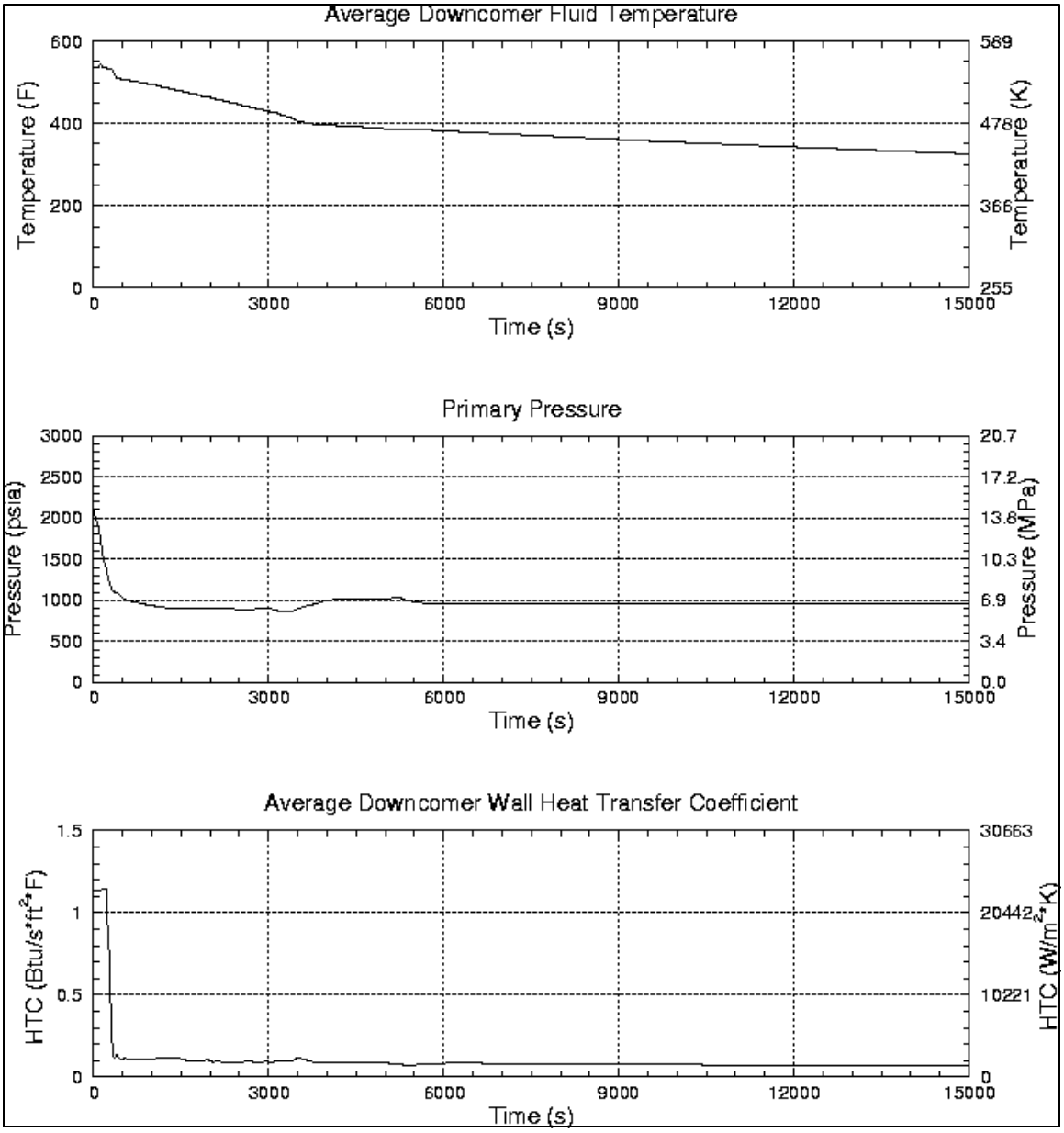

Figure C.2-5: Palisades PTS Results for Case 002

Case Category	LOCA
Primary Failures	5.08 cm (2 in) surge line break. Containment sump recirculation included in the analysis.
Secondary Failures	None.
Operator Actions	None.
Min DC Temp	348.7 K (168.0°F) at 4440 s
Comments	None.

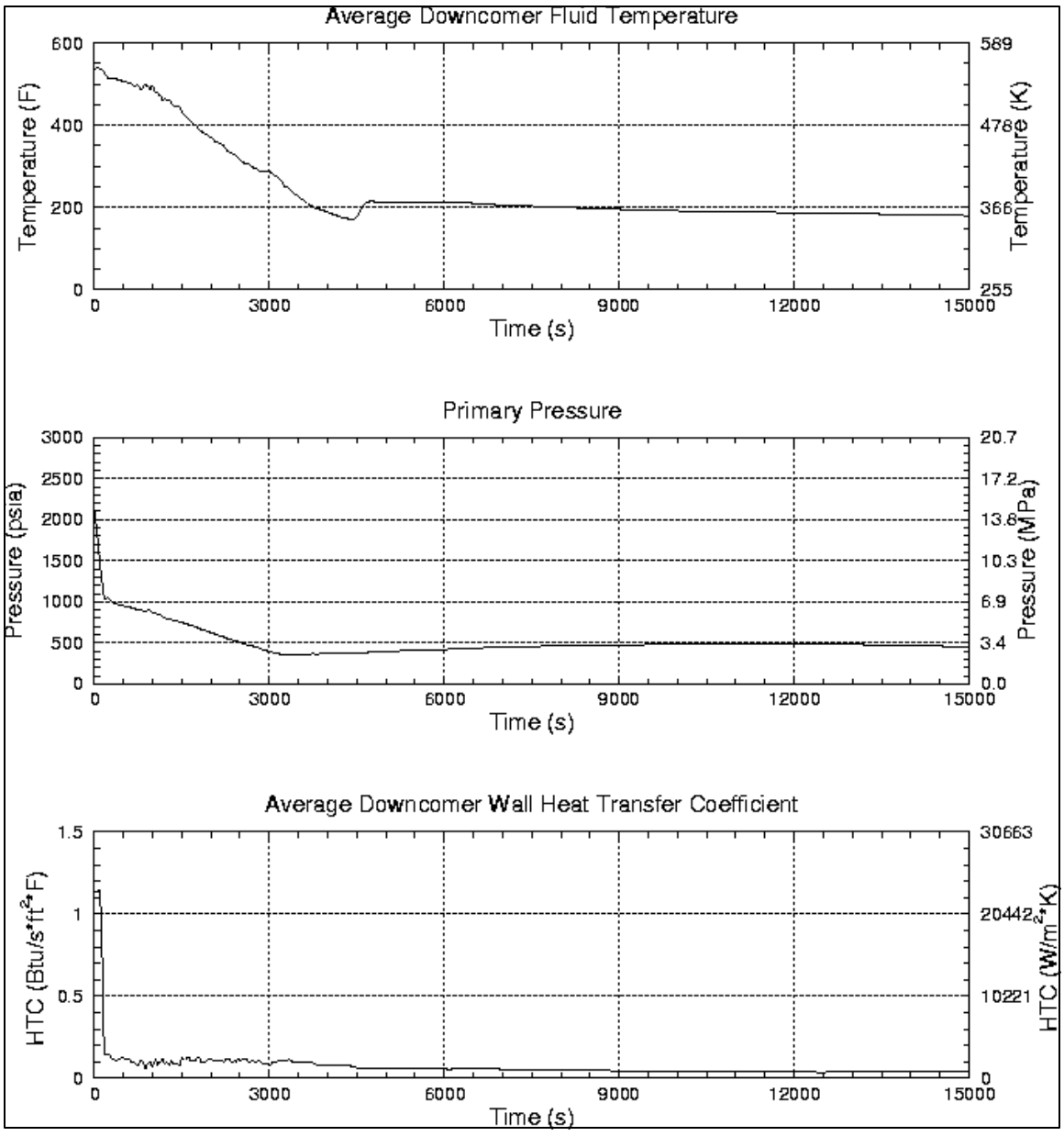

Figure C.2-6: Palisades PTS Results for Case 003

Case Category	LOCA
Primary Failures	7.183 cm (2.828 in) surge line break. Containment sump recirculation included in the analysis.
Secondary Failures	None.
Operator Actions	Operator assumed to throttle HPI if AFW is running with SG WRL > -84% and RCS subcooling > 25 F. HPI is throttled to maintain pressurizer level between 40 and 60 %.
Min DC Temp	339.5 K (151.4°F) at 3510 s
Comments	None.

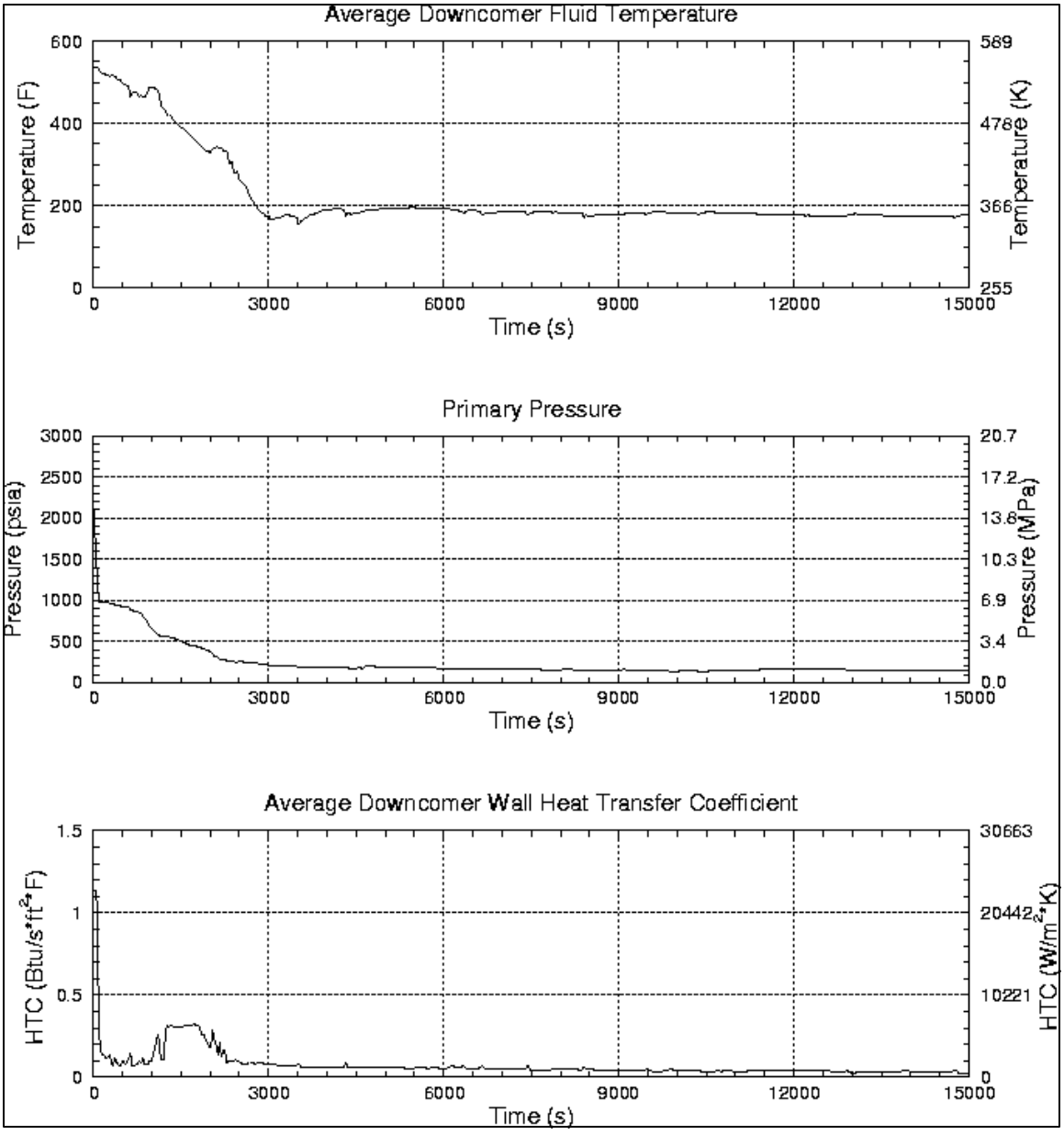

Figure C.2-7: Palisades PTS Results for Case 004

Case Category	LOCA
Primary Failures	10.16 cm (4 inch) surge line break. Containment sump recirculation included in the analysis.
Secondary Failures	None.
Operator Actions	Operator assumed to throttle HPI if AFW is running with SG WRL > -84% and RCS subcooling > 25 F. HPI is throttled to maintain pressurizer level between 40 and 60 %.
Min DC Temp	323.1 K (121.8°F) at 2100 s
Comments	None.

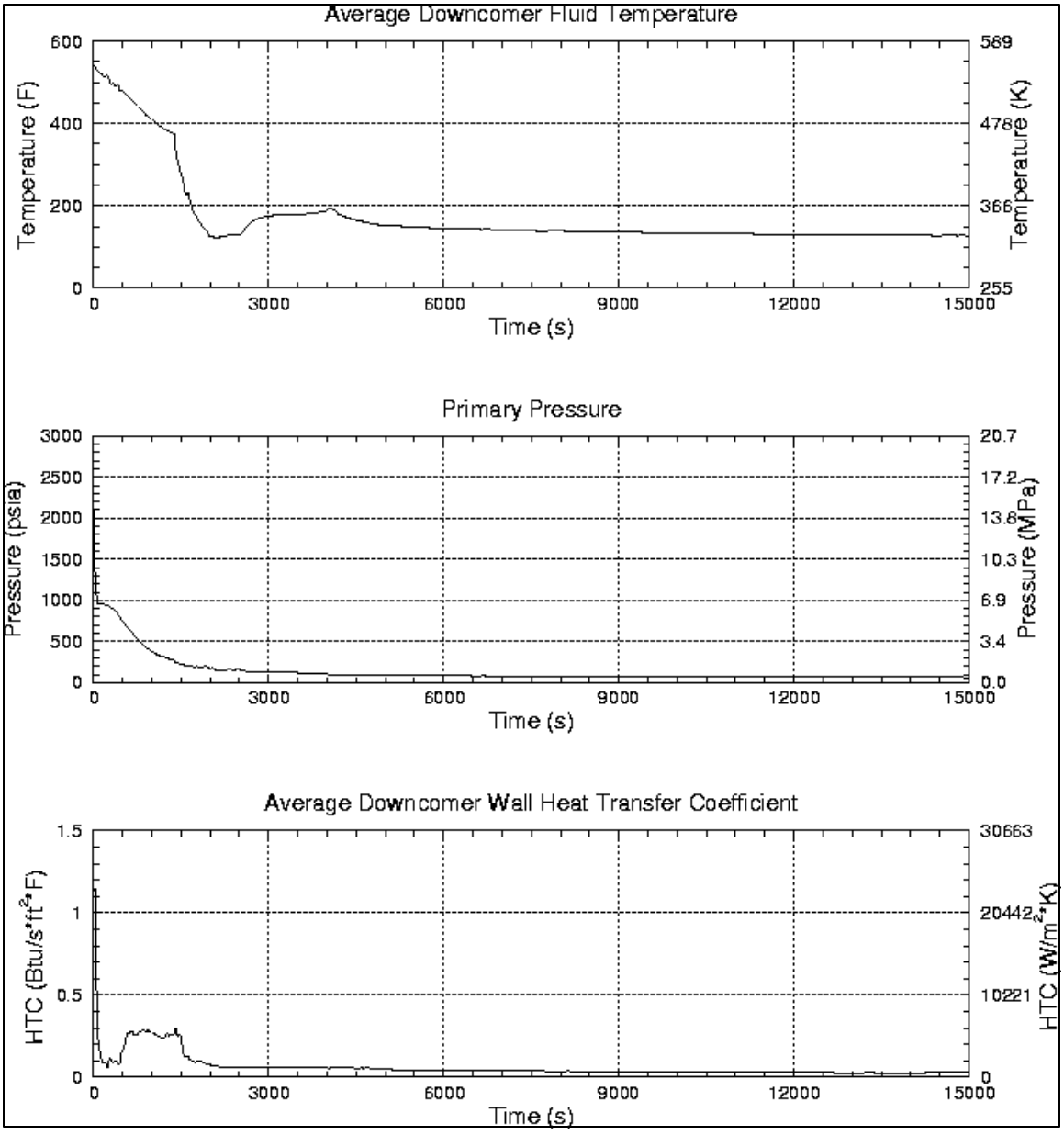

Figure C.2-8: Palisades PTS Results for Case 005

Case Category	LOCA
Primary Failures	14.366 cm (5.656 inch) surge line break. Containment sump recirculation included in the analysis.
Secondary Failures	None.
Operator Actions	Operator assumed to throttle HPI if AFW is running with SG WRL > -84% and RCS subcooling > 25 F. HPI is throttled to maintain pressurizer level between 40 and 60 %.
Min DC Temp	314.1 K (105.7°F) at 1950 s
Comments	None.

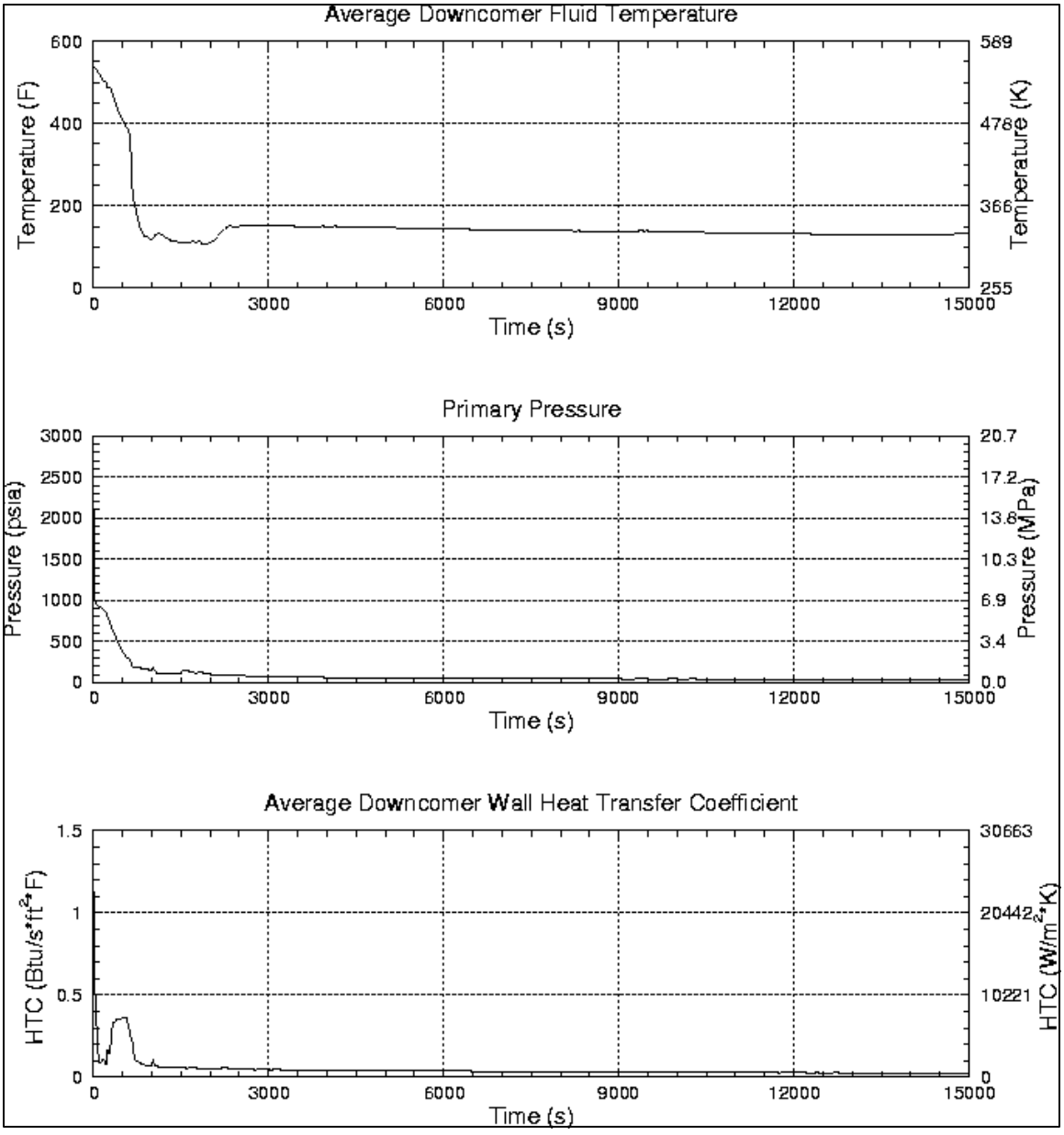

Figure C.2-9: Palisades PTS Results for Case 006

Case Category	LOCA
Primary Failures	20.32 cm (8 inch) surge line break. Containment sump recirculation included in the analysis.
Secondary Failures	None.
Operator Actions	Operator does not throttle HPI.
Min DC Temp	308.2 K (95.1°F) at 1530 s
Comments	Momentum Flux Disabled in DC

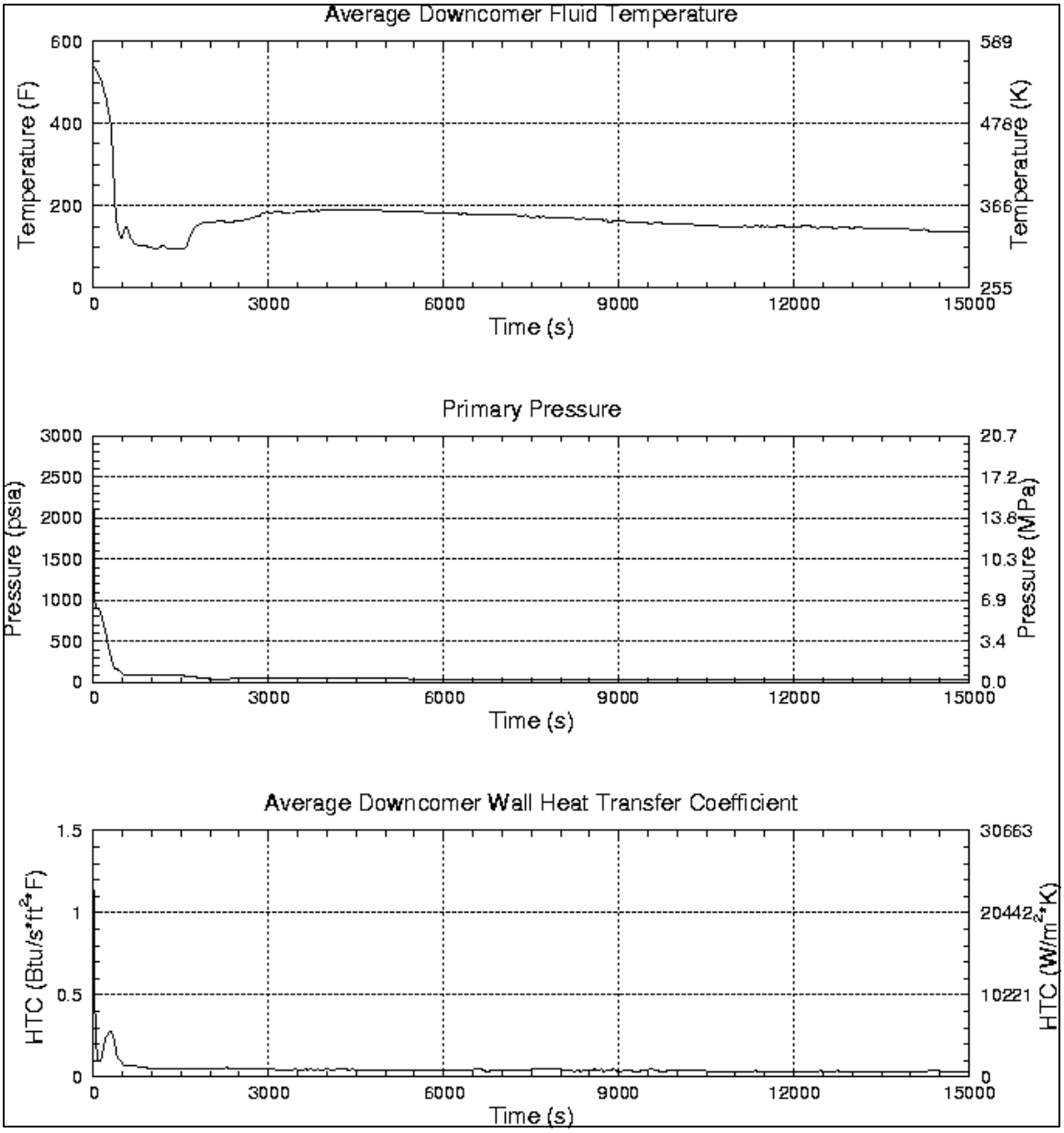

Figure C.2-10: Palisades PTS Results for Case 007

Case Category	LOCA
Primary Failures	5.08 cm (2 in) surge line break. Containment sump recirculation included in the analysis.
Secondary Failures	1 stuck-open ADV on SG-A. No AFW isolation.
Operator Actions	Operator assumed to throttle HPI if AFW is running with SG WRL > -84% and RCS subcooling > 25 F. HPI is throttled to maintain pressurizer level between 40 and 60 %.
Min DC Temp	372.7 K (211.2°F) at 14640 s
Comments	None.

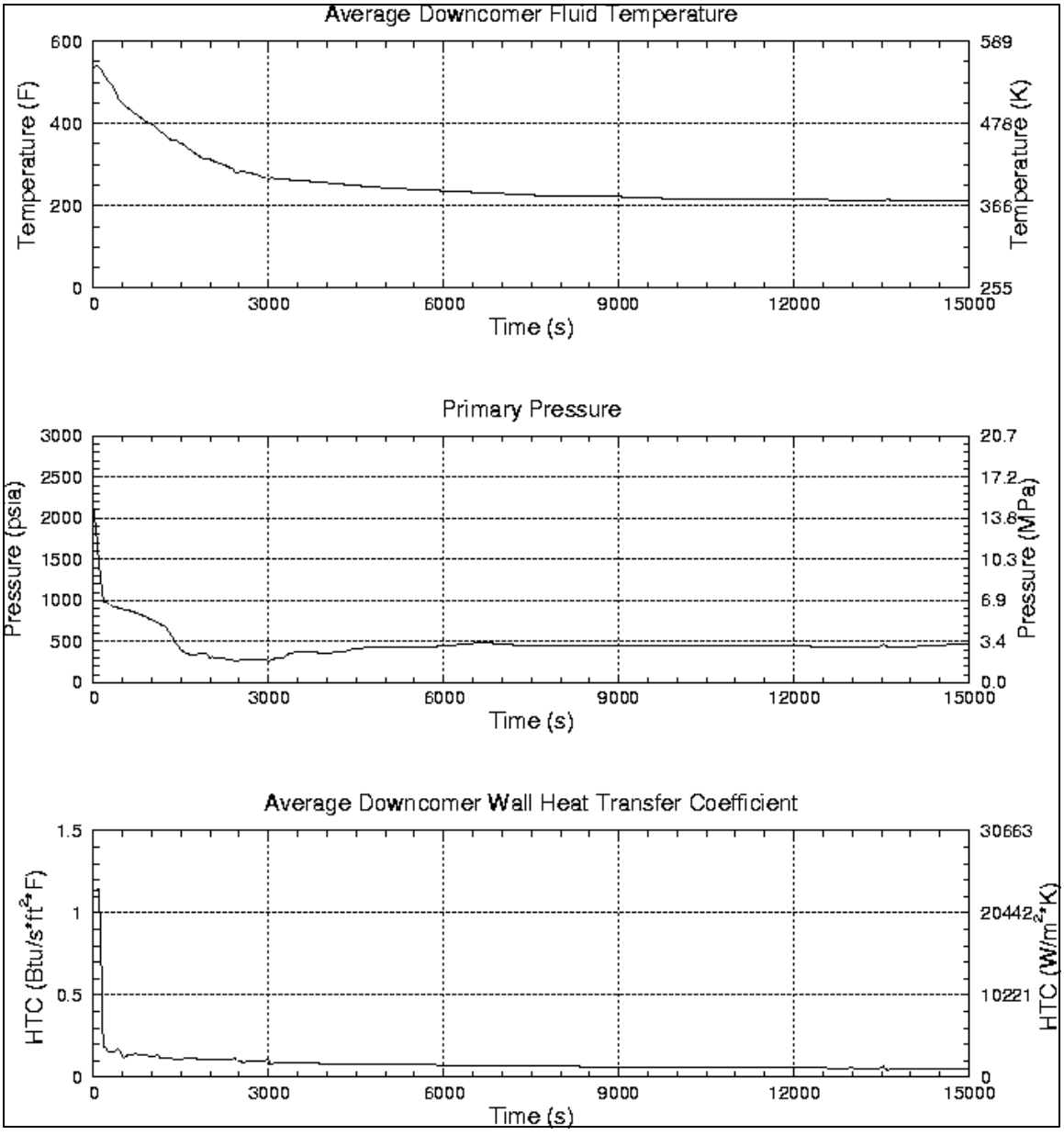

Figure C.2-11: Palisades PTS Results for Case 008

Case Category	LOCA
Primary Failures	5.08 cm (2 in) surge line break. Containment sump recirculation included in the analysis.
Secondary Failures	1 stuck-open ADV on SG-A. Normal MFW/AFW function.
Operator Actions	Operator isolates AFW to affected SG at 15 minutes after initiation. Operator assumed to throttle HPI if AFW is running with SG WRL > -84% and RCS subcooling > 25 F. HPI is throttled to maintain pressurizer level between 40 and 60 %.
Min DC Temp	383.1 K (230.0°F) at 15000 s
Comments	None.

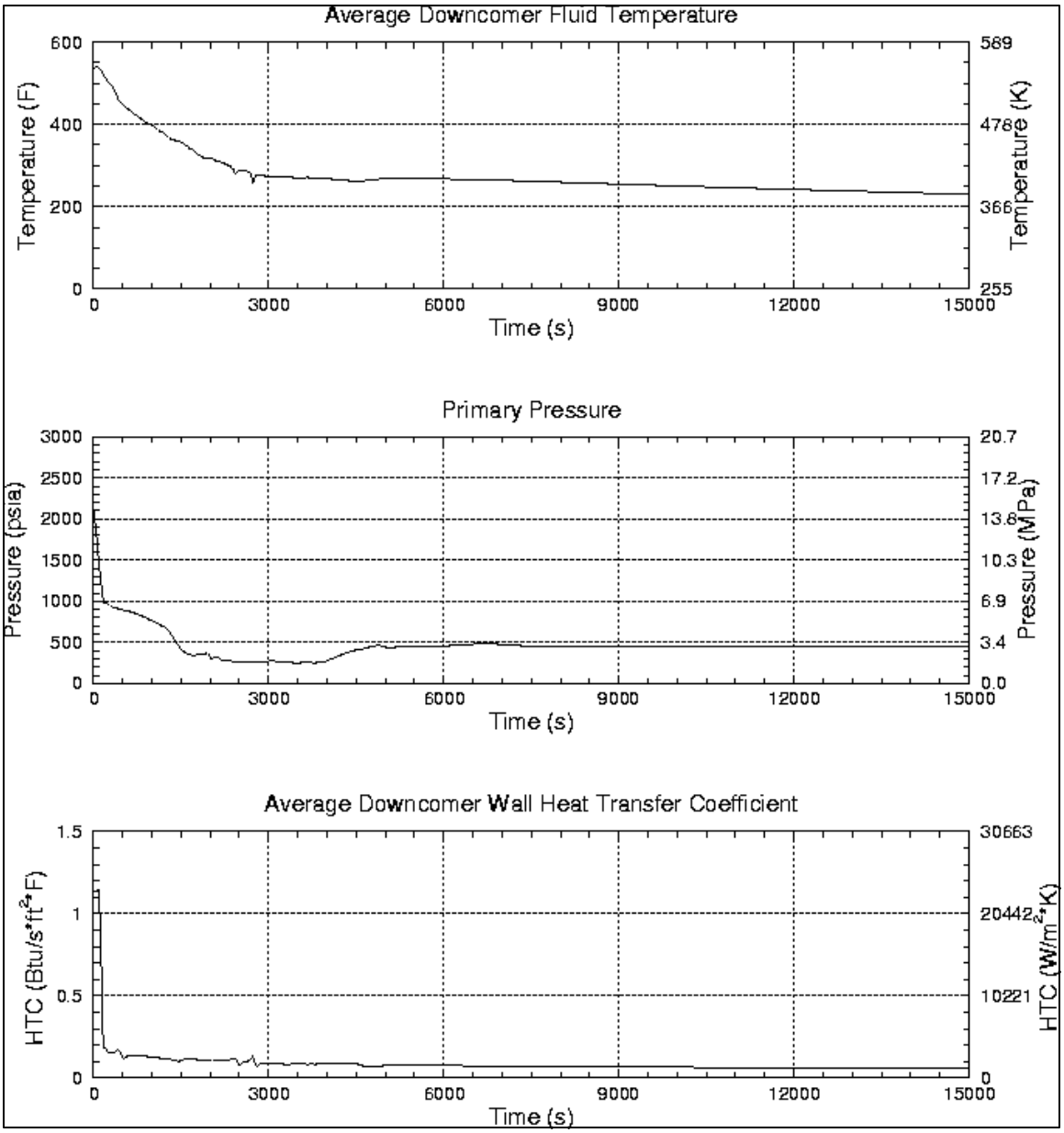

Figure C.2-12: Palisades PTS Results for Case 009

Case Category	LOCA
Primary Failures	5.08 cm (2 in) surge line break. Containment sump recirculation included in the analysis.
Secondary Failures	1 stuck-open ADV on SG-A. Normal MFW/AFW function.
Operator Actions	Operator isolates AFW to affected SG at 30 minutes after initiation. Operator assumed to throttle HPI if AFW is running with SG WRL > -84% and RCS subcooling > 25 F. HPI is throttled to maintain pressurizer level between 40 and 60 %.
Min DC Temp	381.6 K (227.2°F) at 15000 s
Comments	None.

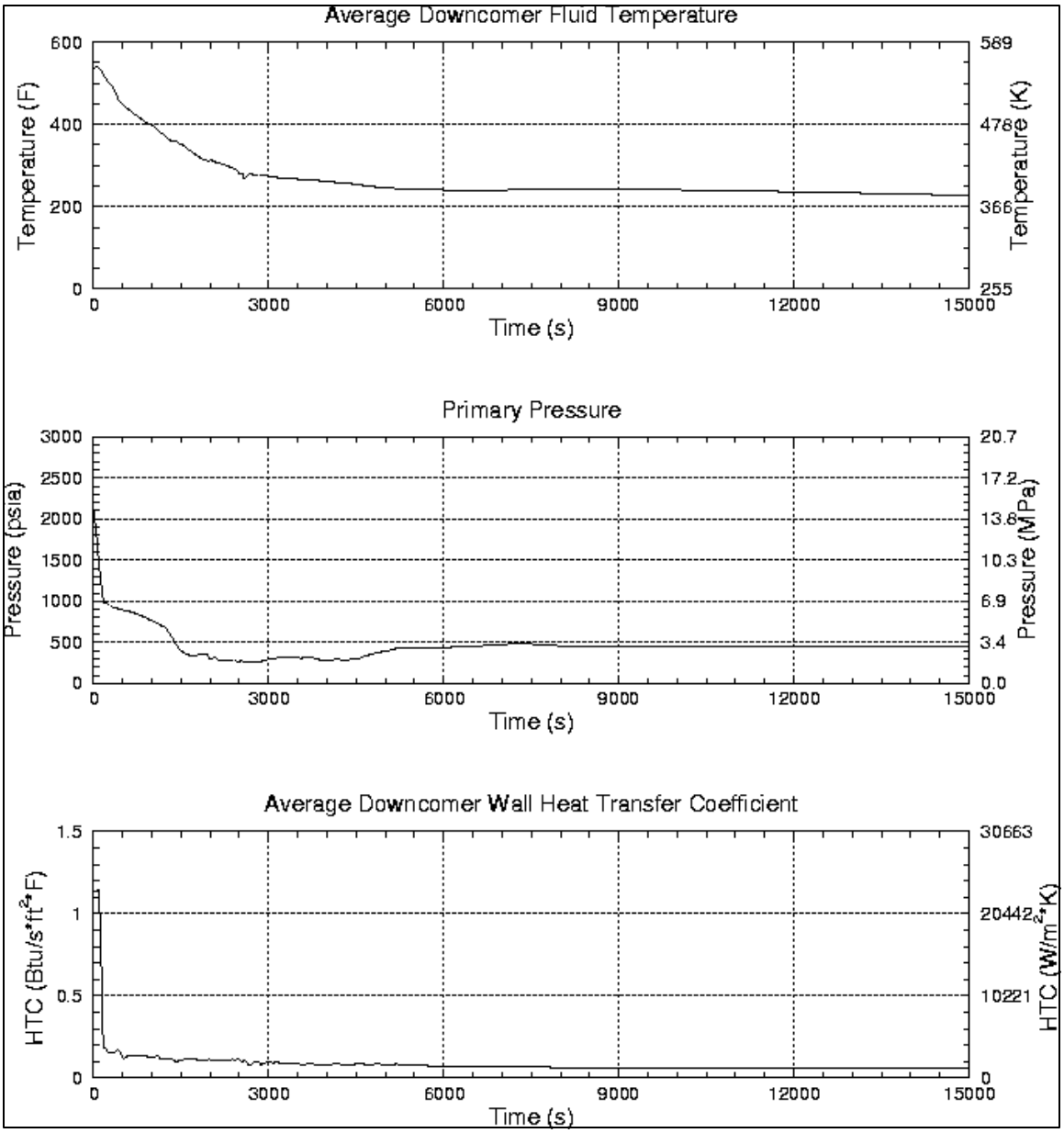

Figure C.2-13: Palisades PTS Results for Case 010

Case Category	LOCA
Primary Failures	5.08 cm (2 in) surge line break. Containment sump recirculation included in the analysis.
Secondary Failures	1 stuck-open ADV on SG-A. Failure to isolate MFW and condensate feed system.
Operator Actions	None.
Min DC Temp	373.0 K (211.8°F) at 15000 s
Comments	None.

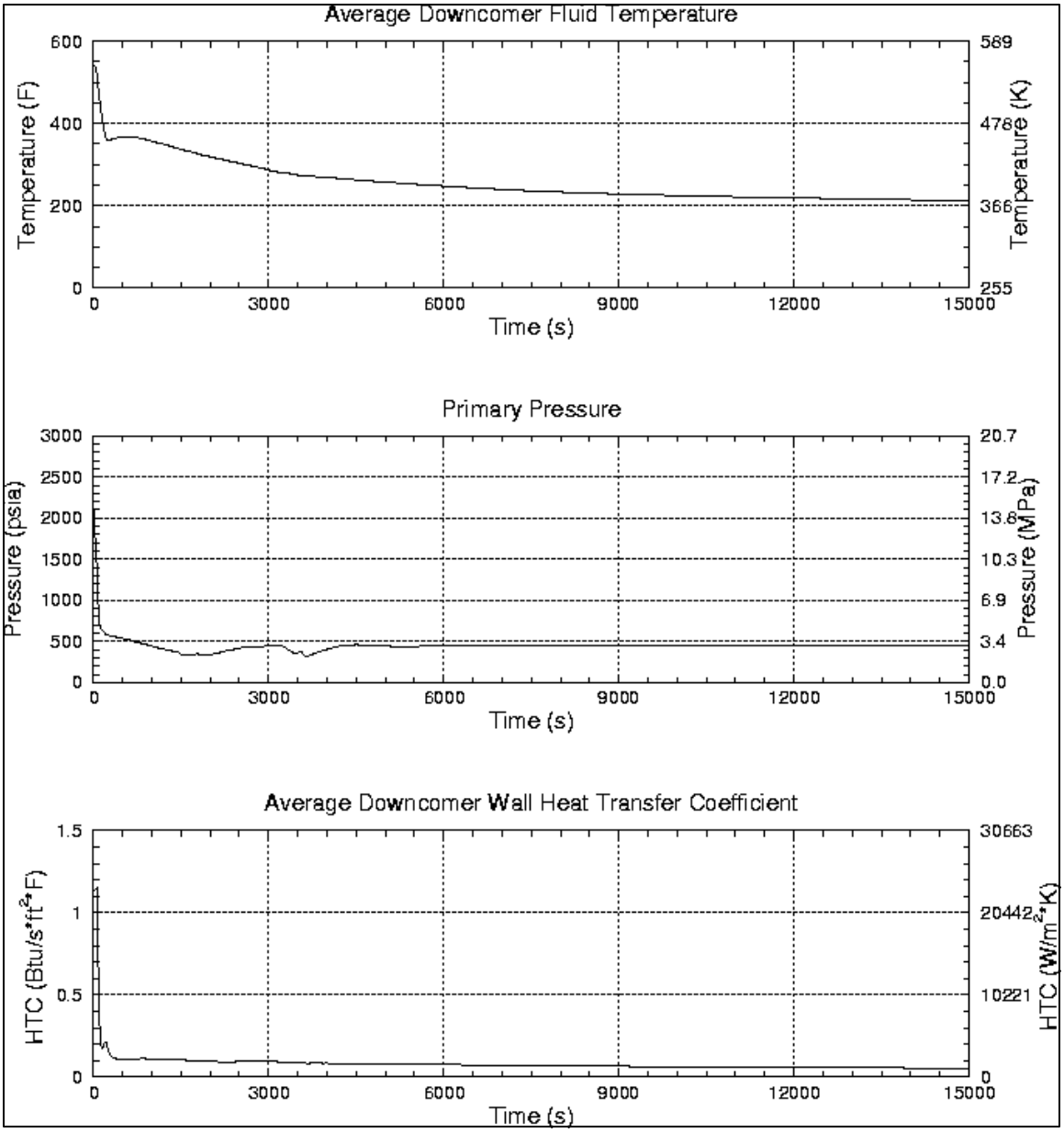

Figure C.2-14: Palisades PTS Results for Case 011

Case Category	LOCA
Primary Failures	5.08 cm (2 in) surge line break. Containment sump recirculation included in the analysis.
Secondary Failures	1 stuck-open ADV on SG-A. Failure of both MSIVs (SG-A and SG-B) to close.
Operator Actions	Operator does not isolate AFW on affected SG. Operator assumed to throttle HPI if AFW is running with SG WRL > -84% and RCS subcooling > 25 F. HPI is throttled to maintain pressurizer level between 40 and 60 %.
Min DC Temp	376.6 K (218.2°F) at 15000 s
Comments	None.

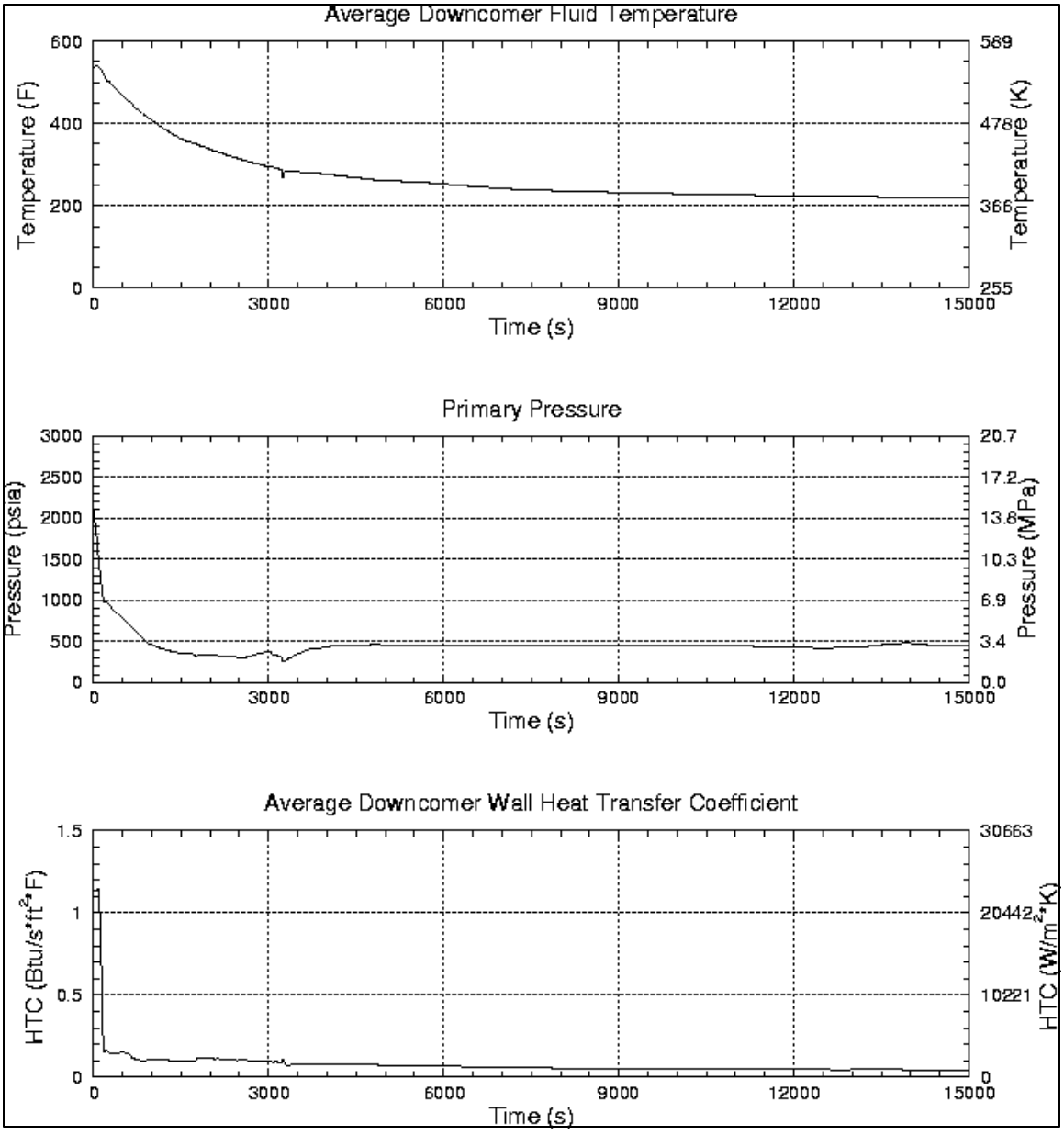

Figure C.2-15: Palisades PTS Results for Case 012

Case Category	TT/RT
Primary Failures	One stuck open pressurizer SRV. Containment spray is assumed not to actuate.
Secondary Failures	None.
Operator Actions	Operator assumed to throttle HPI if AFW is running with SG WRL > -84% and RCS subcooling > 25 F. HPI is throttled to maintain pressurizer level between 40 and 60 %.
Min DC Temp	474.1 K (393.7°F) at 15000 s
Comments	None.

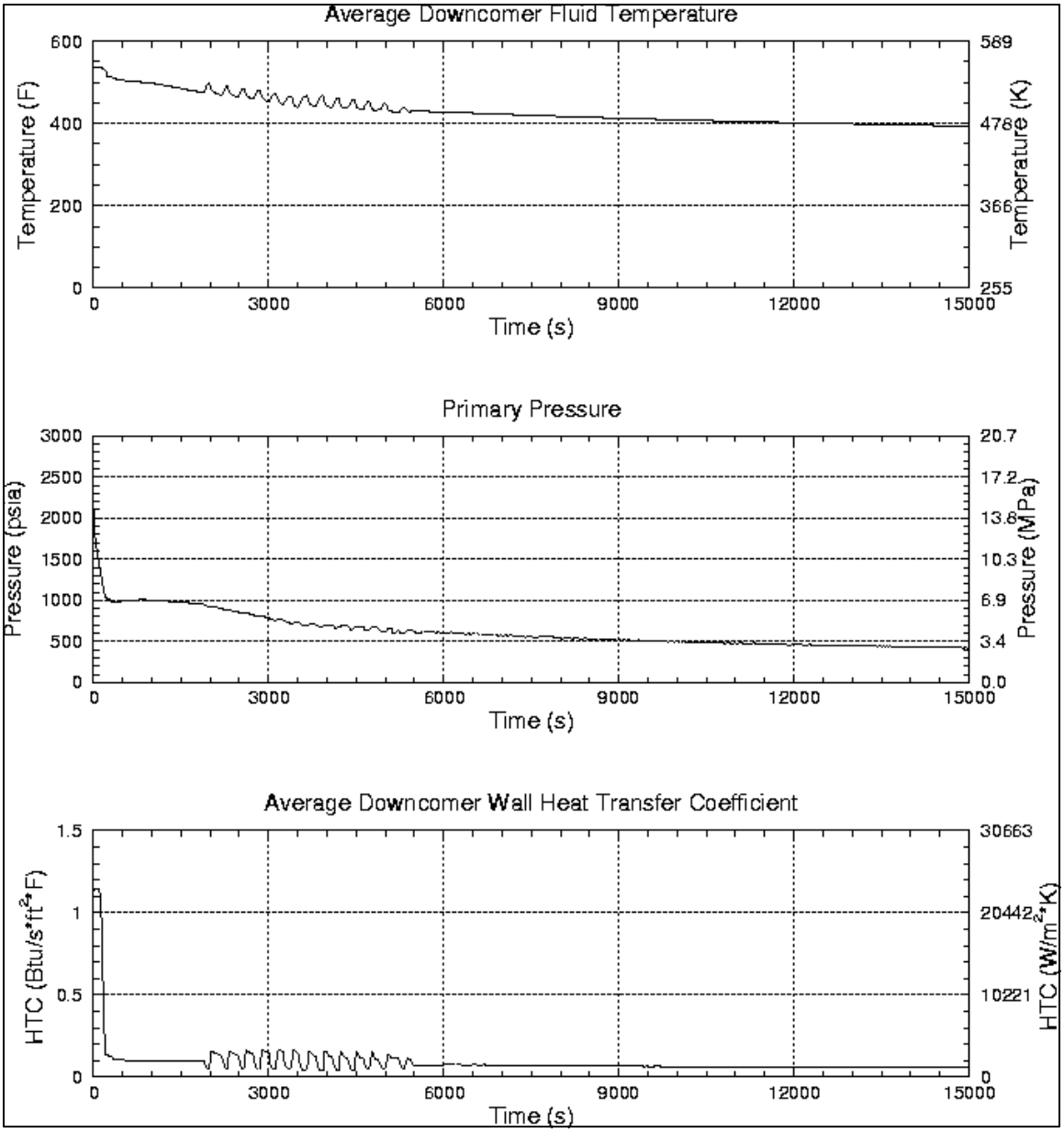

Figure C.2-16: Palisades PTS Results for Case 013

Case Category	TT/RT
Primary Failures	None.
Secondary Failures	2 stuck-open ADVs on SG-A
Operator Actions	Operator assumed to throttle HPI if AFW is running with SG WRL > -84% and RCS subcooling > 25 F. HPI is throttled to maintain pressurizer level between 40 and 60 %.
Min DC Temp	489.3 K (421.0°F) at 1590 s
Comments	None.

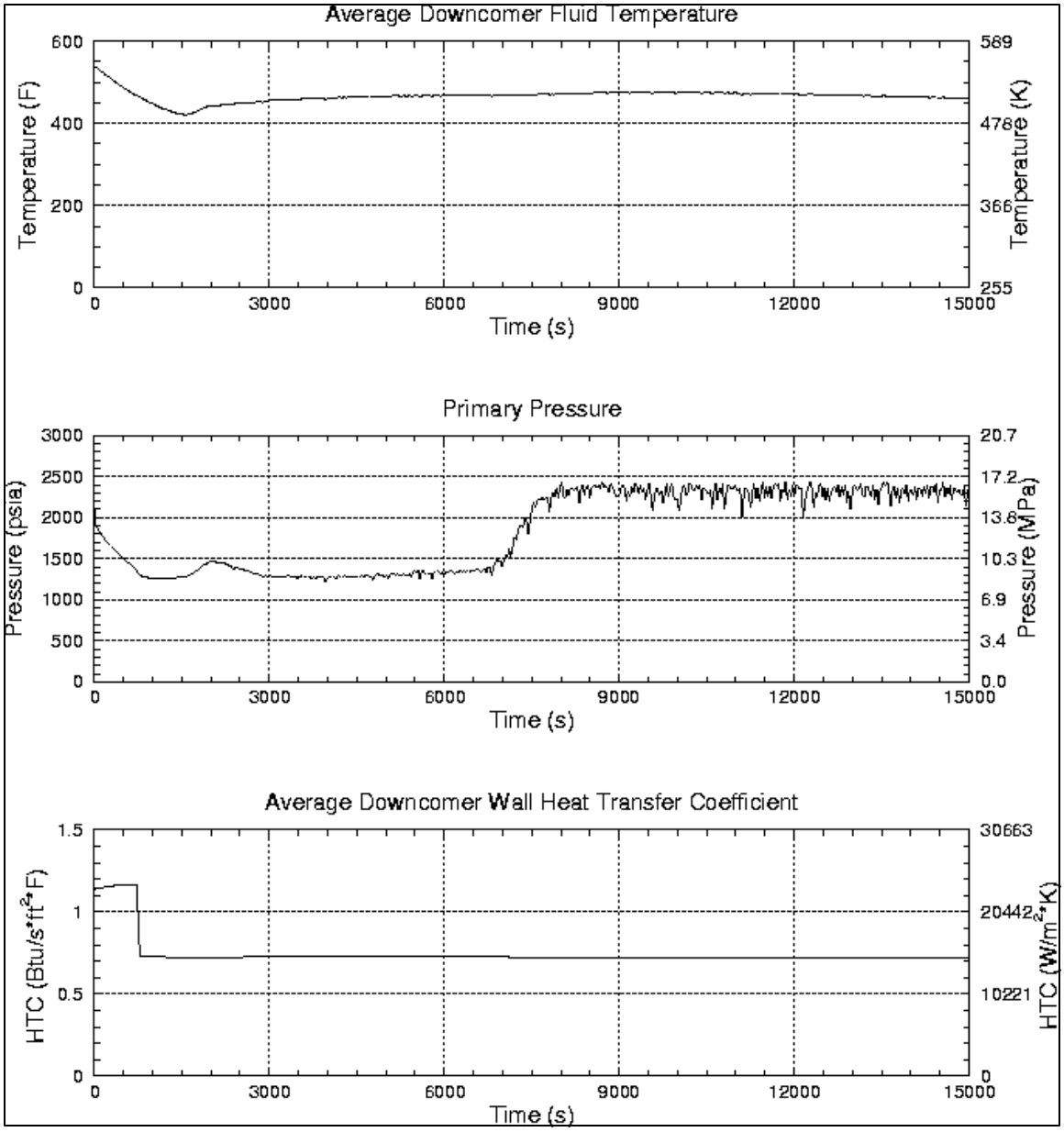

Figure C.2-17: Palisades PTS Results for Case 014

Case Category	TT/RT
Primary Failures	None.
Secondary Failures	2 stuck-open ADVs on SG-A combined with controller failure resulting in the flow from two AFW pumps into affected steam generator.
Operator Actions	Operator starts second AFW pump. Operator isolates AFW to affected SG at 15 minutes after initiation. Operator assumed to throttle HPI if AFW is running with SG WRL > -84% and RCS subcooling > 25 F. HPI is throttled to maintain pressurizer level between 40 and 60 %.
Min DC Temp	469.5 K (385.4°F) at 2490 s
Comments	None.

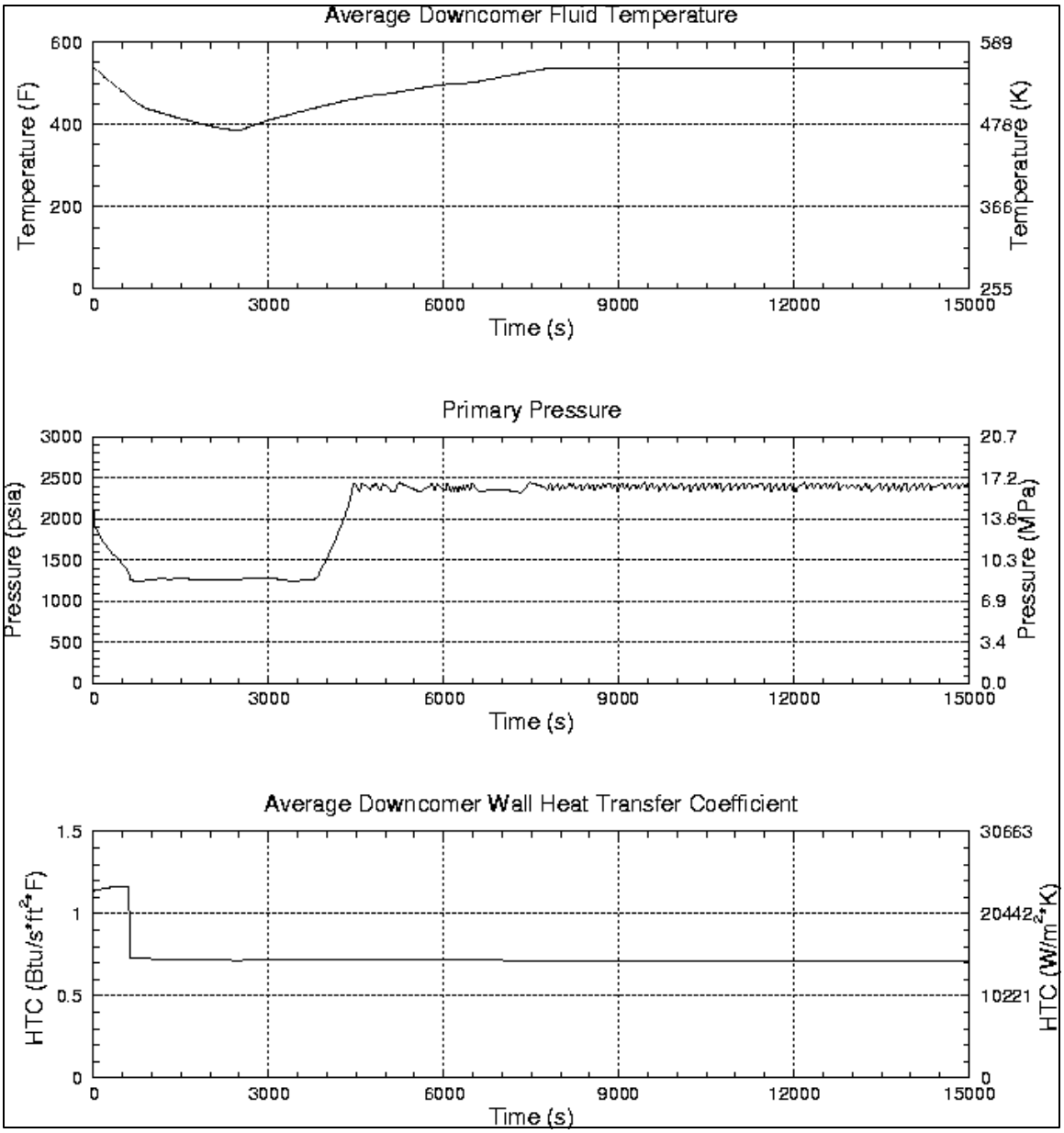

Figure C.2-18: Palisades PTS Results for Case 015

Case Category	TT/RT
Primary Failures	None.
Secondary Failures	2 stuck-open ADVs on SG-A combined with controller failure resulting in the flow from two AFW pumps into affected steam generator.
Operator Actions	Operator starts second AFW pump. Operator isolates AFW to affected SG at 30 minutes after initiation. Operator assumed to throttle HPI if AFW is running with SG WRL > -84% and RCS subcooling > 25 F. HPI is throttled to maintain pressurizer level between 40 and 60 %.
Min DC Temp	451.4 K (352.9°F) at 4620 s
Comments	None.

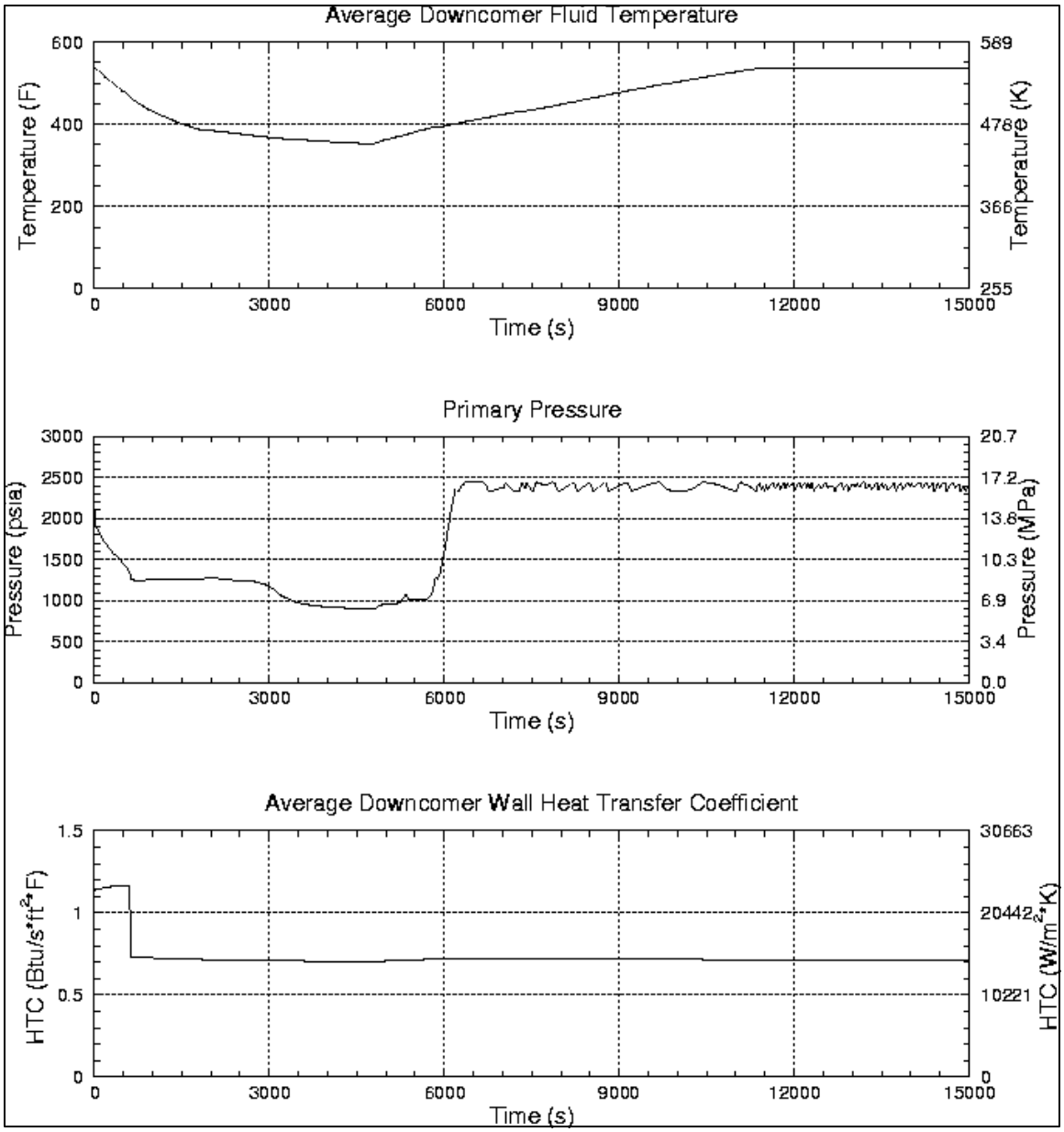

Figure C.2-19: Palisades PTS Results for Case 016

Case Category	TT/RT
Primary Failures	None.
Secondary Failures	2 stuck-open ADVs on SG-A combined with controller failure resulting in the flow from two AFW pumps into affected steam generator.
Operator Actions	Operator starts second AFW pump. Operator assumed to throttle HPI if AFW is running with SG WRL > -84% and RCS subcooling > 25 F. HPI is throttled to maintain pressurizer level between 40 and 60 %.
Min DC Temp	438.9 K (330.3°F) at 9180 s
Comments	None.

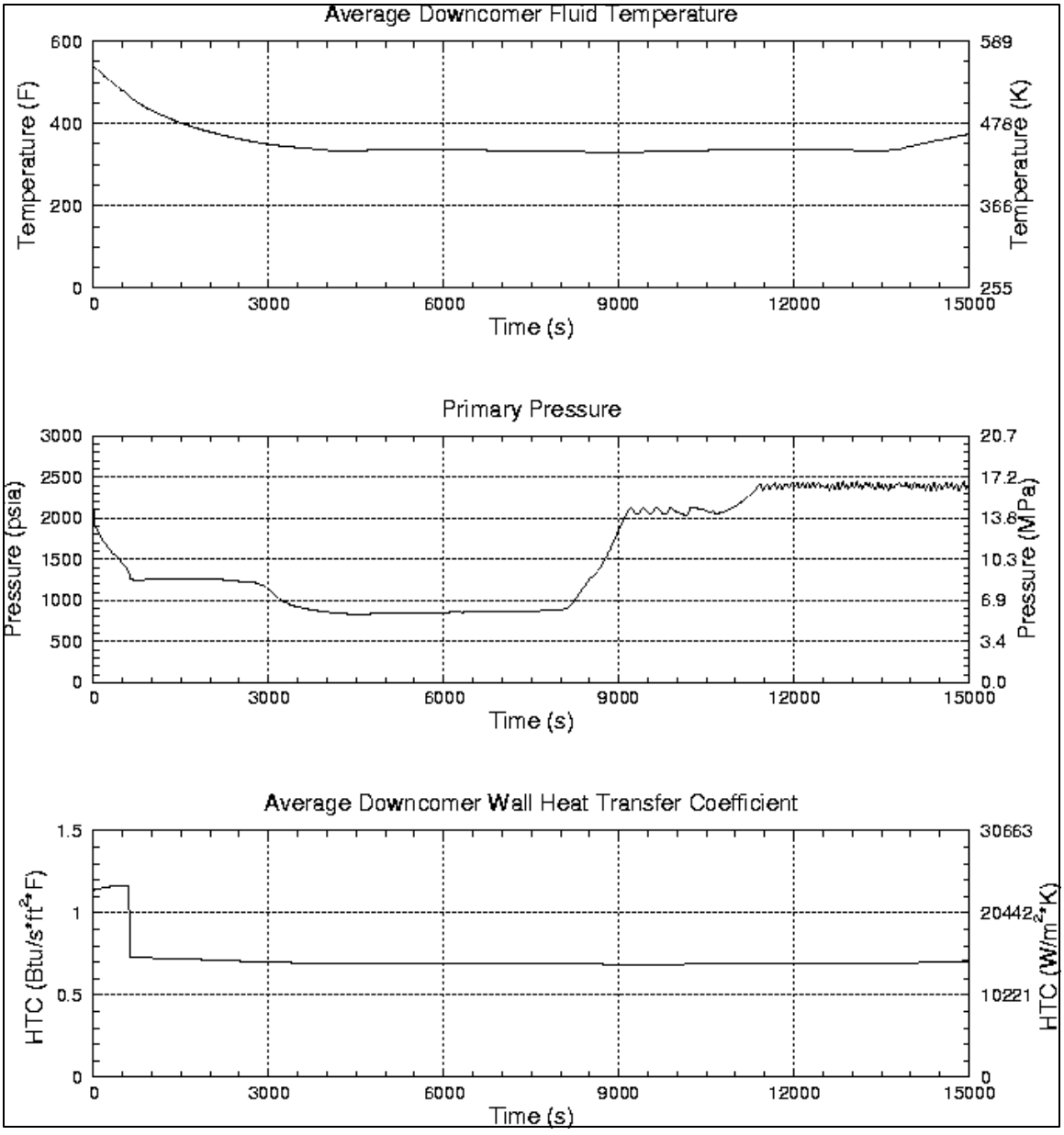

Figure C.2-20: Palisades PTS Results for Case 017

Case Category	TT/RT
Primary Failures	None.
Secondary Failures	1 stuck-open ADV on SG-A. Failure of both MSIVs (SG-A and SG-B) to close.
Operator Actions	Operator does not isolate AFW on affected SG. Normal AFW flow assumed (200 gpm). Operator assumed to throttle HPI if AFW is running with SG WRL > -84% and RCS subcooling > 25 F. HPI is throttled to maintain pressurizer level between 40 and 60 %.
Min DC Temp	443.4 K (338.5°F) at 14130 s
Comments	None.

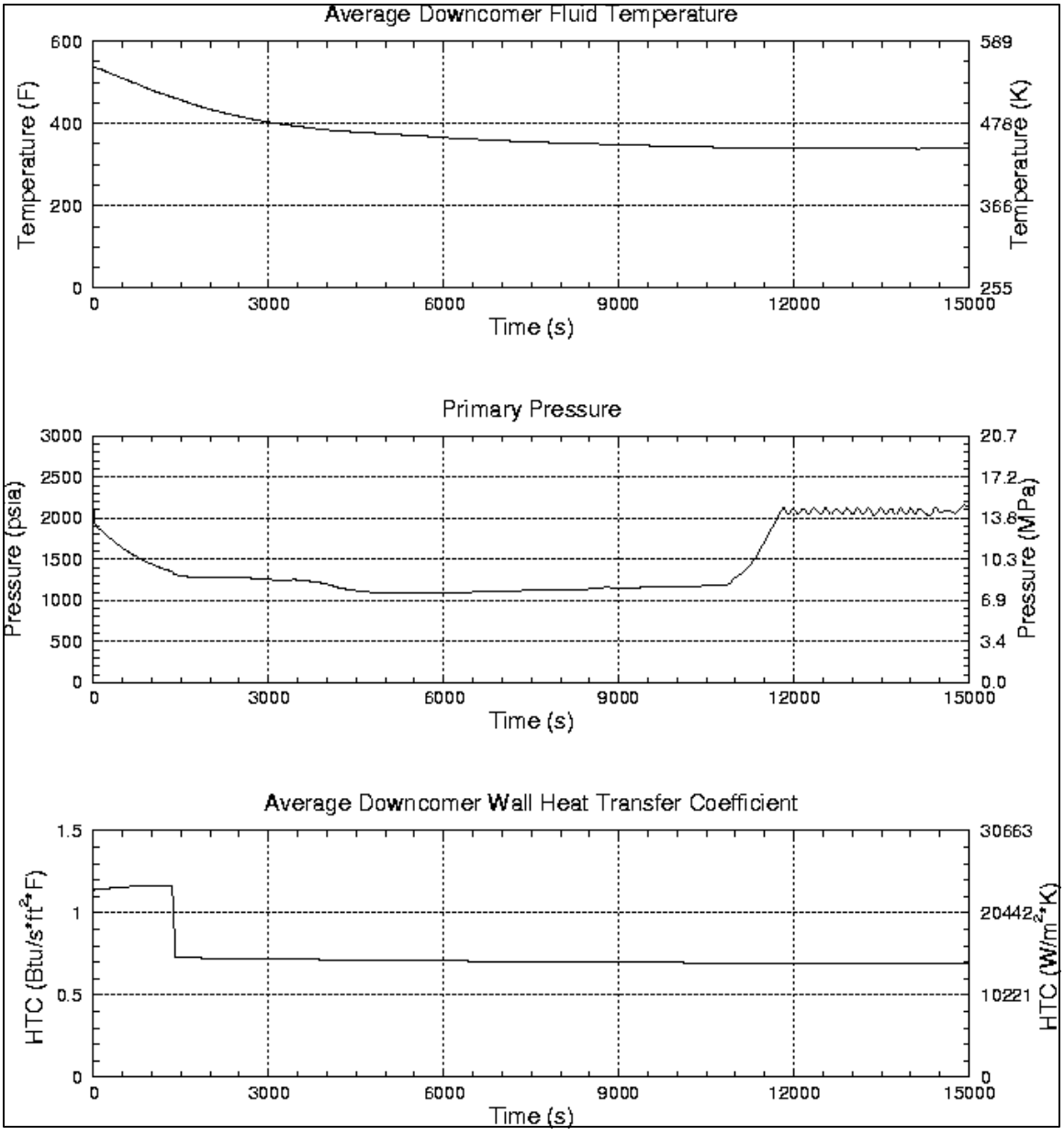

Figure C.2-21: Palisades PTS Results for Case 018

Case Category	TT/RT, HZP
Primary Failures	None.
Secondary Failures	1 stuck-open ADV on SG-A
Operator Actions	None. Operator does not throttle HPI.
Min DC Temp	423.0 K (301.7°F) at 15000 s
Comments	None.

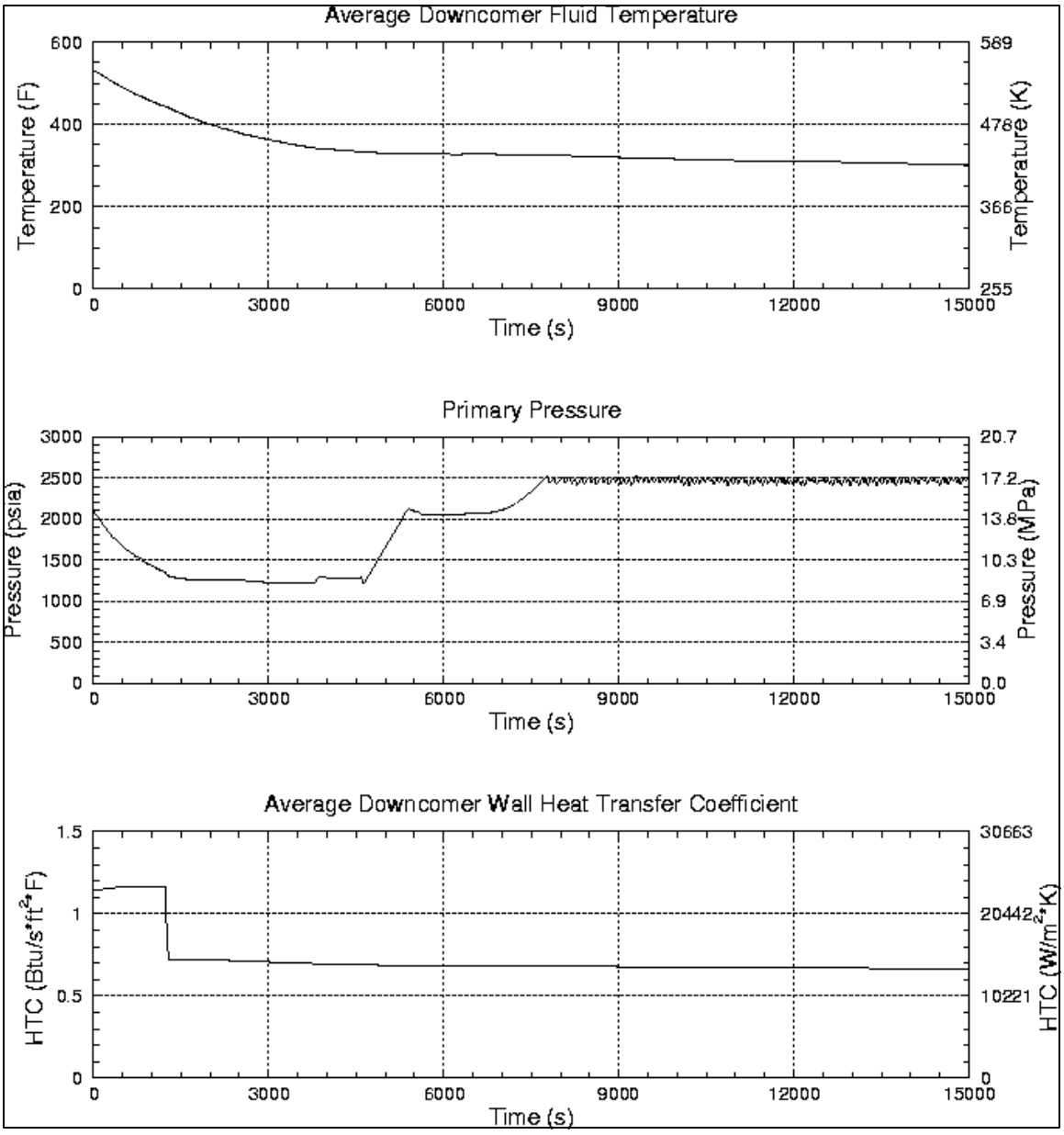

Figure C.2-22: Palisades PTS Results for Case 019

Case Category	TT/RT
Primary Failures	None.
Secondary Failures	SG level control system failure causes SG overfill. MFW continues running and the SGs flood.
Operator Actions	Operator terminates MFW when either water flows to the steam line or 75,000 gallons is pumped into the steam generators. Operator assumed to throttle HPI if AFW is running with SG WRL > -84% and RCS subcooling > 25 F. HPI is throttled to maintain pressurizer level between 40 and 60 %.
Min DC Temp	460.1 K (368.5°F) at 270 s
Comments	None.

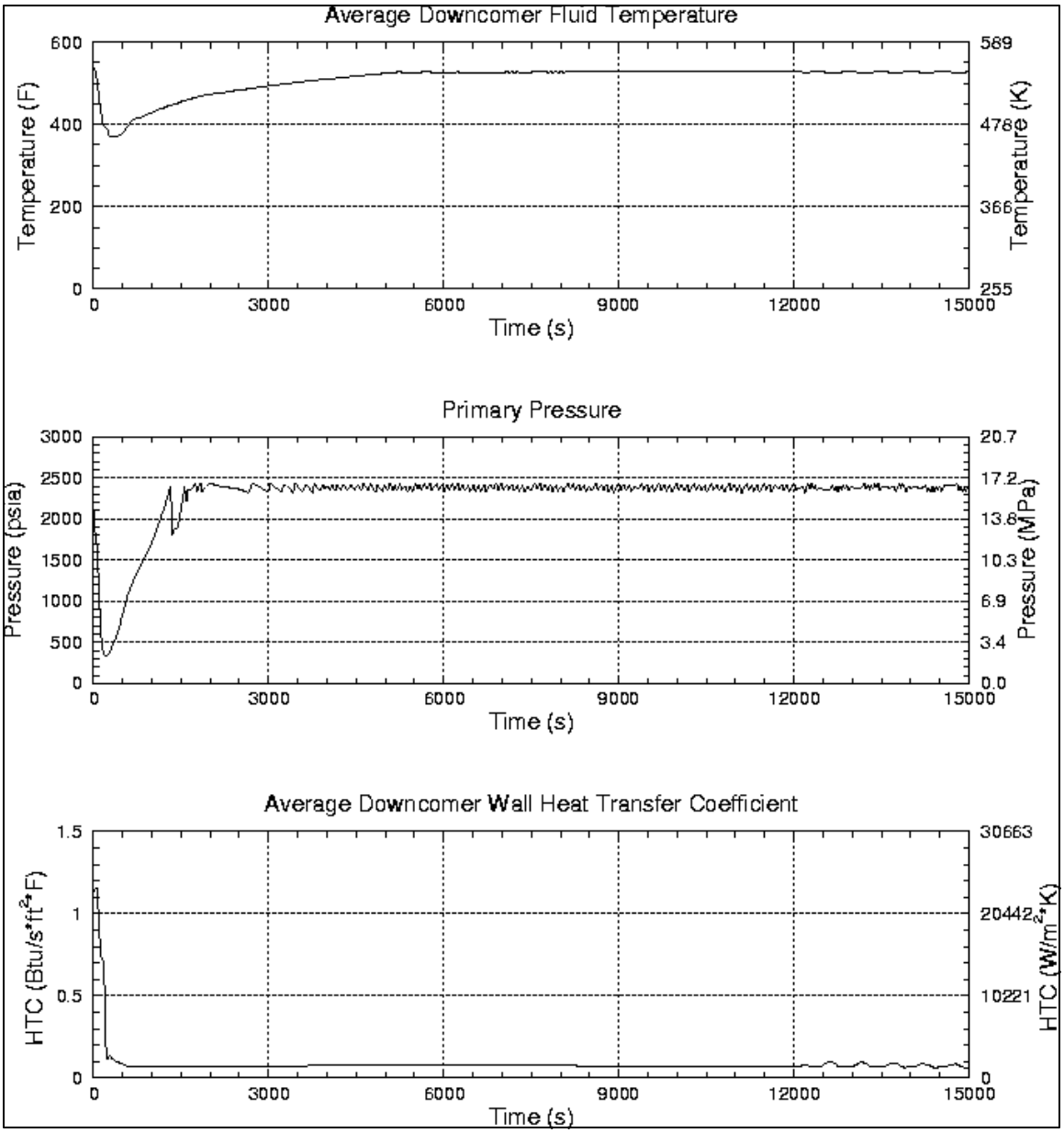

Figure C.2-23: Palisades PTS Results for Case 020

Case Category	TT/RT, HZP
Primary Failures	None.
Secondary Failures	SG level control system failure causes SG overfill. MFW continues running and the SGs flood.
Operator Actions	Operator terminates MFW when either water flows to the steam line or 75,000 gallons is pumped into the steam generators. Operator does not throttle HPI.
Min DC Temp	487.7 K (418.3°F) at 330 s
Comments	None.

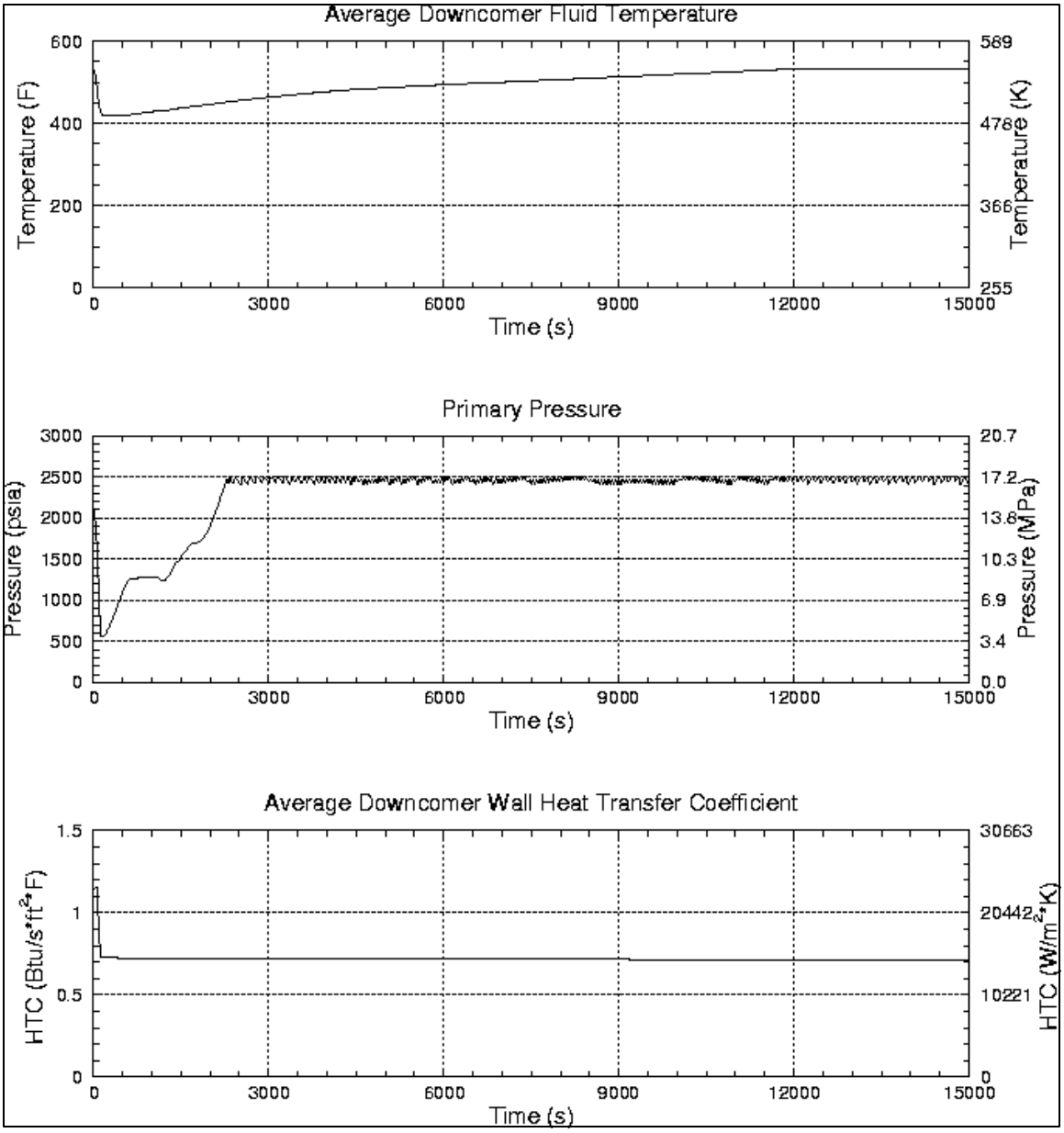

Figure C.2-24: Palisades PTS Results for Case 021

Case Category	TT/RT
Primary Failures	None.
Secondary Failures	Loss of MFW and AFW.
Operator Actions	Operator depressurizes through ADVs and feeds SG's using condensate booster pumps. Operators maintain a cooldown rate within technical specification limits and throttle condensate flow at 84 % level in the steam generator.
Min DC Temp	394.9 K (251.1°F) at 15000 s
Comments	None.

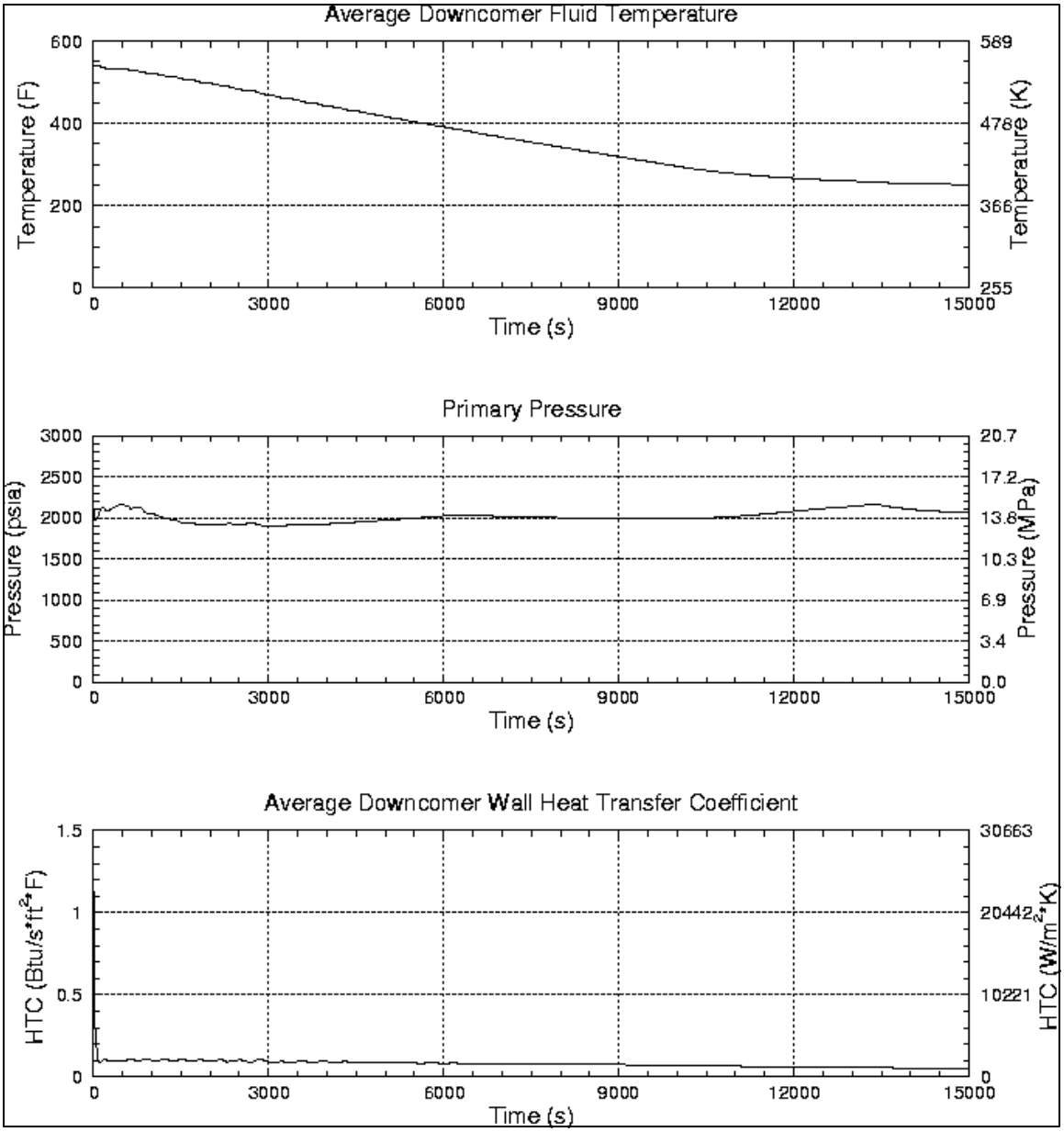

Figure C.2-25: Palisades PTS Results for Case 022

Case Category	TT/RT
Primary Failures	Two stuck-open pressurizer SRVs that reclose at 6000 sec after initiation. Containment spray is assumed not to actuate.
Secondary Failures	None.
Operator Actions	Operator assumed to throttle HPI if AFW is running with SG WRL > -84% and RCS subcooling > 25 F. HPI is throttled to maintain pressurizer level between 40 and 60 %.
Min DC Temp	450.8 K (351.9°F) at 5910 s
Comments	None.

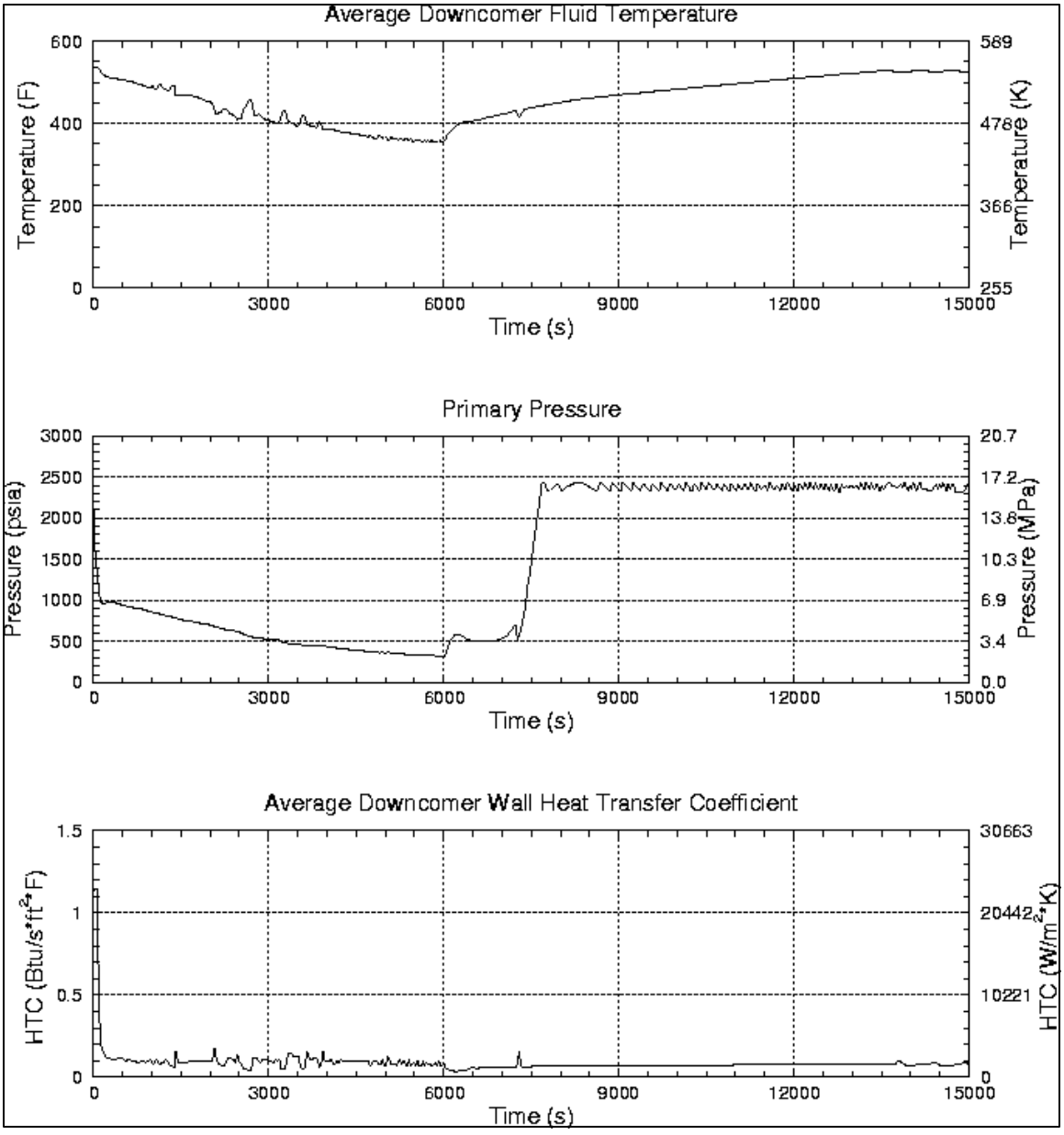

Figure C.2-26: Palisades PTS Results for Case 023

Case Category	MSLB
Primary Failures	None.
Secondary Failures	Break assumed to be inside containment causing containment spray actuation.
Operator Actions	None.
Min DC Temp	431.0 K (316.1°F) at 450 s
Comments	None.

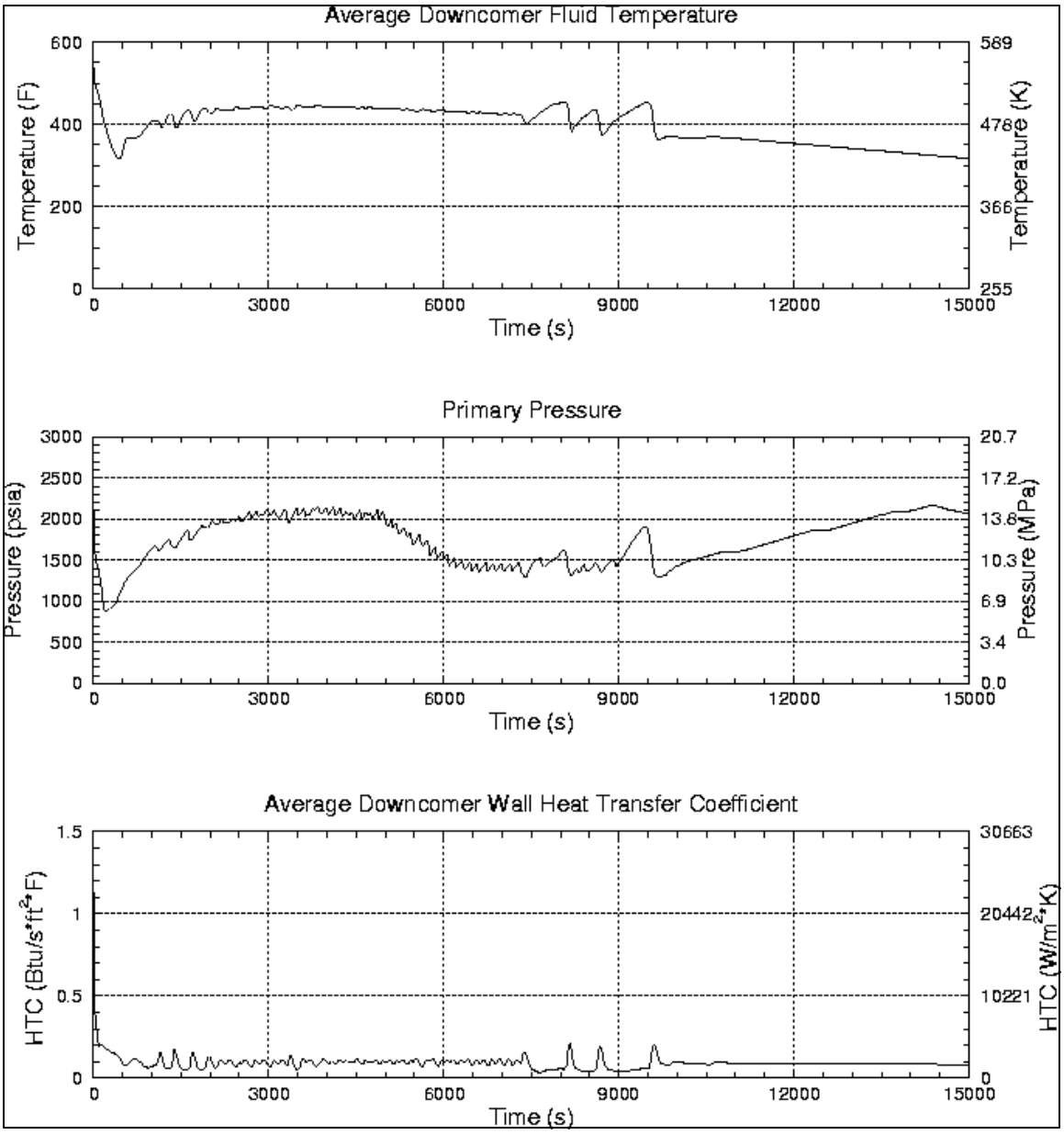

Figure C.2-27: Palisades PTS Results for Case 024

Case Category	MSLB
Primary Failures	None.
Secondary Failures	Break assumed to be inside containment causing containment spray actuation.
Operator Actions	Operator isolates AFW to affected SG at 15 minutes after initiation.
Min DC Temp	431.0 K (316.1°F) at 450 s
Comments	None.

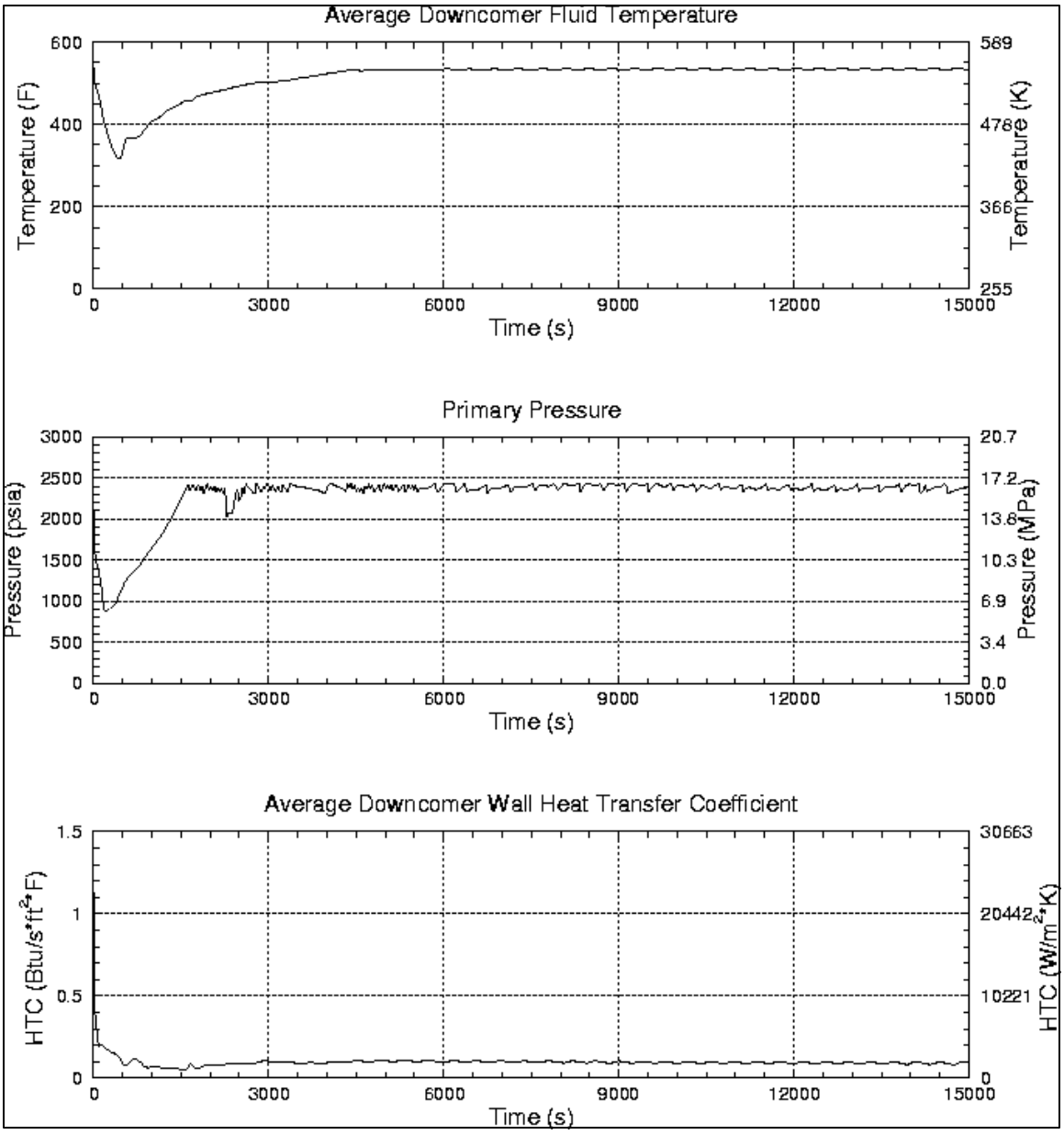

Figure C.2-28: Palisades PTS Results for Case 025

Case Category	MSLB
Primary Failures	None.
Secondary Failures	Break assumed to be inside containment causing containment spray actuation.
Operator Actions	Operator isolates AFW to affected SG at 30 minutes after initiation.
Min DC Temp	431.0 K (316.1°F) at 450 s
Comments	None.

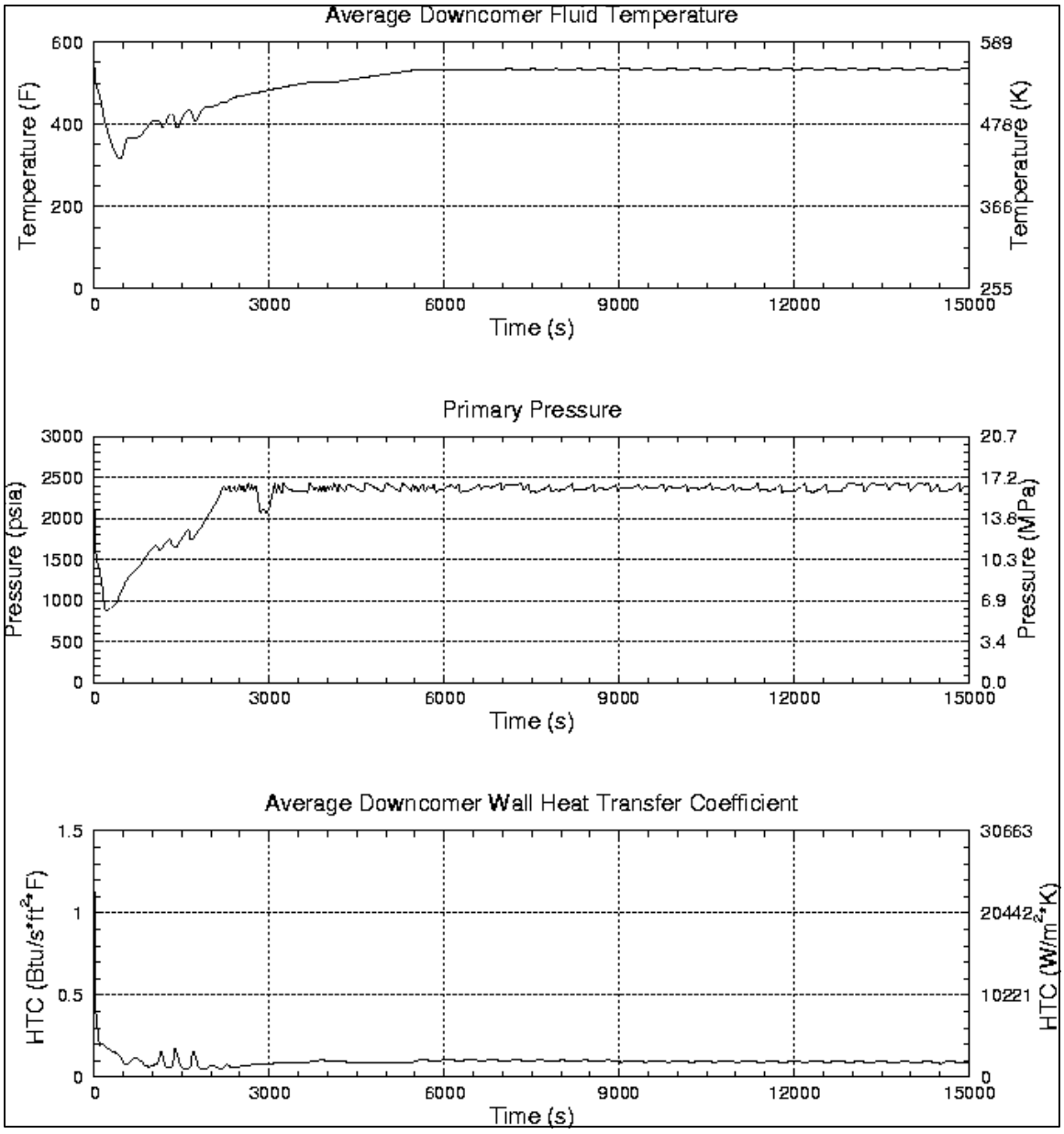

Figure C.2-29: Palisades PTS Results for Case 026

Case Category	MSLB
Primary Failures	None.
Secondary Failures	Controller failure resulting in the flow from two AFW pumps into affected steam generator. Break assumed to be inside containment causing containment spray actuation.
Operator Actions	Operator starts second AFW pump.
Min DC Temp	383.5 K (230.6°F) at 15000 s
Comments	None.

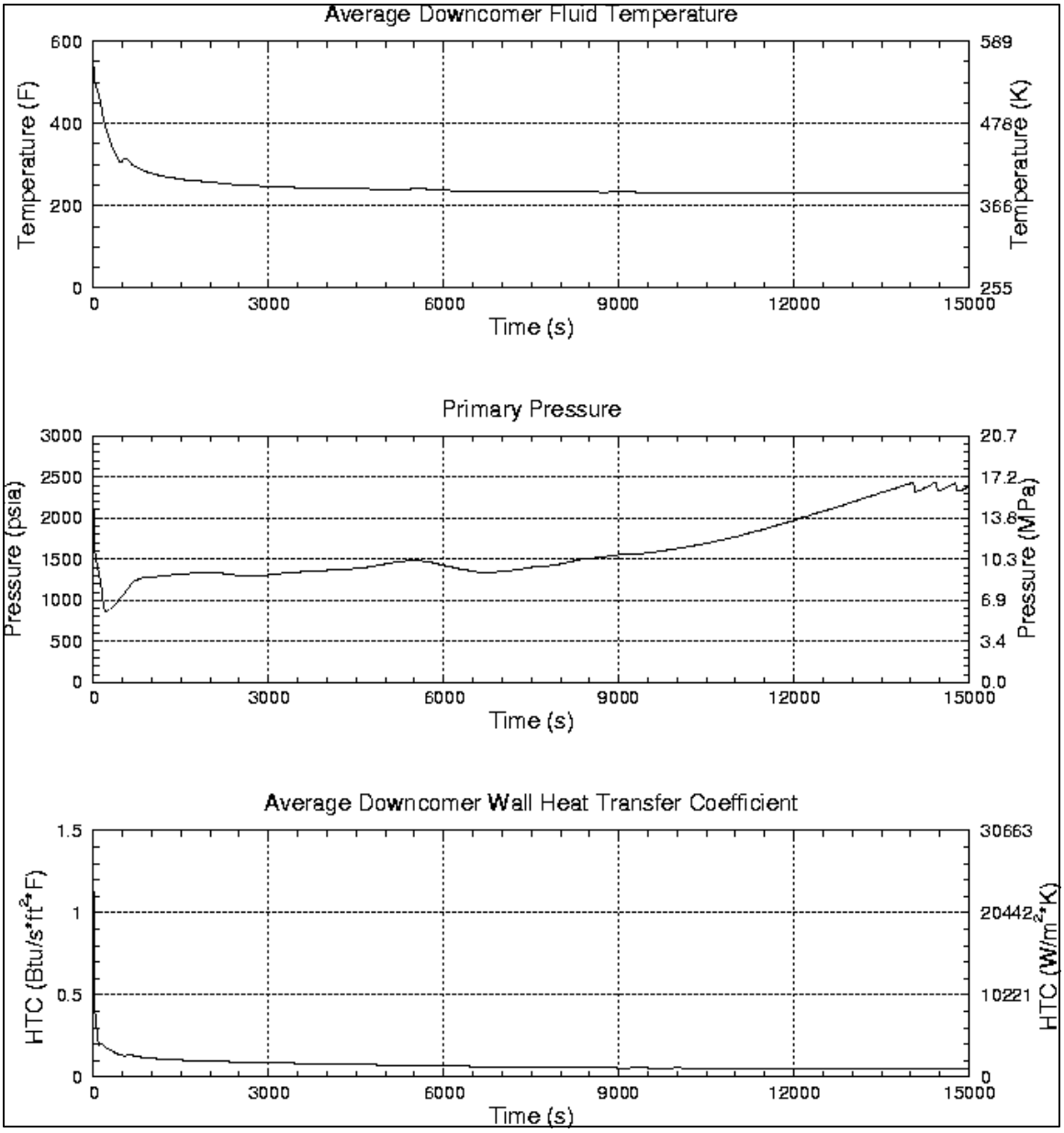

Figure C.2-30: Palisades PTS Results for Case 027

Case Category	MSLB
Primary Failures	None.
Secondary Failures	Failure of both MSIVs to close. Break assumed to be inside containment causing containment spray actuation.
Operator Actions	Operator does not isolate AFW on affected SG.
Min DC Temp	377.1 K (219.1°F) at 4110 s
Comments	None.

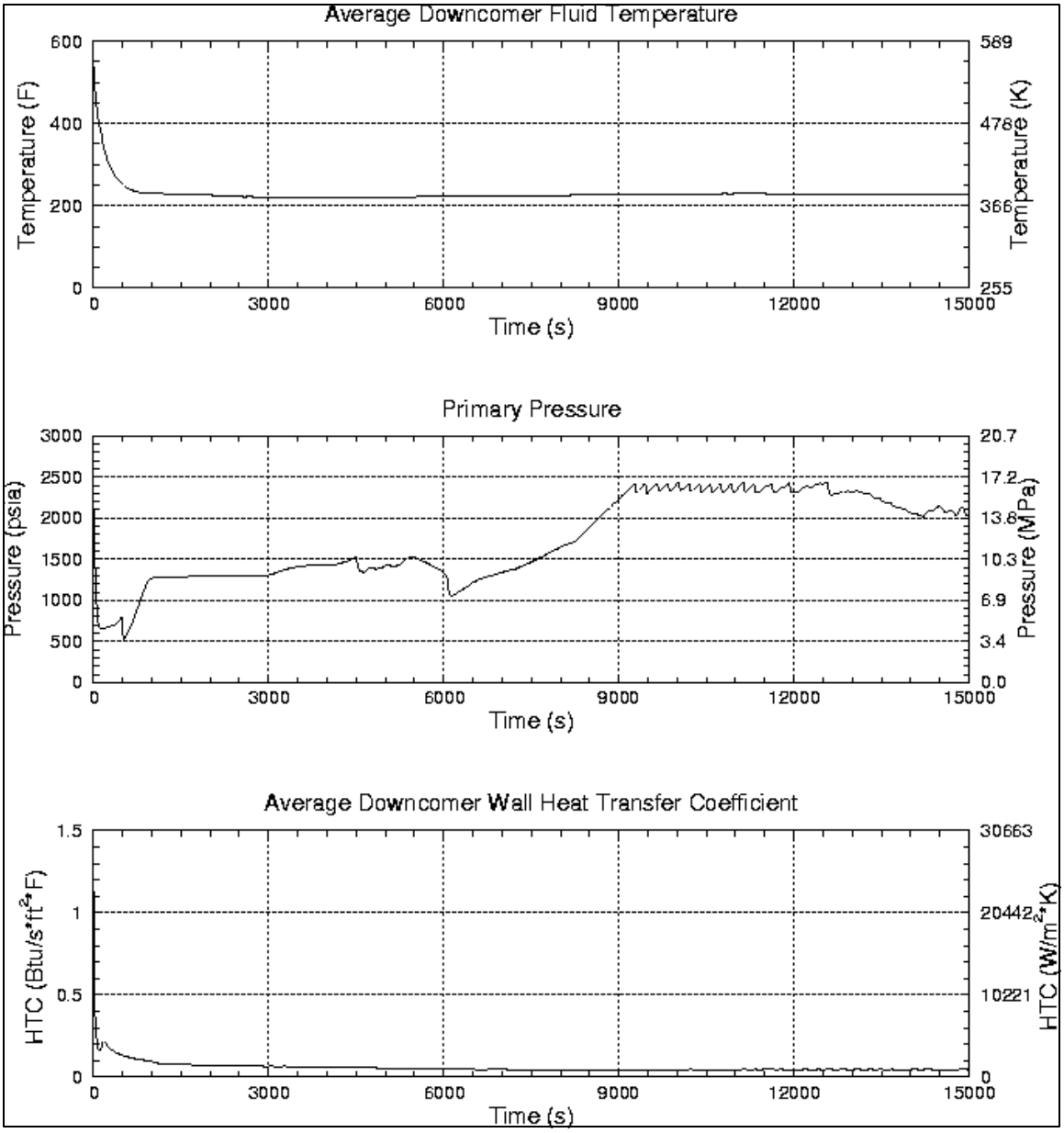

Figure C.2-31: Palisades PTS Results for Case 028

Case Category	MSLB, HZP
Primary Failures	None.
Secondary Failures	None. Break assumed to be inside containment causing containment spray actuation.
Operator Actions	None. Operator does not throttle HPI.
Min DC Temp	379.9 K (224.2°F) at 7410 s
Comments	None.

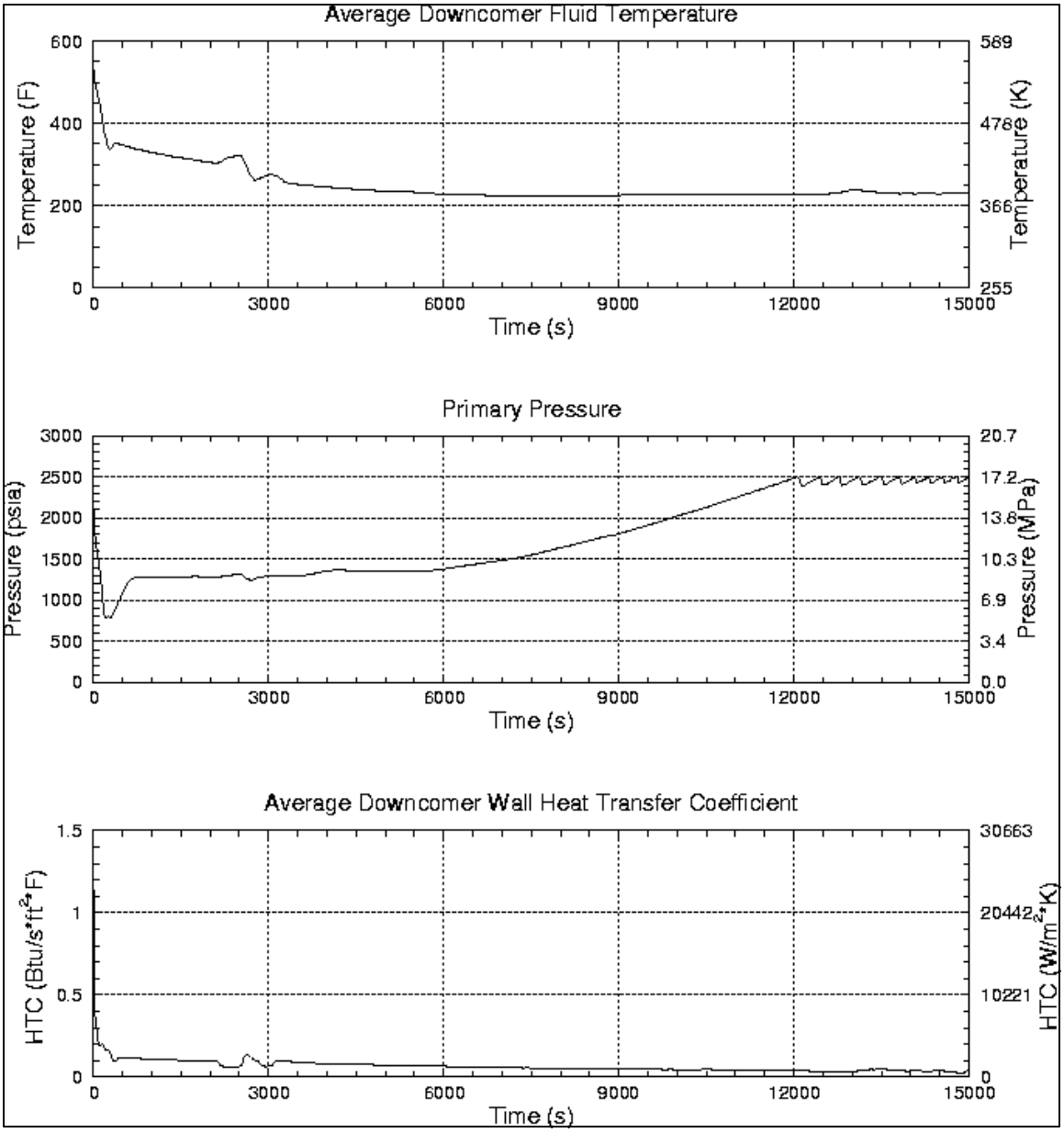

Figure C.2-32: Palisades PTS Results for Case 029

Case Category	LOCA, HZP
Primary Failures	5.08 cm (2 in) surge line break
Secondary Failures	None.
Operator Actions	None. Operator does not throttle HPI.
Min DC Temp	332.8 K (139.3°F) at 15000 s
Comments	None.

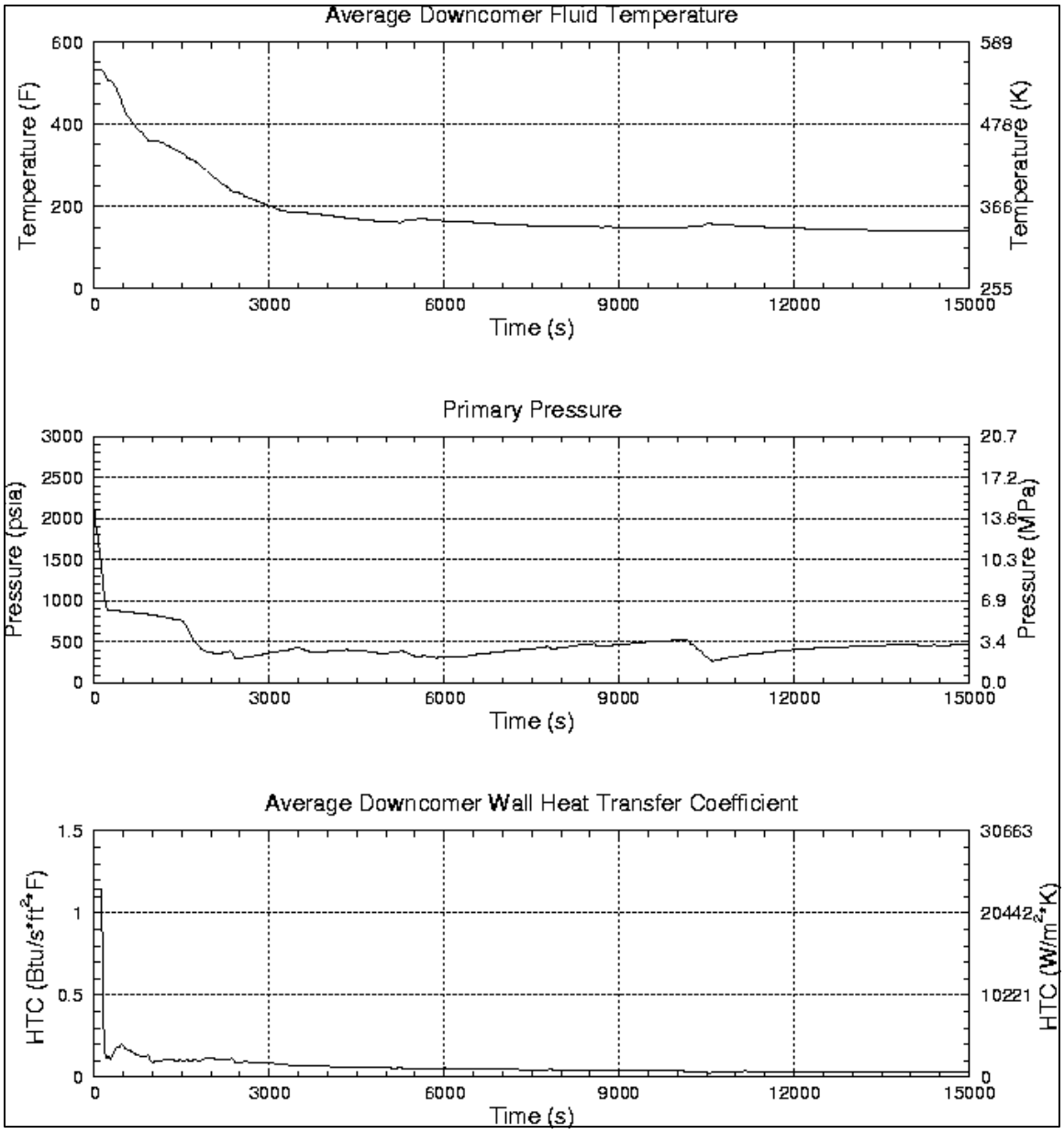

Figure C.2-33: Palisades PTS Results for Case 030

Case Category	TT/RT
Primary Failures	None.
Secondary Failures	Failure of MFW and AFW. Containment spray actuation assumed due to PORV discharge.
Operator Actions	Operator maintains core cooling by "feed and bleed" using HPI to feed and two PORVs to bleed.
Min DC Temp	356.9 K (182.8°F) at 15000 s
Comments	None.

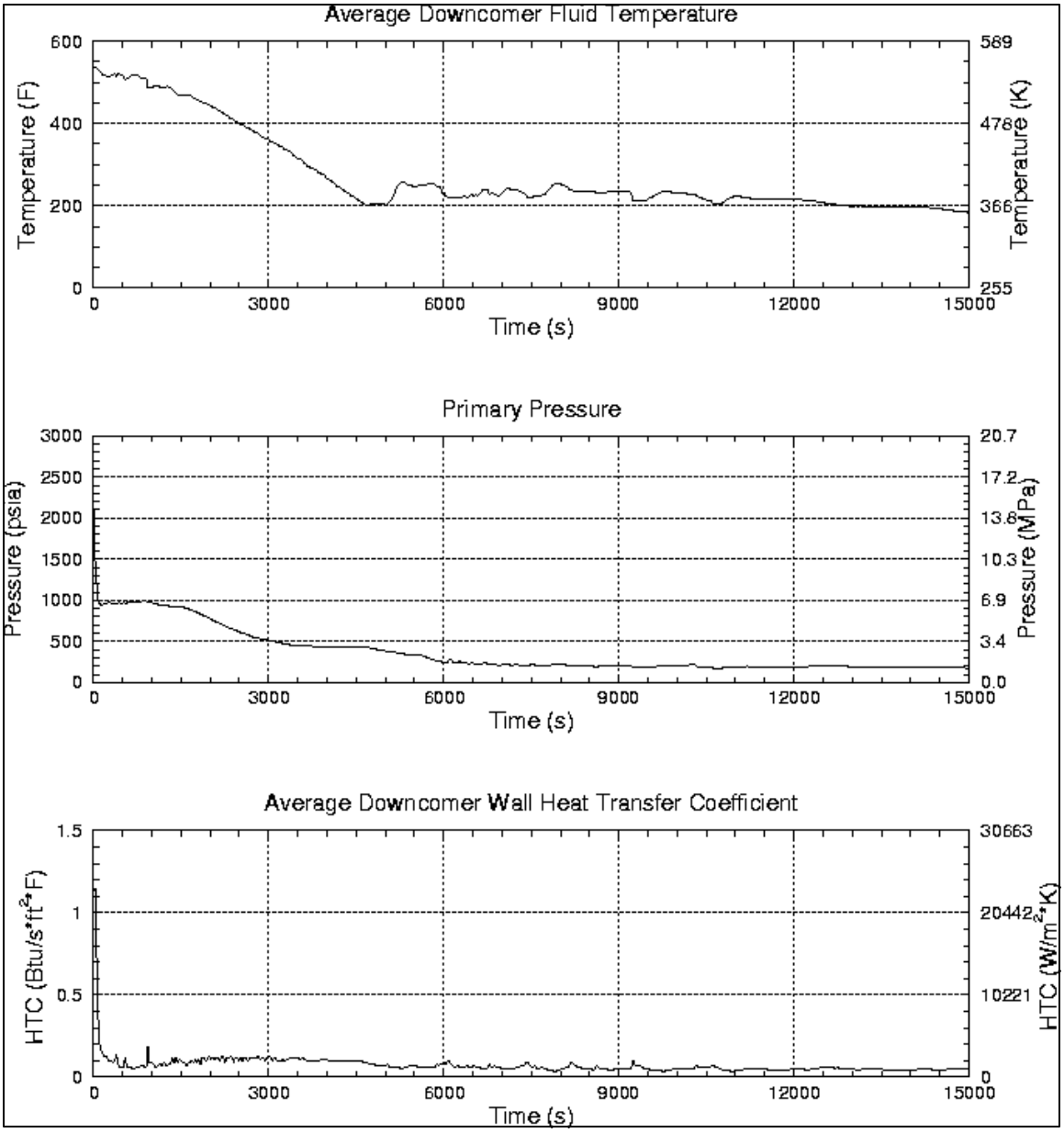

Figure C.2-34: Palisades PTS Results for Case 031

Case Category	TT/RT
Primary Failures	None.
Secondary Failures	Failure of MFW and AFW. Containment spray actuation assumed due to PORV discharge.
Operator Actions	Operator maintains core cooling by "feed and bleed" using HPI to feed and two PORV to bleed. AFW is recovered 15 minutes after initiation of "feed and bleed" cooling. Operator closes PORVs when SG level reaches 60 percent.
Min DC Temp	411.1 K (280.4°F) at 4230 s
Comments	None.

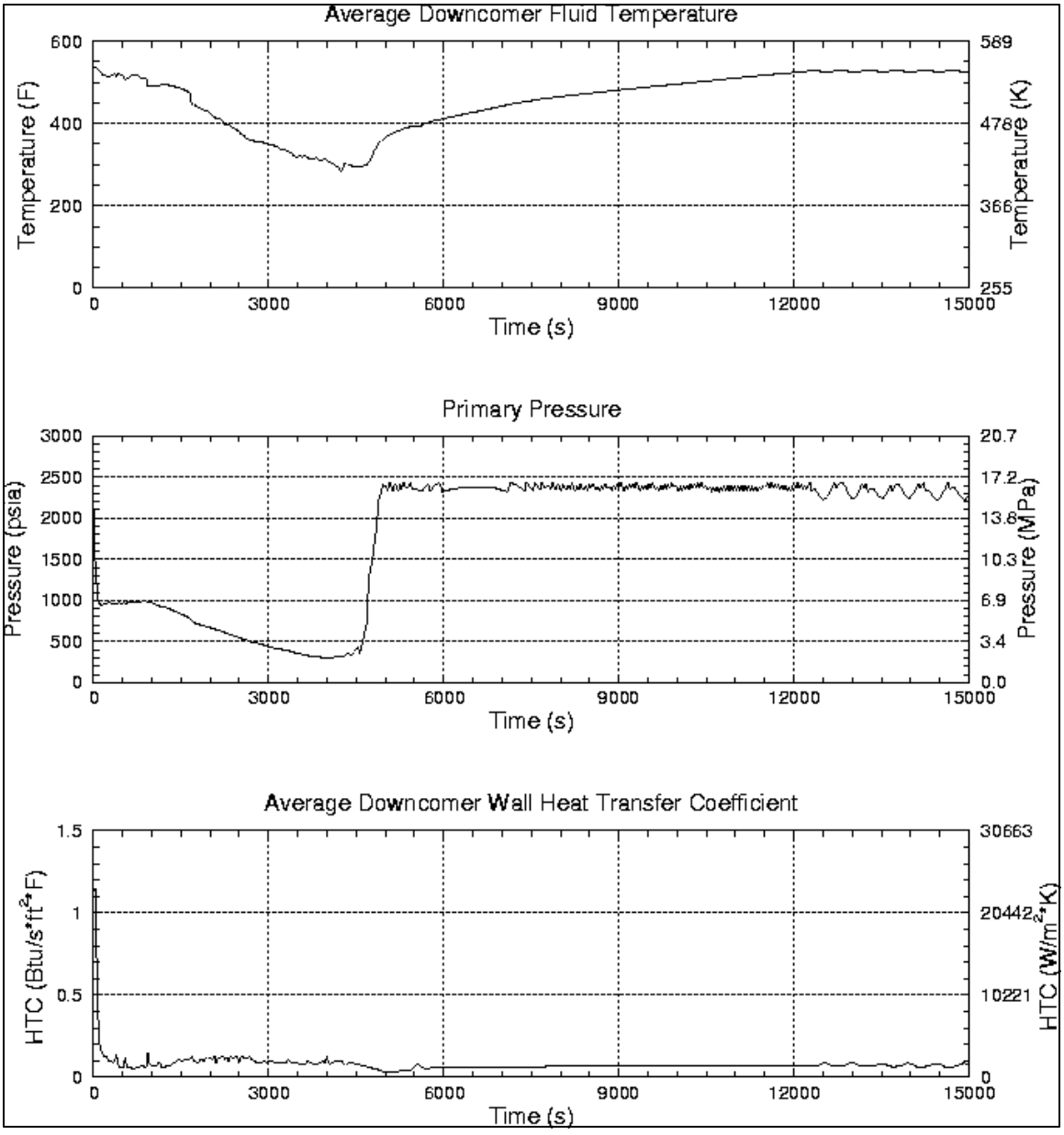

Figure C.2-35: Palisades PTS Results for Case 032

Case Category	TT/RT
Primary Failures	None.
Secondary Failures	Failure of MFW and AFW. Containment spray actuation assumed due to PORV discharge.
Operator Actions	Operator maintains core cooling by "feed and bleed" using HPI to feed and PORV to bleed. AFW is recovered 30 minutes after initiation of "feed and bleed" cooling. Operator closes PORV when SG level reaches 60 percent.
Min DC Temp	402.5 K (264.8°F) at 4800 s
Comments	None.

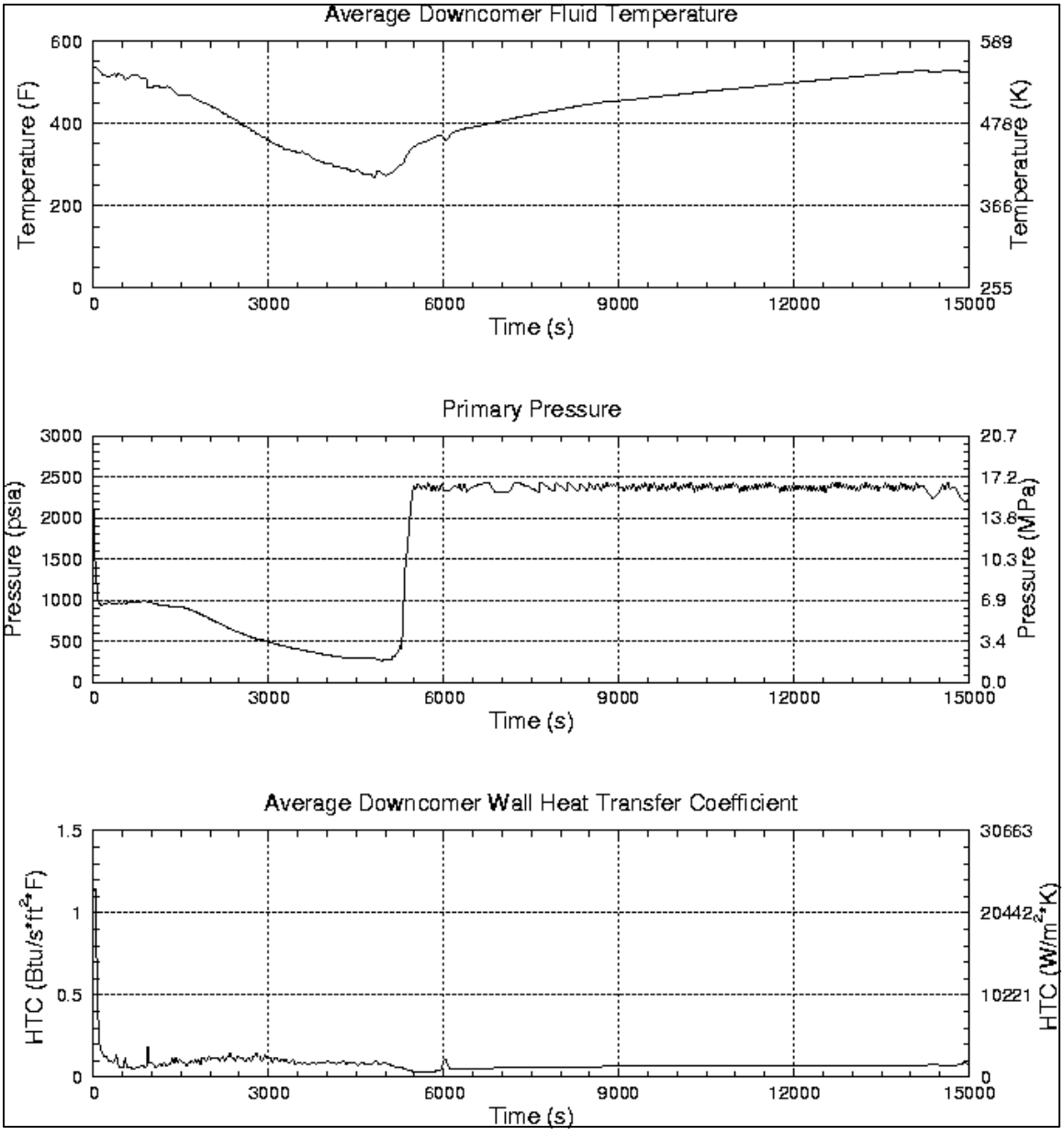

Figure C.2-36: Palisades PTS Results for Case 033

Case Category	MSLB
Primary Failures	Single SG tube ruptures in SG-A due to MSLB vibration.
Secondary Failures	None.
Operator Actions	Operator isolates AFW to affected SG at 15 minutes after initiation. Operator trips RCPs assuming that they do not trip as a result of the event. Operator assumed to throttle HPI if AFW is running with SG WRL > -84% and RCS subcooling > 25 F. HPI is throttled to maintain pressurizer level between 40 and 60 %.
Min DC Temp	377.4 K (219.6°F) at 13770 s
Comments	None.

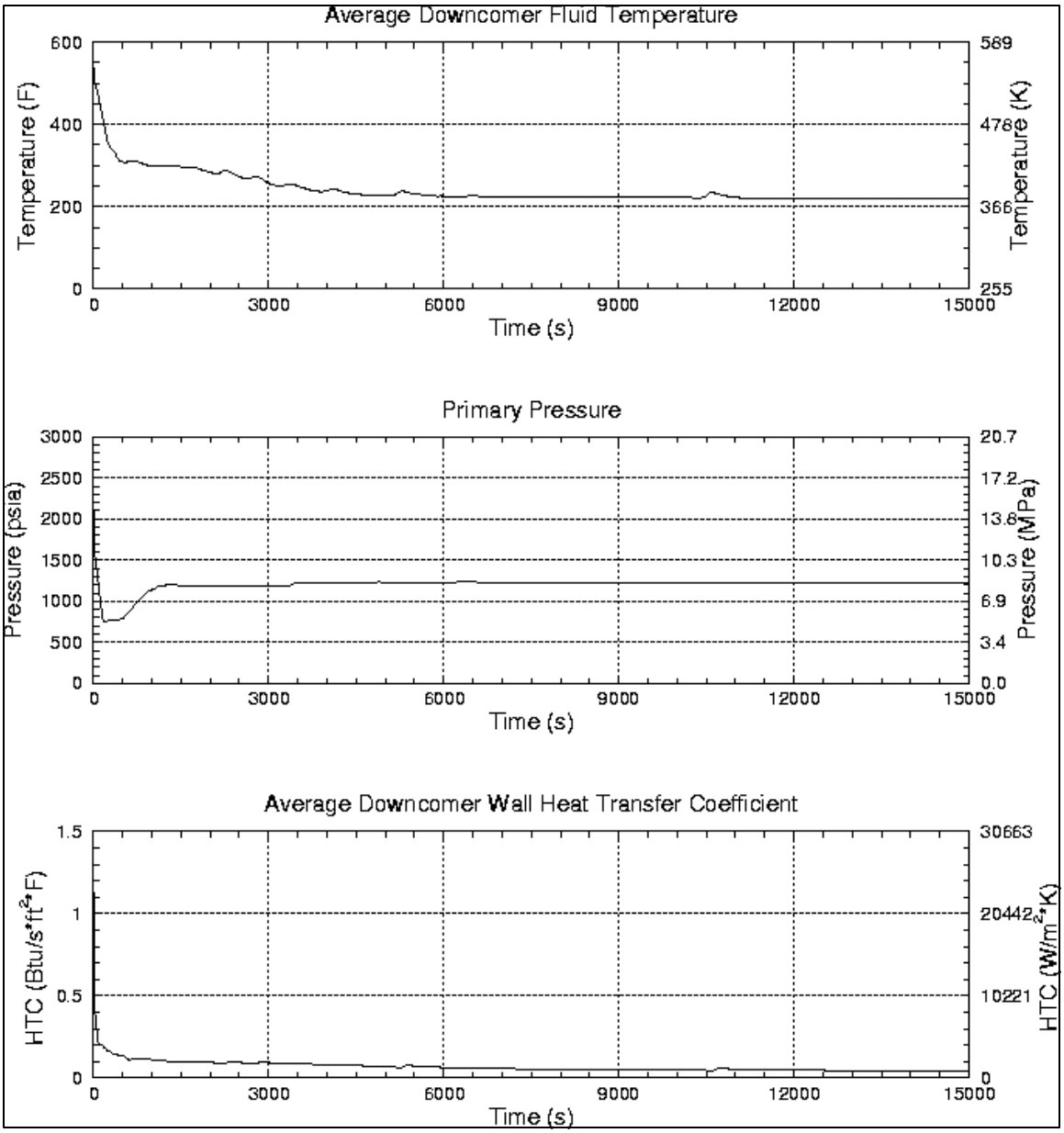

Figure C.2-37: Palisades PTS Results for Case 034

Case Category	MSLB
Primary Failures	Ten SG tubes rupture in SG-A due to MSLB vibration.
Secondary Failures	None.
Operator Actions	Operator isolates AFW to affected SG at 15 minutes after initiation. Operator trips RCPs assuming that they do not trip as a result of the event. Operator assumed to throttle HPI if AFW is running with SG WRL > -84% and RCS subcooling > 25 F. HPI is throttled to maintain pressurizer level between 40 and 60 %.
Min DC Temp	352.7 K (175.2°F) at 840 s
Comments	None.

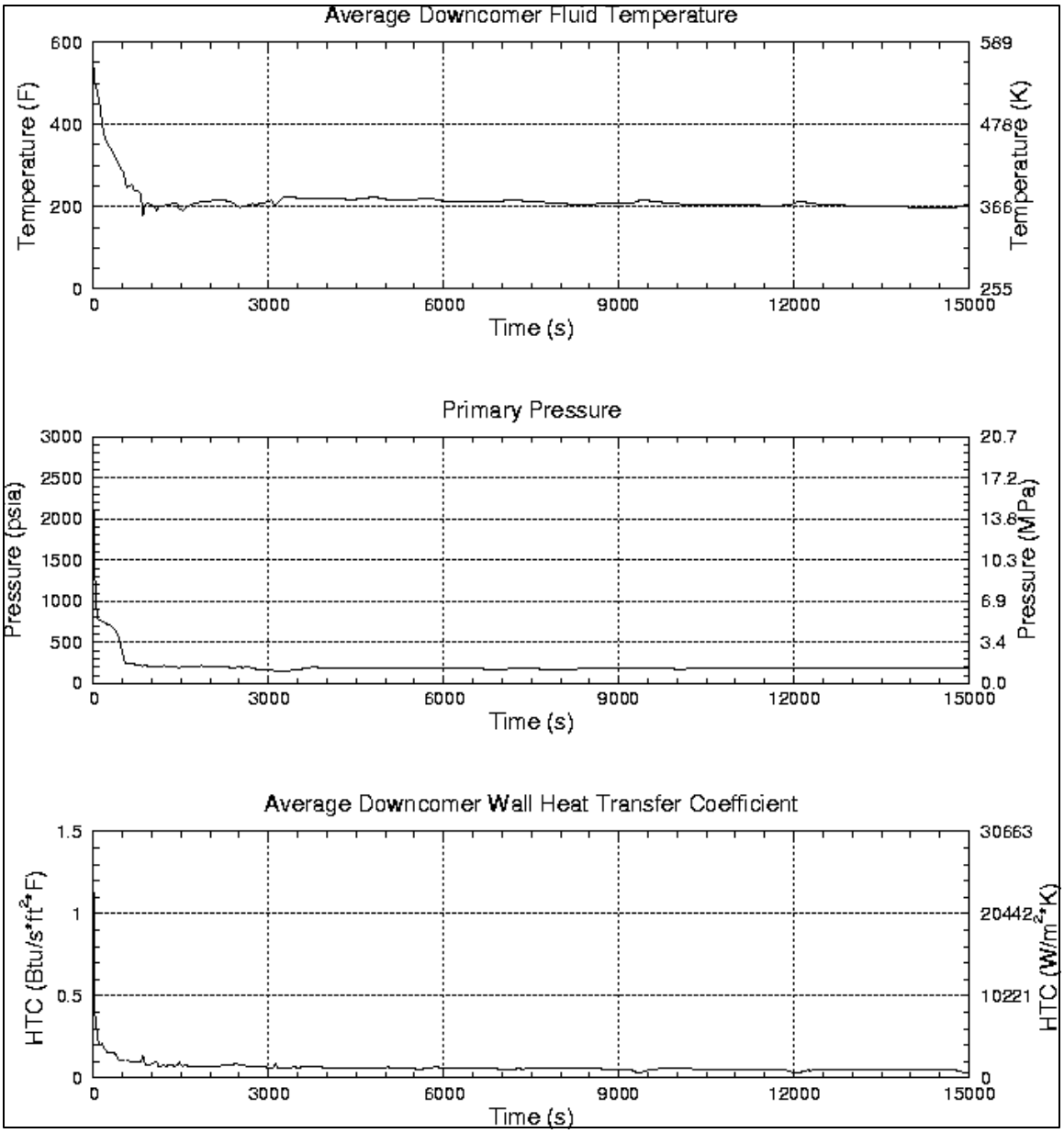

Figure C.2-38: Palisades PTS Results for Case 035

Case Category	MSLB
Primary Failures	None.
Secondary Failures	Controller failure resulting in the flow from two AFW pumps into affected steam generator. Break assumed to be inside containment causing containment spray actuation.
Operator Actions	Operator starts second AFW pump. Operator isolates AFW to affected SG at 15 minutes after initiation.
Min DC Temp	405.4 K (270.1°F) at 1320 s
Comments	None.

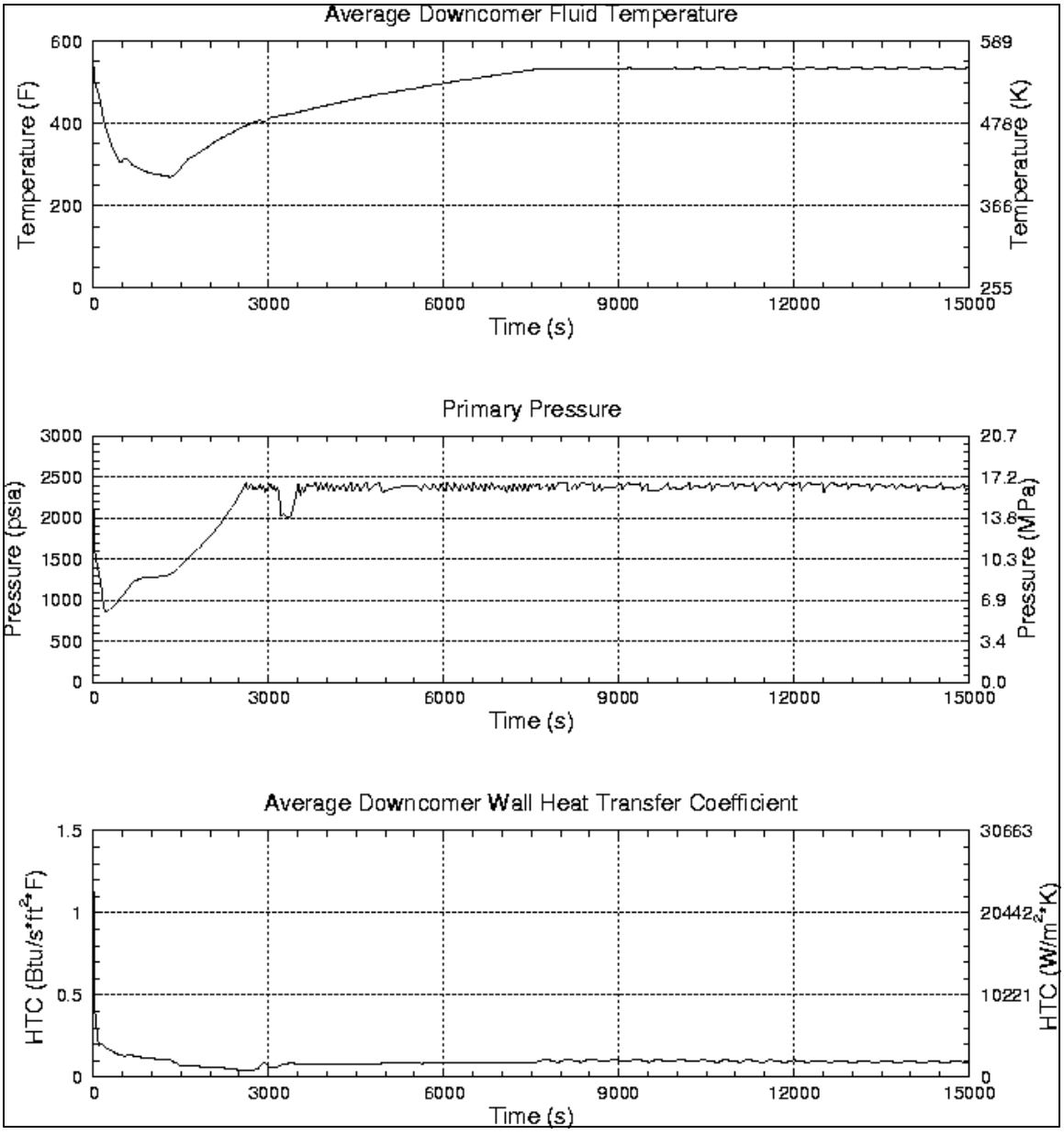

Figure C.2-39: Palisades PTS Results for Case 036

Case Category	MSLB
Primary Failures	None.
Secondary Failures	Controller failure resulting in the flow from two AFW pumps into affected steam generator. Break assumed to be inside containment causing containment spray actuation.
Operator Actions	Operator starts second AFW pump. Operator isolates AFW to affected SG at 30 minutes after initiation.
Min DC Temp	391.7 K (245.4°F) at 3210 s
Comments	None.

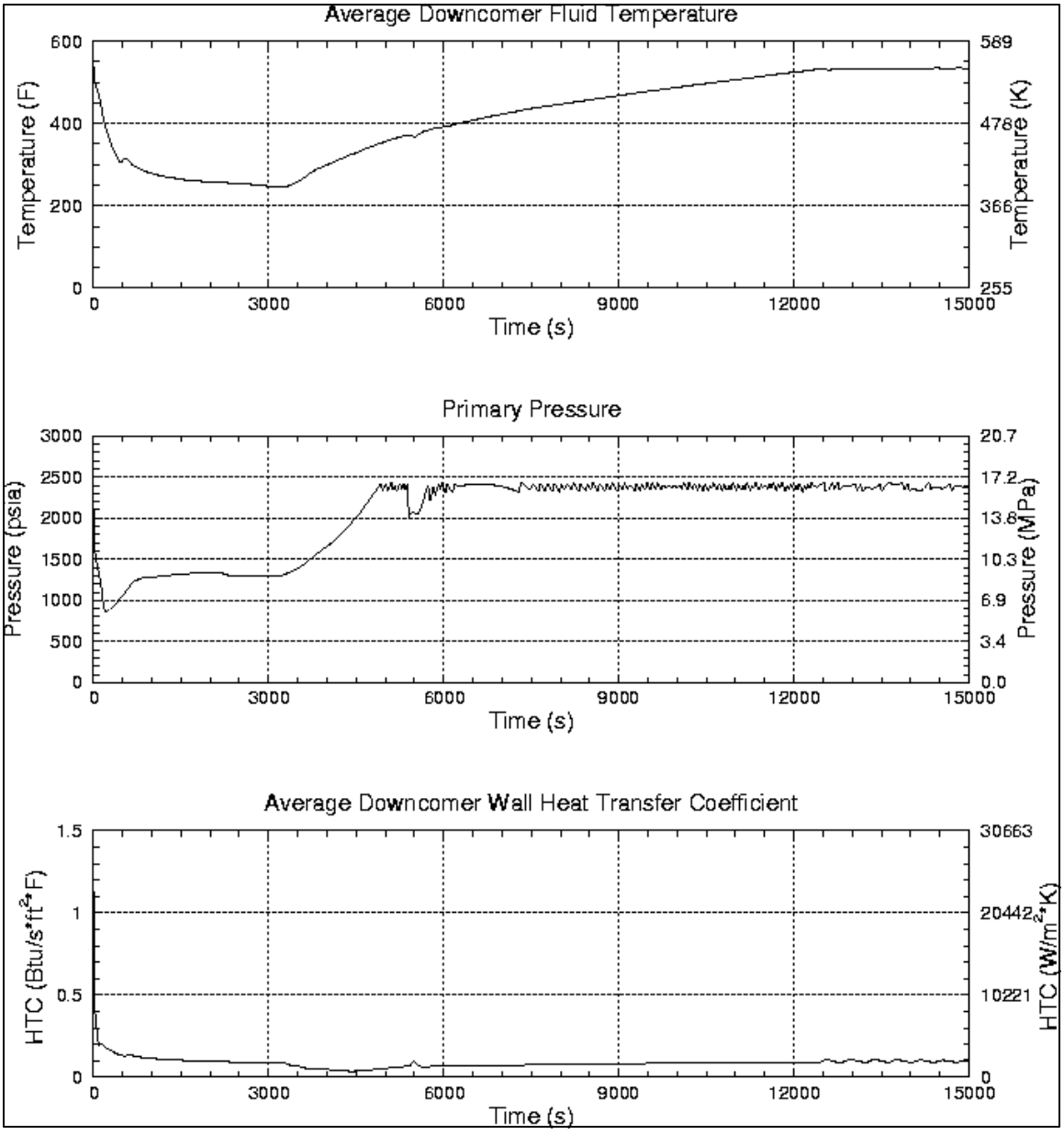

Figure C.2-40: Palisades PTS Results for Case 037

Case Category	TT/RT
Primary Failures	None.
Secondary Failures	Loss of MFW and AFW.
Operator Actions	Operator depressurizes through ADVs and feeds SG's using condensate booster pumps. Feed is terminated once SG's are filled.
Min DC Temp	403.2 K (266.1°F) at 1110 s
Comments	None.

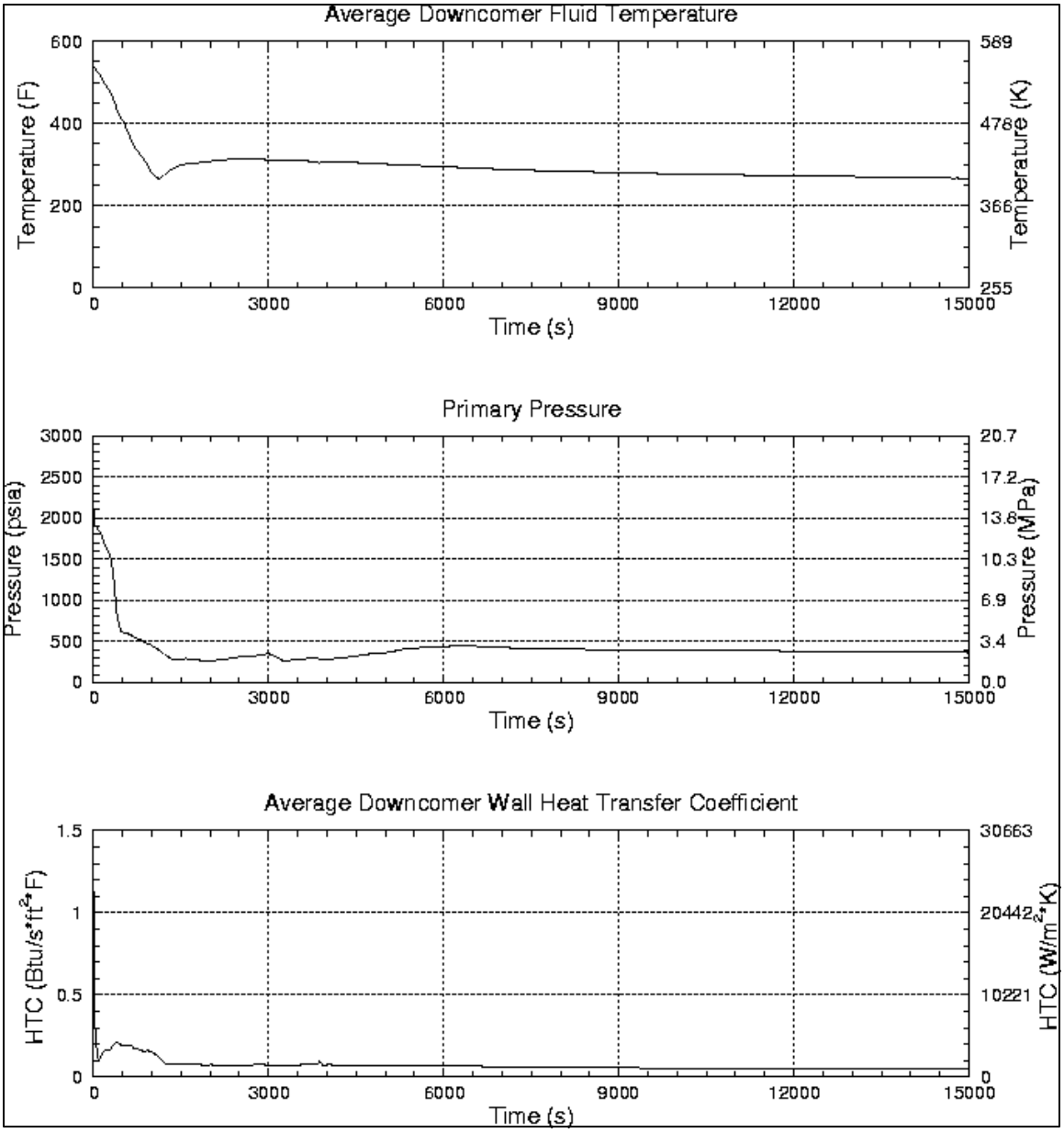

Figure C.2-41: Palisades PTS Results for Case 038

Case Category	LOCA
Primary Failures	27.94 cm (11 in) hot leg break. Containment sump recirculation included in the analysis.
Secondary Failures	None.
Operator Actions	None. Operator does not throttle HPI.
Min DC Temp	308.5 K (95.6°F) at 1290 s
Comments	Momentum Flux Disabled in DC

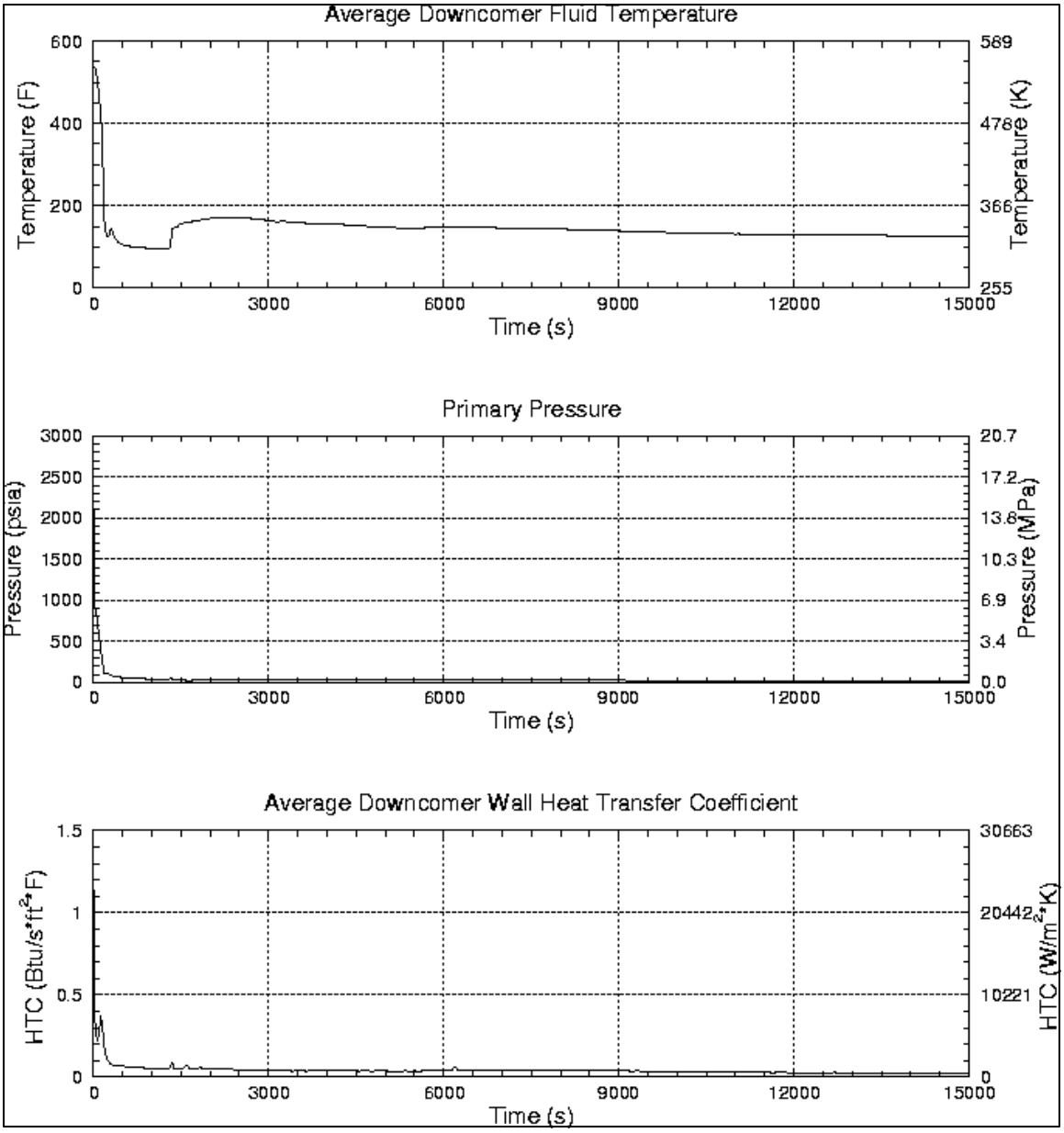

Figure C.2-42: Palisades PTS Results for Case 039

Case Category	LOCA
Primary Failures	40.64 cm (16 in) hot leg break. Containment sump recirculation included in the analysis.
Secondary Failures	None.
Operator Actions	None. Operator does not throttle HPI.
Min DC Temp	307.8 K (94.4°F) at 1260 s
Comments	Momentum Flux Disabled in DC

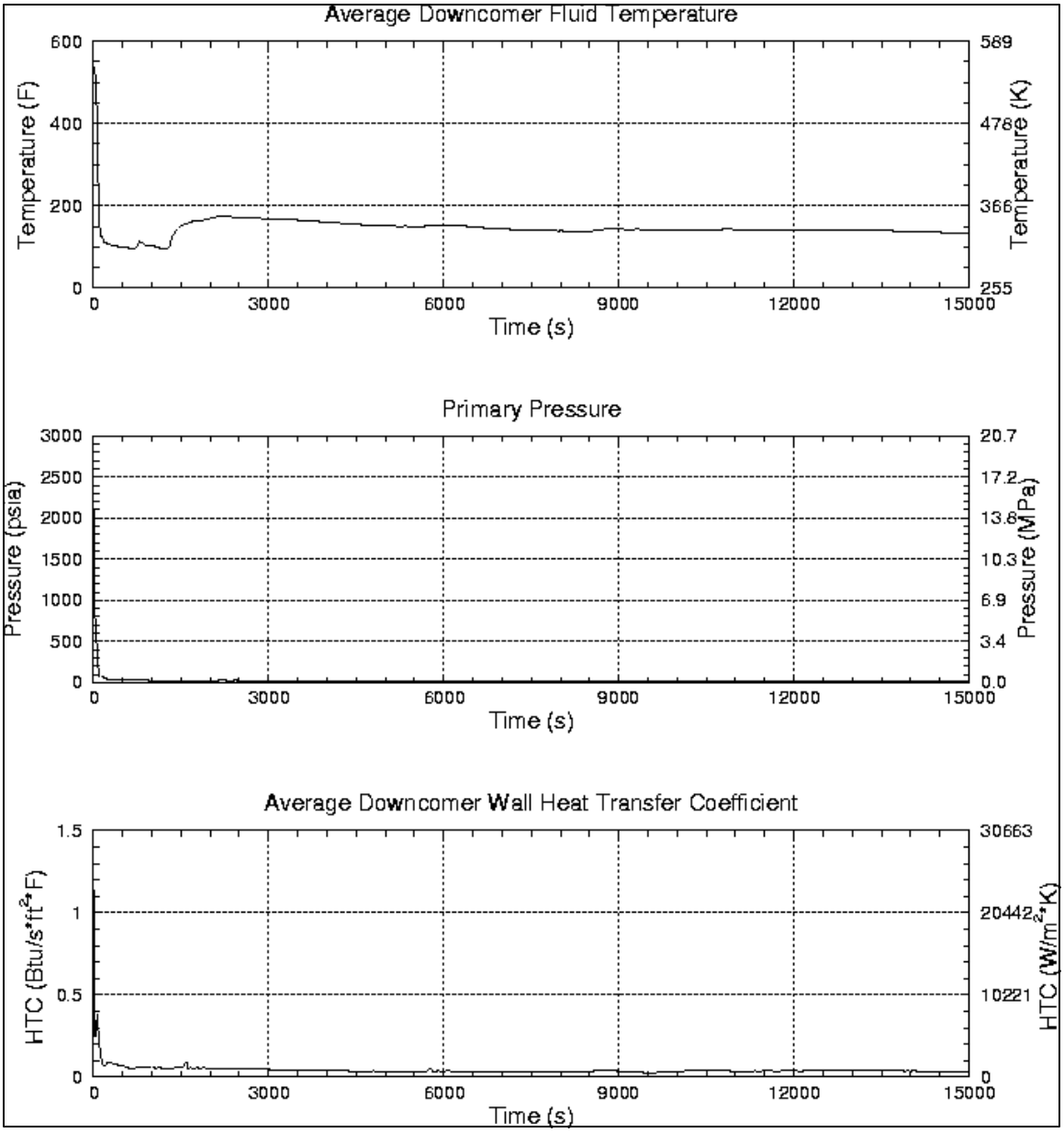

Figure C.2-43: Palisades PTS Results for Case 040

Case Category	LOCA
Primary Failures	55.88 cm (22 in) hot leg break. Containment sump recirculation included in the analysis.
Secondary Failures	None.
Operator Actions	None. Operator does not throttle HPI.
Min DC Temp	308.8 K (96.1°F) at 1200 s
Comments	Momentum Flux Disabled in DC, Could Not Run with High Reverse K, Therefore Not Used

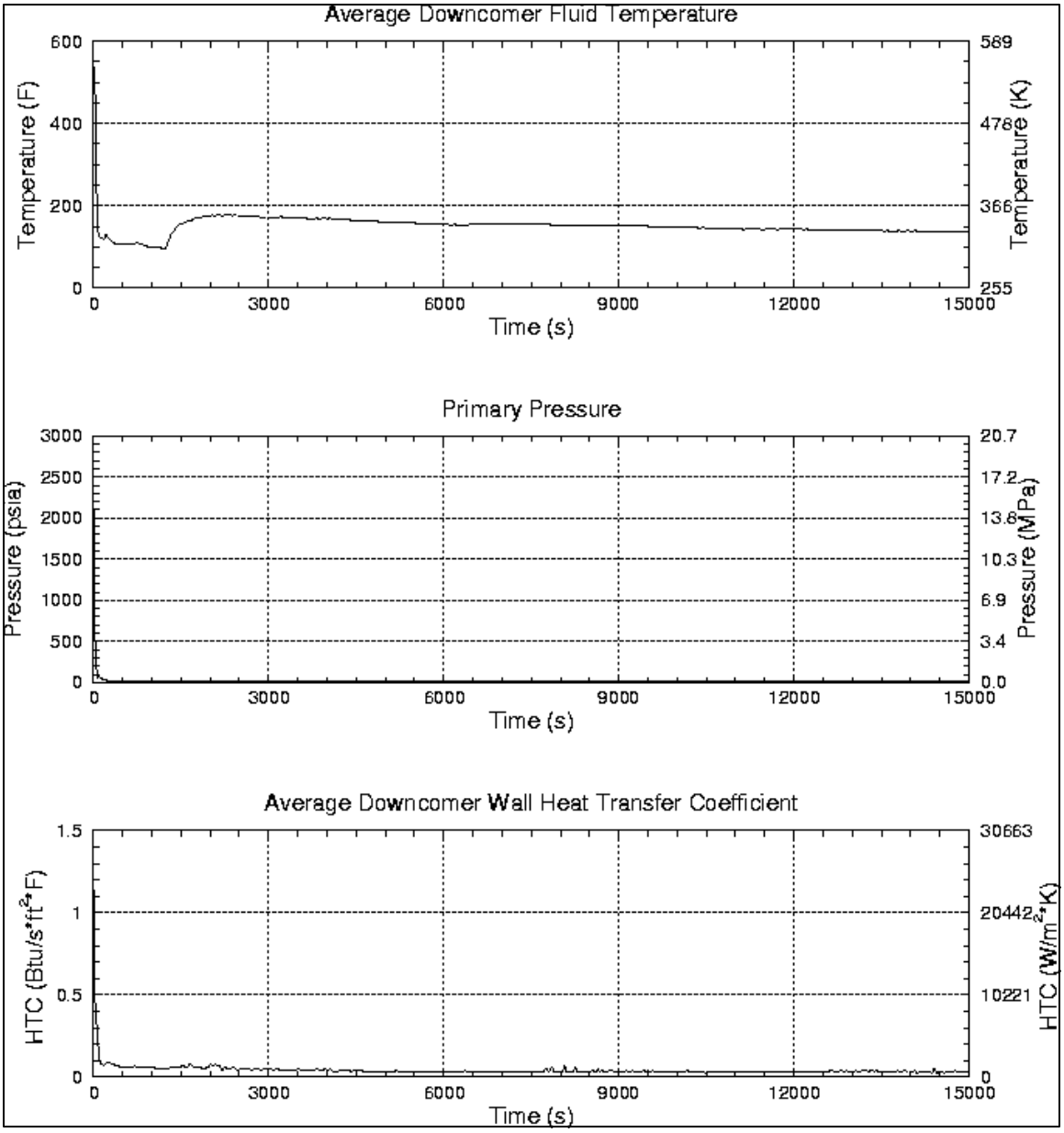

Figure C.2-44: Palisades PTS Results for Case 041

Case Category	TT/RT
Primary Failures	Two stuck open pressurizer SRVs. Containment spray is assumed not to actuate.
Secondary Failures	None.
Operator Actions	Operator assumed to throttle HPI if AFW is running with SG WRL > -84% and RCS subcooling > 25 F. HPI is throttled to maintain pressurizer level between 40 and 60 %.
Min DC Temp	419.1 K (294.8°F) at 14910 s
Comments	None.

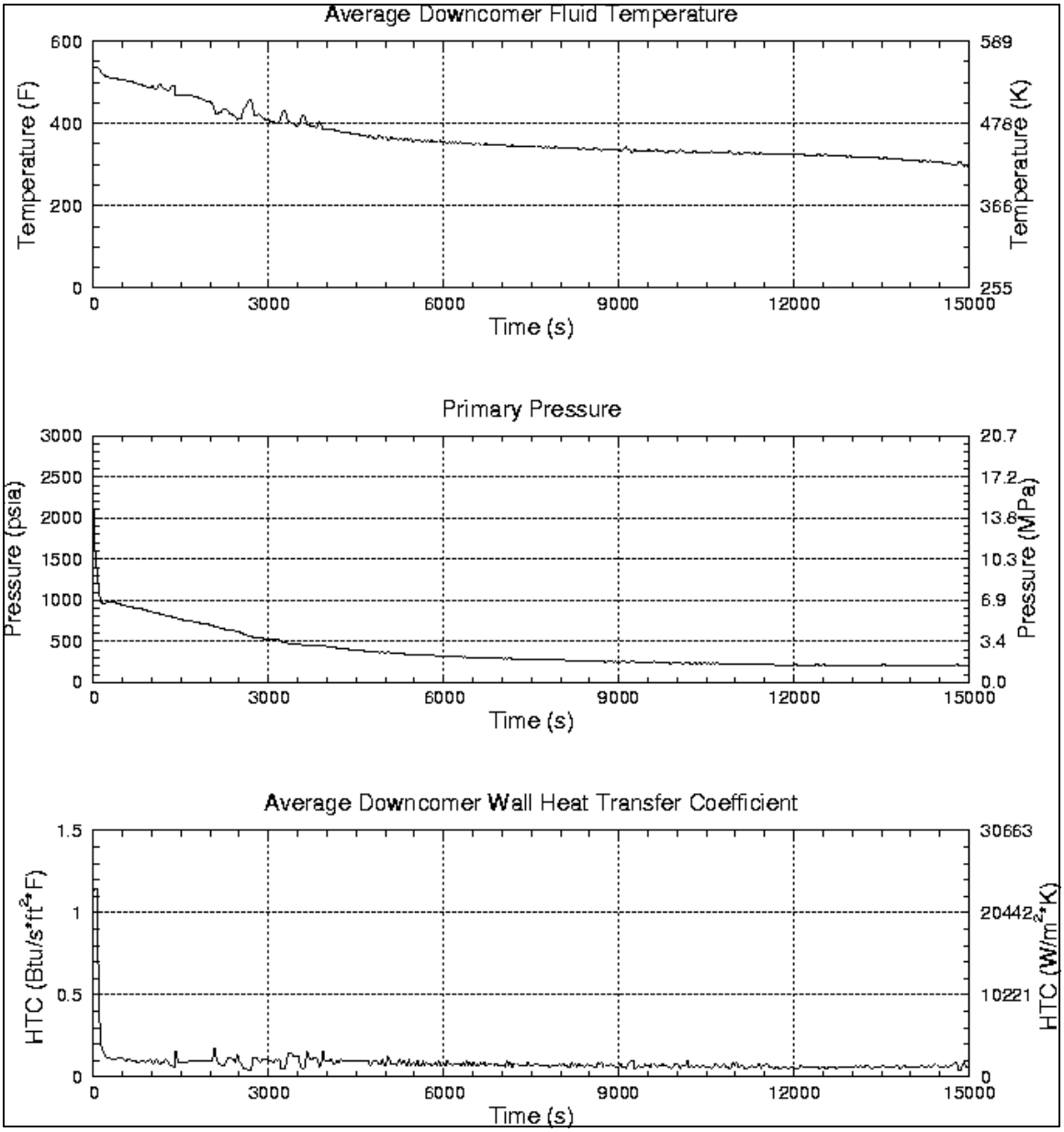

Figure C.2-45: Palisades PTS Results for Case 042

Case Category	TT/RT
Primary Failures	None.
Secondary Failures	Failure of MFW and AFW.
Operator Actions	Operator maintains core cooling by "feed and bleed" using HPI to feed and two PORVs to bleed.
Min DC Temp	344.0 K (159.6°F) at 12900 s
Comments	None.

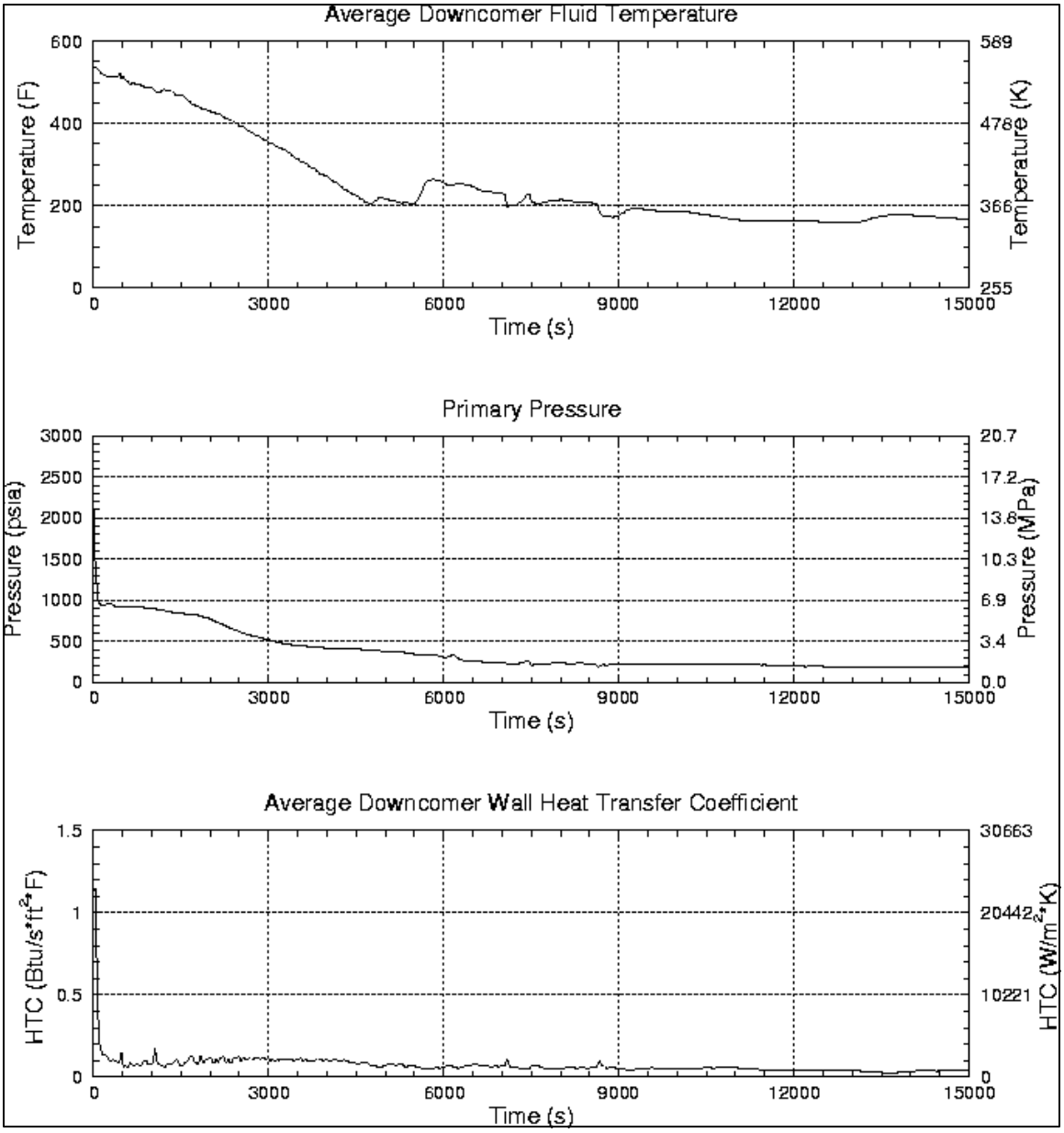

Figure C.2-46: Palisades PTS Results for Case 043

Case Category	TT/RT
Primary Failures	None.
Secondary Failures	Failure of MFW and AFW.
Operator Actions	Operator maintains core cooling by "feed and bleed" using HPI to feed and two PORV to bleed. AFW is recovered 15 minutes after initiation of "feed and bleed" cooling. Operator closes PORVs when SG level reaches 60 percent.
Min DC Temp	407.6 K (274.0°F) at 4440 s
Comments	None.

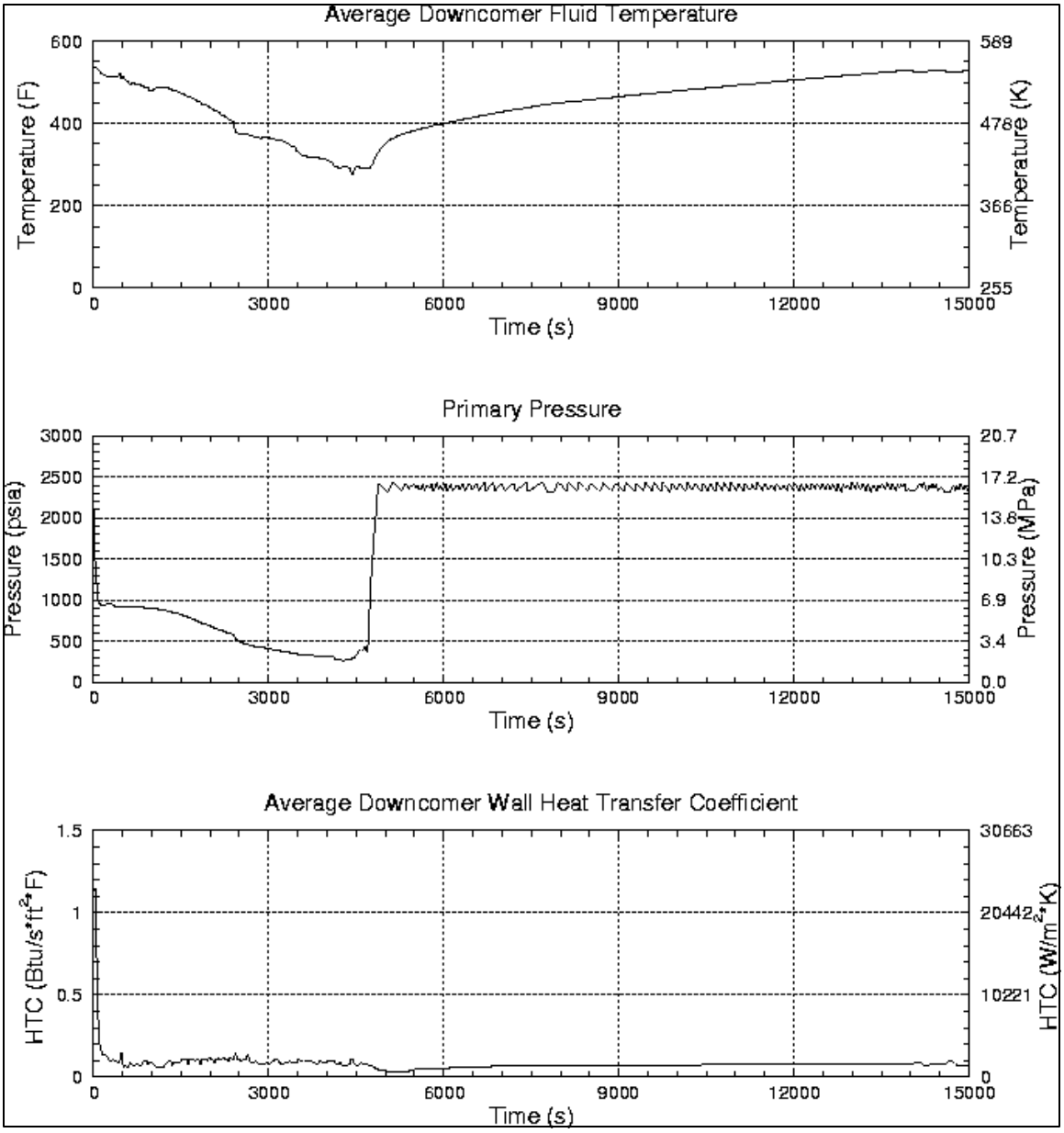

Figure C.2-47: Palisades PTS Results for Case 044

Case Category	LOCA
Primary Failures	5.08 cm (2 in) surge line break. Containment sump recirculation included in the analysis.
Secondary Failures	None.
Operator Actions	None.
Min DC Temp	384.5 K (232.4°F) at 4320 s
Comments	No High Reverse Flow Loss Coefficients

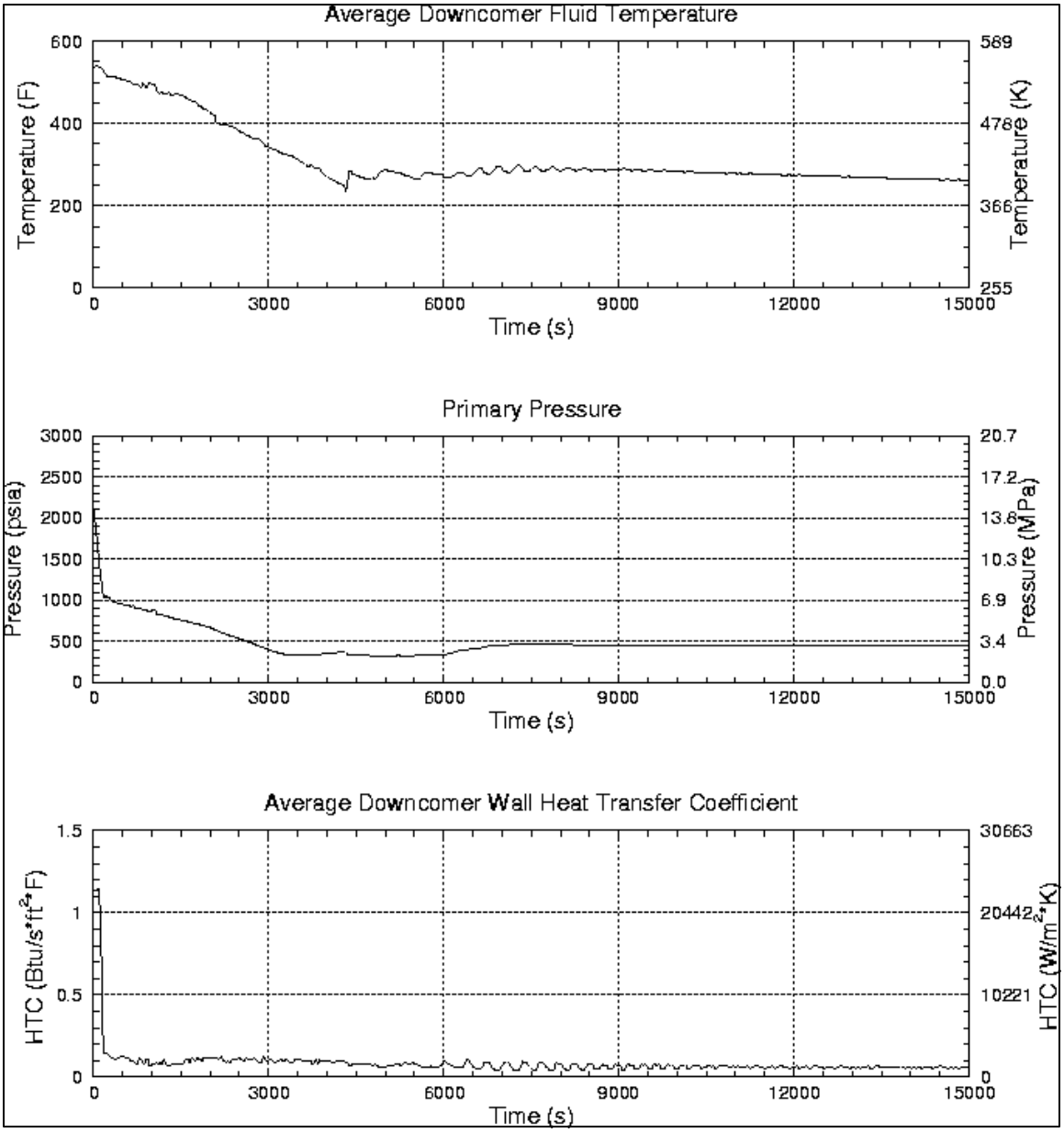

Figure C.2-48: Palisades PTS Results for Case 045

Case Category	LOCA
Primary Failures	10.16 cm (4 inch) surge line break. Containment sump recirculation included in the analysis.
Secondary Failures	None.
Operator Actions	Operator assumed to throttle HPI if AFW is running with SG WRL > -84% and RCS subcooling > 25 F. HPI is throttled to maintain pressurizer level between 40 and 60 %.
Min DC Temp	320.0 K (116.3°F) at 2160 s
Comments	No High Reverse Flow Loss Coefficients

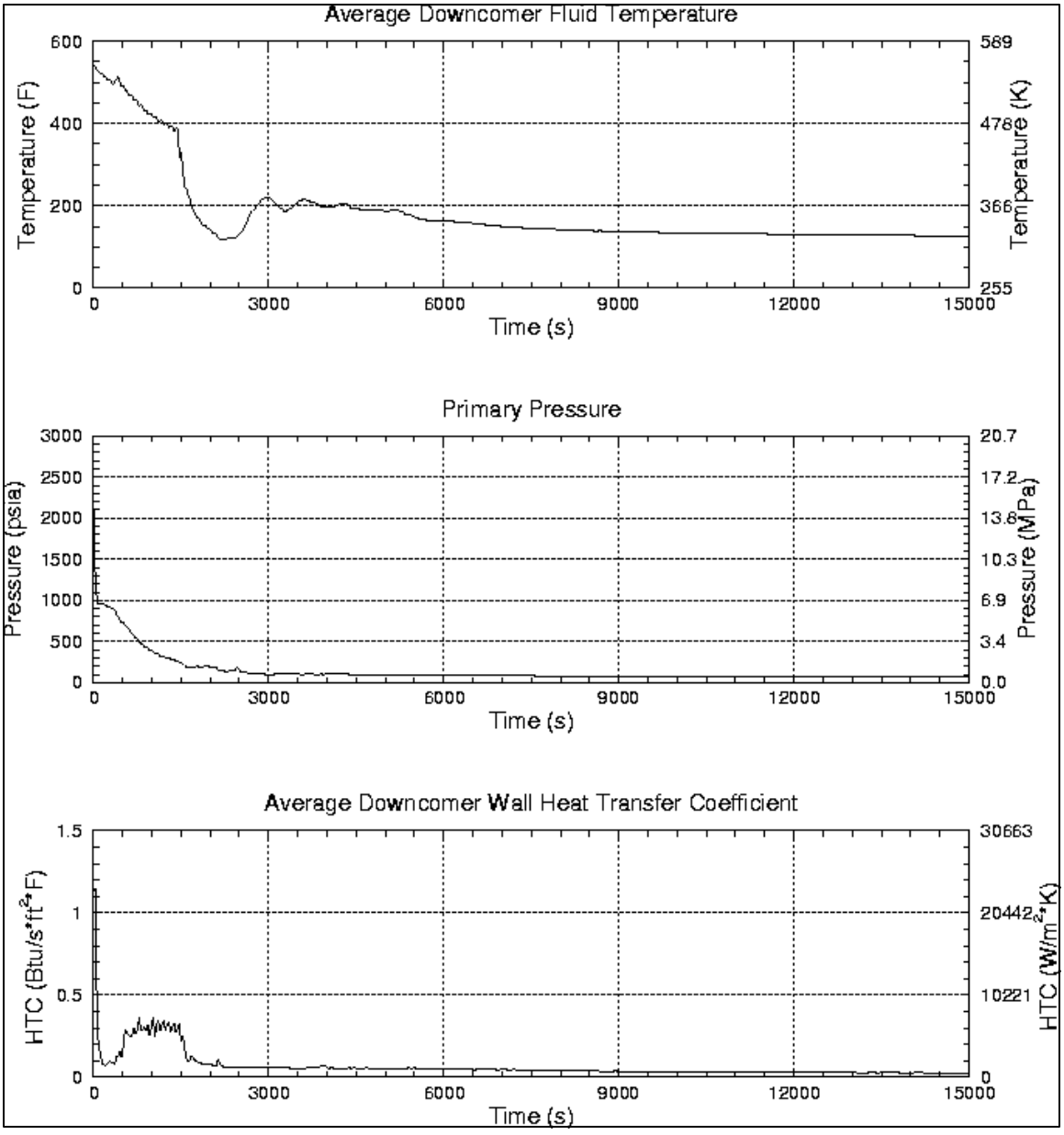

Figure C.2-49: Palisades PTS Results for Case 046

Case Category	LOCA
Primary Failures	40.64 cm (16 in) hot leg break. Containment sump recirculation included in the analysis.
Secondary Failures	None.
Operator Actions	None. Operator does not throttle HPI.
Min DC Temp	309.2 K (96.9°F) at 1170 s
Comments	No High Reverse Flow Loss Coefficients, Momentum Flux Disabled in the DC

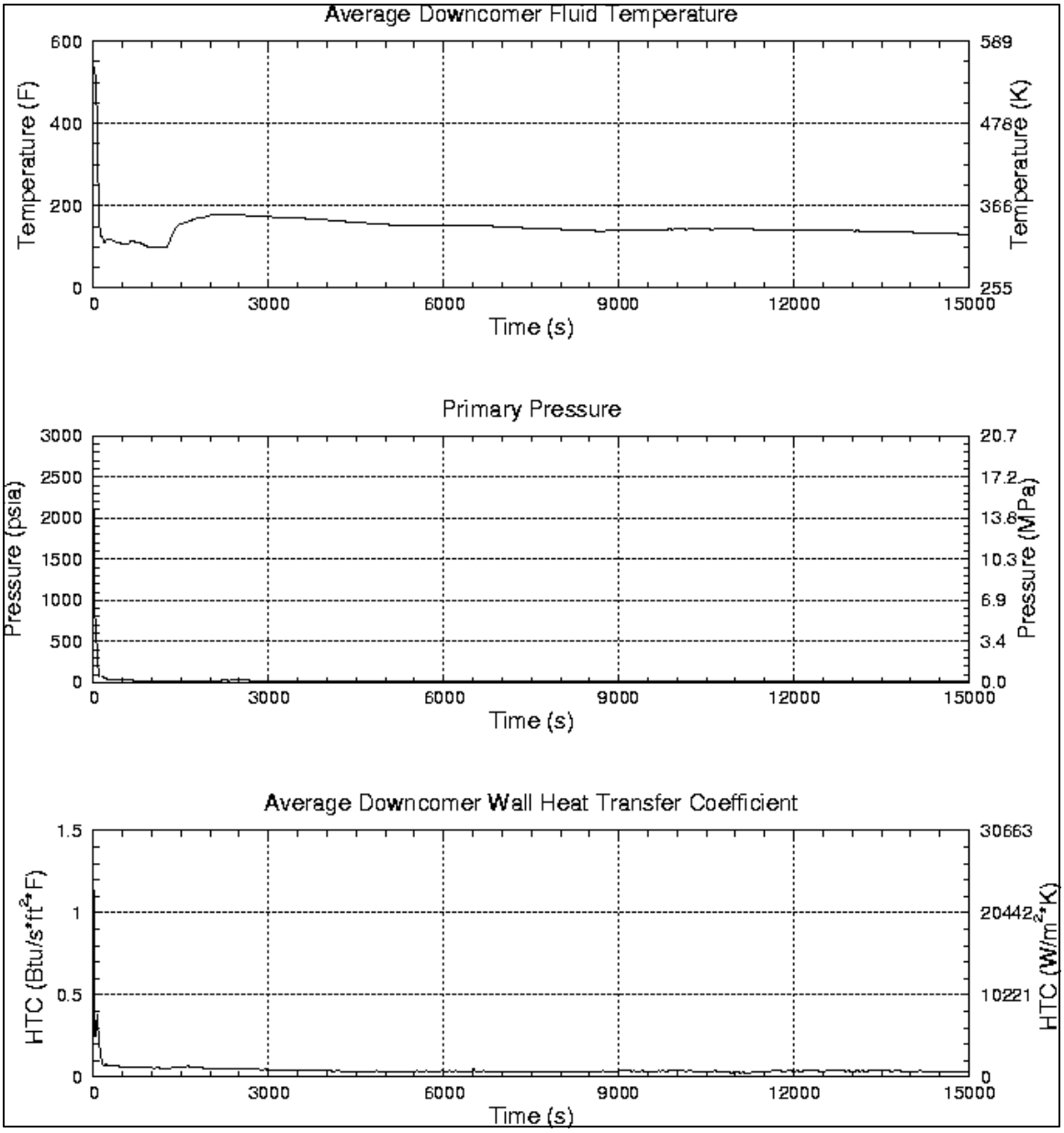

Figure C.2-50: Palisades PTS Results for Case 047

Case Category	TT/RT, HZP
Primary Failures	Two stuck-open pressurizer SRVs that reclose at 6000 sec after initiation. Containment spray is assumed not to actuate.
Secondary Failures	None.
Operator Actions	None. Operator does not throttle HPI.
Min DC Temp	351.3 K (172.6°F) at 6360 s
Comments	None.

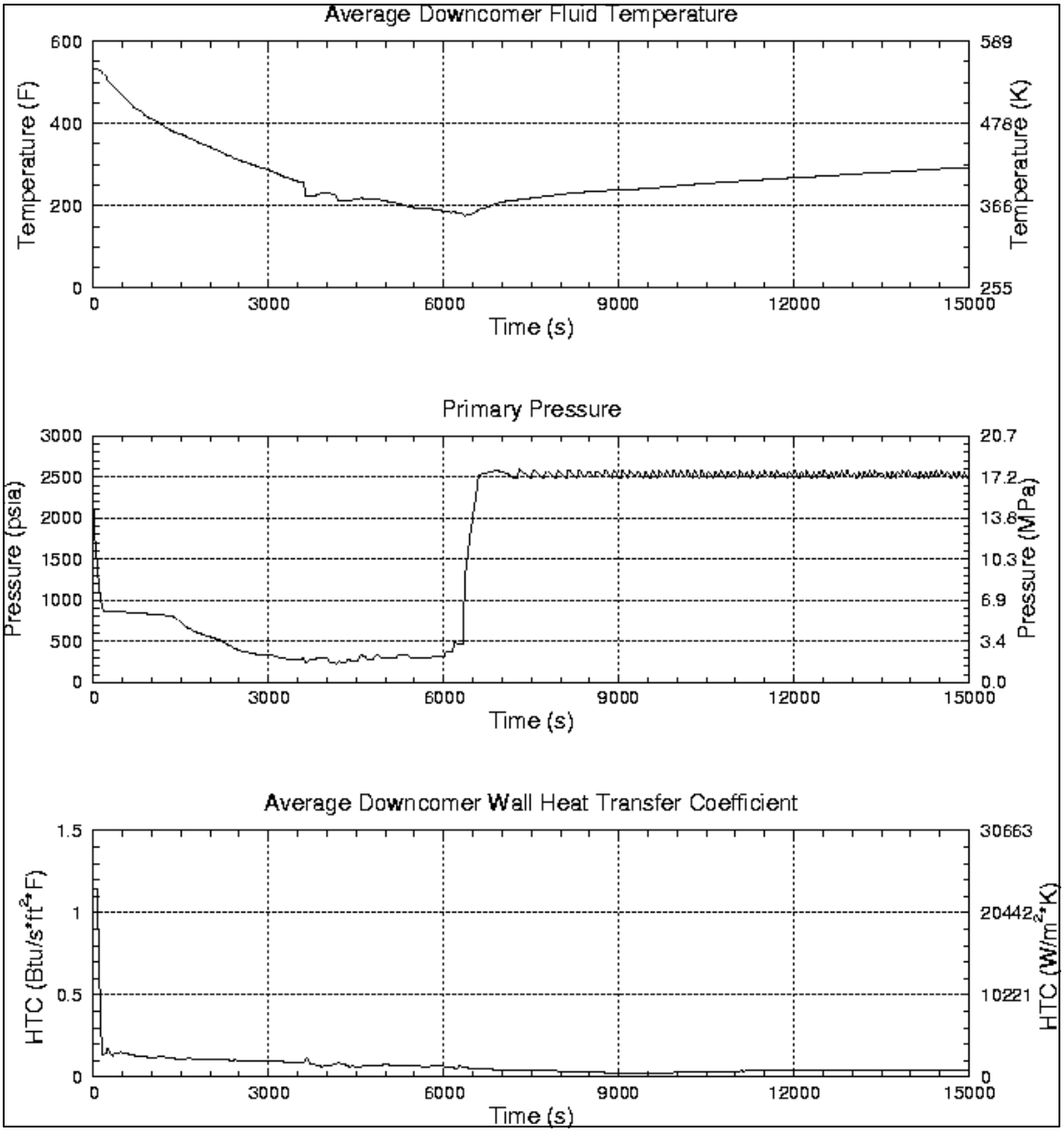

Figure C.2-51: Palisades PTS Results for Case 048

Case Category	MSLB, HZP
Primary Failures	None.
Secondary Failures	Break assumed to be inside containment causing containment spray actuation.
Operator Actions	Operator isolates AFW to affected SG at 30 minutes after initiation. Operator does not throttle HPI.
Min DC Temp	426.1 K (307.4°F) at 1920 s
Comments	None.

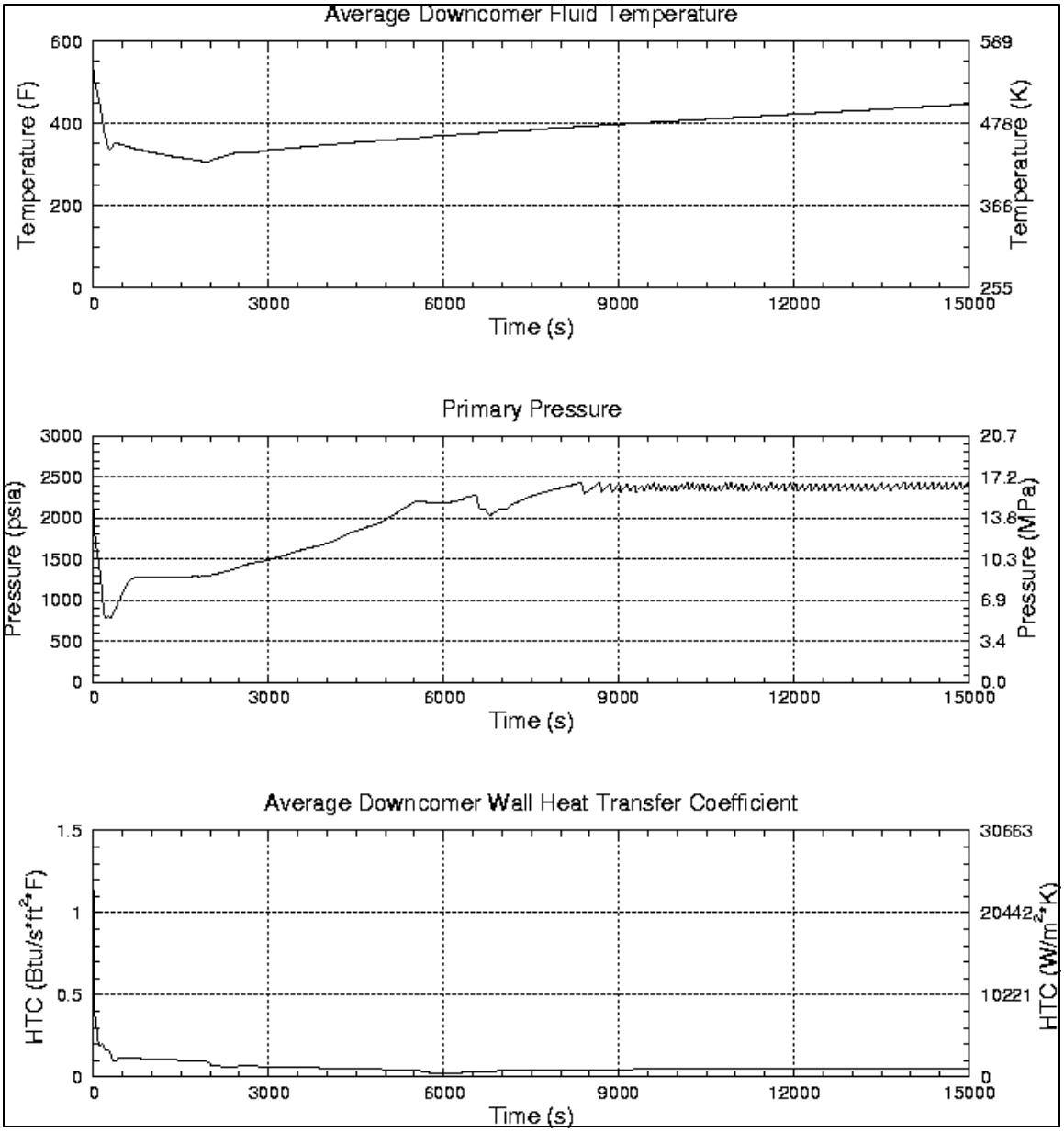

Figure C.2-52: Palisades PTS Results for Case 049

Case Category	MSLB, HZP
Primary Failures	None.
Secondary Failures	Controller failure resulting in the flow from two AFW pumps into affected steam generator. Break assumed to be inside containment causing containment spray actuation.
Operator Actions	Operator starts second AFW pump. Operator does not throttle HPI.
Min DC Temp	348.0 K (166.8°F) at 15000 s
Comments	None.

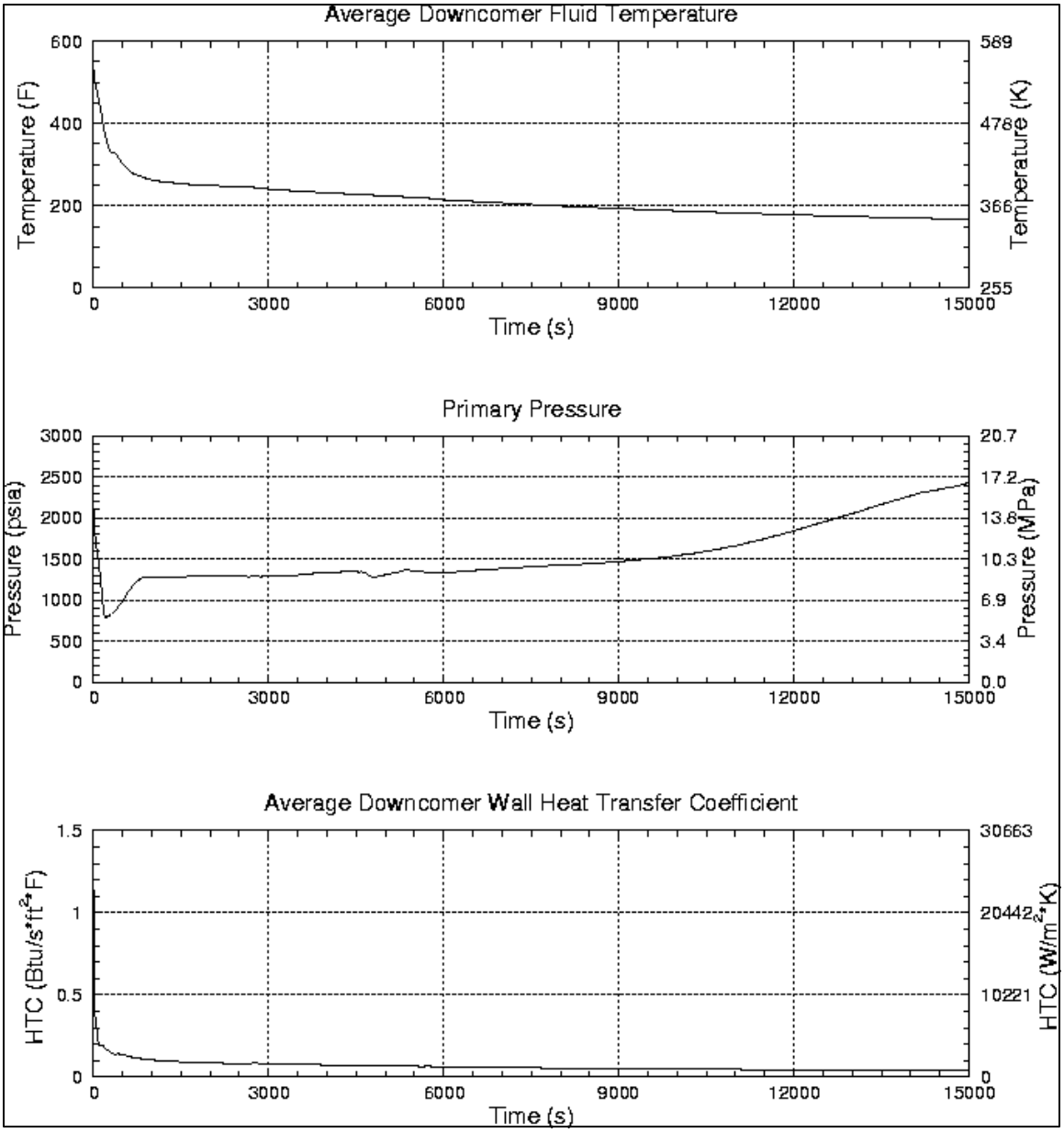

Figure C.2-53: Palisades PTS Results for Case 050

Case Category	MSLB, HZP
Primary Failures	None.
Secondary Failures	Failure of both MSIVs to close. Break assumed to be inside containment causing containment spray actuation.
Operator Actions	Operator does not isolate AFW on affected SG. Operator does not throttle HPI.
Min DC Temp	375.3 K (215.9°F) at 3150 s
Comments	None.

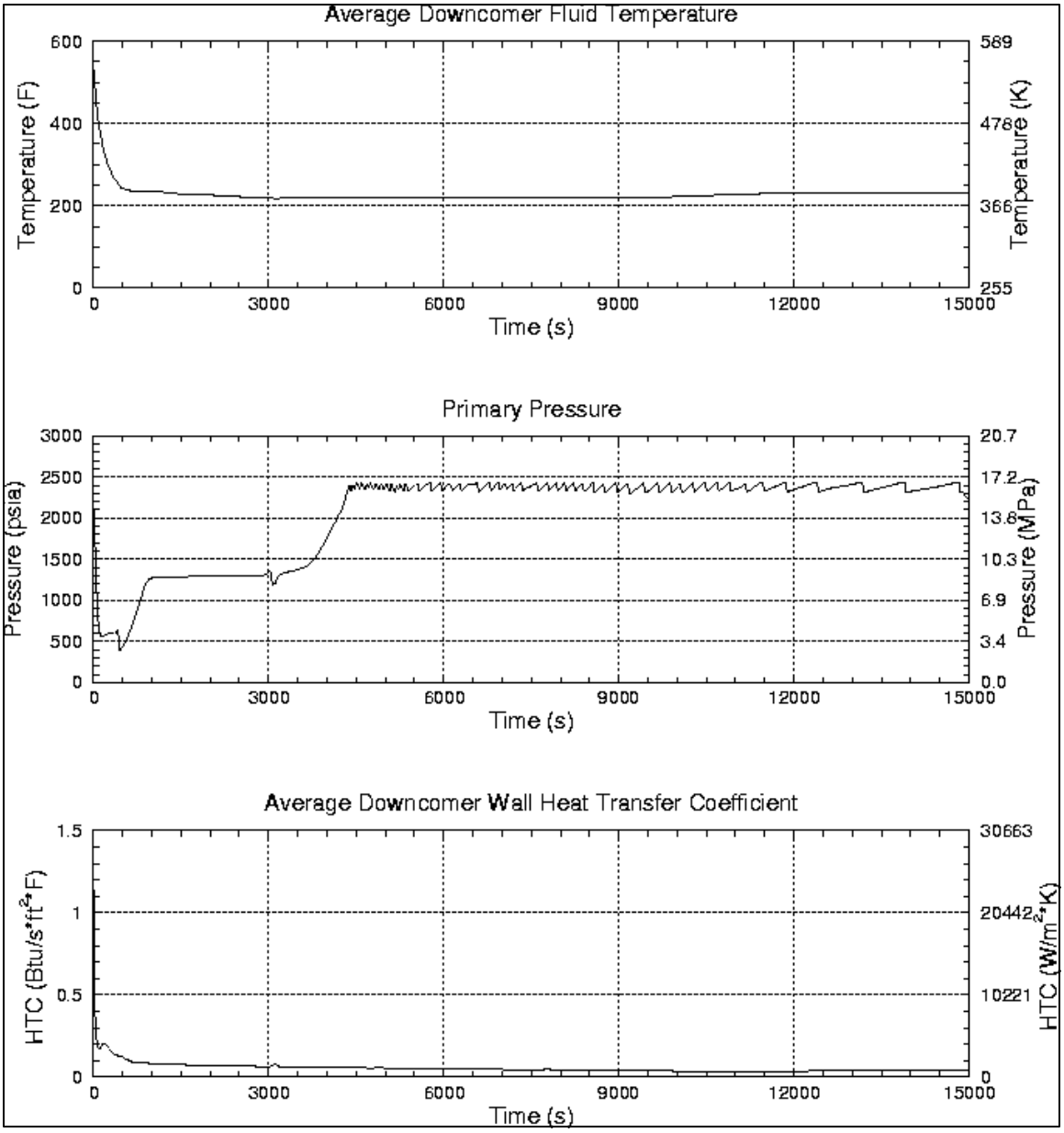

Figure C.2-54: Palisades PTS Results for Case 051

Case Category	TT/RT, HZP
Primary Failures	None.
Secondary Failures	1 stuck-open ADV on SG-A. Failure of both MSIVs (SG-A and SG-B) to close.
Operator Actions	Operator does not isolate AFW on affected SG. Normal AFW flow assumed (200 gpm). Operator does not throttle HPI.
Min DC Temp	424.6 K (304.7°F) at 14850 s
Comments	None.

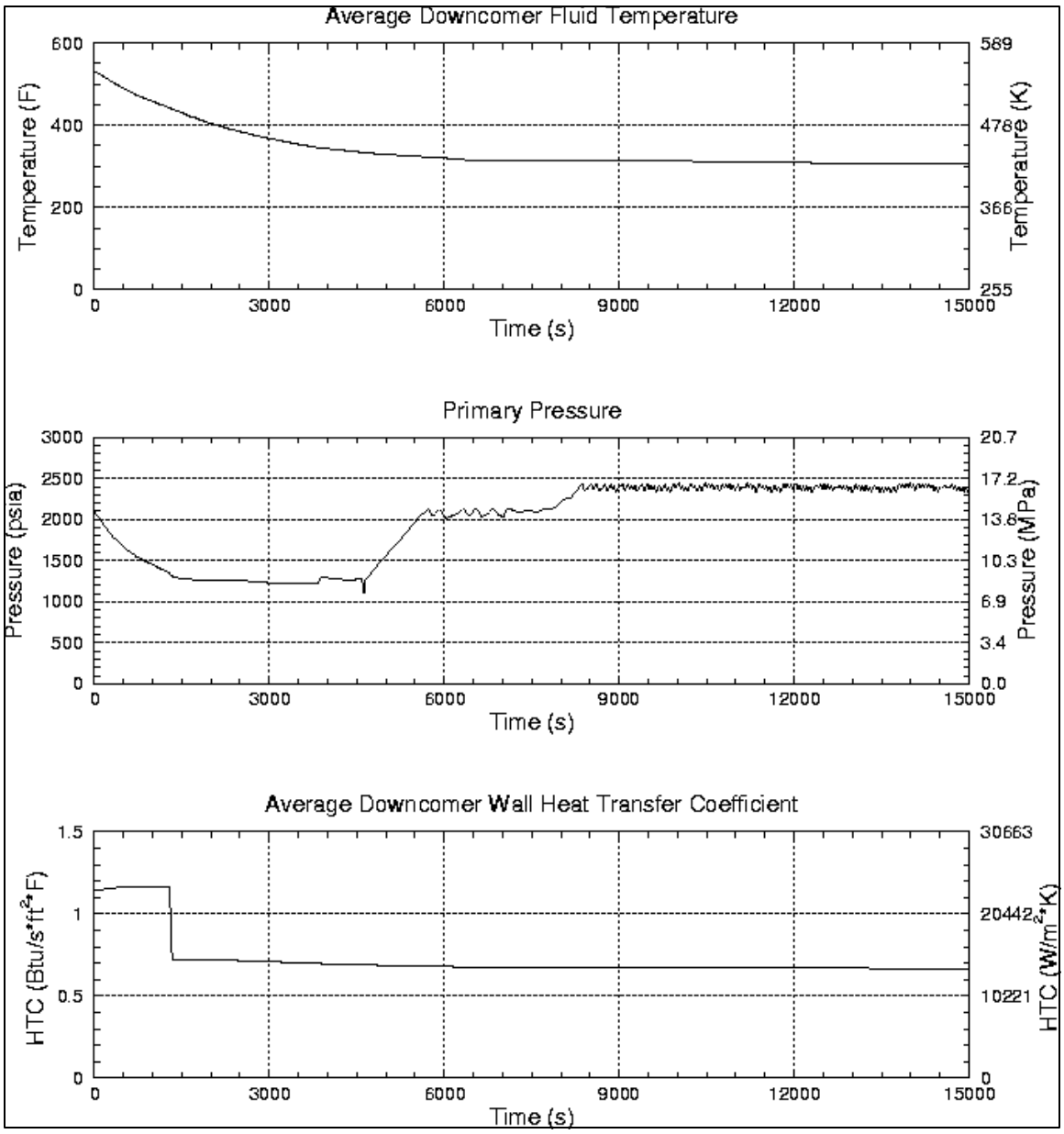

Figure C.2-55: Palisades PTS Results for Case 052

Case Category	TT/RT
Primary Failures	Two stuck-open pressurizer SRVs that reclose at 6000 sec after initiation. Containment spray is assumed not to actuate.
Secondary Failures	None.
Operator Actions	None. Operator does not throttle HPI.
Min DC Temp	433.1 K (319.9°F) at 5970 s
Comments	None.

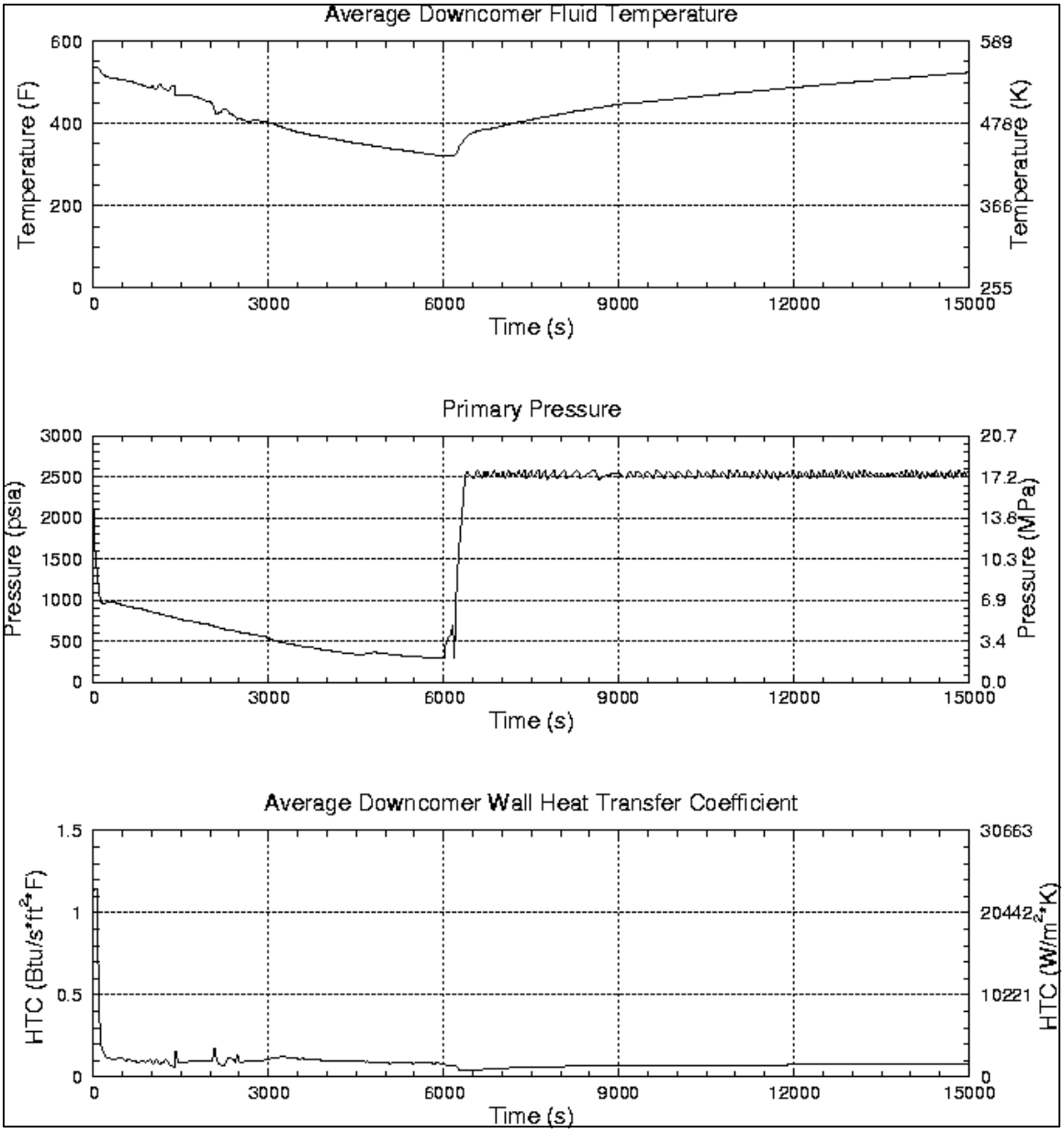

Figure C.2-56: Palisades PTS Results for Case 053

Case Category	MSLB
Primary Failures	None.
Secondary Failures	Failure of both MSIVs to close. Break assumed to be inside containment causing containment spray actuation.
Operator Actions	Operator does not isolate AFW on affected SG. Operator does not throttle HPI.
Min DC Temp	377.1 K (219.1°F) at 4110 s
Comments	None.

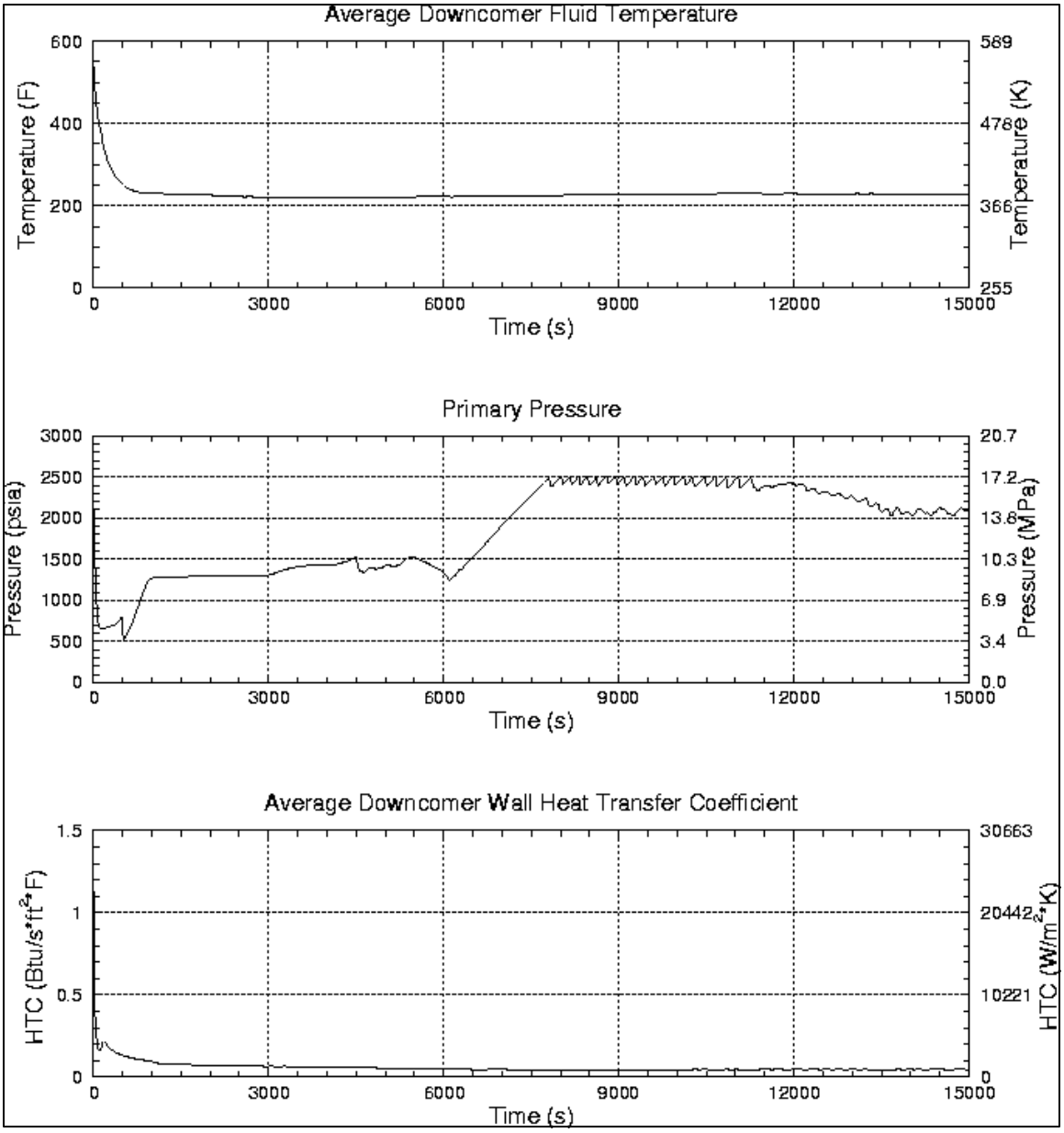

Figure C.2-57: Palisades PTS Results for Case 054

Case Category	TT/RT
Primary Failures	None.
Secondary Failures	2 stuck-open ADVs on SG-A combined with controller failure resulting in the flow from two AFW pumps into affected steam generator.
Operator Actions	Operator starts second AFW pump.
Min DC Temp	437.4 K (327.7°F) at 4320 s
Comments	None.

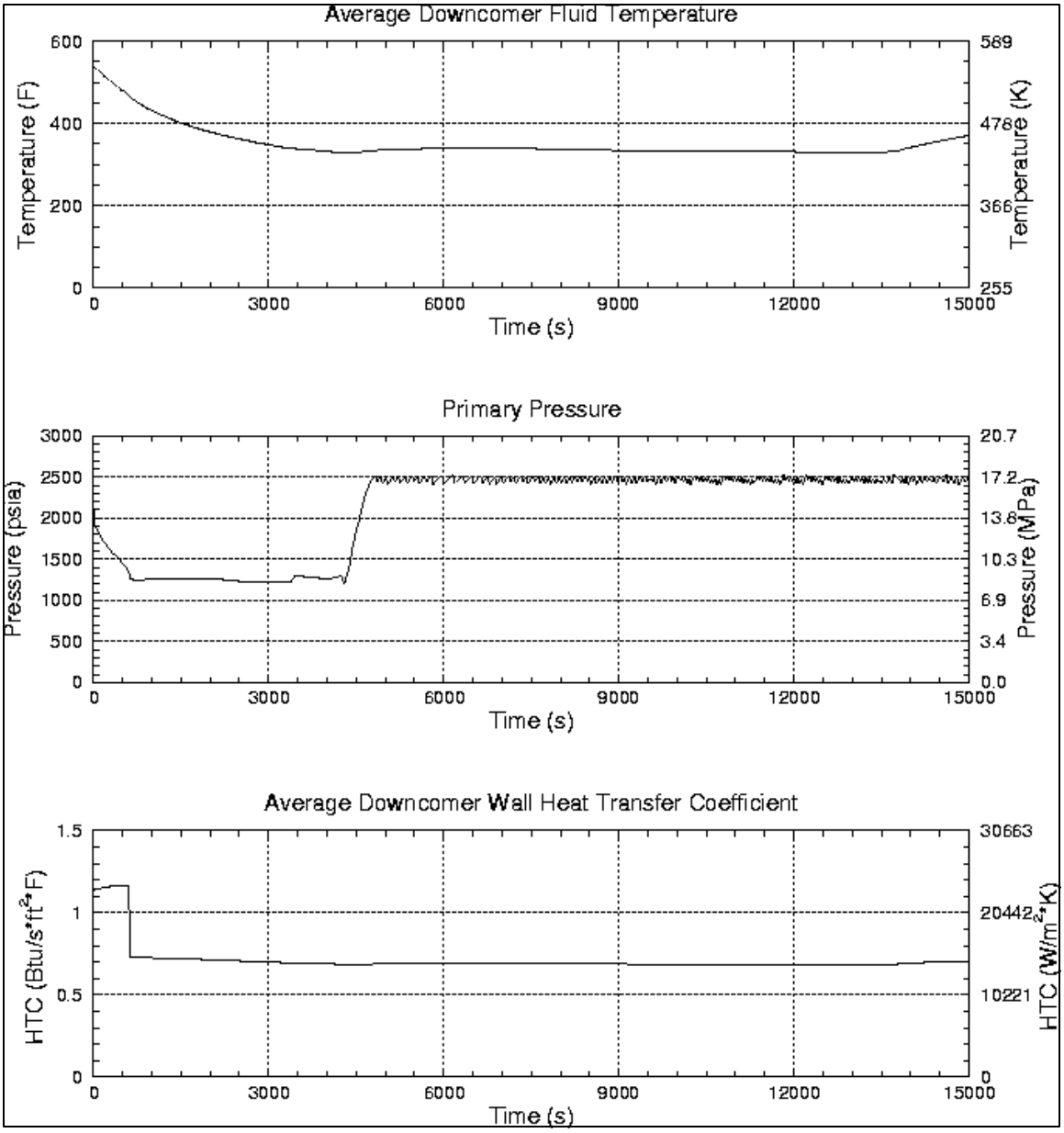

Figure C.2-58: Palisades PTS Results for Case 055

Case Category	LOCA
Primary Failures	2.54 cm (1 inch) surge line break. Containment sump recirculation included in the analysis. Both HPI and charging are assumed to fail.
Secondary Failures	None.
Operator Actions	Operator initiates emergency depressurization by opening all TBV's ADVs and one pressurizer PORV. Operator trips two of the four reactor coolant pumps. When temperature and pressure start to level off, HPI and charging are restored. The operator is assumed to reclose the PORV and the TBV's and ADV's. Operator controls secondary side pressure. Operator does not throttle HPI.
Min DC Temp	394.6 K (250.7°F) at 3990 s
Comments	None.

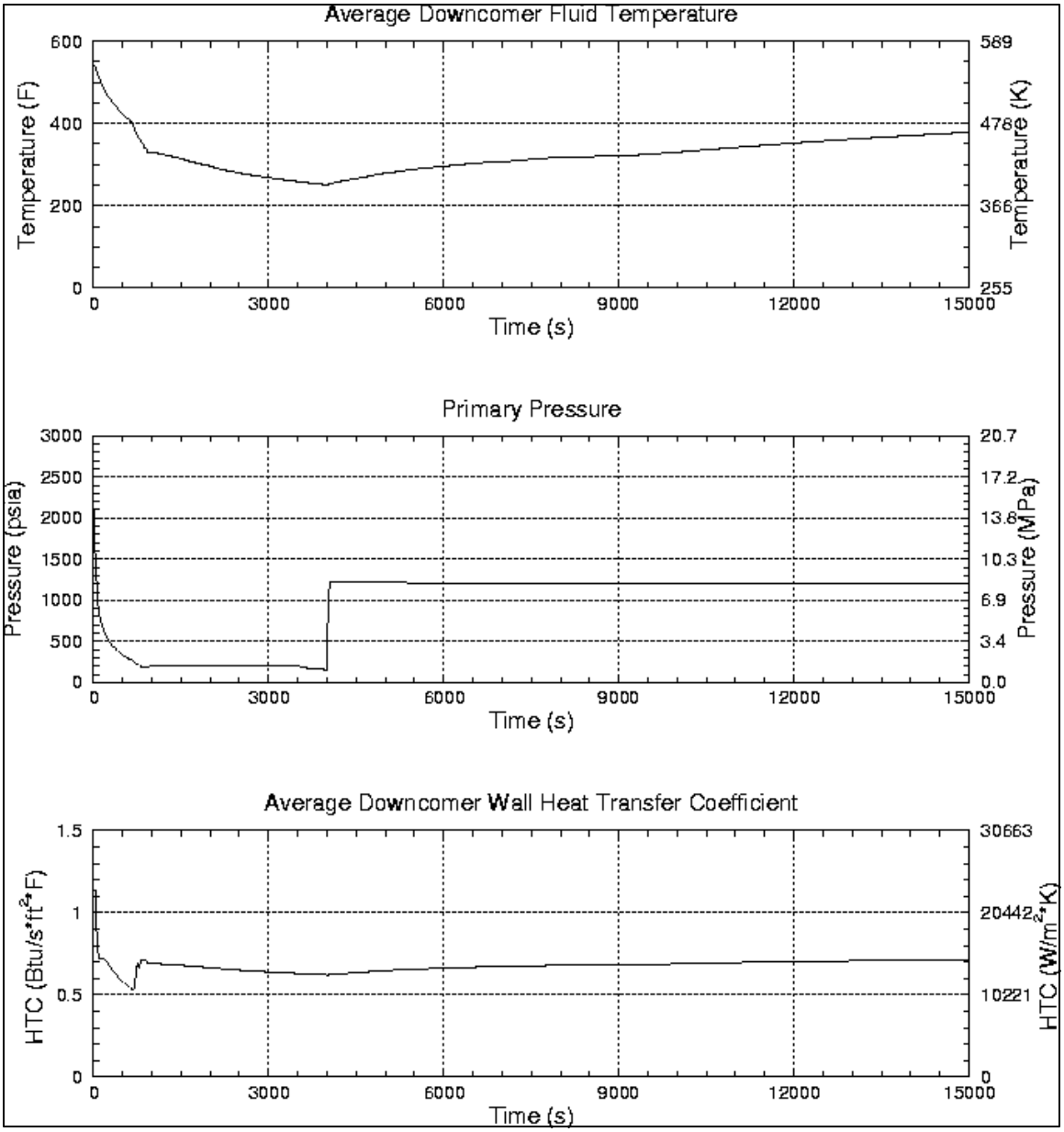

Figure C.2-59: Palisades PTS Results for Case 056

Case Category	LOCA
Primary Failures	40.64 cm (16 in) hot leg break. Containment sump recirculation included in the analysis.
Secondary Failures	None.
Operator Actions	None.
Min DC Temp	308.4 K (95.5°F) at 1260 s
Comments	Case Run Using RELAP5/MOD3.3 as a Sensitivity

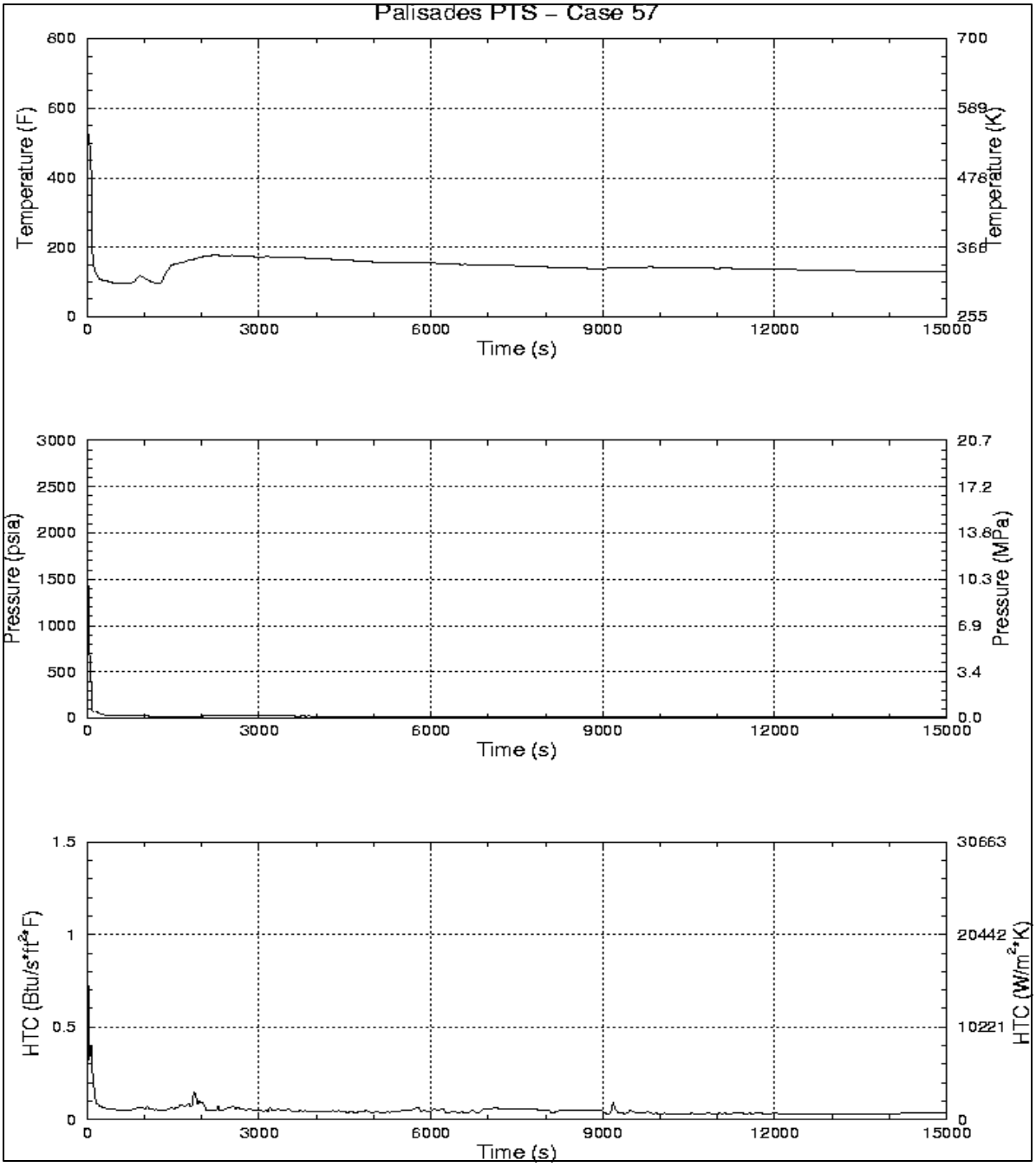

Figure C.2-60: Palisades PTS Results for Case 057

Case Category	LOCA
Primary Failures	10.16 cm (4 in) cold leg break. Winter conditions assumed (HPI and LPI injection temp = 40 F, Accumulator temp = 60 F)
Secondary Failures	None.
Operator Actions	None. Operator does not throttle HPI.
Min DC Temp	331.0 K (136.2°F) at 2700 s
Comments	Momentum Flux Disabled in the DC

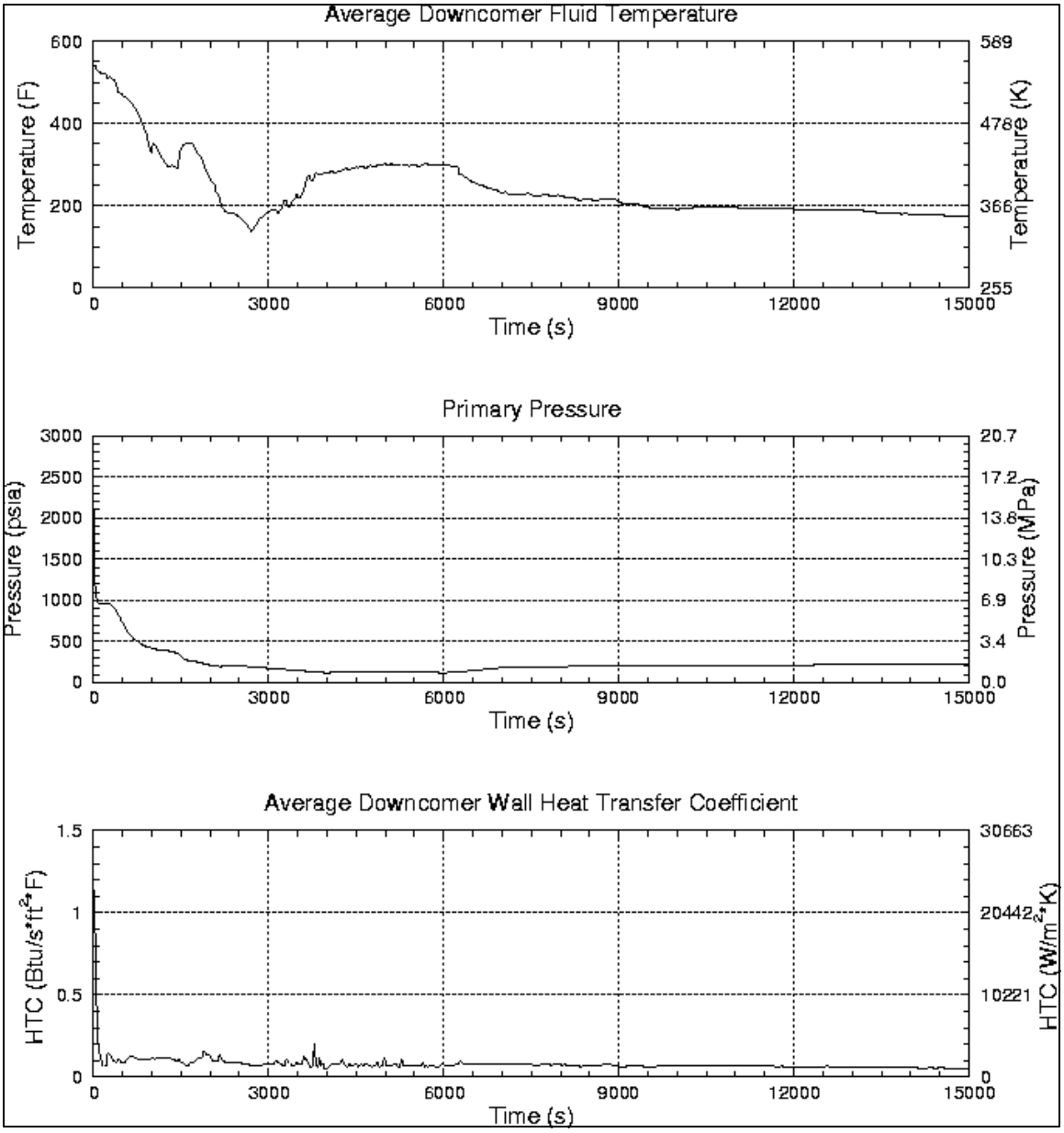

Figure C.2-61: Palisades PTS Results for Case 058

Case Category	LOCA
Primary Failures	10.16 cm (4 in) cold leg break. Summer conditions assumed (HPI and LPI injection temp = 100 F, Accumulator temp = 90 F)
Secondary Failures	None.
Operator Actions	None. Operator does not throttle HPI.
Min DC Temp	350.7 K (171.6°F) at 14940 s
Comments	Momentum Flux Disabled in the DC

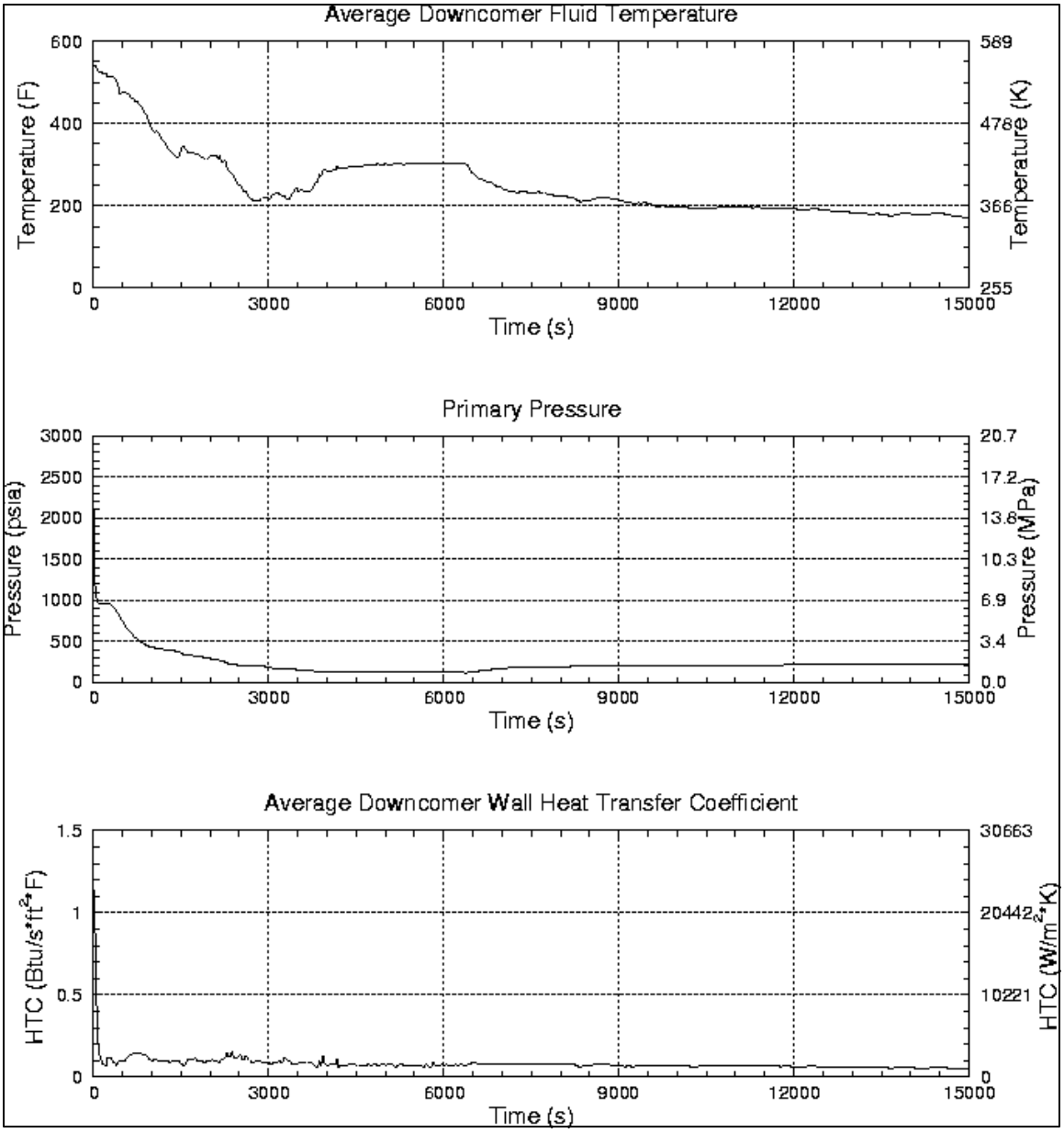

Figure C.2-62: Palisades PTS Results for Case 059

Case Category	LOCA
Primary Failures	5.08 cm (2 in) surge line break. Winter conditions assumed (HPI and LPI injection temp = 40 F, Accumulator temp = 60 F)
Secondary Failures	None.
Operator Actions	None. Operator does not throttle HPI.
Min DC Temp	351.3 K (172.7°F) at 3540 s
Comments	None.

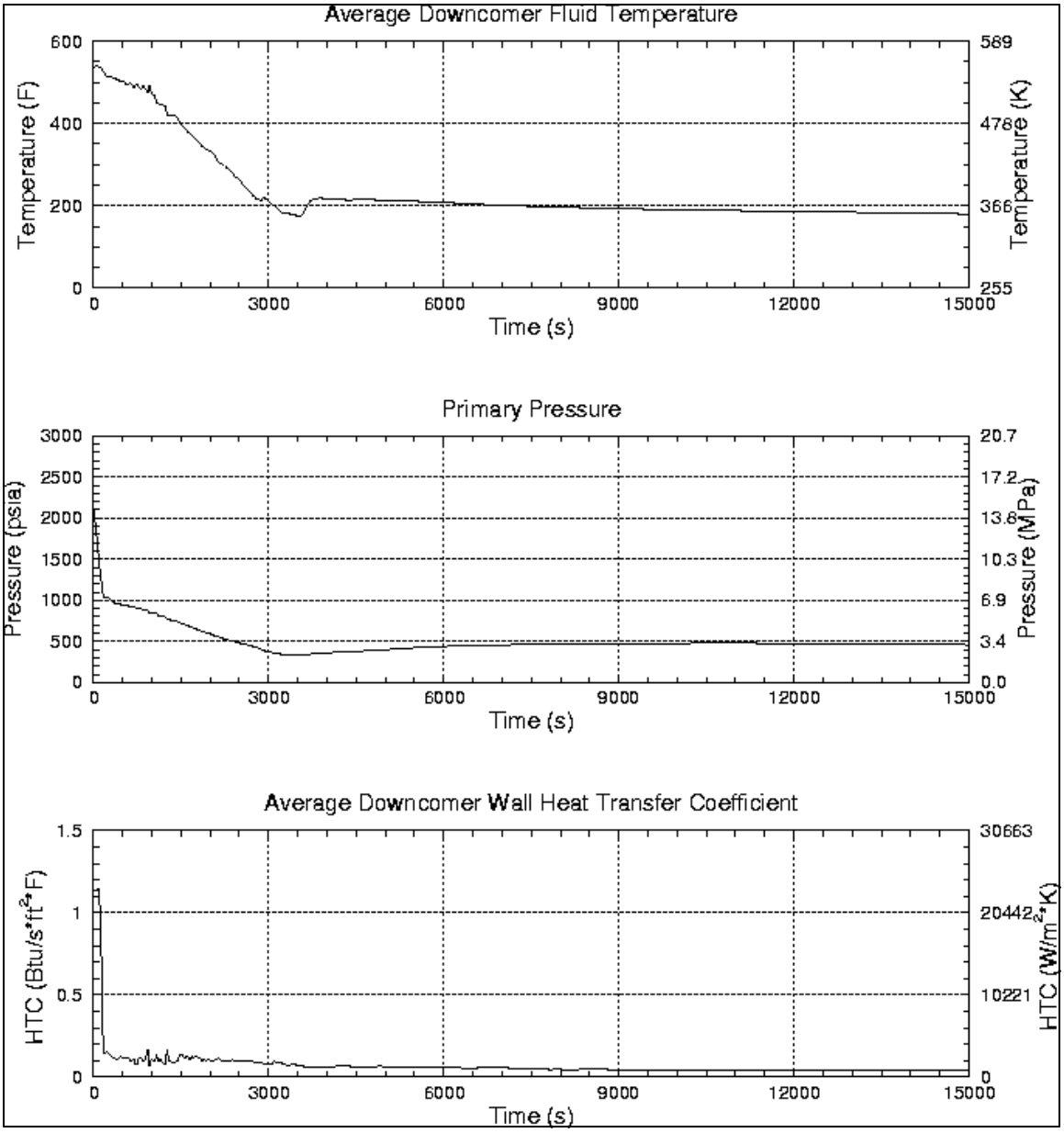

Figure C.2-63: Palisades PTS Results for Case 060

Case Category	LOCA
Primary Failures	7.18 cm (2.8 in) cold leg break. Summer conditions assumed (HPI and LPI injection temp = 100 F, Accumulator temp = 90 F)
Secondary Failures	None.
Operator Actions	None. Operator does not throttle HPI.
Min DC Temp	383.4 K (230.4°F) at 8940 s
Comments	Momentum Flux Disabled in the DC

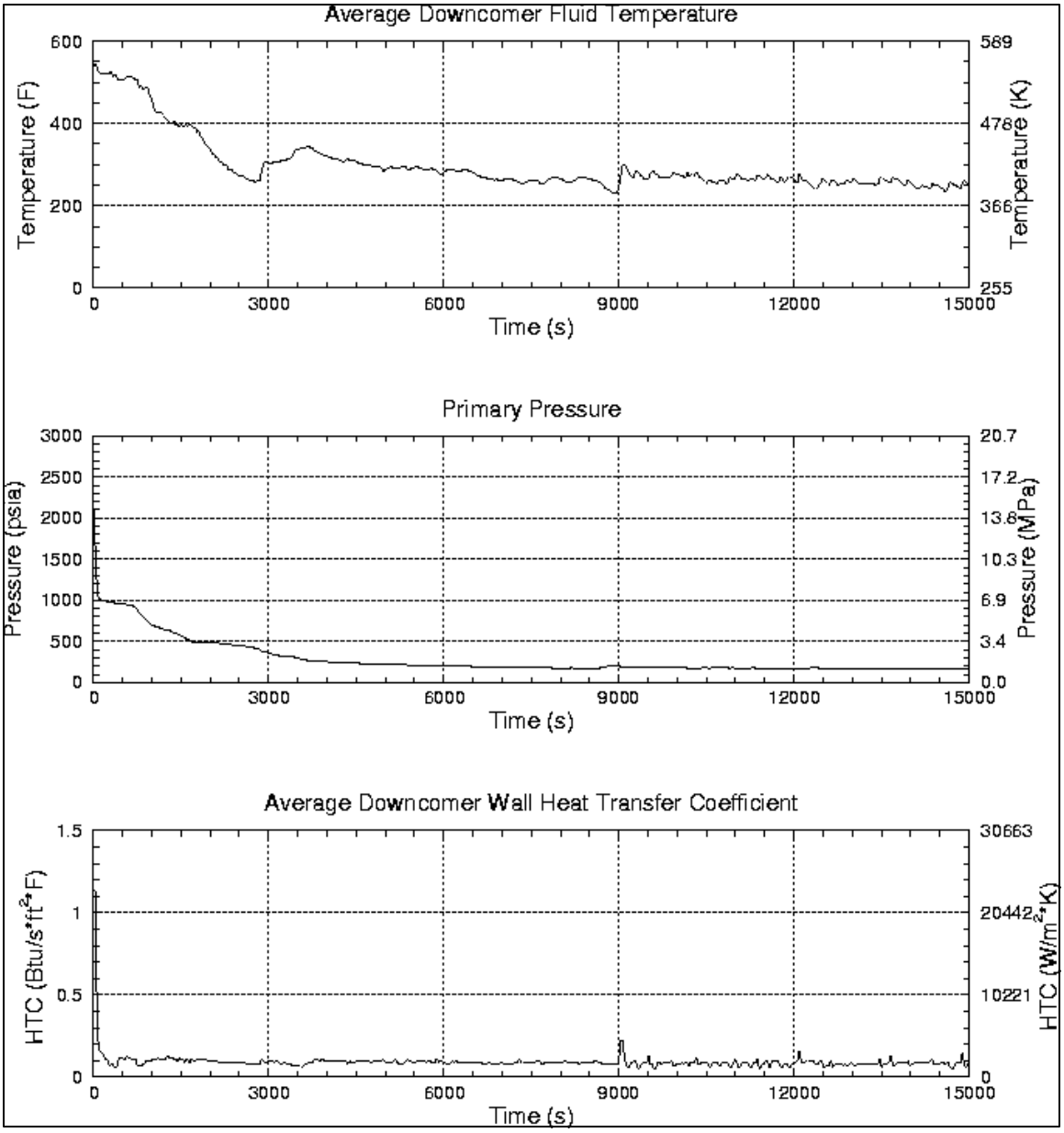

Figure C.2-64: Palisades PTS Results for Case 061

Case Category	LOCA
Primary Failures	20.32 cm (8 in) cold leg break. Winter conditions assumed (HPI and LPI injection temp = 40 F, Accumulator temp = 60 F)
Secondary Failures	None.
Operator Actions	None. Operator does not throttle HPI.
Min DC Temp	308.0 K (94.7°F) at 1470 s
Comments	Momentum Flux Disabled in the DC

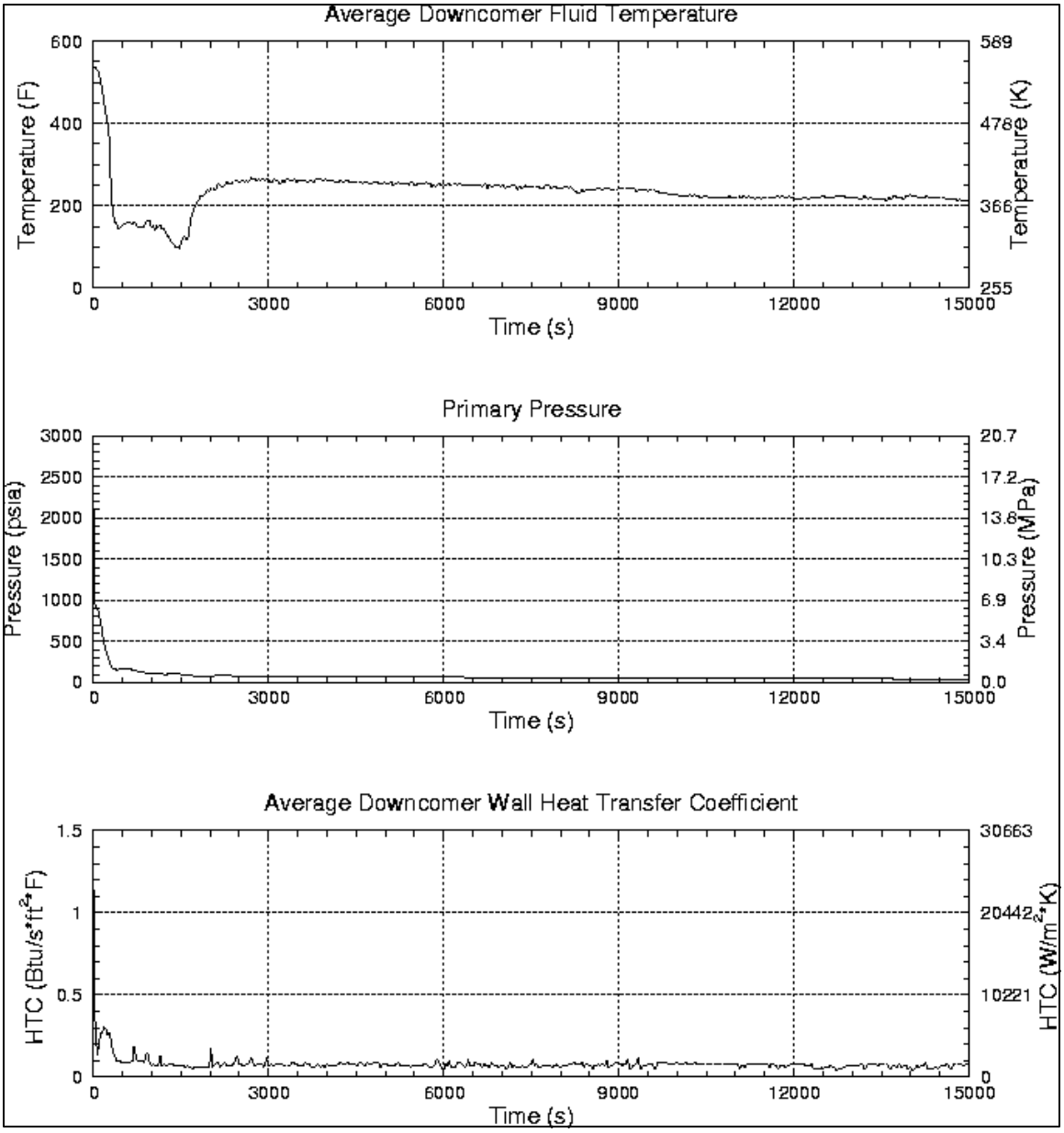

Figure C.2-65: Palisades PTS Results for Case 062

Case Category	LOCA
Primary Failures	14.37 cm (5.656 in) cold leg break. Winter conditions assumed (HPI and LPI injection temp = 40 F, Accumulator temp = 60 F)
Secondary Failures	None.
Operator Actions	None. Operator does not throttle HPI.
Min DC Temp	306.4 K (91.8°F) at 2070 s
Comments	Momentum Flux Disabled in the DC

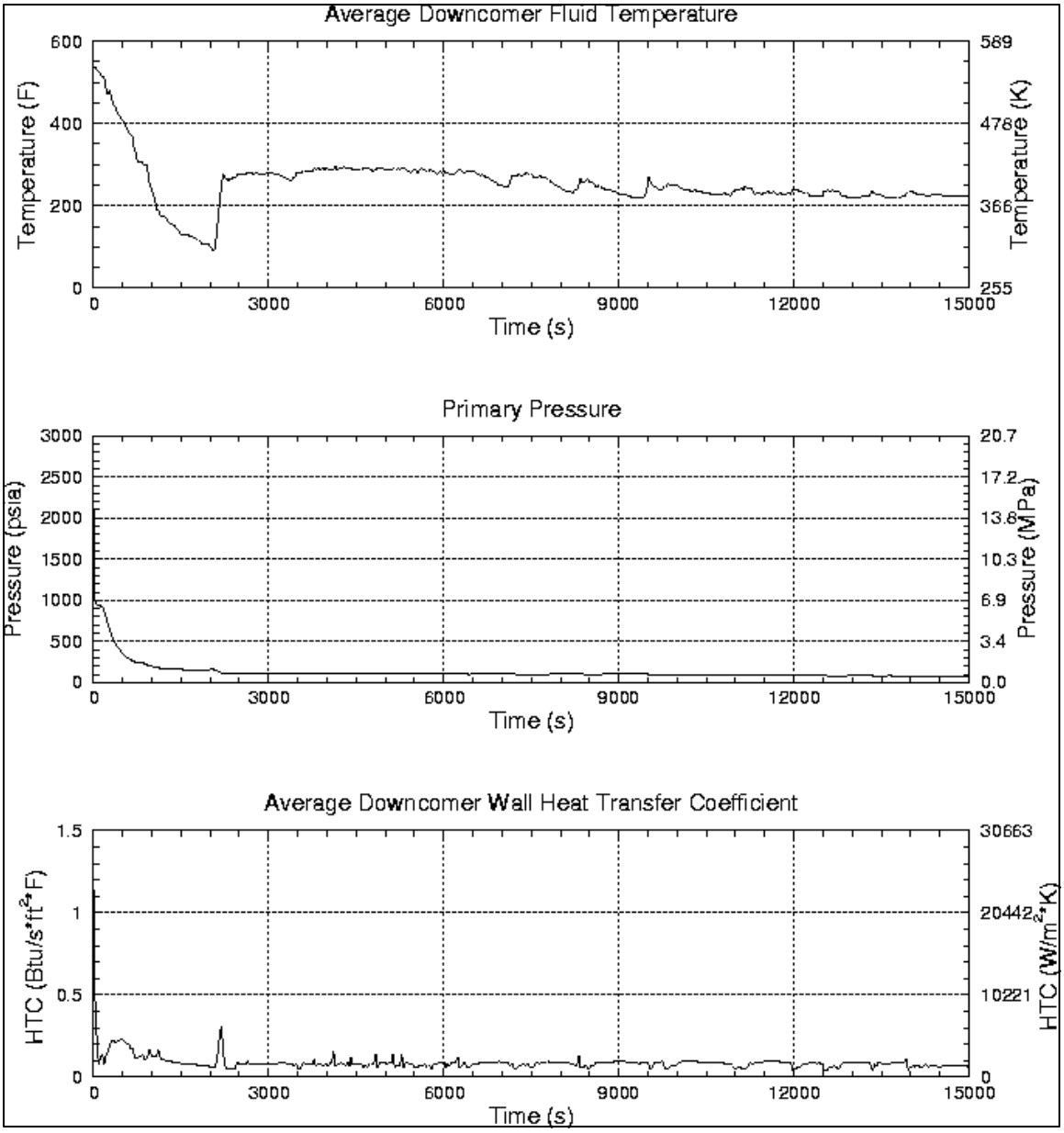

Figure C.2-66: Palisades PTS Results for Case 063

Case Category	LOCA
Primary Failures	10.16 cm (4 in) surge line break. Summer conditions assumed (HPI and LPI injection temp = 100 F, Accumulator temp = 90 F)
Secondary Failures	None.
Operator Actions	None. Operator does not throttle HPI.
Min DC Temp	322.8 K (121.4°F) at 2730 s
Comments	None.

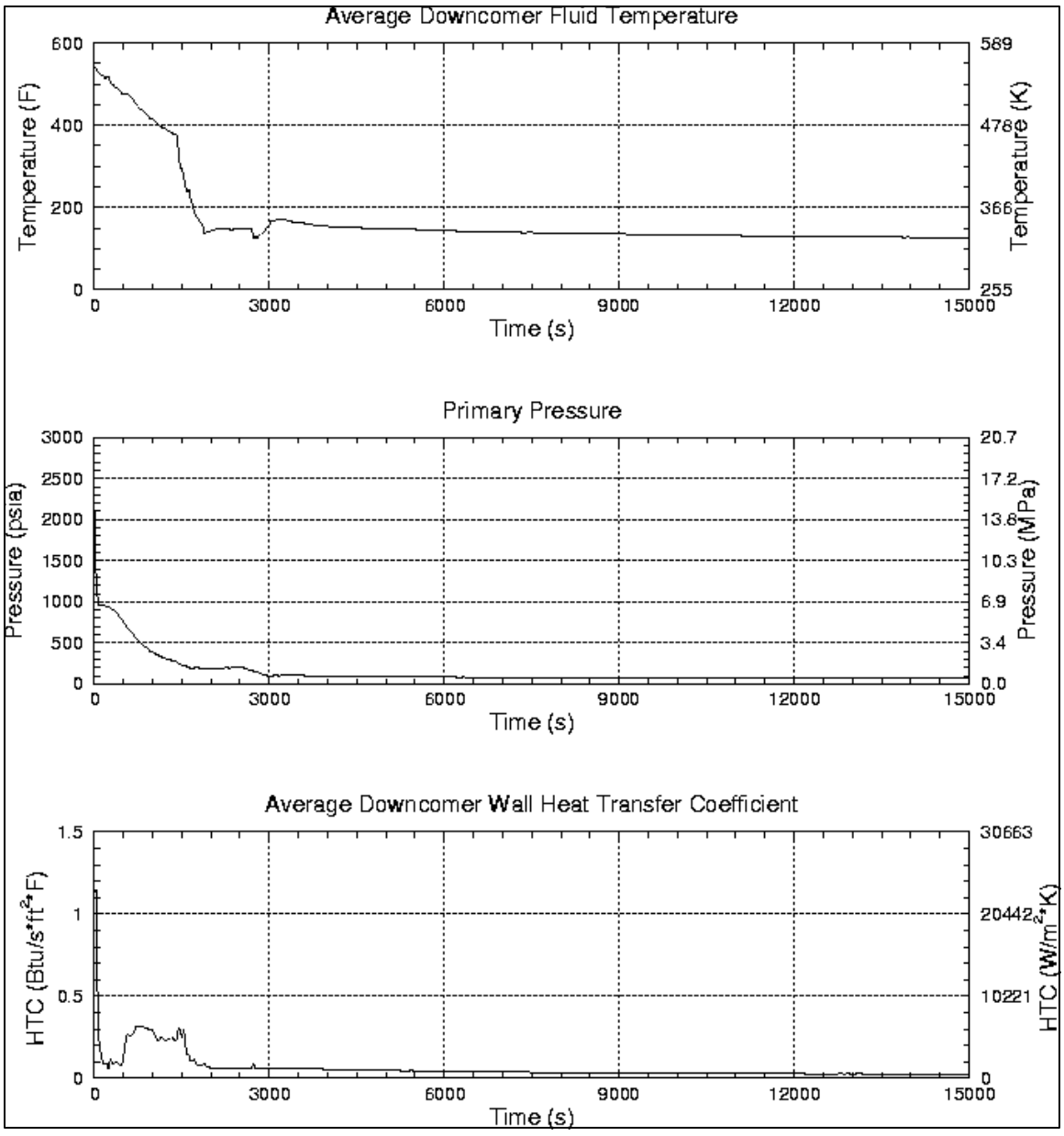

Figure C.2-67: Palisades PTS Results for Case 064

Case Category	RT
Primary Failures	One stuck-open pressurizer SRV that recloses at 6000 sec after initiation. Containment spray is assumed not to actuate.
Secondary Failures	None.
Operator Actions	None. Operator does not throttle HPI.
Min DC Temp	366.1 K (199.3°F) at 6570 s
Comments	None

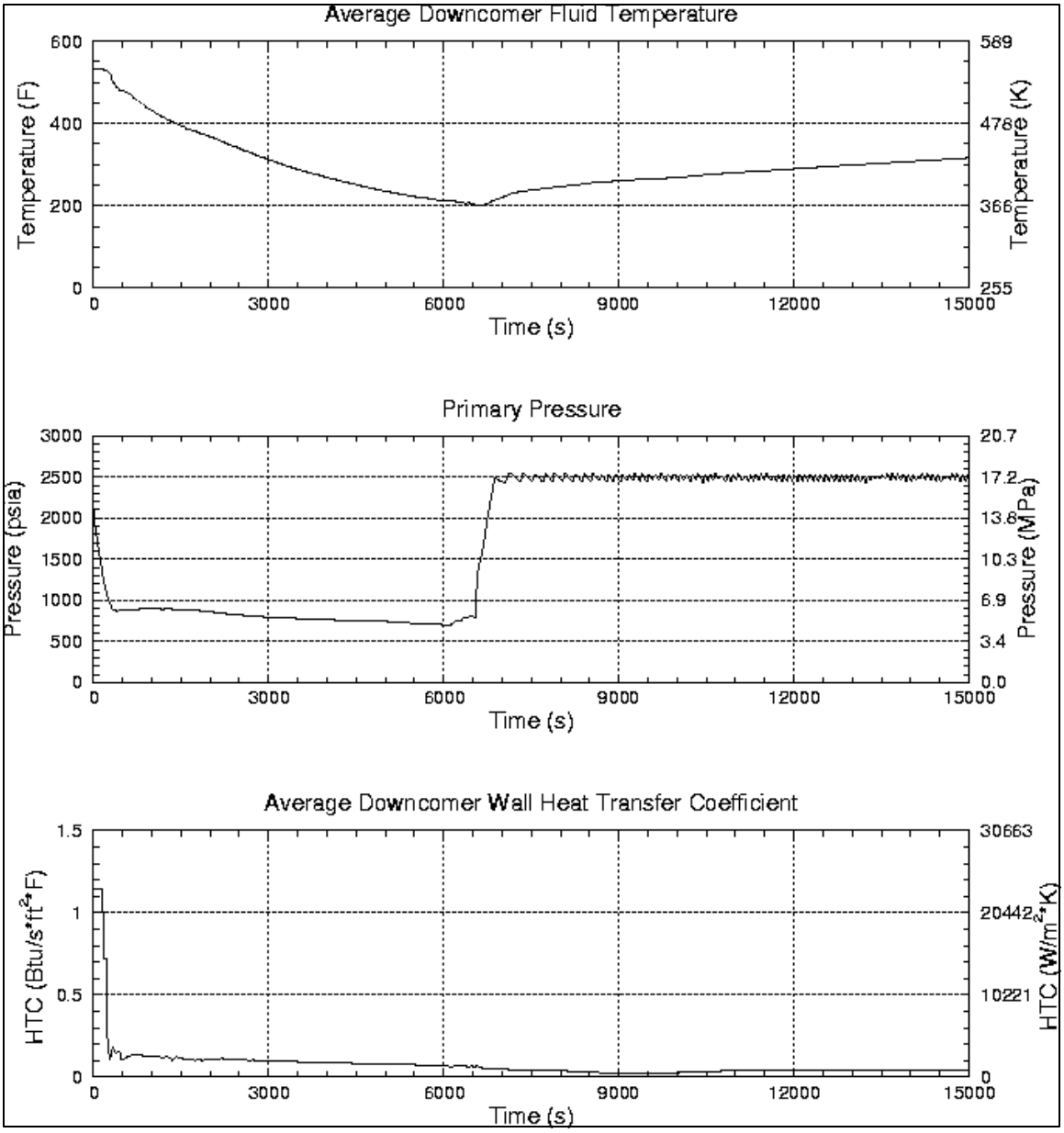

Figure C.2-68: Palisades PTS Results for Case 065