PTS Consistency Effort

Problem Statement:

Various anomalies have been identified in several thermal hydraulic computer analyses (e.g., differences in the input assumptions such as one- or two-dimensional downcomer modeling; momentum flux considerations "on" vs. "off"). To demonstrate that these anomalies did not affect the overall conclusion of the PTS project (i.e., that the risk from PTS events is much lower than previously calculated, which will allow revision of the PTS rule to be considered), a review of the thermal hydraulic analyses is required. This review is particularly desirable since comparison of various thermal hydraulic analyses' results can help to identify problems in several different areas, including operator actions, equipment limitations, etc.

Prior to this coordinated evaluation of the thermal hydraulic runs, an anomaly was discovered that could have affected the overall PTS project results. The anomaly was corrected and 75 thermal hydraulic runs were performed again as a result of the evaluation.

Methodology:

To determine if these anomalies would challenge the results of the PTS project, a sample of the current thermal hydraulic analyses were reviewed by a team of personnel from each area of PRA, TH, and PFM.

The sample was developed so that, in as much as possible, similar type scenarios could be evaluated between the different base case plants, as well as, for each single plant. For example, the 16 inch LOCA cases for each base case plant were evaluated for consistency. Similarly, a comparison of varying size LOCAs (16 inch, 8 inch, 4 inch, etc) for each single plant was evaluated. The cases were evaluated by comparing the response of Temperature, Pressure, and Heat Transfer Coefficient parameters to expected trends for the type of scenario analyzed.

The focus of the evaluations was toward the first 10,000 seconds of the event as the parameters that would affect a TWCF were not as severe after that point. For example the initial temperature change across the RPV wall immediately following an event would be large, however as the event progresses, the colder temperature water would remain on the inside face of the vessel wall. The RPV would cool down and the change in temperature would decrease inducing less stress across the wall.

If an anomaly was determined to be detrimental to the PTS project, the sample size was increased to evaluate the affect on the overall PTS project results.

Analysis:

Each comparison run presented herein includes a description of the scenario evaluated, our expectations for that run, and our evaluation of the results. If an anomaly is identified, the effect on the PTS project is discussed.

See attached sheets.

Conclusion:

There were few discrepancies between the expected results and the computer runs. Each anomaly identified was evaluated and determined to have no significant effect on the PTS project results.

Consistency Effort Data Sheet

Run Number:

Beaver Valley - 9
Oconee - 156
Palisades - 40

Accident type:

16” Loss of Coolant Accident (LOCA)

Conditions:

Oconee-156 emergency core cooling system (ECCS) suction switches to containment sump, hot full power (HFP)
Palisades-40 ECCS suction switches to containment sump, hot full power
Beaver Valley-9 hot full power

Expectations:

Temperature and pressure should trend consistently.

Results:

Beaver Valley cools down slightly faster than Palisades and Oconee. Beaver Valley has colder injection water as it is cooled all year long. Oconee has a slightly slower cool down due to vent values in the downcomer.

Beaver Valley temperature slope is slightly different from 0-1000s due to throttling of high pressure injection (HPI).

All three plants have temperature increases between 1000s and 2000s as the injection flow switches to the containment sump which supplies much warmer water.

Consistency Effort Data Sheet

Run Number:

Beaver Valley - 7
Oconee - 164
Palisades - 62

Accident type:

8" LOCA

Conditions:

Oconee-164 ECCS suction switches to containment sump, HFP, surge line break.
Beaver Valley-7 hot full power, surge line break, with ECCS swap to containment sump
Palisades-62 Winter conditions, ECCS water 40^{o}F, Safety Injection Tank (SIT) 60^{o}F, cold leg break, ECCS swaps to containment sump.

Expectations:

Since Palisades Break is on the cold leg, some of the ECCS water will go out the break versus into the downcomer; therefore temperature is not expected to drop as low as the other plants.

Results:

Recirculation Actuation Signal (RAS) occurs between 1000s and 2000s causing an increase in temperature. Oconee temperature drop is not as quick due to the vent valves in the vessel. Palisades low pressure injection (LPI) pumps stop on RAS therefore the final temperature is higher due to lower injection flow into the system.

Consistency Effort Data Sheet

Run Number:

Beaver Valley - 56
Oconee - 172
Palisades - 58

Accident type:

4" LOCA

Conditions:

Oconee - 172 cold leg break, ECCS suction swaps to CNTMT sump, HFP
Beaver Valley - 56 surge line break, hot zero power (HZP)*
Palisades - 58 cold leg break, winter conditions (cool ECCS water), HFP

* Beaver Valley hot zero power - this case represents very cold conditions for a hot full power case. See University of MD report.

Expectations:

Beaver Valley cool down should be quickened due to low heat load in core.
RAS occurs after 3000s.
Temperature of Oconee will decrease slower due vent valves.

Results:

Following RAS palisades, temperature higher due to LPI secured
Temperature increase in Palisades, at 1500s is due to backflow out of the cold leg break,
Oconee rate of temperature decrease at 2000s due to LPI.

Consistency Effort Data Sheet

Run Number:

Beaver Valley - 3
Oconee - 110
Palisades - 60

Accident type:

2" LOCA

Conditions:

Oconee -110 HPI failure, 15 min later turbine bypass valves (TBV) open to cool RCS and lower pressure to allow safety injection tank (SIT) & LPI flow. Surge line break.

Beaver Valley -3 surge line break

Palisades – 60 surge line break

Expectations:

With HPI failure at Oconee, pressure and temperature should not track Beaver Valley and Palisades.

Results:
Beaver Valley & Palisades temperature and pressure track very well. The 2 spikes in temperature at 2000s are due to the throttling of HPI.

Consistency Effort Data Sheet

Run Number:

Beaver Valley -2
Palisades -2

Accident type:

1.4” LOCA

Conditions:

Palisades - 2 surge line, HFP
Beaver Valley -2 surge line, HFP

Expectations:

Temperature and pressure should track well.

Results:

As expected.

Consistency Effort Data Sheet

Run Number:

Palisades - 40
Palisades - 62
Palisades - 58
Palisades - 60
Palisades - 2

Accident type:

Loss of Coolant Accidents of varying sizes at Palisades

Conditions:

16” hot leg w/RAS, no HPI throttling
8” cold leg winter, w/RAS, no HPI throttling
4” cold leg winter, w/RAS, no HPI throttling
2” surge line, winter, w/RAS, no HPI throttling
1.4” surge line, w/RAS

Expectations:

Pressure & Temperature curves should vary based on size of the break. The larger the break, the faster the depressurization and lower the temp. With the HPI throttling for the 1.4” break, the temperature should end up warmer.

Results:

As expected.

Consistency Effort Data Sheet

Run Number:

Oconee – 156
Oconee – 164
Oconee – 172
Oconee – 110
Oconee - 12

Accident type:

Various LOCA size breaks

Conditions:

16” hot leg w/RAS, no HPI throttling
8” surge line, with RAS, no HPI throttling
4” cold leg, with RAS, no HPI throttling
2” surge line, HPI failure,15 minutes Operations open TBV’s to reduce RCS pressure and allow SIT discharge and LPI flow
1” surge line, with stuck open MSSV, HPI throttled

Expectations:

Case number 110 should not track with other cases. Remaining cases should track well, with the larger breaks having the fastest decrease in pressure and temperature. RAS will occur later as the break size decreases.

Results:

Increased rate of temperature decrease at 2000s due to LPI occurring.

Consistency Effort Data Sheet

Run Number:

Beaver Valley - 9
Beaver Valley - 7
Beaver Valley - 56
Beaver Valley - 3
Beaver Valley -2

Accident type:

Various size LOCA's at Beaver Valley

Conditions:

16" hot leg, HFP
8" surge line, HFP
4" surge line, HZP
2" surge line, HFP
1.4" surge line, HFP

Expectations:

Case 56 HZP which is modeling cold conditions for HFP. See University of MD report. The temperature in this case will decrease faster than a HFP case. The temperature and pressure curves should track well with larger break, decreasing faster than small break.

Results:

As expected.

Consistency Effort Data Sheet

Run Number:

Beaver Valley - 74
Palisades - 24
Oconee - 27
Oconee - 89

Accident type:

Main Steam Line Break

Conditions:

Beaver Valley - 74 Double guillotine ended break of main steam line, HFP, Auxiliary Feed Water (AFW) continues to feed
Palisades - 24 MSLB in containment (Reactor Coolant Pumps (RCP's) off), HFP
Oconee - 27 Turbine Trip/Reactor Trip (TT/RT), one stuck open main steam safety valve (MSSV), throttling HPI, AFW continues to feed
Oconee - 9 TT/RT, Loss of Main Feed Water (MFW), AFW, turbine bypass valves opened to decrease pressure to feed with condensate booster pumps.

Expectations:

These are very different transients. Case 89 is not a MSLB. Case 24 has the reactor coolant pumps secured due to adverse containment environment. This will decrease the heat transfer coefficient. Oconee and BV have high head HPI pumps. Palisades HPI pumps shut off heat is ~ 1200 psi therefore the pressure at Oconee will recover much faster.
Case 27 with

Results:

The "humps" in the temperature graph of Palisades -24 is the RCS attempting to reach natural circulation. As the natural circulation starts, there is an increase in heat transfer coefficient and a slight cool down.

Graphs were not expected to trend well, however they were consistent with the scenario described.

Consistency Effort Data Sheet

Run Number:

Beaver Valley - 102
Palisades - 24

Accident type:

MSLB in CNTMT

Conditions:

Beaver Valley – 102 HZP, AFW feeds for 30 min, HPI throttle 30 minutes after allowed, RCP's off

Palisades - 24 HFP, RCP's off.

Expectations:

These events are similar. Pressure control by HPI – Palisades' shutoff head 1250 psi, Beaver Valley has high head pumps.

Results:

Initially Temperature drops consistent, until Palisades HPI reaches shut off head, then only charging pumps therefore temperature is higher (lower flow) and pressure increase is slower.

Consistency Effort Data Sheet

Run Number:

Beaver Valley - 118
Beaver Valley - 112
Beaver Valley - 110

Accident type:

MSLB with HPI throttle at various times (after allowed).

Conditions:

Beaver Valley - 118 small break, No HPI throttling, HFP
Beaver Valley – 112 small break, AFW feeds, RCP's off, HPI throttled at 30 min past allowed, HFP
Beaver Valley - 110 small MSLB, AFW continues to feed for 30 min, HPI throttled 60 min after allowed, HFP

Expectations:

RCP's are tripped when criteria in procedures is met for case 118.

Results:

Except for effect of RCP's graphs track very well. For case 110 HPI is secured 1000s after throttling, this results in pressure and temperature increase.

Consistency Effort Data Sheet

Run Number:

Beaver Valley - 113
Beaver Valley - 111

Accident type:

MSLB with HPI throttled at various times (after allowed).

Conditions:

Beaver Valley - 113 MSLB, HZP, HPI throttled 30 min after allowed, RCP's tripped
Beaver Valley - 111 MSLB, HZP, HPI throttled 60 min after allowed, RCP's tripped

Expectations:

Pressure and temperature curves should trend well, with case 111 pressure decrease 30 min after case 113

Results:

As expected.

Consistency Effort Data Sheet

Run Number:

Beaver Valley - 103
Beaver Valley - 105

Accident type:

MSLB with HPI throttling at various times after allowed. HZP

Conditions:

Beaver Valley – 103 HZP, AFW flow for 30 minutes, RCP's off, HPI throttled 30 minutes after allowed
Beaver Valley – 105 HZP, AFW flow for 30 minutes, RCP's off, HPI throttled 60 minutes after allowed.

Expectations:

Graphs should trend well, with pressure decrease at HPI throttling time

Results:

As expected

Consistency Effort Data Sheet

Run Number:

Beaver Valley - 102
Beaver Valley - 104

Accident type:

MSLB with HPI throttling at various times after allowed. HFP

Conditions:

Beaver Valley – 102 HFP, AFW feeds the steam generator for 30 min, RCP's off, HPI throttled 30 minutes after allowed
Beaver Valley – 104 HFP, AFW flow for 30 minutes, RCP's off, HPI throttled 60 minutes after allowed.

Expectations:

Graphs should trend well, with pressure decrease at HPI throttling time

Results:

Graphs trend well, until throttling criteria is no longer met, then pressure and temperature increase

Consistency Effort Data Sheet

Run Number:

Beaver Valley - 106
Beaver Valley - 107

Accident type:

MSLB with HPI throttling at 30 min after allowed

Conditions:

Beaver Valley - 106 RCPs off, HFP
Beaver Valley - 107 RCPs off, HZP

Expectations:

Pressure and Temperature for HZP case (107) will decrease faster than HFP case

Results:

As expected.

Consistency Effort Data Sheet

Run Number:

Palisades - 049
Palisades - 050
Palisades - 051

Accident type:

MSLB various failures occurring

Conditions:

Palisades - 49 HZP, RCP's off, AFW isolated 30 minutes, No HPI throttling
Palisades – 50 HZP, RCP's off, 2 AFW pumps operating, No HPI throttling
Palisades - 51 HZP, MSIV's fail open, AFW continues, No HPI throttling

Expectations:

MSLB in CNTMT – Temperature and Pressure decrease quickly
For AFW continuing to feed and steam generator is not isolated, RCS temperature should reach saturation temperature of secondary side pressure ($212^{o}F$)
For AFW continuing and MSIV's shut, s/g will eventually go solid and temperature will trend below saturation of secondary side (below $212^{o}F$)
For AFW secured, MSIV's shut, Temperature will increase since no cooling mechanism
Pressure in all three cases should eventually reach safety relief valve (SRV) pressure

Results:

As expected

Consistency Effort Data Sheet

Run Number:

Palisades - 24
Palisades - 26
Palisades - 34

Accident type:

MSLB with various failures

Conditions:

Palisades - 24 HFP, RCP's off
Palisades - 26 HFP, RCP's off, AFW isolate 30 min
Palisades - 34 MSLB w/ Steam Generator Tube Rupture (SGTR), RCP's off, HPI throttling when allowed, SG isolated within 15 minutes, HFP

Expectations:

SGTR requires pressure to be decreased to minimize the pressure difference across the SG tubes which minimizes RCS leakage into secondary side. Isolating AFW to S/G will cause temperature to rise.

Results:

In case 24 with AFW continuing, the RCS temperature will decrease slowly since the movement of fluid in the primary is via the charging pumps. As can be seen in the temperature on pressure graphs, the "humps" between 1000s and 2000s and again between 7000s and 10000s are a result of natural circ. With natural circ, the flow is significantly larger and the HTC increase and more cooling occurs.

Consistency Effort Data Sheet

Run Number:

Oconee - 100
Oconee - 101

Accident type:

MSLB

Conditions:

Oconee - 100 Turbine drive AFW pump tripped, HPI throttled at 20 minutes after allowed, HZP
Oconee – 101 HZP, HPI throttled, no trip of AFW.

Expectations:

As steam blows down, the RCS temperature should reach the saturation temperature of the secondary side ($212^{o}F$)
RCS pressure will increase as HPI fills the RCS. When HPI is throttled, the pressure will decrease.

Results:

As expected.

Consistency Effort Data Sheet

Run Number:

Oconee - 27
Oconee - 99

Accident type:

MSLB

Conditions:

Oconee - 27 AFW does not trip, HFP, HPI throttled
Oconee – 99 AFW does trip, HFP throttled 20 min after allowed

Expectations:

As steam blows down, the RCS temperature should reach the saturation temperature of the secondary side.
RCS pressure will increase as HPI fills the RCS. When HPI is throttled, the pressure will decrease to meet the throttling criteria.

Results:

As expected.

Consistency Effort Data Sheet

Run Number:

Palisades - 55
Beaver Valley - 78
Oconee - 28

Accident type:

Various size MSL leaks (ADV's, MSSV's, etc.)

Conditions:

Palisades - 55 TT/RT, 2 atmospheric dump valves (ADV's) open, AFW feeding, HFP
Beaver Valley - 78 TT/RT, Loss of MFW/AFW, all ADV's open, HFP
Oconee - 28 TT/RT, stuck open MSSV, HFP

Expectations:

Small steam leaks should result in slight cooling with resultant, decrease in RCS pressure HPI flow should recover the pressure quickly in Beaver Valley and Oconee, however the 1250 psi shutoff head of the HPI at Palisades and subsequent charging pump flow will require a longer period for pressure to recover.

Results:

As expected.

Consistency Effort Data Sheet

Run Number:

Beaver Valley - 71
Beaver Valley - 98
Beaver Valley - 100

Accident type:

One stuck open (SO) primary safety valve with HPI throttling at various times after allowed

Conditions:

BV – 71 TT/RT, 1 50 SRV, HZP, no HPI throttled
BV – 98 TT/RT, 1 50 SRV, HZP, HPI throttled within one minute of allowed
BV –100 TT/RT, 1 50 SRV, HZP, HPI throttled within 10 minutes of allowed

Expectations:

HZP case should allow HPI throttling to control RCS pressure, If HPI not throttled, when valve re-closes at 6000s

Results:

As expected.
Case 98, HPSI is throttled at 1000s and adjusted to maintain criteria.

Consistency Effort Data Sheet

Run Number:

Beaver Valley - 60
Beaver Valley - 95
Beaver Valley - 96

Accident type:

One SO SRV with HPI throttled at various times

Conditions:

Beaver Valley - 60 One SO SRV, HPI throttling, valve recluses at 6000s, HFP
Beaver Valley - 95 RT/TT, one SO SRV, HPI throttled within 1 minute of allowed, HFP
Beaver Valley - 96 RT/TT, one SO SRV, HPI throttled within 10 minute of allowed, HFP

Expectations:

Plots will trend closely

Results:

As expected

Consistency Effort Data Sheet

Run Number:

Beaver Valley - 97
Beaver Valley - 99
Beaver Valley - 101
Beaver Valley - 59

Accident type:

One SO primary SRV with re-closure at 3000s at HZP and various HPI throttling times. Case 59 is at HFP.

Conditions:

BV – 97 HZP, RT/TT, one stuck open primary SRV, No HPI throttling
BV – 99 HZP, RT/TT, one stuck open primary SRV, HPI throttled 1 minute after allowed
BV – 101 HZP, RT/TT, one stuck open primary SRV, HPI throttled 10 minutes after allowed
BV – 59 RT/TT, HFP, one stuck open primary SRV, No HPI throttling

Expectations:

When the valve re-closes at 3000s, if no HPI throttling has occurred, pressure will increase quickly. If throttling occurs, then pressure should be controlled. Case 59 is a HFP case and temperature will not decrease as fast or as far due to the hot condition in the core. When throttling occurs, temperature will increase due to the decreased amount of flow into the RCS.

Results:

As expected, except for the HPI throttling 10 minutes after allowed. In this case, the throttling occurred too late to prevent re-pressurization. However once throttling occurred, pressure came down as expected.

Consistency Effort Data Sheet

Run Number:

Oconee - 109
Oconee - 112
Oconee - 113

Accident type:

One stuck open primary SRV w/valve re-closure at 6000s and various HPI throttling times

Conditions:

Oconee - 109 HFP, no HPI throttling
Oconee - 112 HFP, HPI throttled 1 minute after allowed
Oconee - 113 HFP, HPI throttled 10 minutes after allowed

Expectations:

Pressure and Temperature will decrease. When HPI is throttled, pressure should be controlled and temperature will increase faster.

Results:

The HPI throttling did not control RCS pressure. Heat output of the core was high and re-pressurized the RCS.

Consistency Effort Data Sheet

Run Number:

Oconee - 149
Oconee - 114
Oconee - 115

Accident type:

One SO primary SRV with re-closure at 3000s at HFP and various HPI throttling times

Conditions:

Oconee - 149 TT/RT, no HPI throttling, HFP
Oconee - 114 TT/RT, HPI throttled within 1 minute of allowed, HFP
Oconee - 115 TT/RT, HPI throttled within 10 min of allowed, HFP

Expectations:

Pressure& Temperature will decrease. HPI throttling should control press. After throttling HPI, temperature should increase due to the reduced flow into the core.

Results:

Heat output of the core in the HFP case causes the RCS pressure to increase even through HPI throttling. The temperature & pressure spikes between 6000s and 10000s are attempts of the RCS to start natural circulation. When natural circulation initiates, the pressure and temperature decrease until conditions are not optimal.

Consistency Effort Data Sheet

Run Number:

Oconee - 168
Oconee - 123
Oconee - 124

Accident type:

One SO primary SRV at HZP with valve re-closure at 3000s and varying HPI throttling times.

Conditions:

Oconee - 168 TT/RT, no HPI throttling
Oconee - 123 TT/RT, HPI throttled within 1 min of allowed.
Oconee - 124 TT/RT, HPI throttled within 10 min of allowed

Expectations:

Temperature & Pressure decrease. As HPI is throttled, the temperature will increase due to lower flow into the RCS. HPI throttling should control RCS pressure.

Results:

As expected.

Consistency Effort Data Sheet

Run Number:

Oconee - 165 TT/RT, HZP, no HPI throttling
Oconee - 121 TT/RT, HZP, HPI throttling within 1 min of allowed
Oconee - 122 TT/RT, HZP, HPI throttling within 10 min of allowed

Accident type:

One SO primary SRV with re-closure at 6000s and HZP with varying HPI injection times

Conditions:

Oconee - 165 TT/RT, HZP, no HPI throttling
Oconee - 121 TT/RT, HZP, HPI throttling within 1 min of allowed
Oconee - 122 TT/RT, HZP, HPI throttling within 10 min of allowed

Expectations:

Pressure & temperature decrease. As HPI is throttled, temperature will increase due to reduced ECCS flow into the core. HPI throttling control RCS pressure

Results:

As expected.

Consistency Effort Data Sheet

Run Number:

Beaver Valley - 70
Beaver Valley - 89
Beaver Valley - 91

Accident type:

Two SO primary SRV's with valve re-closure at 6000s, with varying times of HPI injections at HZP

Conditions:

Beaver Valley - 70 TT/RT, HZP, no throttling
Beaver Valley - 89 TT/RT, HZP, HPI throttled within 1 minute of allowed
Beaver Valley - 91 TT/RT, HZP, HPI throttled within 10 minutes of allowed.

Expectations:

Pressure& Temperature decrease. HZP case should allow throttling of HPI to control pressure. RCS temperature will increase as HPI is throttled due to lower flow.

Results:

As expected.

Consistency Effort Data Sheet

Run Number:

Beaver Valley - 62
Beaver Valley - 86
Beaver Valley - 87

Accident type:

Two SO primary SRV's at HZP with valve re-closure at 6000s

Conditions:

Beaver Valley - 62 TT/RT, HFP, no HPI throttling
Beaver Valley - 86 TT/RT, HFP, HPI throttled within 1 minute of allowed
Beaver Valley - 87 TT/RT, HFP, HPI throttled within 10 minutes

Expectations:

Pressure& Temperature decrease. HPI throttling will result in temperature increases due to reduced flow. Since this is a HFP case, HPI throttling may not control pressure due to higher heat content in core.

Results:

As expected.

Consistency Effort Data Sheet

Run Number:

Beaver Valley - 69
Beaver Valley - 88
Beaver Valley - 90
Beaver Valley - 61

Accident type:

Two SO primary SRV's, at HZP with varying HPI injection times
Case 61 is at HFP. Valve re-closure at 3000's

Conditions:

Beaver Valley - 69 RT/TT, HZP, no HPI throttling
Beaver Valley - 88 RT/TT, HZP, HPI controlled within 1 minute after allowed
Beaver Valley - 90 RT/TT, HZP, HPI controlled within 10 minutes
Beaver Valley - 61 RT/TT, HFP, no HPI throttling

Expectations:

Pressure& Temperature decrease. As HPI is throttled, temperature will rise due to lower flow
Case 61 in a HFP case for comparison

Results:

Pressure& Temperature decrease. As HPI is throttled, Temperature will increase due to less flow.
BV – 90 case has pressure increase at 10000s, HPI is no longer throttled until 11000s.

Consistency Effort Data Sheet

Run Number:

Palisades - 48
Palisades - 42

Accident type:

Two SO primary SRV's, with varying times of throttling

Conditions:

Palisades - 48 RT/TT, HZP, no throttling of HPI
Palisades - 42 TT/RT, HFP, HPI throttled as soon as allowed

Expectations:

Pressure& Temperature would drop. The HFP case would result in slower temperature decrease.
Without HPI throttling, the RCS pressure would increase to the SRV set point

Results:

As expected.

Consistency Effort Data Sheet

Run Number:

Beaver Valley - 71
Oconee - 165
Palisades - 65

Accident type:

One stuck open primary SRV at HZP with valve re-closure at 6000s

Conditions:

Beaver Valley - 71 no HPI throttling
Oconee - 165 no HPI throttling
Palisades - 65 no HPI throttling

Expectations:

Pressure& Temperature will decrease. The decrease will be based on the SRV size. The larger valves will cool down and lose pressure faster.

Results:

As expected.
Palisades has small SRV's and the HPI system is not high head pumps therefore flow to the RCS is less and temperature will not decrease as much. These low head pumps also effect how fast the RCS refills after valve re-closure.

Consistency Effort Data Sheet

Run Number:

Beaver Valley - 98
Oconee - 112

Accident type:

One SO primary SRV w/ HPI throttling at 1 minute after allowed

Conditions:

Beaver Valley - 98 Valve re-closes at 6000s, HFP
Oconee - 112 valve re-closes at 6000s, HZP

Expectations:

Pressure& Temperature curves should track well.

Results:

Temperature charger for BV at 1000s is due to HPI throttling subsequent decrease is due to SIT injection/LPI.
Pressure& Temperature for the HFP case is higher due to the heat load of the RCS.

Consistency Effort Data Sheet

Run Number:

Beaver Valley - 100
Oconee - 122

Accident type:

One SO primary SRV, HPI throttled at 10 minutes of allowed.
Valve recluses at 6000s

Conditions:

Beaver Valley - 100 HZP
Oconee - 122 HFP

Expectations:

Pressure & Temperature curves should track well with the HFP case slightly higher.

Results:

Pressure peak at 7000s is due to HPI injection throttled too late to compensation for the heat load in the RCS, due to the HFP case.

Consistency Effort Data Sheet

Run Number:

Beaver Valley - 70
Palisades - 48

Accident type:

Two SO primary SRV's, Valve re-closes at 6000s

Conditions:

Beaver Valley - 70 HZP, no HPI throttling
Palisades - 48 HZP, no HPI throttling

Expectations:

Palisades T&P curves should decrease at a slower rate since the SRV capacity is lower.

Results:

As expected.

Consistency Effort Data Sheet

Run Number:

Beaver Valley - 86
Palisades - 42

Accident type:

Two SO primary SRV's

Conditions:

Beaver Valley - 86 HFP, HPI throttled within one minute of allowed valve re-closure at 6000s
Palisades - 42 HFP, HPI throttled ASAP

Expectations:

Due to smaller SRV, Palisades Temperature will not decrease as fast

Results:

Because of heat load in the core, throttling HPI cannot control

Consistency Effort Data Sheet

Run Number:

Beaver Valley - 71
Beaver Valley - 70

Accident type:

One and Two SO primary SRV's no HPI throttling

Conditions:

Beaver Valley - 71 One SO primary SRV
Beaver Valley - 70 Two SO primary SRV

Expectations:

Temperature & Pressure should decrease faster for the 2 valve case US. The 1 valve case w/o HPI throttling, RCS pressure will increase

Results:

As expected.

Consistency Effort Data Sheet

Run Number:

Beaver Valley - 60
Beaver Valley - 62

Accident type:

One & Two SO primary SRV, no HPI throttling, HFP, valve re-closure at 6000s

Conditions:

Beaver Valley - 60 one SO primary SRV
Beaver Valley - 62 Two SO primary SRV

Expectations:

Pressure& Temperature should decrease faster for the 2 valve case

Results:

As expected

Consistency Effort Data Sheet

Run Number:

Palisades - 65
Palisades - 48

Accident type:

One and Two SO primary SRV's, HZP, no HPI throttling, valve re-closure at 6000s

Conditions:

Palisades - 65 One SO primary SRV
Palisades - 48 Two SO primary SRV

Expectations:

Pressure& Temperature should decrease faster for the 2 valve case, however since those are HZP cases, the trends should be very close

Results:

As expected.

Consistency Effort Data Sheet

Run Number:

Beaver Valley - 98
Beaver Valley - 89

Accident type:

One and two SO primary SRV's, HPI throttling at 1 minute, HZP

Conditions:

Beaver Valley - 98 One SO primary SRU
Beaver Valley - 89 Two SO primary SRV's

Expectations:

Pressure& temperature curves should decrease faster for the two SO valve case

Results:

Temperature "hump" between 1000s and 2000s results from HPI throttling

Consistency Effort Data Sheet

Run Number:

Beaver Valley - 100
Beaver Valley - 91

Accident type:

One and two SO primary SRV's w/valve re-closure at 6000s, HZP, HPI throttled within 10 min of allowed.

Conditions:

Beaver Valley - 100 one SO primary SRU
Beaver Valley - 91 Two SO primary SRV's

Expectations:

Pressure& Temperature should decrease faster for the two valve case

Results:

As expected

Consistency Effort Data Sheet

Run Number:

Beaver Valley - 108
Beaver Valley - 110

Accident type:

All MSSV's open on one steam line
HPI throttled at SO and 60 minutes
HFP

Conditions:

Beaver Valley - 108 HPI throttled at 30 min of allowed
Beaver Valley - 110 HPI throttled at 60 min of allowed

Expectations:

Pressure& temperature should decrease. When HPI is throttled, Temperature will increase due to decreased ECCS flow and Pressure should decrease.

Results:

As expected.
Pressure increases after throttling since this is a HFP case. The heat generated from the core causes the pressure to increase.

Consistency Effort Data Sheet

Run Number:

Beaver Valley - 109
Beaver Valley - 111

Accident type:

Small MSLB HZP
HPI throttled at 30 and 60 min

Conditions:

Beaver Valley - 109 HPI throttled within 30 min of allowed
Beaver Valley - 111 HPF throttled within 60 min of allowed

Expectations:

Pressure& temperature should trend together. When HPI is throttled, Pressure should decrease and temperature should increase.

Results:

Temperature did not increase. This is a HZP case therefore not much heat generated from the core.

Consistency Effort Data Sheet

Run Number:

Palisades - 19
Palisades - 55
Oconee - 28

Accident type:

Small MSLB

Conditions:

Oconee - 28 TT/RT, 1 stuck open MSSU (8%)
Palisades - 19 RT, 1 ADV (2.5%) open, no HPI throttling
Palisades - 55 RT/TT, 2 AFW pps feed, 2 ADV's (5%) open

Expectations:

Pressure& Temperature decrease. HPI will refill the RCS, increasing Pressure the Palisades. Pressure increase slowly due to charging pump refill (low head HPI).

Results:

As expected.

Consistency Effort Data Sheet

Run Number:

Beaver Valley - 114
Palisades - 61
Beaver Valley - 115

Accident type:

LOCA HFP

Conditions:

Beaver Valley - 114 2.8 surge line, no HPI throttled. Heat transfer area increase 30%
Beaver Valley - 115 2.8 CL break, no HPI throttled
Palisades - 61 2.8 CL break, no HPI

Expectations:

Since the heat transfer area is increased by 30% in case 114, Temperature should drop faster.

Results:

As expected.

Consistency Effort Data Sheet

Run Number:

Palisades - 64
Palisades - 59
Palisades - 58
Palisades - 56

Accident type:

LOCA

Conditions:

Palisades - 64 4" surge, no HPI, summer
Palisades - 59 4" CL, no HPI, summer
Palisades - 58 4" CL, no HPI, winter
Palisades - 56 1" surge line, HPI & charging fail, depress RCS by TBV's and ADV's. HPI restored as indication level off.

Expectations:

Injection of ECCS into a cold leg with a break will reduce flow into the RCS. Therefore CL break temperature should be higher than surge line, winter conditions provide cooler water to RCS.

For case 56 when HPI is restored, RCS pressure should increase to shut off head of pumps.

Results:

As expected.

Consistency Effort Data Sheet

Run Number:

Palisades - 27
Palisades - 50

Accident type:

MSLB

Conditions:

Palisades - 27 1 ADV open, no HPI
Palisades - 50 2 AFW pps feed steam generators

Expectations:

Graph should trend together.
With 2 AFW pps feeding, the temperature should be slightly lower.

Results:

As expected

Consistency Effort Data Sheet

Run Number:

Palisades - 51
Palisades - 54

Accident type:

MSLB

Conditions:

Palisades - 51 MSIV's fail, RCP's off, no HPI throttling. HZP
Palisades - 54 MSIV's fail RCPs off, no HPI, HZP

Expectations:

S/G should blow down longer for HFP case, more energy in the core. The RCS pressure will remain lower as the blow down occurs.

Results:

As expected

Consistency Effort Data Sheet

Run Number:

Palisades - 63
Beaver Valley - 117
Oconee - 160

Accident type:

LOCA RAS occurs

Conditions:

Palisades - 63 5.6" CL break, winter, no HPI
Beaver Valley - 117 5.6" CL break, no HPI, summer
Oconee - 160 5.6" surge line, no HPI

Expectations:

Summer conditions should result in warmer temperature
Surge line will get all ECCS flow vs. CL losing some ECCS flow out the break.

Results:

As expected.

Temperature increase at 2000s for Palisades is from RAS (LPSI, trip).

Consistency Effort Data Sheet

Run Number:

Beaver Valley - 108
Beaver Valley - 109
Beaver Valley - 111

Accident type:

Small MSLB

Conditions:

Beaver Valley - 108 HFP, HPI throttled at 30 min
Beaver Valley - 109 HZP, HPI throttled at 30 min
Beaver Valley - 111 HZP, HPI throttled at 60 min

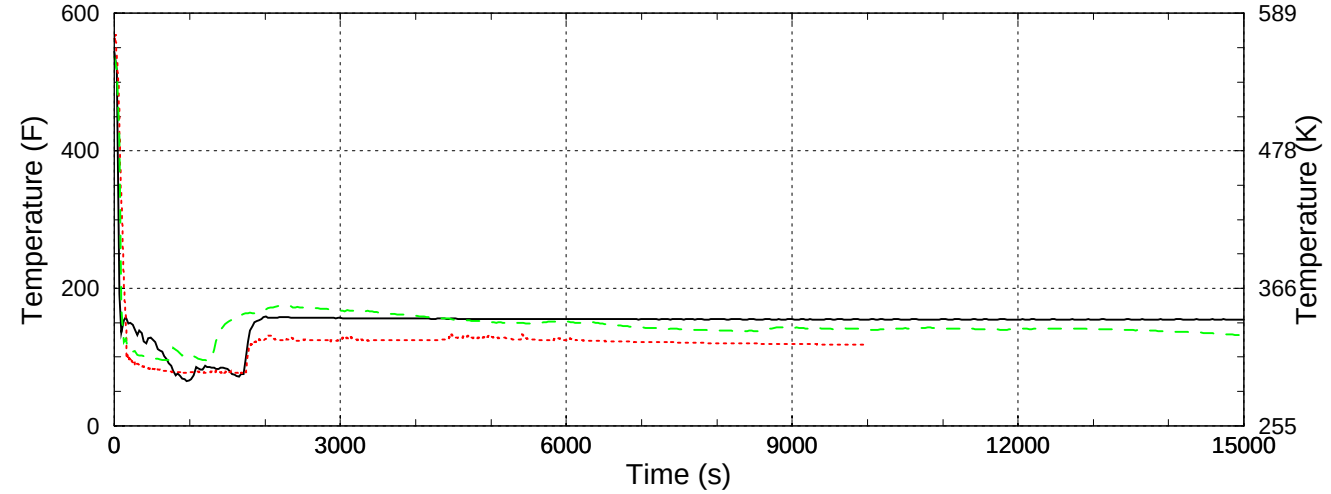
Expectations:

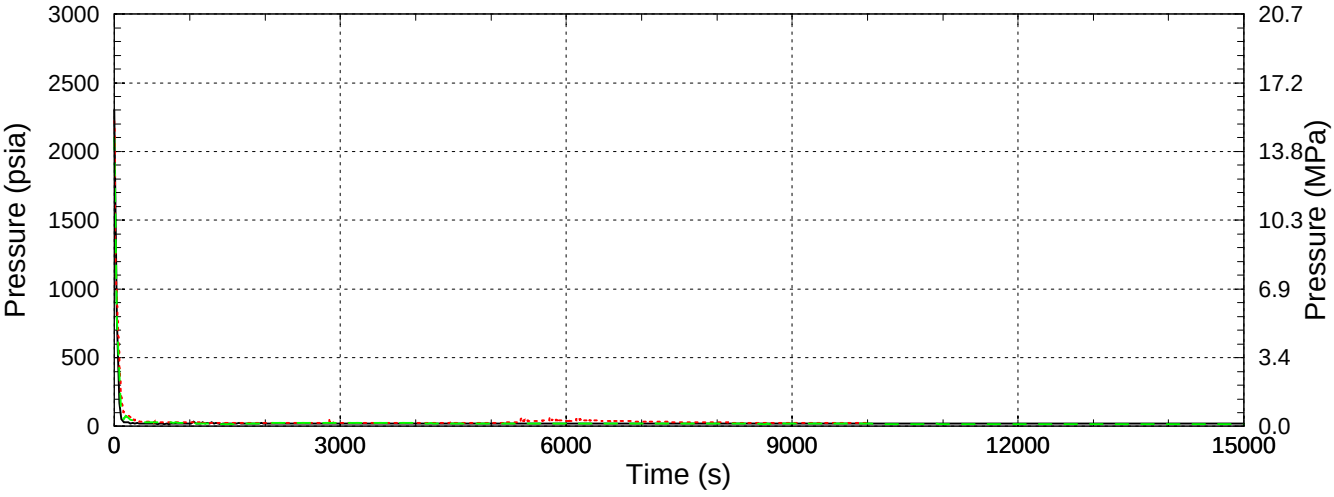
Temperature should increase after HPI throttling
Cases 109 and 111 should trend closely w/ 30 min delay of pressure decrease due to HPI throttling
Case 108 HPI throttling criteria should be met later due to higher energy in the core

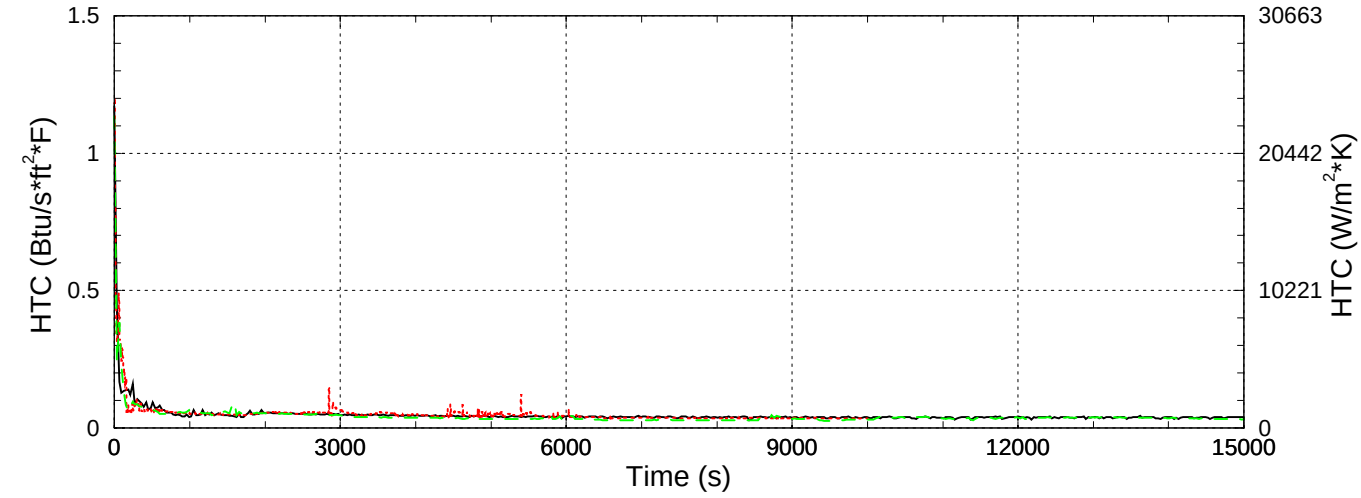
Results:

As expected

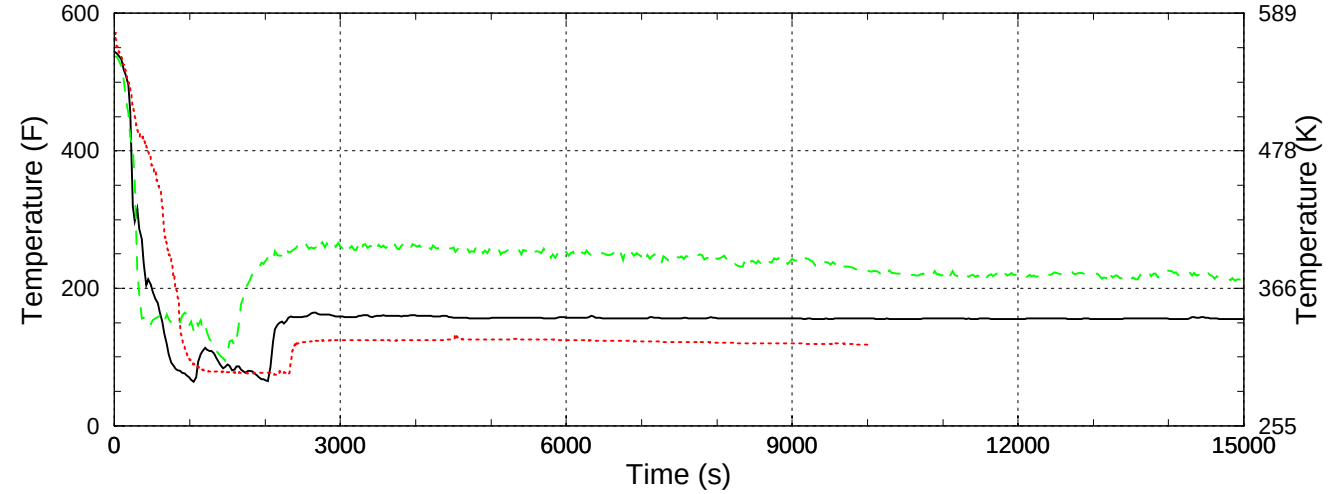
Beaver Valley Case 009 (black) −vs− Oconee Case 156 (red) −vs− Palisades Case 040 (green)

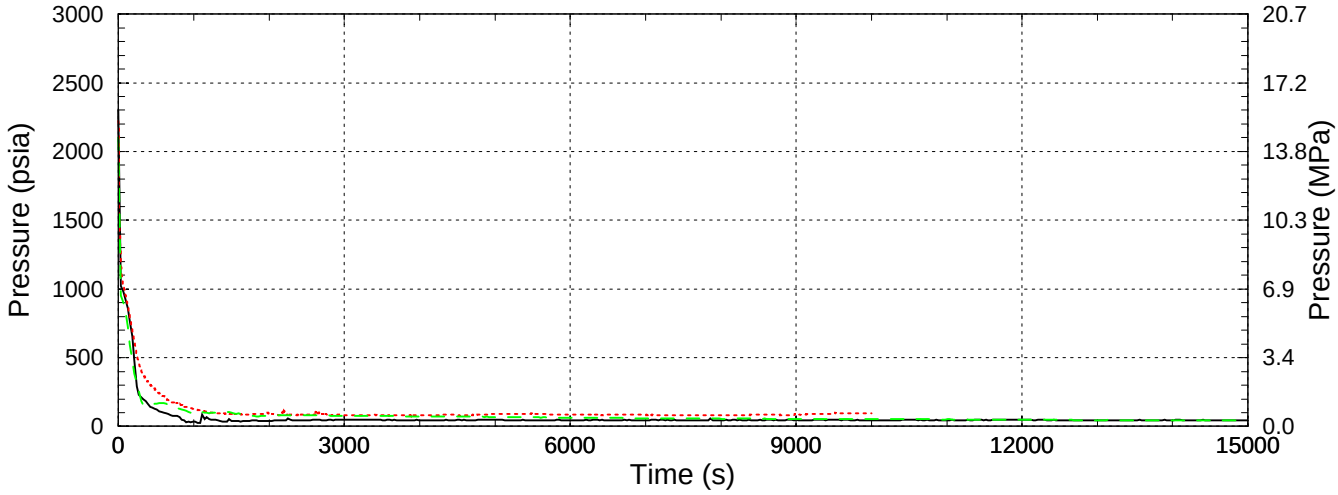


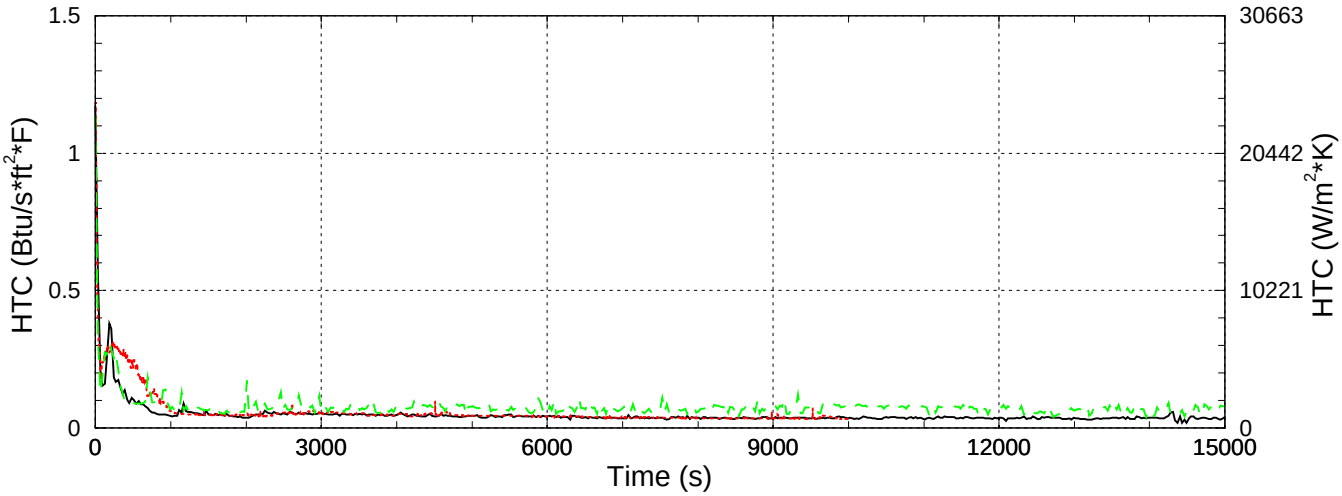




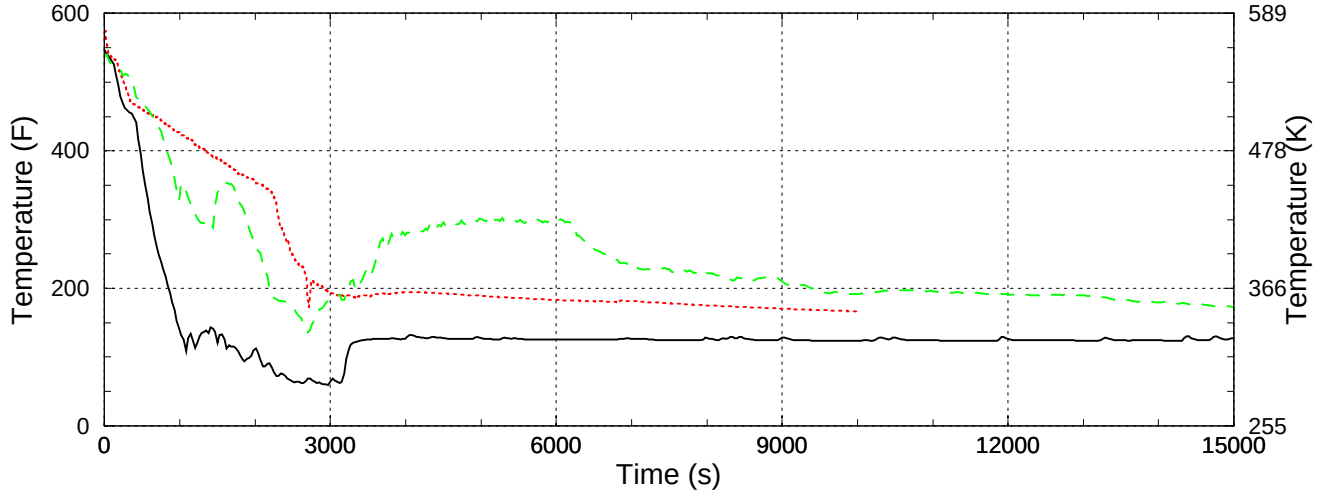
Beaver Valley Case 007 (black) −vs− Oconee Case 164 (red) −vs− Palisades Case 062 (green)

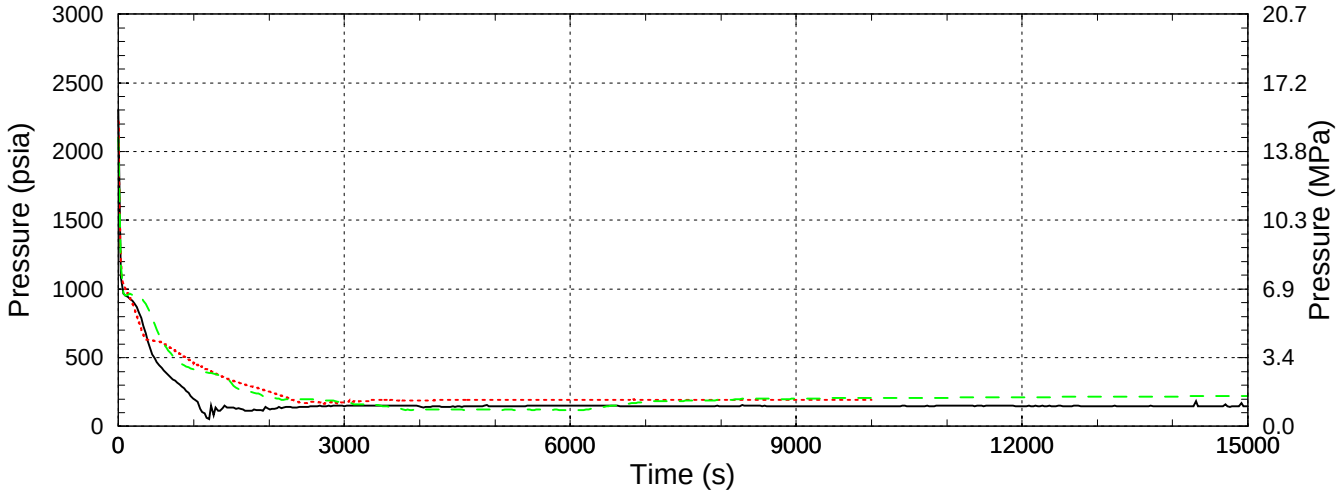


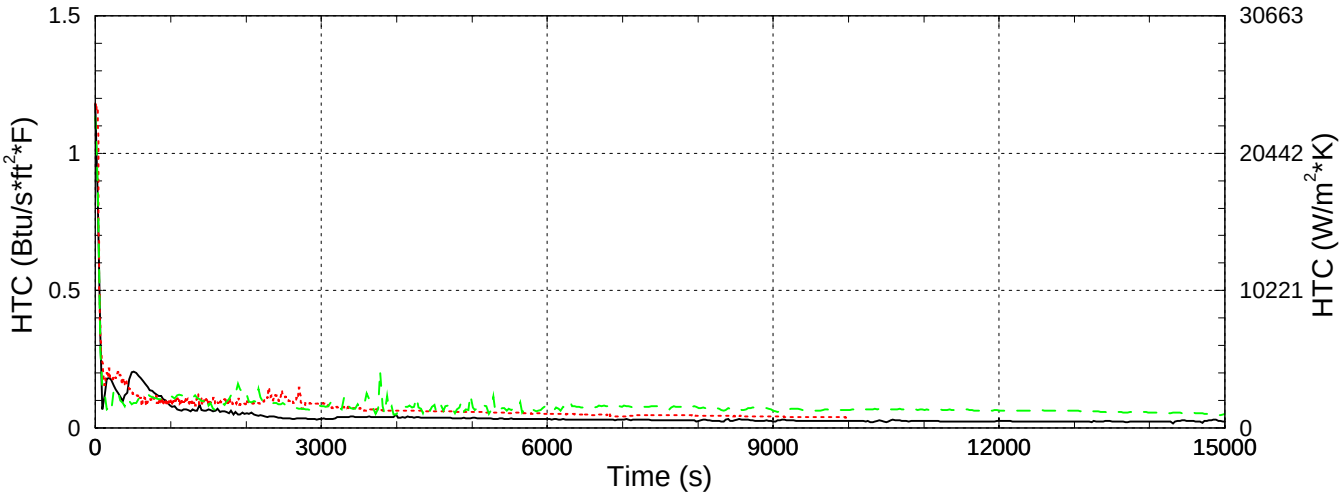




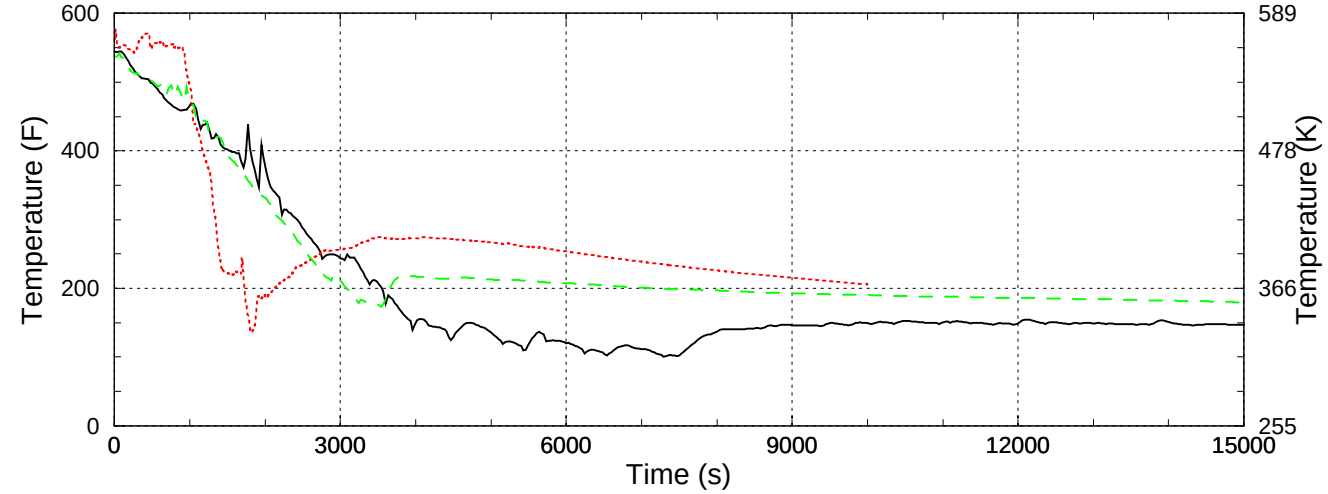
Beaver Valley Case 056 (black) −vs− Oconee Case 172 (red) −vs− Palisades Case 058 (green)

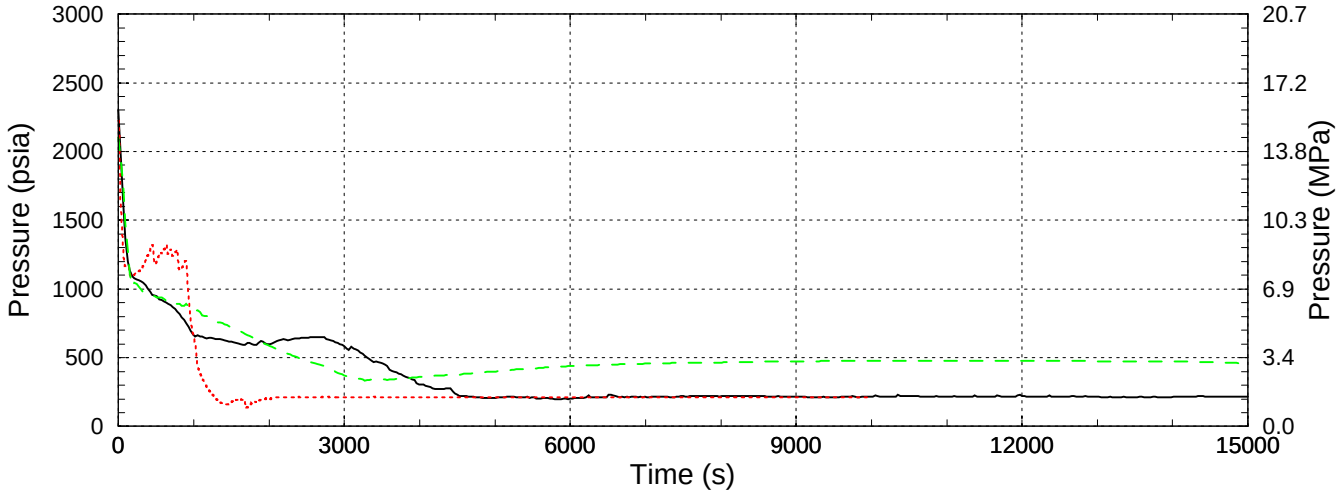


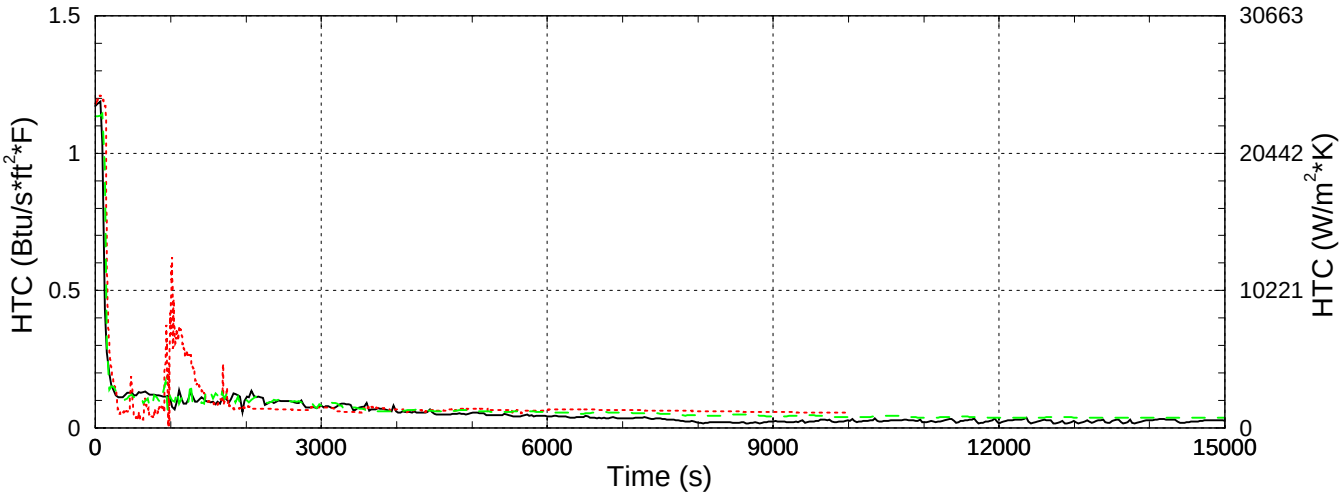




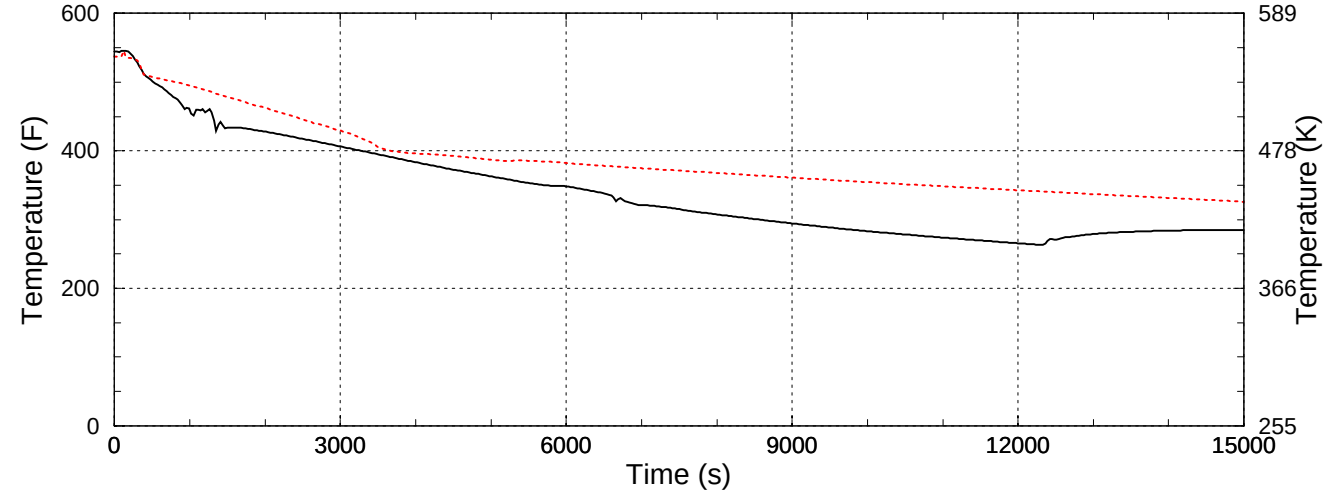
Beaver Valley Case 003 (black) −vs− Oconee Case 110 (red) −vs− Palisades Case 060 (green)

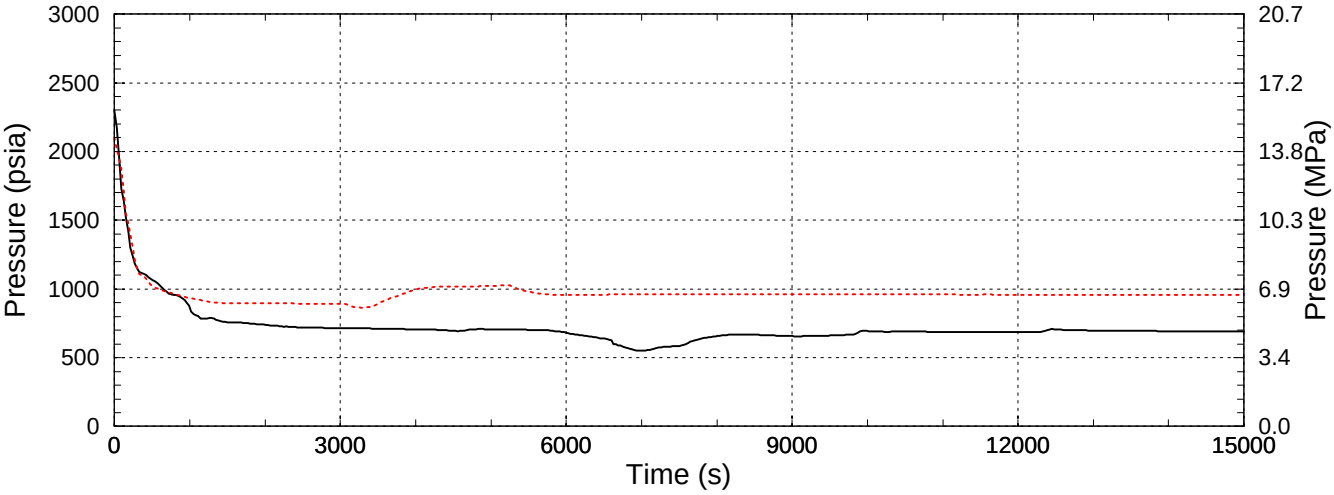


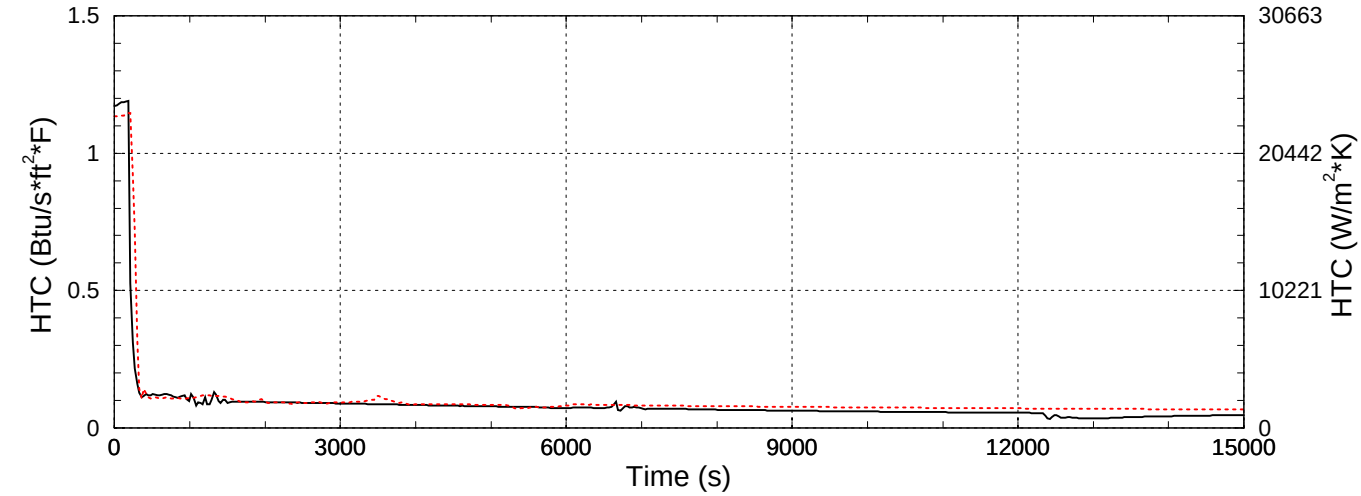


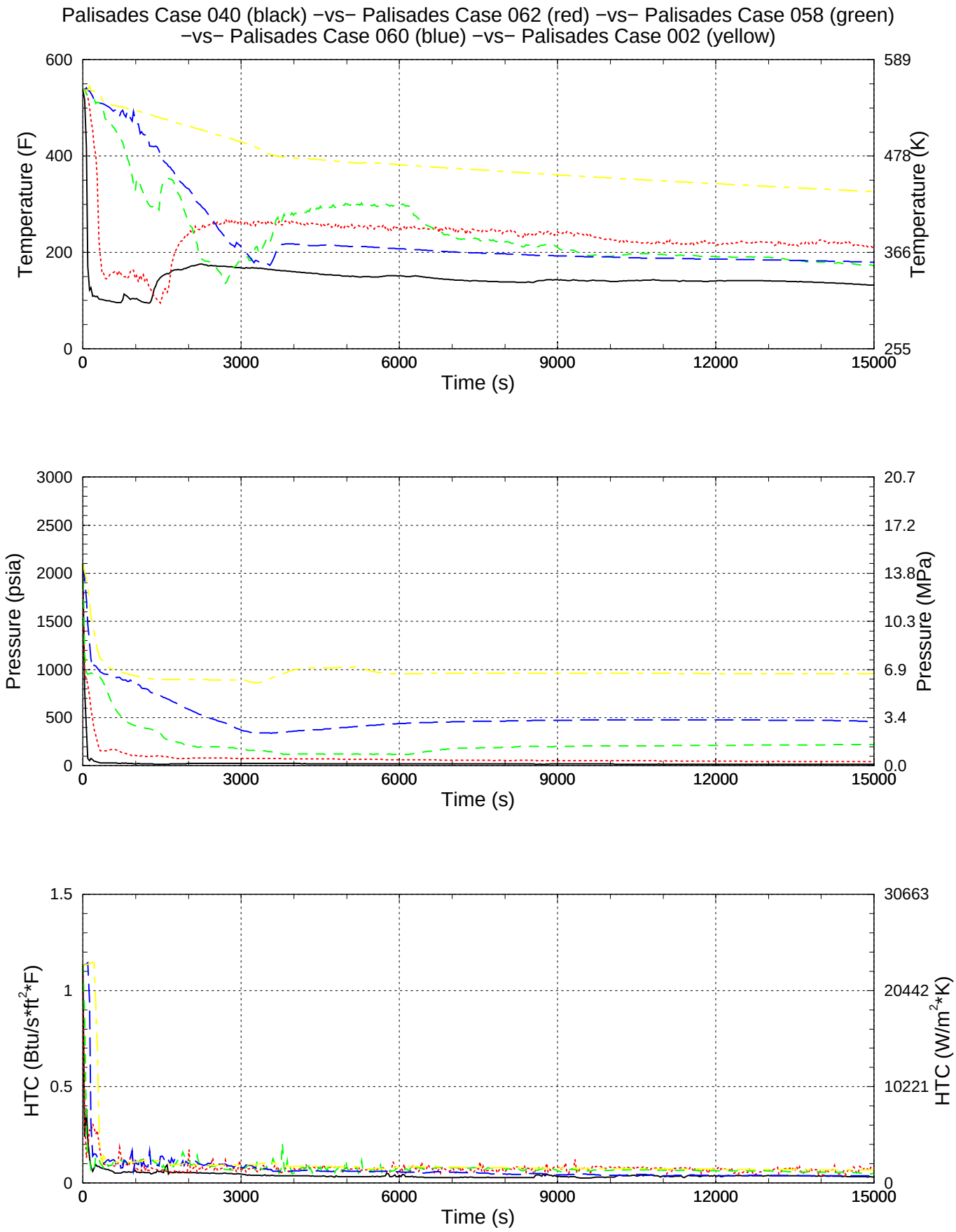


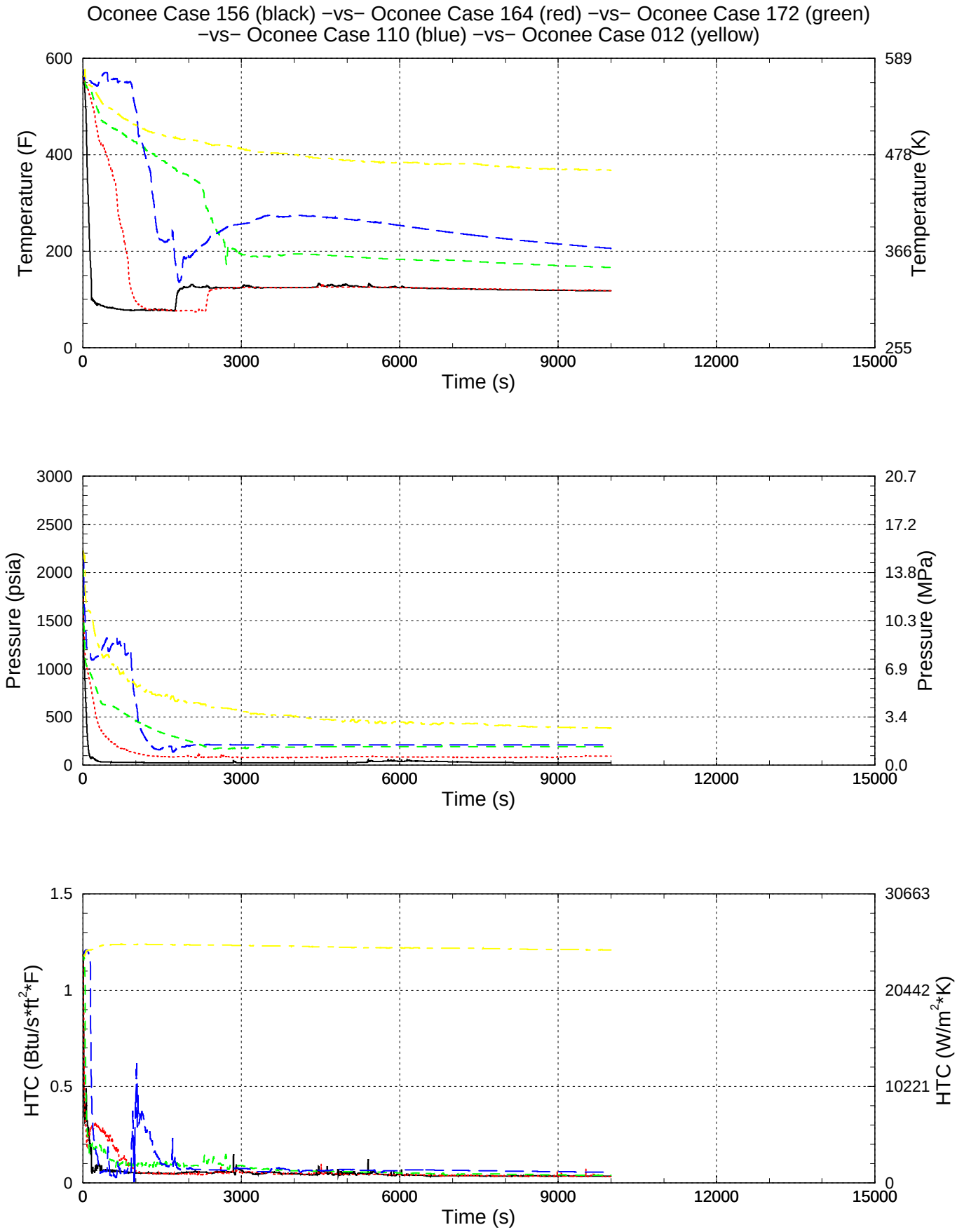
Beaver Valley Case 002 (black) −vs− Palisades Case 002 (red)



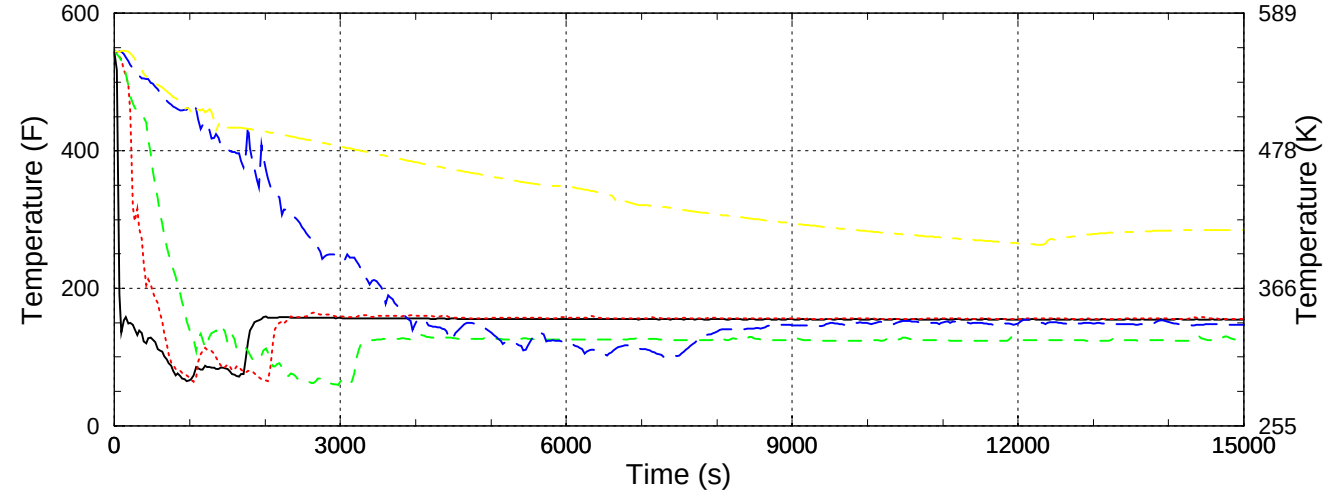


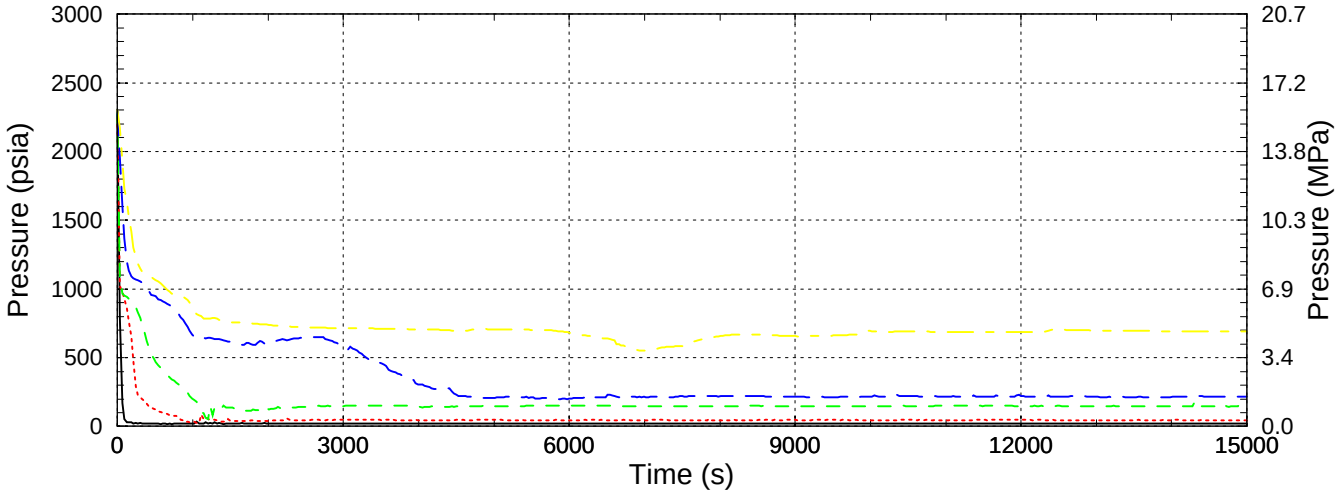


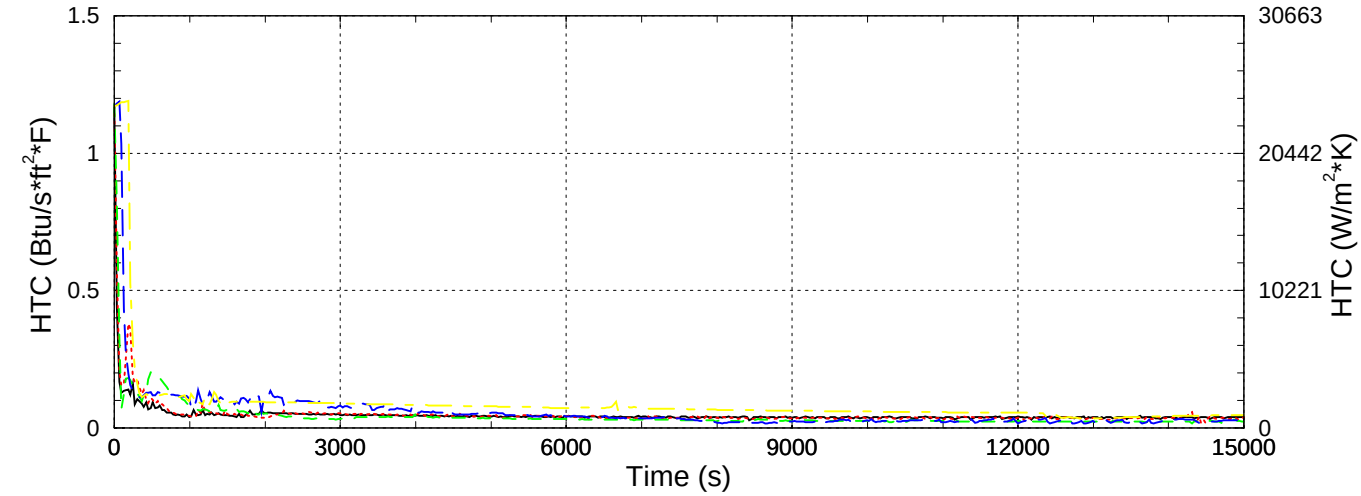

Palisades Case 040 (black) −vs− Palisades Case 062 (red) −vs− Palisades Case 058 (green)
−vs− Palisades Case 060 (blue) −vs− Palisades Case 002 (yellow)
Temperature (F)
Temperature (K)
Time (s)
600
400
200
0
589
478
366
255
0
3000
6000
9000
12000
15000
Pressure (psia)
Pressure (MPa)
Time (s)
3000
2500
2000
1500
1000
500
0
20.7
17.2
13.8
10.3
6.9
3.4
0.0
HTC (Btu/s*ft2*F)
HTC (W/m2*K)
Time (s)
1.5
1
0.5
0
30663
20442
10221
0


Oconee Case 156 (black) −vs− Oconee Case 164 (red) −vs− Oconee Case 172 (green)
−vs− Oconee Case 110 (blue) −vs− Oconee Case 012 (yellow)
Temperature (F)
Temperature (K)
Time (s)
600
400
200
0
589
478
366
255
0
3000
6000
9000
12000
15000
Pressure (psia)
Pressure (MPa)
3000
2500
2000
1500
1000
500
0
20.7
17.2
13.8
10.3
6.9
3.4
0.0
HTC (Btu/s*ft2*F)
HTC (W/m2*K)
1.5
1
0.5
30663
20442
10221

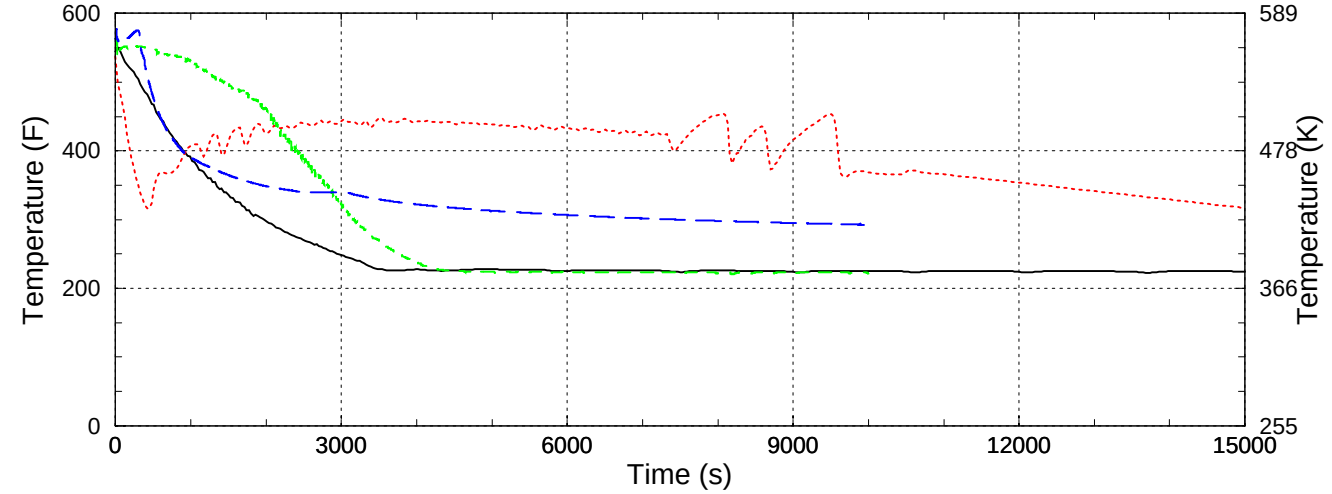
Beaver Valley Case 009 (black) −vs− Beaver Valley Case 007 (red) −vs− Beaver Valley Case 056 (green)
−vs− Beaver Valley Case 003 (blue) −vs− Beaver Valley Case 002 (yellow)

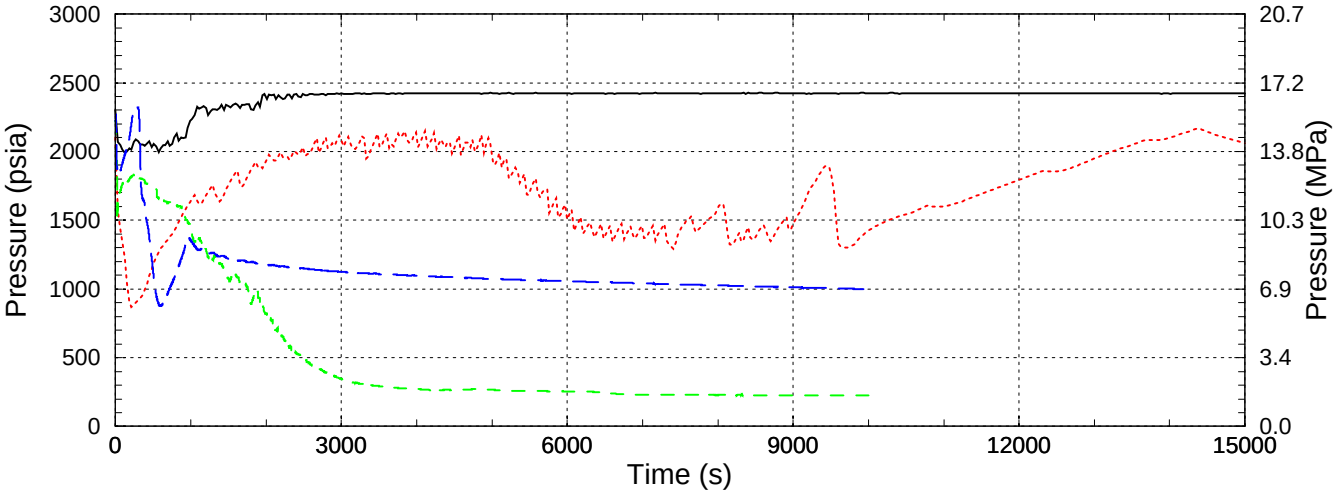


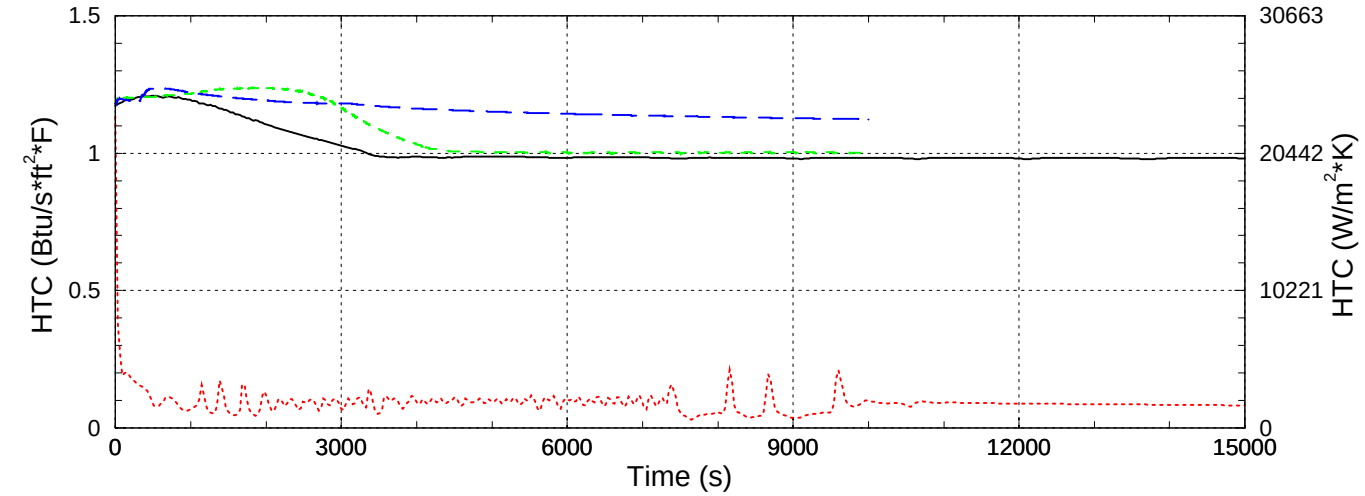




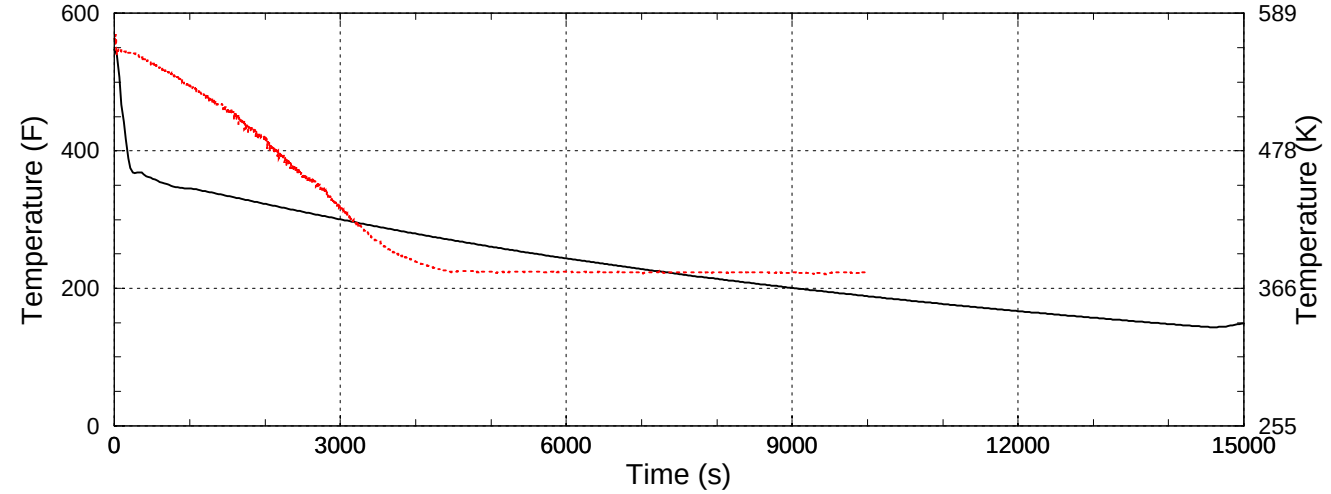
Beaver Valley Case 074 (black) −vs− Palisades Case 024 (red) −vs− Oconee Case 027 (green)
−vs− Oconee Case 089 (blue)

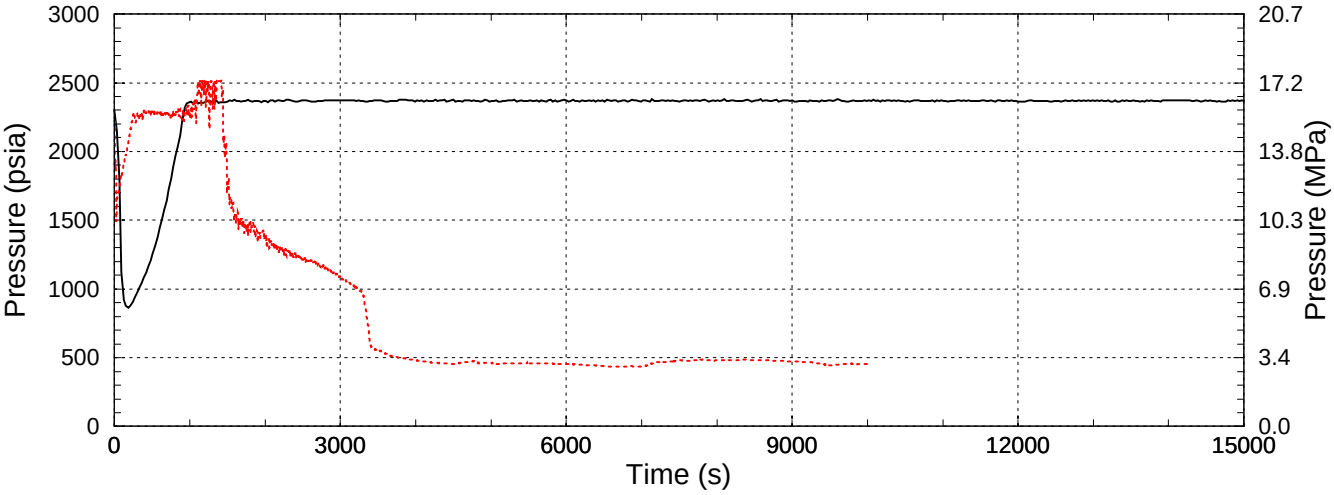


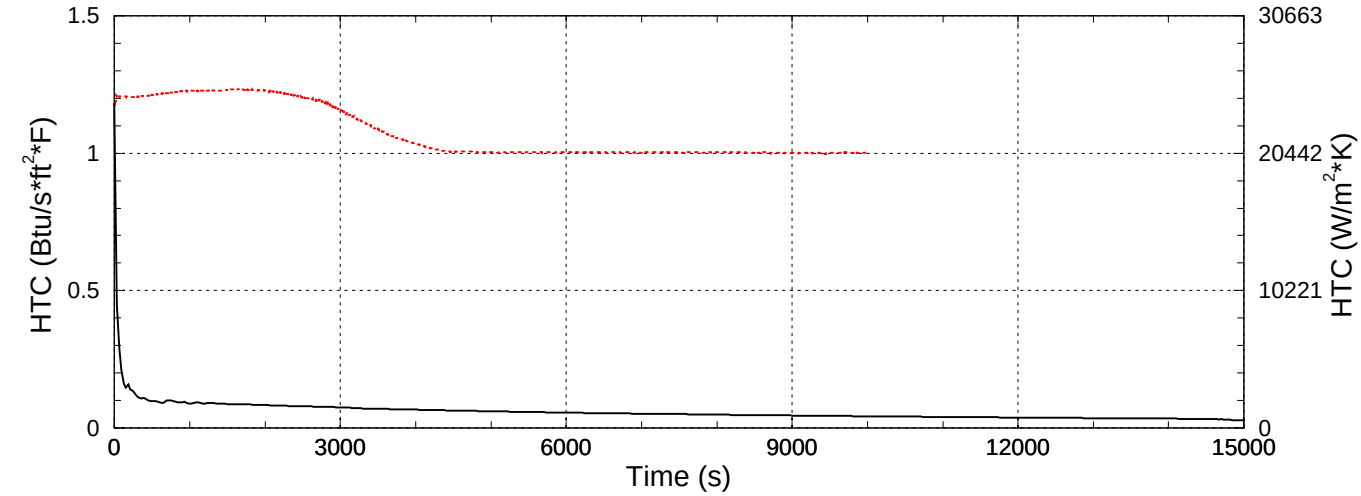




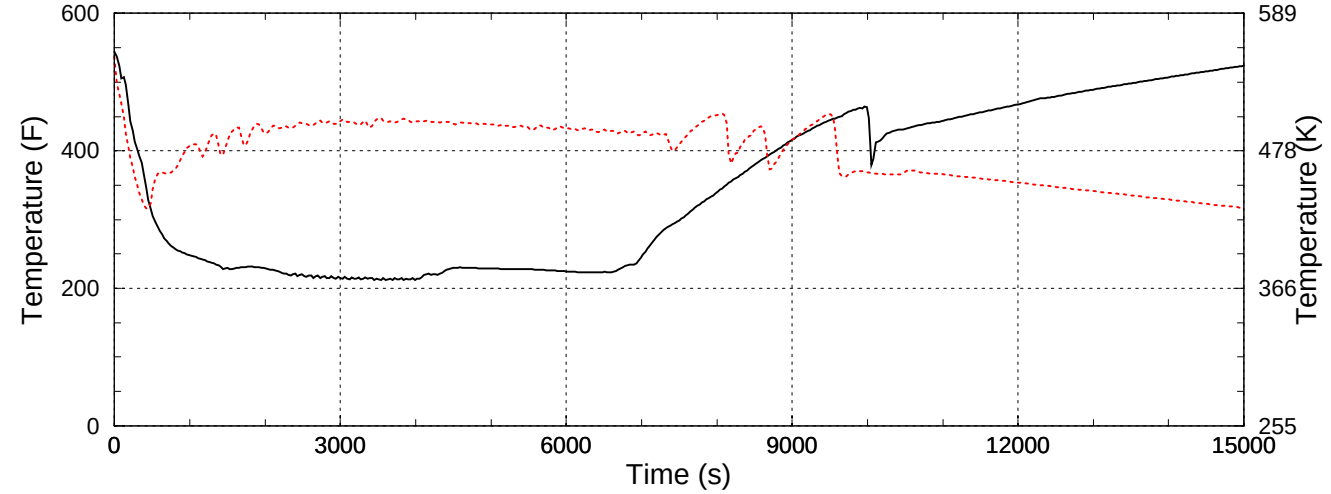
Beaver Valley Case 076 (black) −vs− Oconee Case 099 (red)

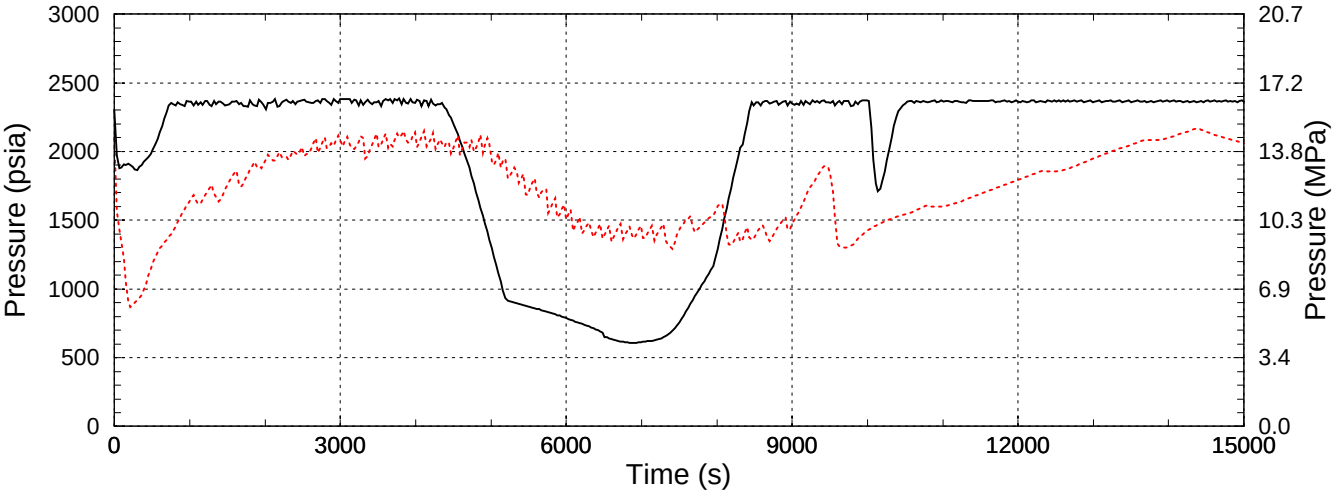


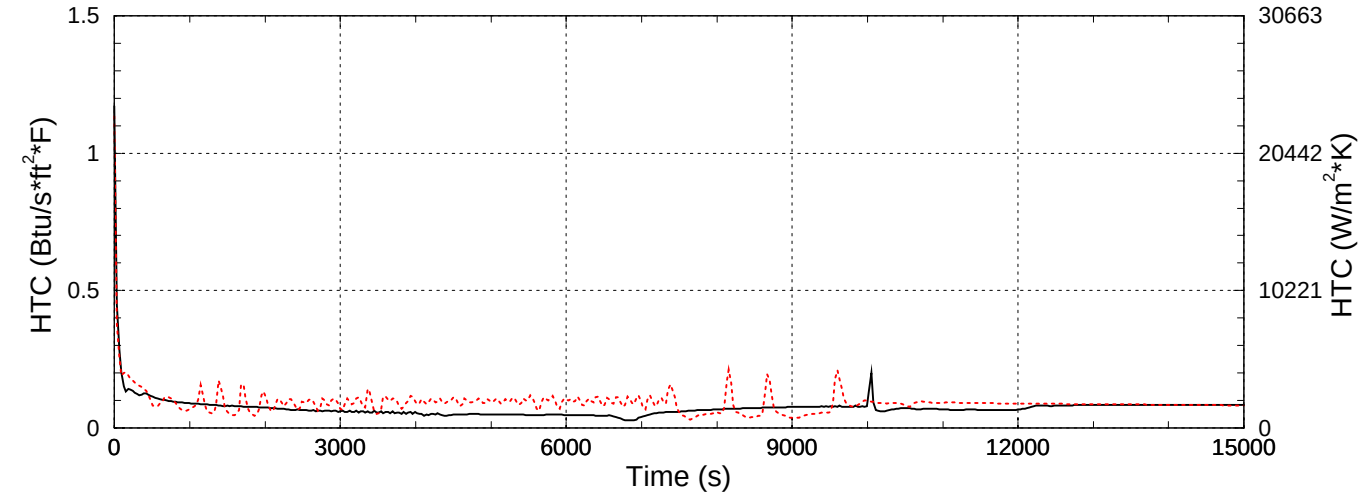




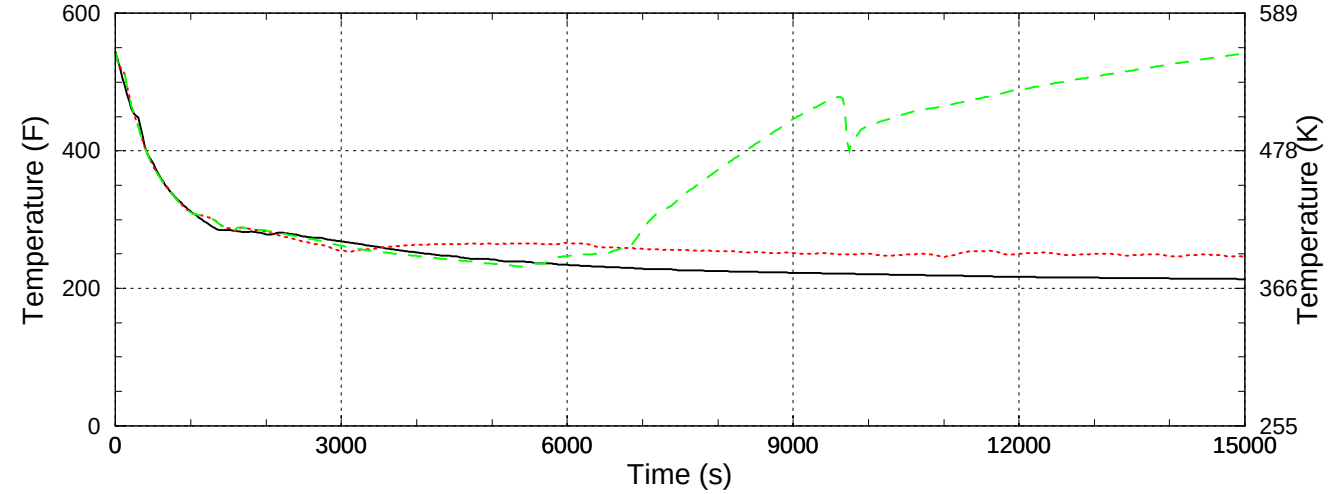
Beaver Valley Case 102 (black) −vs− Palisades Case 024 (red)

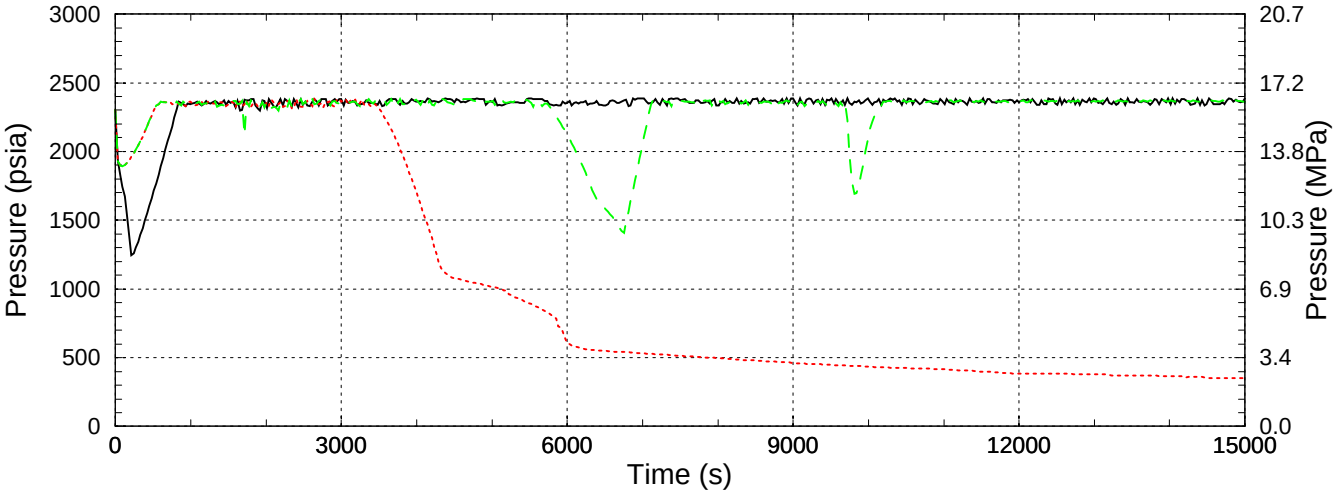


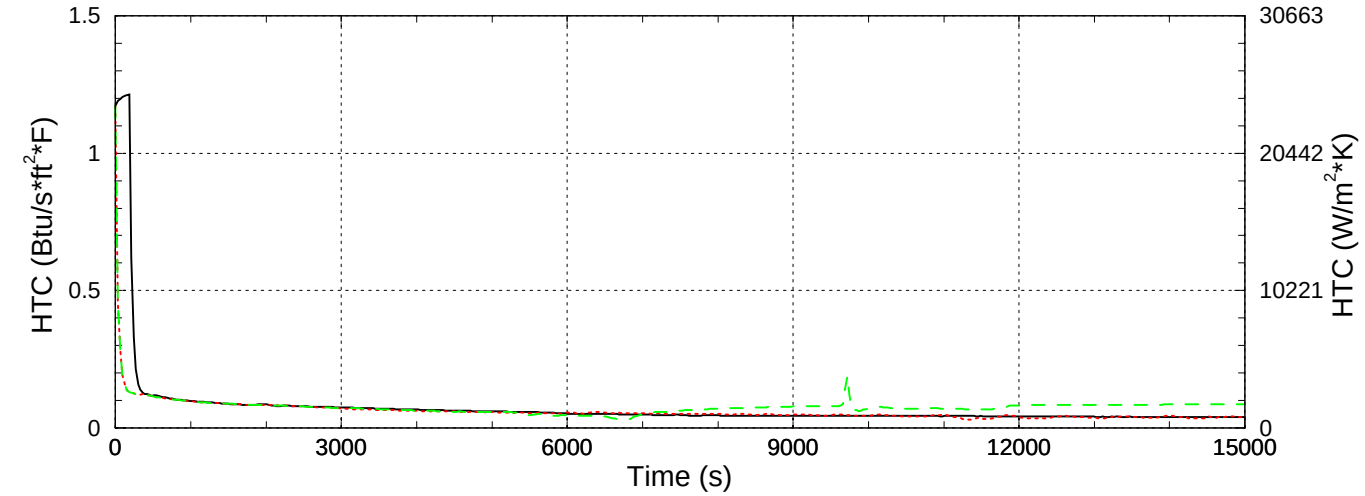




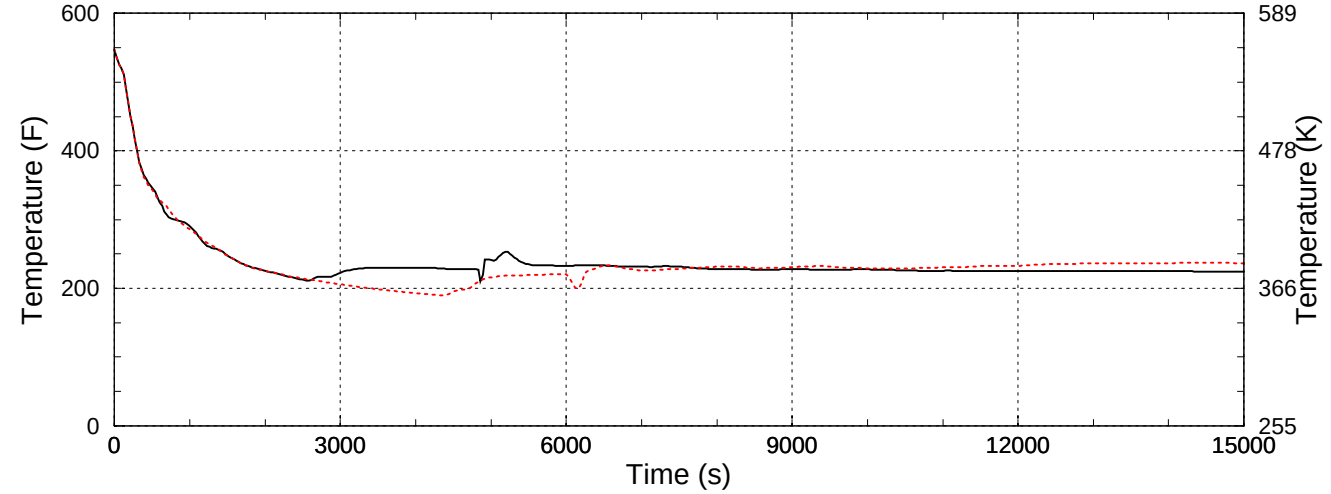
Beaver Valley Case 118 (black) −vs− Beaver Valley Case 112 (red) −vs− Beaver Valley Case 110 (green)

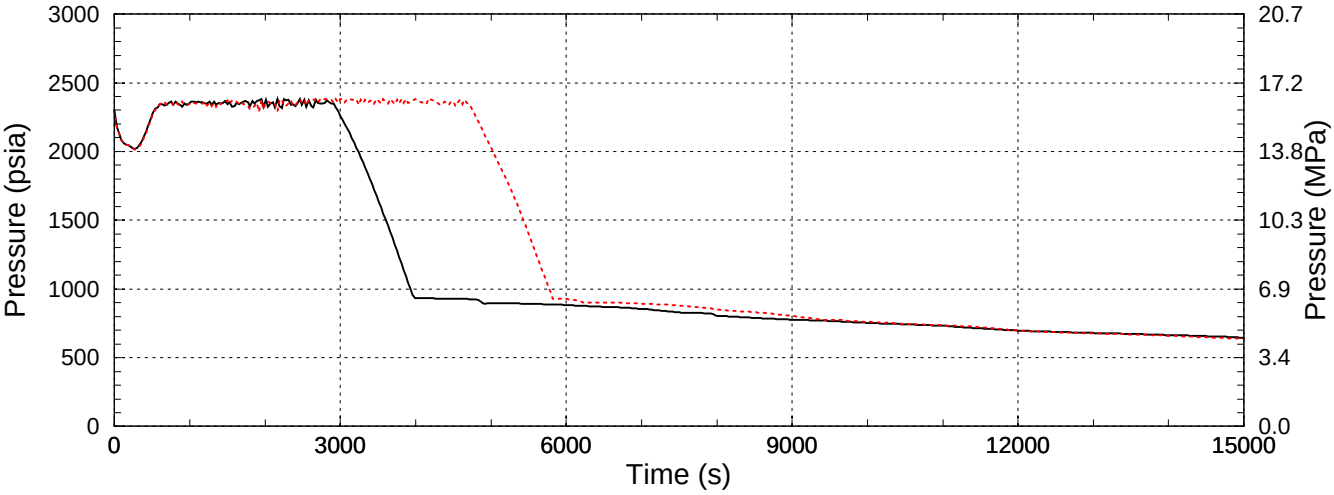


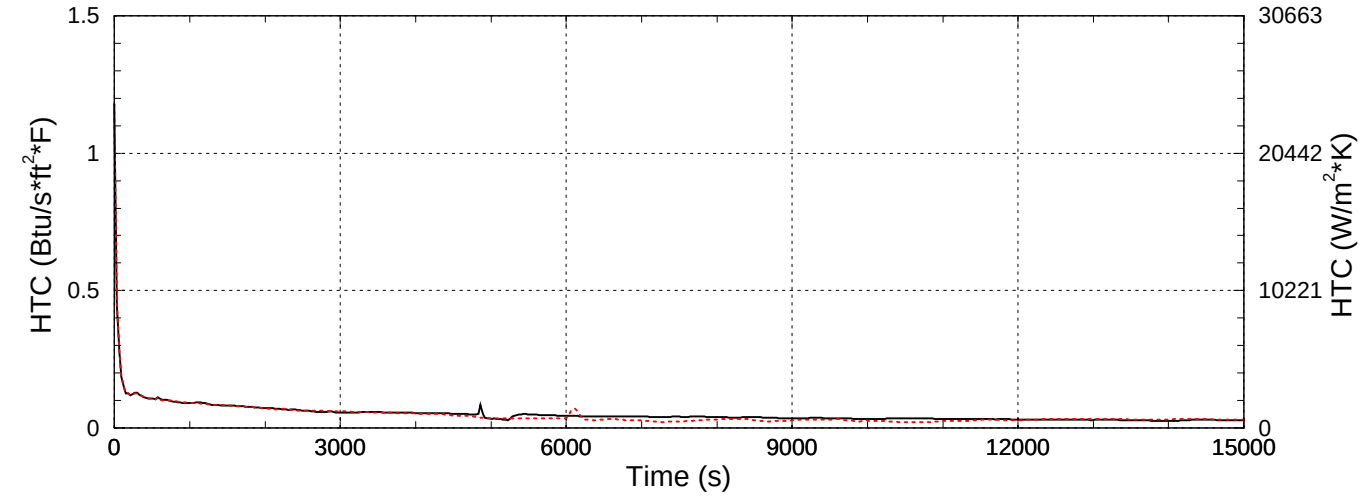




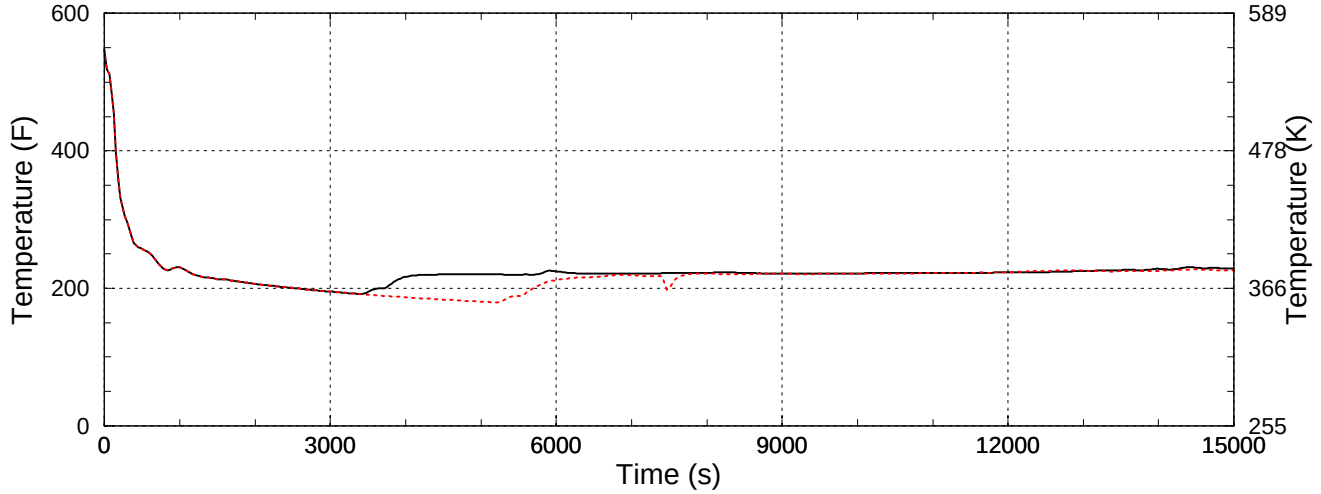
Beaver Valley Case 113 (black) −vs− Beaver Valley Case 111 (red)

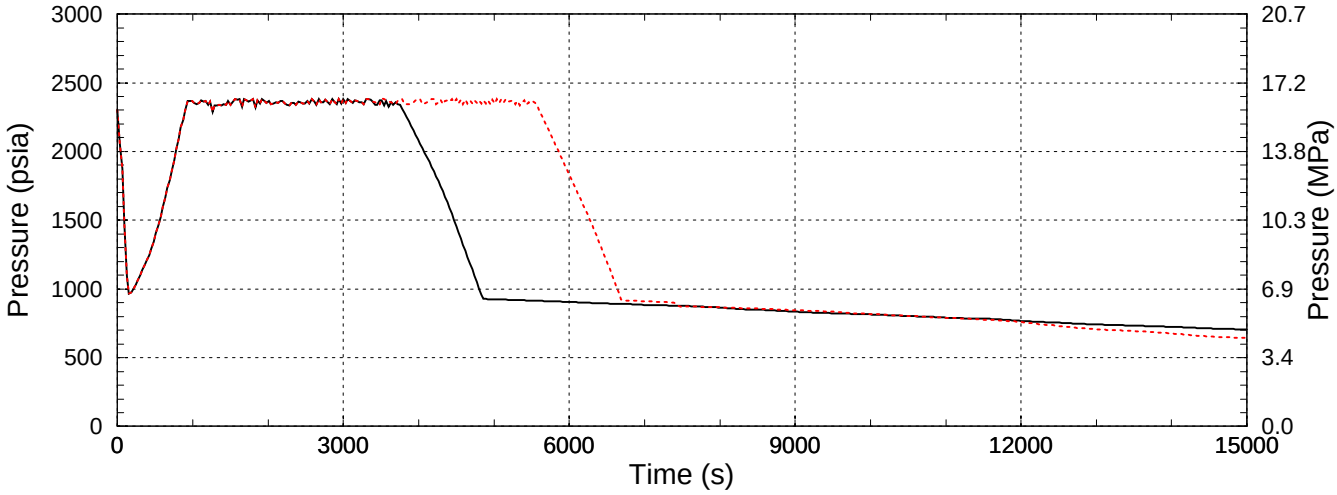


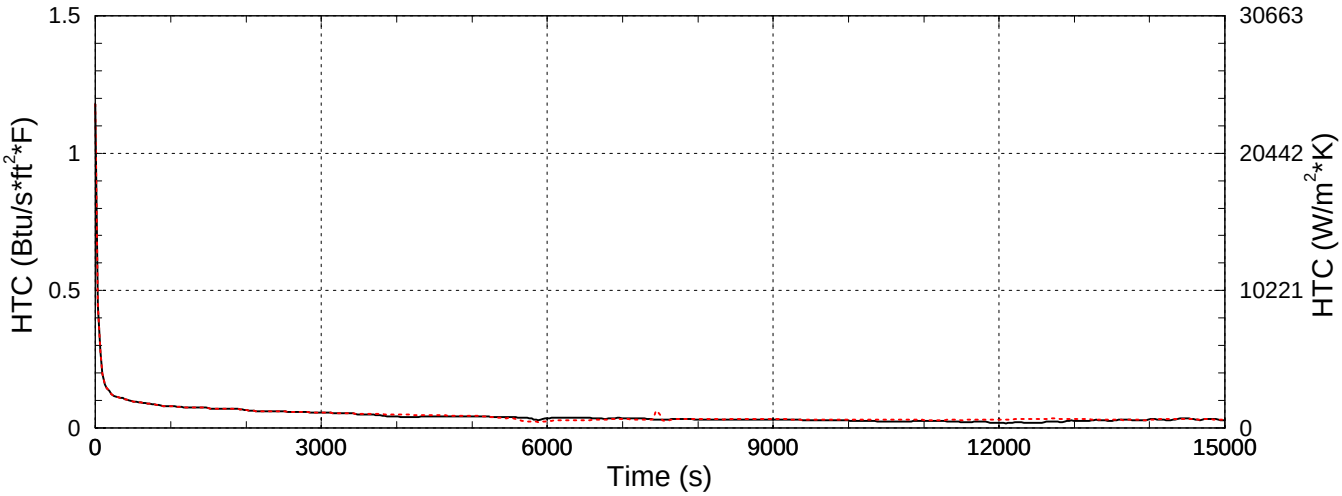




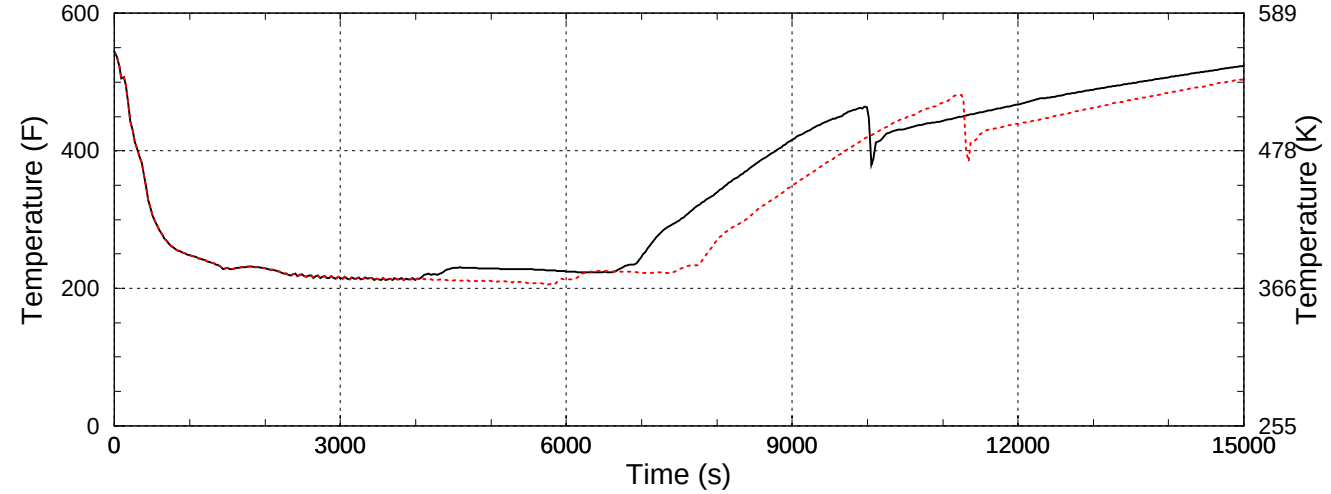
Beaver Valley Case 103 (black) −vs− Beaver Valley Case 105 (red)

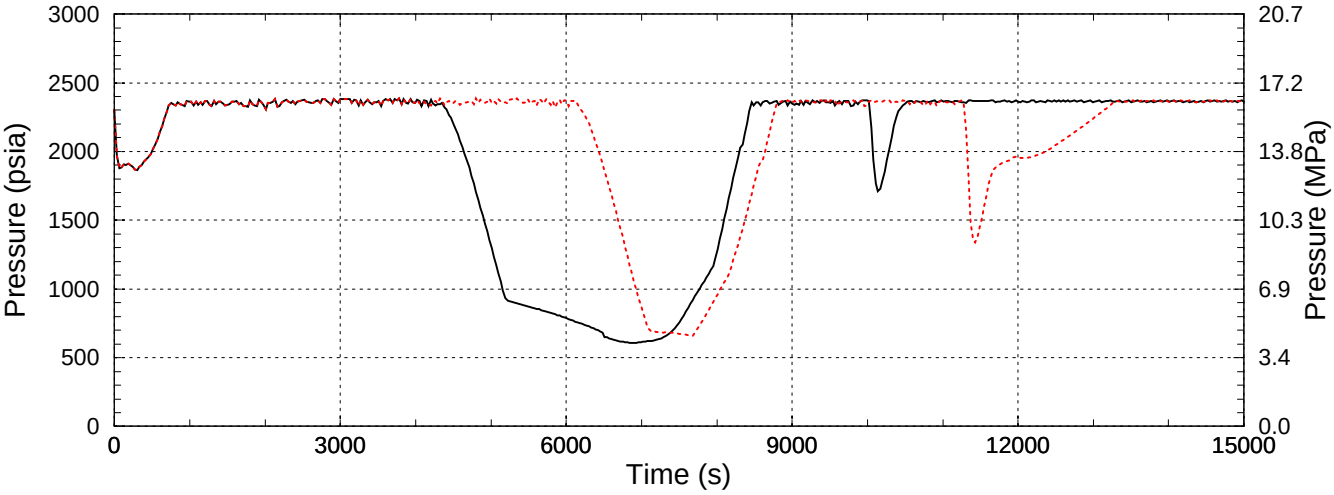


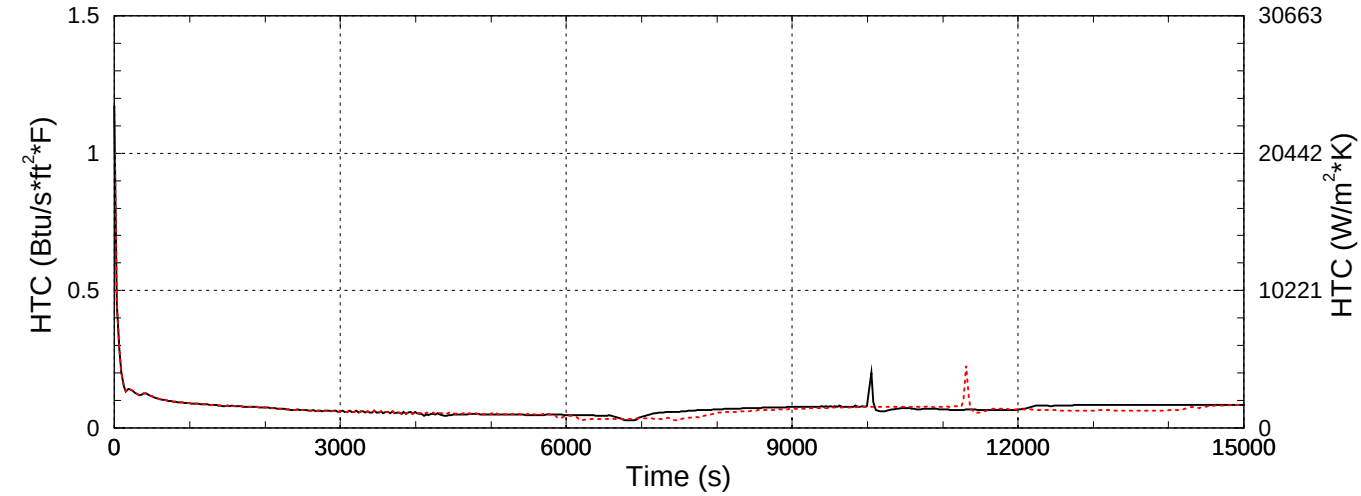




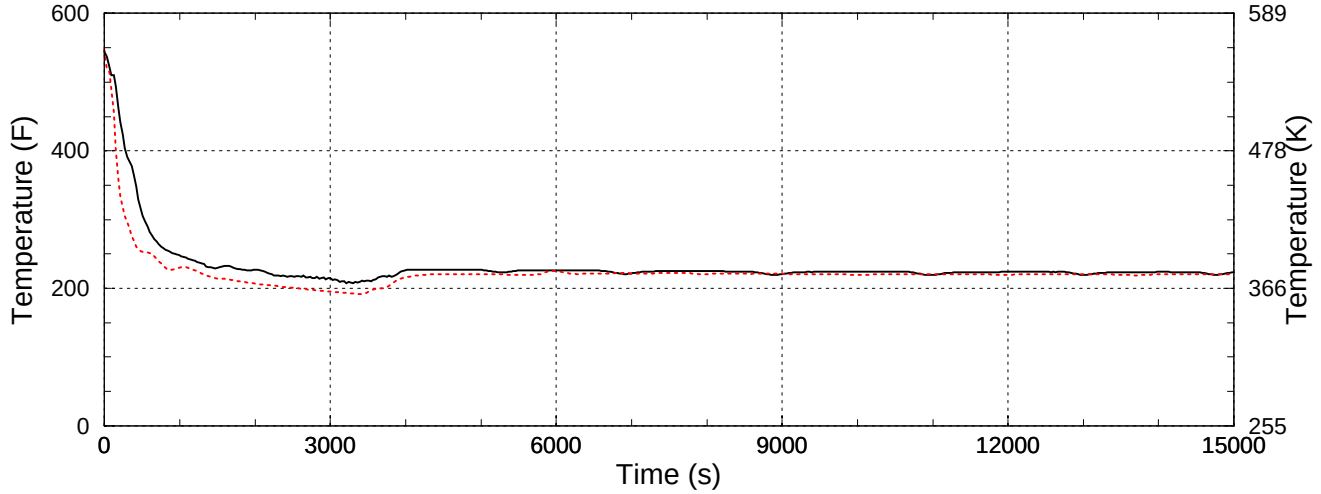
Beaver Valley Case 102 (black) −vs− Beaver Valley Case 104 (red)

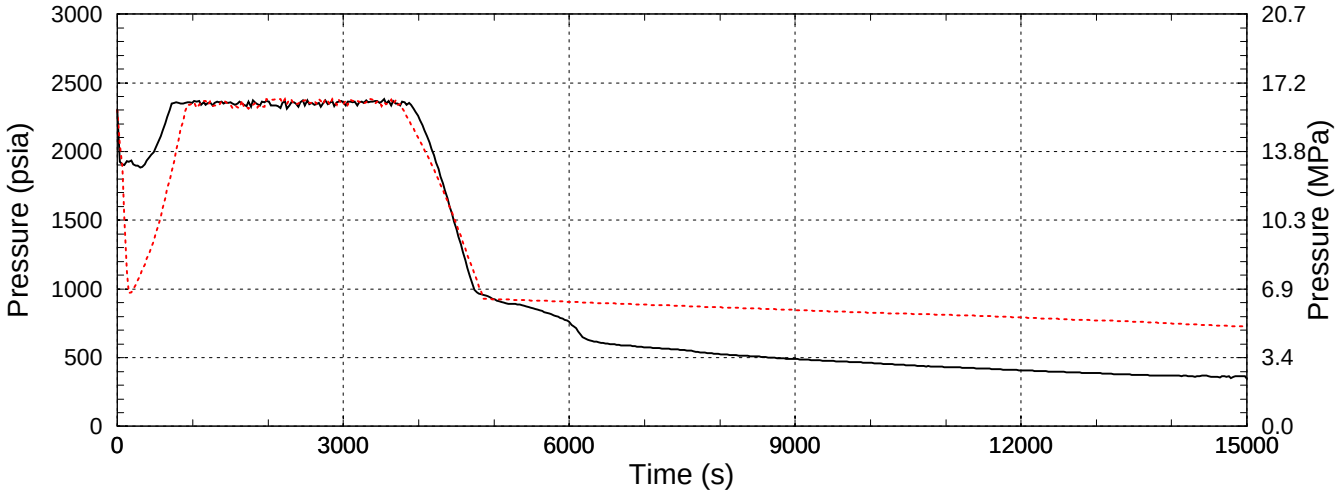


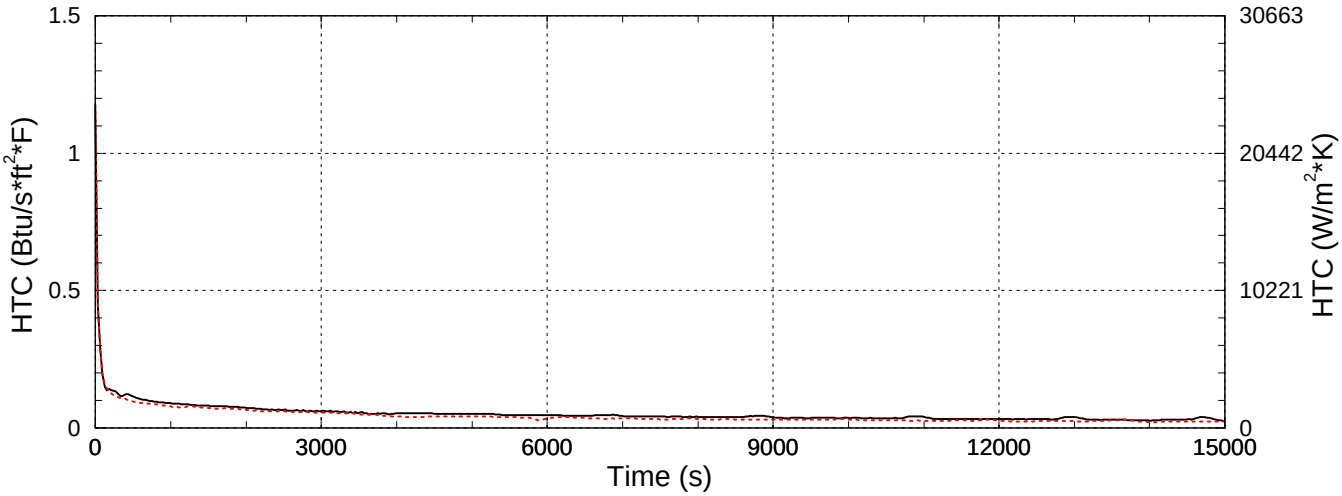




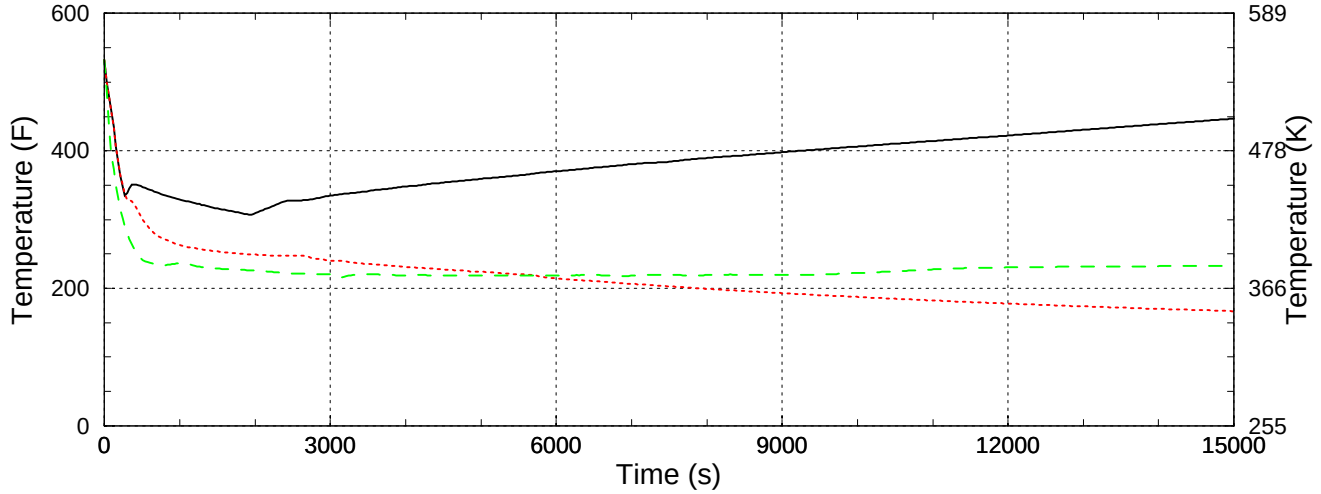
Beaver Valley Case 106 (black) −vs− Beaver Valley Case 107 (red)

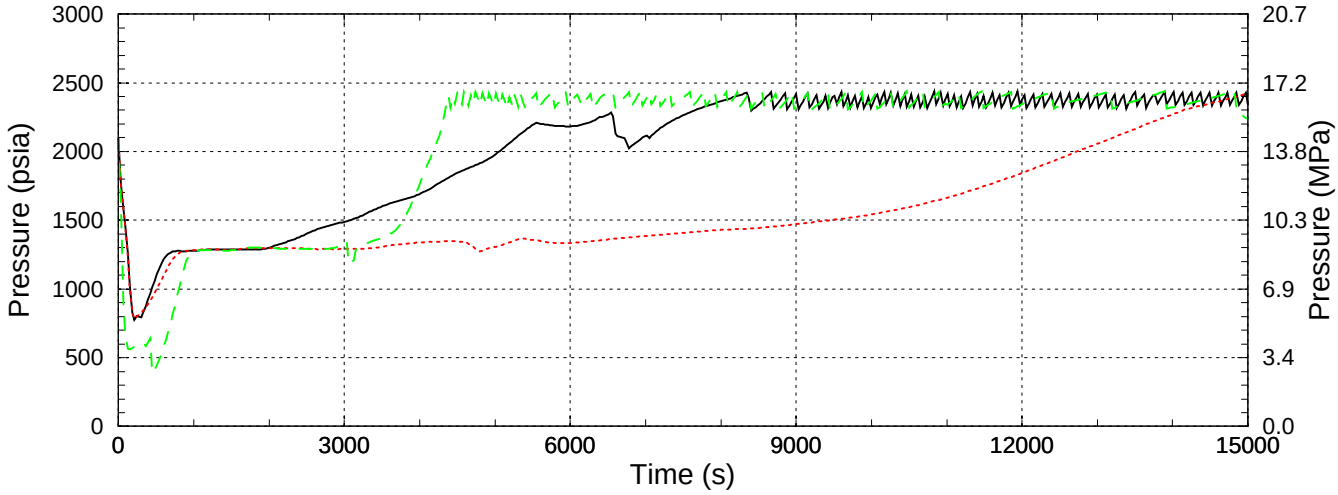


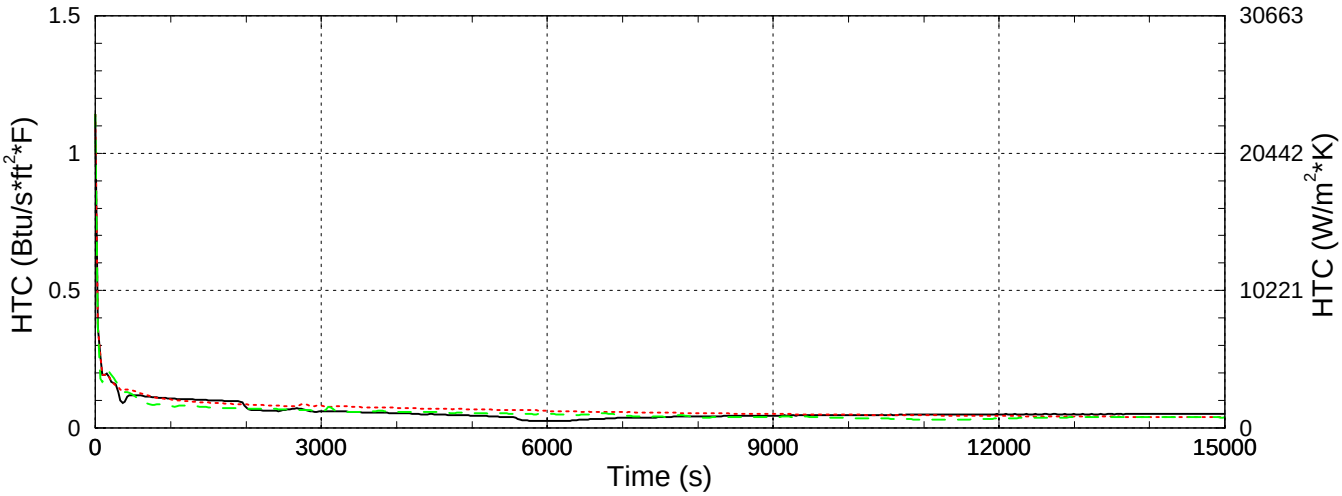




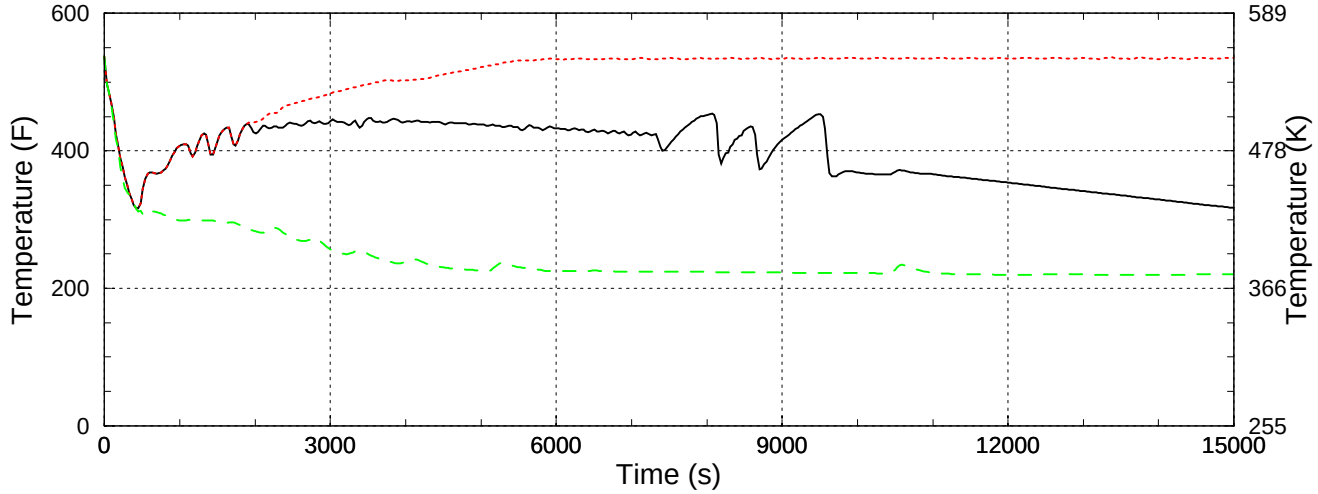
Palisades Case 049 (black) −vs− Palisades Case 050 (red) −vs− Palisades Case 051 (green)

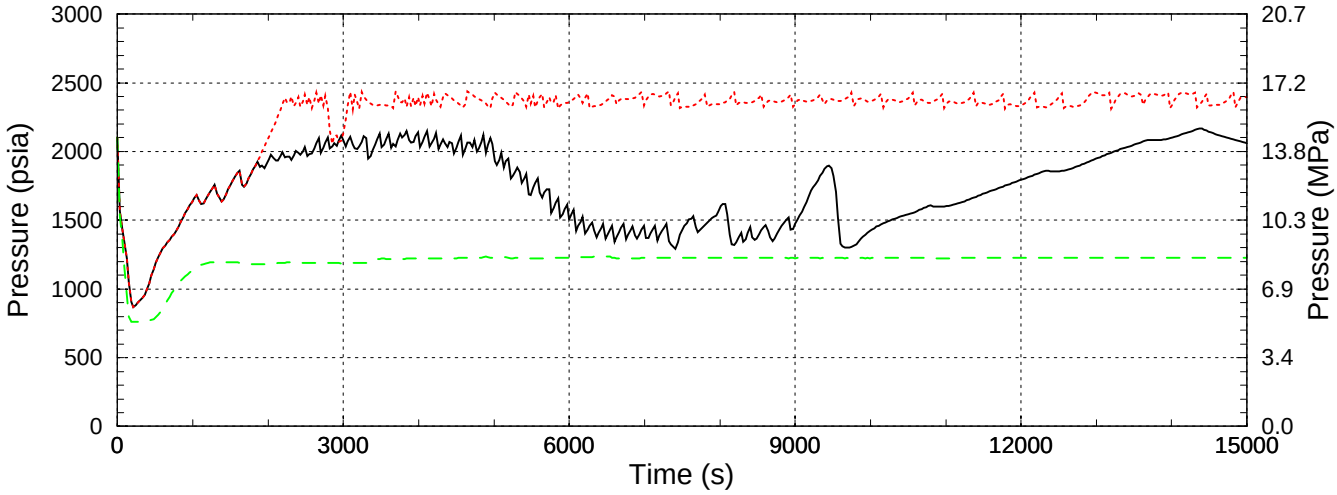


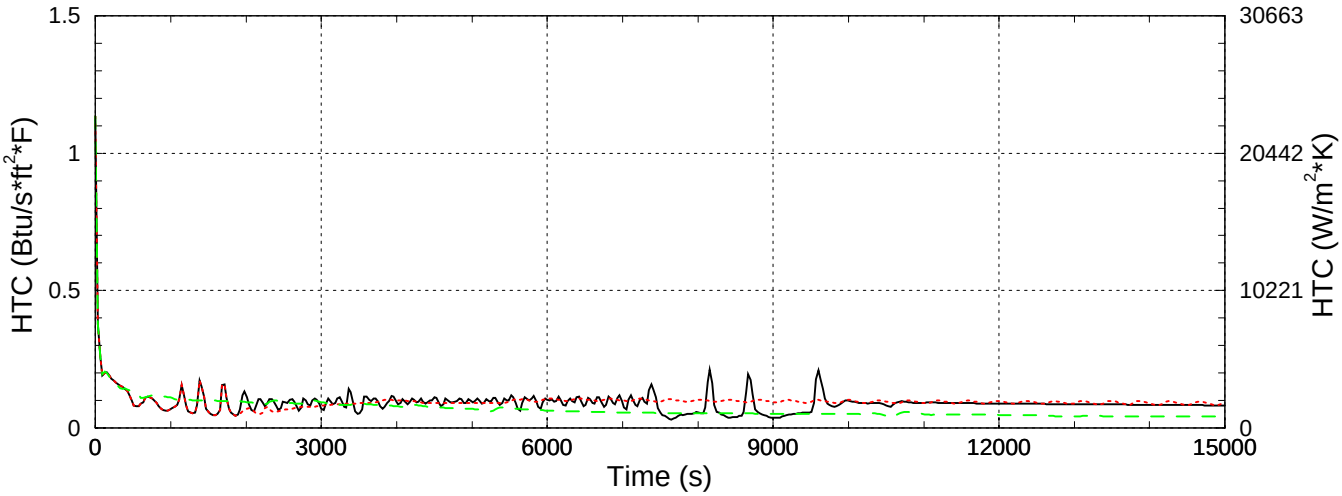




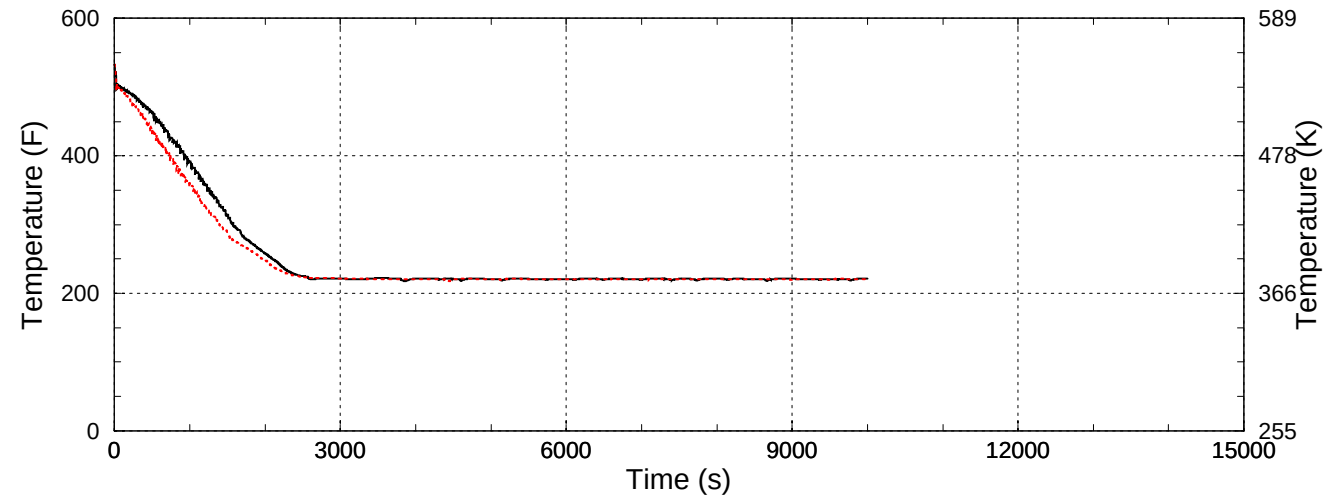
Palisades Case 024 (black) −vs− Palisades Case 026 (red) −vs− Palisades Case 034 (green)

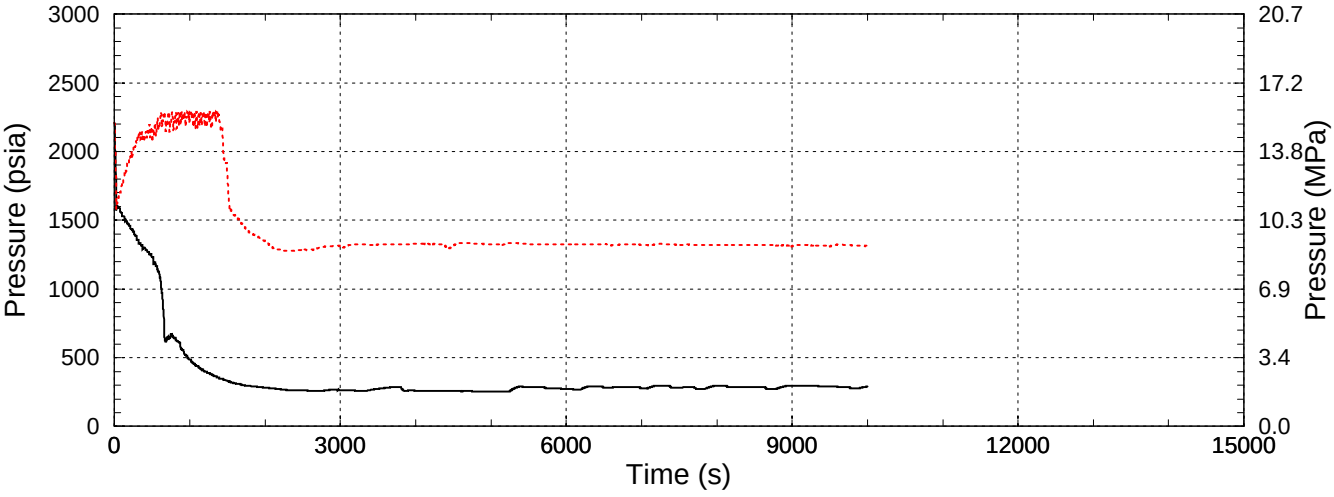


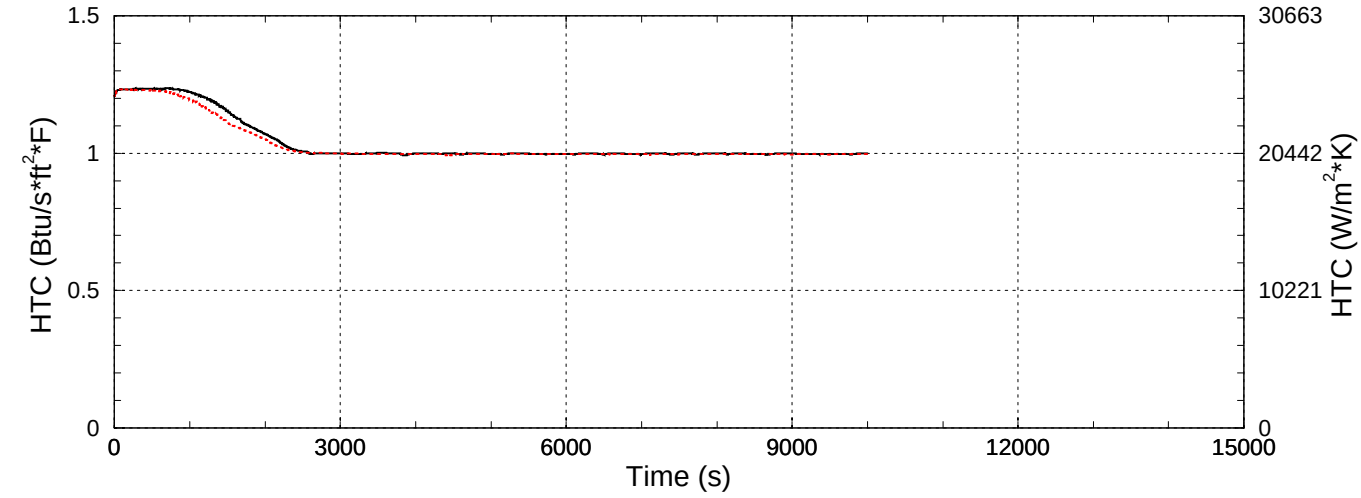




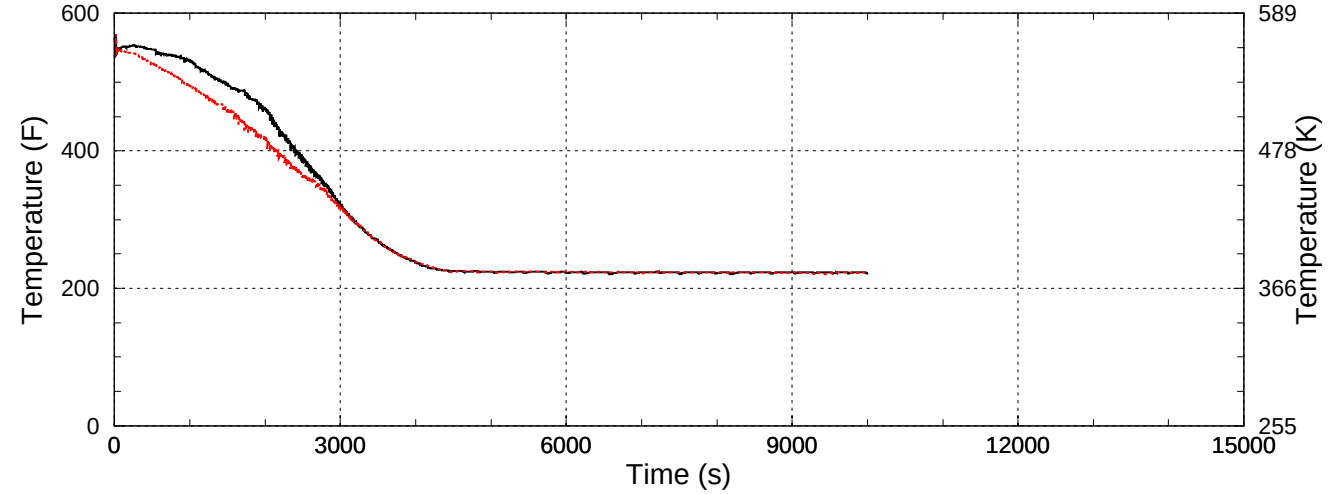
Oconee Case 101 (black) −vs− Oconee Case 100 (red)

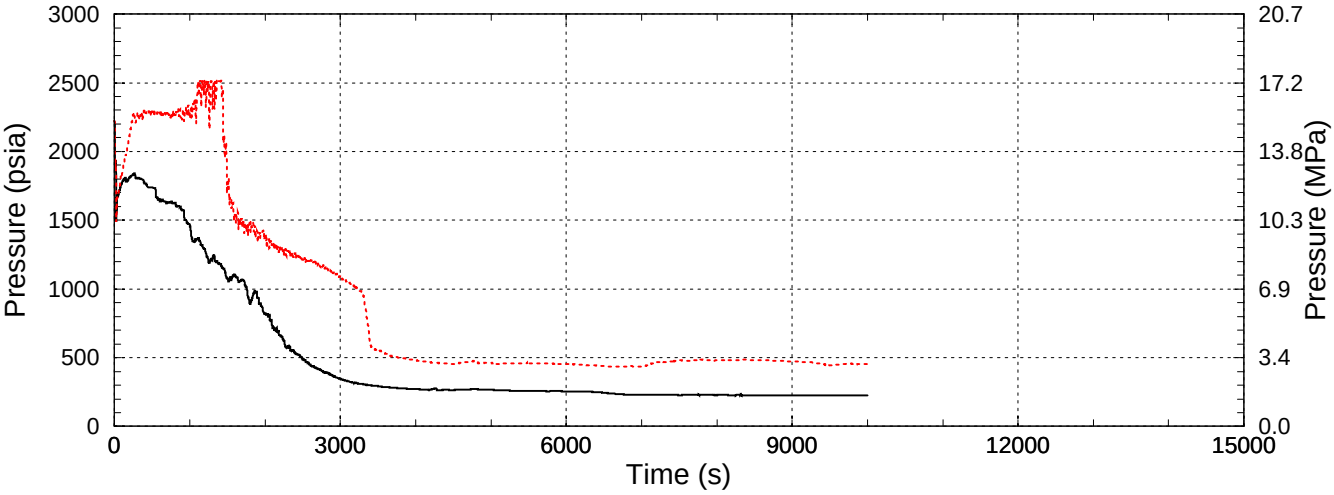


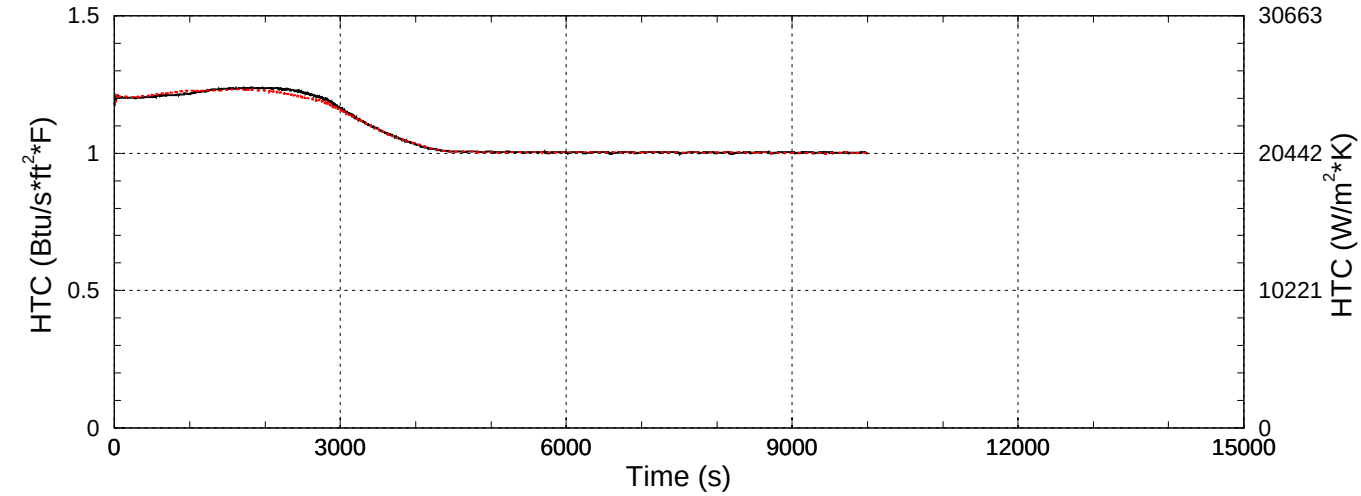




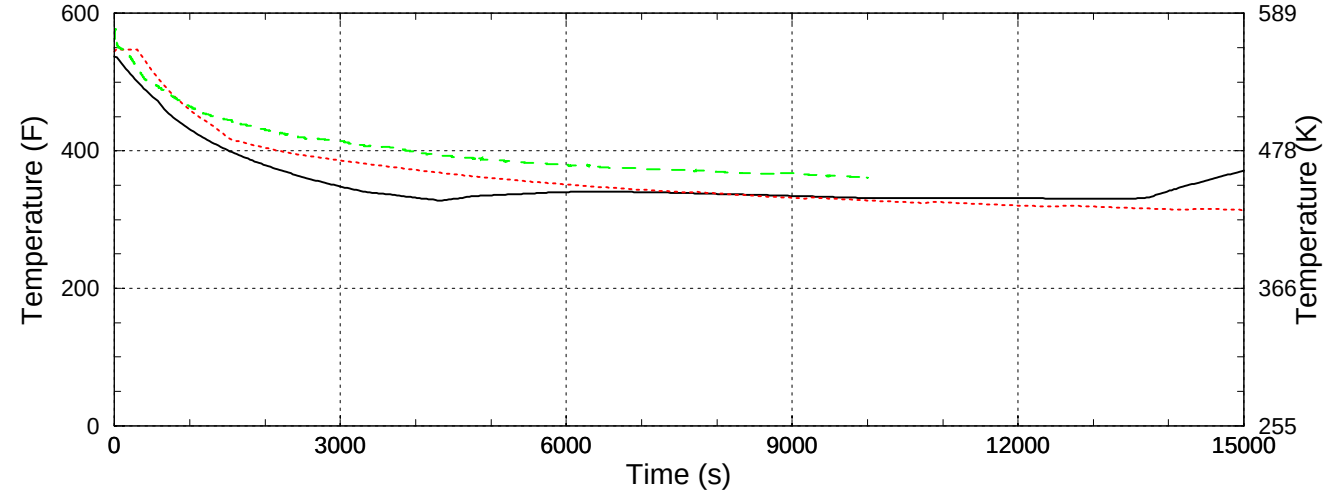
Oconee Case 027 (black) −vs− Oconee Case 099 (red)

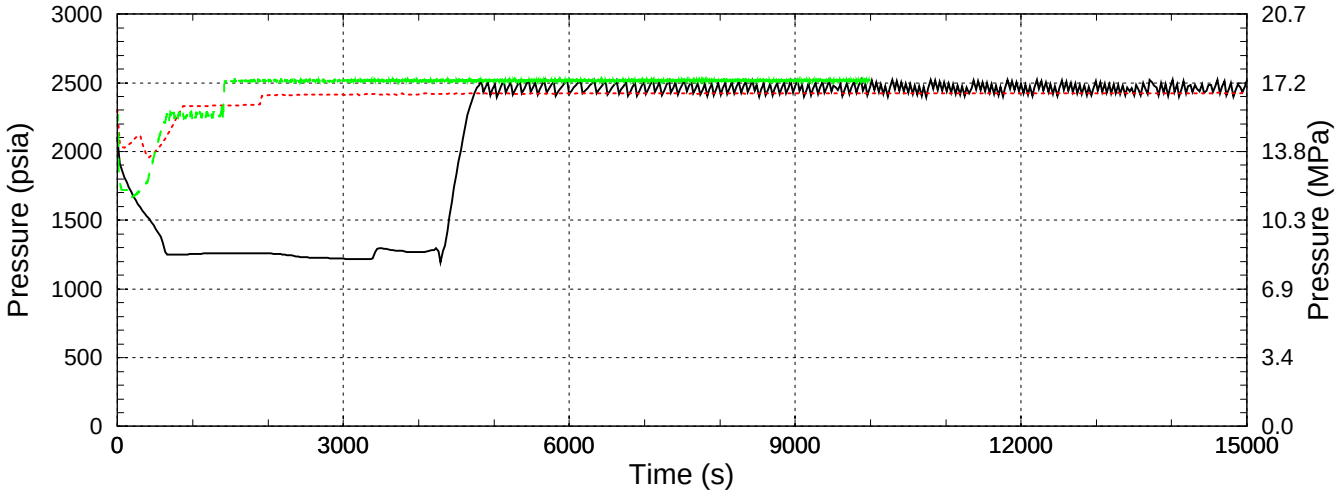


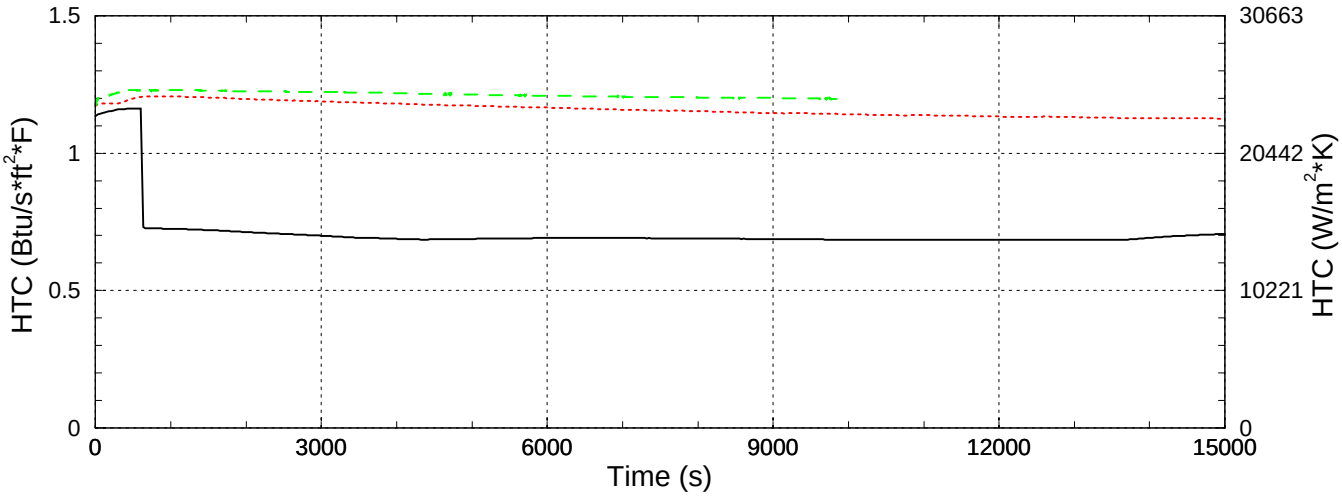




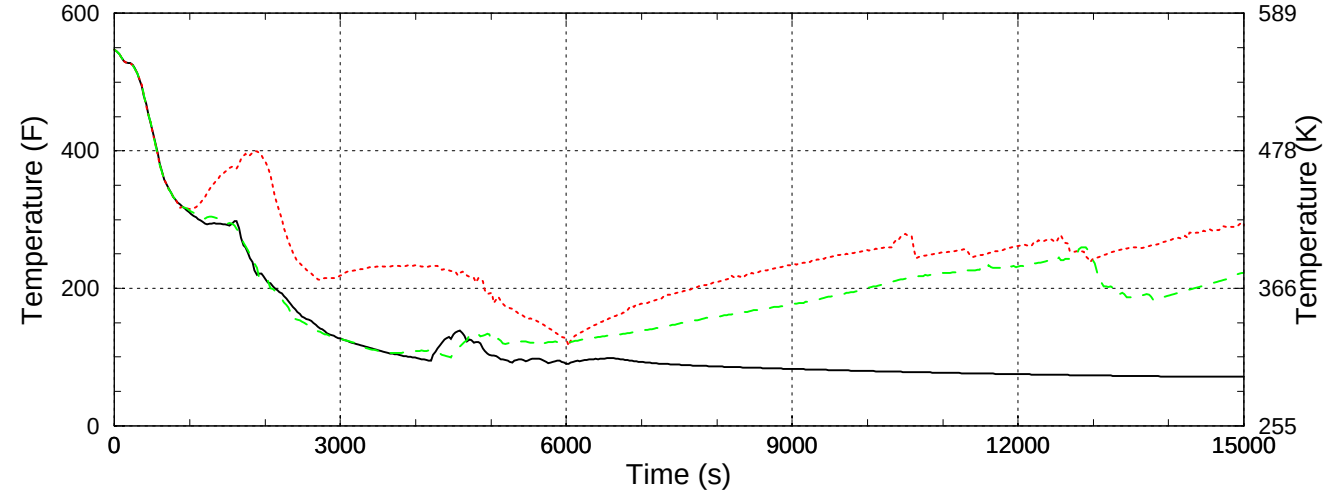
Palisades Case 055 (black) −vs− Beaver Valley Case 078 (red) −vs− Oconee Case 028 (green)

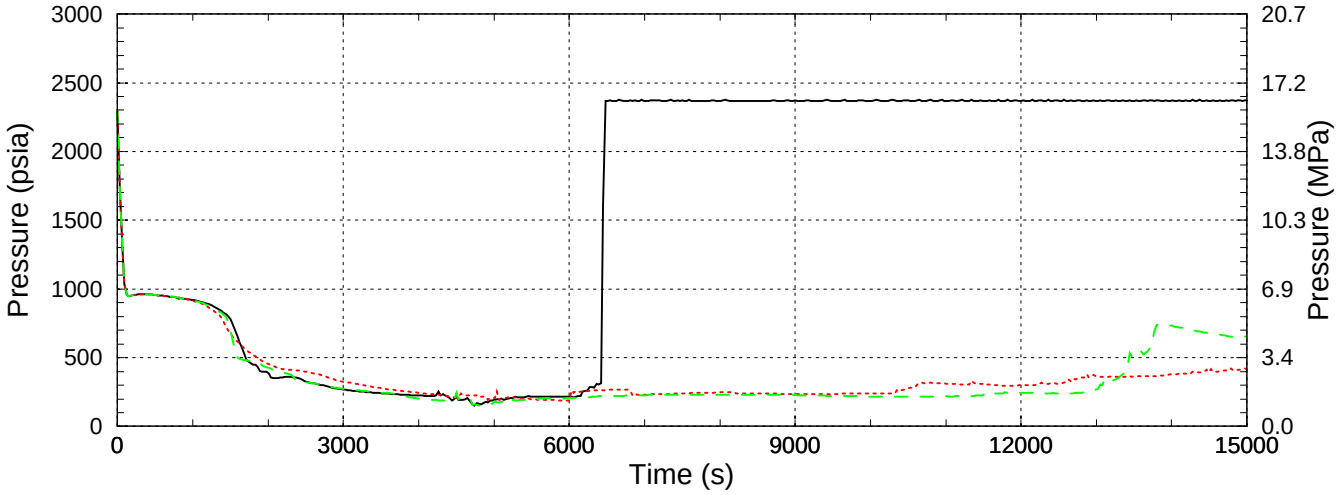


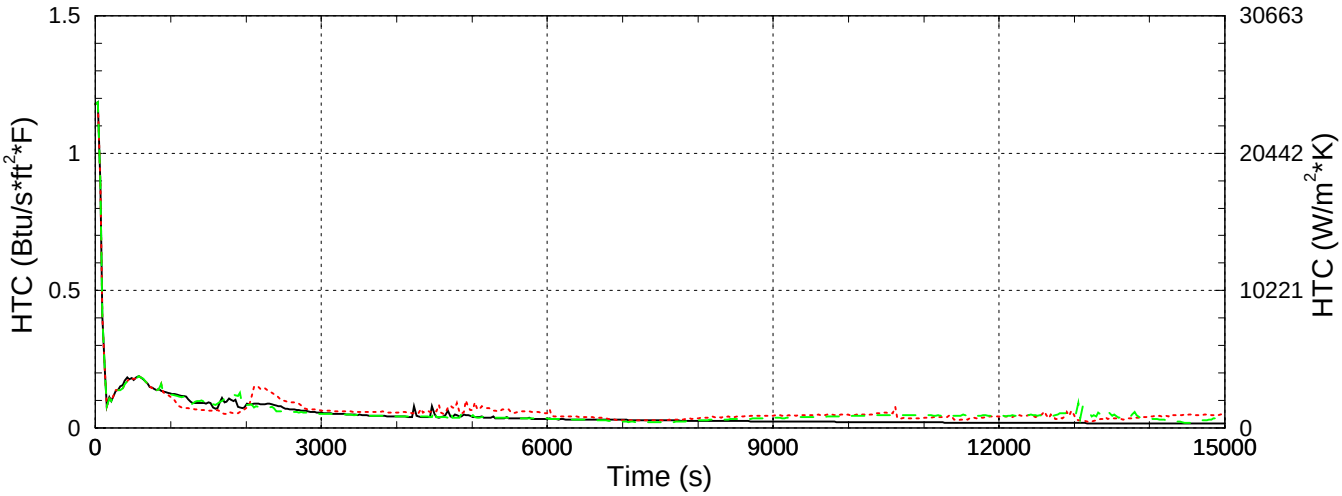




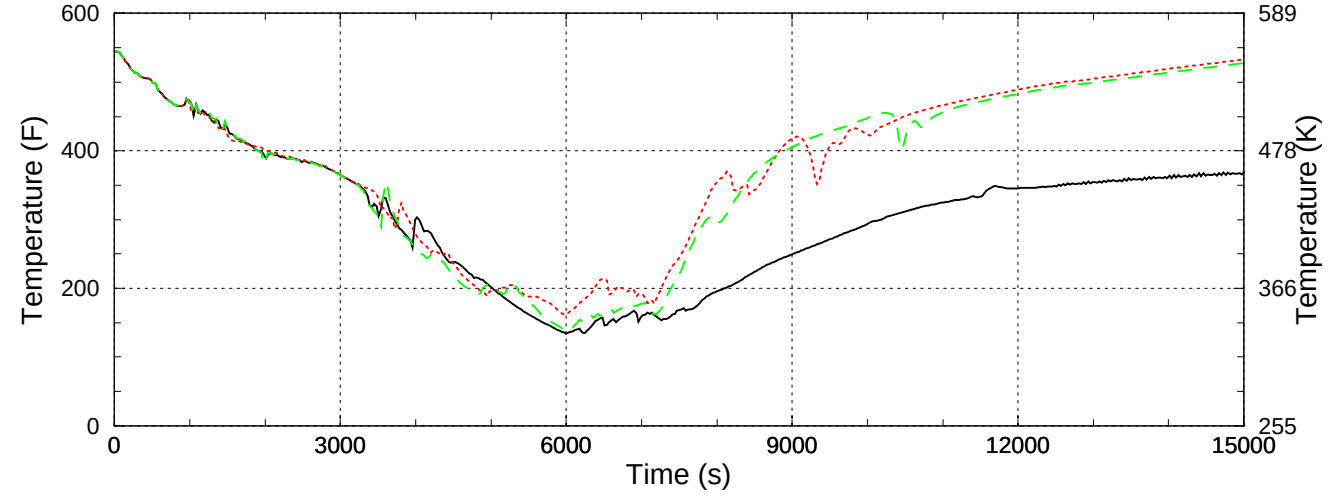
Beaver Valley Case 071 (black) −vs− Beaver Valley Case 098 (red) −vs− Beaver Valley Case 100 (green)

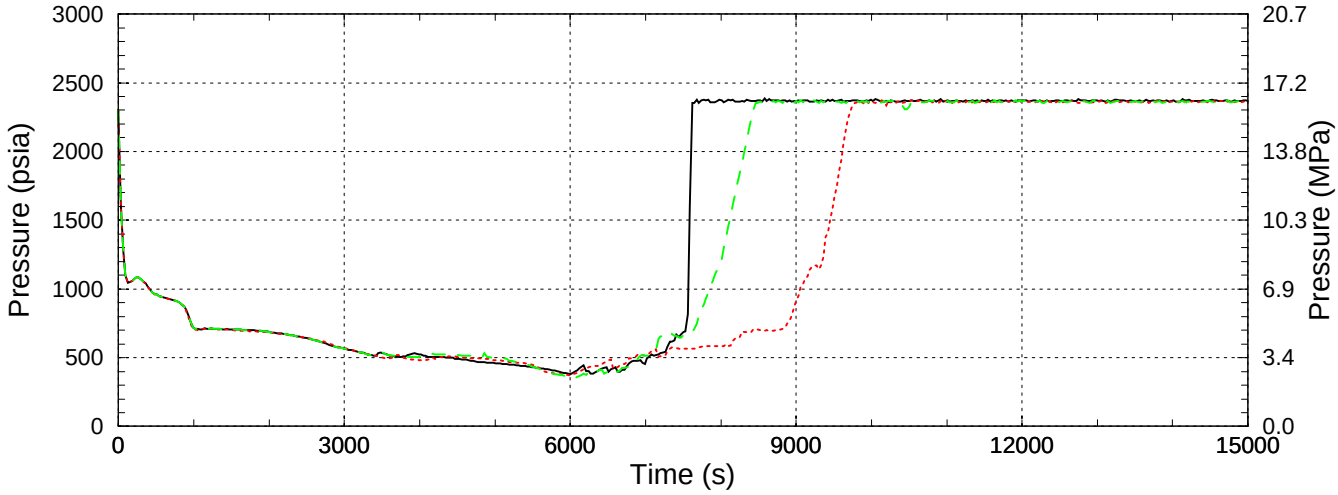


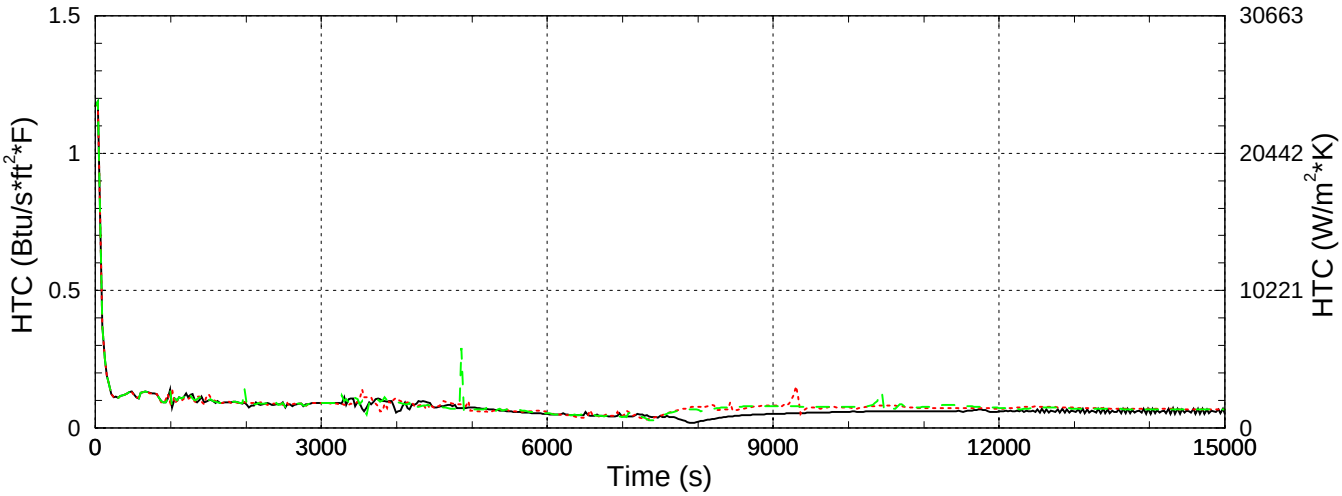




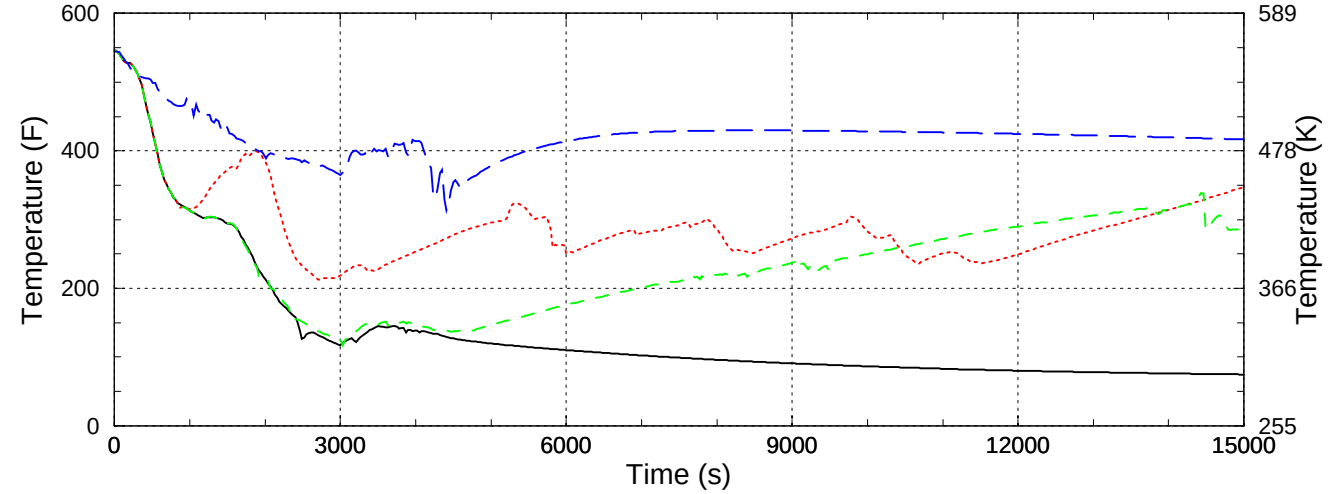
Beaver Valley Case 060 (black) −vs− Beaver Valley Case 095 (red) −vs− Beaver Valley Case 096 (green)

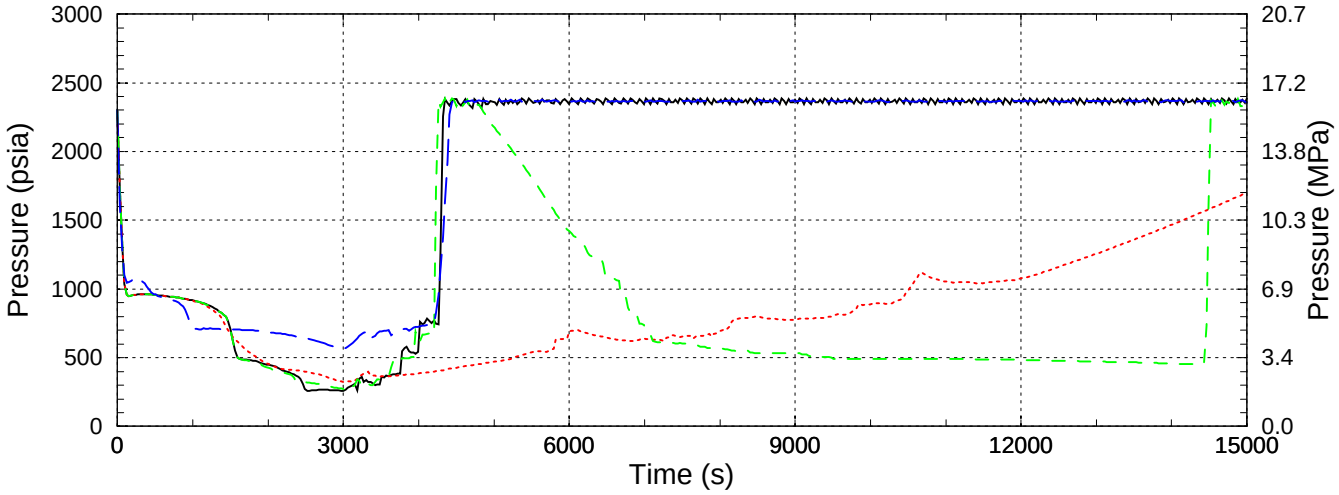


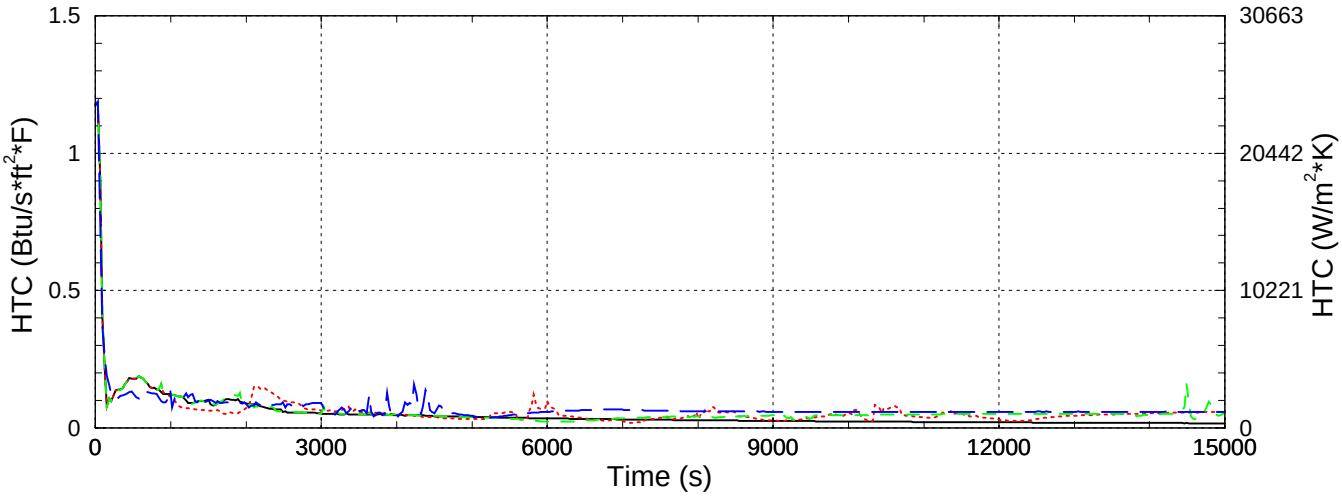




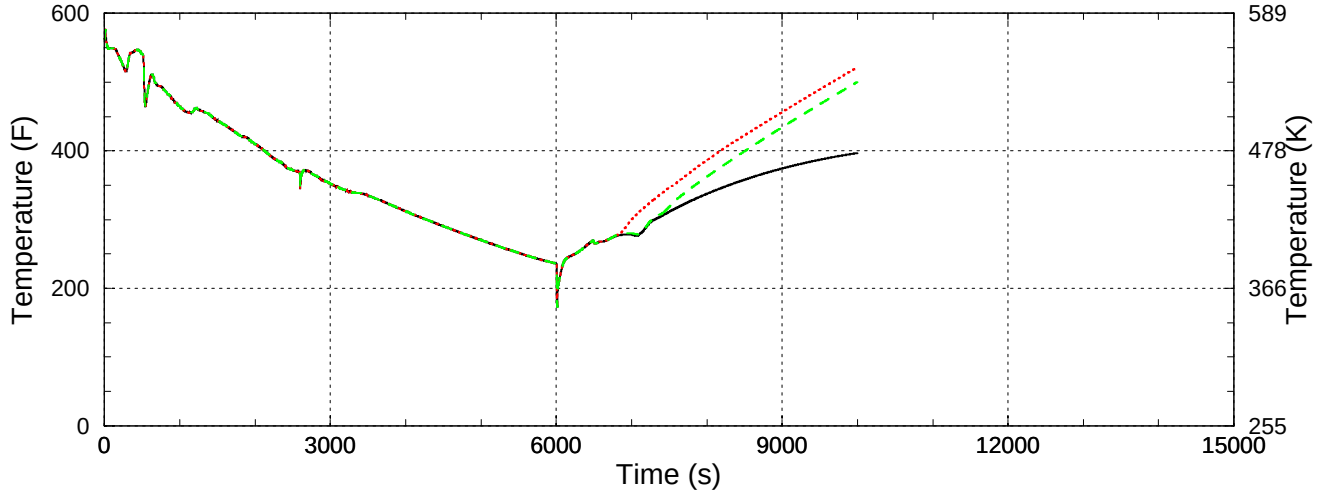
Beaver Valley Case 097 (black) −vs− Beaver Valley Case 099 (red) −vs− Beaver Valley Case 101 (green)
−vs− Beaver Valley Case 059 (blue)

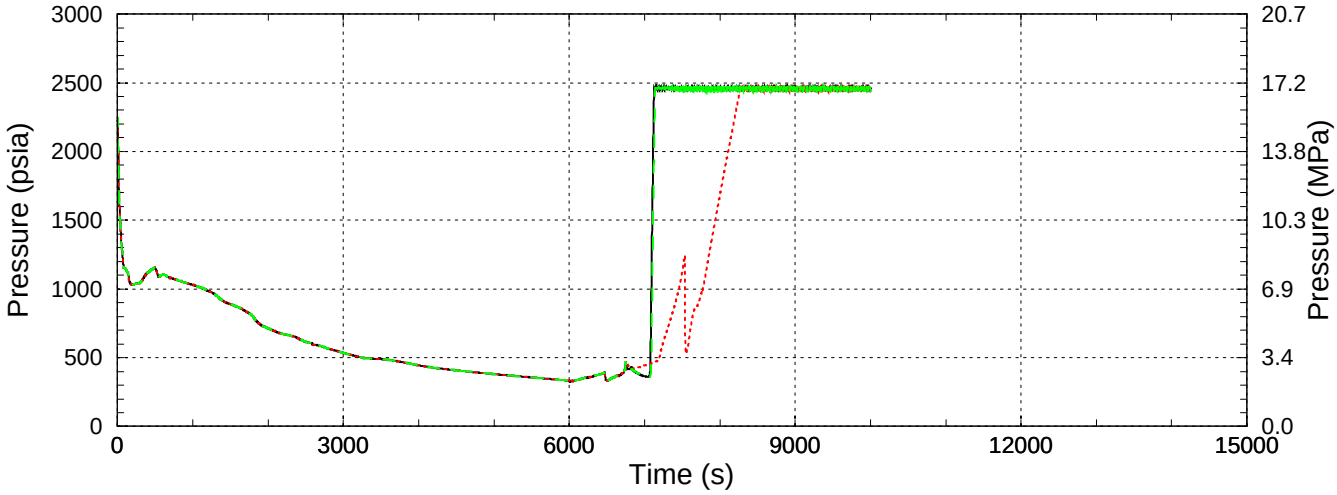


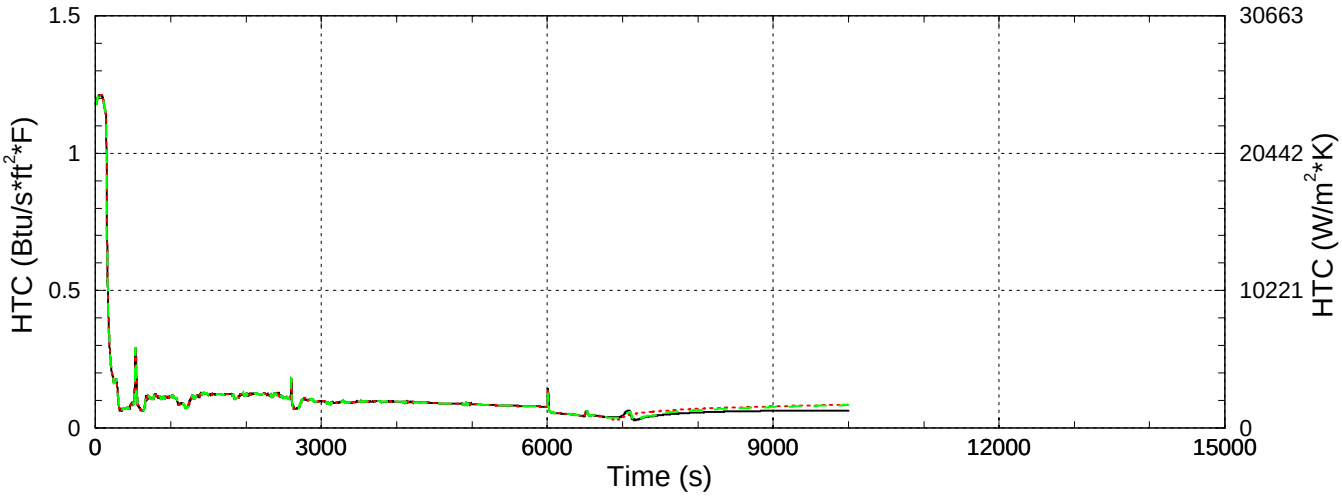




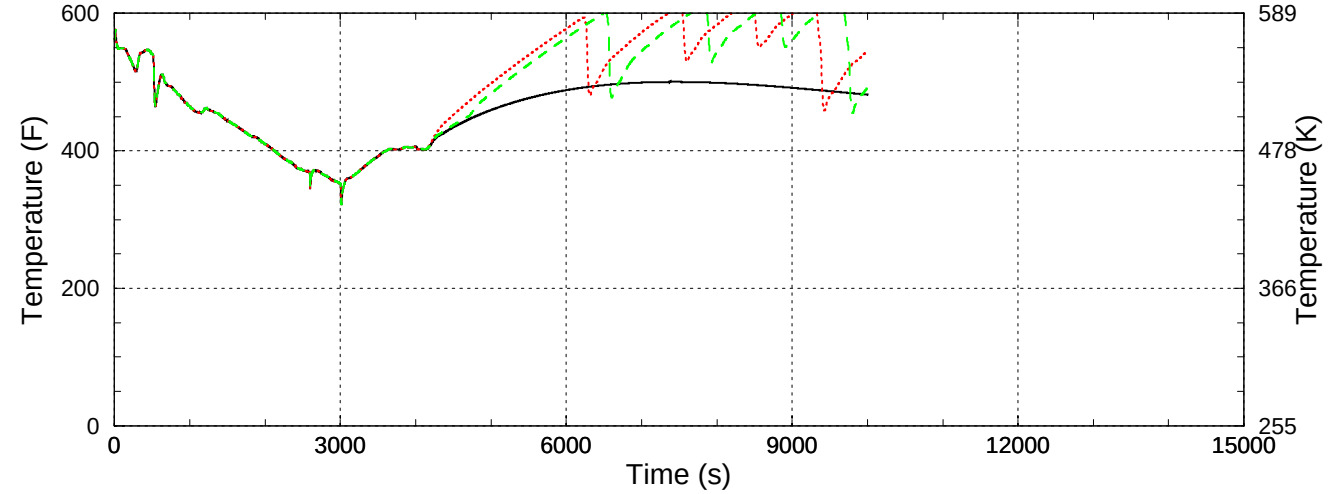
Oconee Case 109 (black) −vs− Oconee Case 112 (red) −vs− Oconee Case 113 (green)

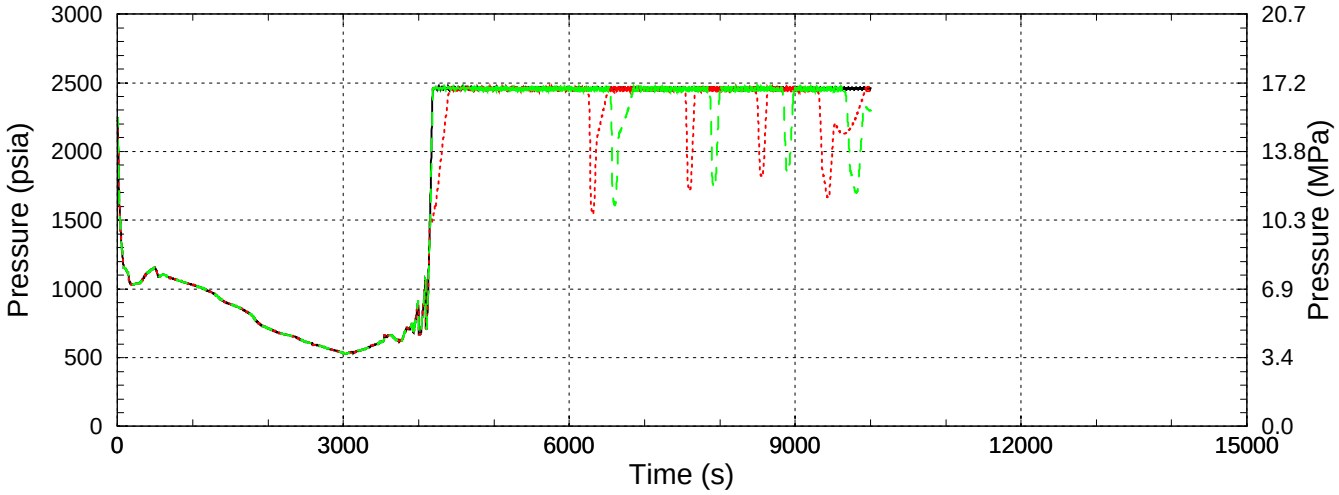


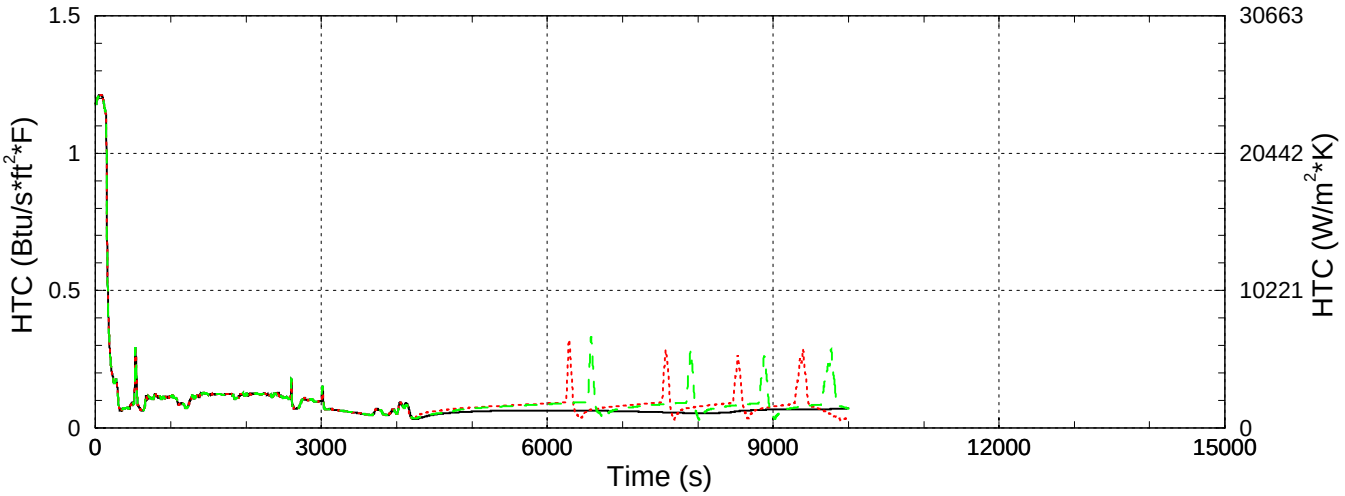




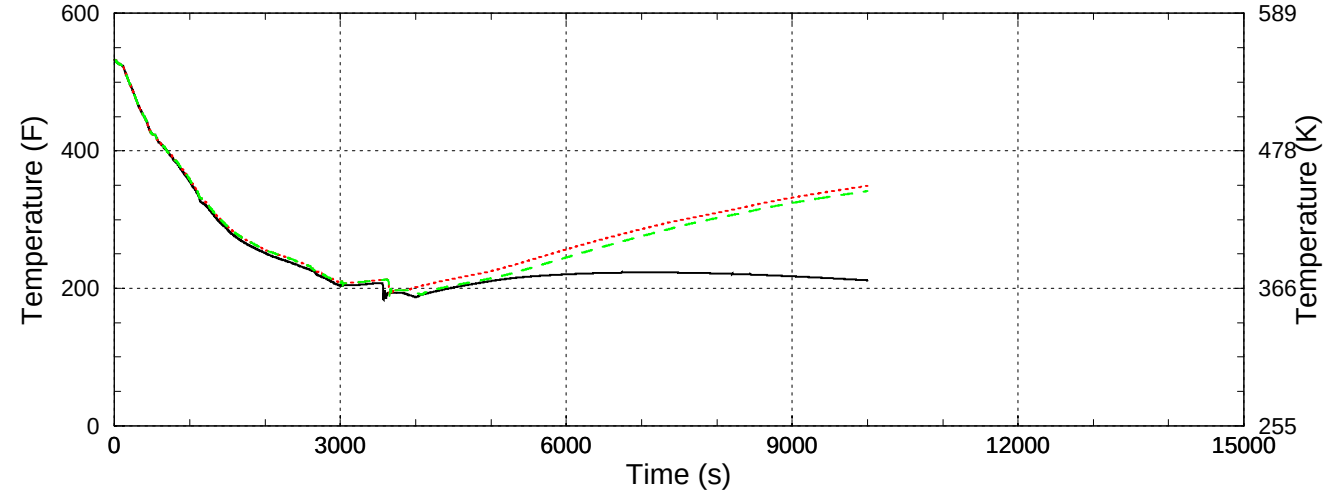
Oconee Case 149 (black) −vs− Oconee Case 114 (red) −vs− Oconee Case 115 (green)

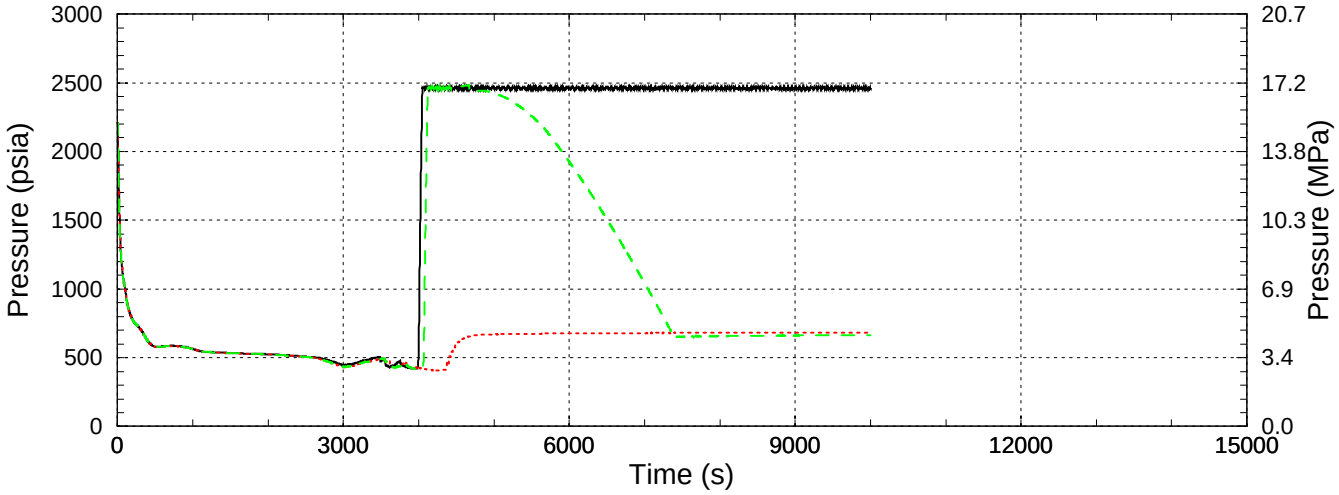


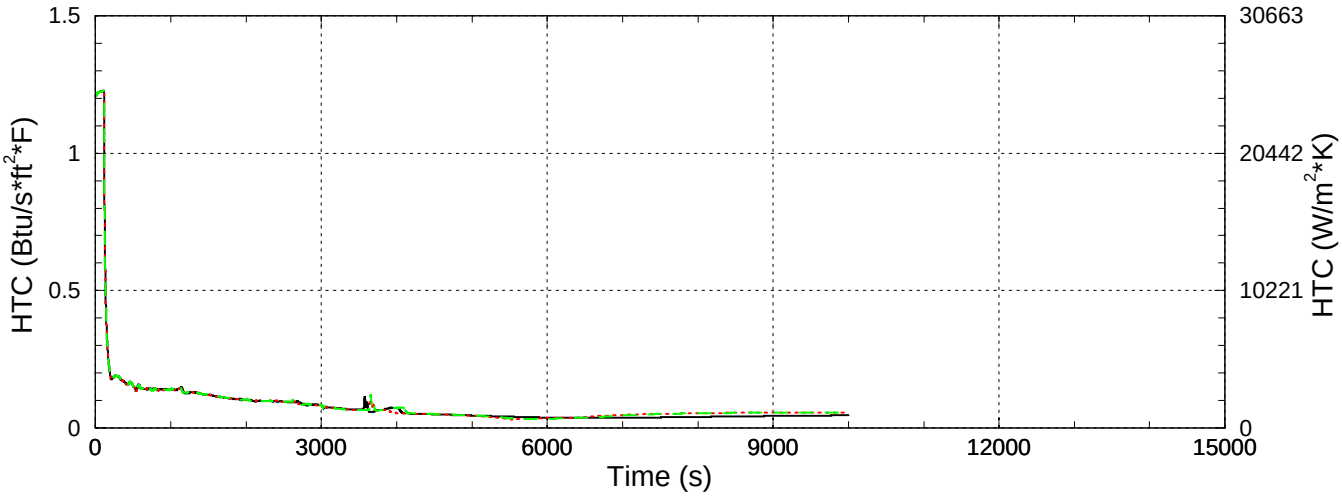




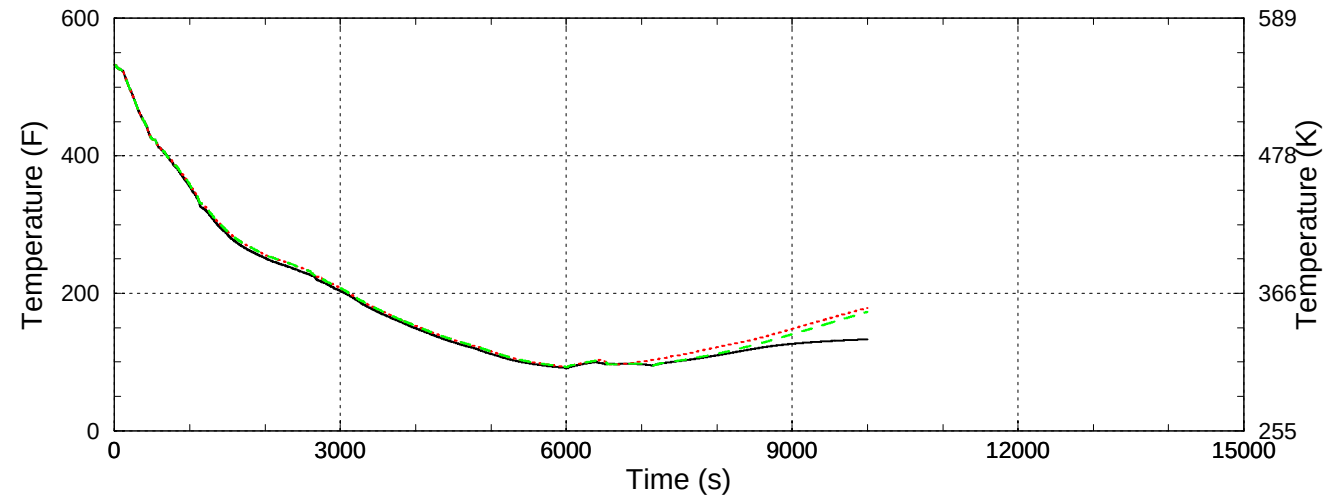
Oconee Case 168 (black) −vs− Oconee Case 123 (red) −vs− Oconee Case 124 (green)

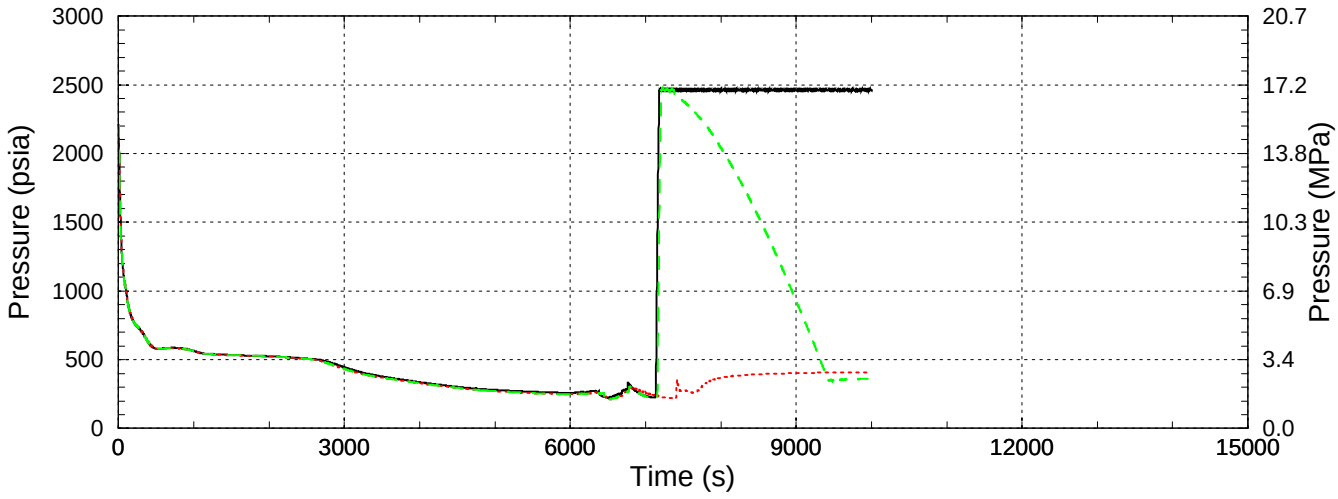


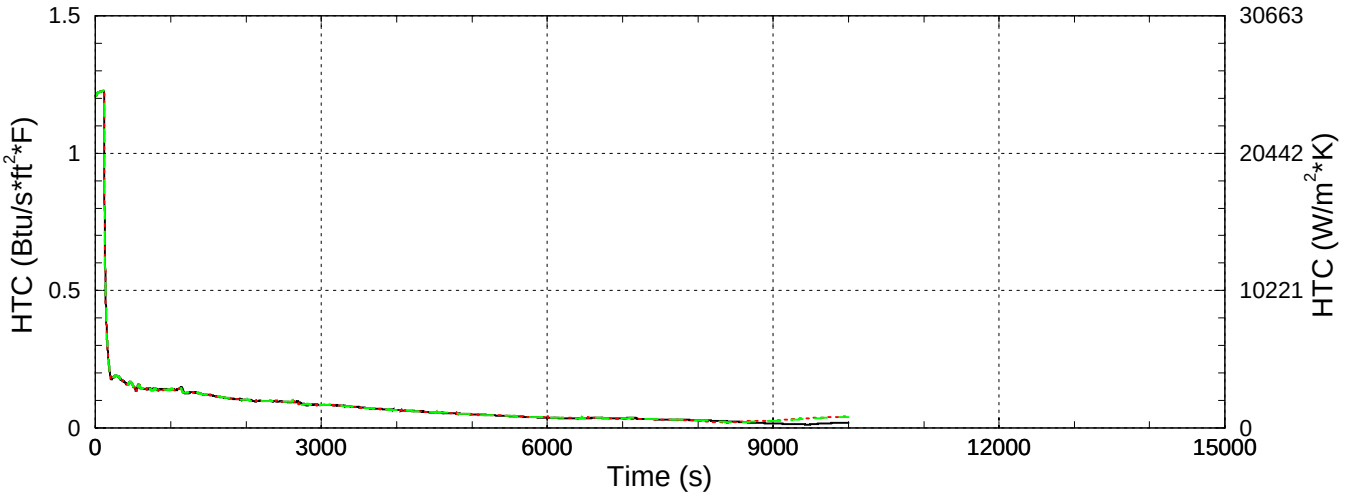




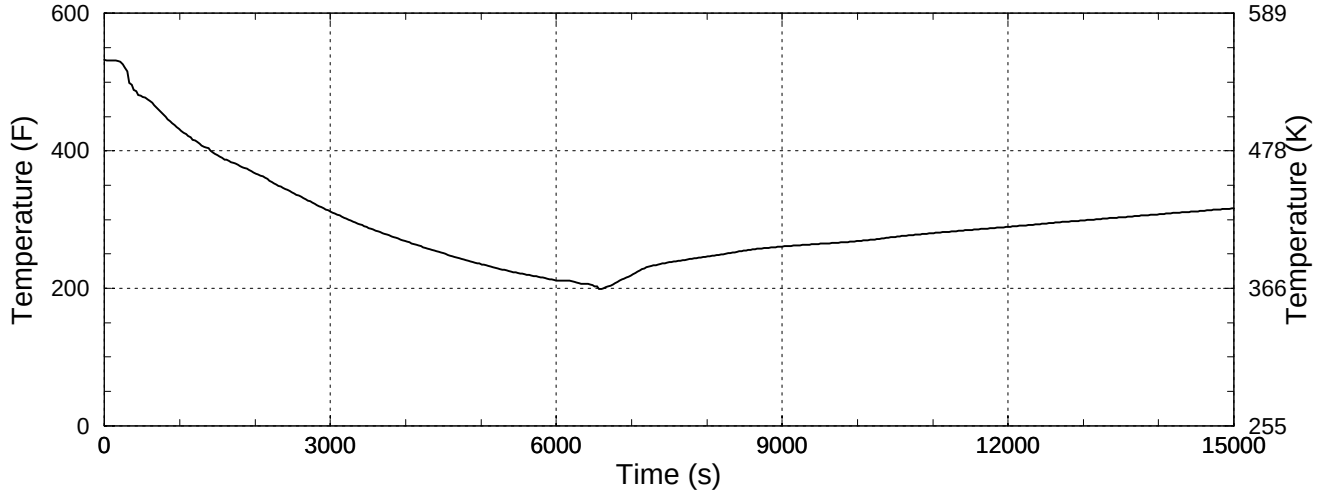
Oconee Case 165 (black) −vs− Oconee Case 121 (red) −vs− Oconee Case 122 (green)

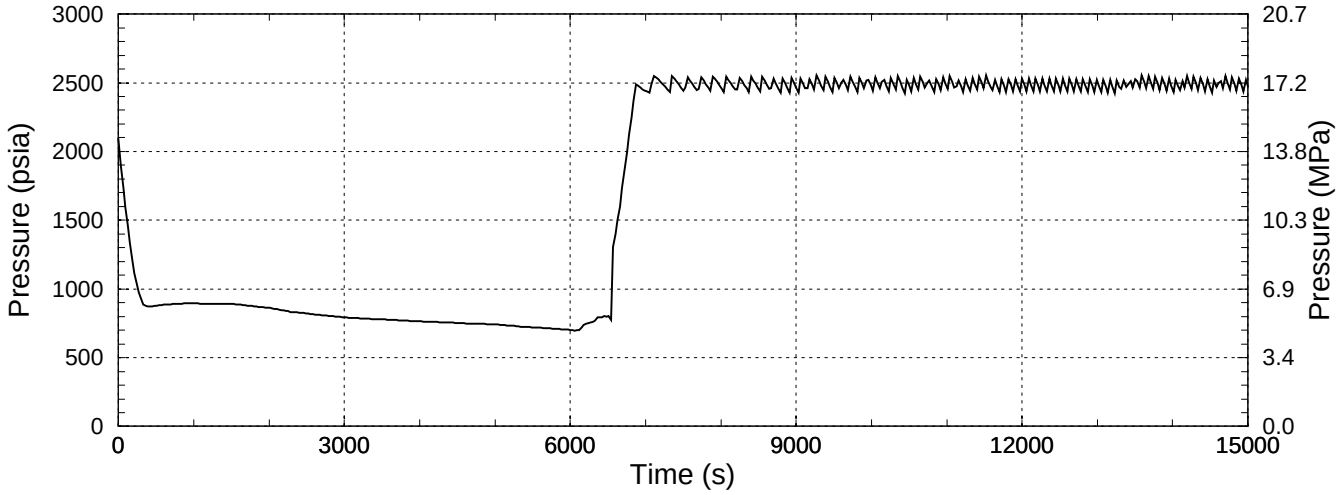


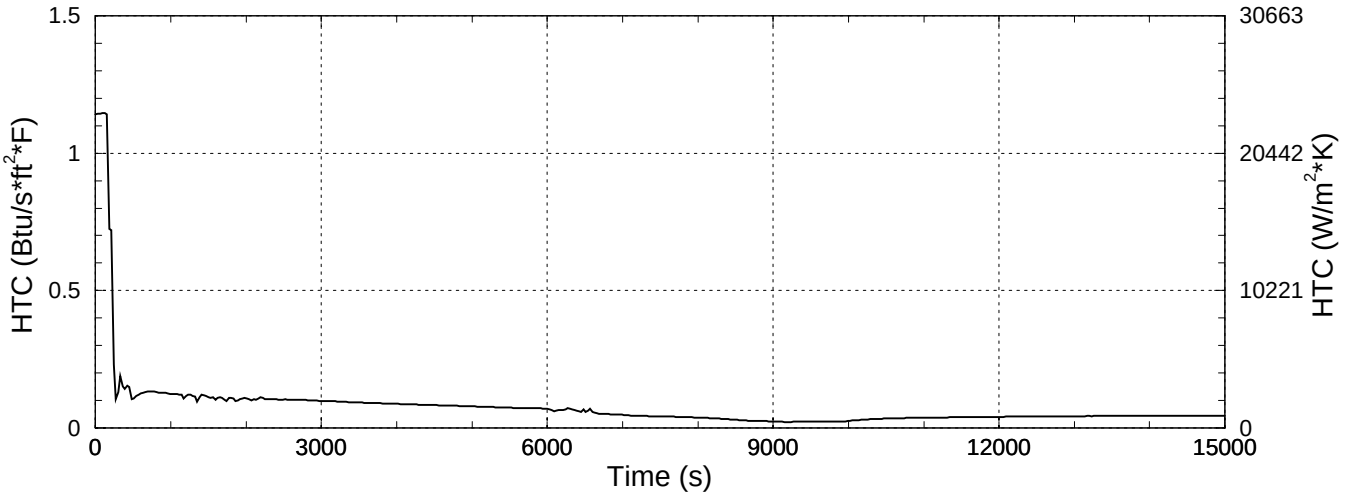




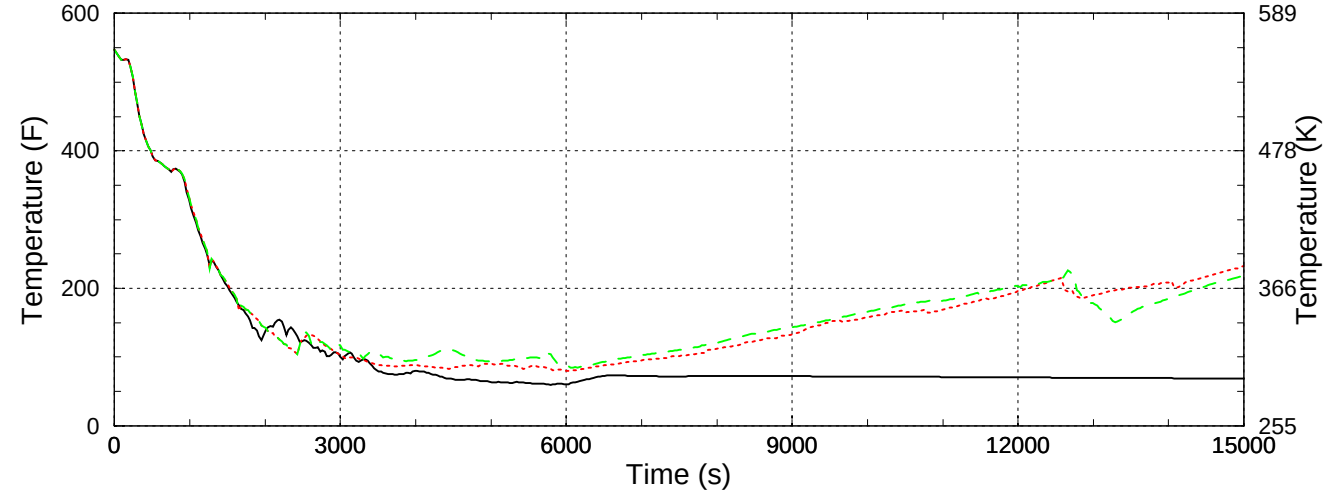
Palisades Case 065 (black)

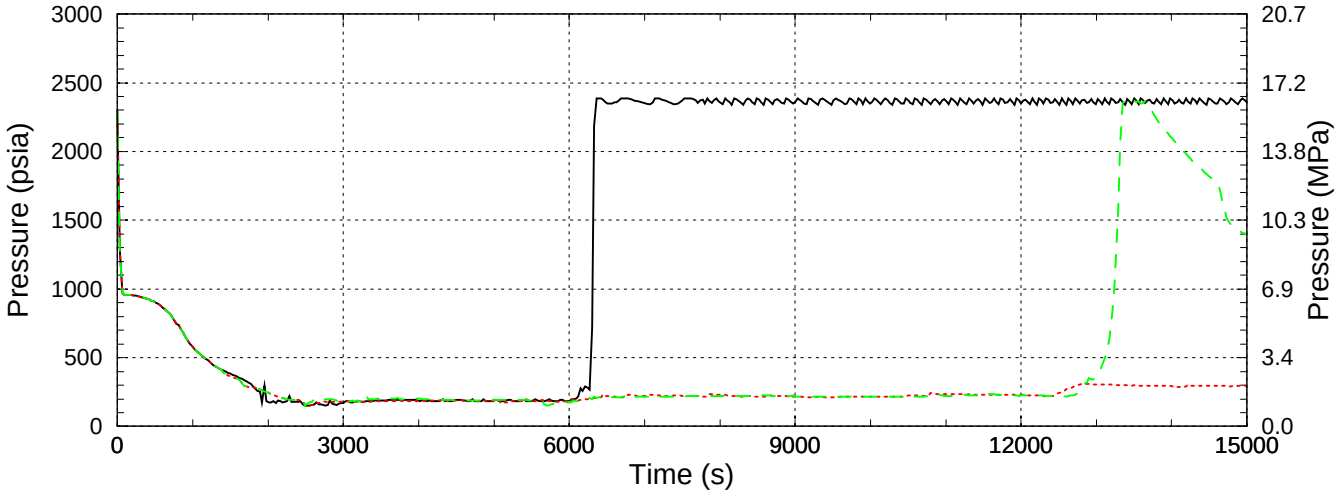


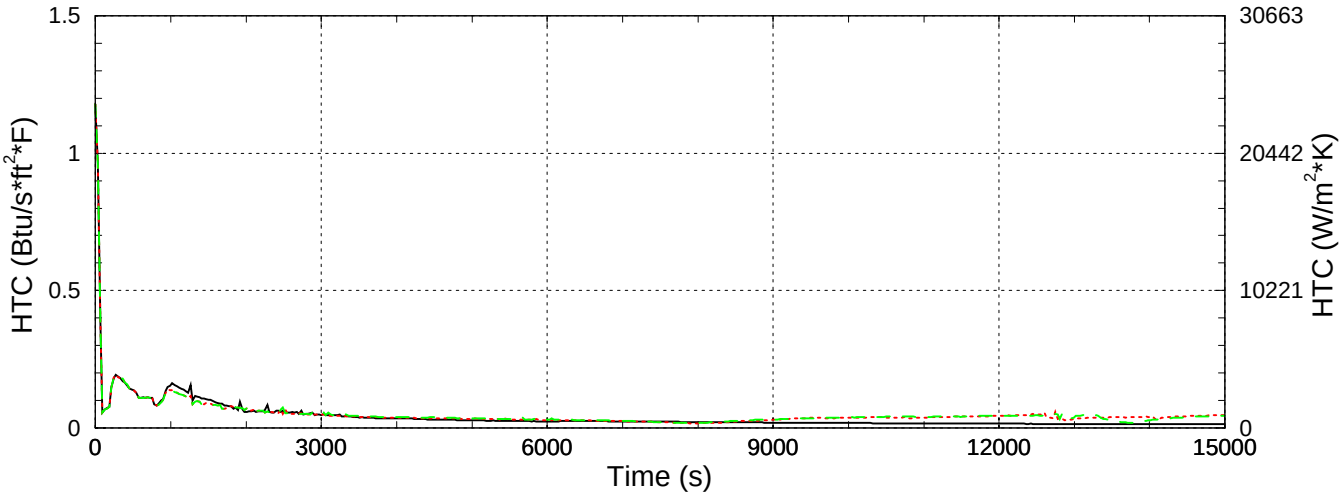




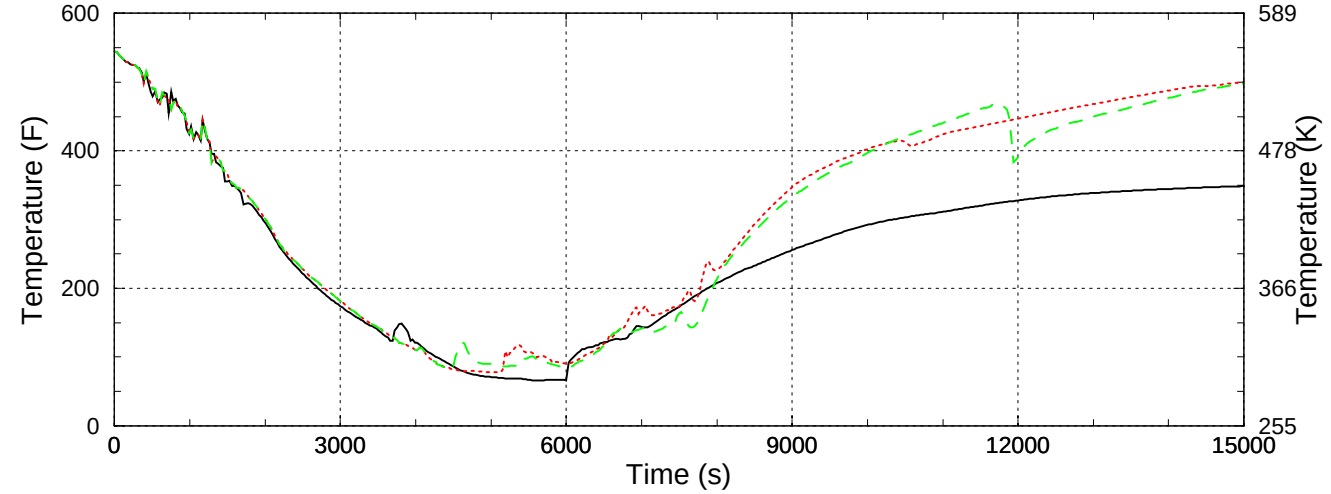
Beaver Valley Case 070 (black) −vs− Beaver Valley Case 089 (red) −vs− Beaver Valley Case 091 (green)

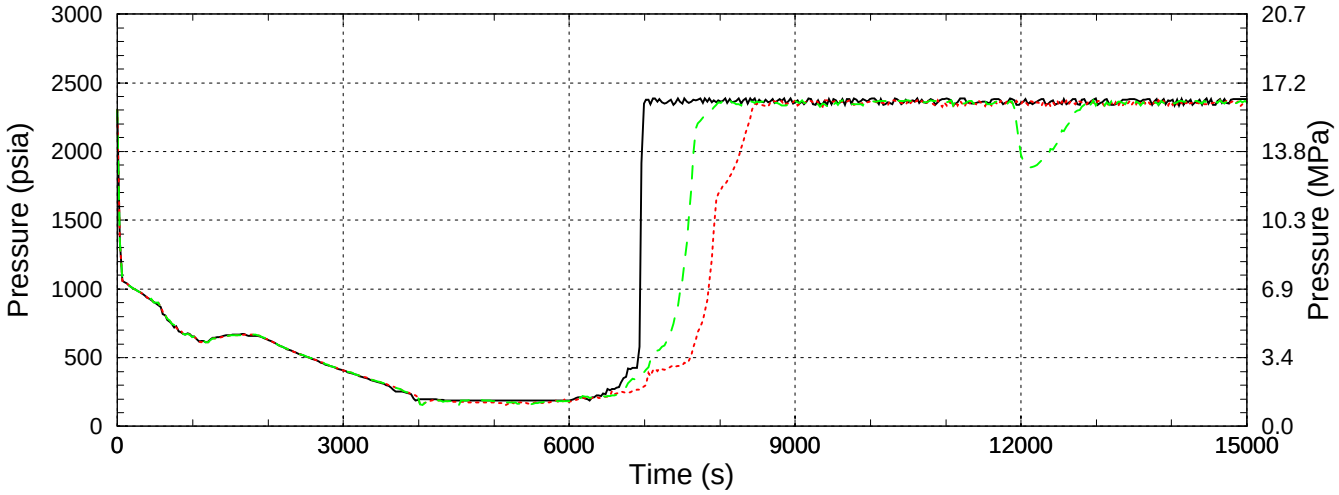


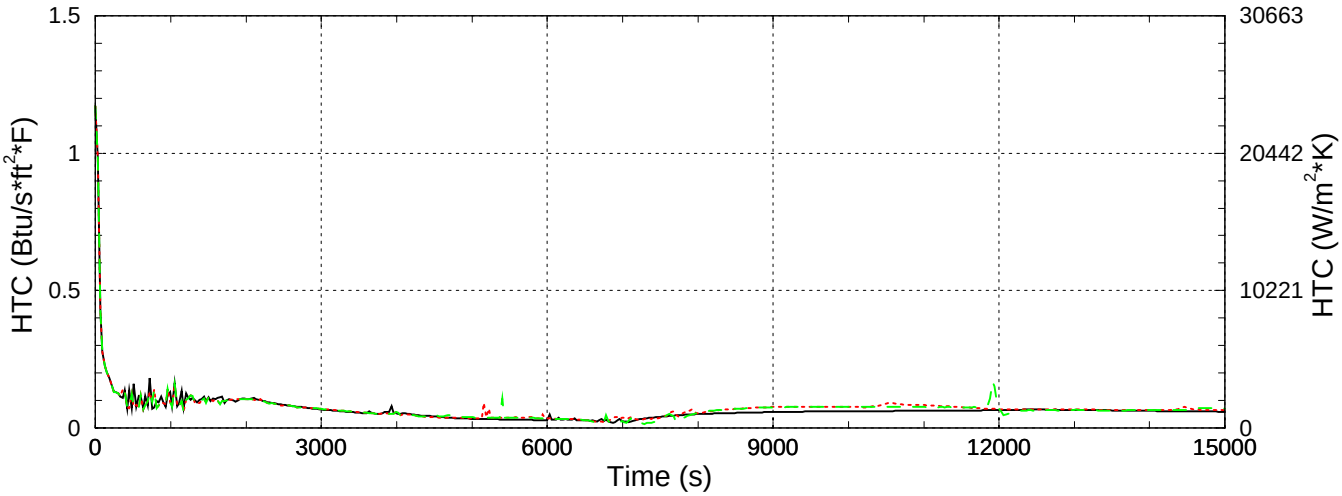




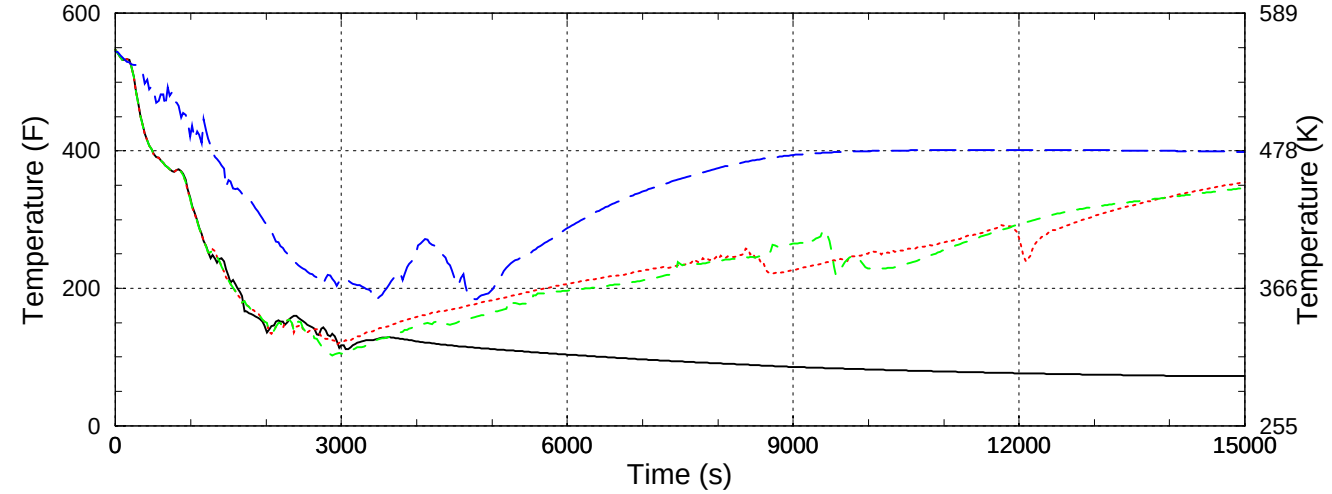
Beaver Valley Case 062 (black) −vs− Beaver Valley Case 086 (red) −vs− Beaver Valley Case 087 (green)

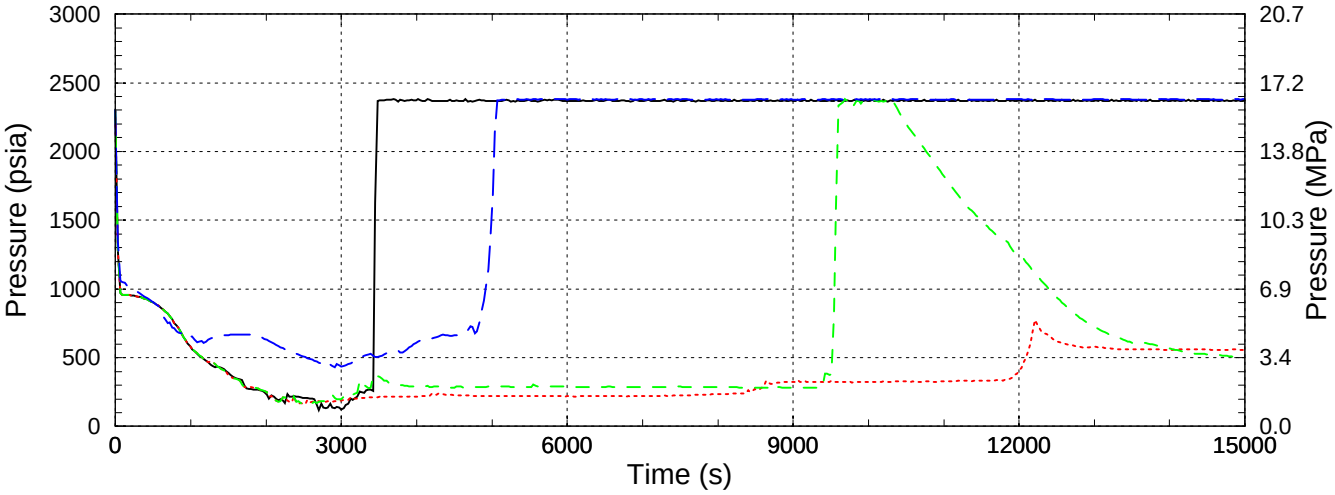


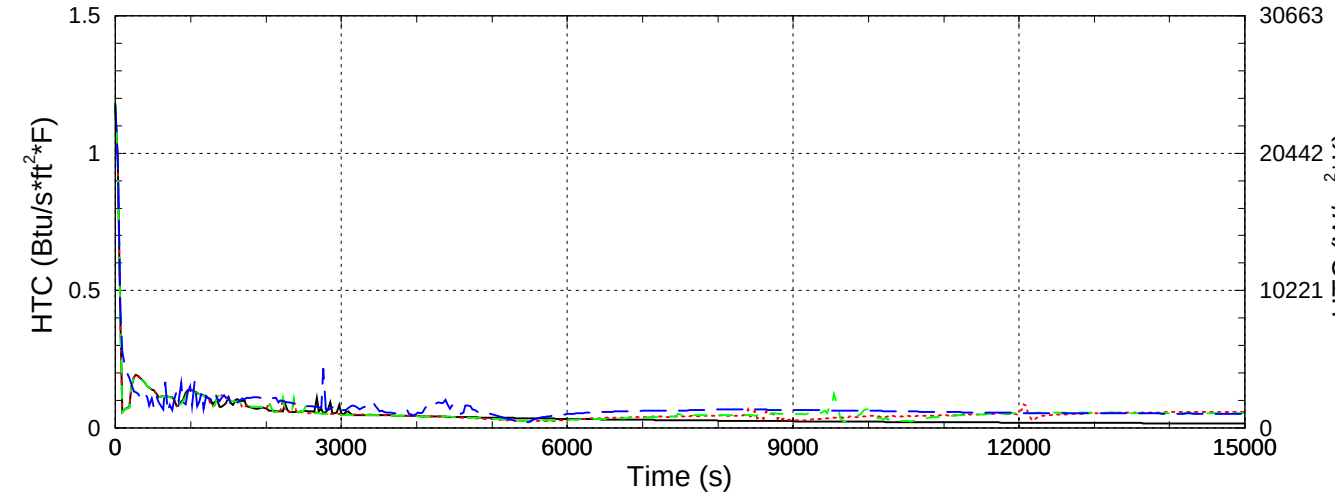




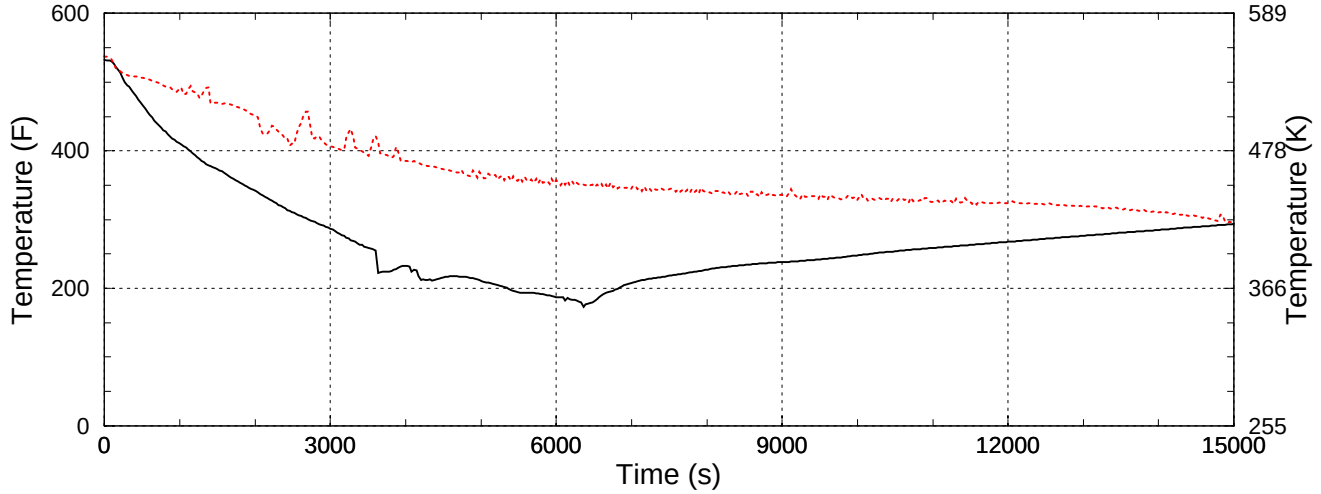
Beaver Valley Case 069 (black) −vs− Beaver Valley Case 088 (red) −vs− Beaver Valley Case 090 (green)
−vs− Beaver Valley Case 061 (blue)

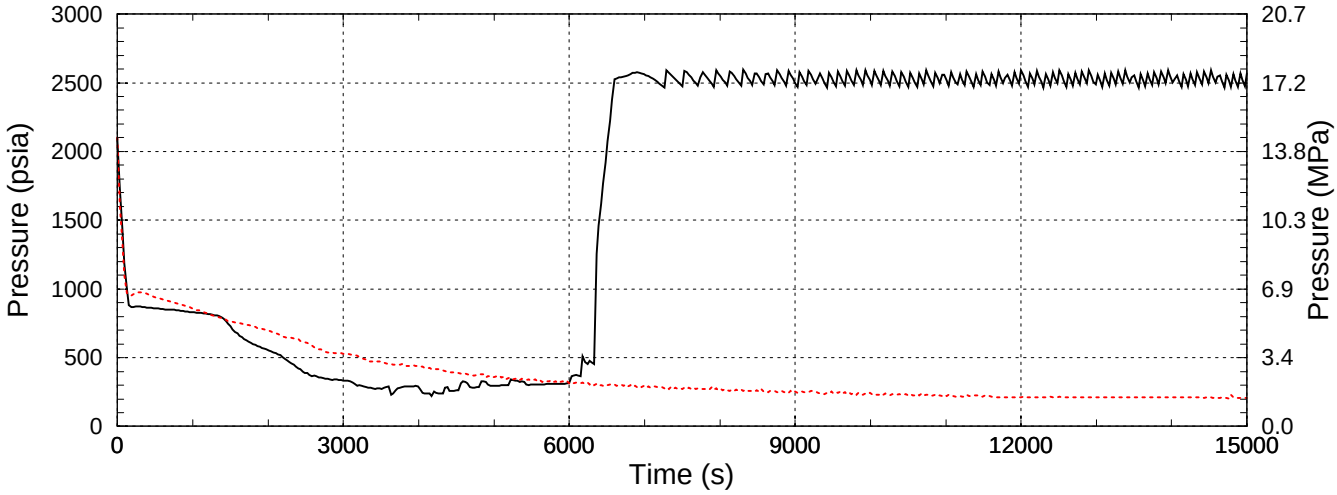


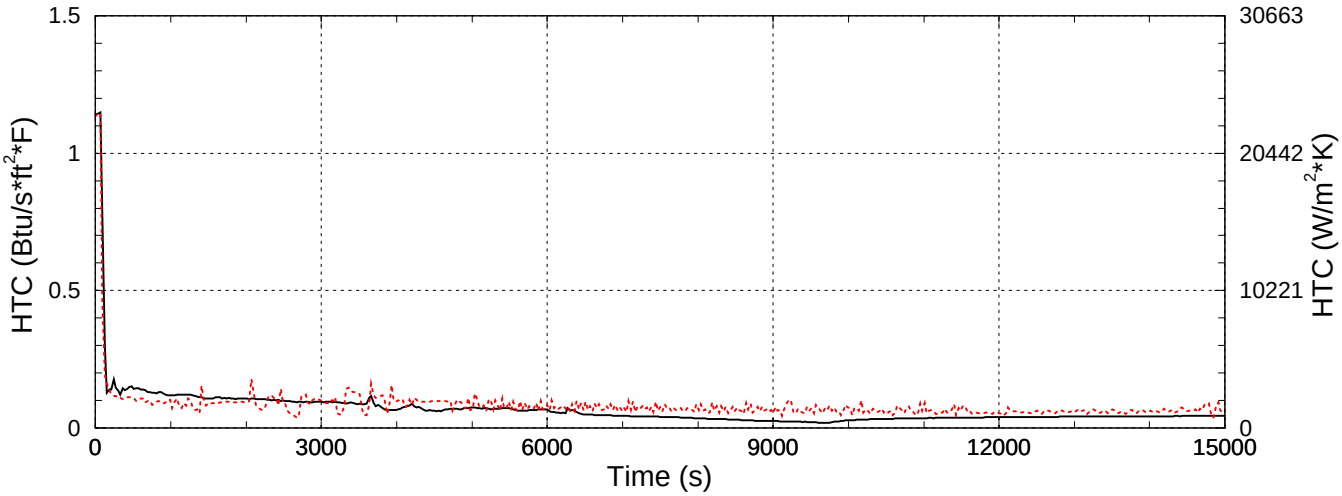




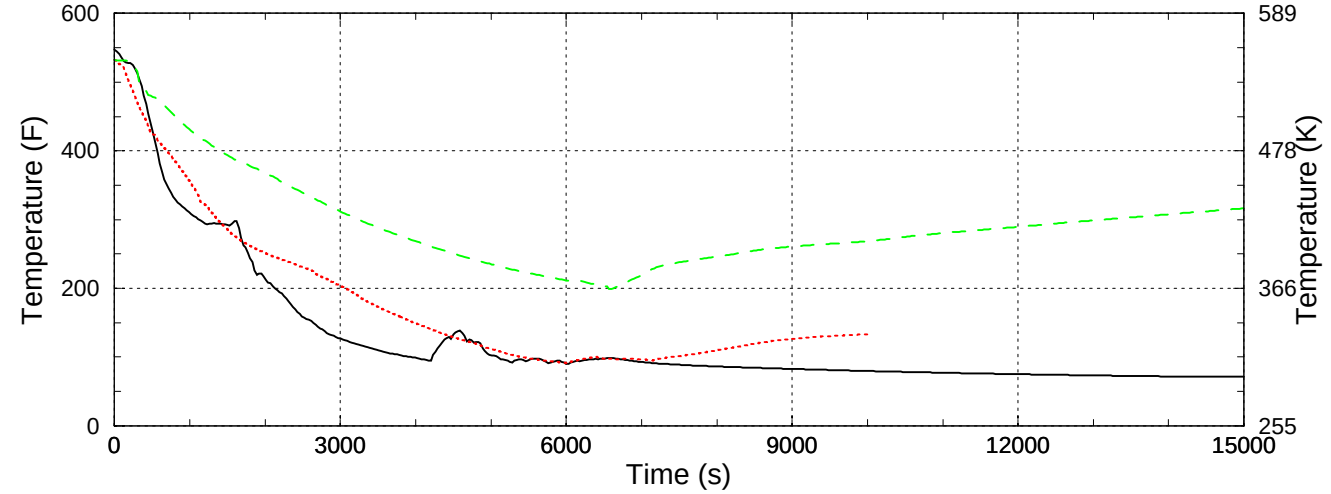
Palisades Case 048 (black) −vs− Palisades Case 042 (red)

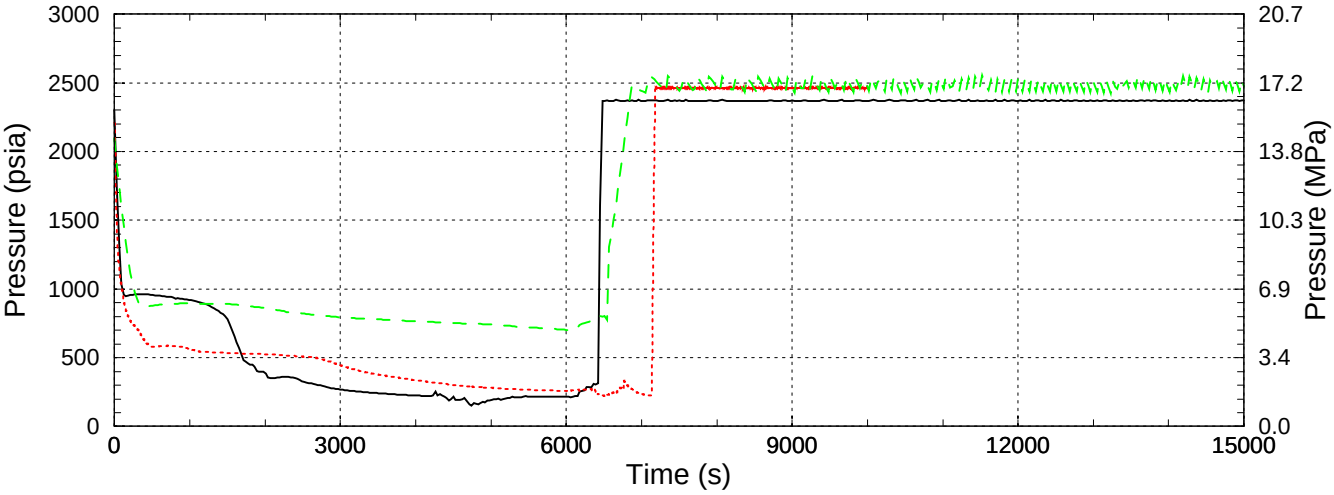


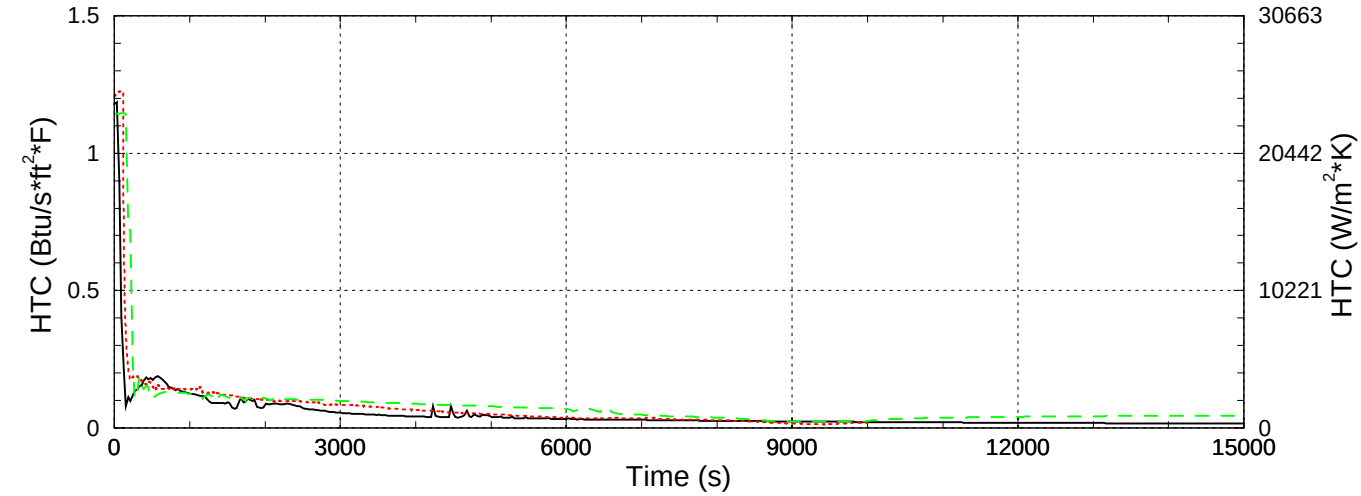




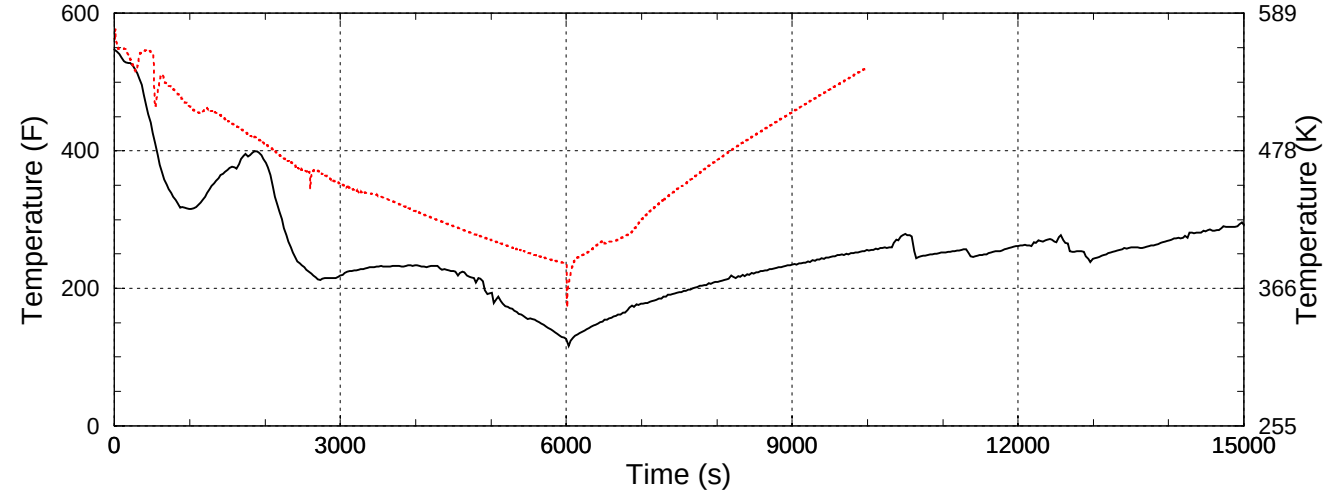
Beaver Valley Case 071 (black) −vs− Oconee Case 165 (red) −vs− Palisades Case 065 (green)

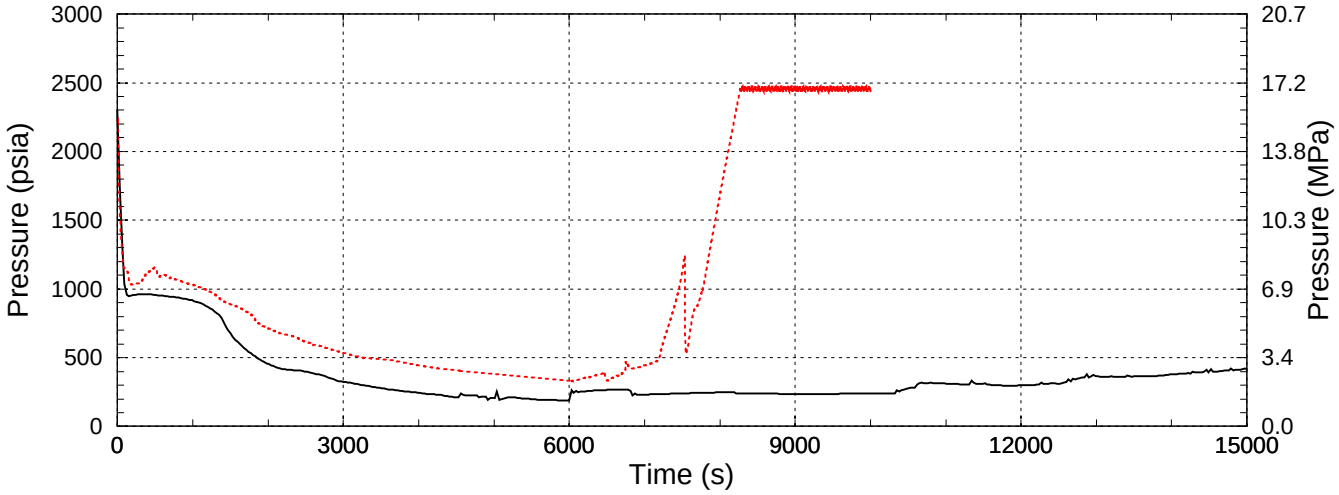


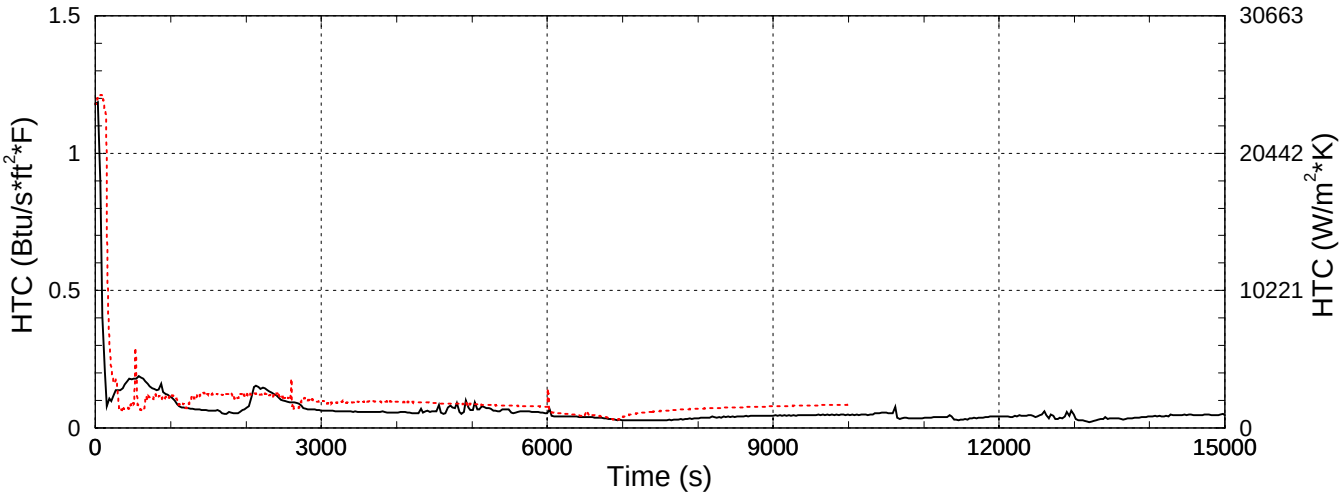




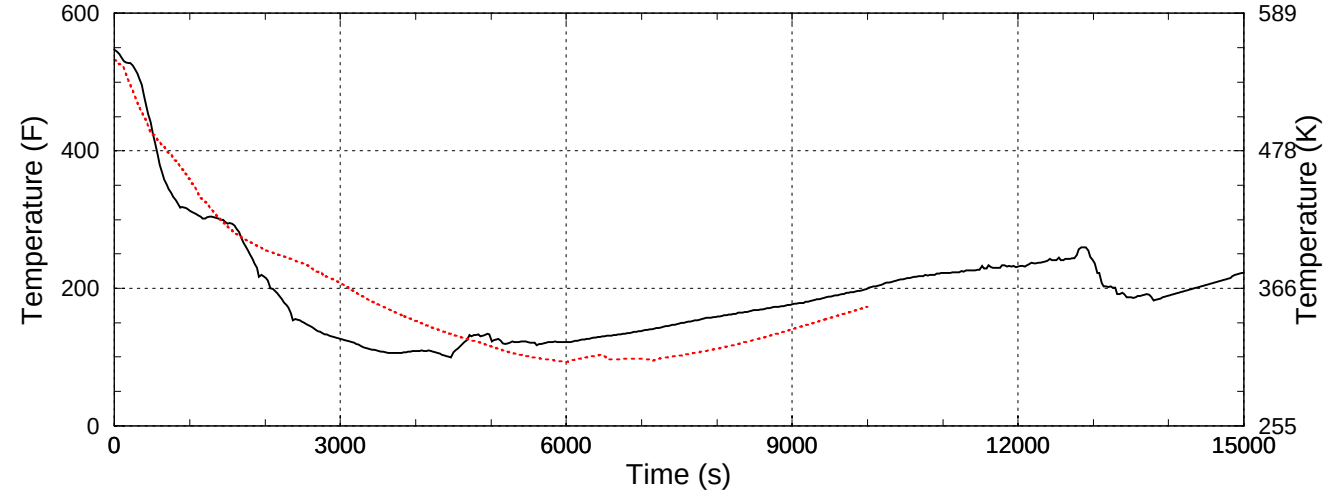
Beaver Valley Case 098 (black) −vs− Oconee Case 112 (red)

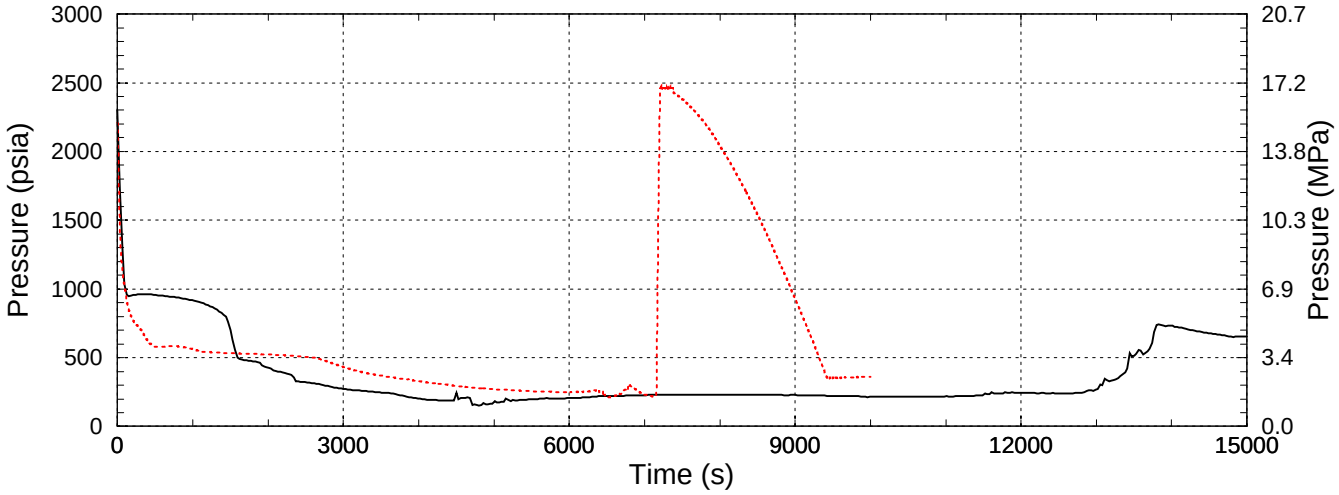


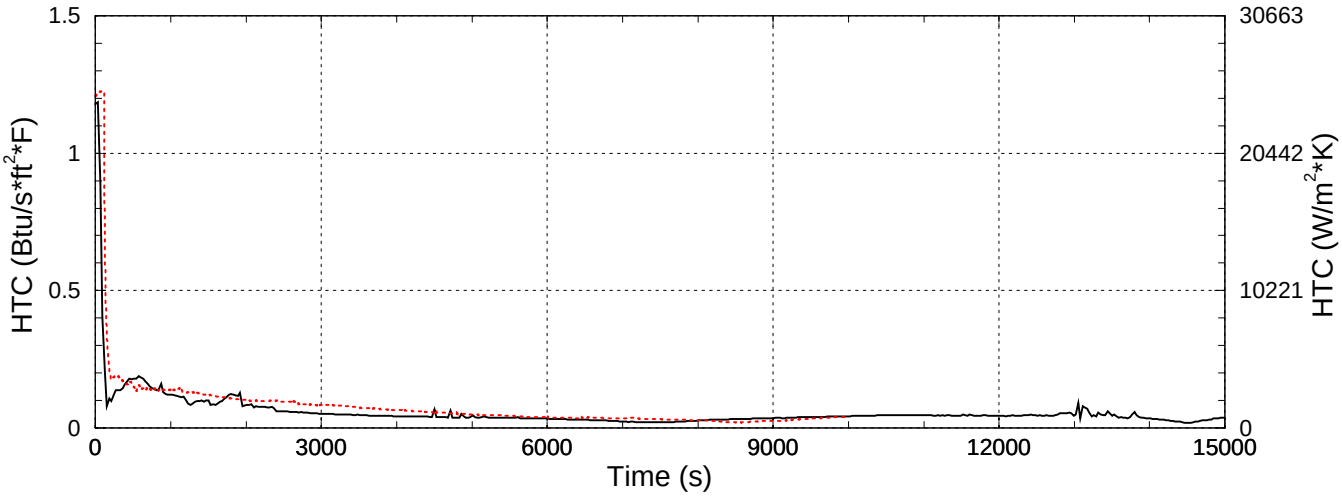




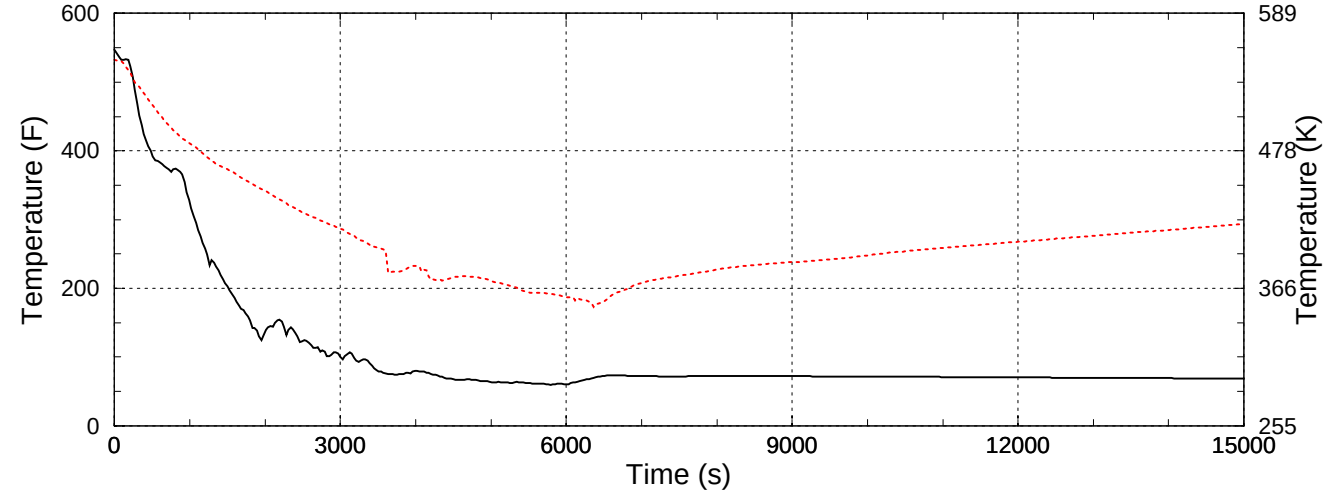
Beaver Valley Case 100 (black) −vs− Oconee Case 122 (red)

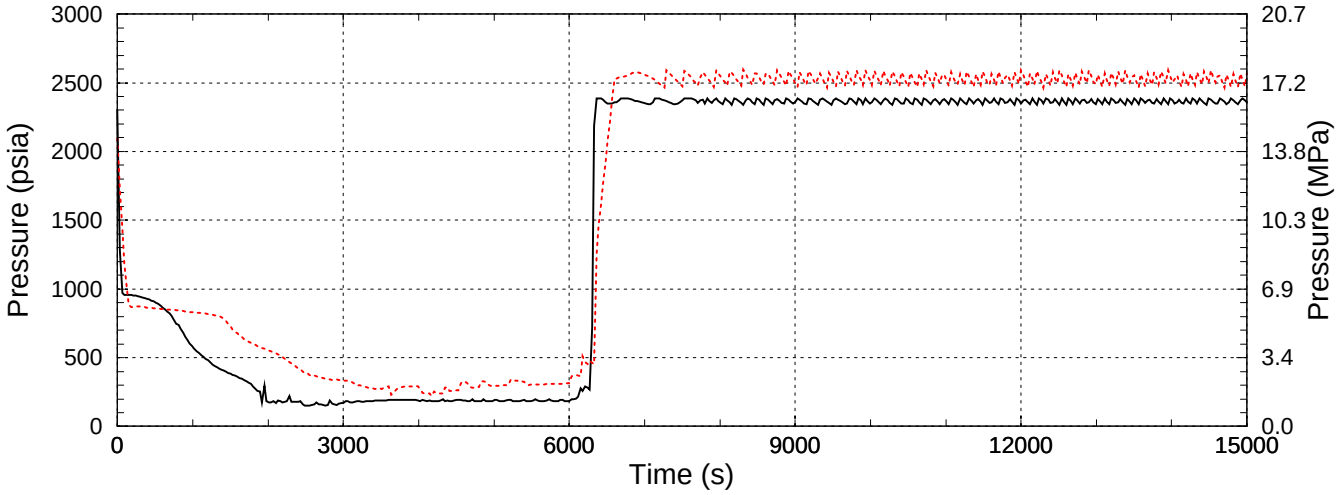


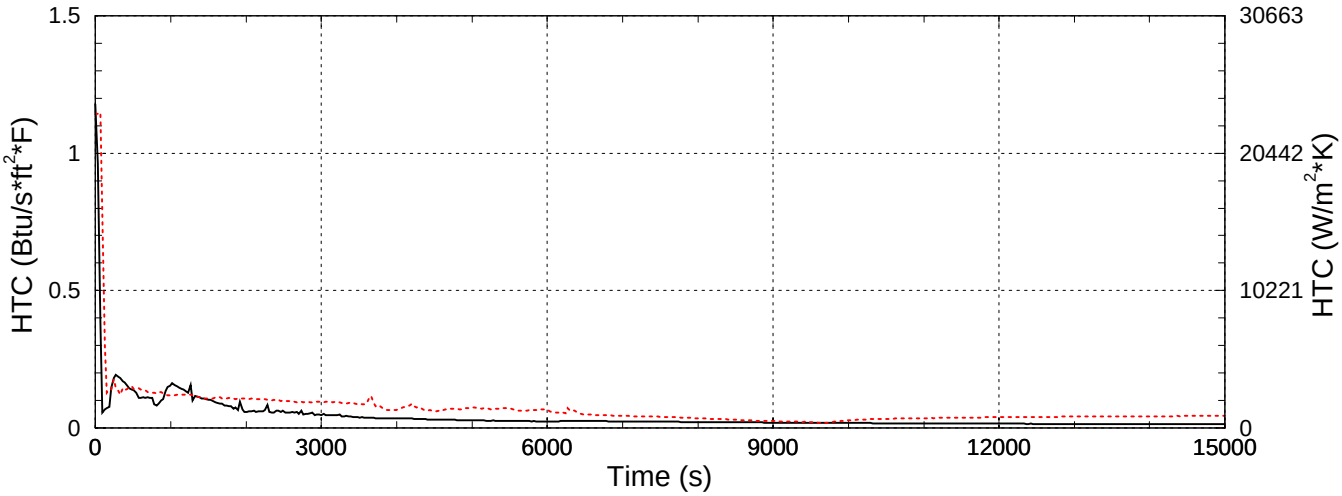




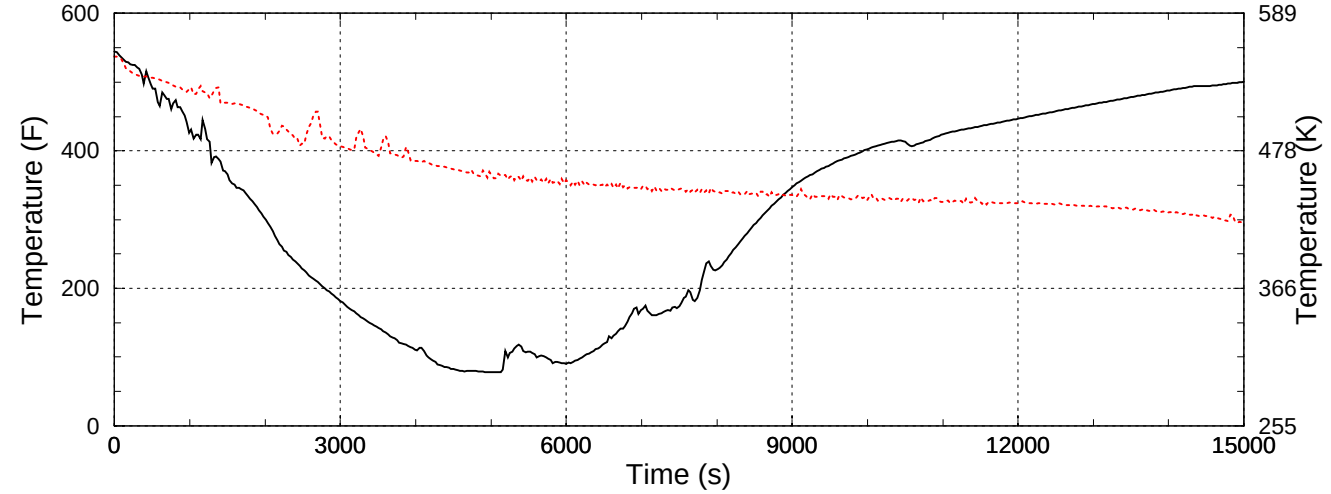
Beaver Valley Case 070 (black) −vs− Palisades Case 048 (red)

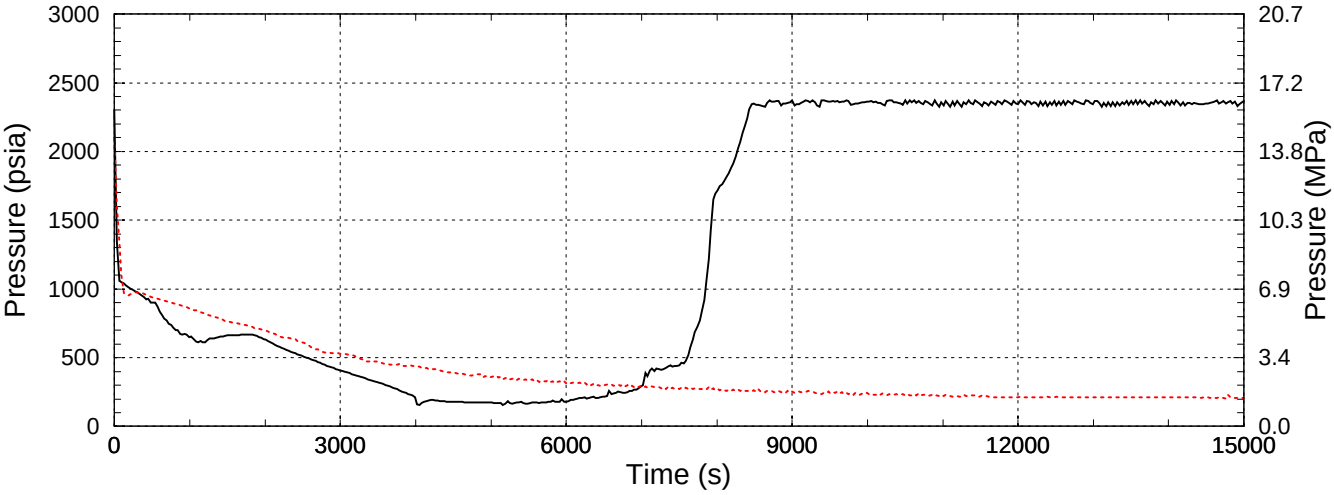


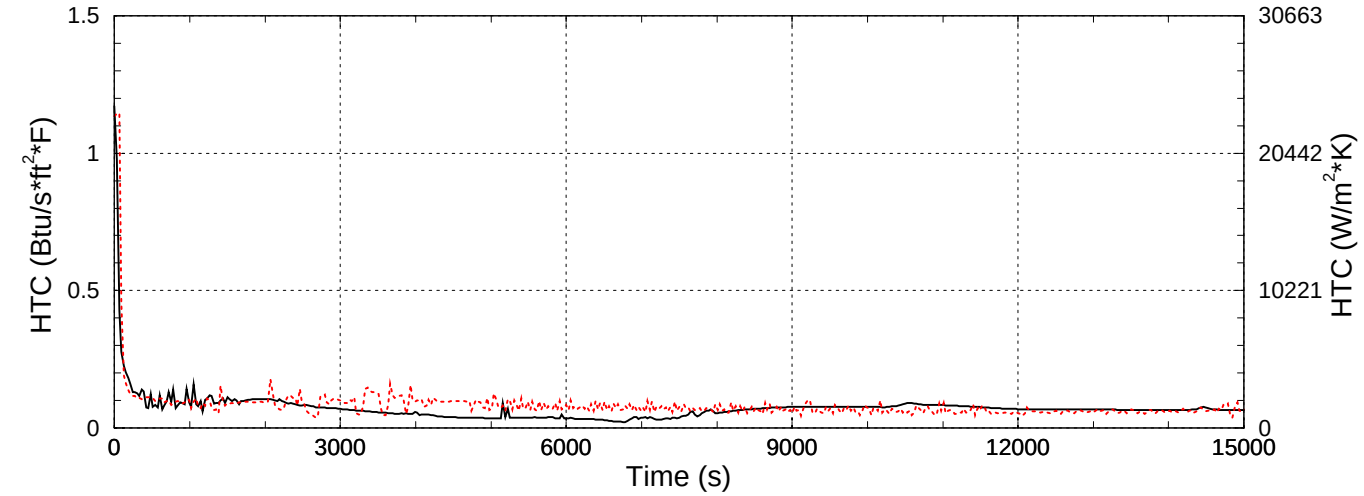




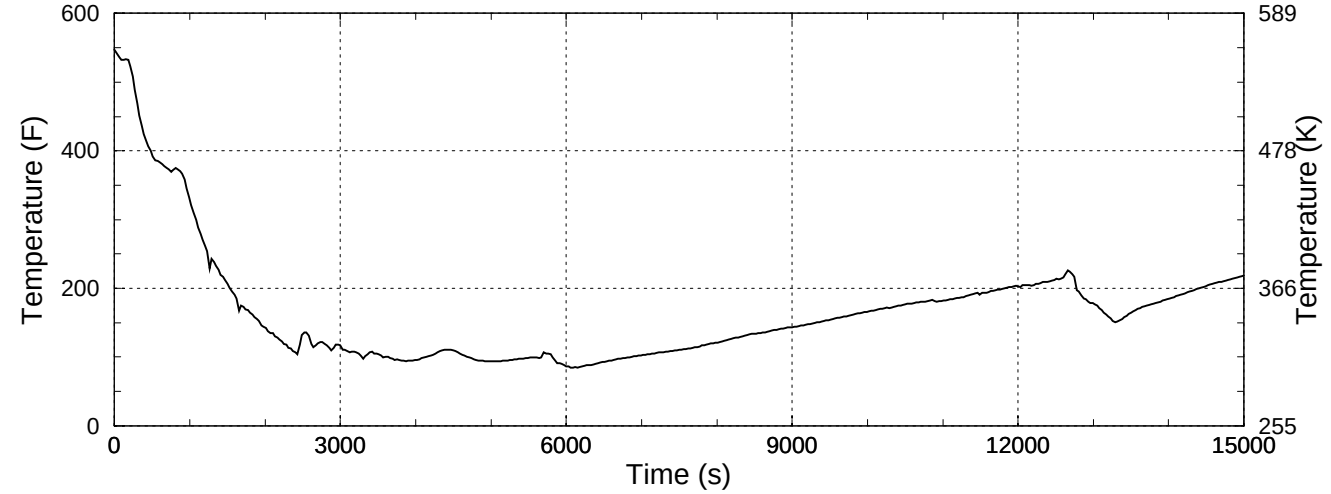
Beaver Valley Case 086 (black) −vs− Palisades Case 042 (red)

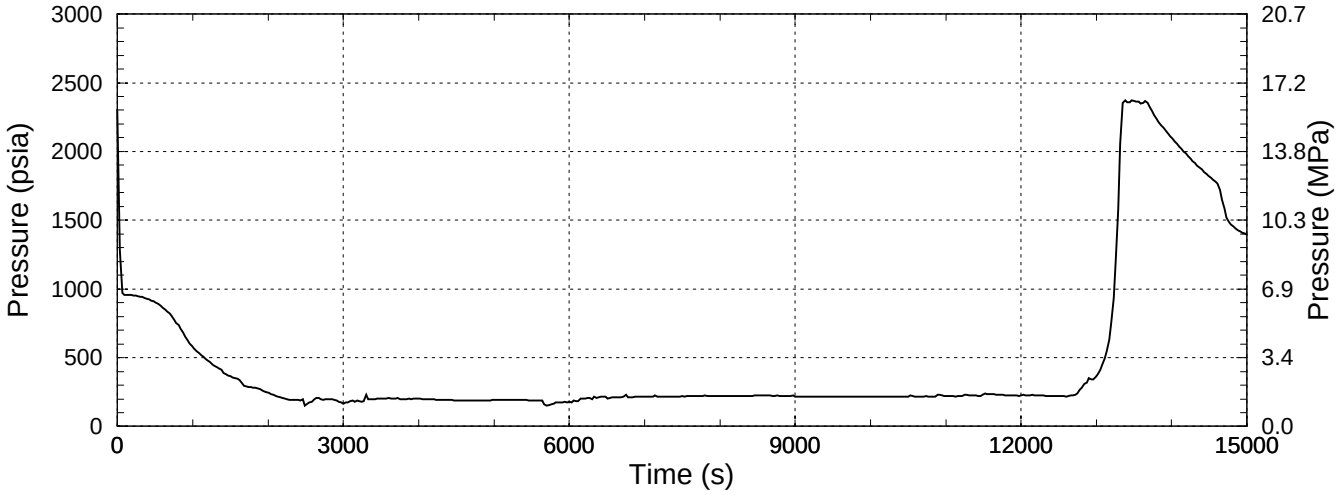


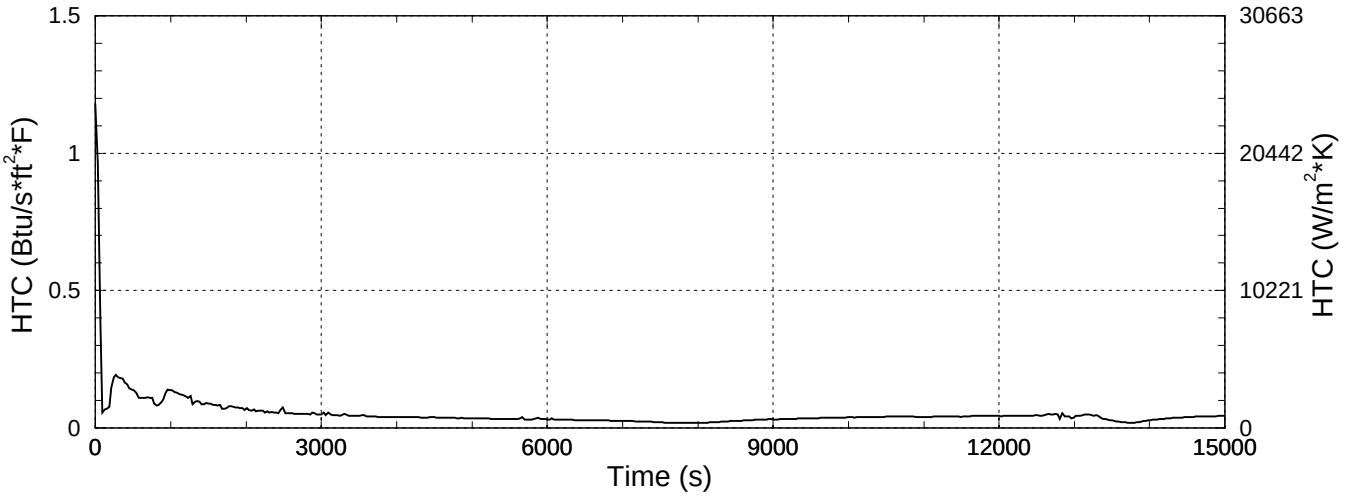




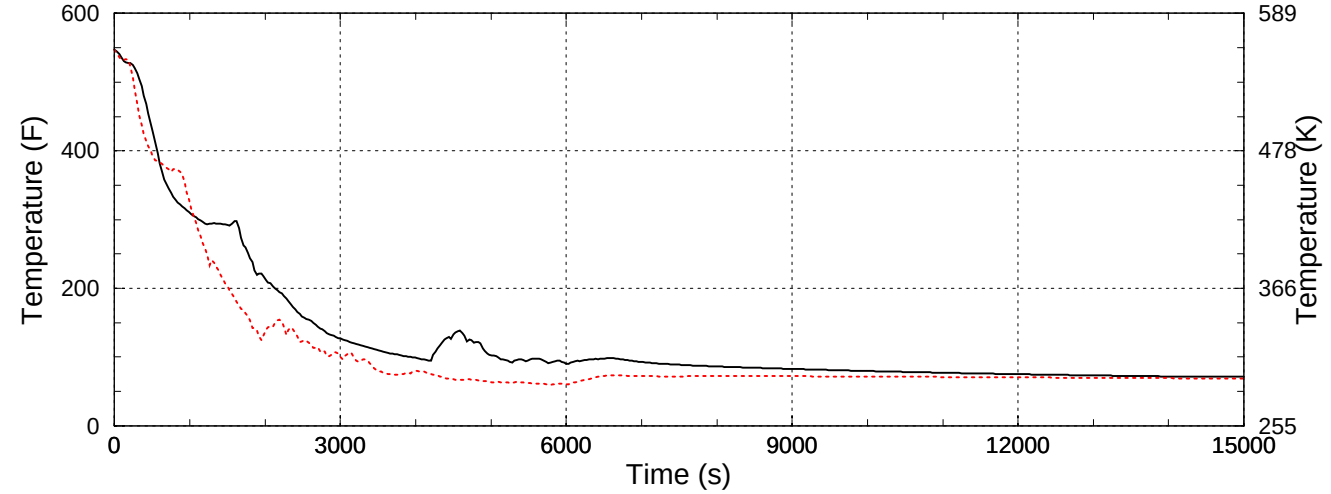
Beaver Valley Case 091 (black)

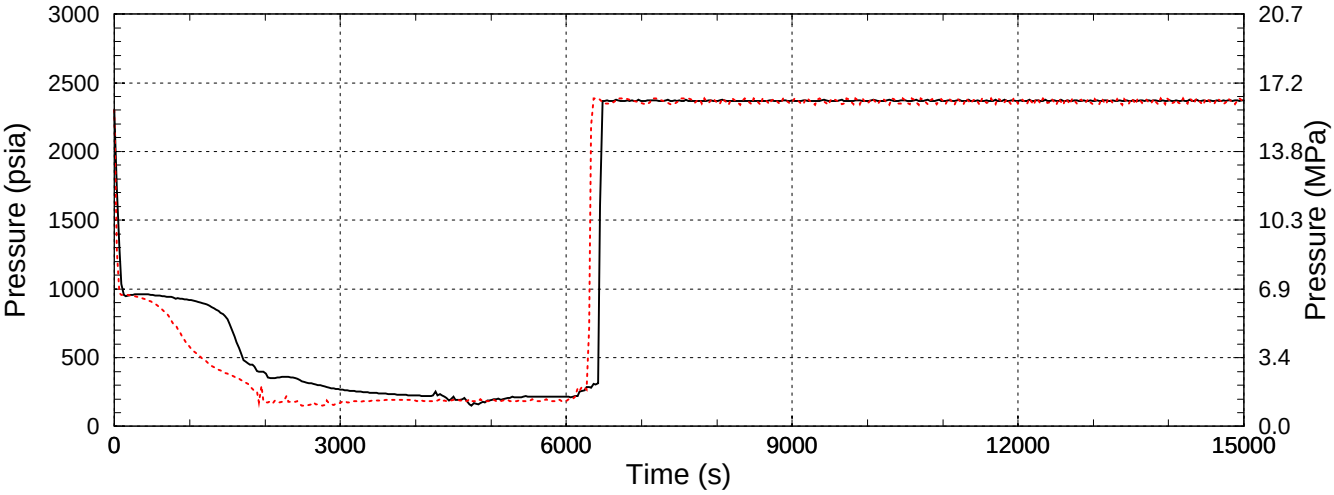


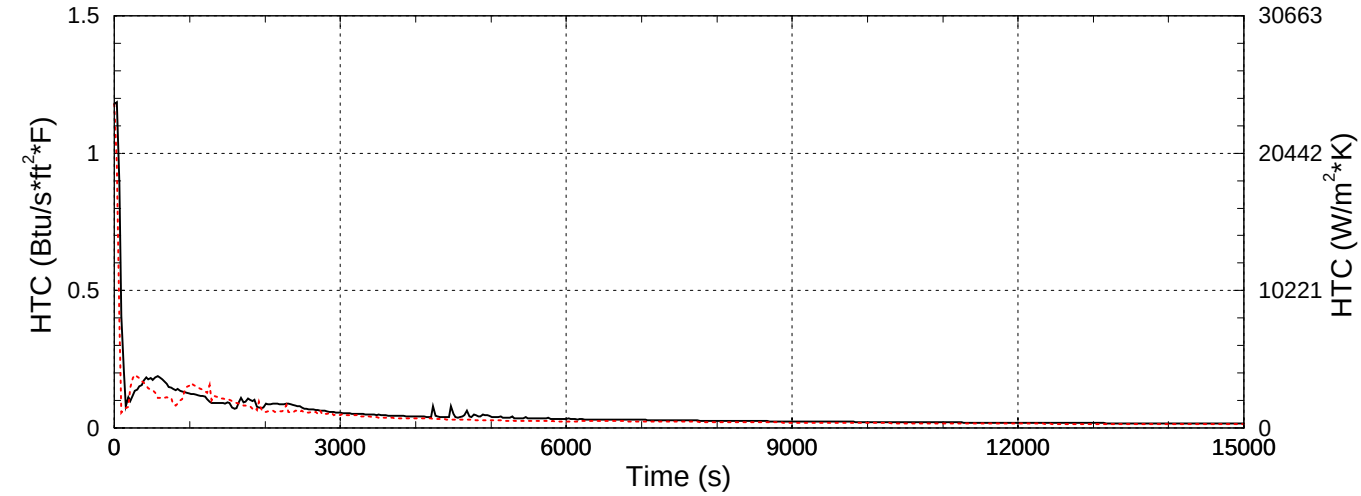




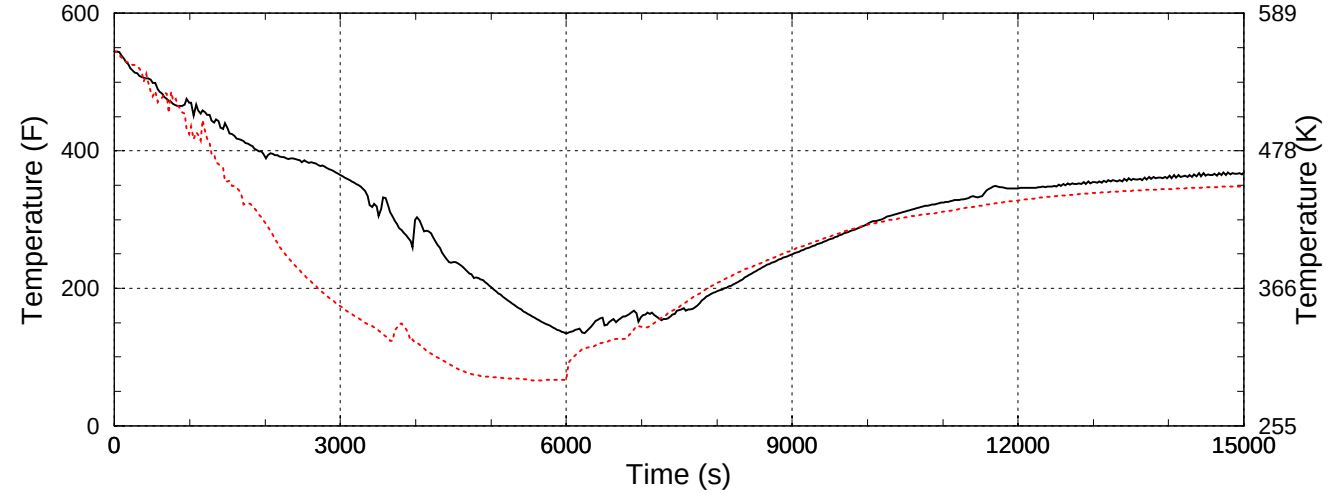
Beaver Valley Case 071 (black) −vs− Beaver Valley Case 070 (red)

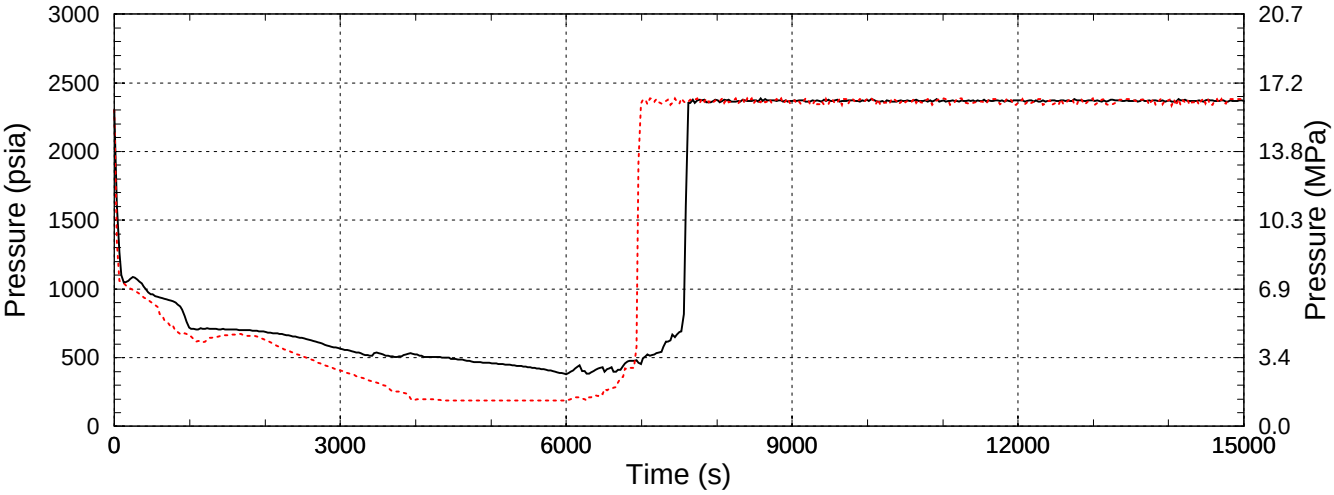


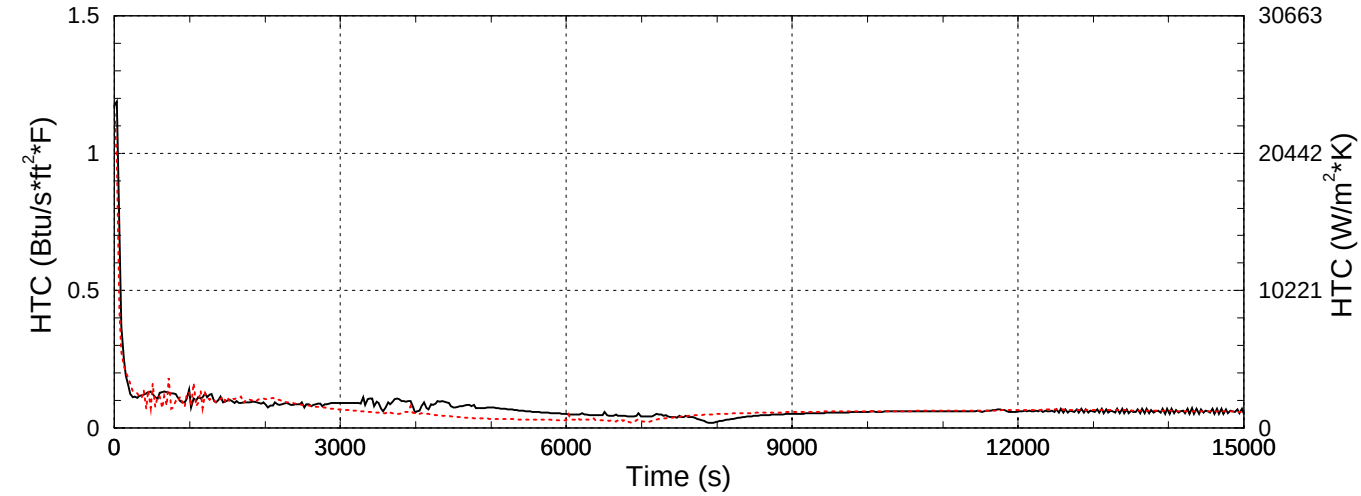




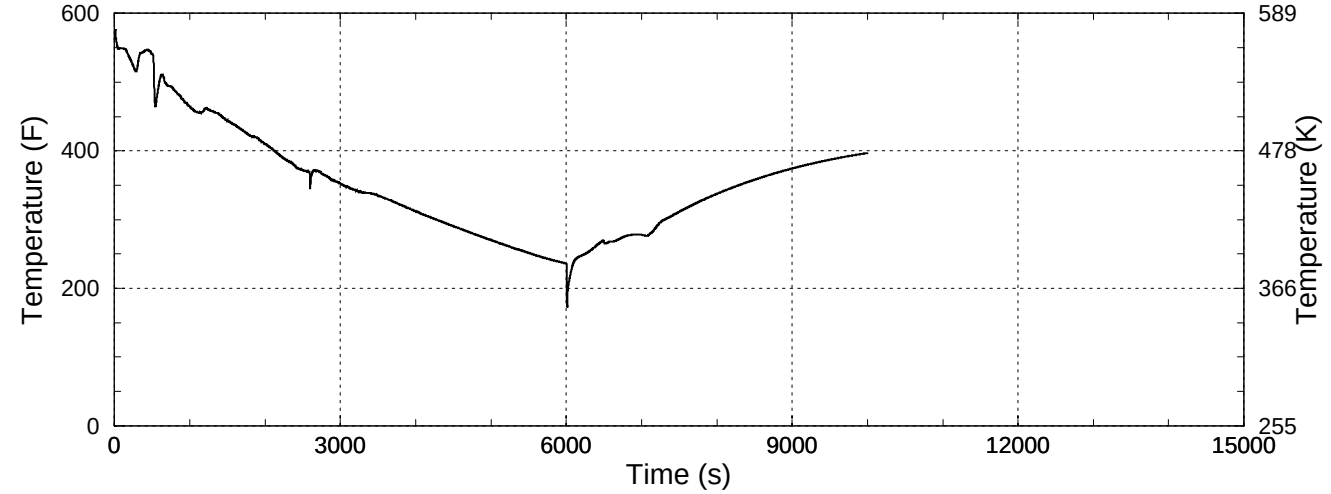
Beaver Valley Case 060 (black) −vs− Beaver Valley Case 062 (red)

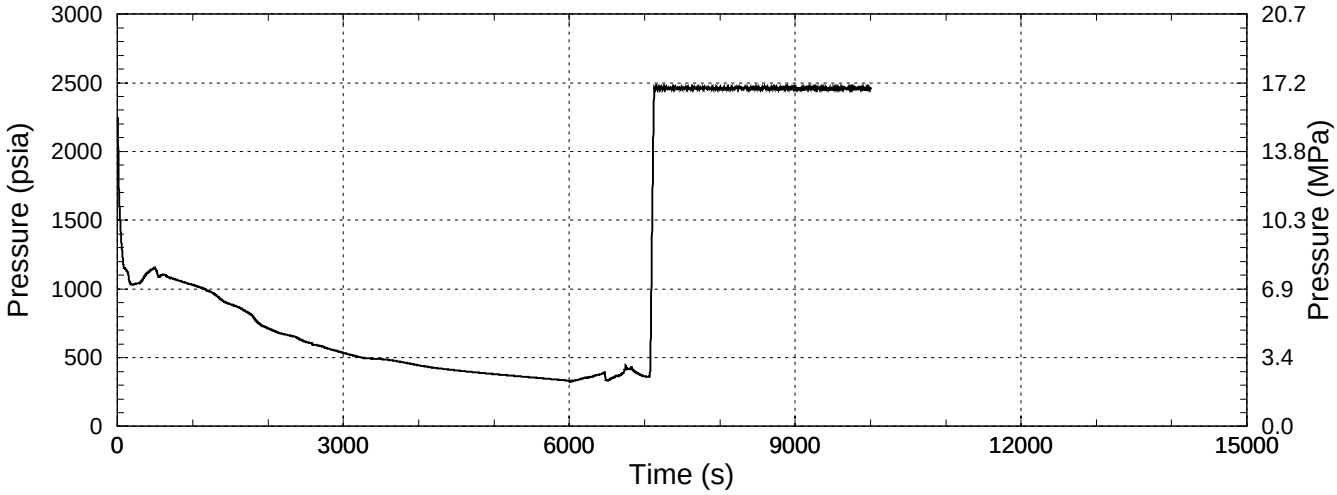


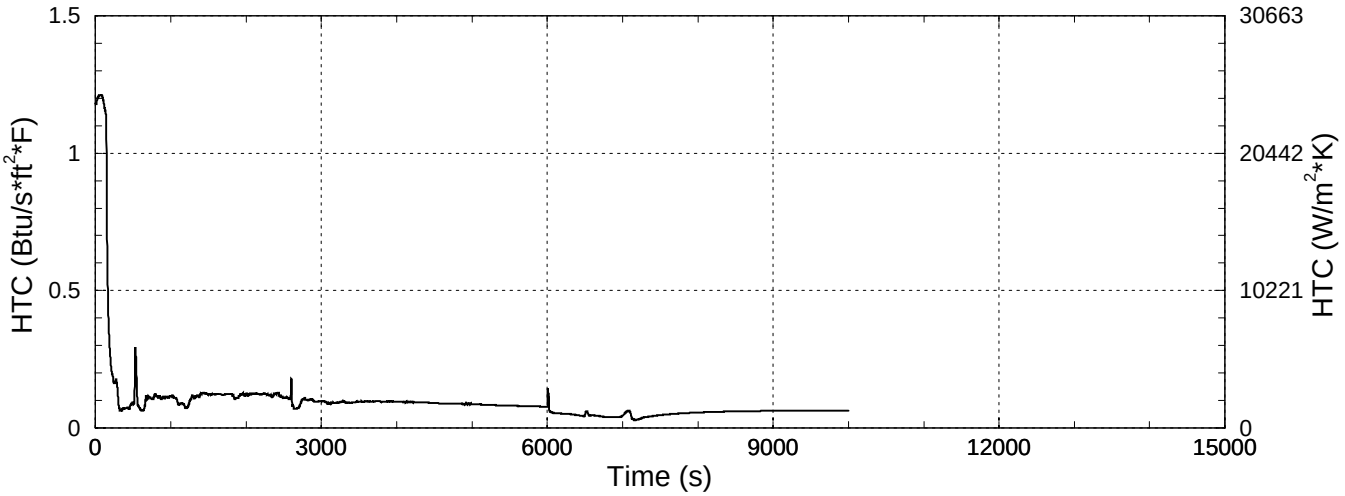




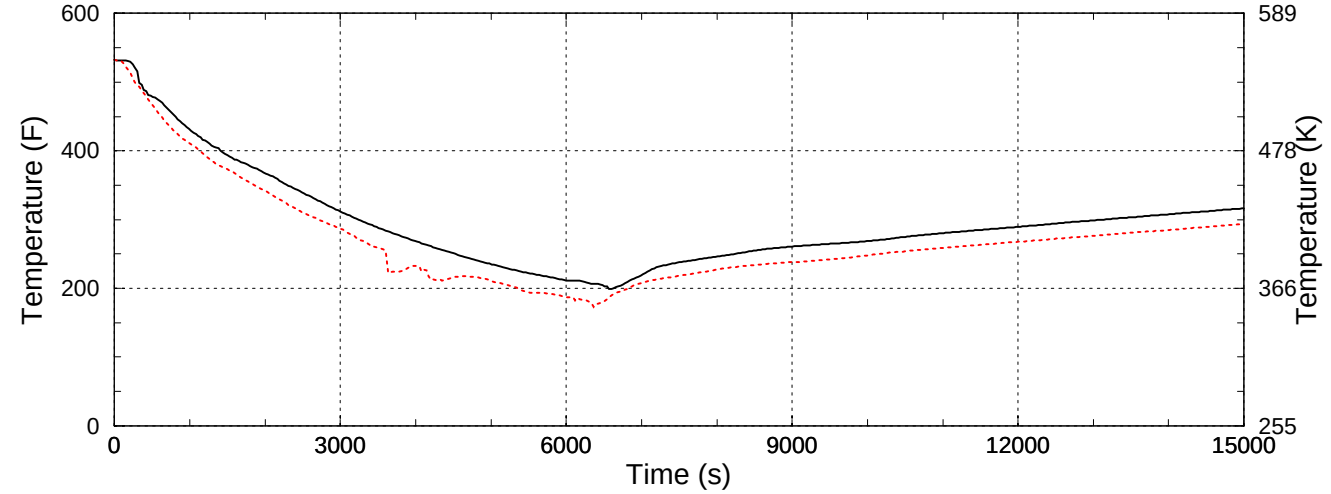
Oconee Case 109 (black)

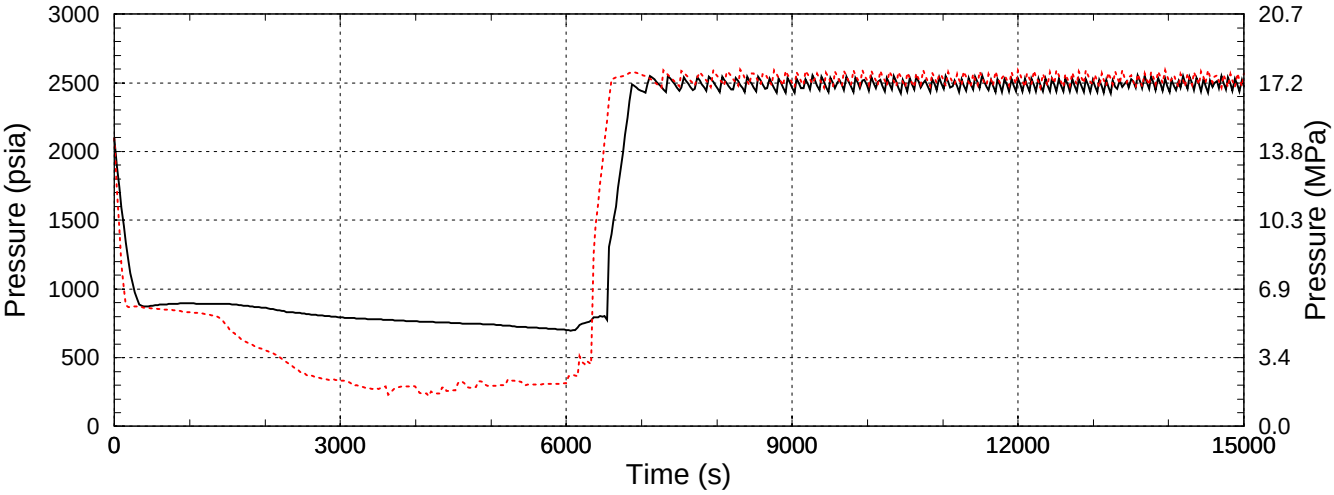


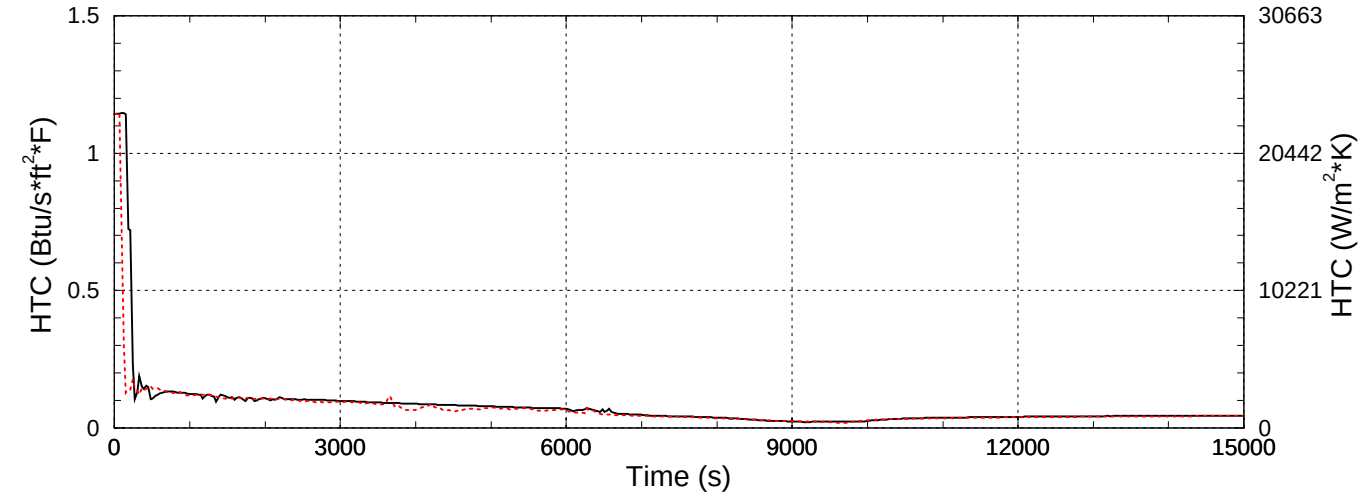




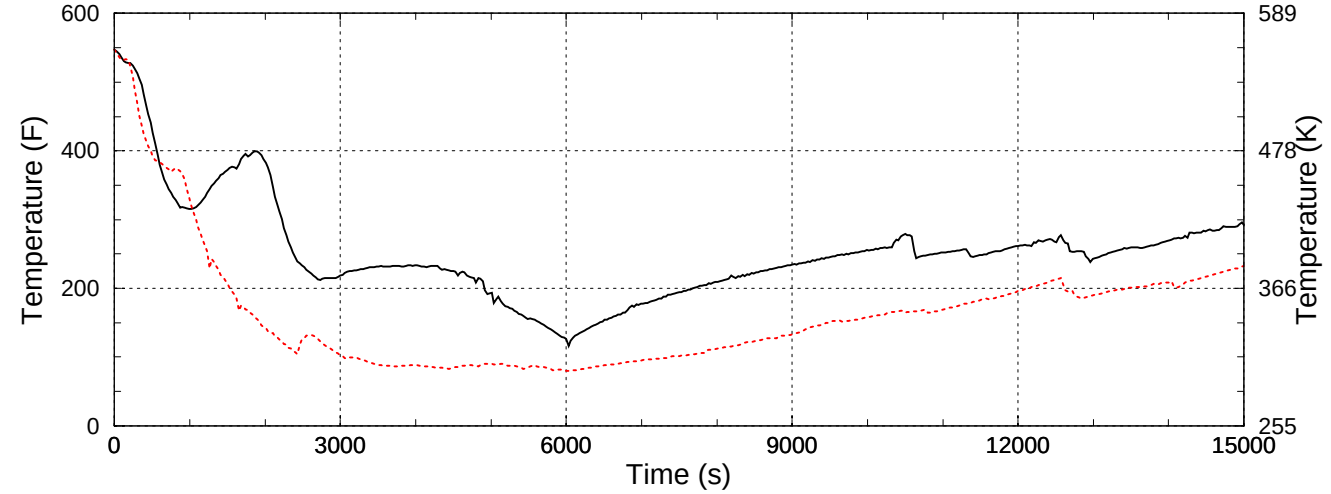
Palisades Case 065 (black) −vs− Palisades Case 048 (red)

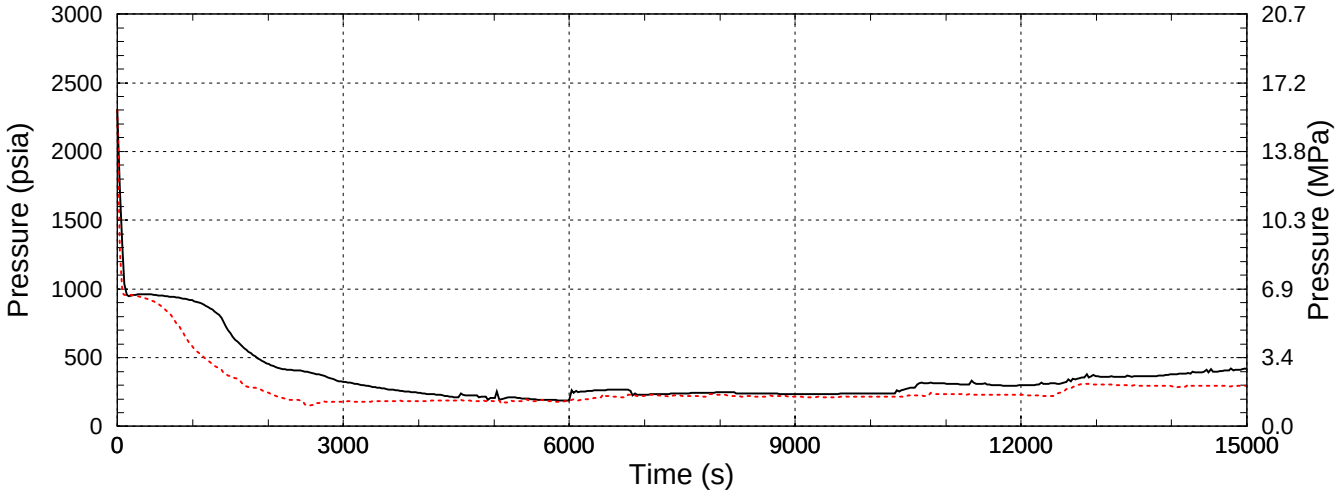


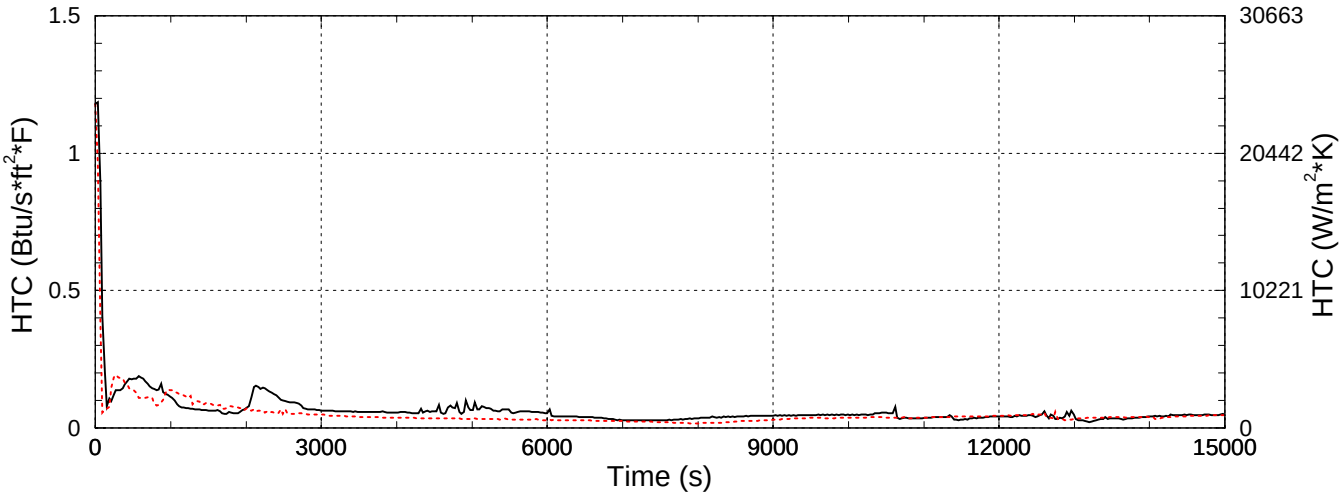




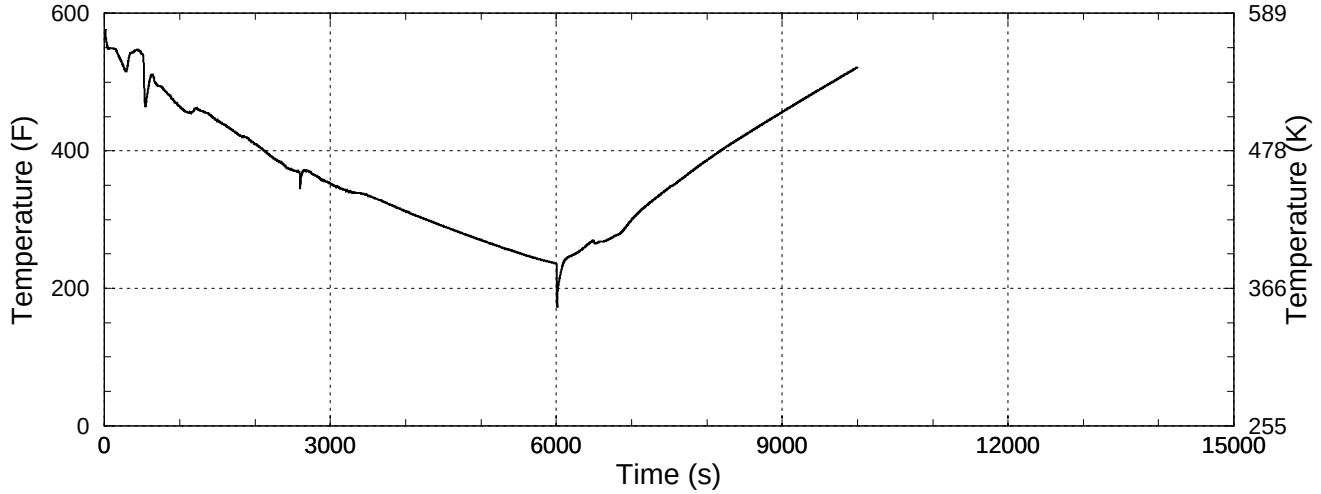
Beaver Valley Case 098 (black) −vs− Beaver Valley Case 089 (red)

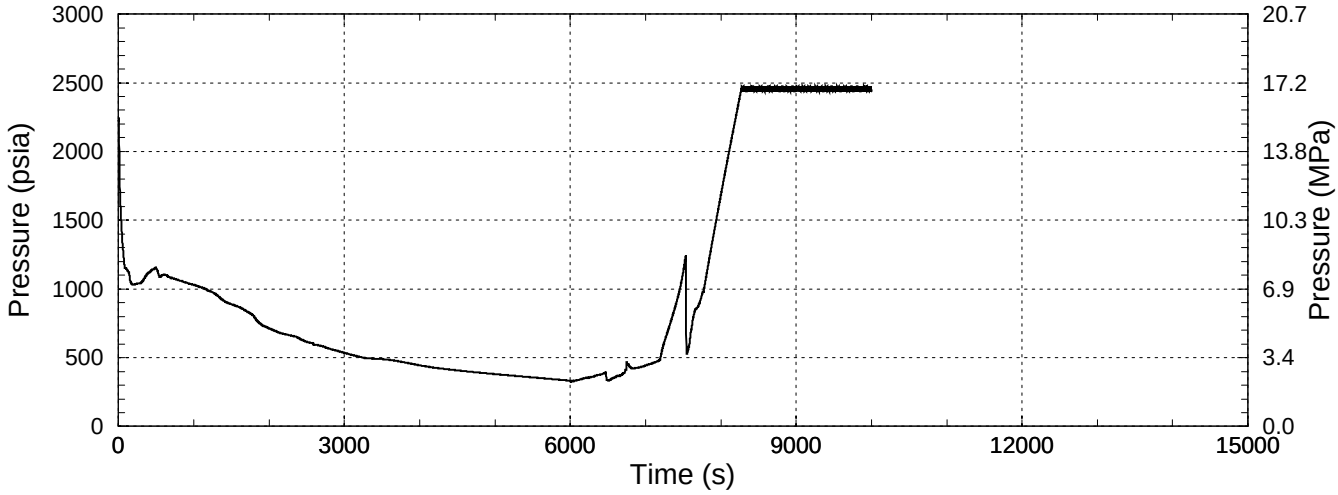


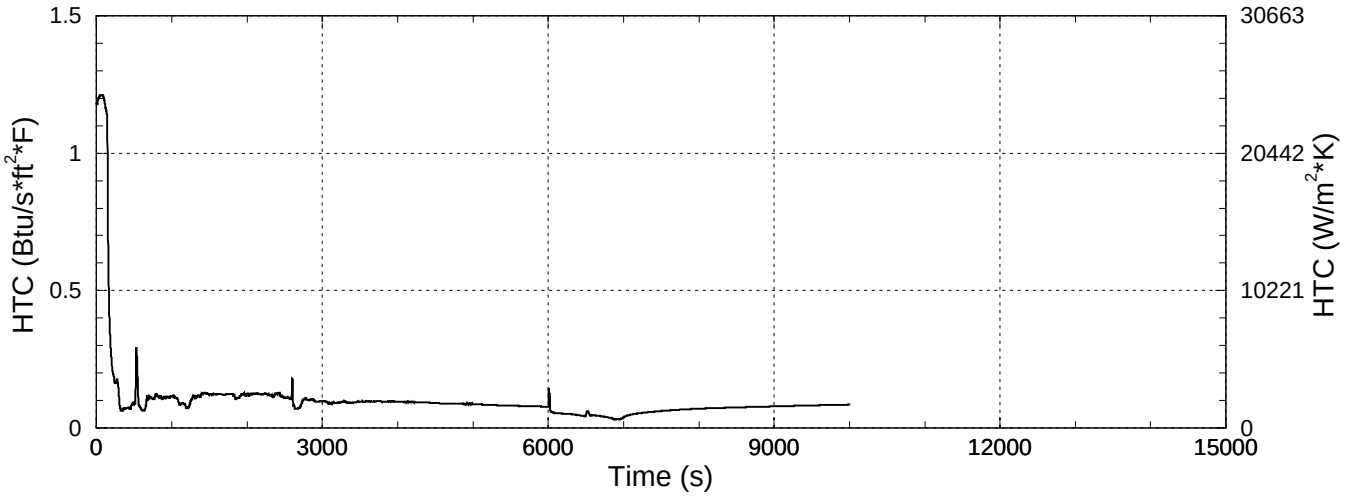




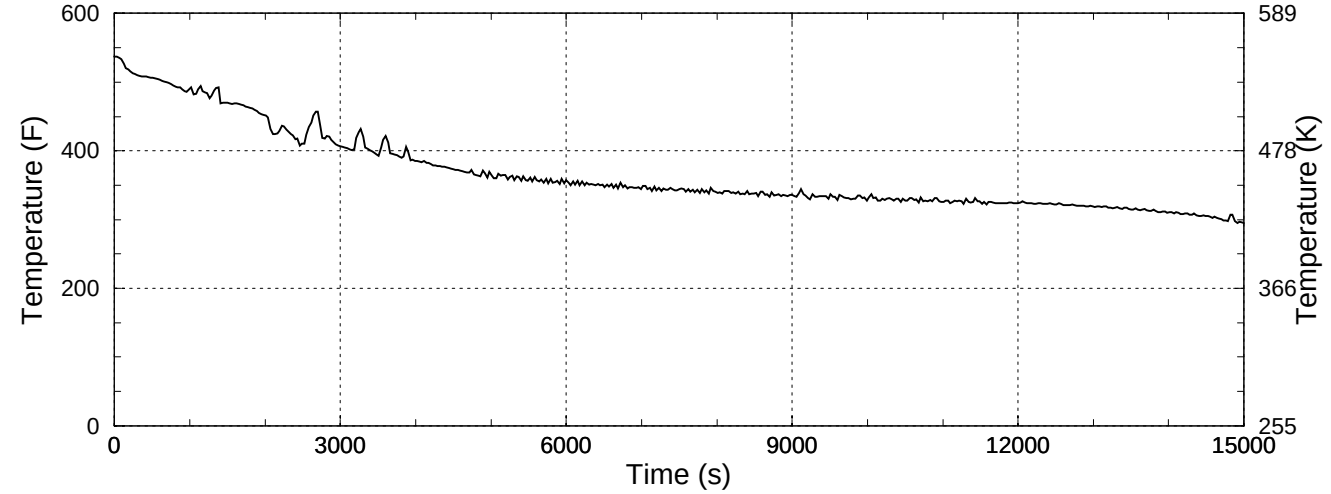
Oconee Case 112 (black)

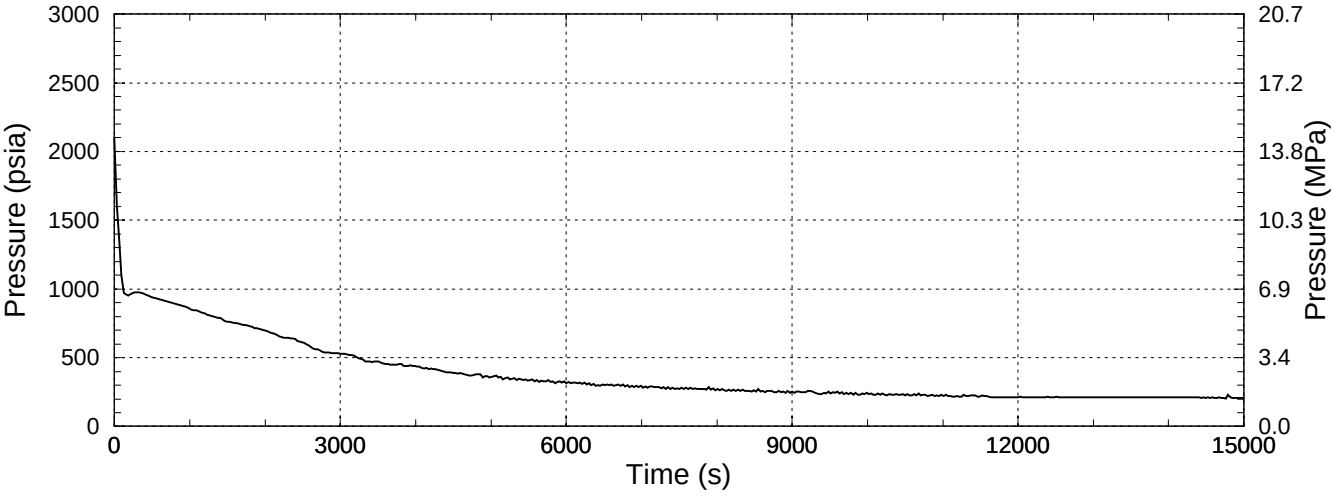


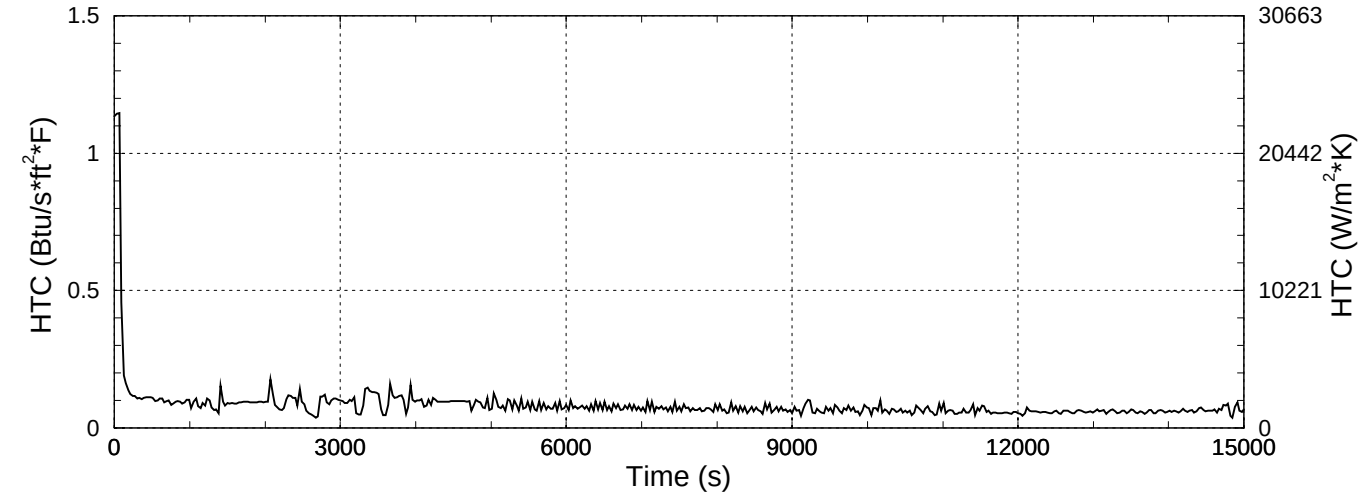




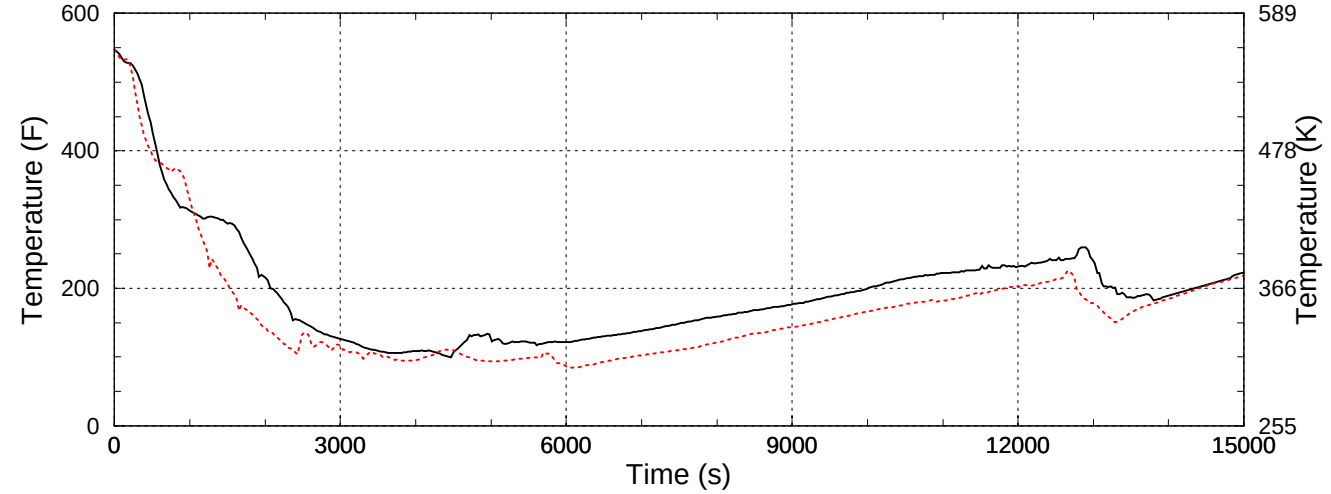
Palisades Case 042 (black)

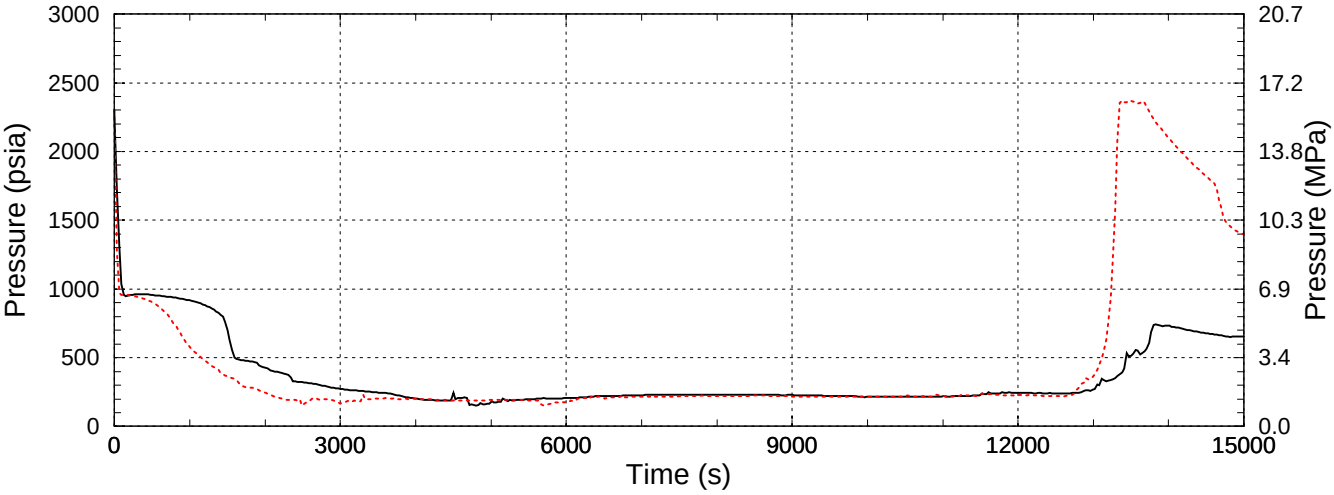


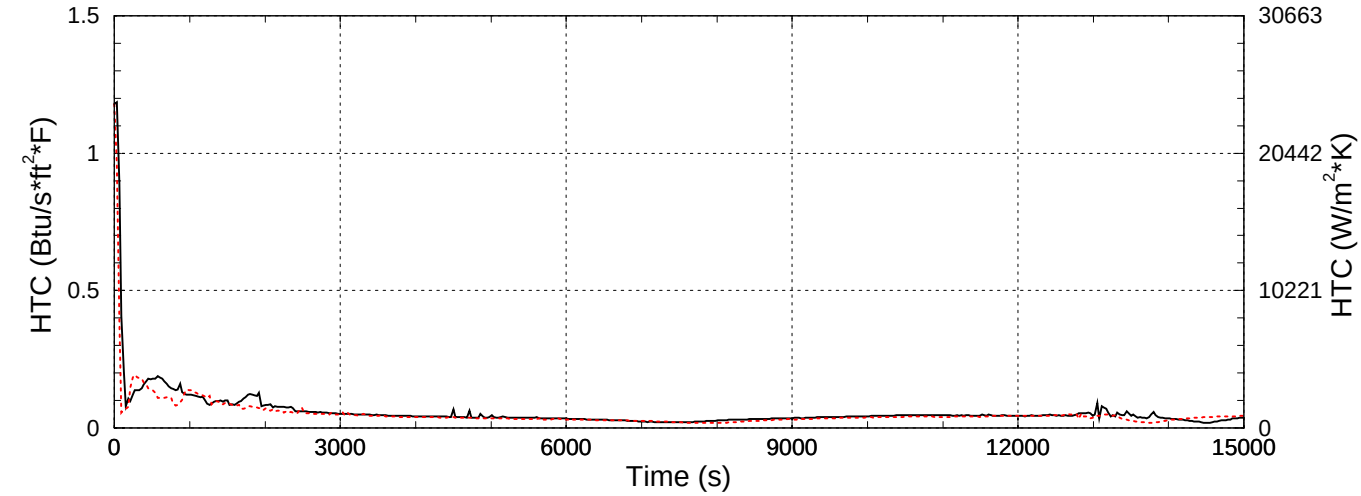




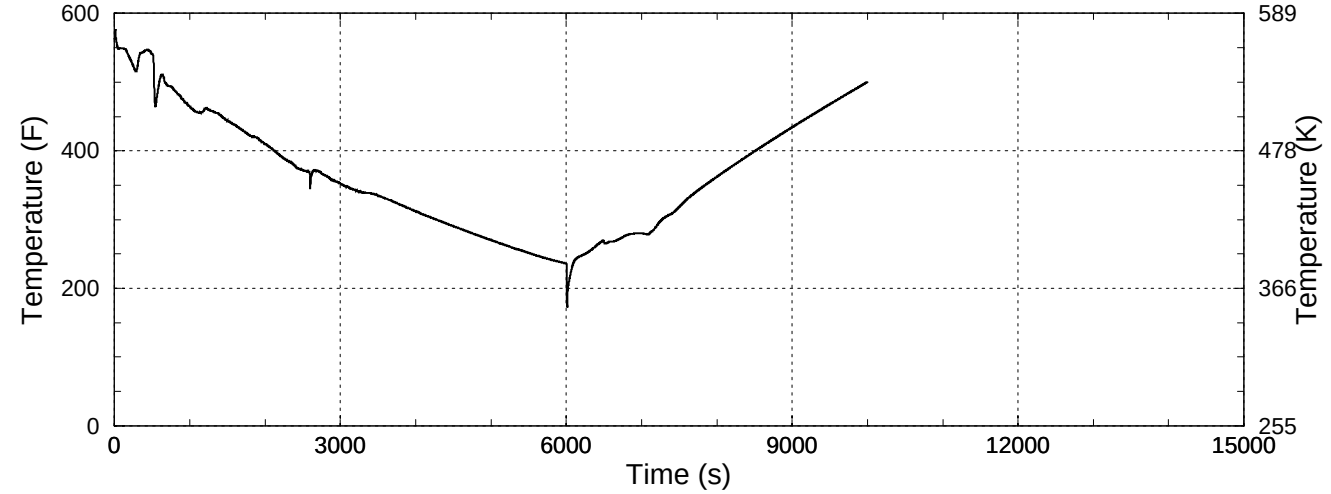
Beaver Valley Case 100 (black) −vs− Beaver Valley Case 091 (red)

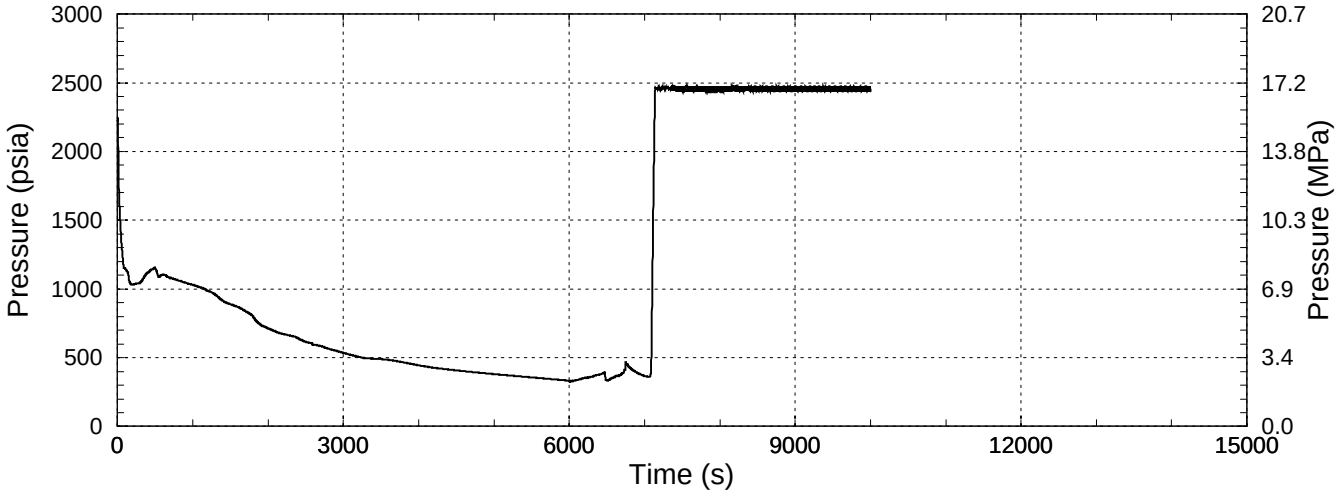


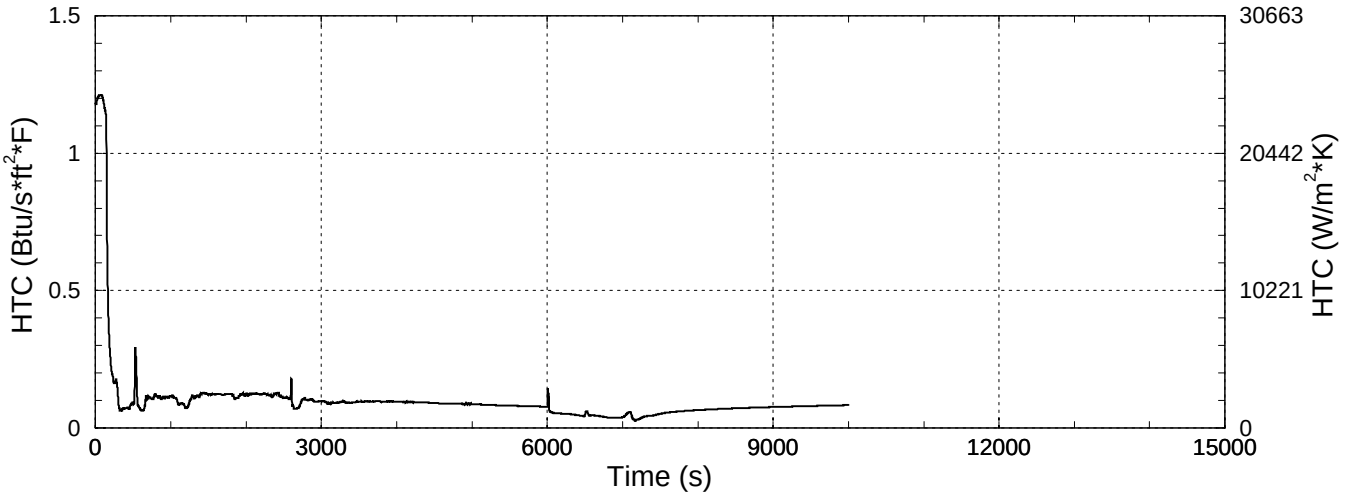




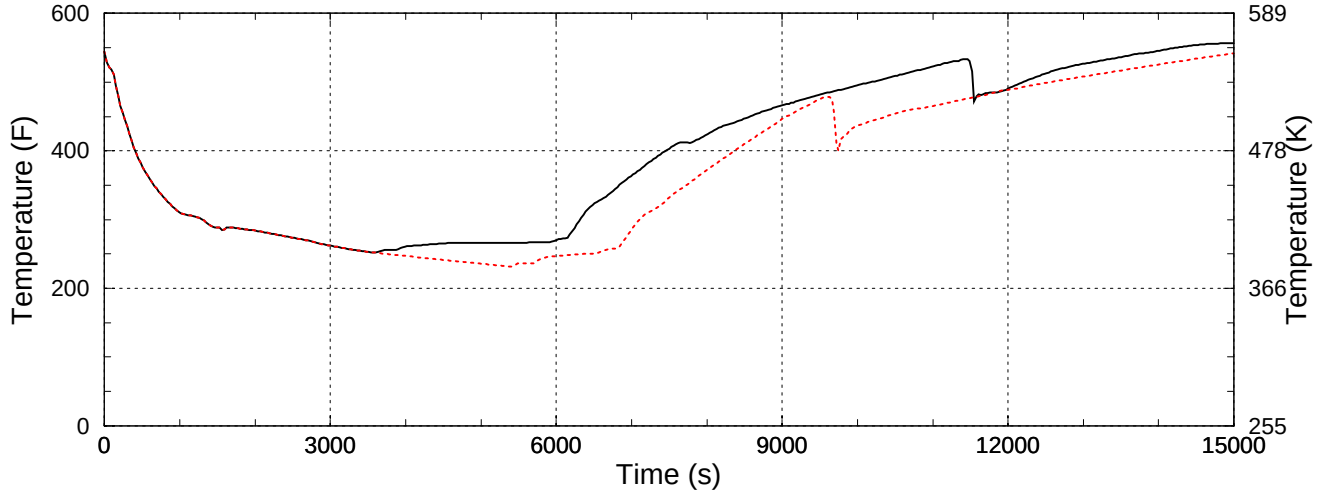
Oconee Case 113 (black)

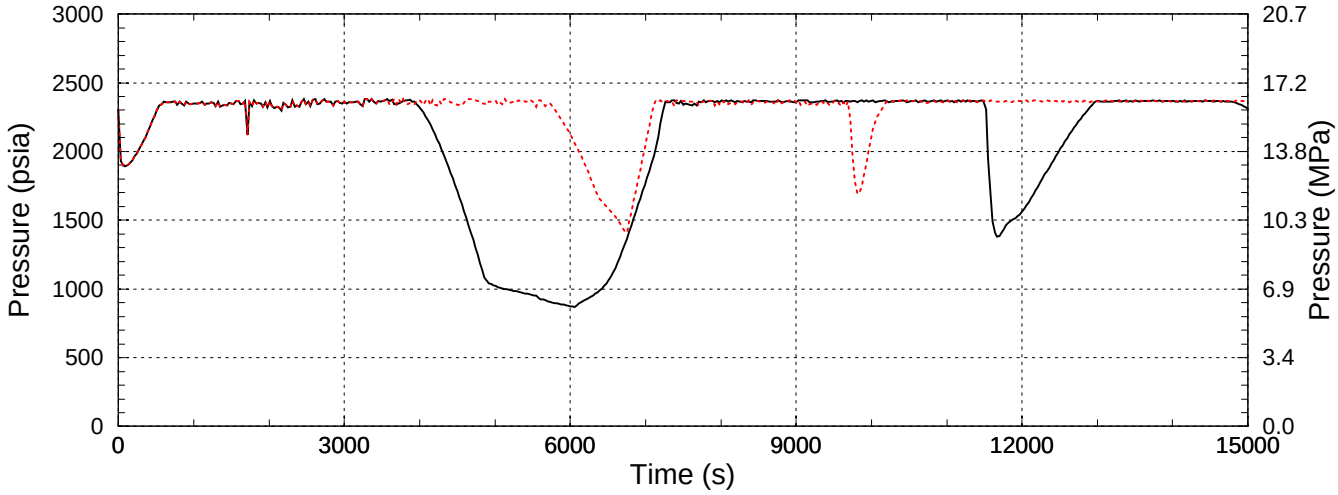


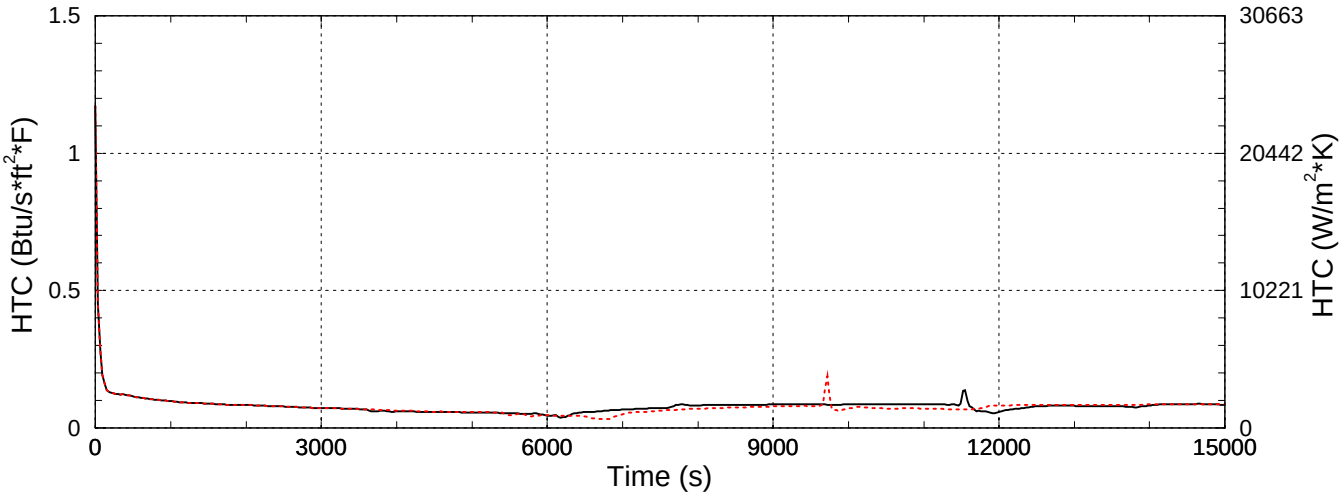




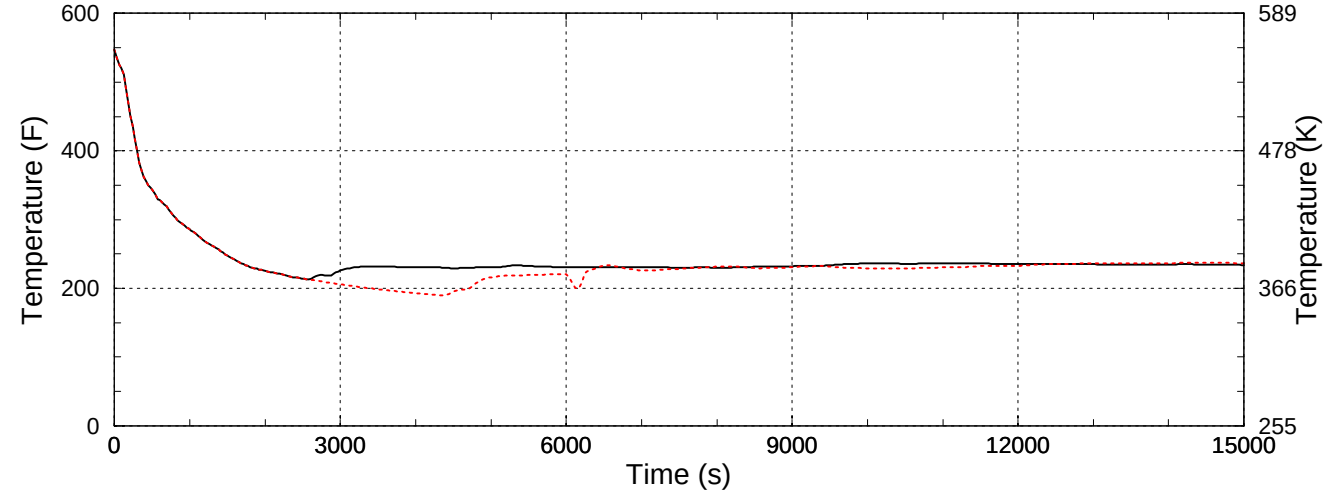
Beaver Valley Case 108 (black) −vs− Beaver Valley Case 110 (red)

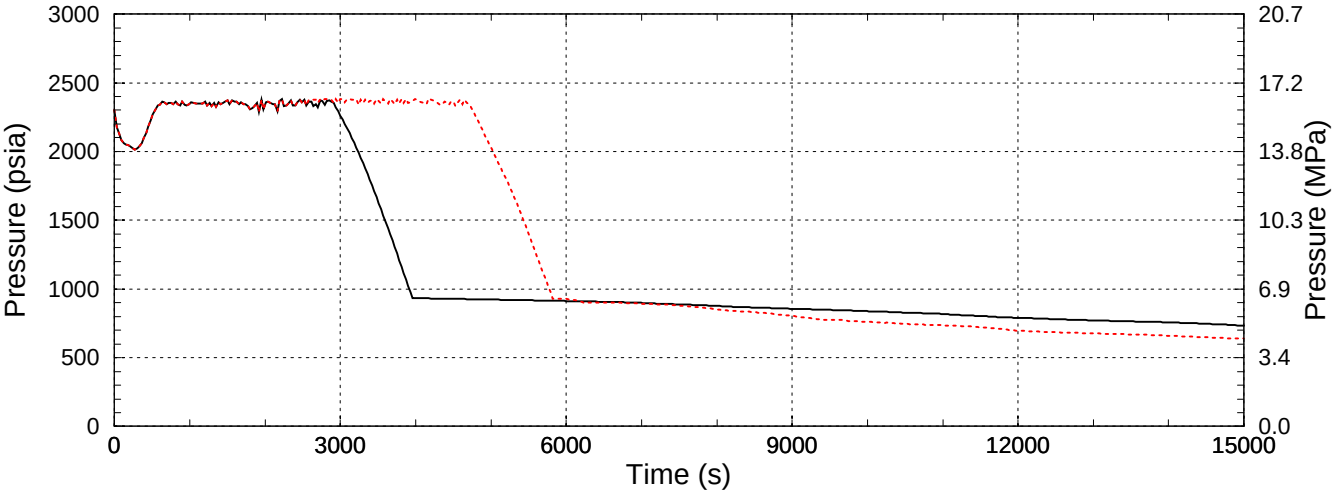


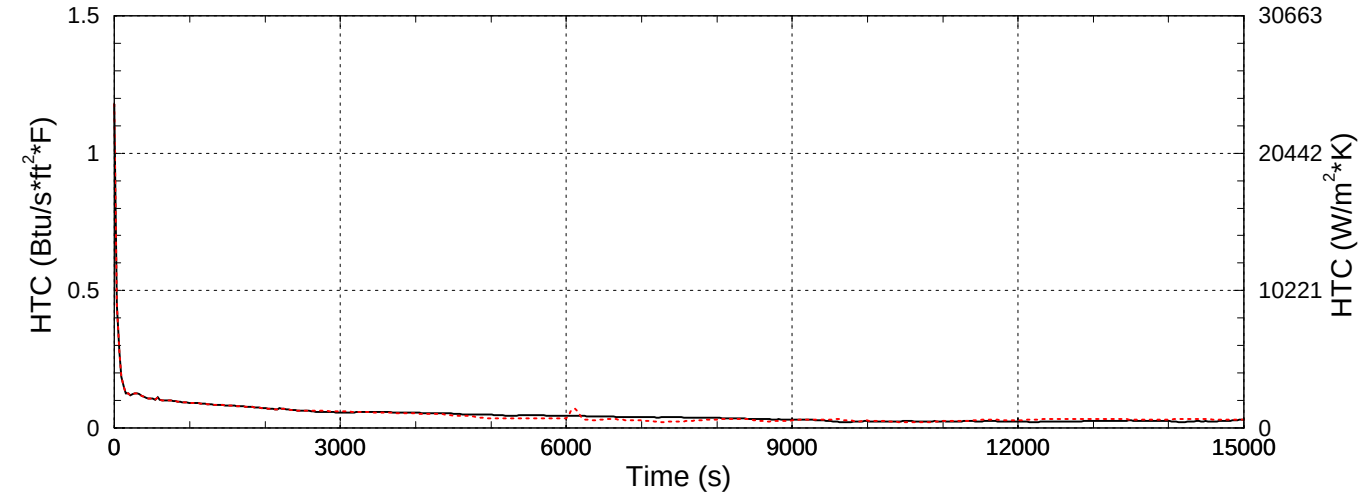




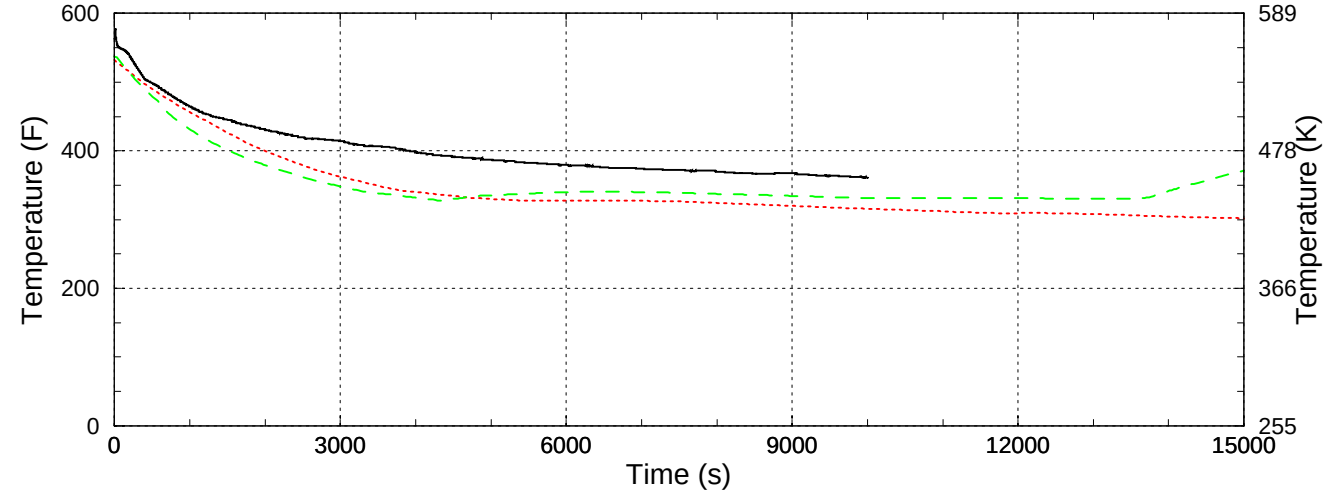
Beaver Valley Case 109 (black) −vs− Beaver Valley Case 111 (red)

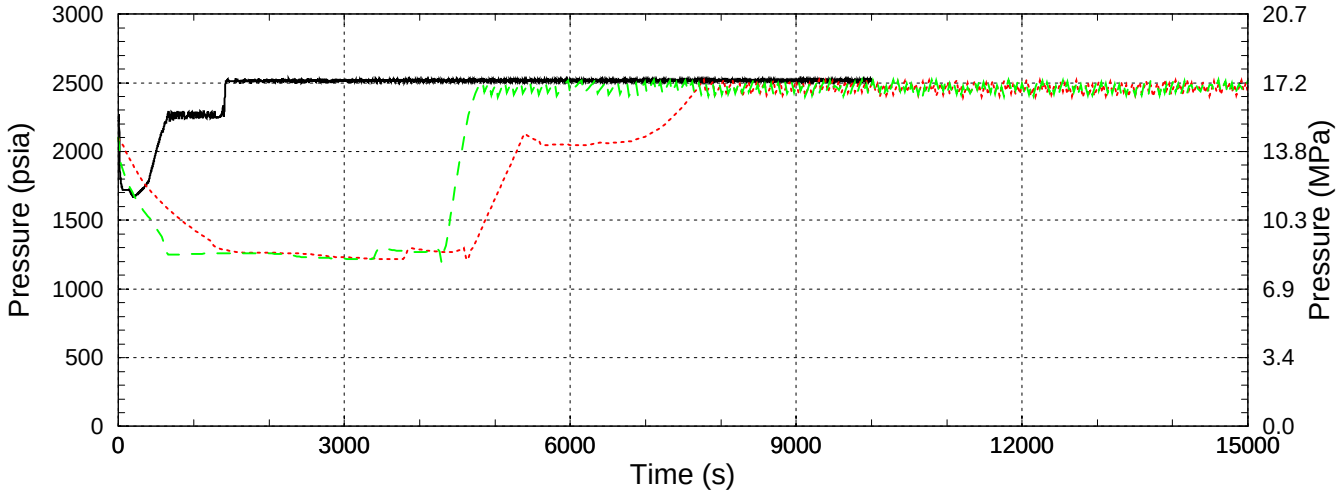


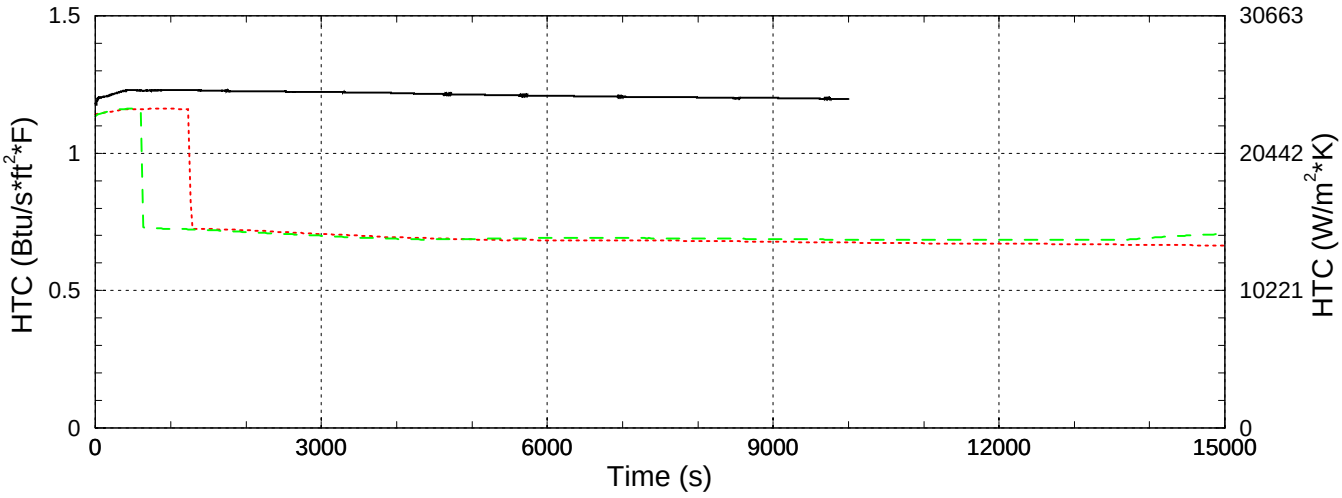




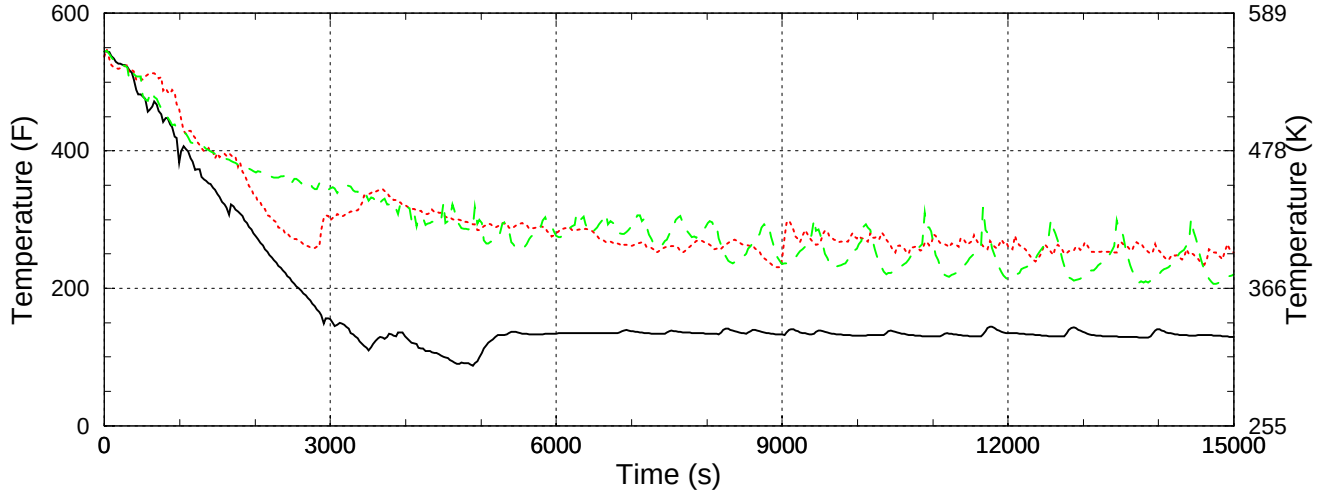
Oconee Case 028 (black) −vs− Palisades Case 019 (red) −vs− Palisades Case 055 (green)

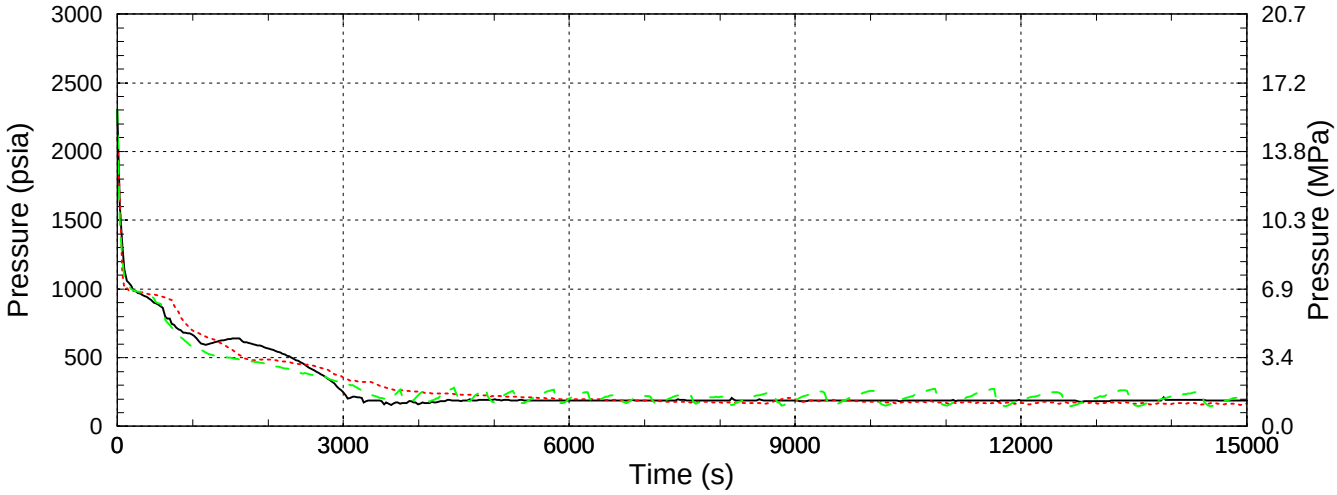


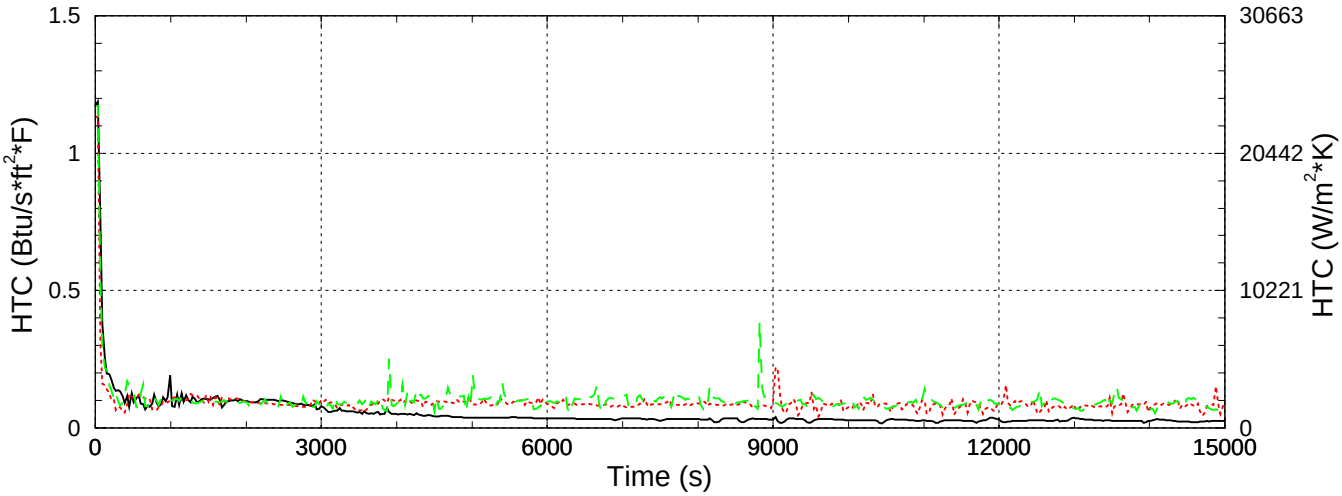




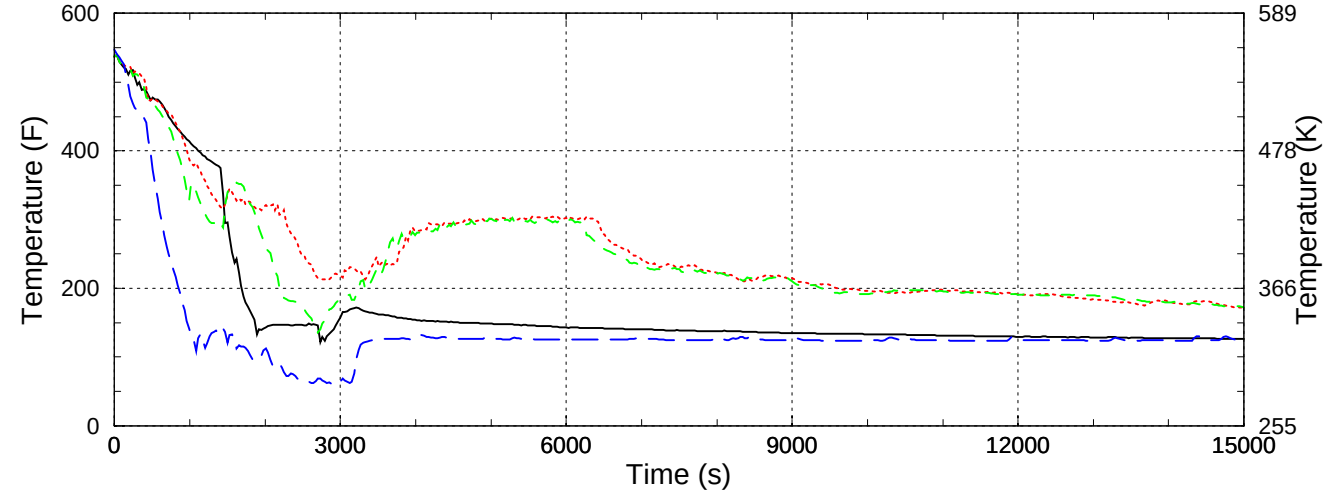
Beaver Valley Case 114 (black) −vs− Palisades Case 061 (red) −vs− Beaver Valley Case 115 (green)

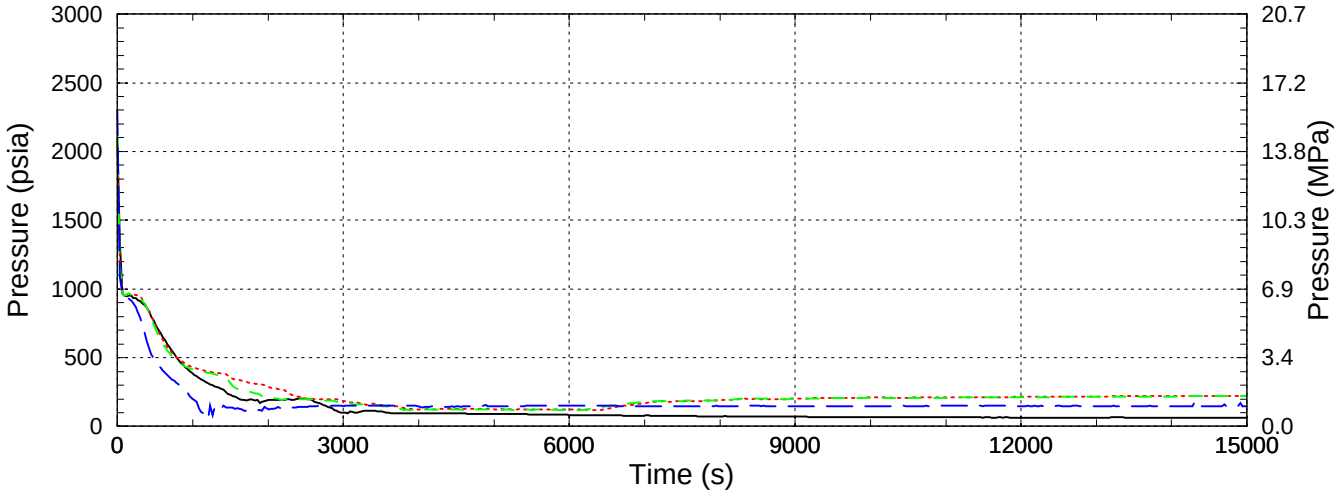


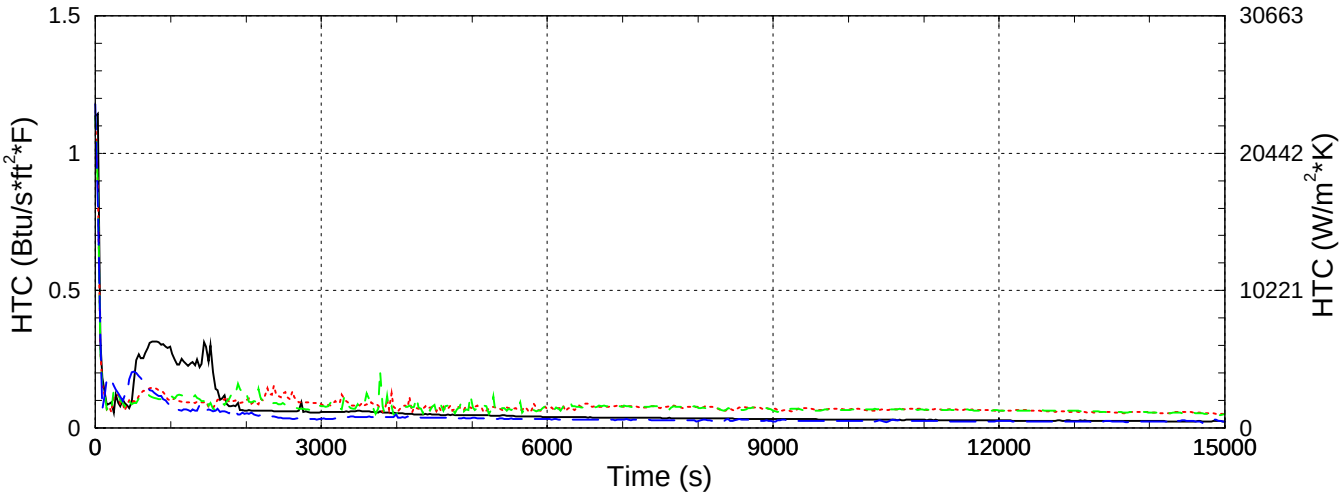




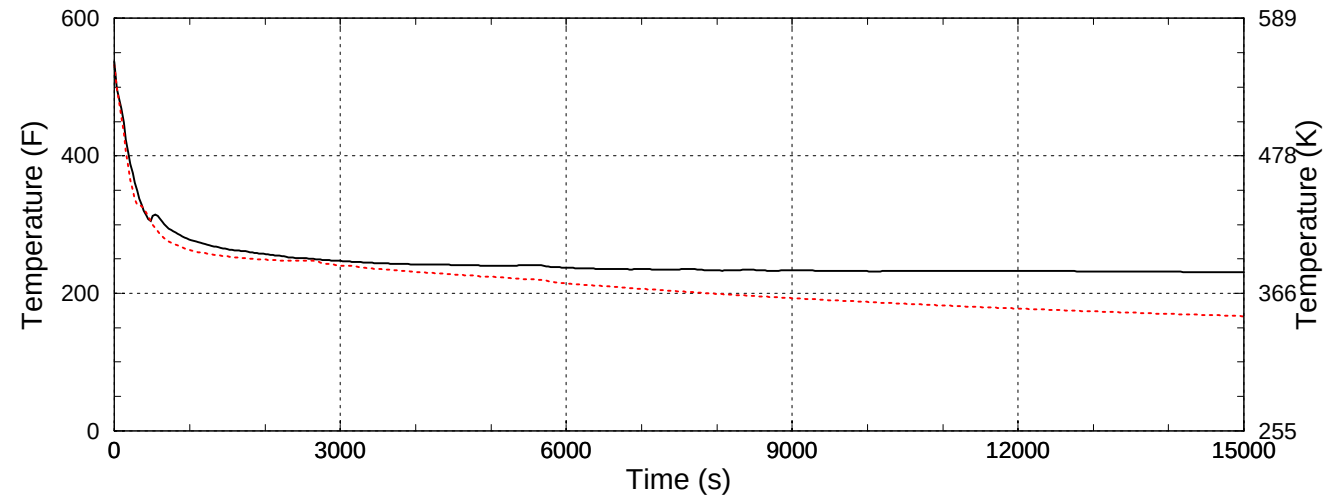
Palisades Case 064 (black) −vs− Palisades Case 059 (red) −vs− Palisades Case 058 (green)
−vs− Beaver Valley Case 056 (blue)

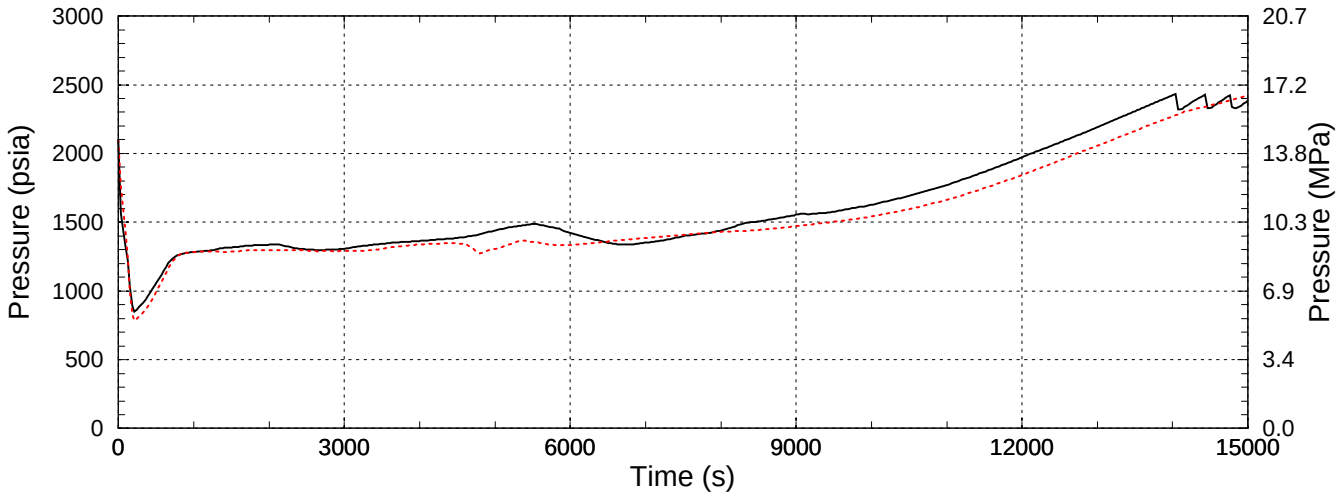


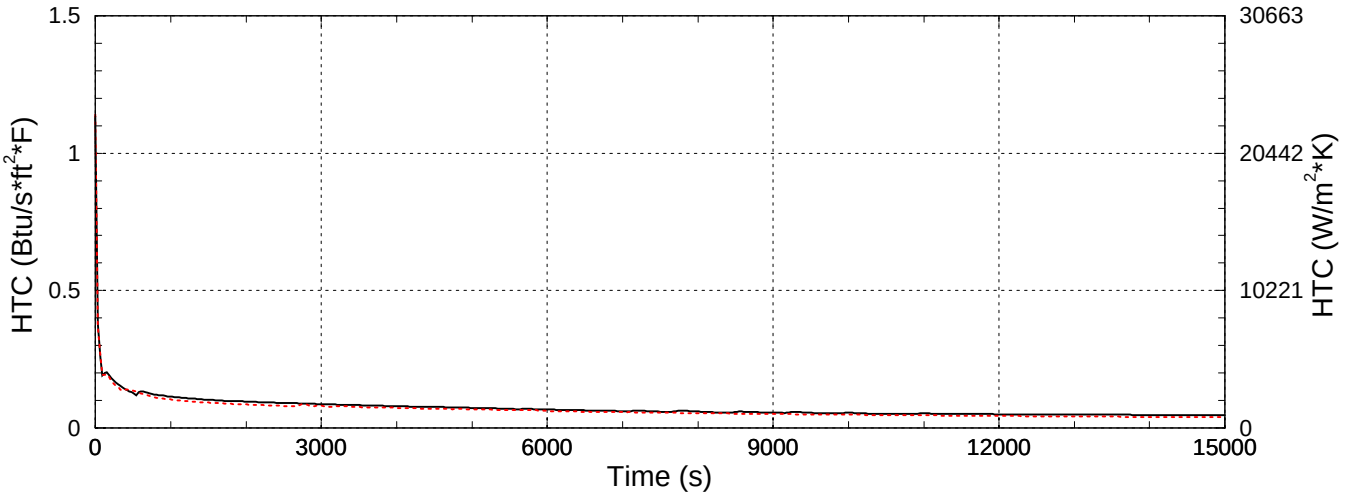




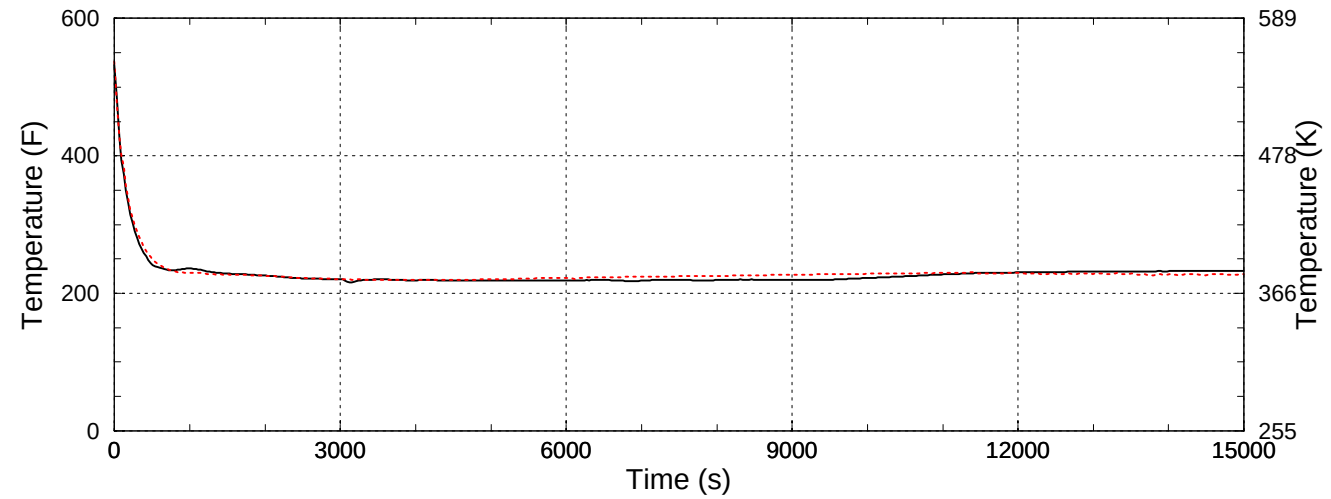
Palisades Case 027 (black) −vs− Palisades Case 050 (red)

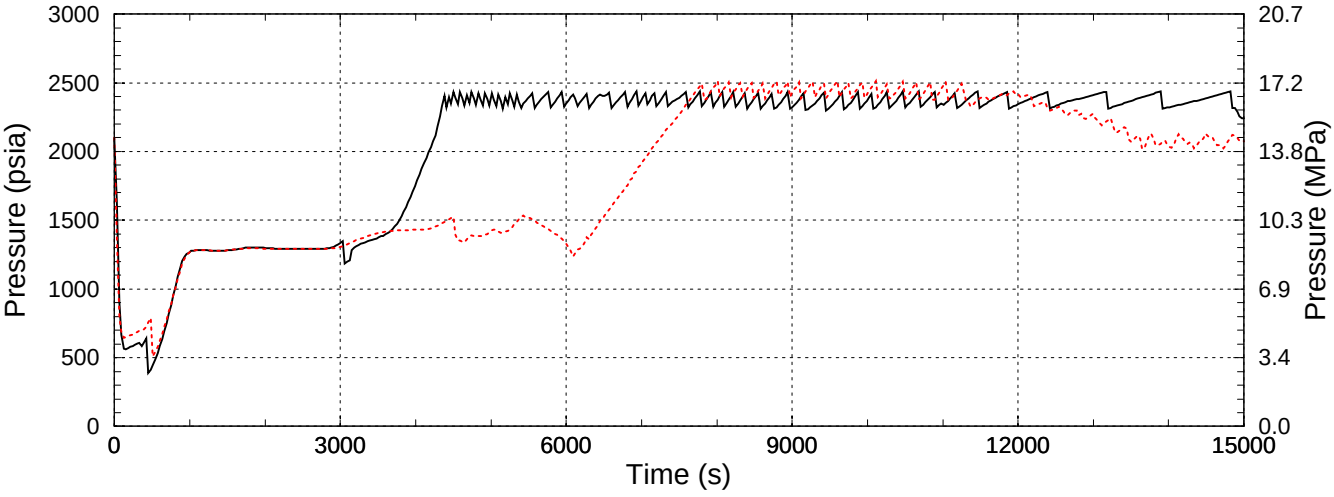


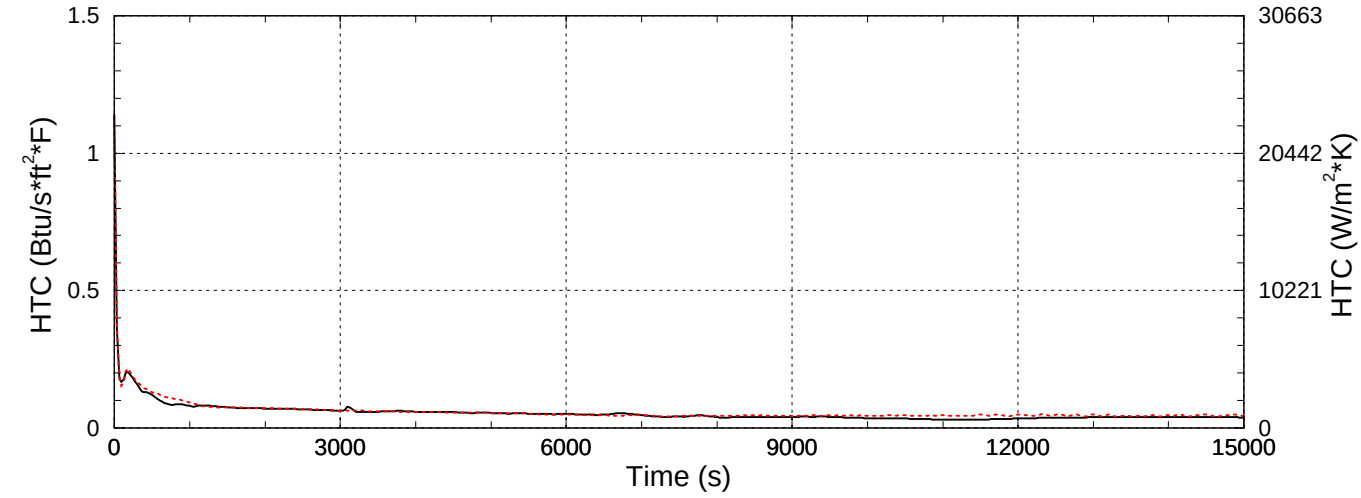




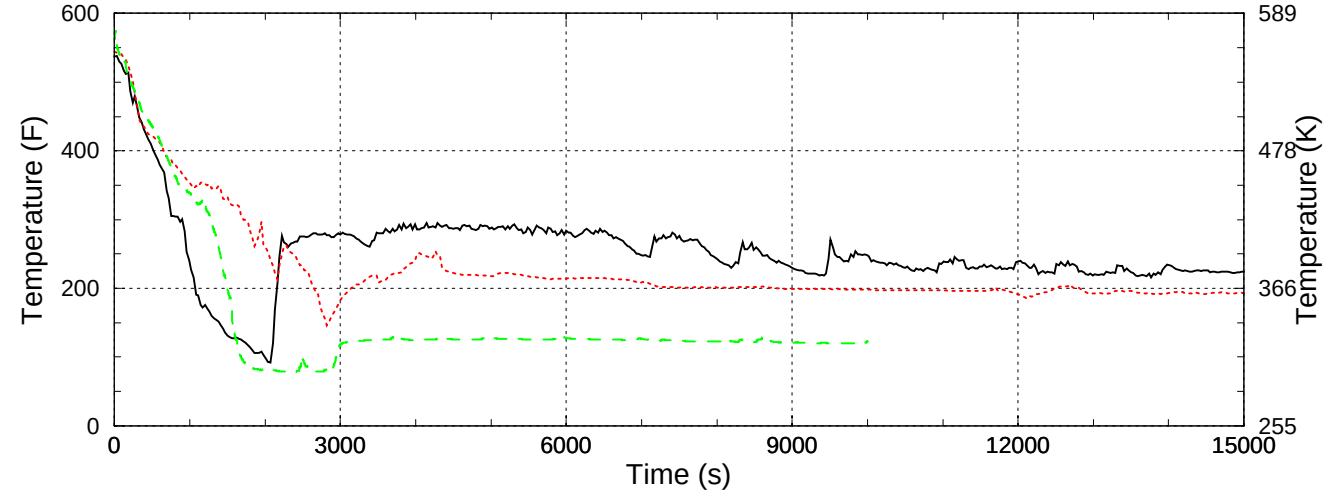
Palisades Case 051 (black) −vs− Palisades Case 054 (red)

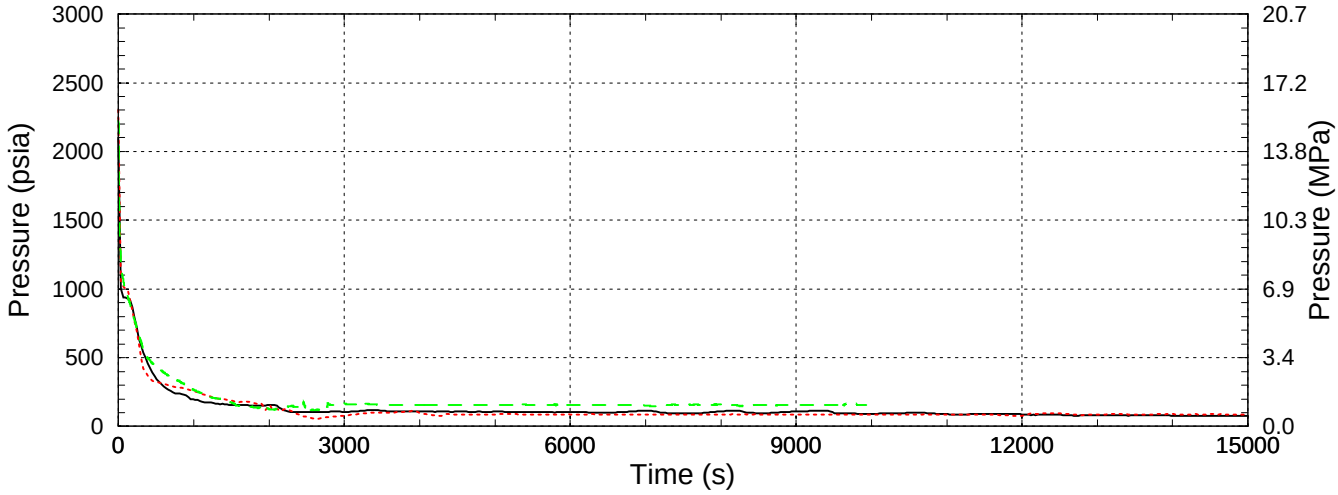


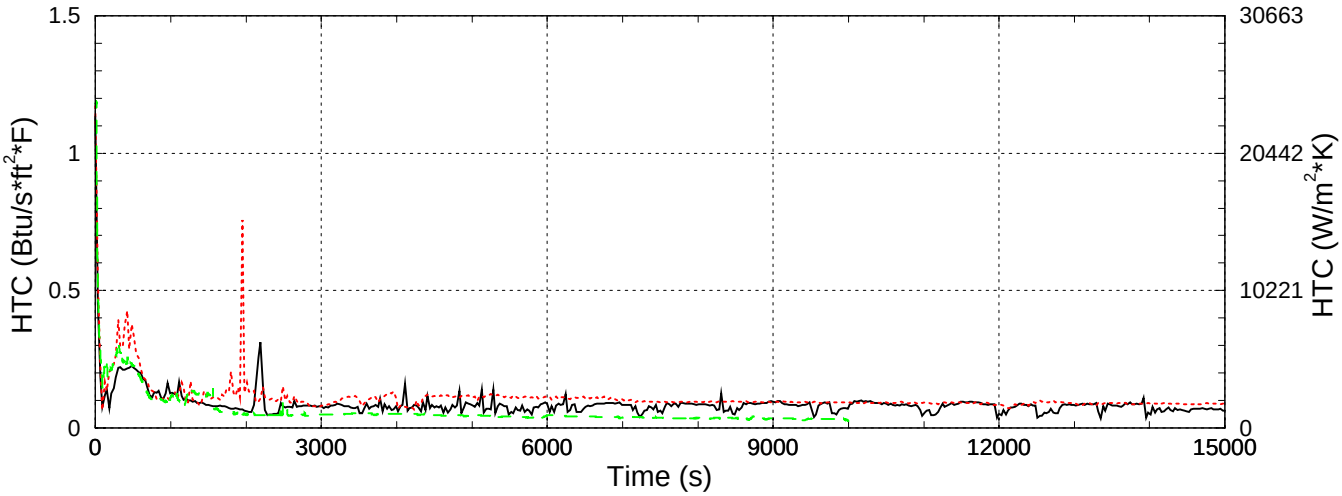




Palisades Case 063 (black) −vs− Beaver Valley Case 117 (red) −vs− Oconee Case 160 (green)







Beaver Valley Case 108 (black) −vs− Beaver Valley Case 109 (red) −vs− Beaver Valley Case 111 (green)