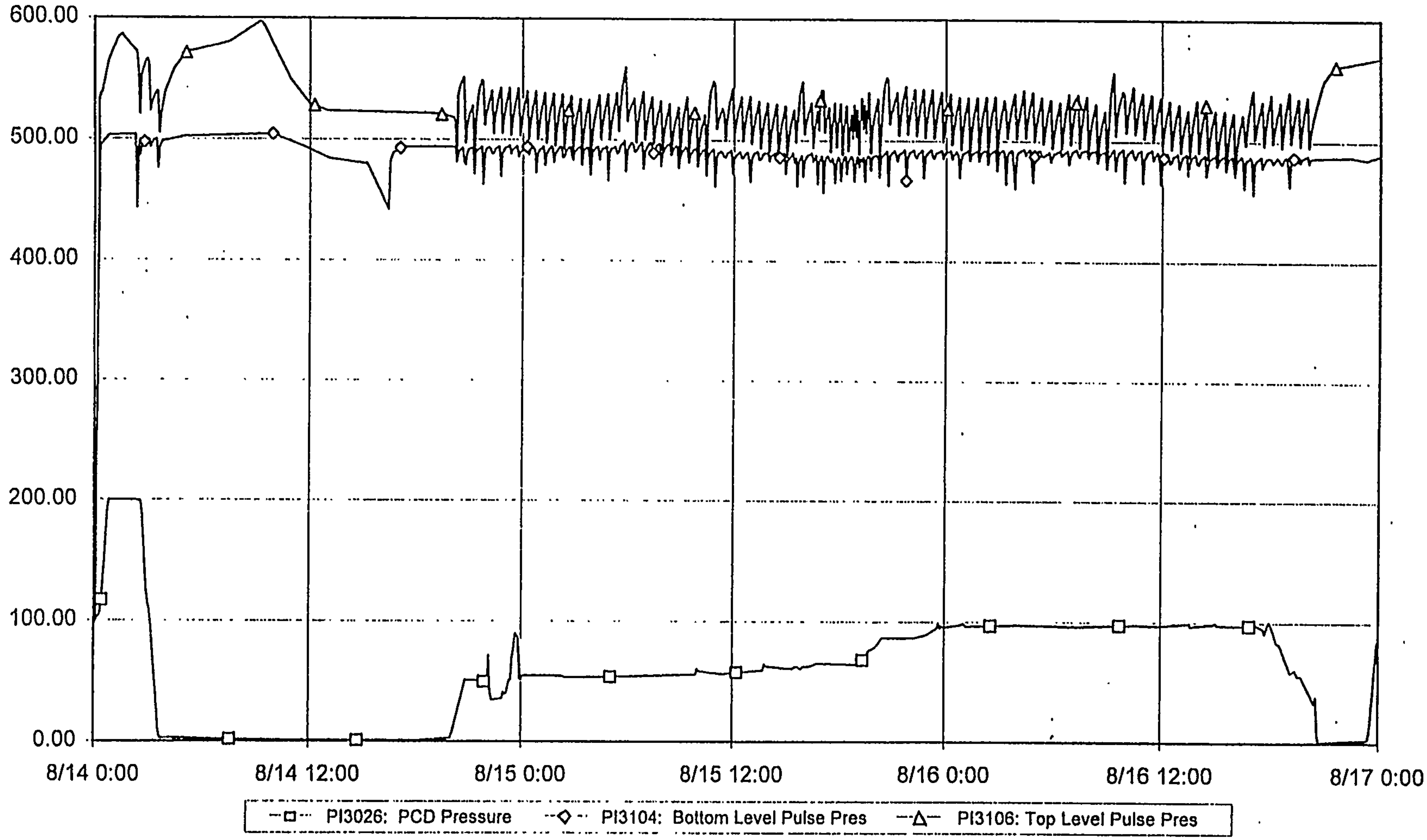
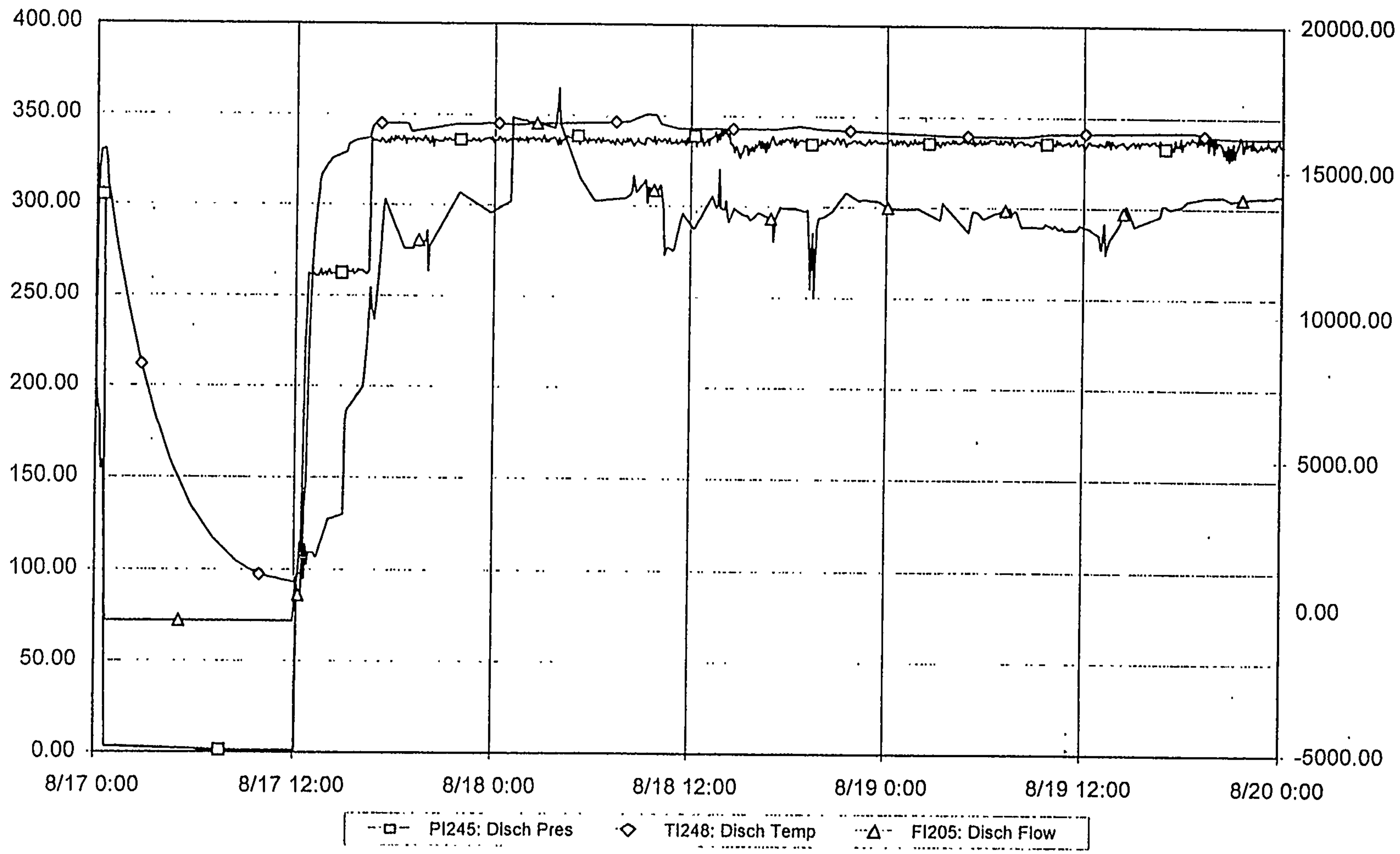


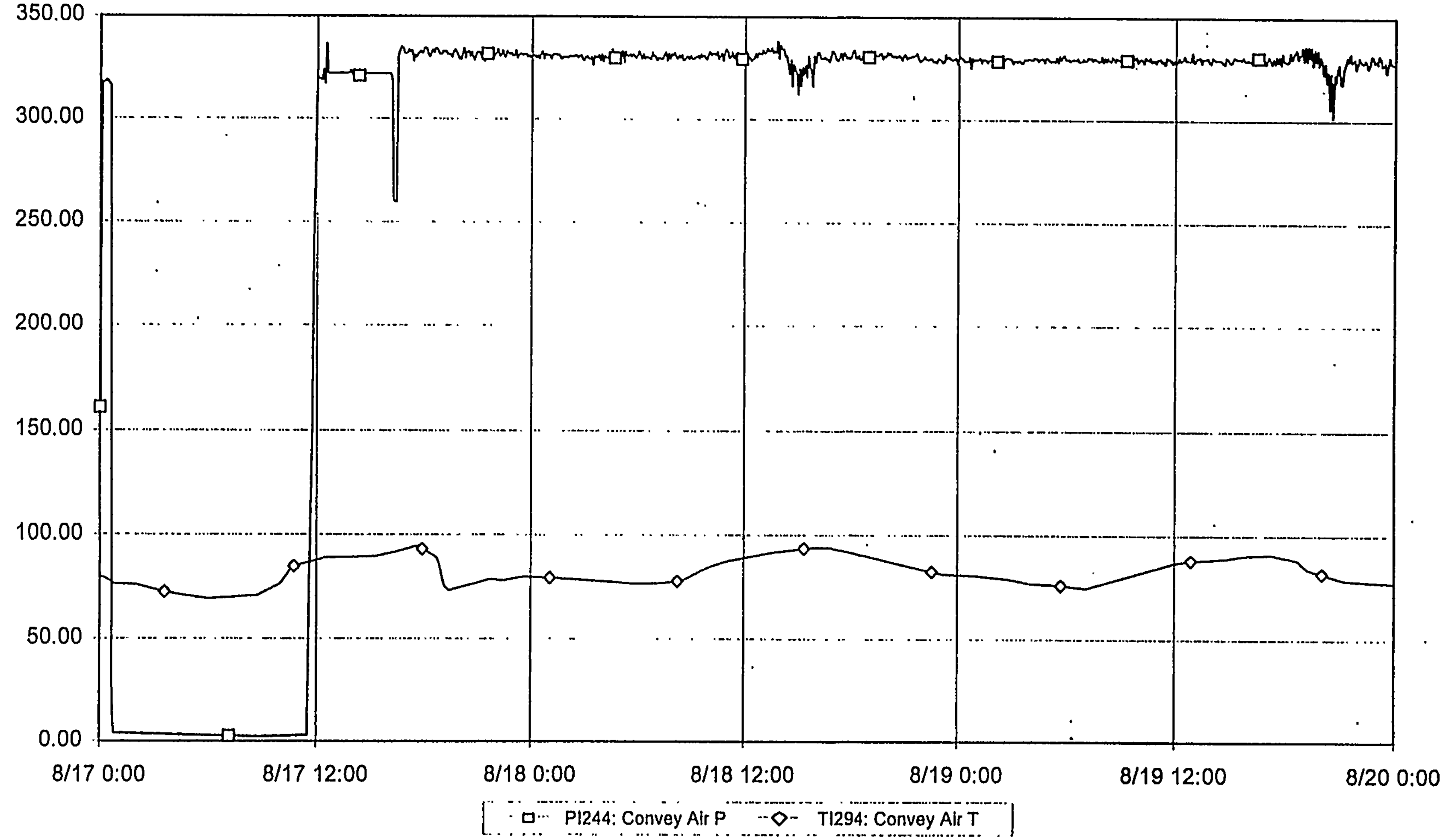
DOE Plot 46 of 47 - 5 minute data

5.1.7-27 PCD Pressure and Pulse Pressure for August 14 Through August 16, 1996



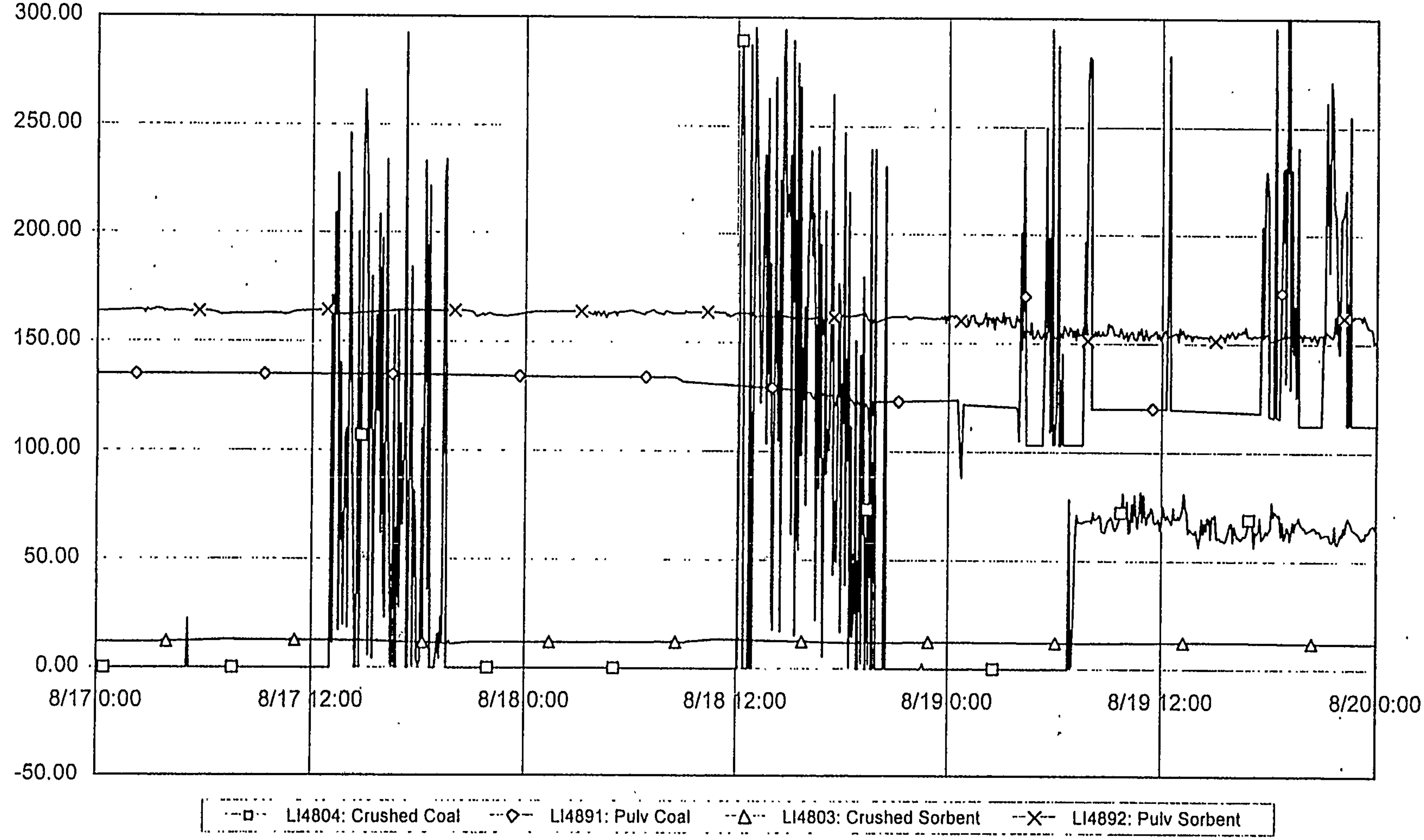
DOE Plot 1 of 47 - 5 minute data

5.1.7-28 C00201 System Profile for August 17 Through August 19, 1996



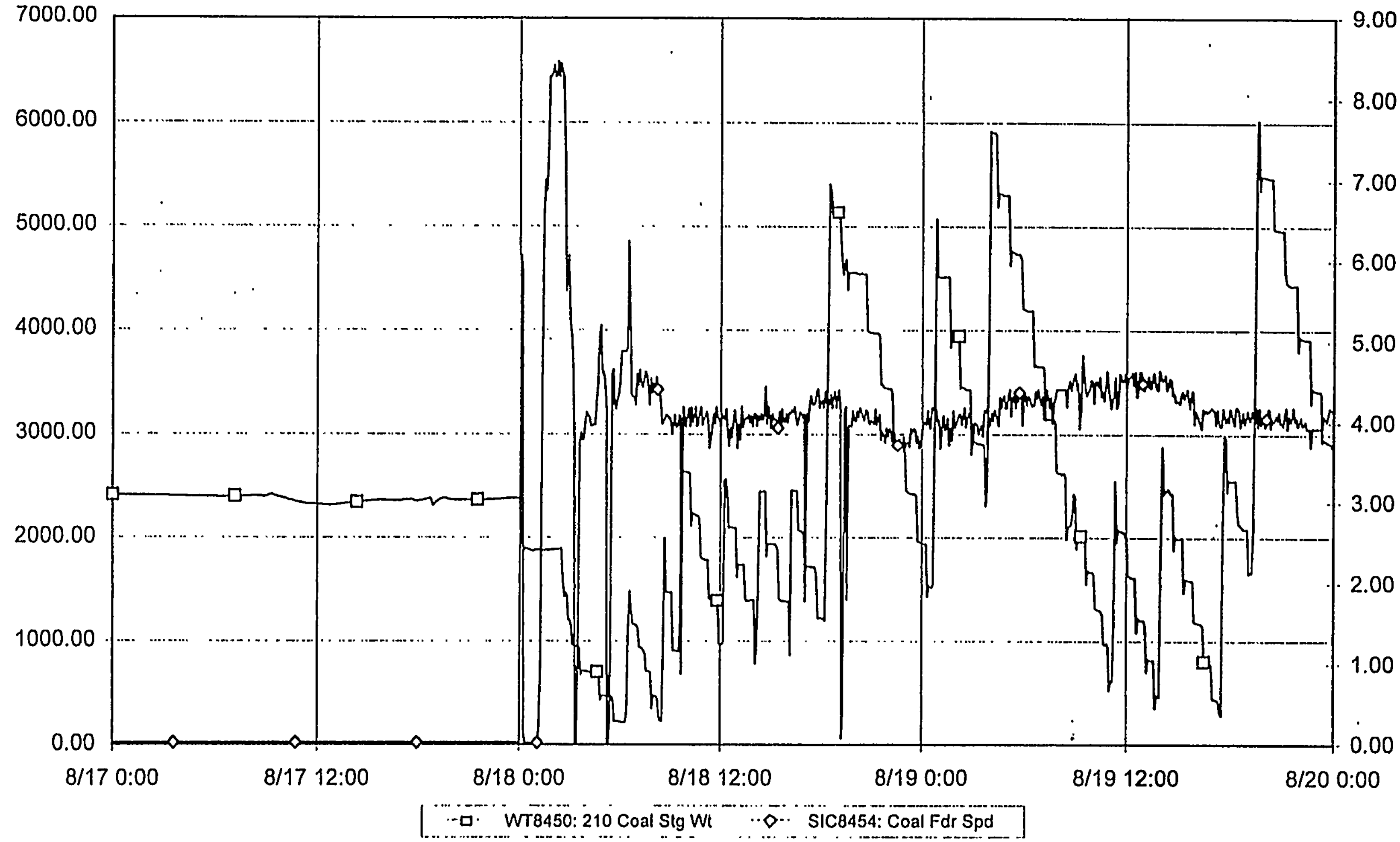
DOE Plot 5 of 47 - 5 minute data

5.1.7-29 Transport Air System for August 17 Through August 19, 1996



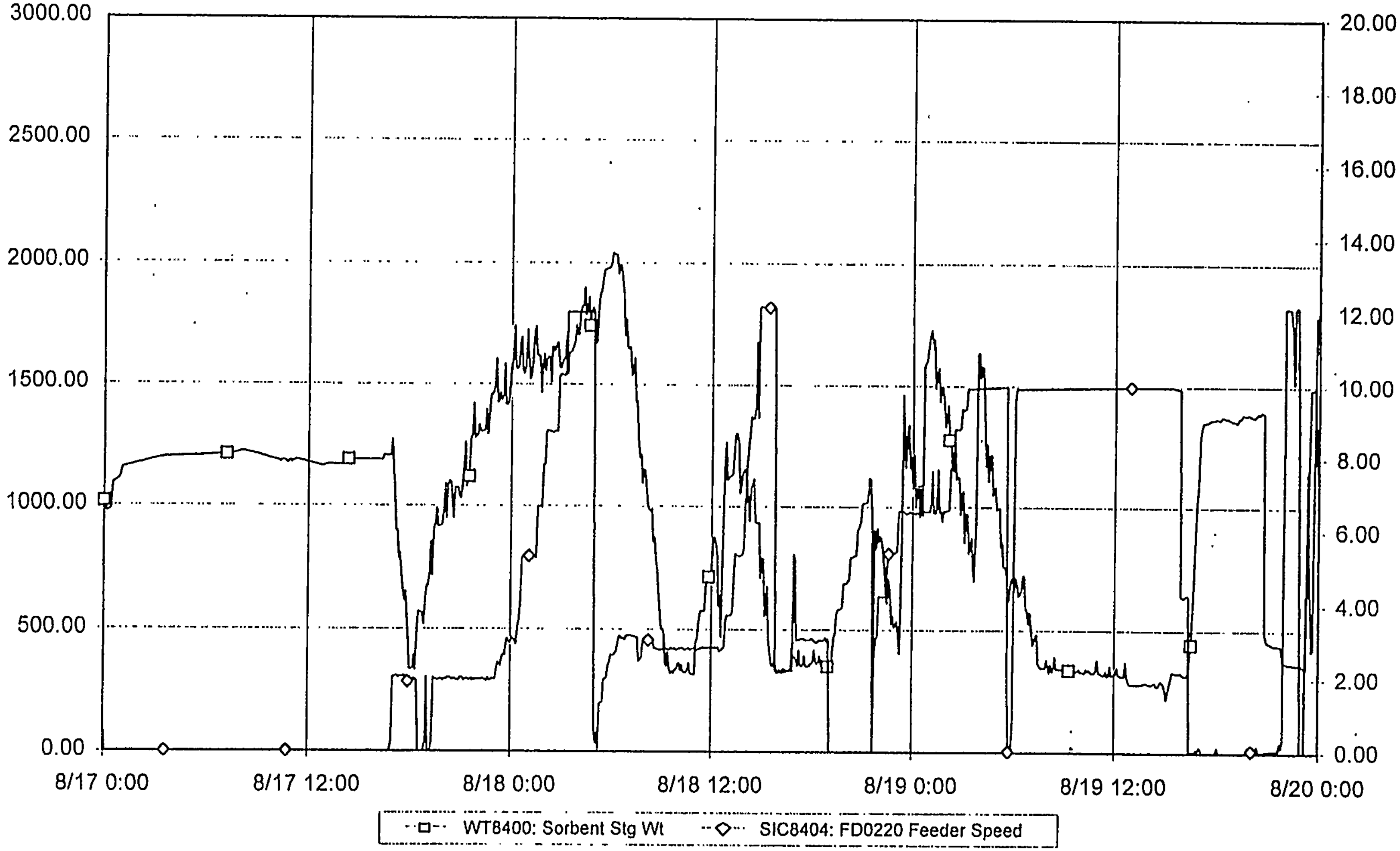
DOE Plot 6 of 47 - 5 minute data

5.1.7-30 Coal and Sorbent Silo Levels for August 17 Through August 19, 1996



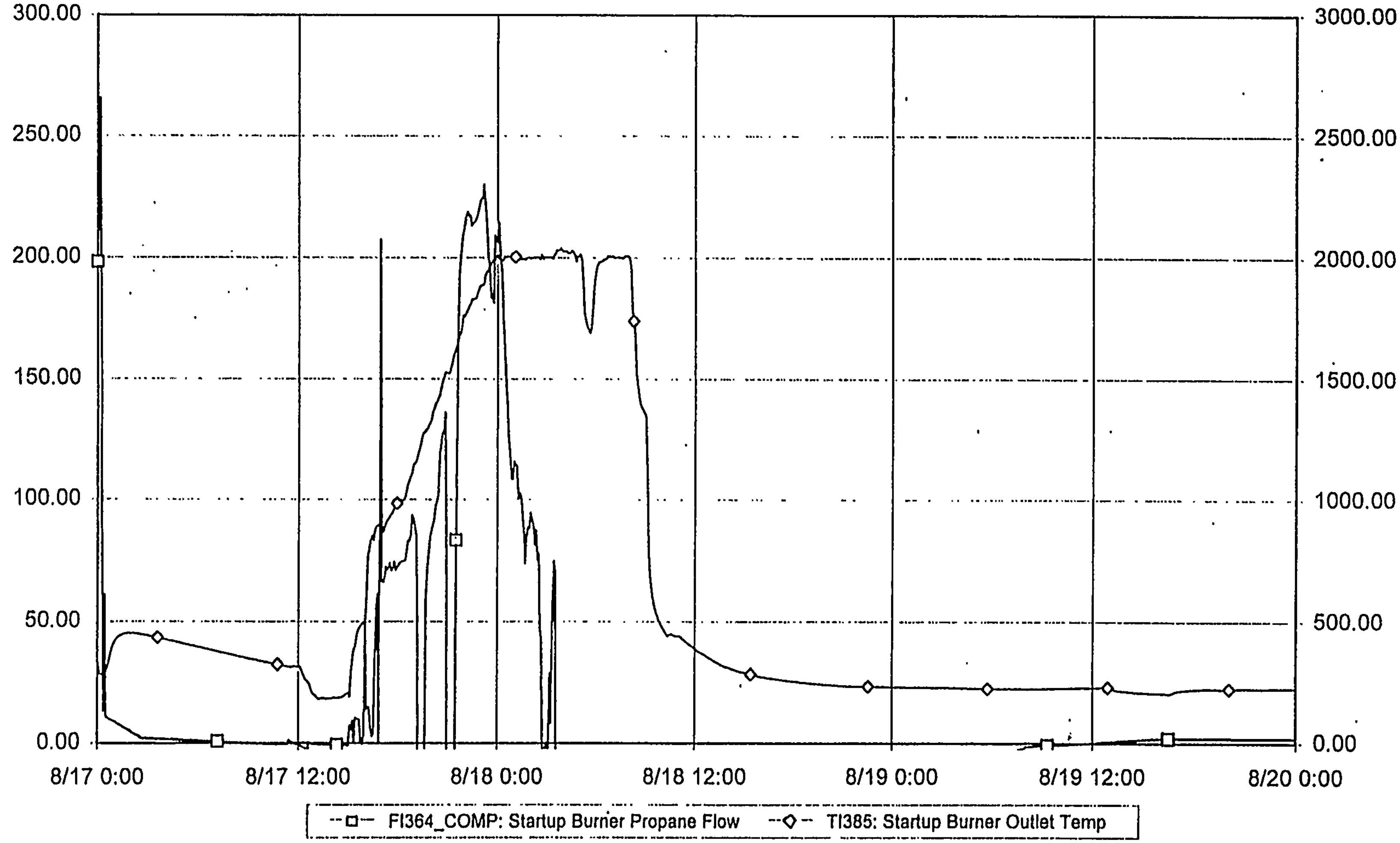
DOE Plot 7 of 47 - 5 minute data

5.1.7-31 Coal Feed for August 17 Through August 19, 1996



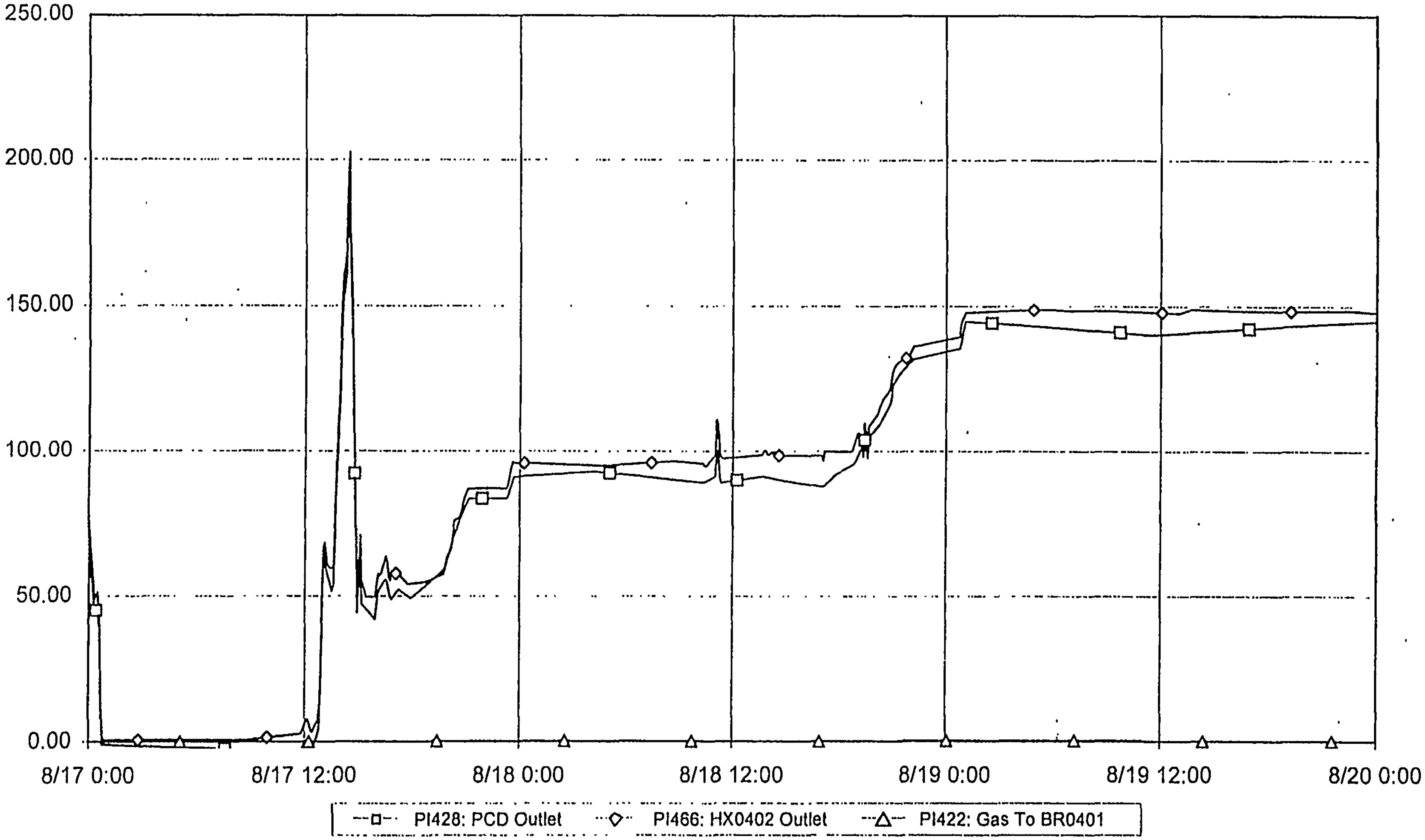
DOE Plot 8 of 47 - 5 minute data

5.1.7-32 Sorbent Feed for August 17 Through August 19, 1996



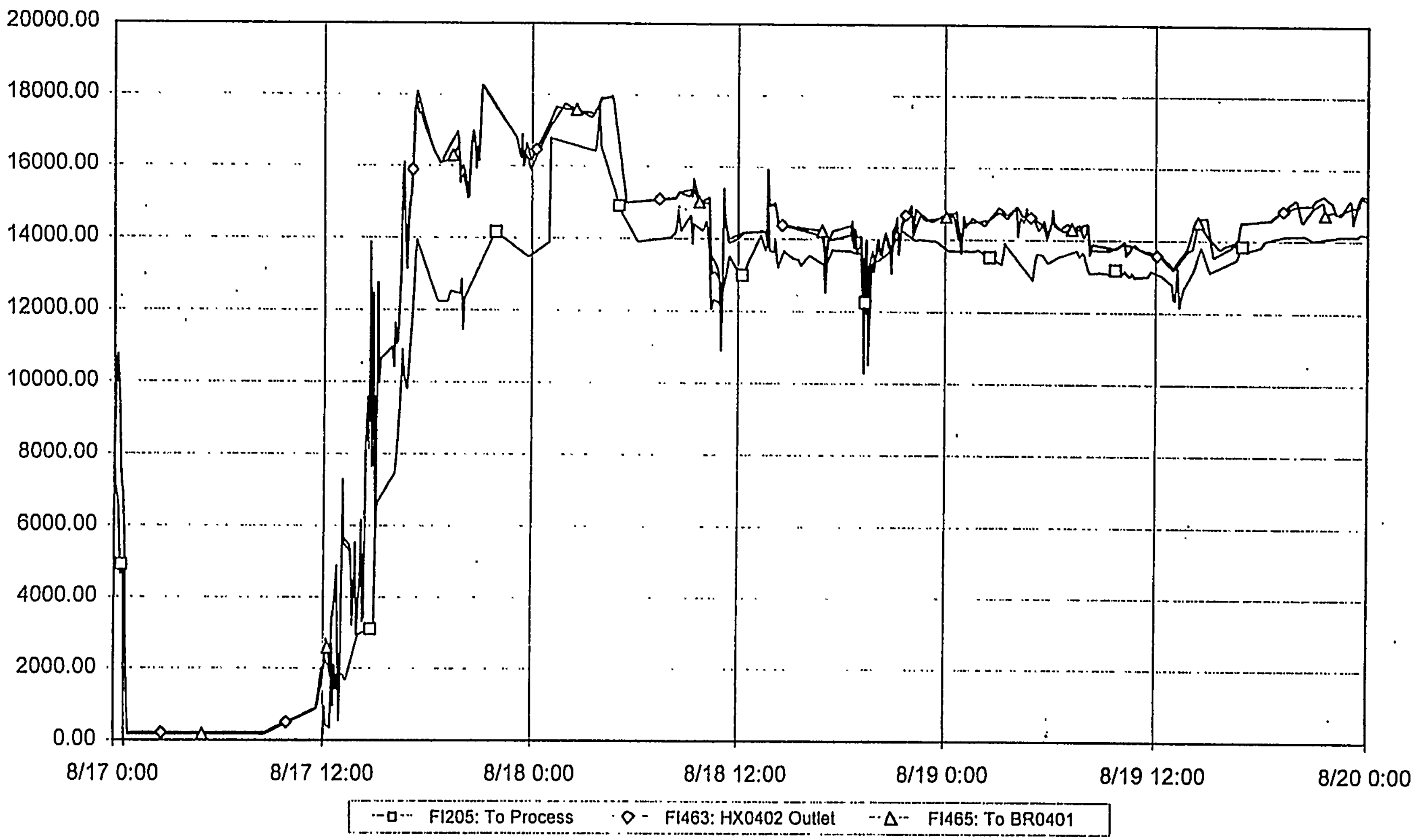
DOE Plot 9 of 47 - 5 minute data

5.1.7-33 Start-Up Burner Flow/Temperature for August 17 Through August 19, 1996



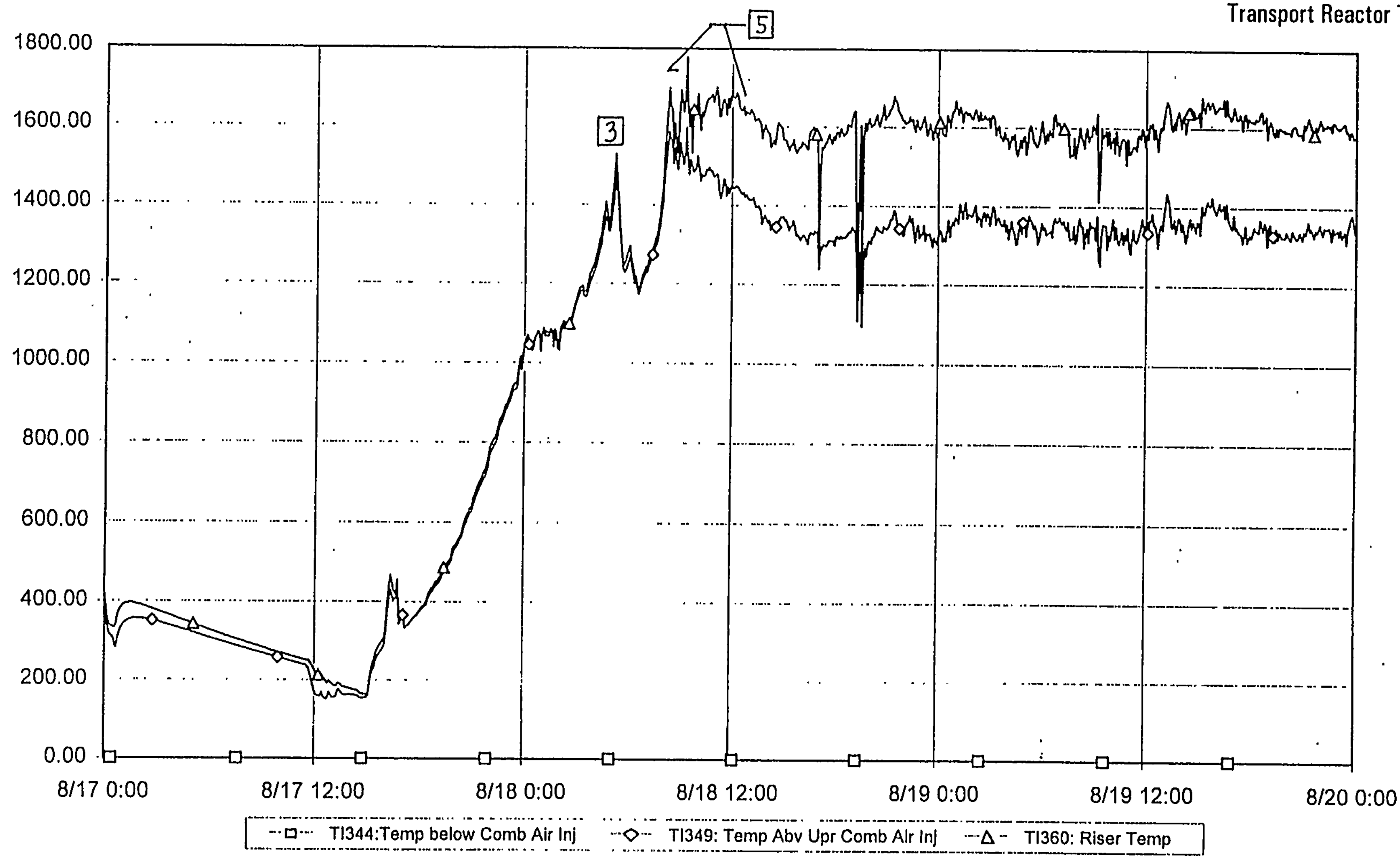
DOE Plot 10 of 47 - 5 minute data

5.1.7-34 System Pressures Downstream of PCD for August 17 Through August 19, 1996



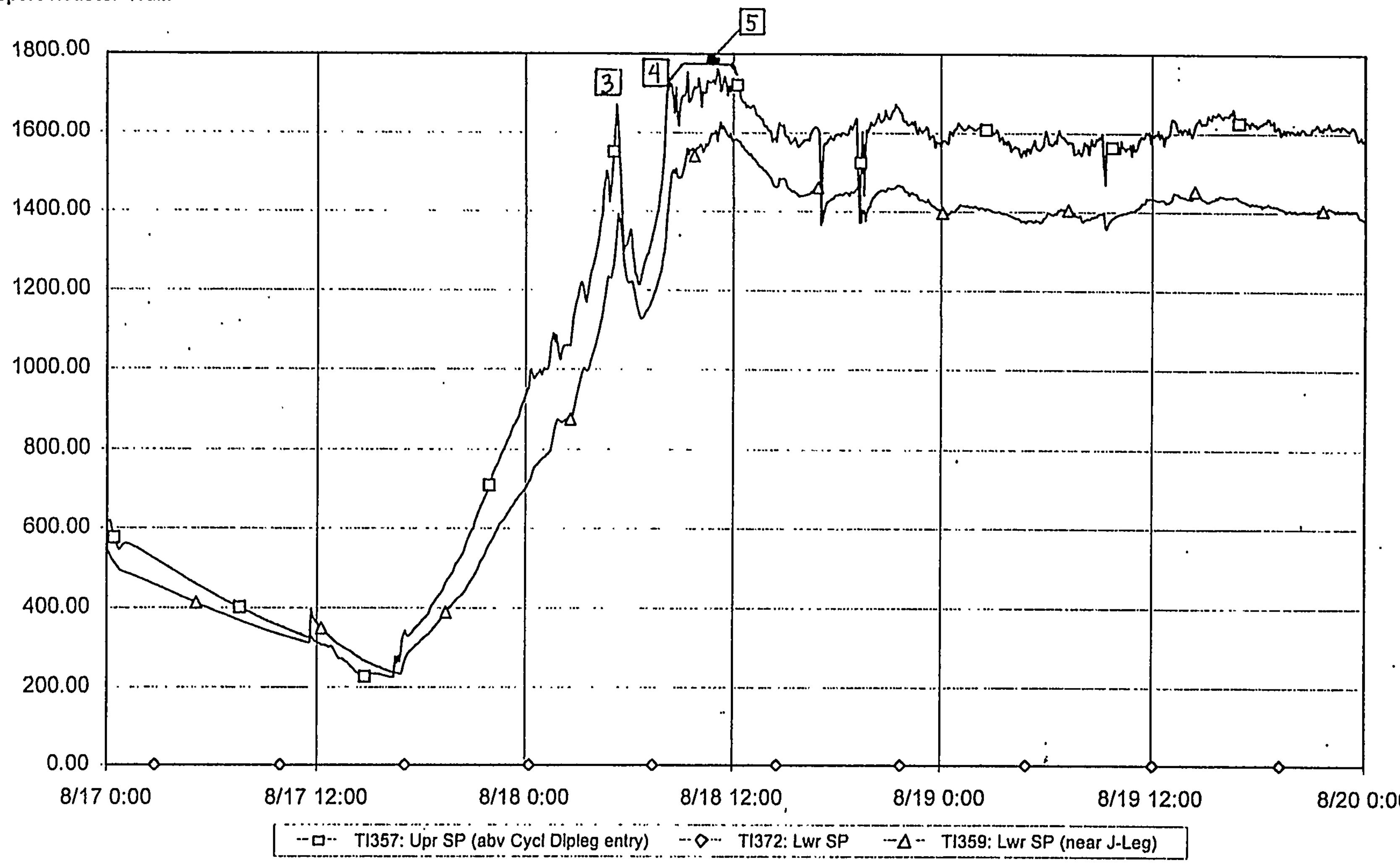
DOE Plot 11 of 47 - 5 minute data

5.1.7-35 Total Gas In/Out Flow Rates for August 17 Through August 19, 1996



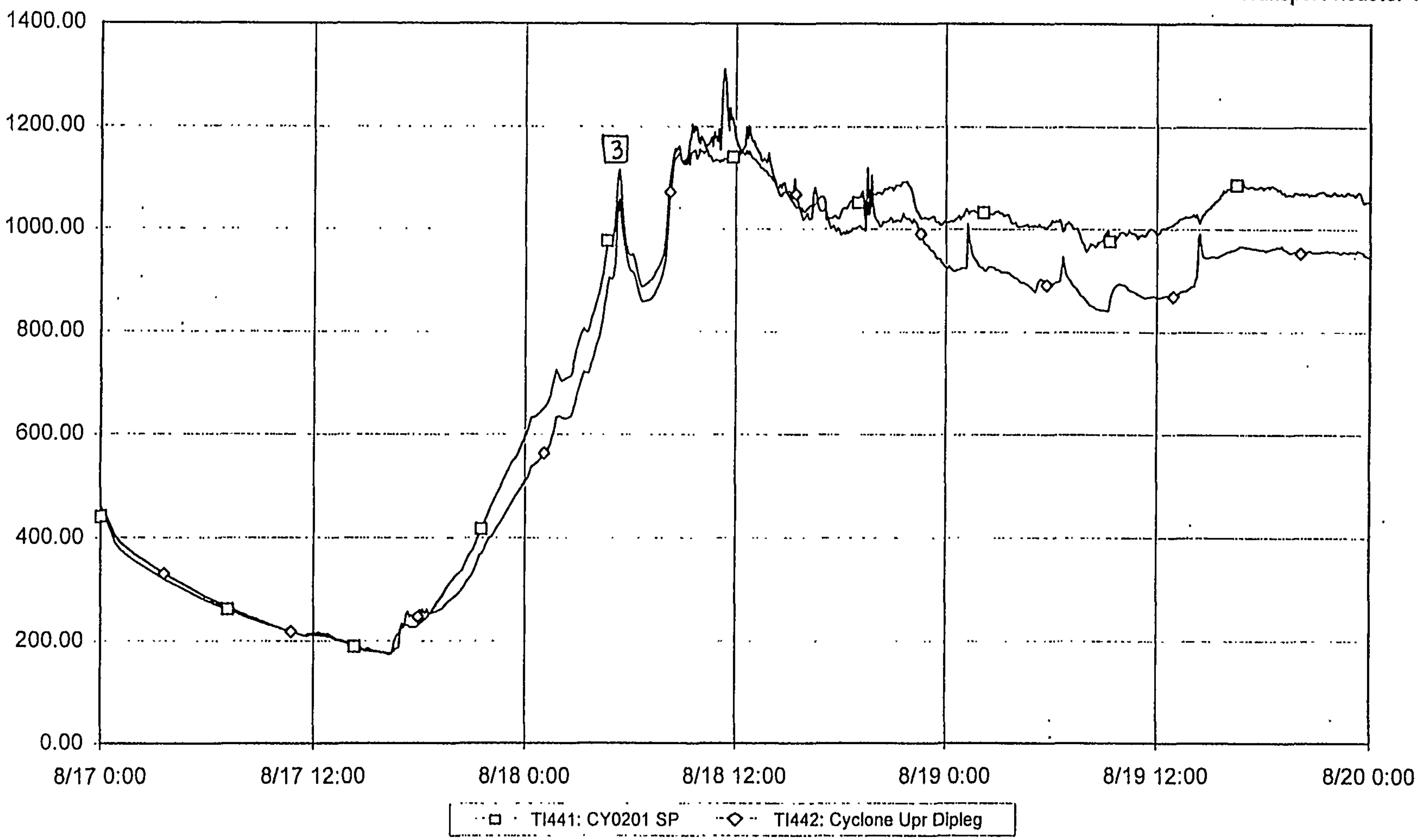
DOE Plot 12 of 47 - 5 minute data

5.1.7-36 Reactor Mixing Zone and Riser Temperatures for August 17 Through August 19, 1996



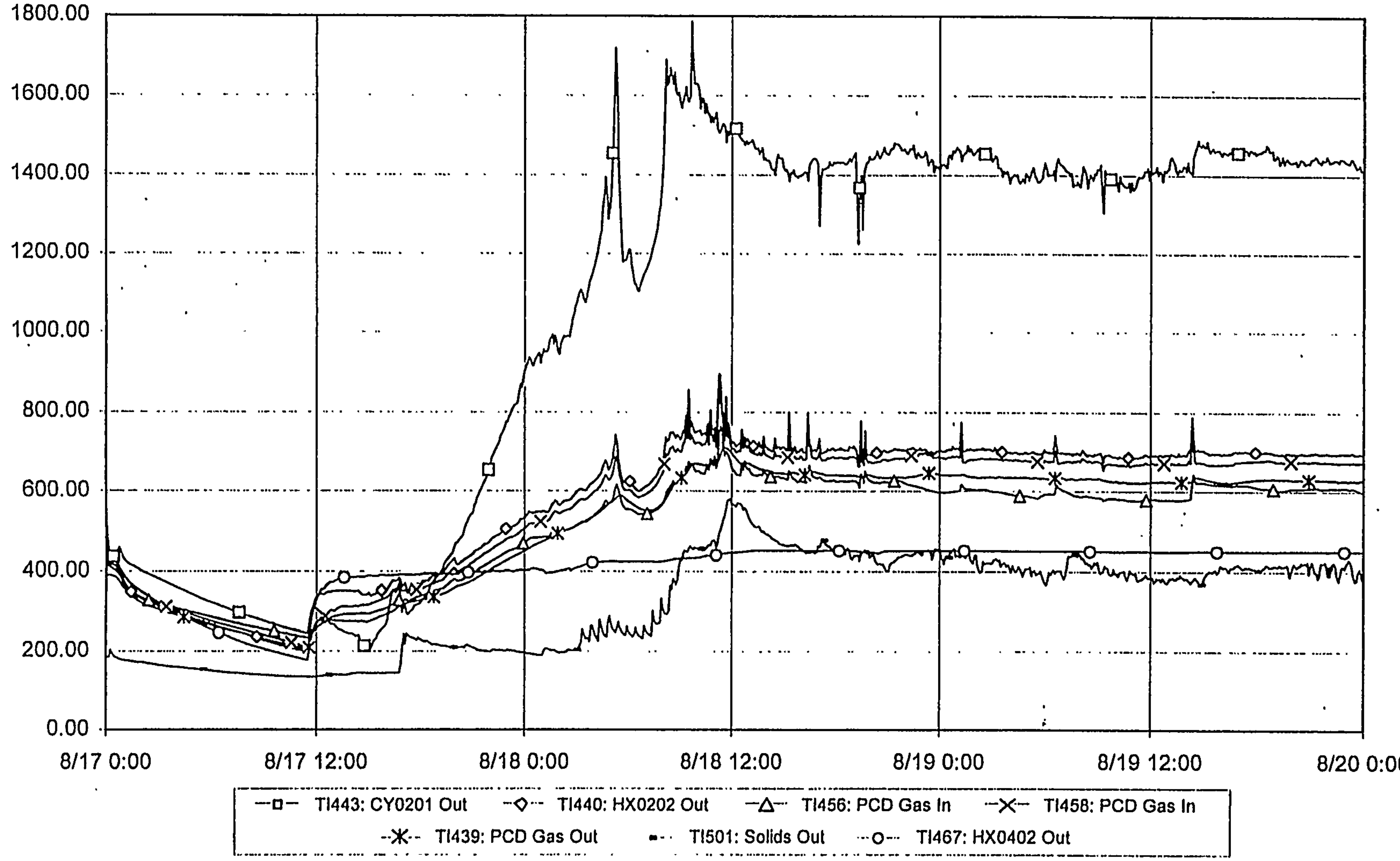
DOE Plot 13 of 47 - 5 minute data

5.1.7-37 Standpipe Temperatures for August 17 Through August 19, 1996



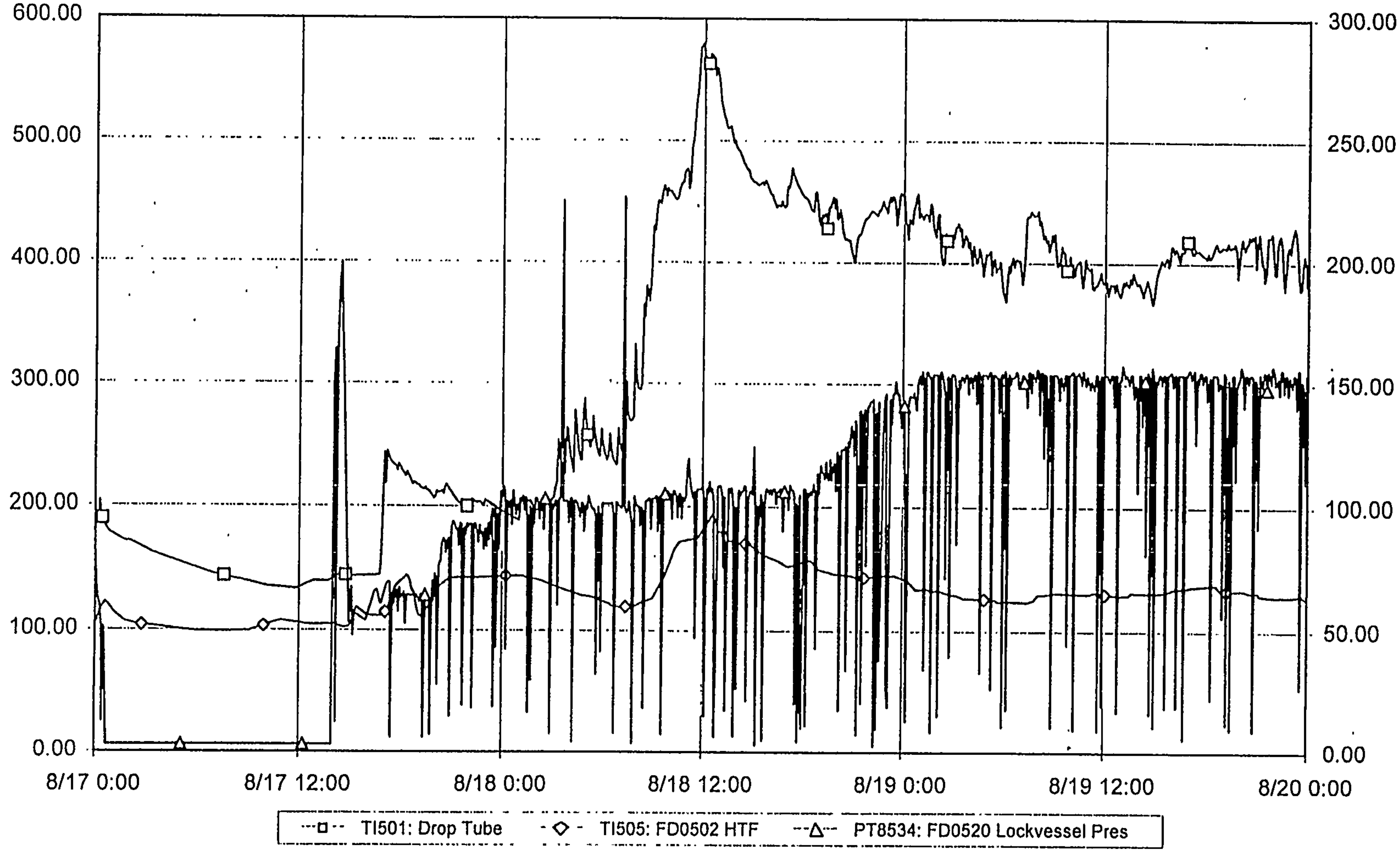
DOE Plot 14 of 47 - 5 minute data

5.1.7-38 Cyclone Dipleg Temperatures for August 17 Through August 19, 1996



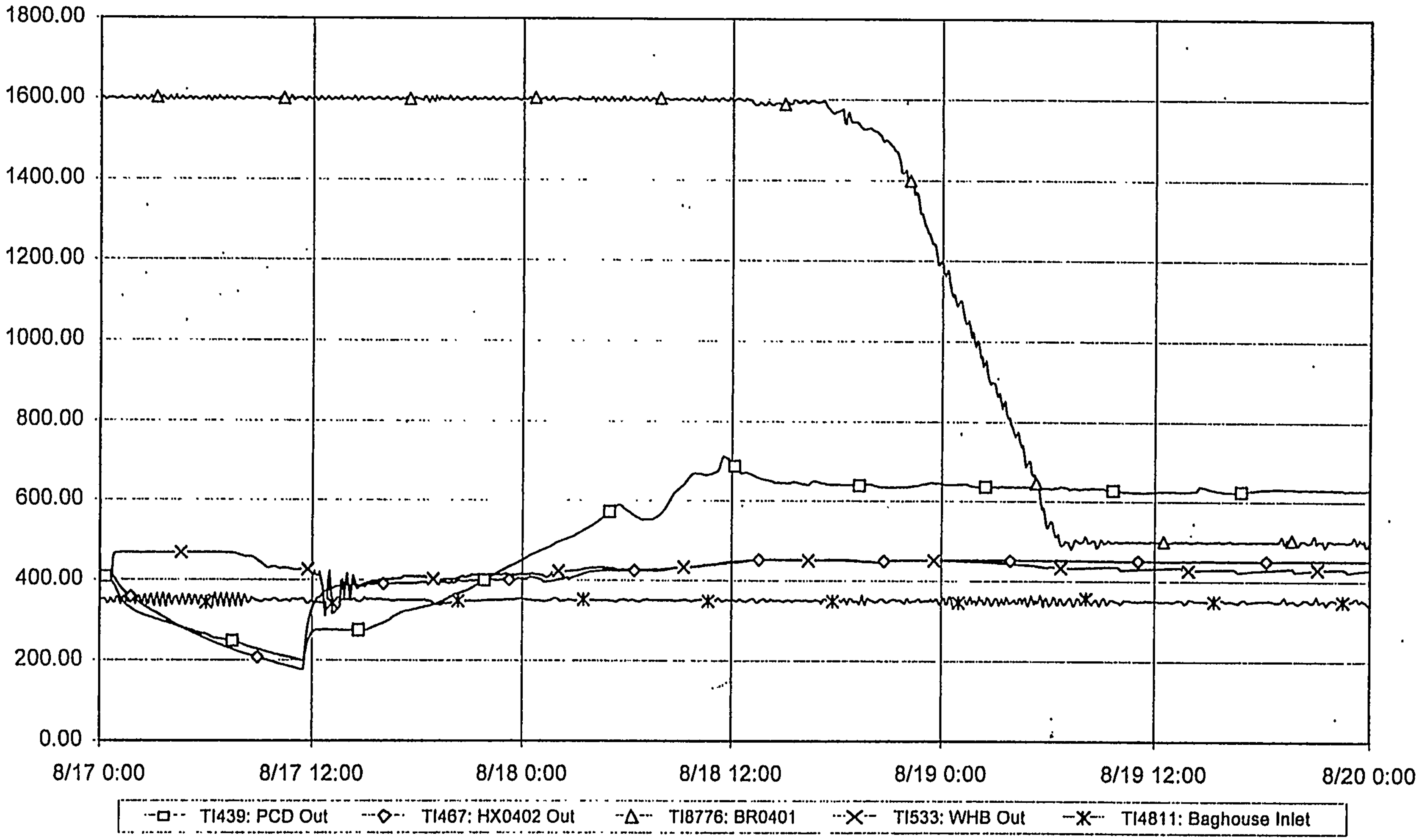
DOE Plot 15 of 47 - 5 minute data

5.1.7-39 Temperature Profiles Downstream of Reactor for August 17 Through August 19, 1996



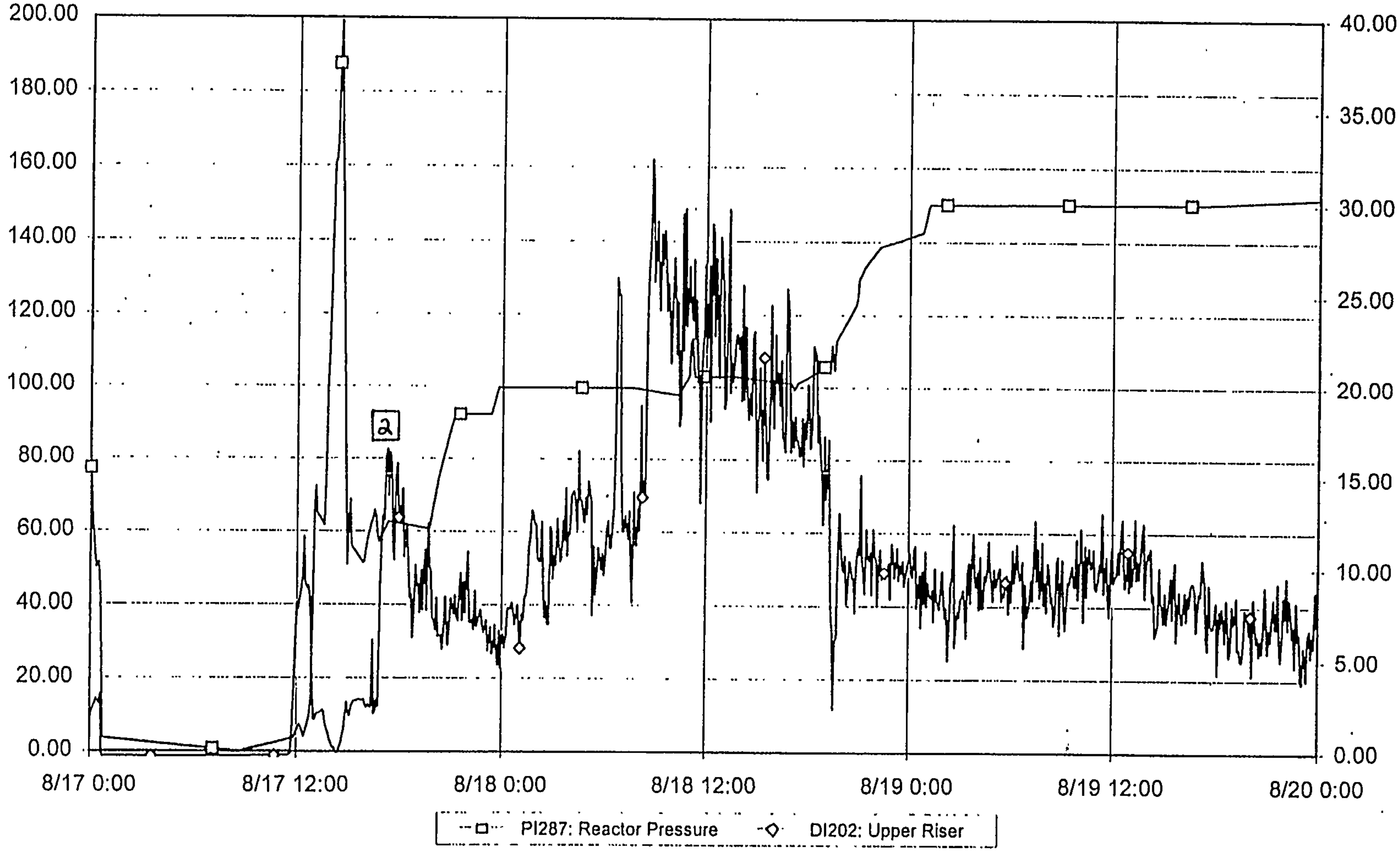
DOE Plot 16 of 47 - 5 minute data

5.1.7-40 PCD Ash Temperatures for August 17 Through August 19, 1996



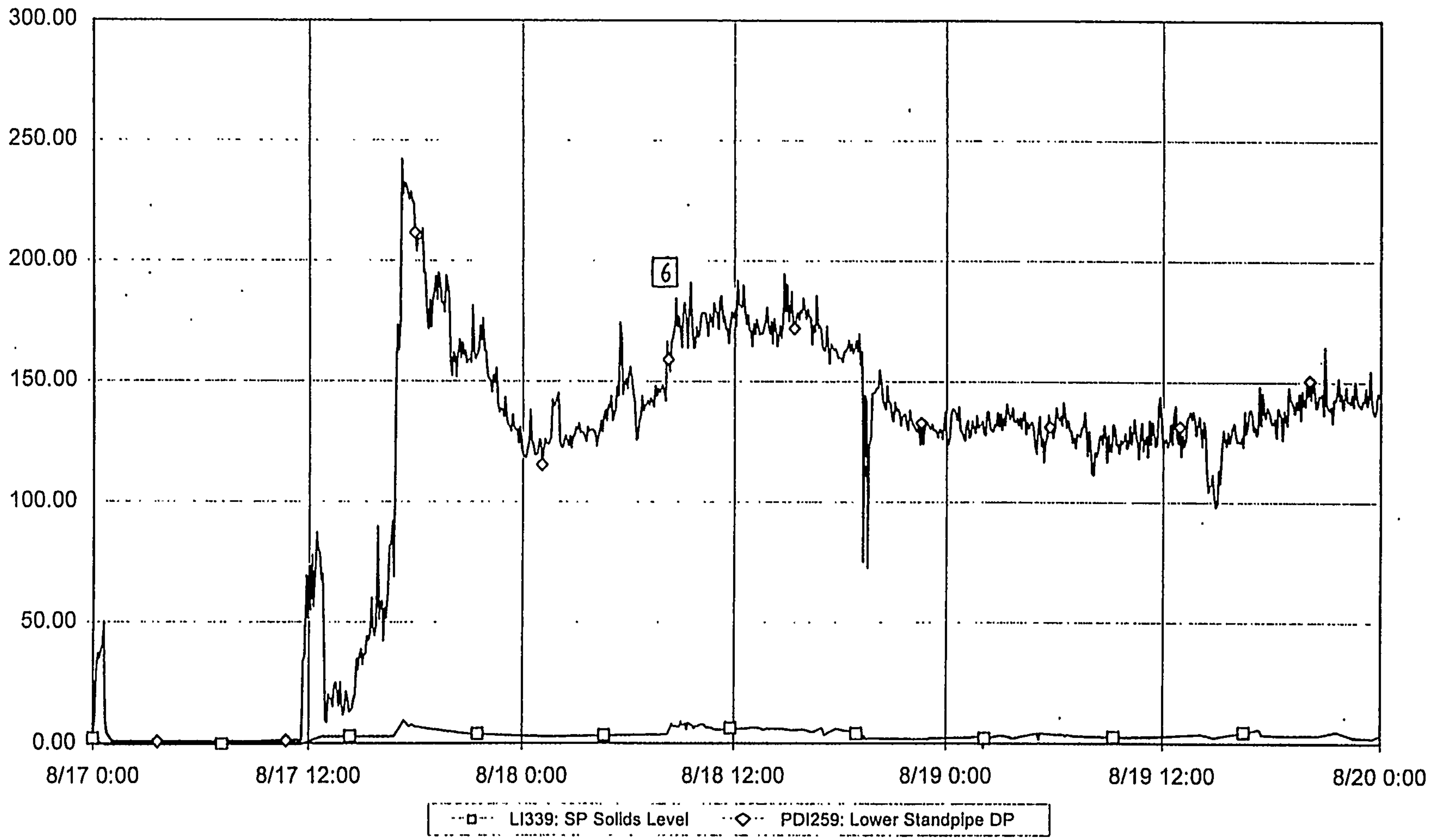
DOE Plot 17 of 47 - 5 minute data

5.1.7-41 System Temperatures Downstream of PCD for August 17 Through August 19, 1996



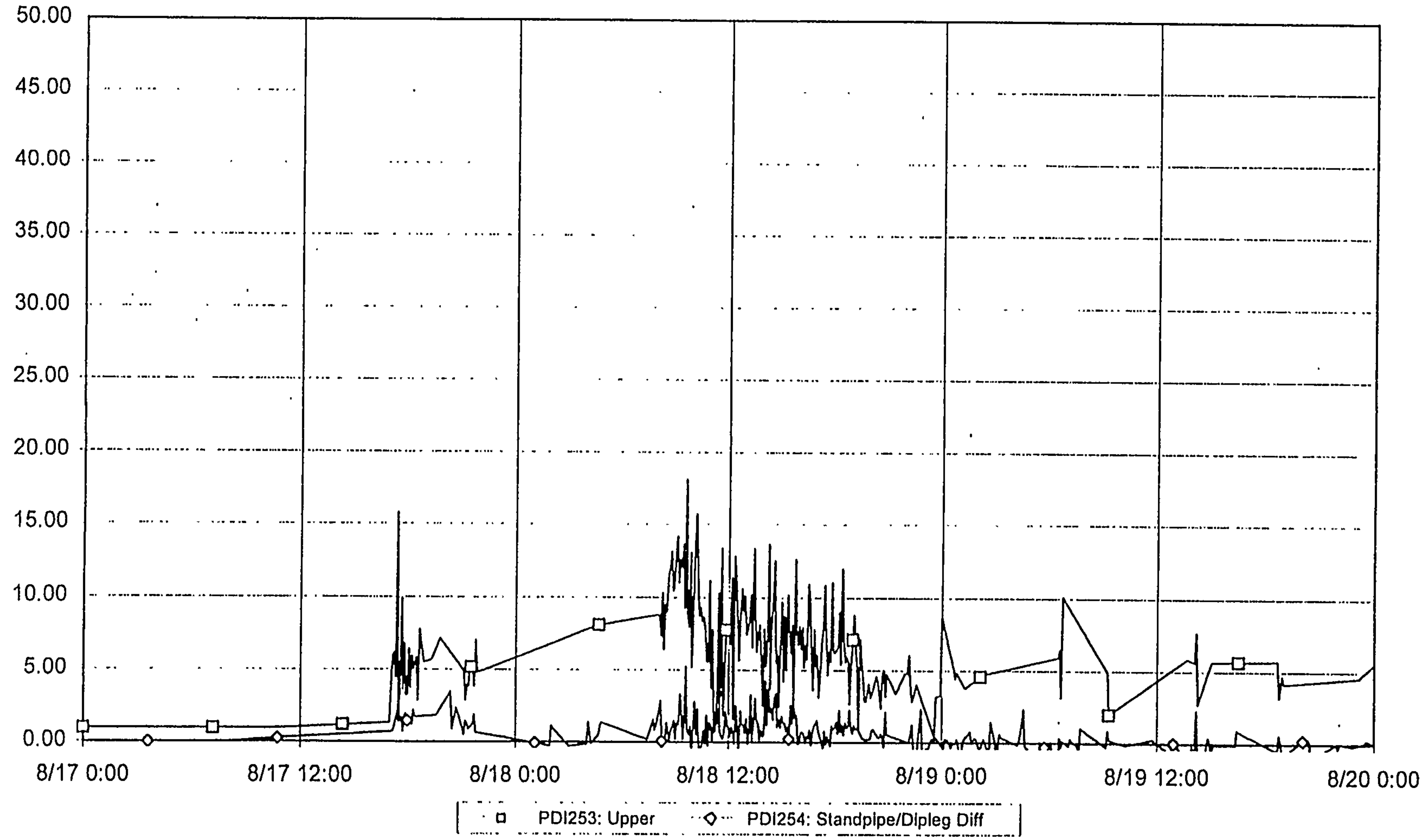
DOE Plot 19 of 47 - 5 minute data

5.1.7-42 Reactor Pressure/Riser DP Profiles for August 17 Through August 19, 1996



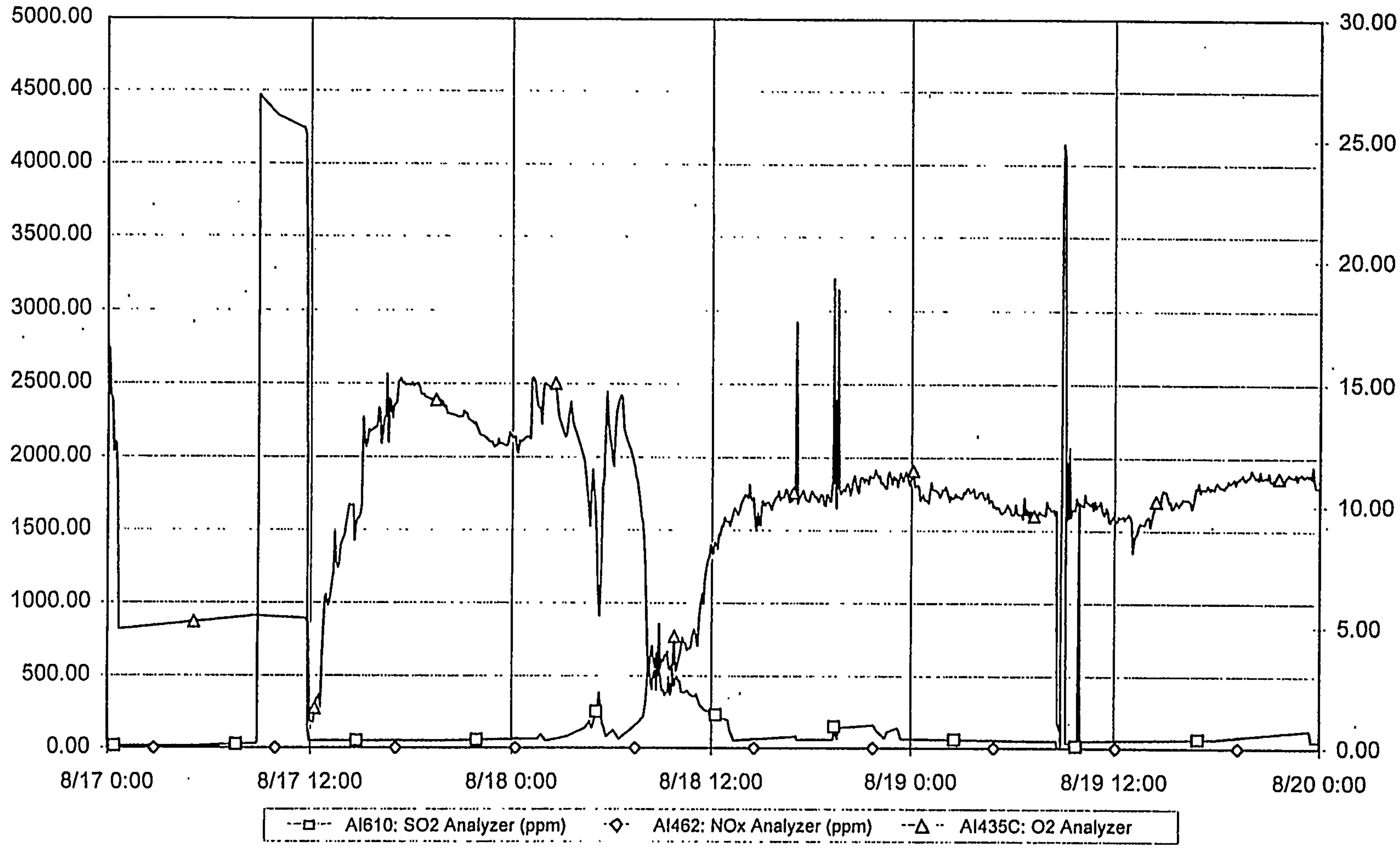
DOE Plot 20 of 47 - 5 minute data

5.1.7-43 Standpipe DP Profiles for August 17 Through August 19, 1996



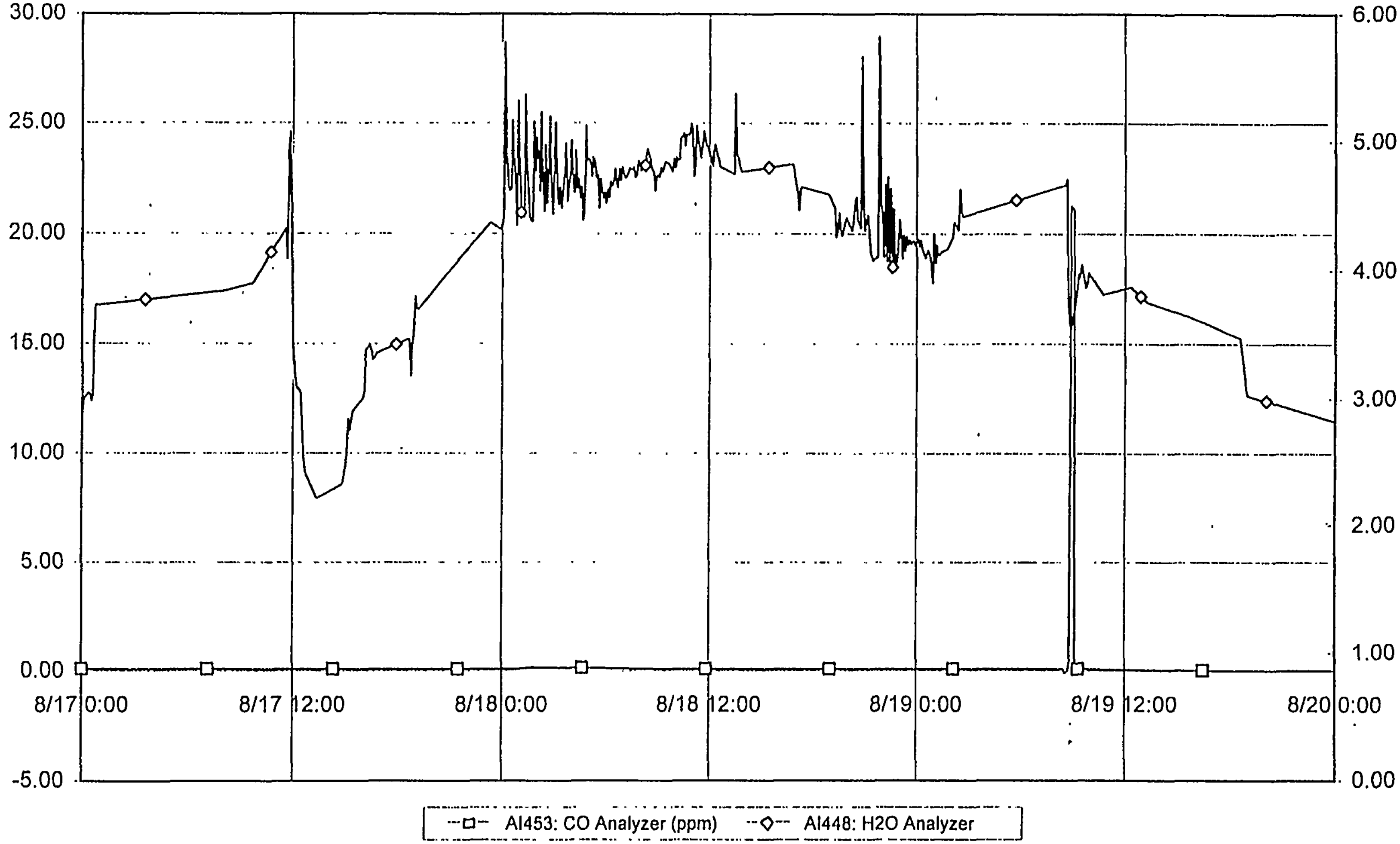
DOE Plot 21 of 47 - 5 minute data

5.1.7-44 CY0201 Dipleg DP Profiles for August 17 Through August 19, 1996



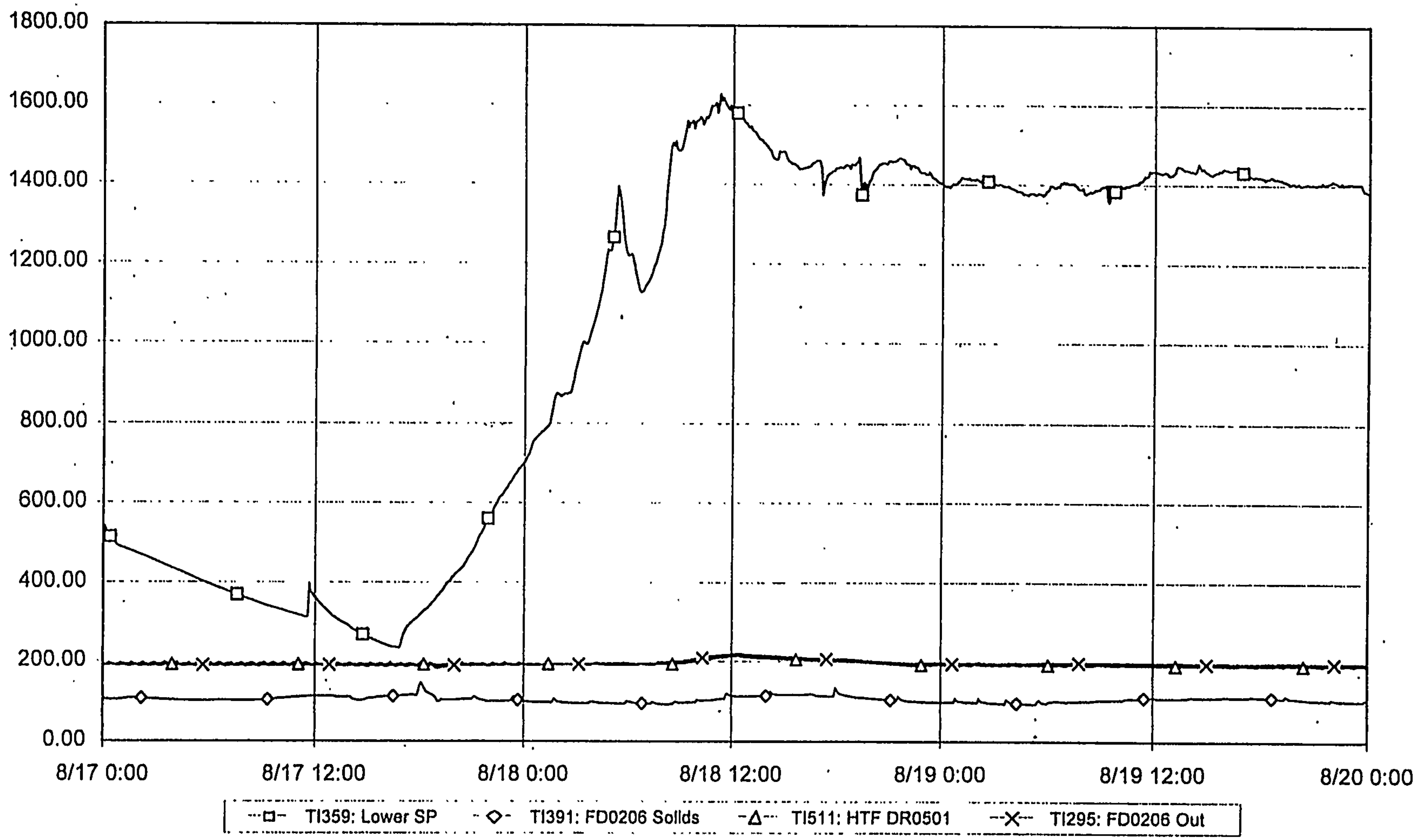
DOE Plot 23 of 47 - 5 minute data

5.1.7-45 O_2, SO_2, and NO_x Analyzers for August 17 Through August 19, 1996



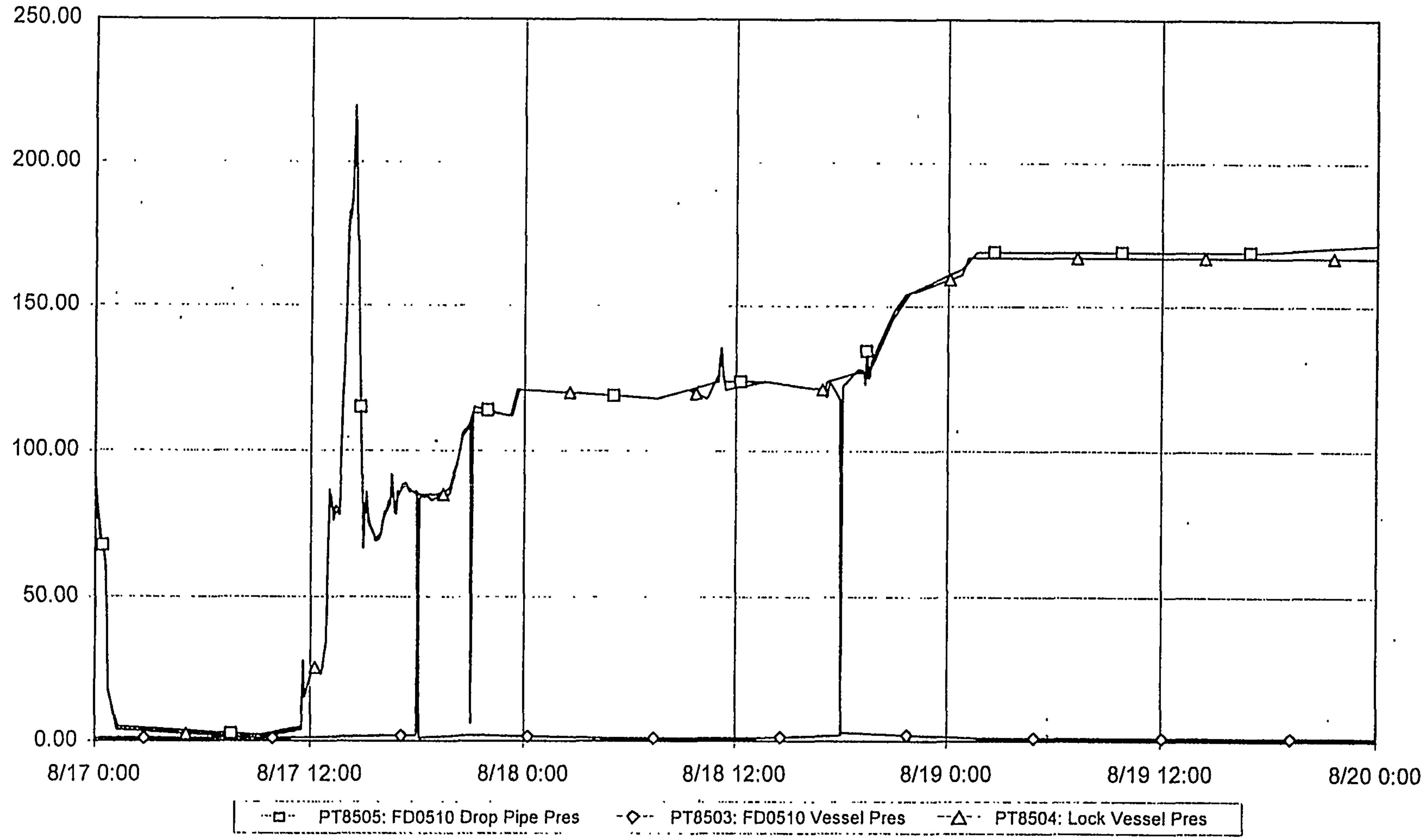
DOE Plot 24 of 47 - 5 minute data

5.1.7-46 CO and H_2O Analyzer for August 17 Through August 19, 1996



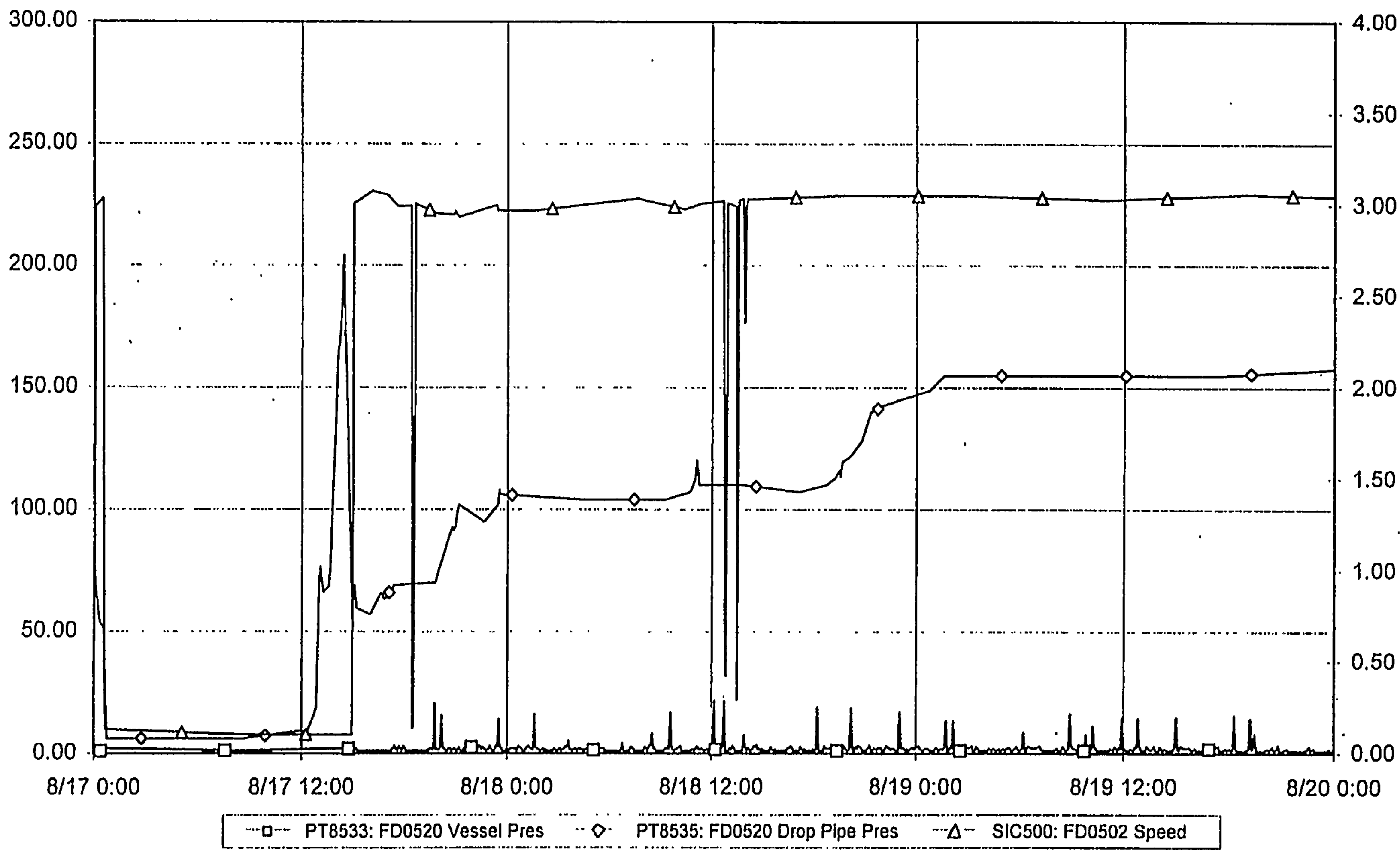
DOE Plot 28 of 47 - 5 minute data

5.1.7-47 FD0510 Temperature Profiles for August 17 Through August 19, 1996



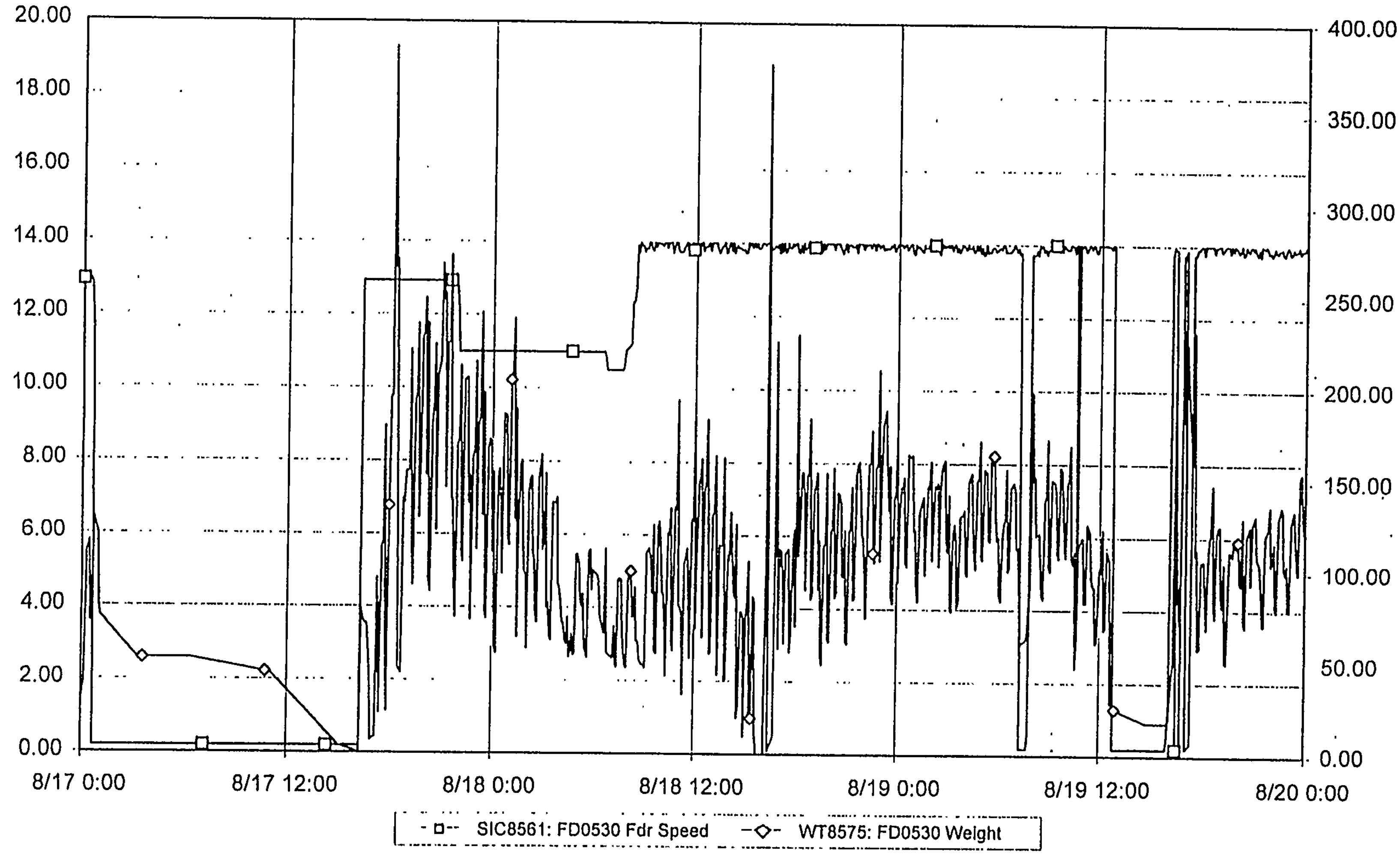
DOE Plot 29 of 47 - 5 minute data

5.1.7-48 FD0206 Pressure Profiles for August 17 Through August 19, 1996



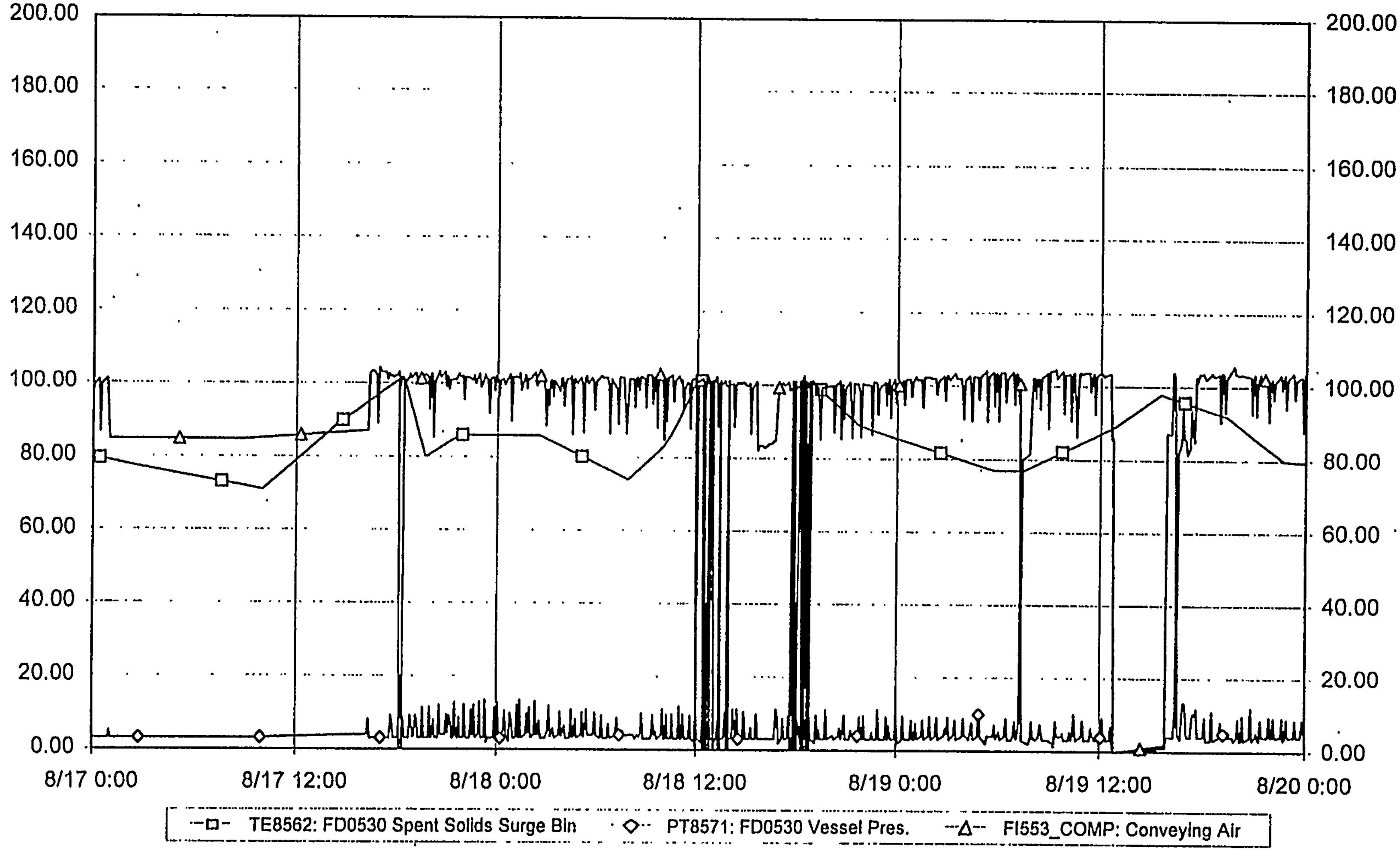
DOE Plot 30 of 47 - 5 minute data

5.1.7-49 FD0520 Pressures for August 17 Through August 19, 1996



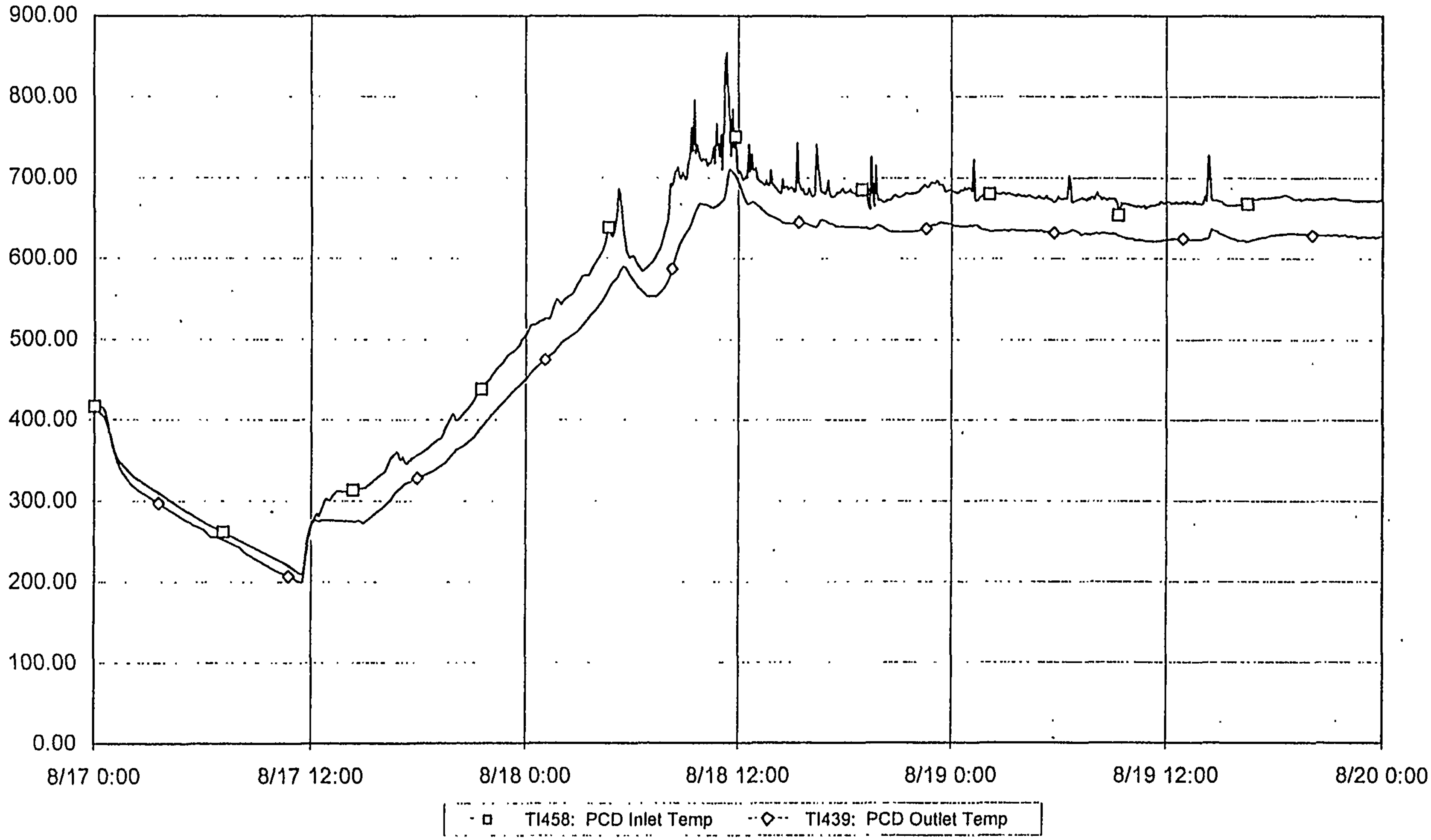
DOE Plot 31 of 47 - 5 minute data

5.1.7-50 FD0530 Feeder for August 17 Through August 19, 1996



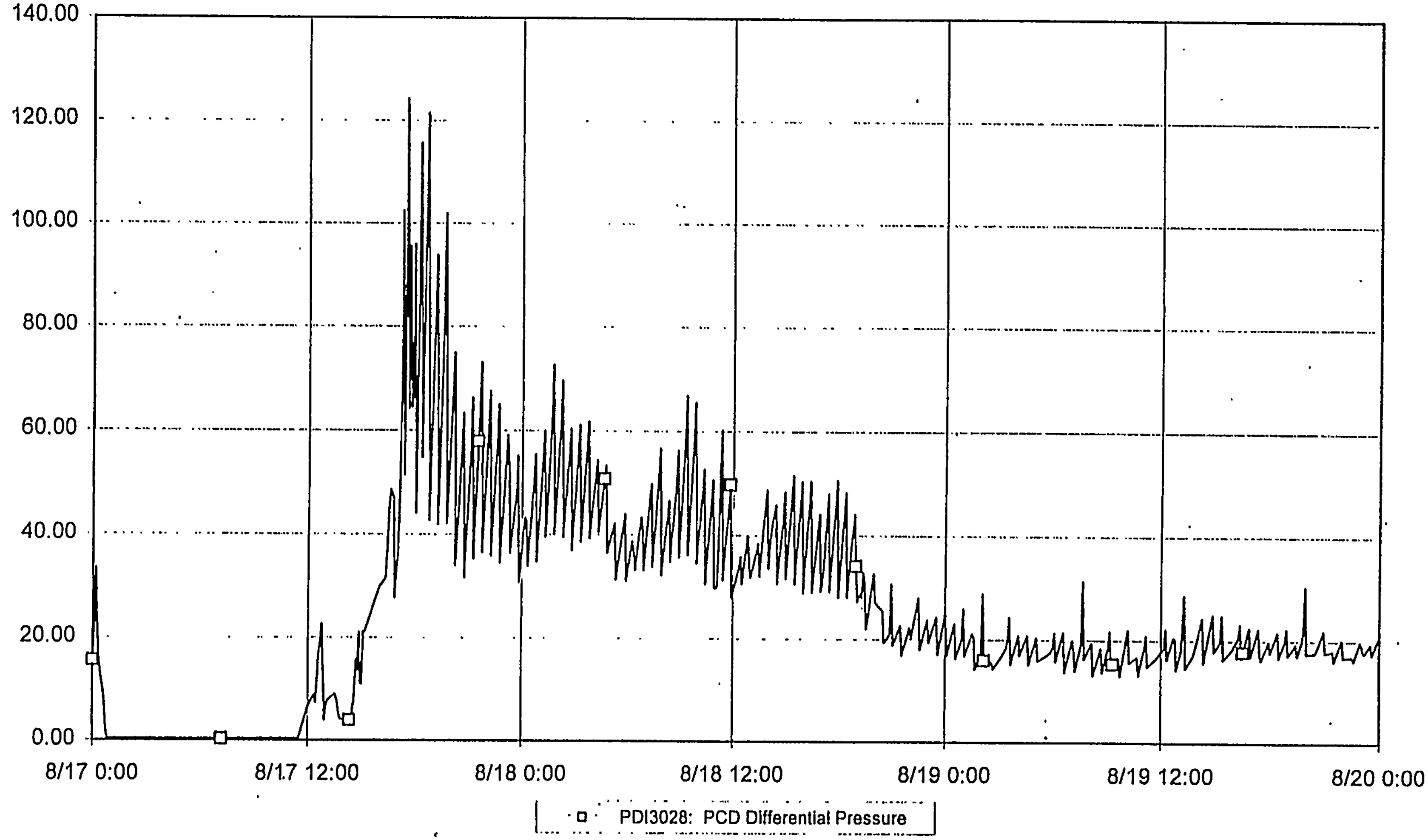
DOE Plot 32 of 47 - 5 minute data

5.1.7-51 FD0530 Feeder for August 17 Through August 19, 1996



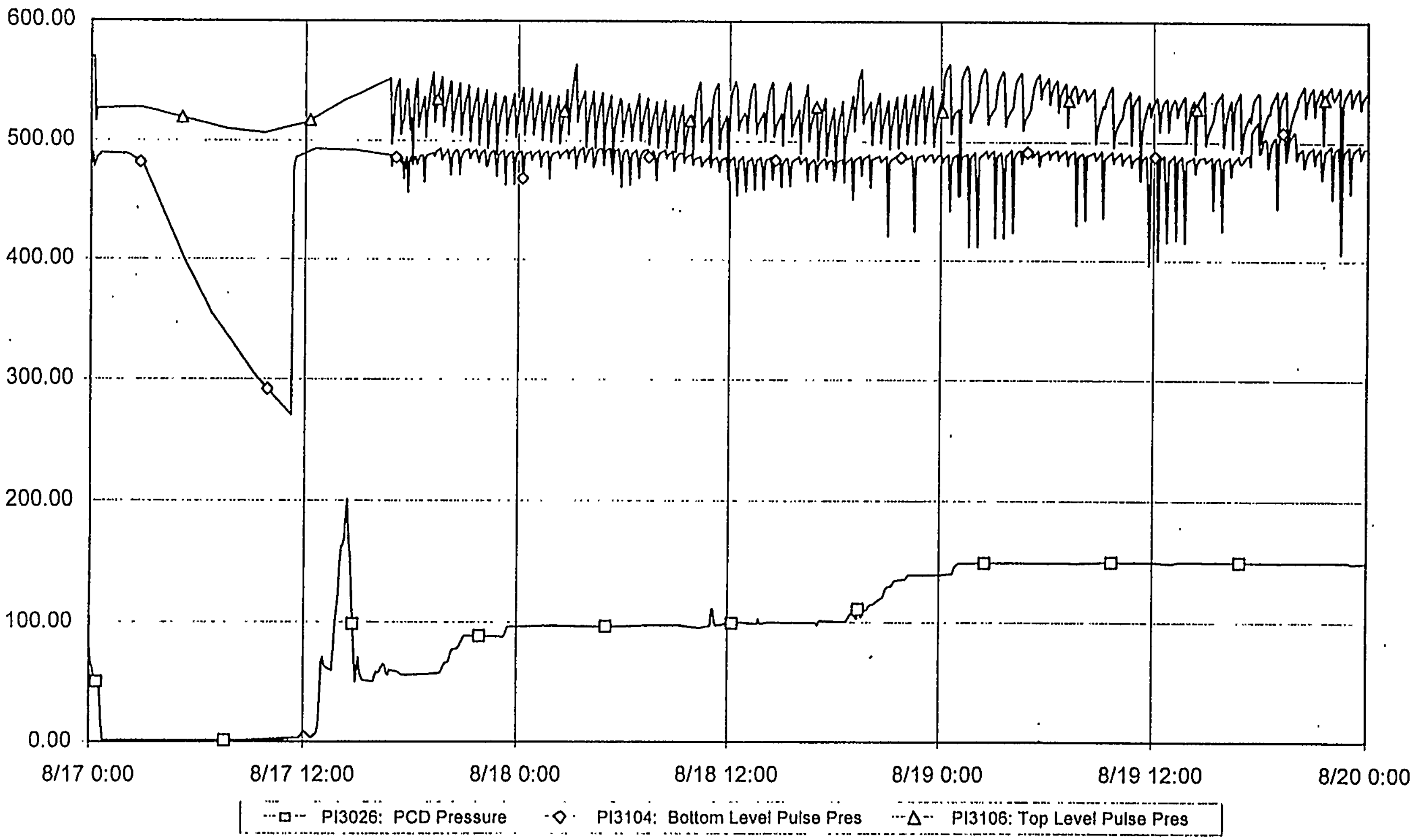
DOE Plot 44 of 47 - 5 minute data

5.1.7-52 PCD Temperatures for August 17 Through August 19, 1996



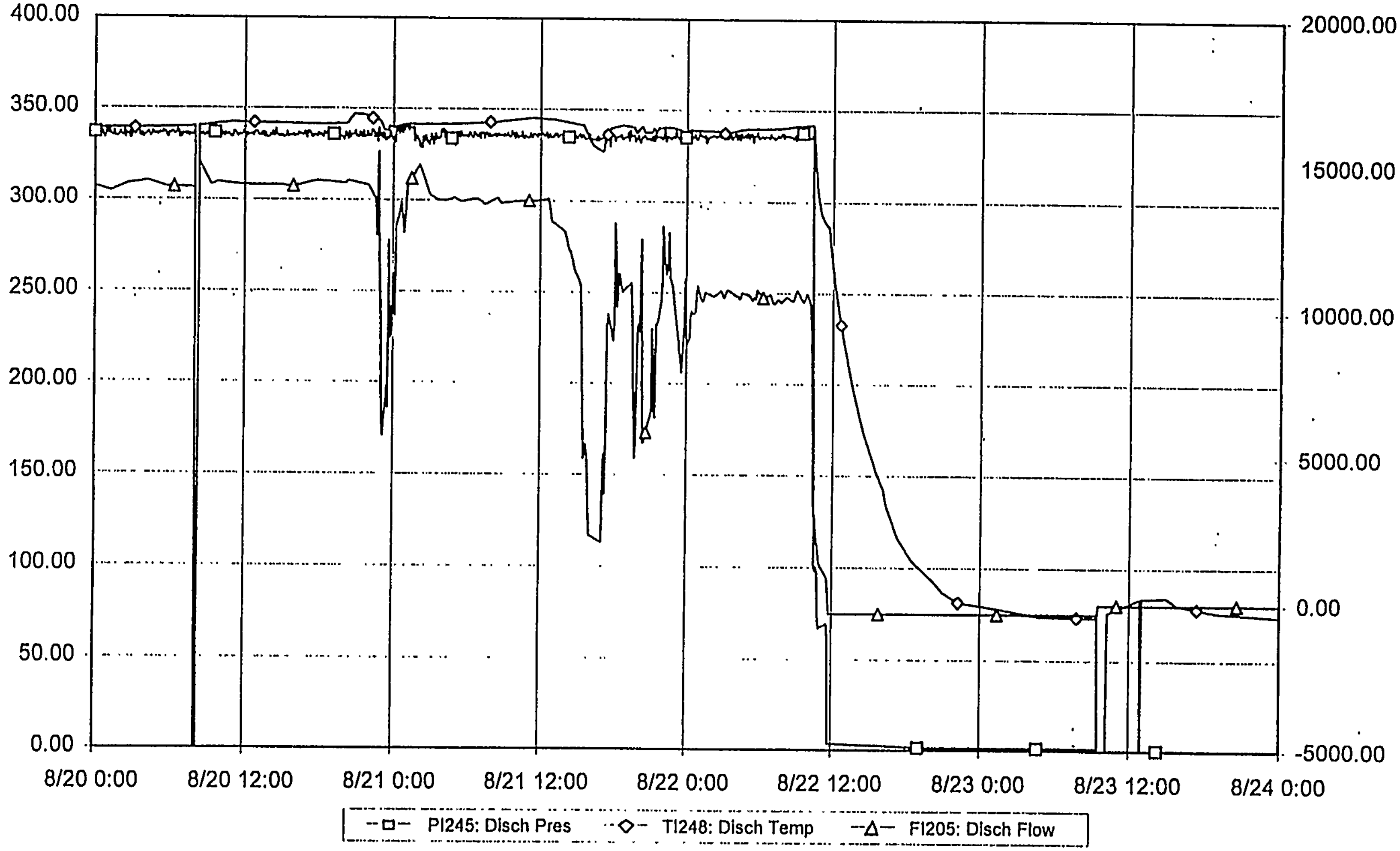
DOE Plot 45 of 47 - 5 minute data

5.1.7-53 PCD Differential Pressures for August 17 Through August 19, 1996



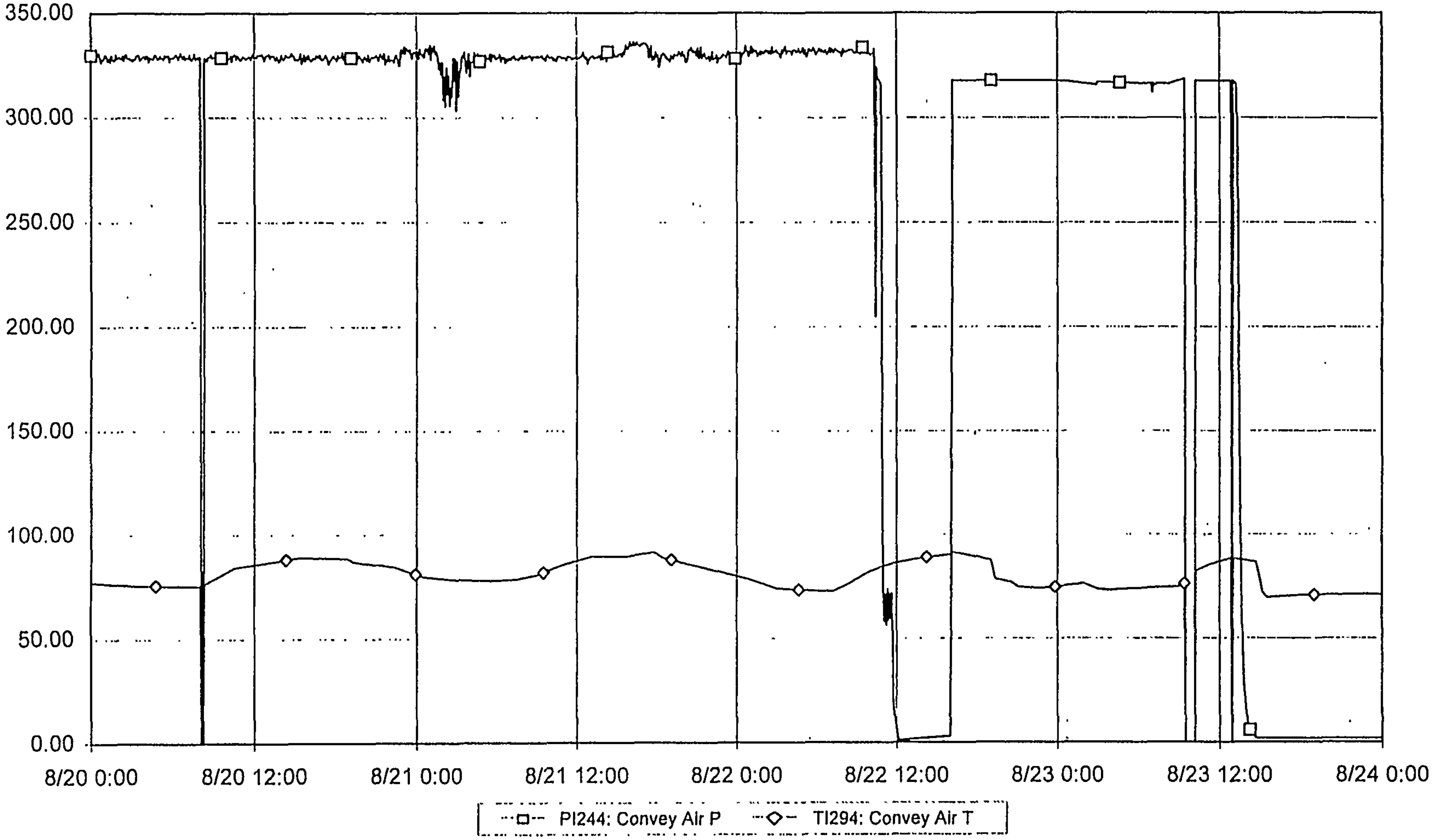
DOE Plot 46 of 47 - 5 minute data

5.1.7.54 PCD Pressure and Pulse Pressure for August 17 Through August 19, 1996



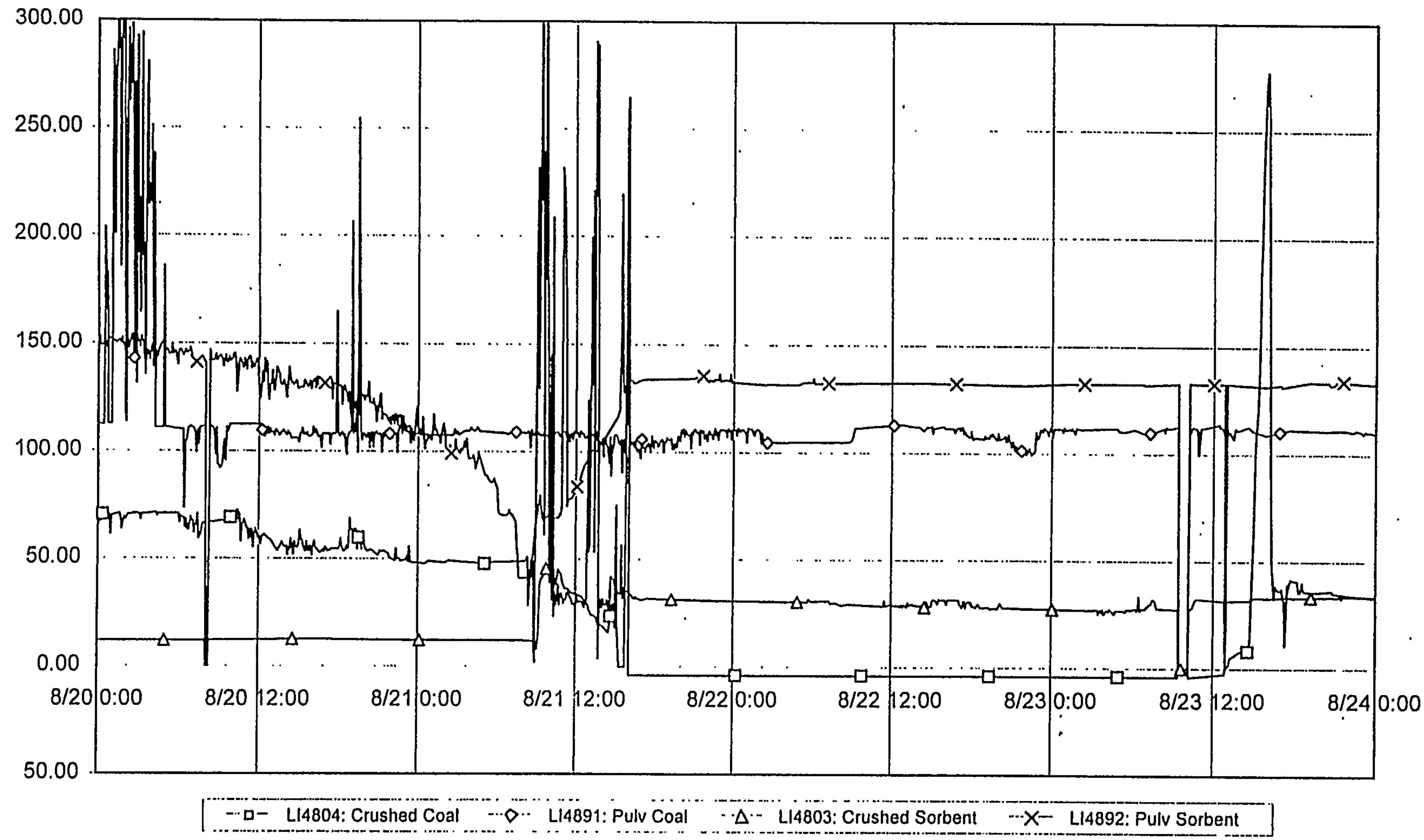
DOE Plot 1 of 47 - 5 minute data

5.1.7-55 C00201 System Profile for August 20 Through August 23, 1996



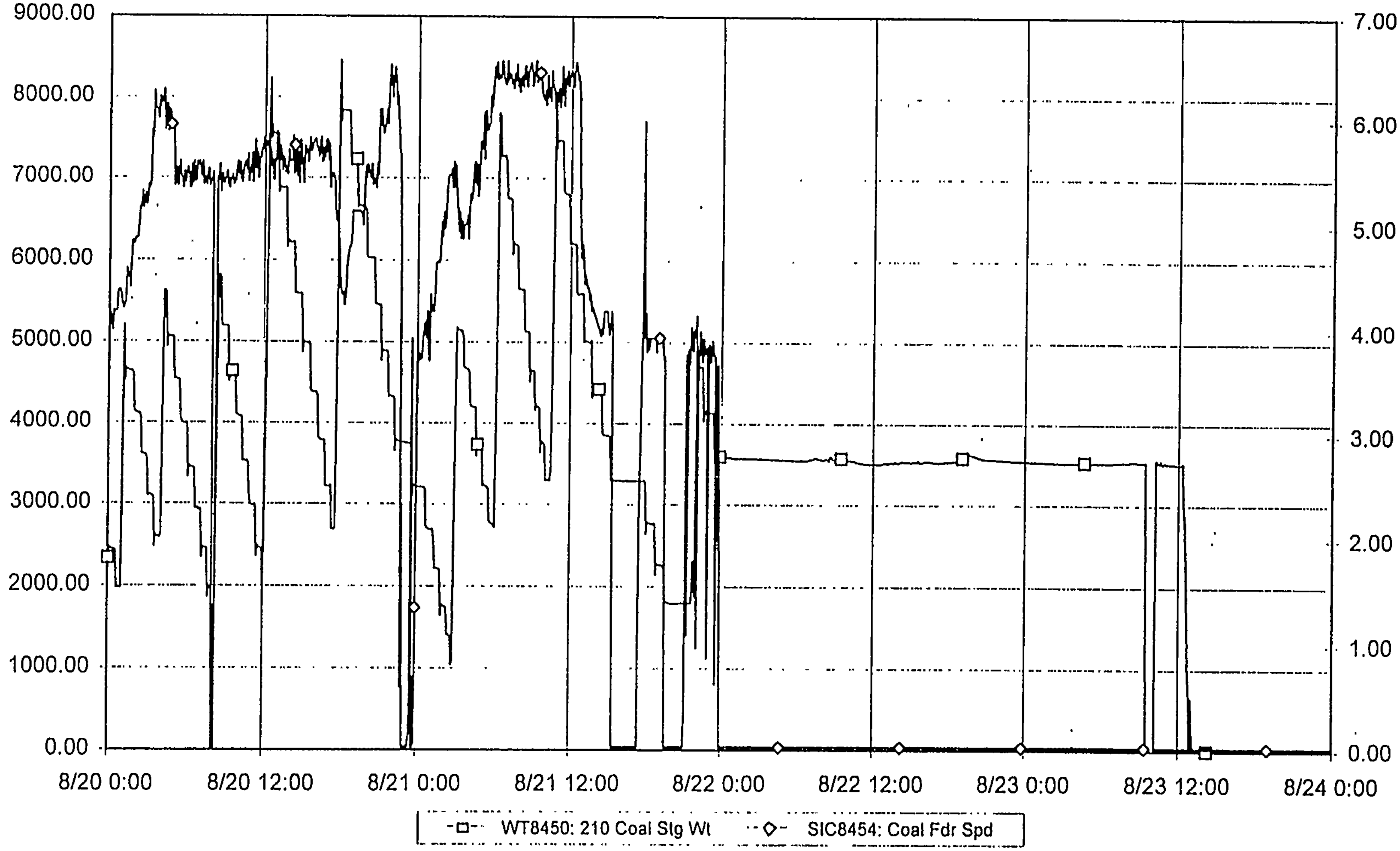
DOE Plot 5 of 47 - 5 minute data

5.1.7-56 Transport Air System for August 20 Through August 23, 1996



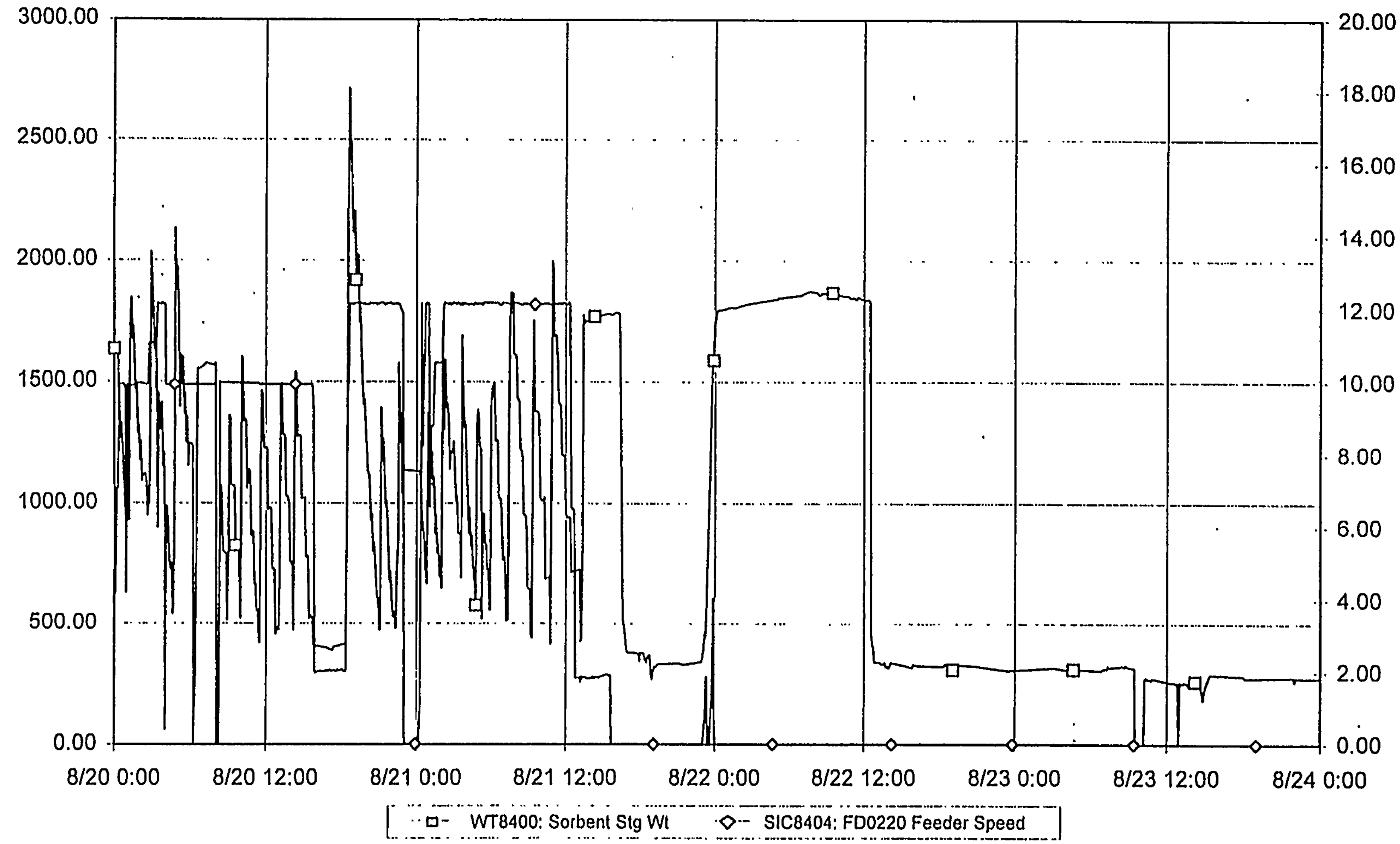
DOE Plot 6 of 47 - 5 minute data

5.1.7-57 Coal and Sorbent Silo Levels for August 20 Through August 23, 1996



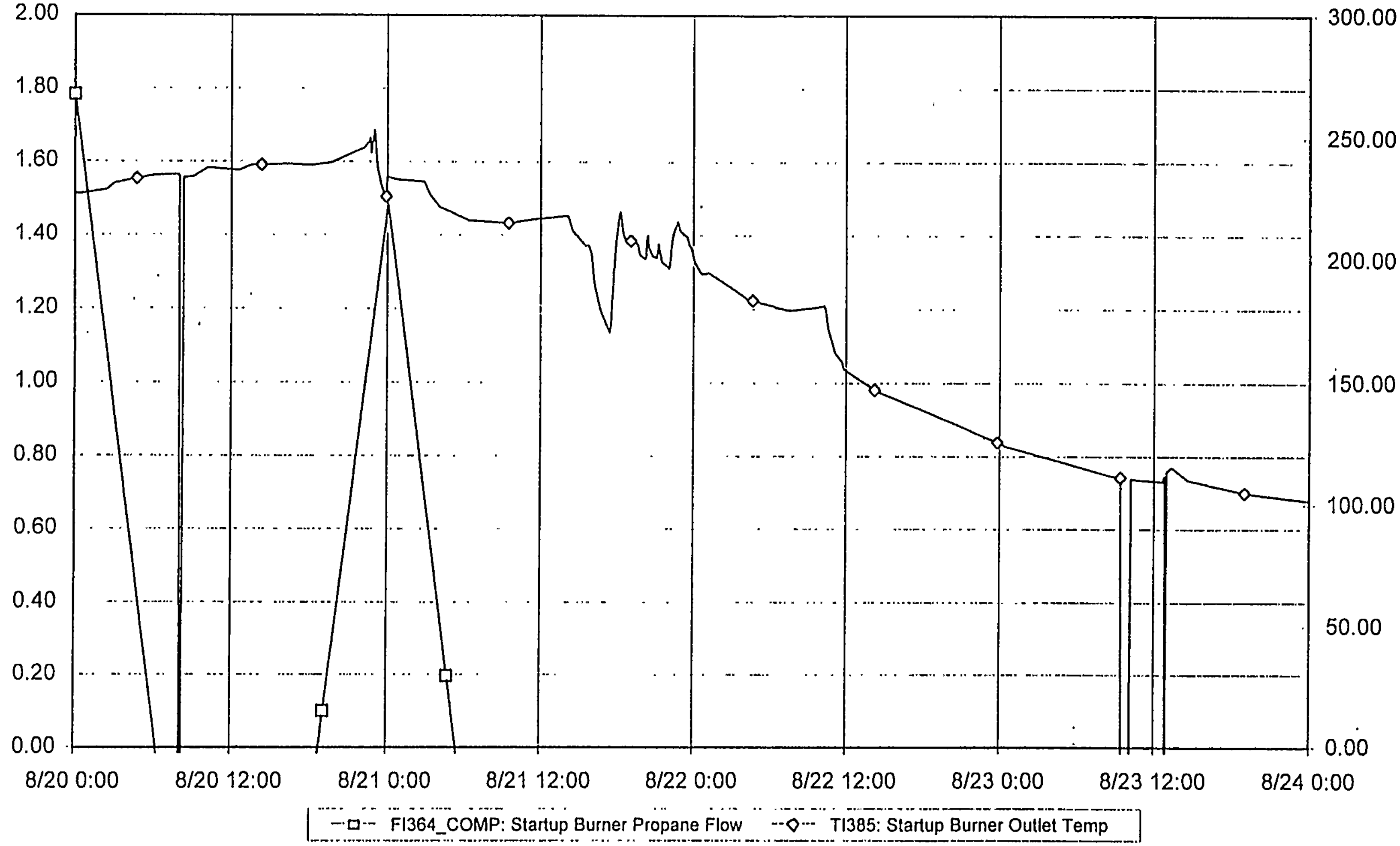
DOE Plot 7 of 47 - 5 minute data

5.1.7-58 Coal Feed for August 20 Through August 23, 1996



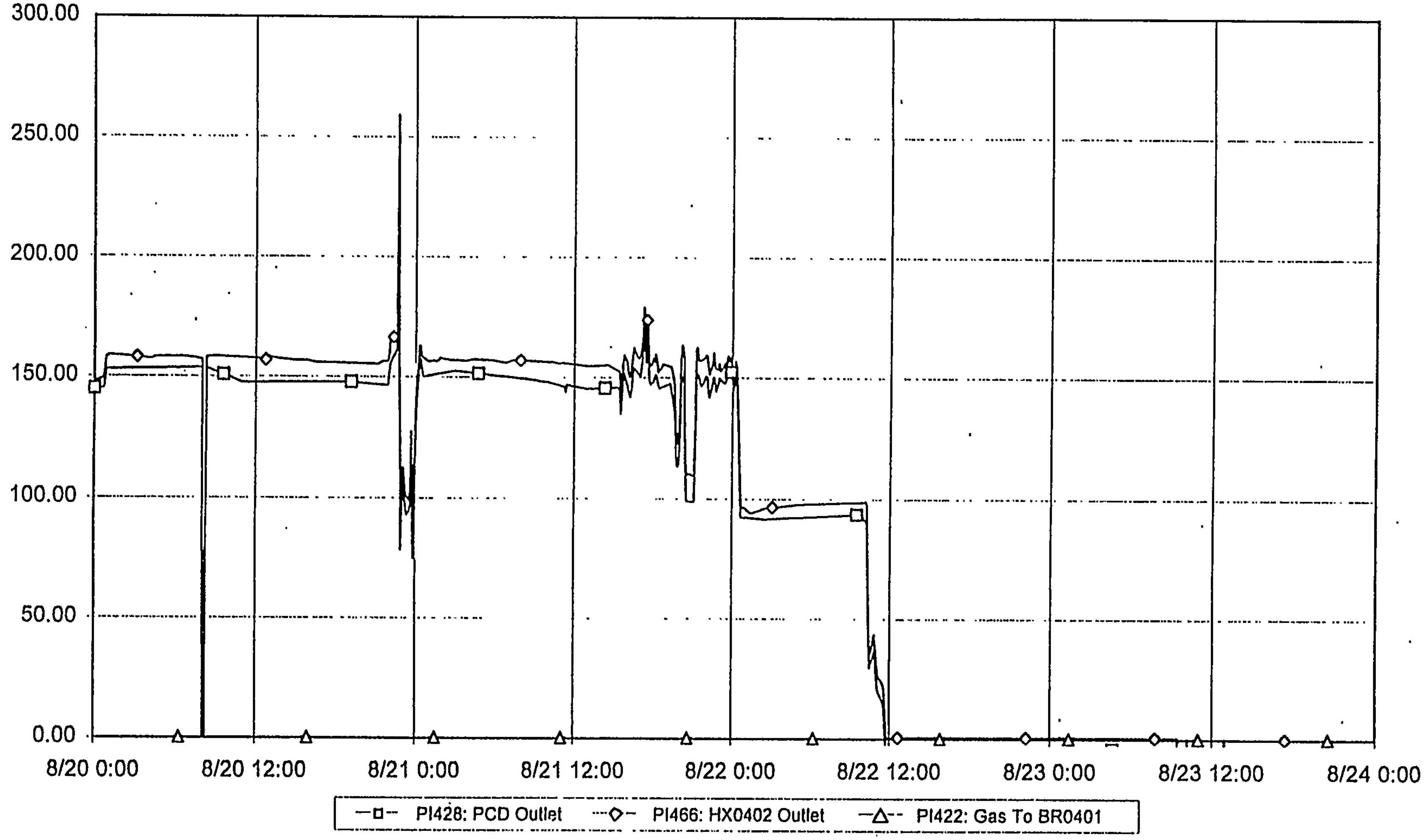
DOE Plot 8 of 47 - 5 minute data

5.1.7-59 Sorbent Feed for August 20 Through August 23, 1996



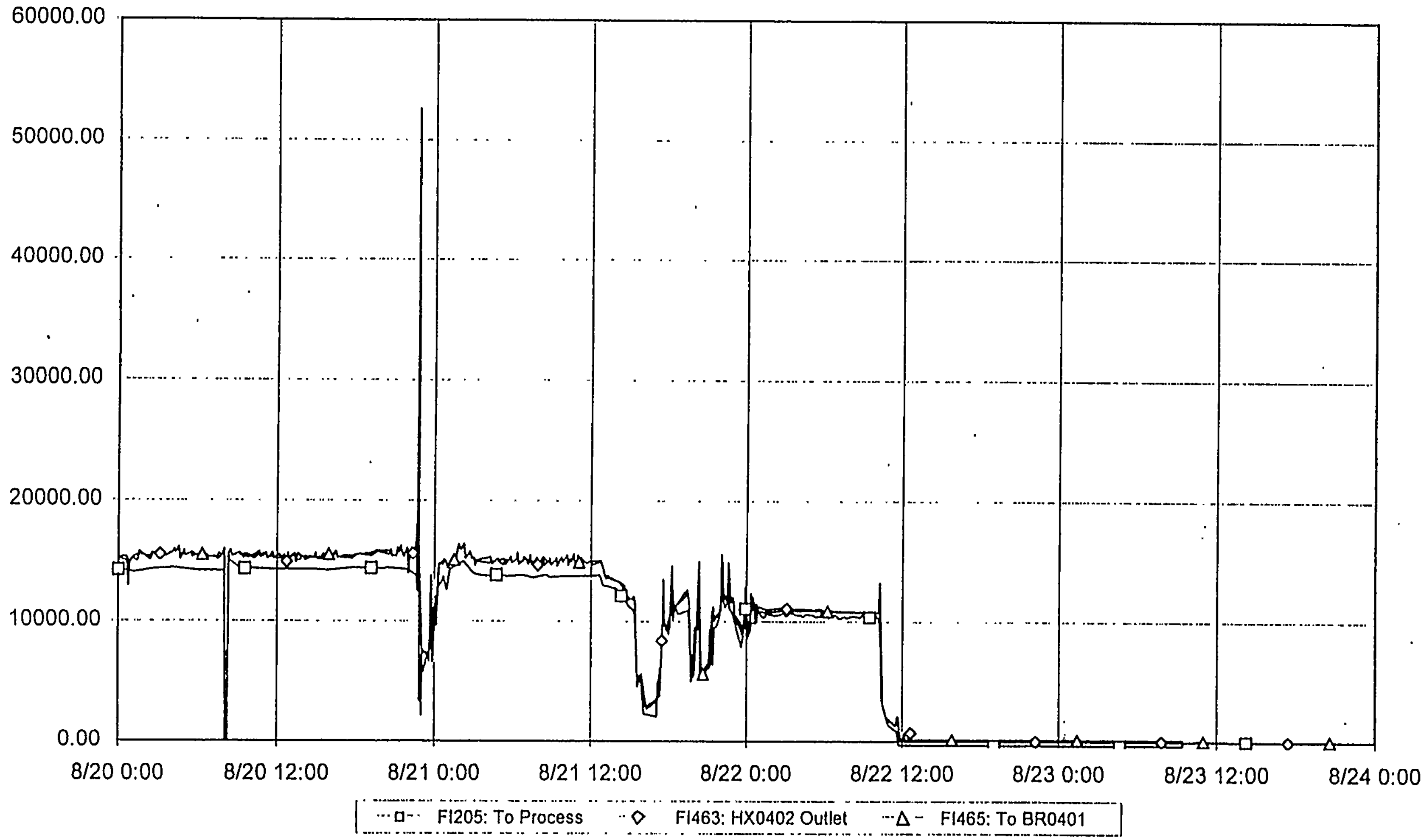
DOE Plot 9 of 47 - 5 minute data

5.1.7-60 Start-Up Burner Flow/Temperature for August 20 Through August 23, 1996



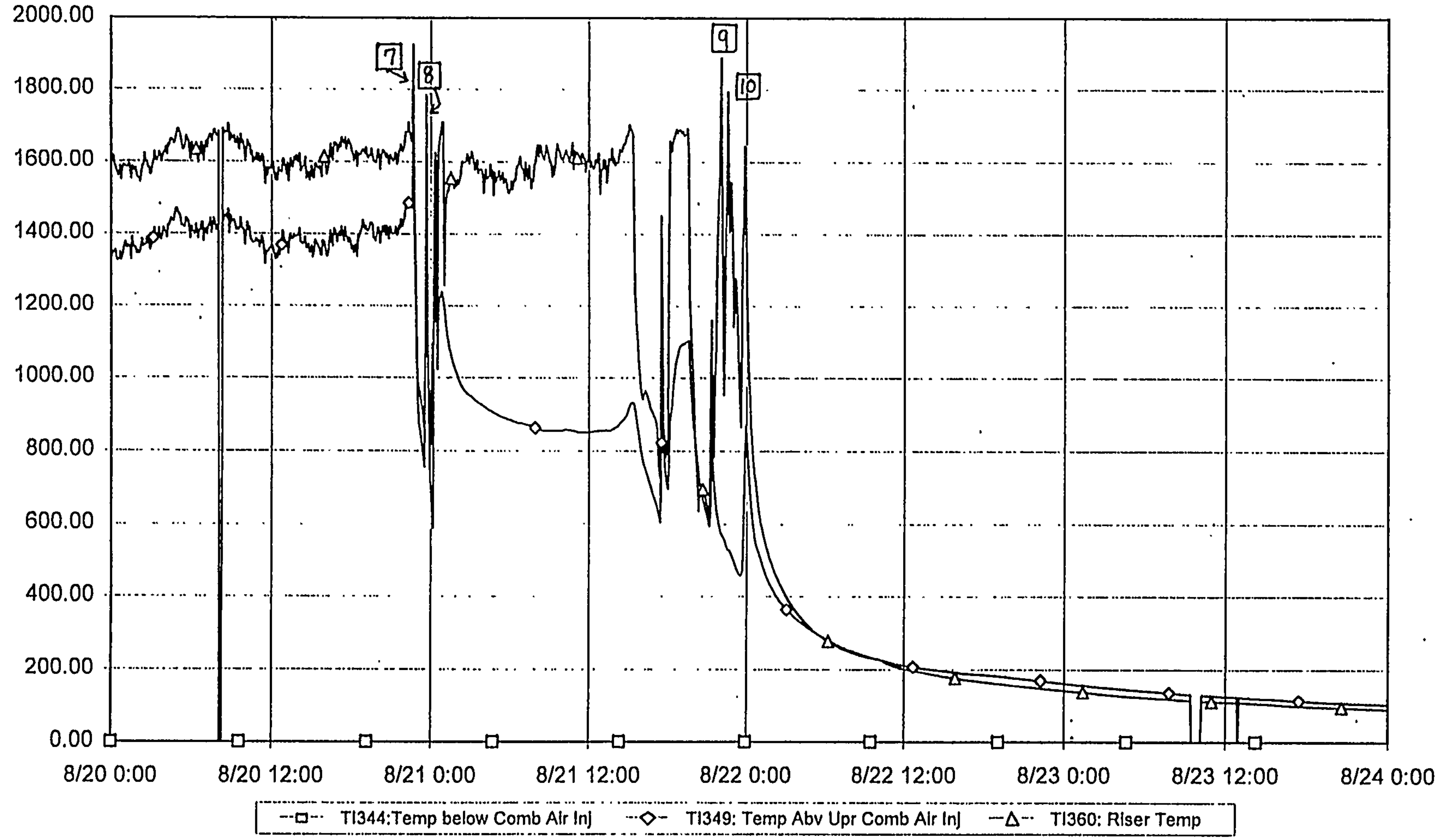
DOE Plot 10 of 47 - 5 minute data

5.1.7-61 System Pressures Downstream of PCD for August 20 Through August 23, 1996



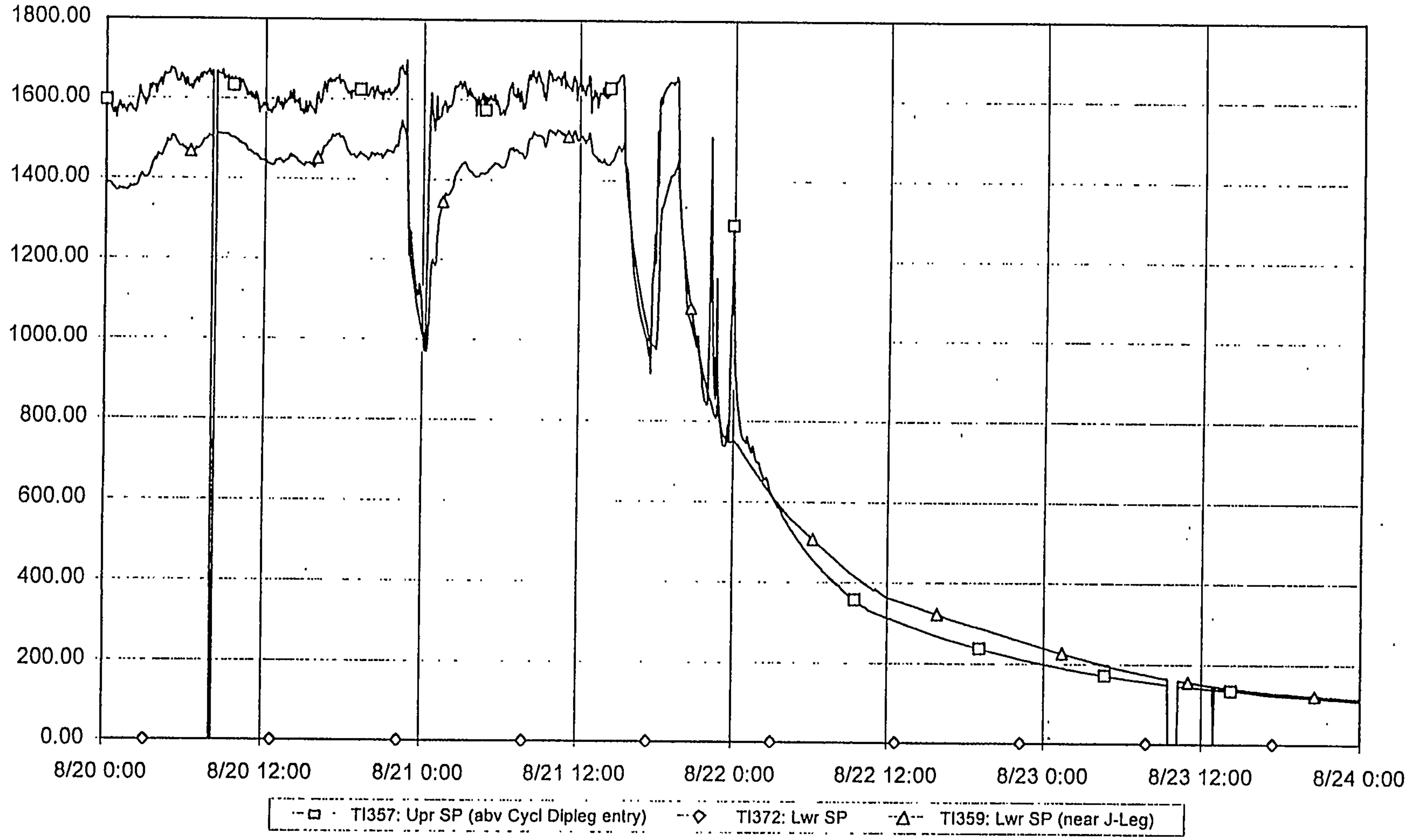
DOE Plot 11 of 47 - 5 minute data

5.1.7-62 Total Gas In/Out Flow Rates for August 20 Through August 23, 1996



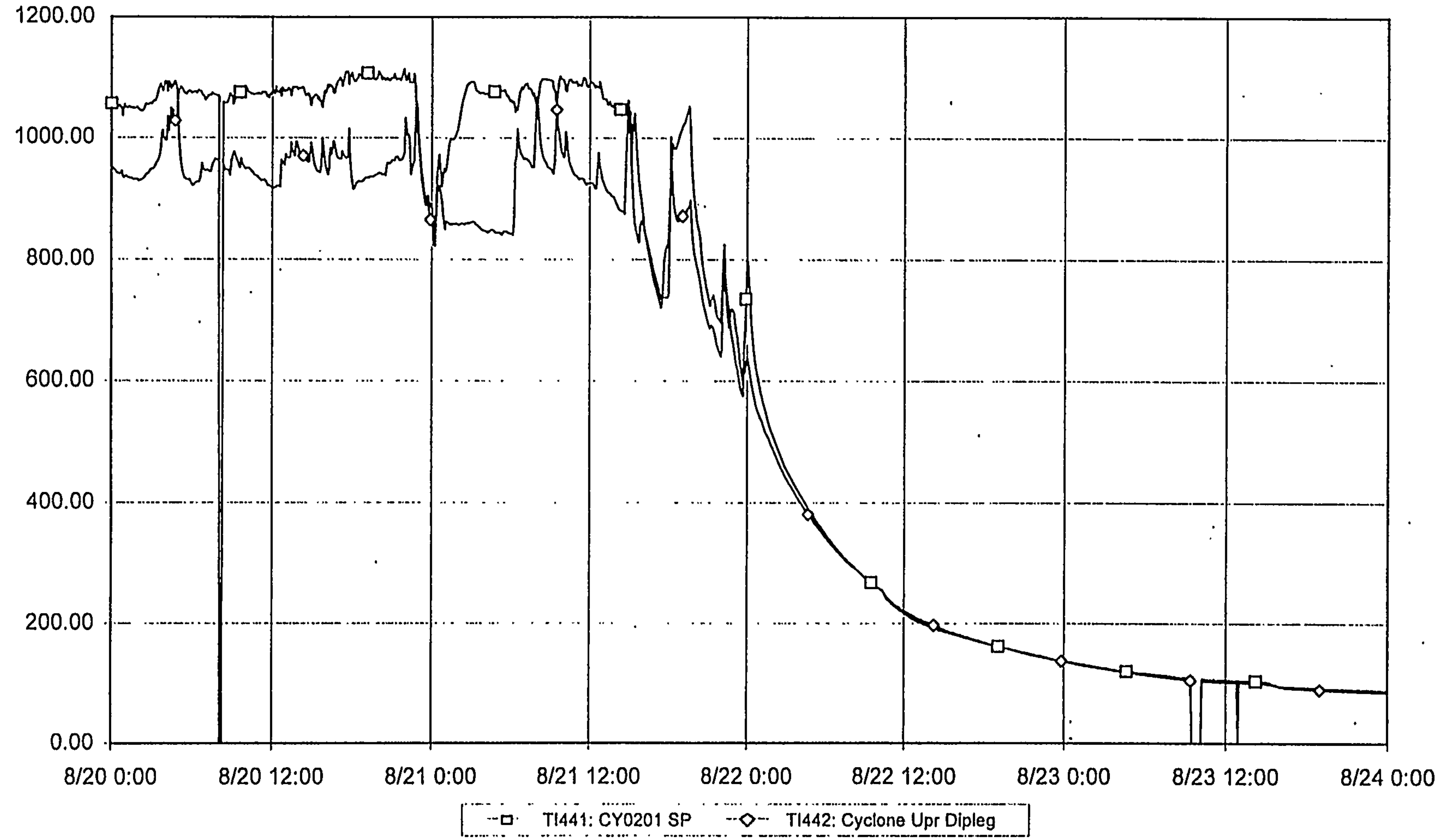
DOE Plot 12 of 47 - 5 minute data

5.1.7-63 Reactor Mixing Zone and Riser Temperatures for August 20 Through August 23, 1996



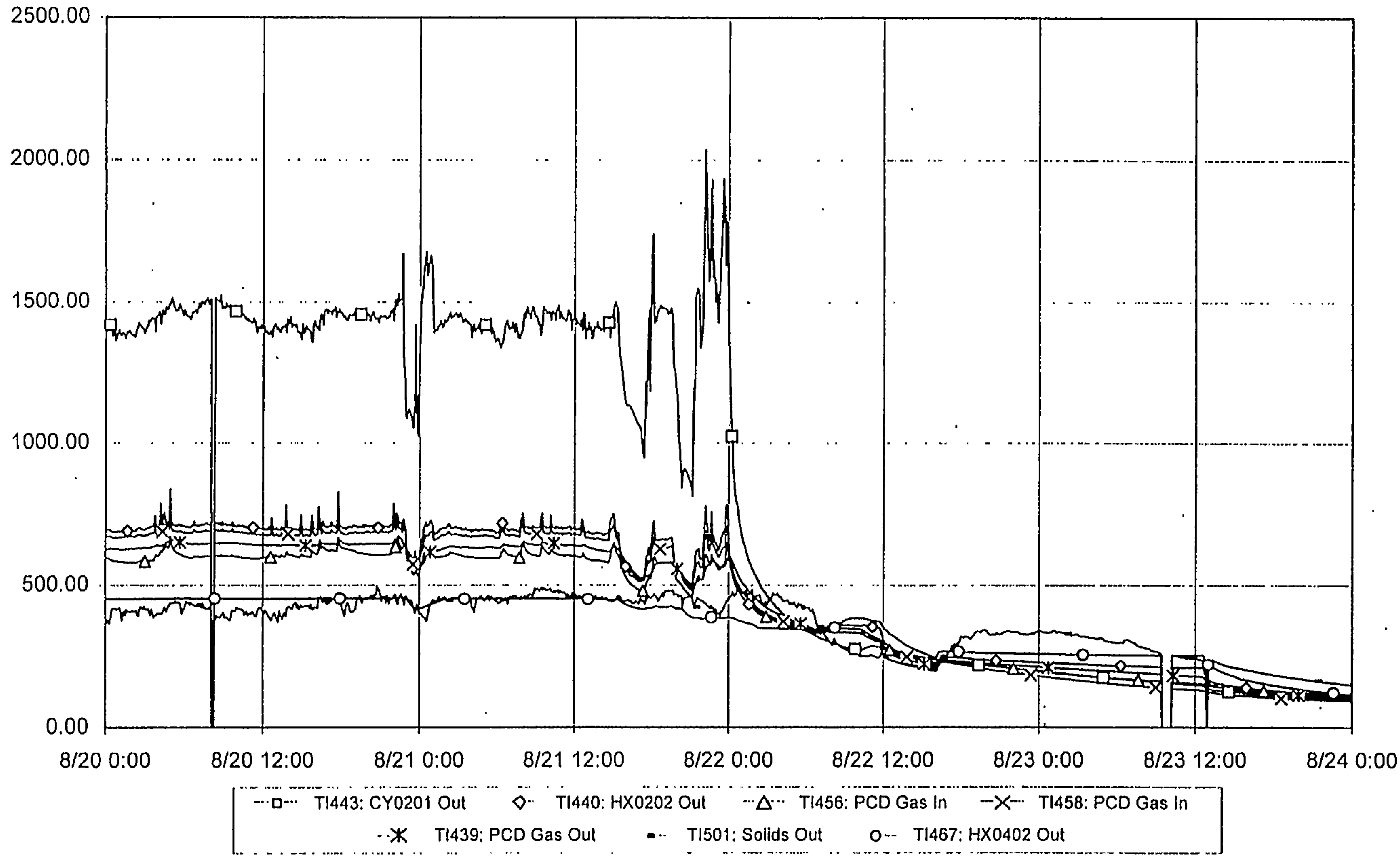
DOE Plot 13 of 47 - 5 minute data

5.1.7-64 Standpipe Temperatures for August 20 Through August 23, 1996



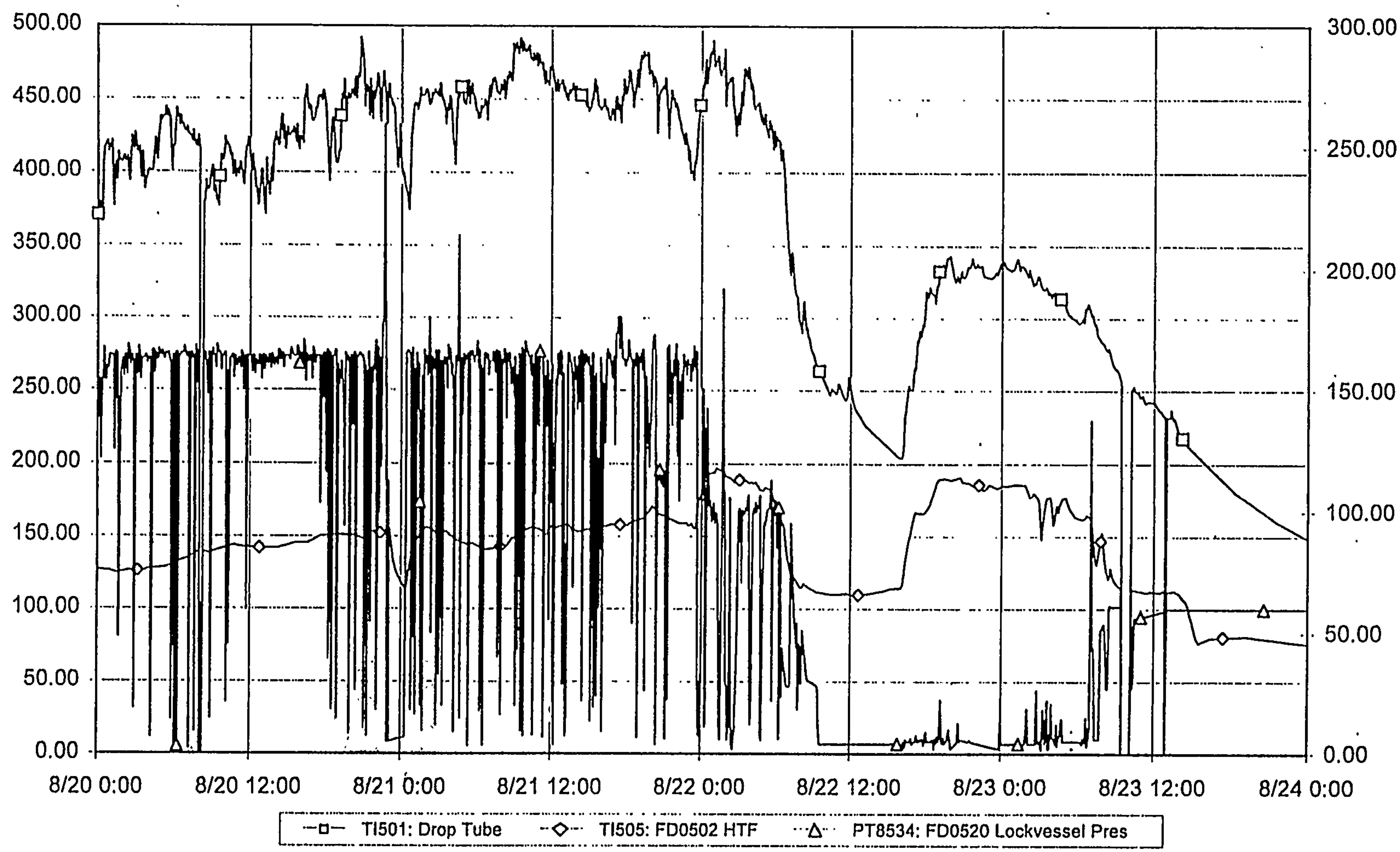
DOE Plot 14 of 47 - 5 minute data

5.1.7-65 Cyclone Dipleg Temperatures for August 20 Through August 23, 1996



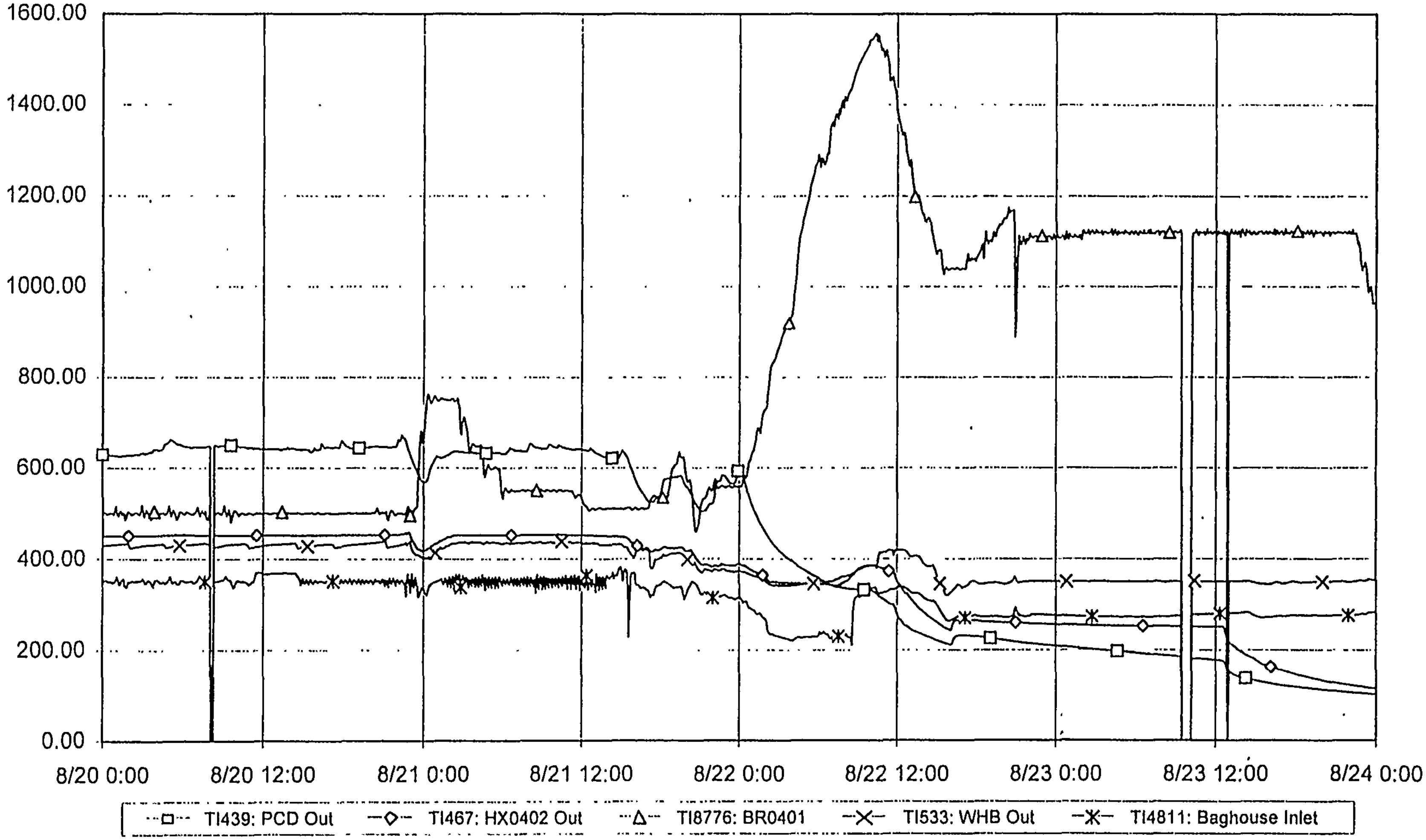
DOE Plot 15 of 47 - 5 minute data

5.1.7-66 Temperature Profiles Downstream of Reactor for August 20 Through August 23, 1996



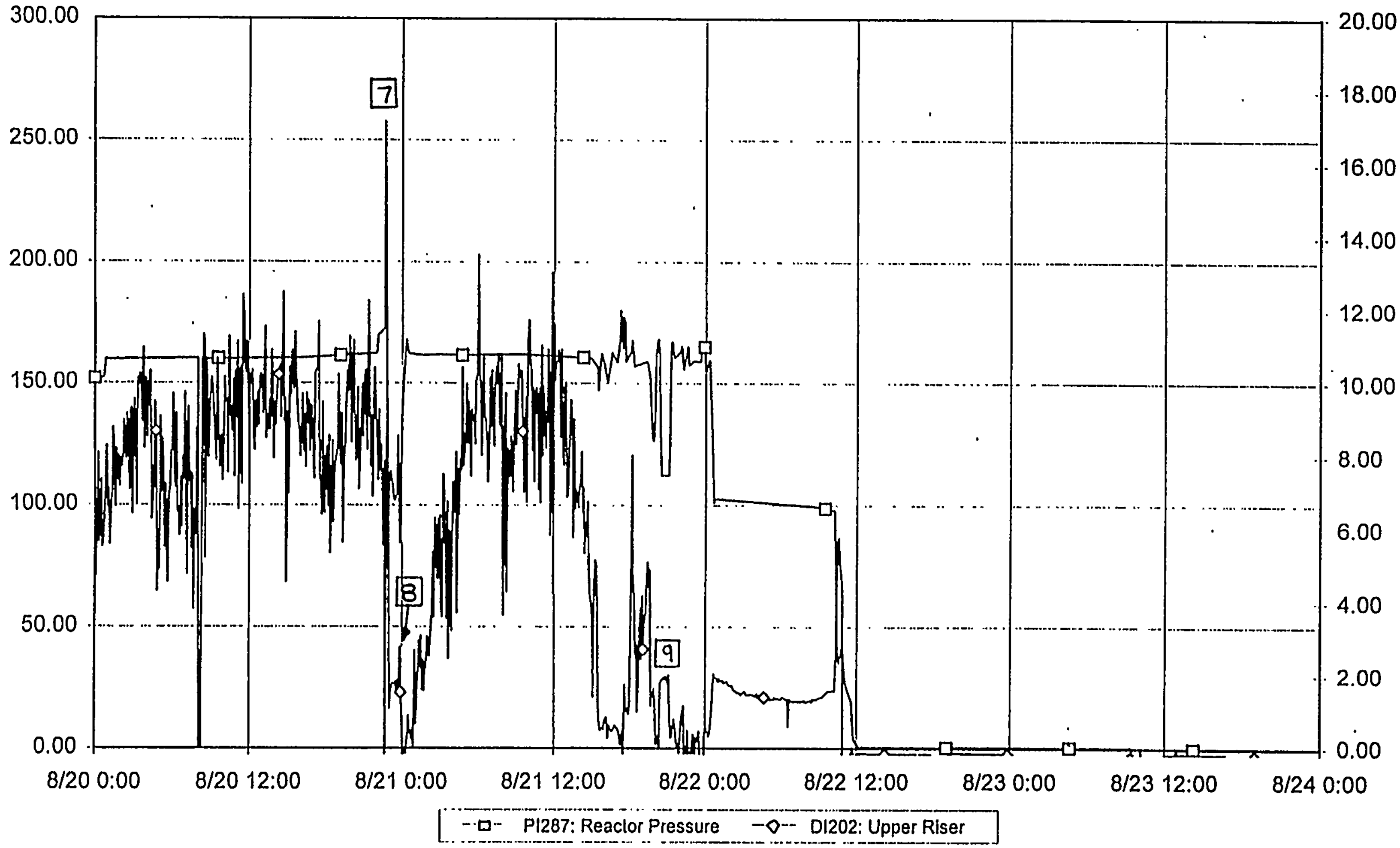
DOE Plot 16 of 47 - 5 minute data

Figure 5.1.7-67 PCD Ash Temperatures for August 20 Through August 23, 1996



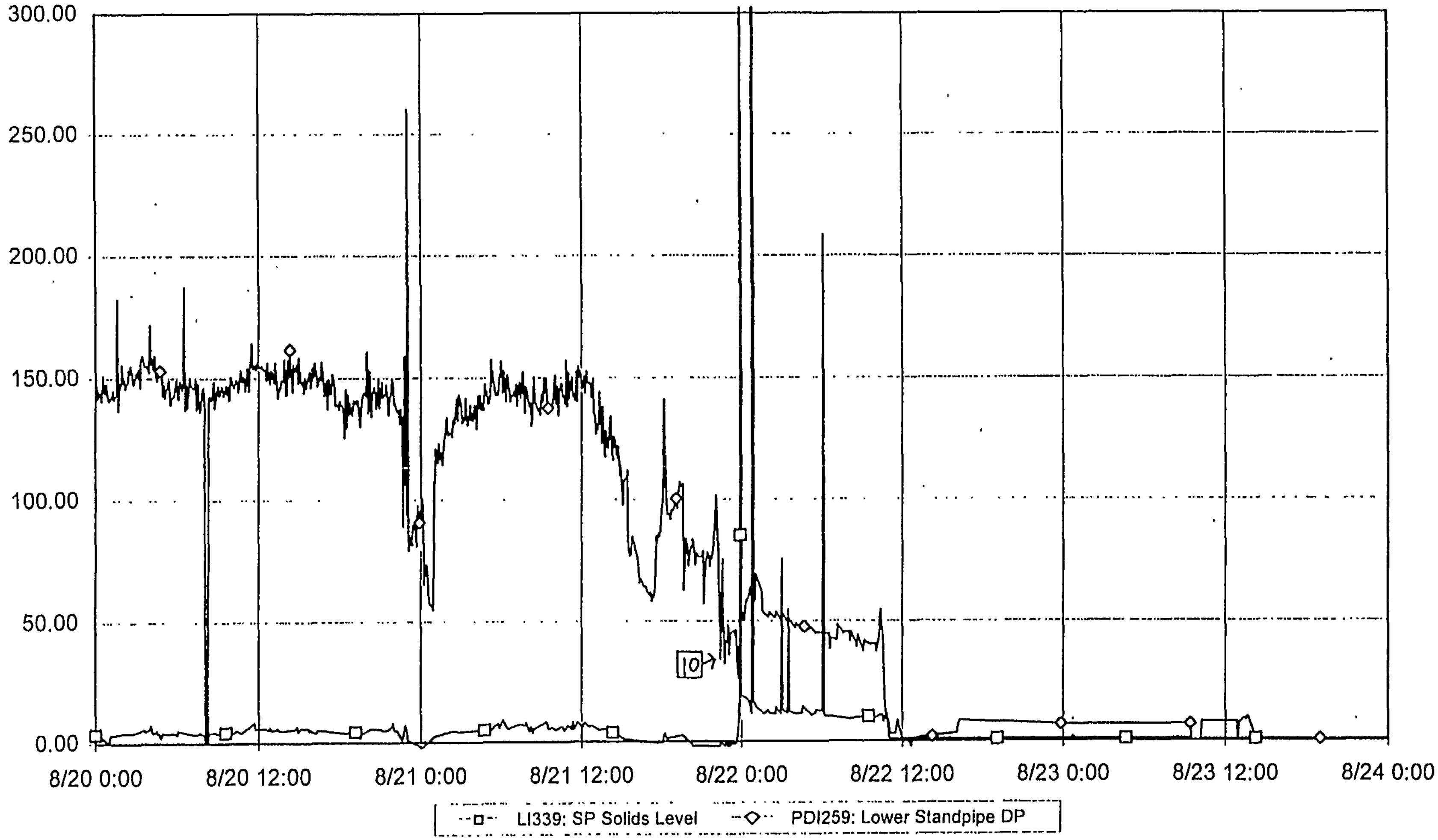
DOE Plot 17 of 47 - 5 minute data

Figure 5.1.7-68 System Temperatures Downstream of PCD for August 20 Through August 23, 1996



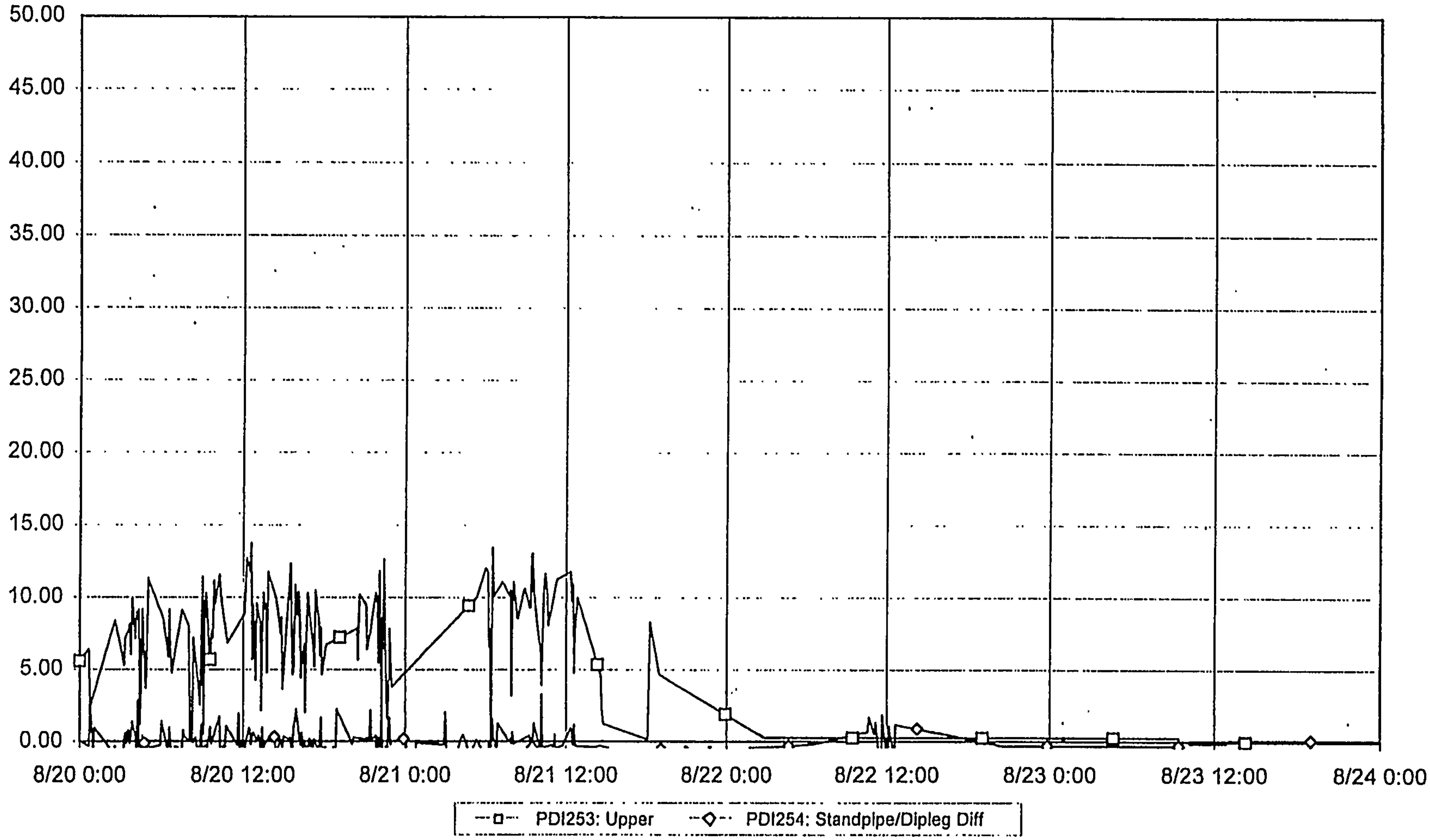
DOE Plot 19 of 47 - 5 minute data

Figure 5.1.7-69 Reactor Pressure/Riser DP Profiles for August 20 Through August 23, 1996



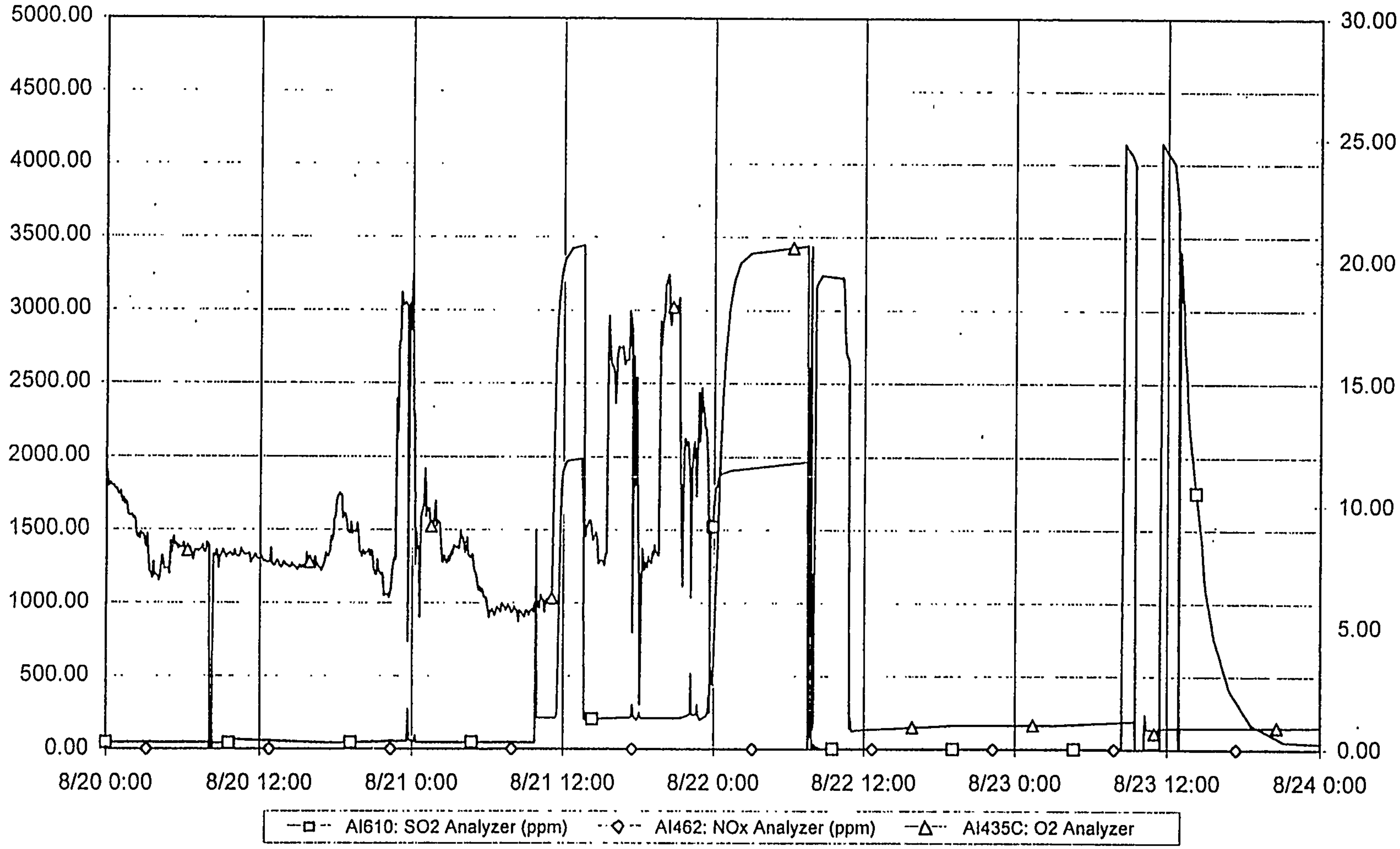
DOE Plot 20 of 47 - 5 minute data

Figure 5.1.7-70 Standpipe DP Profiles for August 20 Through August 23, 1996



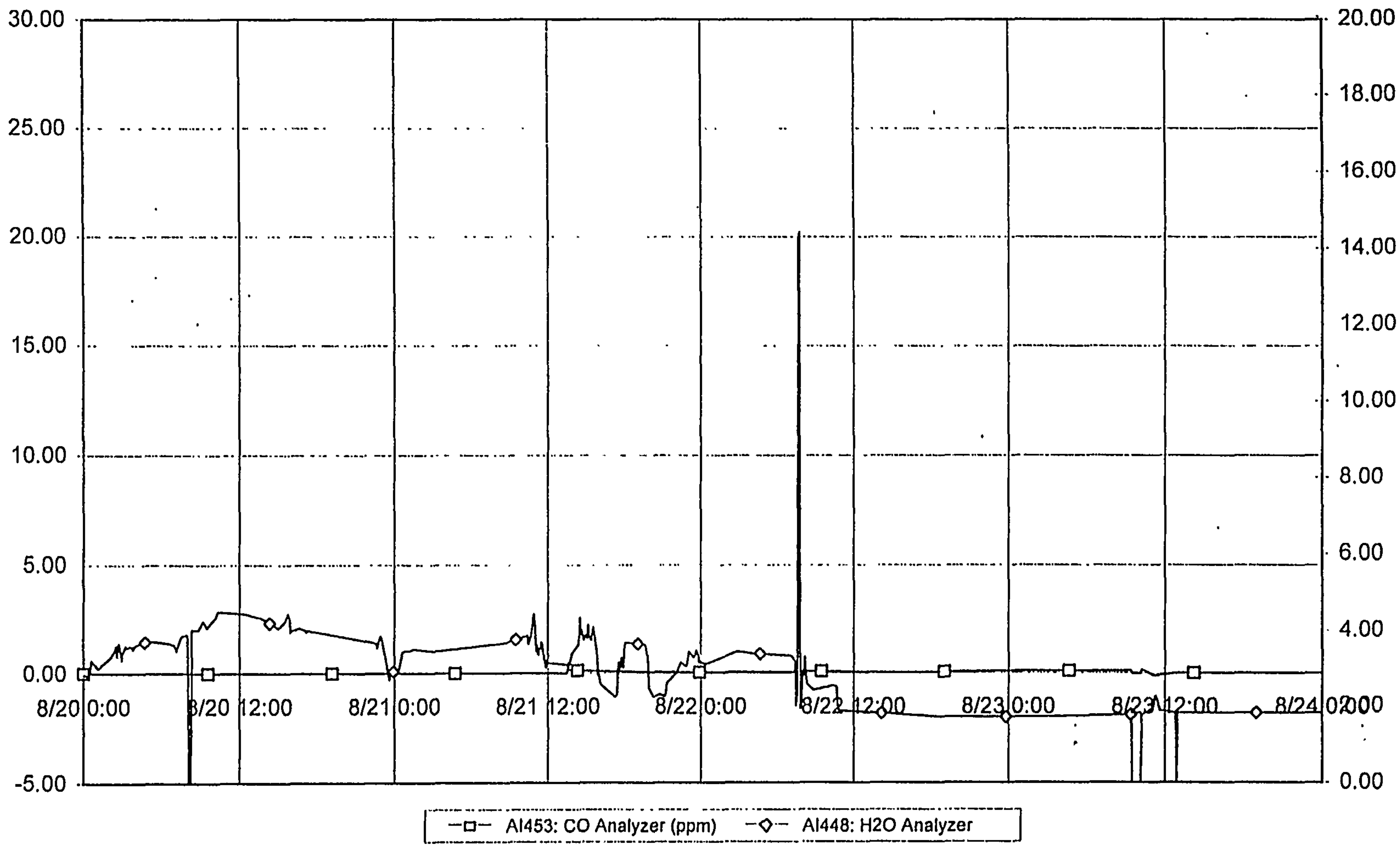
DOE Plot 21 of 47 - 5 minute data

Figure 5.1.7-71 CY0201 Dipleg DP Profiles for August 20 Through August 23, 1996



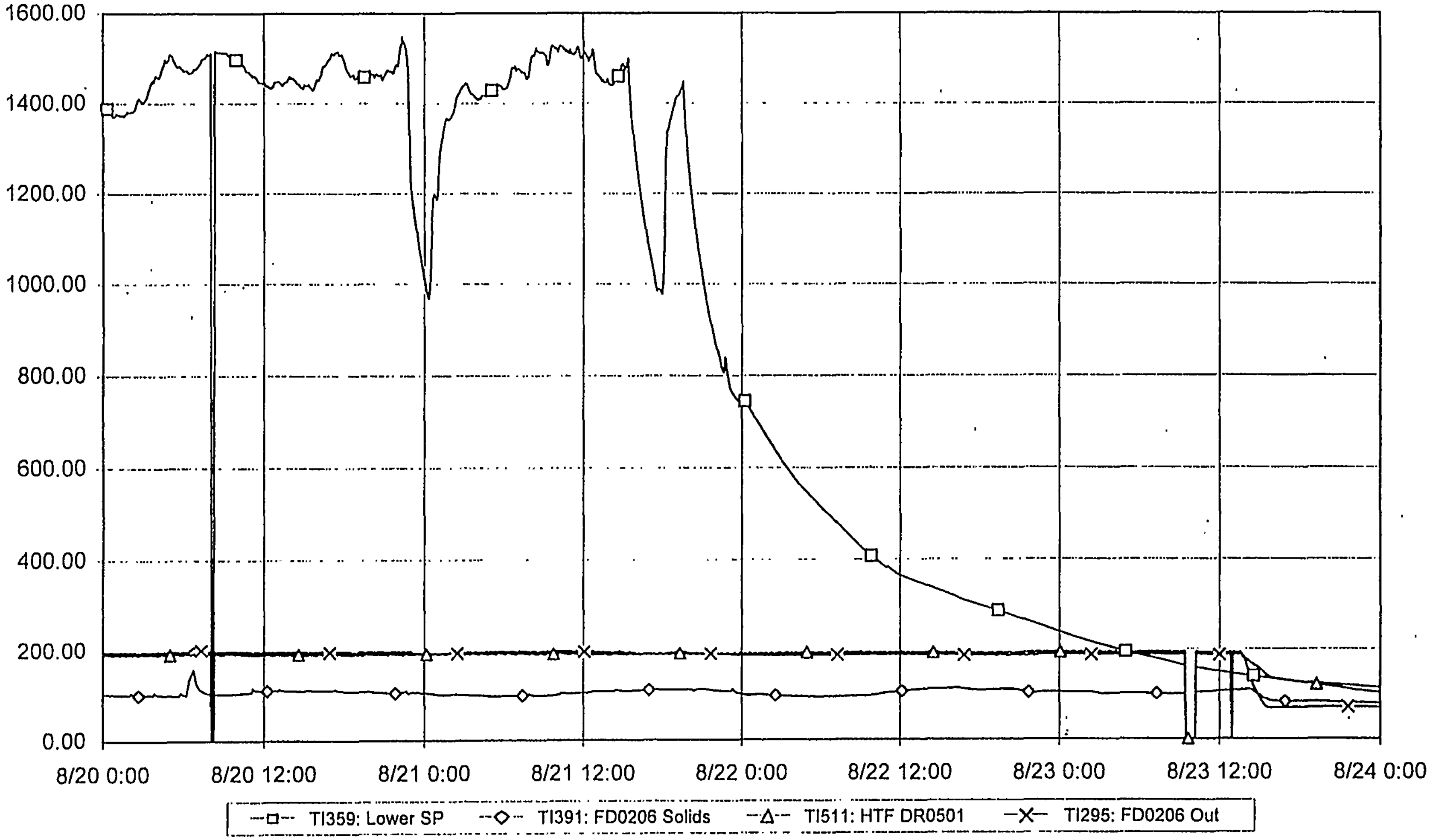
DOE Plot 23 of 47 - 5 minute data

Figure 5.1.7-72 O_2, SO_2, and NO_x Analyzers for August 20 Through August 23, 1996



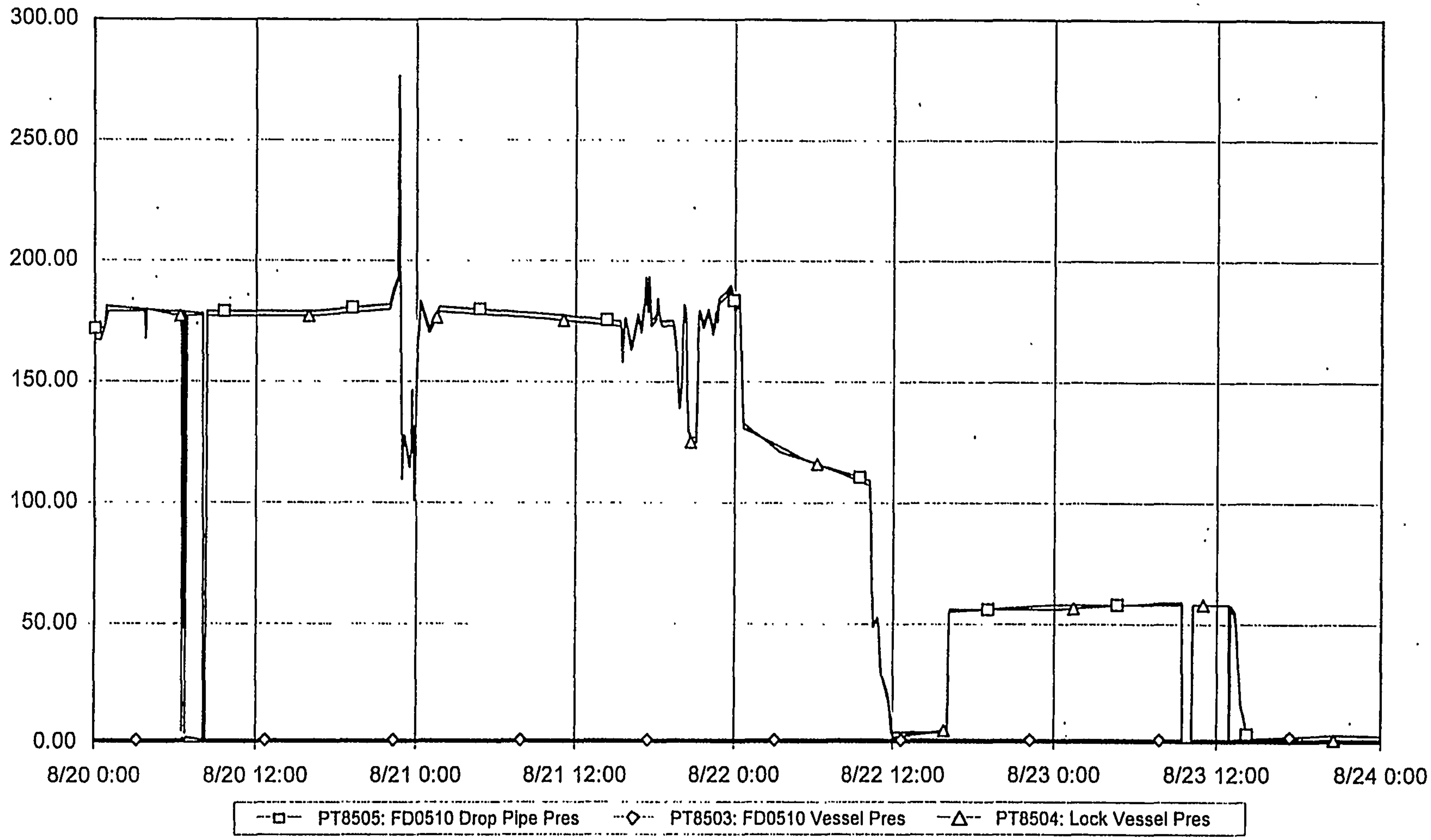
DOE Plot 24 of 47 - 5 minute data

Figure 5.1.7-73 CO and H_2O Analyzer for August 20 Through August 23, 1996



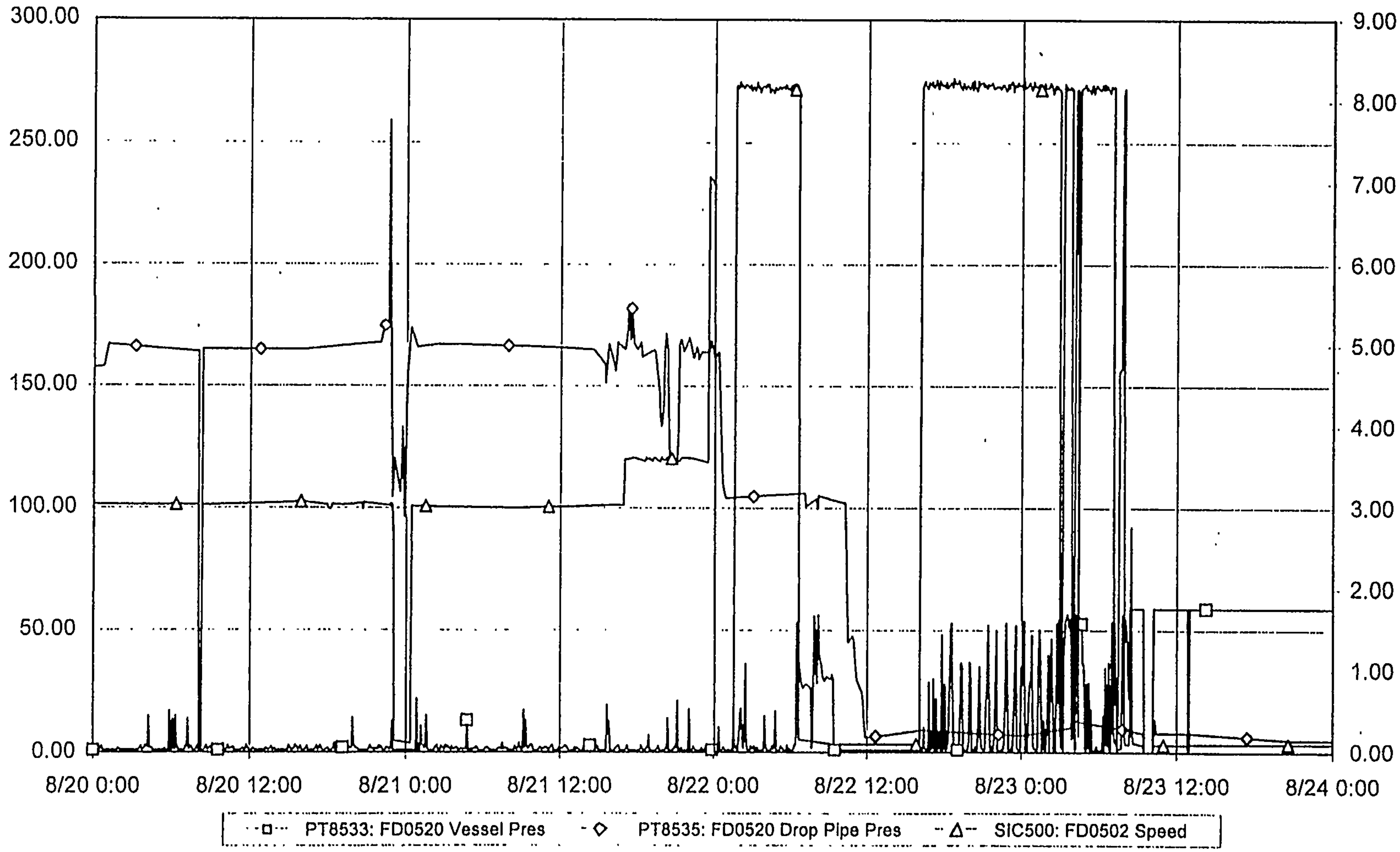
DOE Plot 28 of 47 - 5 minute data

Figure 5.1.7-74 FD0510 Temperature Profiles for August 20 Through August 23, 1996



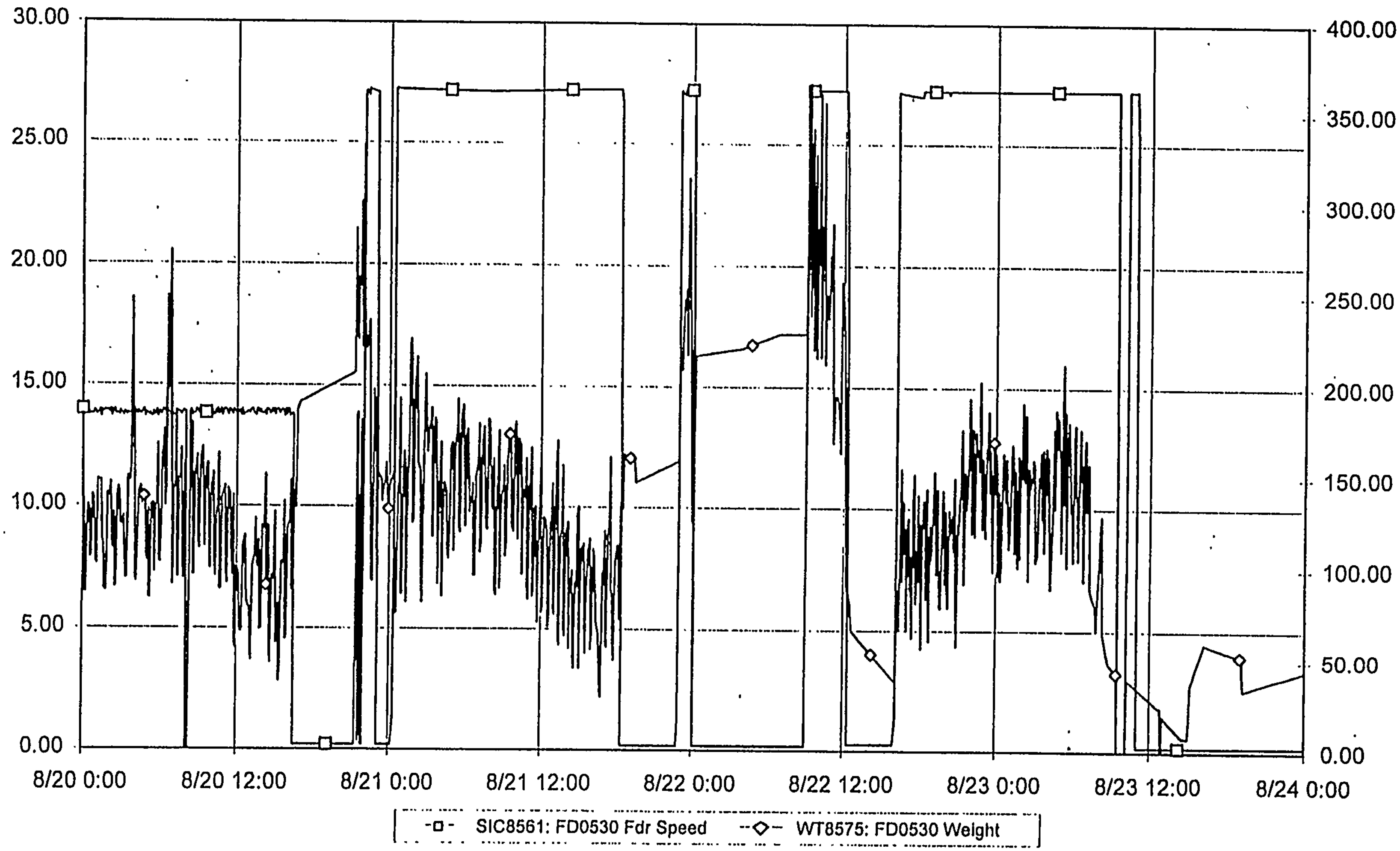
DOE Plot 29 of 47 - 5 minute data

Figure 5.1.7-75 FD0206 Pressure Profiles for August 20 Through August 23, 1996



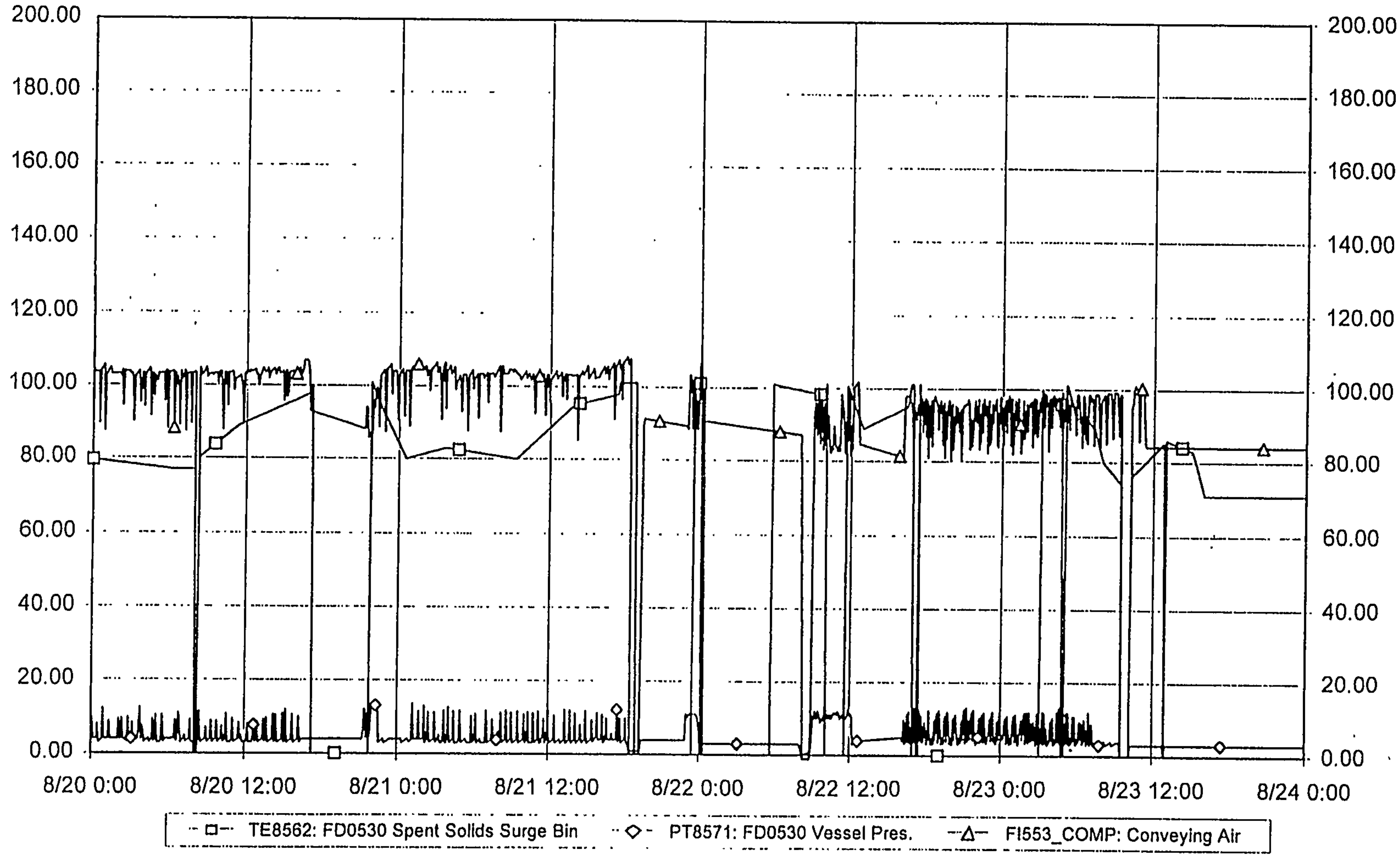
DOE Plot 30 of 47 - 5 minute data

Figure 5.1.7-76 FD0520 Pressures for August 20 Through August 23, 1996



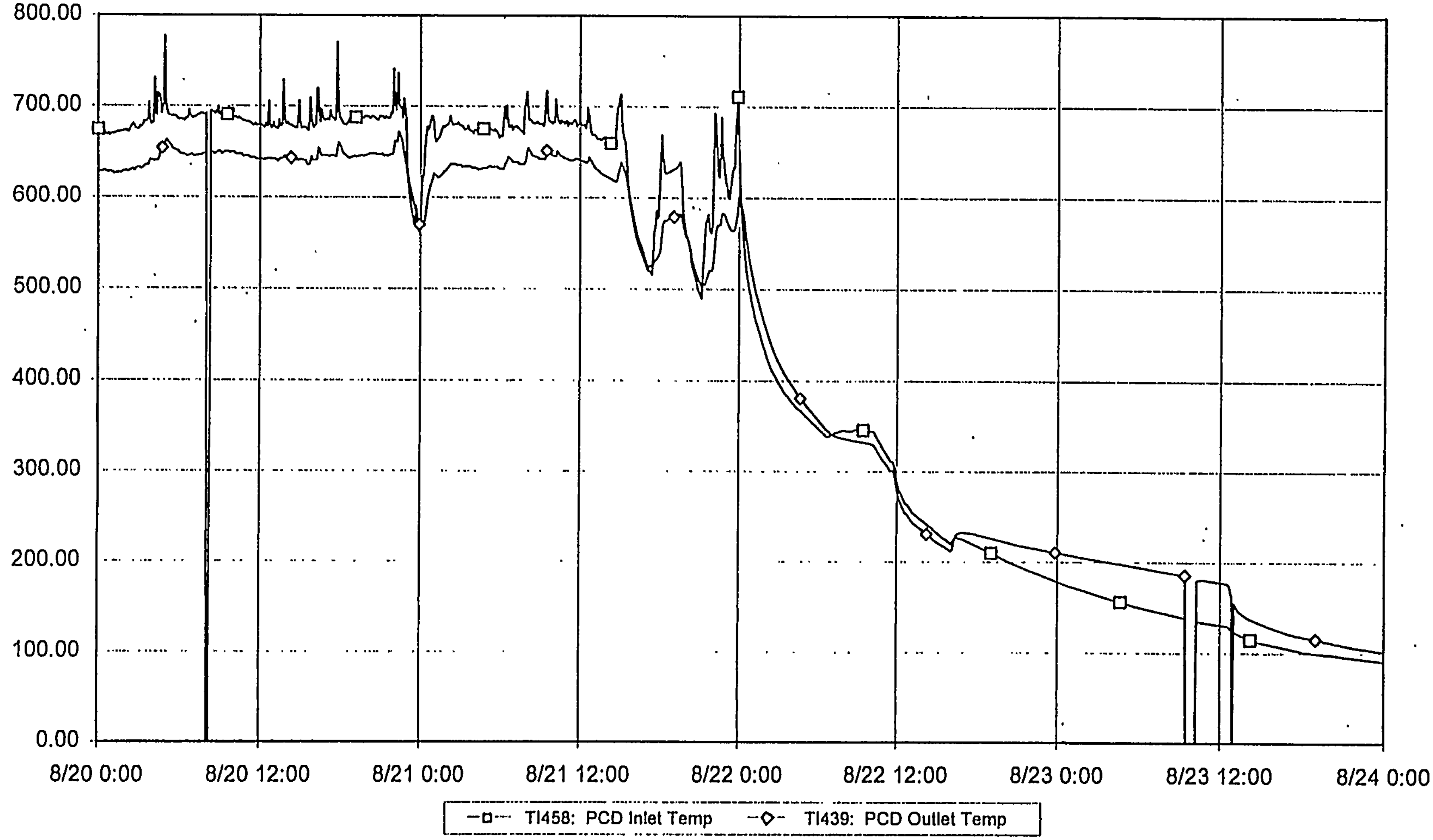
DOE Plot 31 of 47 - 5 minute data

Figure 5.1.7-77 FD0530 Feeder for August 20 Through 23, 1996



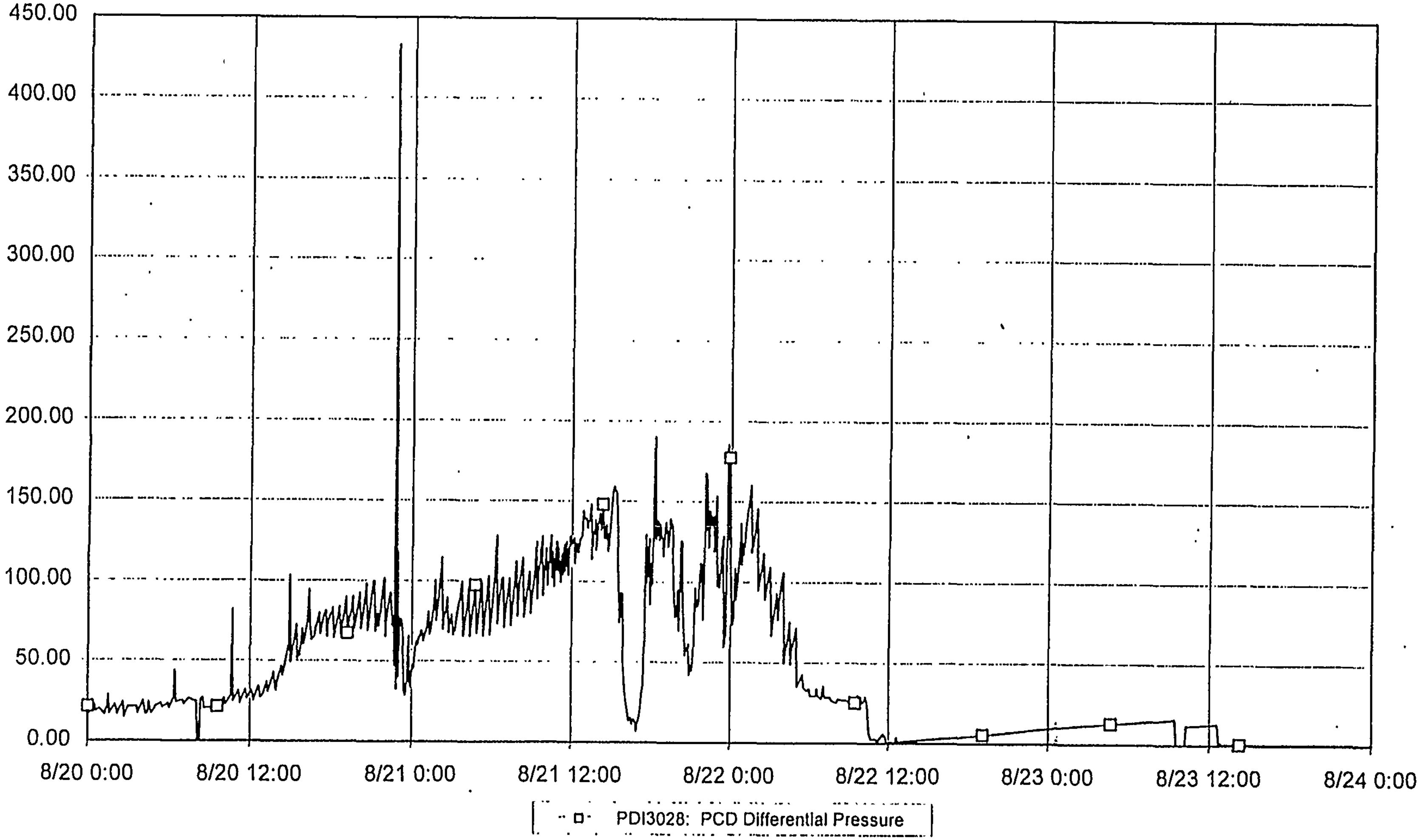
DOE Plot 32 of 47 - 5 minute data

Figure 5.1.7-78 FD0530 Feeder for August 20 Through 23, 1996



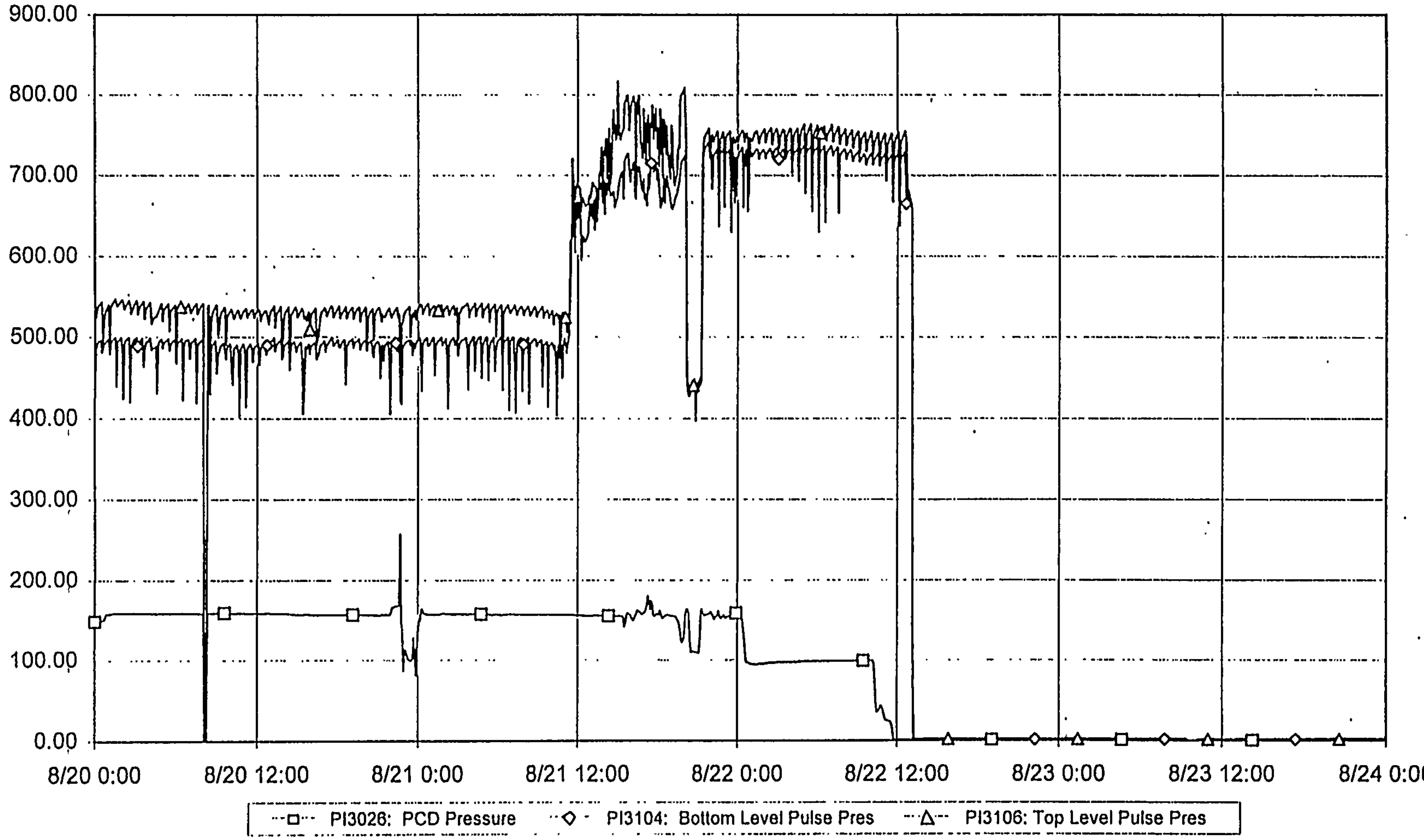
DOE Plot 44 of 47 - 5 minute data

Figure 5.1.7-79 PCD Temperatures for August 20 Through 23, 1996



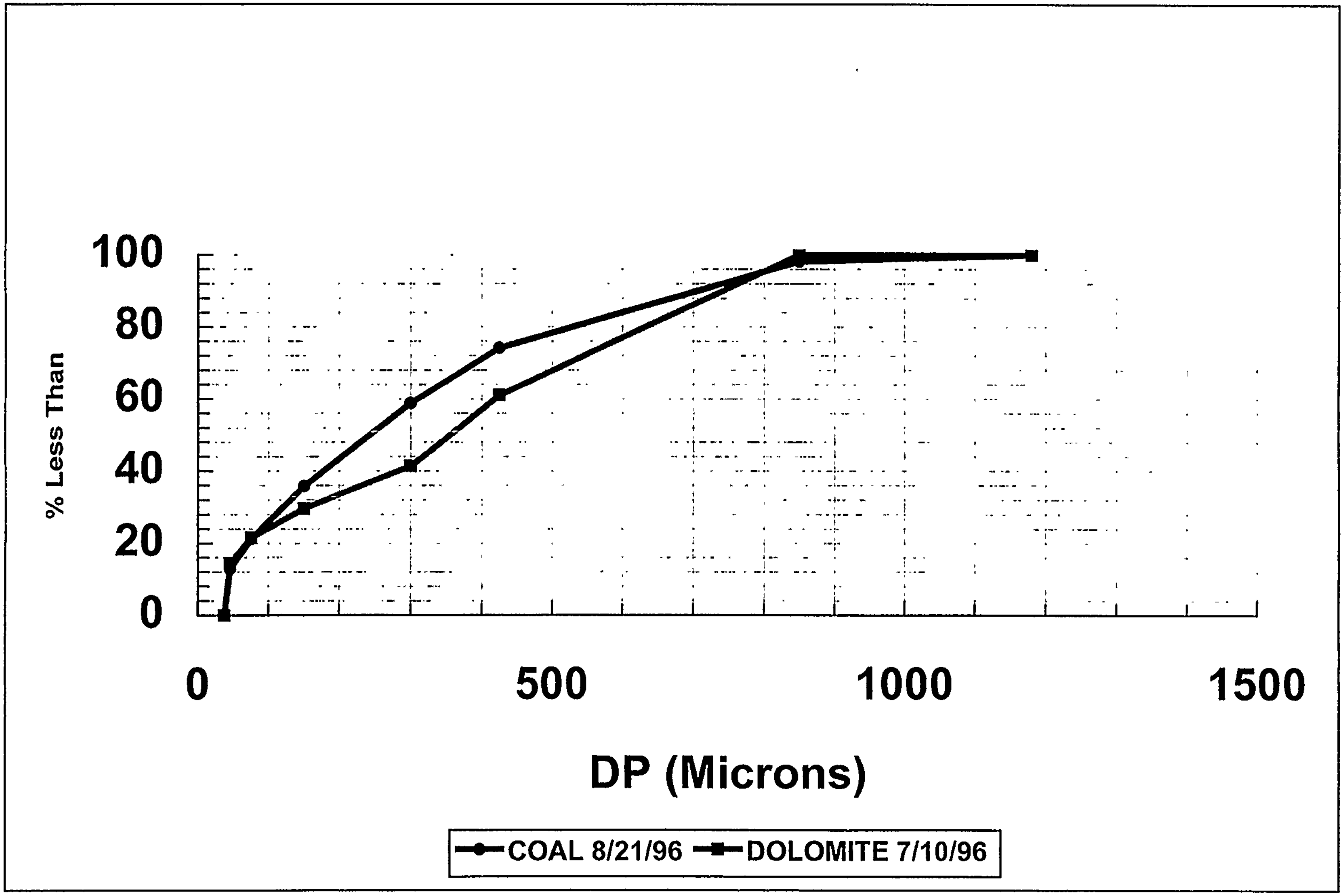
DOE Plot 45 of 47 - 5 minute data

Figure 5.1.7-80 PCD Differential Pressures for August 20 Through 23, 1996

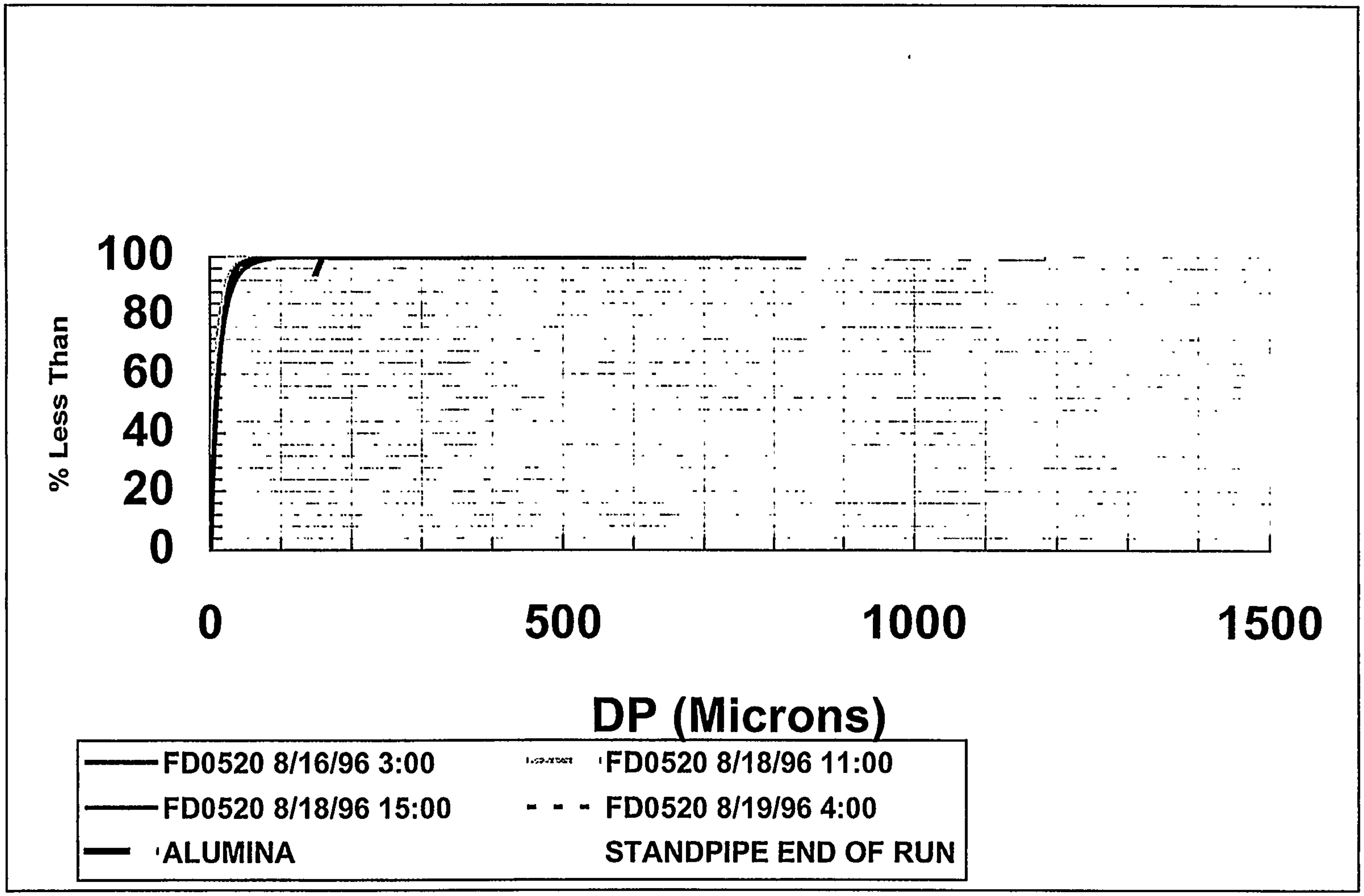


DOE Plot 46 of 47 - 5 minute data

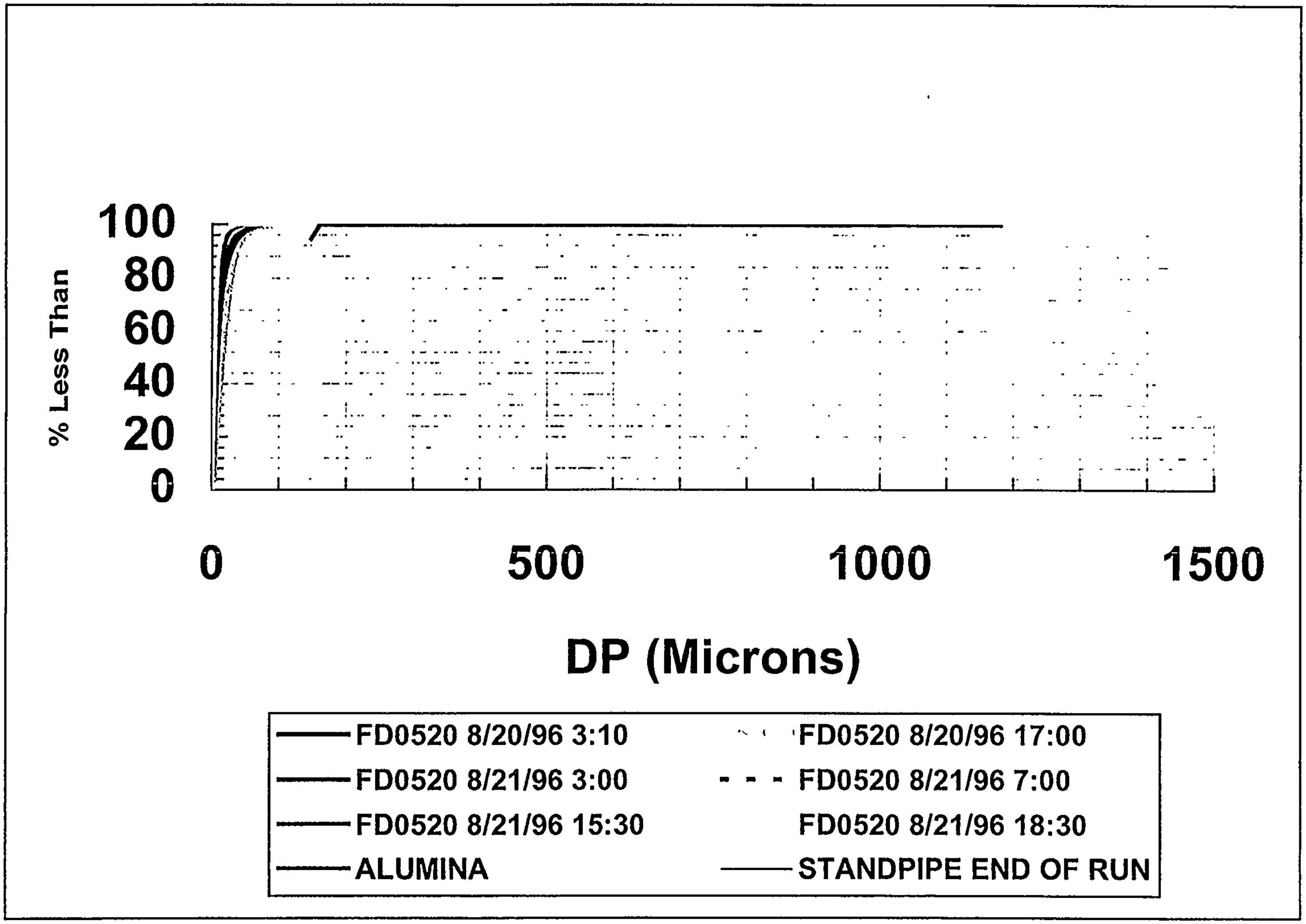
Figure 5.1.7-81 PCD Pressure and Pulse Pressure for August 20 Through 23, 1996



5.1.7-82 Coal and Dolomite Solids Size Distribution Run CCT1C



5.1.7-83 Solids Size Distribution Run CCT1C August 16 to 19, 1996



5.1.7-84 Solids Size Distribution Run CCT1C August 20 to 21, 1996

5.1.8 Characterization Test Run CCT2A

5.1.8.1 Introduction and Test Objective

Prior to the start of test run CCT2A, a newly fabricated reactor start-up burner (BR0201) pilot assembly was installed. The deposits found in the reactor system following the CCT1C commissioning test run were cleaned. Due to the difficulty experienced in inspecting and cleaning the various sections of the reactor, additional inspection ports and a flange near the top of the riser were deemed necessary for safe maintenance without causing damage to the refractory. The objective of the CCT2 test run was to continue the combustion characterization tests with silica sand as the inert start-up bed material. Sand was chosen as the start-up bed material as it is one of the likely choices in a larger unit. Sand is also available in a wide range of sizes, has good attrition properties, and is inexpensive.

The combustion characterization test run (CCT2A) was a three-phase test carried out between September 27 and October 14, 1996. Process raw data for this run are provided in figures 5.1.8-1 to 5.1.8-43. The figures provide trends for various tags in three time periods: September 27 to 30, from October 2 to 6, and from October 14 to 17.

5.1.8.2 Test Chronology

Starting September 27 the transport reactor (RX0201) was leak tested at 310 psig (event 1, figure 5.1.8-8). Selected differential pressure bleeds were balanced at both 60 and 160 psig. The reactor was depressurized and the leaks were repaired. On September 28, 1996, the HTF system, the thermal oxidizer (BR0401) (event 2, figure 5.1.8-7), and back-pulsing of the PCD were started. On September 29 instrumentation problems with the thermal oxidizer slowed progress. The primary gas cooler (HX0202) was cut-in to prewarm the PCD. The dense-phase systems were dry run for ~20 minutes to check their operability.

On October 1, 1996, the reactor was leak tested at 310 psig, and no leaks were found. The seal on the spent solids transporter system (FD0510) spheri valve was lost, so the reactor system was shutdown to repair the valve seal. The following day the reactor system was again started, and several attempts were made to light the start-up burner pilot all of which were unsuccessful. The flame rod was taken out and tested. The flame rod was replaced, the BR0210 pilot was relit, and the outlet temperature was held at 500°F for 6 hours (event 3, figure 5.1.8-11). The reactor J-leg aeration flow (FI681) was set so that the hot air from BR0201 would be forced through the riser instead of preferentially flowing through the standpipe and out through the cyclone. This balanced the temperature in the reactor riser and standpipe. After the 6-hour hold the main burner was lit, and a 3-hour hold at 800°F was started (event 4, figure 5.1.8-11).

The burner exit temperature was then gradually increased to 1,000°F and held for 3 hours. Then the burner exit temperature was raised to 1,200°F at about 50°F per hour and maintained for 8 hours. The combustor heat exchanger (HX0203) J-leg aeration flow (FI680) and the reactor combustion air flow (FI201) were varied to induce hot air into the HX0203 J-leg, but neither worked. Finally air through FI230 to HX0203 was increased to use the hot air from compressor to heat up HX0203. During start-up and operations the skin temperatures were monitored closely.

On October 4 a total of 17,325 lb of sand were fed into the reactor. During the day the start-up burner tripped once but was relit after the reactor pressure was lowered to 50 psig (event 5, figures 5.1.8-11 and -21). Solids circulation was started and the reactor pressure was increased to 90 psig to reduce riser velocity and maintain the burner firing rate. Approximately 3,300 lb of additional sand were added into the reactor. Around 07:30 the start-up burner tripped and the reactor system was shutdown (event 6, figures 5.1.8-11, -14 to -17, and -21). After replacing the burnt flame tip, the reactor system was started again. Attempts to relight the burner were unsuccessful; so, the reactor system was shutdown. When the BR0201 pilot assembly was pulled, the pilot nozzle was found to be plugged with rust from the propane line, and the burner eductor tube had slight burn marks.

On October 6, 1996, after the pilot nozzle had been cleaned, the reactor was started again and the pilot was relit. Flows were set to start reactor solids circulation, but BR0201 tripped again (event 7, figures 5.1.8-11, -14 to -17, and -21). The reactor system was shutdown after several unsuccessful attempts were made to relight the burner. During every attempt the pilot was lit, but the flame rod did not detect the flame. Upon inspection the tip of the flame rod was again found burnt which made the flame rod shorter and out of the flame zone.

The problem of flame rod tip burnout was traced to inadequate cooling of the tip with the new pilot assembly that was installed at the start of CCT2A test run. In the old pilot assembly, a hole was drilled in the flame rod guide tube at the site to induce air and provide cooling to the flame rod tip. Apparently this cooling was sufficient and necessary to maintain the physical integrity of the tip. Due to uncertainty of the amount of inducted air for cooling, an external forced cooling purge was installed to provide the necessary cooling for the flame rod tip and prevent burnout.

On October 13 auxiliary systems needed for transport reactor start-up were put in service. The following day the start-up burner pilot was lit with the newly installed cooling purge to the flame rod tip. The burner was shutdown after 2 hours to visually inspect the flame rod tip. The flame rod had some discoloration on the tip (which is about 6 inches long), but there were no signs of burn marks. The burner was assembled, all systems were restarted, and the pilot was lit with reactor pressure set at 75 psig. About 3,000 lb of sand were added to the reactor with a low carryover rate to the PCD.

On October 15 BR0201 was shutdown and the reactor was depressurized to 15 psig to blow out the plugged aeration nozzles (event 8, figure 5.1.8-36). The pilot was lit, the reactor was gradually pressurized to 100 psig, and the main burner was lit (event 9, figures 5.1.8-26 and -36). Solids circulation was then started. Another 1,500 lb of sand were added to the reactor to maintain the inventory. The thermal oxidizer tripped causing momentary fluctuations in the propane flow from the vaporizer that then tripped BR0201. The reactor pressure was reduced to 60 psig and BR0201 was started. The aeration to HX0203 J-leg was reduced to decrease the solids circulation rate, and thus, the solid carryover rate to the PCD. Another 1,400 lb of solids were loaded into reactor to makeup for the excessive carryover to the PCD. The fluidizing air flow rate (FIC230) to HX0203 and the vent control valve (PDV384) positions were varied to evaluate their effect on solids carryover. The solids carryover seemed to be lessened with FIC230 lowered and with PDV384 closed. However, there was still excessive carryover to the PCD, and as a result, aeration to both the J-legs were reduced to lower the circulation rate. The burner exit temperature was increased at 100°F/hr, and 3,000 lb of sand were added to the reactor. The burner tripped for an unknown reason and was relit after the solids circulation rate and the reactor pressure were decreased (event 10, figures 5.1.8-26 and -36). Increasing the J-legs aeration then increased the solid circulation rate.

The reactor pressure was increased to 75 psig. The HX0203 J-leg aeration (FIC680) was reduced so that the level in the reactor standpipe could be built up using the solids in the HX0203. The reactor pressure was then increased to 80 psig to reduce the riser velocity (event 11, figure 5.1.8-36). After establishing a sufficient level in the reactor standpipe, FIC680 was increased to increase circulation. This resulted in a large carryover of solids to the PCD, and in a temperature increase in the primary cyclone dipleg temperatures which indicated that the cyclone was experiencing a larger loading and a correspondingly larger separation of solids (event 12, figure 5.1.8-31). The FIC680 was decreased to reduce the carryover to PCD and allow sufficient time to empty the PCD cone of solids. Once the PCD was empty of solids, both FIC680 and FIC681 (the reactor J-leg aeration) were increased in preparation to perform a cyclone spoiling test. The spoiling gas was introduced into the primary cyclone to make sure that the solids in the cone section of the cyclone were draining freely into the radix. It appeared from the cyclone dipleg temperatures that the solids from the cyclone were flowing down as slugs. The FIC681 was increased to determine if solids carryover was present with reactor standpipe circulation alone. As more solids were added to the reactor the differential pressure across the disengager increased, indicating an increased loading of the solids. The solids carryover to the PCD also showed a corresponding increase.

The spoiling gas tests were completed and all standpipe aeration nozzles were closed. No significant change in solids carryover or the flow of solids into the cyclone dipleg due to spoiling was observed. The FIC680 was increased to increase the circulation rate through the combustion heat exchanger and increase the level in the standpipe (event 13, figure 5.1.8-37). The PDV384 was opened, FIC230 was increased, and FIC680 was varied to expand the solid bed in the heat exchanger and increase the circulation through HX0203. Sand drained from the process was fed back into reactor to increase the inventory levels, but the combination of solids circulation and solids feed to the reactor increased the solids carryover rate. The burner firing rate was decreased (event 14, figure 5.1.8-26) to lower velocities, but the solids carryover to PCD continued to be excessive, so the reactor system was shutdown on October 17. It was suspected that there may be possible restriction in the cyclone system or that possibly the solids may not be draining well from the disengager and the cyclone, resulting in reentrainment.

5.1.8.3 Test Run CCT2A Observations

The reactor start-up burner performed well at higher pressures after modifications were made to the pilot assembly to eliminate safety concerns with the retracting mechanism. Also, a cooling purge was installed on the burner detection mechanism. It was necessary to operate the burner at higher pressures in order to reduce the superficial riser gas velocity during start-up. Excessive solids carryover from the reactor to the filter vessel continued to be of concern and various tests were performed to understand the cause. It was suspected that a restriction in the disengager or primary cyclone was affecting their performance. The system was shut down and inspections revealed deposits in the disengager as well as in the primary cyclone that were left over from the previous test run. The deposits were removed and the system was put together for further testing.

5.1.8.4 Post-Test Activities

The period between the test run CCT1C and the beginning of the next test (CCT2B) was used to review the operating data obtained during the first coal combustion test (CCT1C) and the hot sand solids circulation test (CCT2A) during which excessive solids carryover was experienced. Both MWK and GEESI were consulted about the excessive loss of solids from the reactor loop during the hot sand circulation run. Process review meetings were held between DOE, MWK, Westinghouse, and SCS to understand the results from the previous coal combustion test and find out why extensive agglomerate formation occurred during the test. It was recommended that the solids level in the standpipe be raised to seal the cyclone dipleg to avoid gas from the disengager short-circuiting the cyclone through the cyclone dipleg. Several useful resolutions came out of the review meetings. Some of the important ones are:

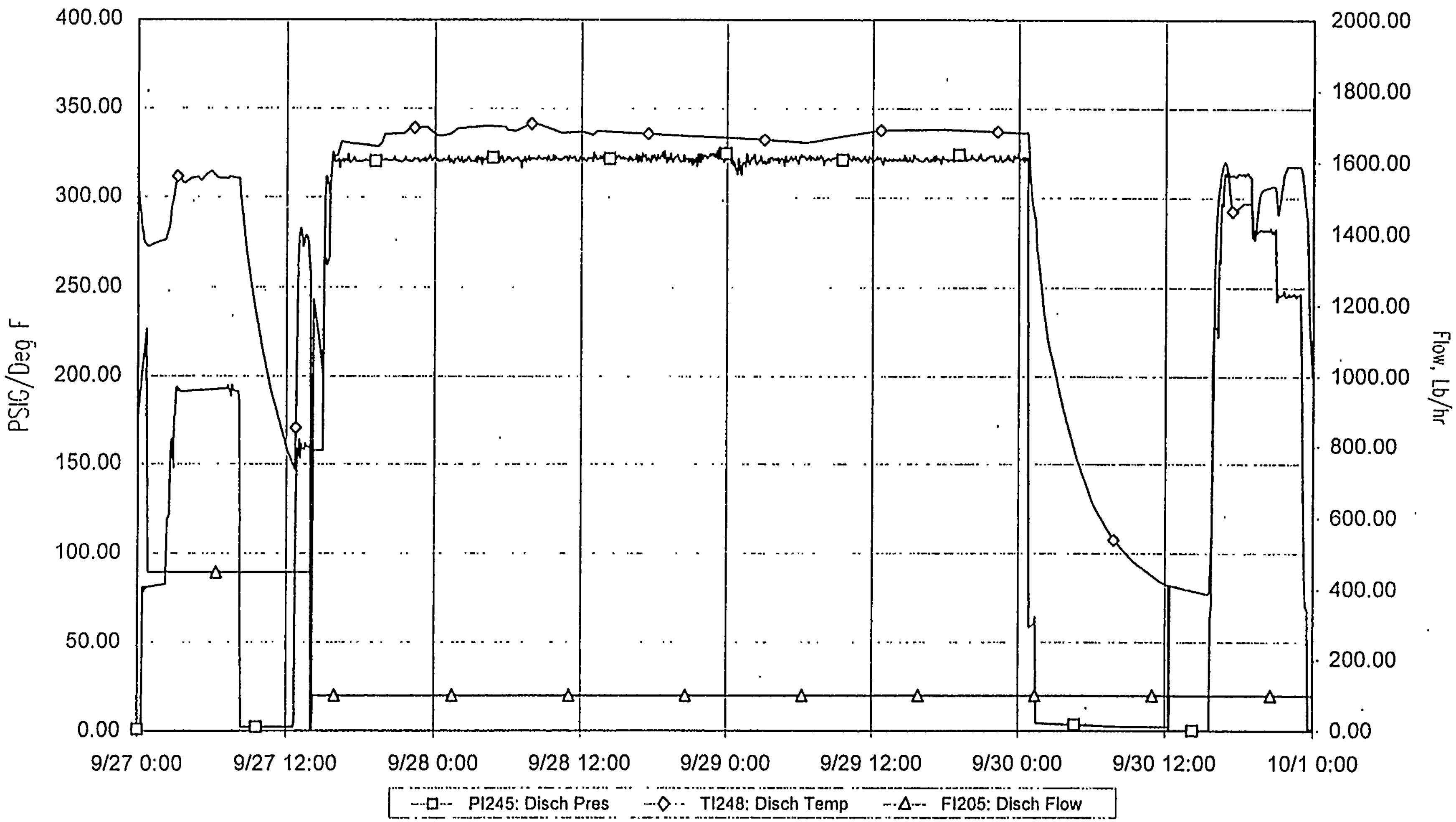
A. The PCD team, after reviewing the data from the previous test, developed a better understanding of the PCD instrumentation and the interpretation of the temperature and differential pressure data. Previously, the filter differential pressure was monitored. The data analyses showed that monitoring the differential temperature profile in the PCD and FD0520 dump cycle would provide better indication of solids level and draining rate out of the PCD hopper.

B. Dolomite will not be used for bed material makeup but only for sulfur capture. The requirement for sulfur capture is far less than the requirement for bed makeup. Also, material from the filter vessel below a certain mean size and distribution will not be used again to makeup for lost reactor bed level.

C. An attempt will be made to add sufficient bed material to seal the cyclone dipleg.

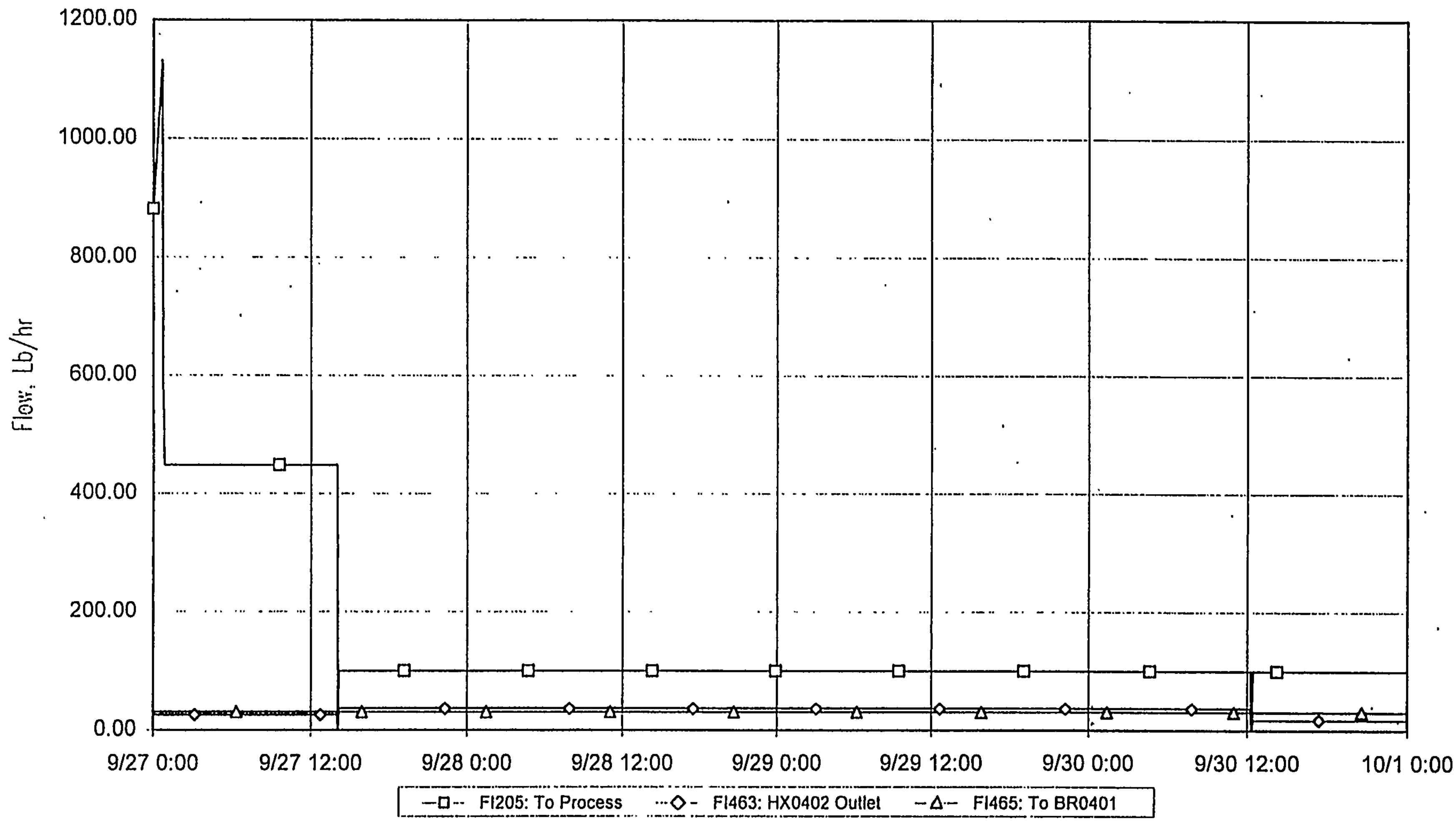
D. To reduce the carbon build up in the bed during start-up, injection of carbonaceous material to assist reactor preheat will not be attempted until the mixing zone temperature is at least 1,000°F. Also, Belle Ayre subbituminous coal will be mixed with the coke breeze in a 4:1 ratio by weight to increase its volatile content and improve its ignition properties.

The deposits found in the disengager and cyclone after the hot solids circulation run were removed and the crossover reconnected. Figures 5.1.8-44 and -45 show the disengager before and after deposits were removed, and figures 5.1.8-46 and -47 show the cyclone before and after the deposits were removed. After this run, the reactor loop solids were drained for the disengager cleaning. The combustor heat exchanger solids were not drained.



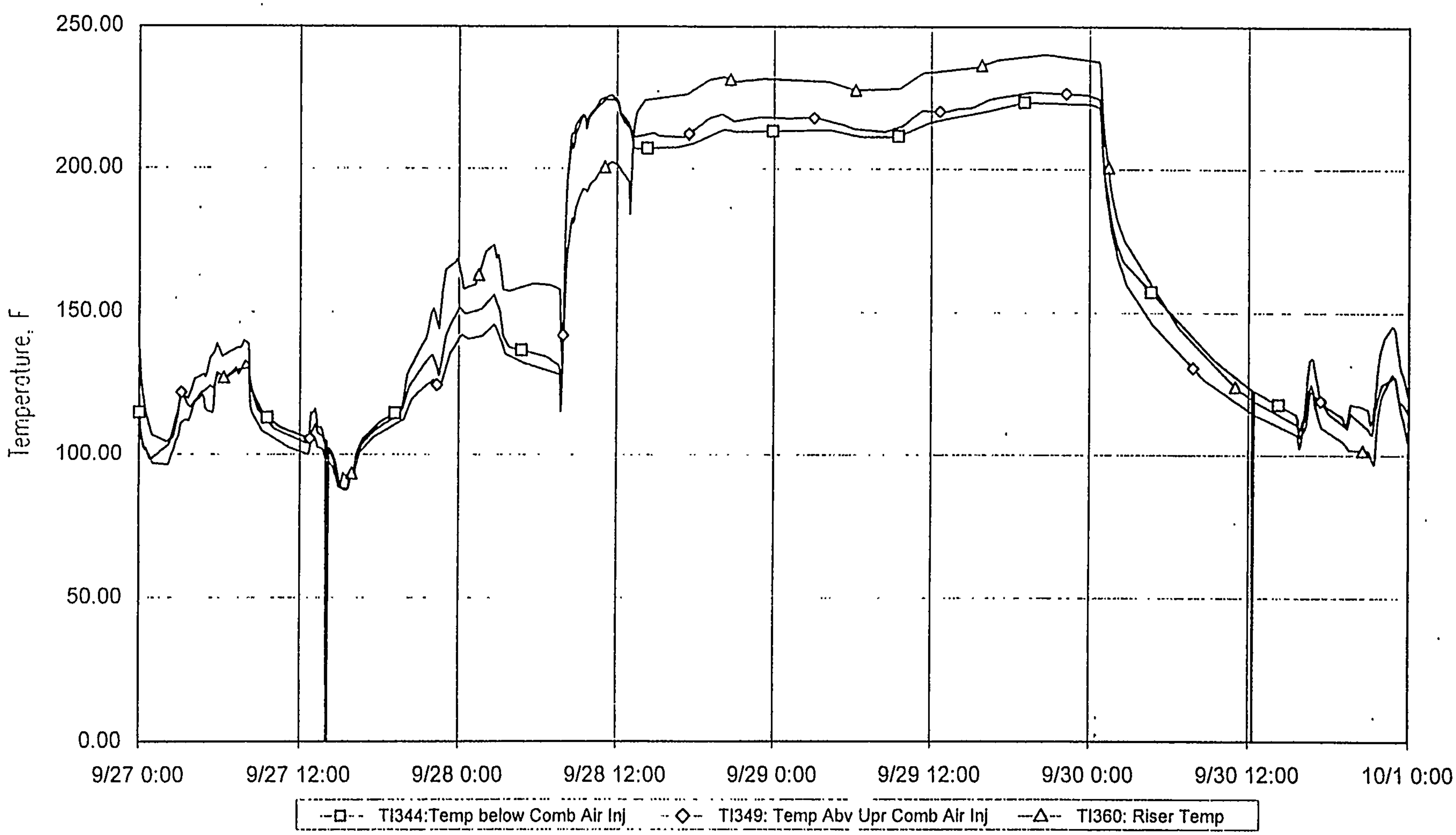
DOE Plot 1 of 45 - 5 minute data

Figure 5.1.8-1 C00201 System Profile for September 27 through September 30, 1996



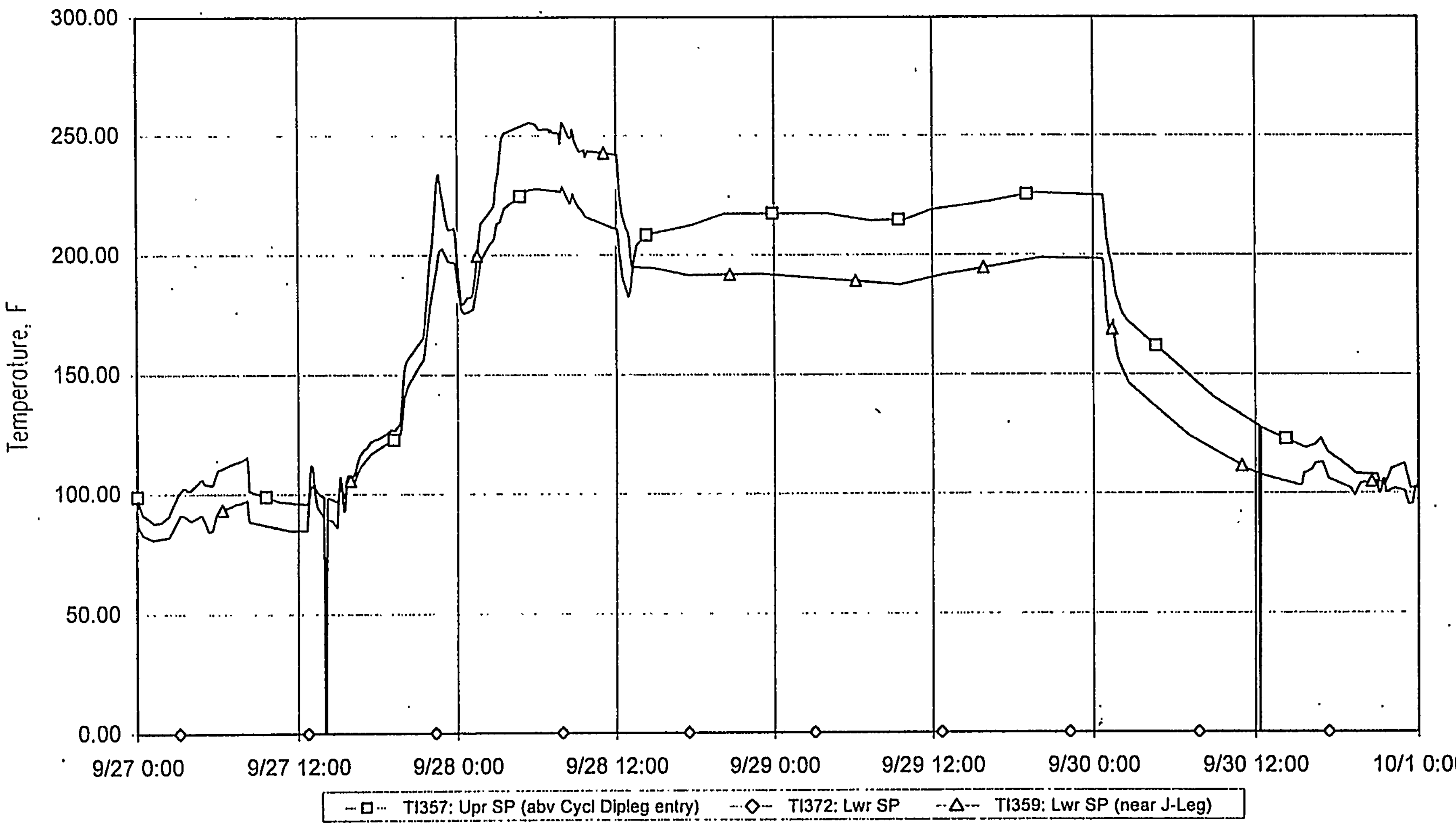
DOE Plot 13 of 45 - 5 minute data

Figure 5.1.8-2 Total Gas In/Out Flow Rates for September 27 through September 30, 1996



DOE Plot 14 of 45 - 5 minute data

Figure 5.1.8-3 Reactor Mixing Zone and Riser Temperatures for September 27 through September 30, 1996



DOE Plot 15 of 45 - 5 minute data

Figure 5.1.8-4 Standpipe Temperatures for September 27 through September 30, 1996

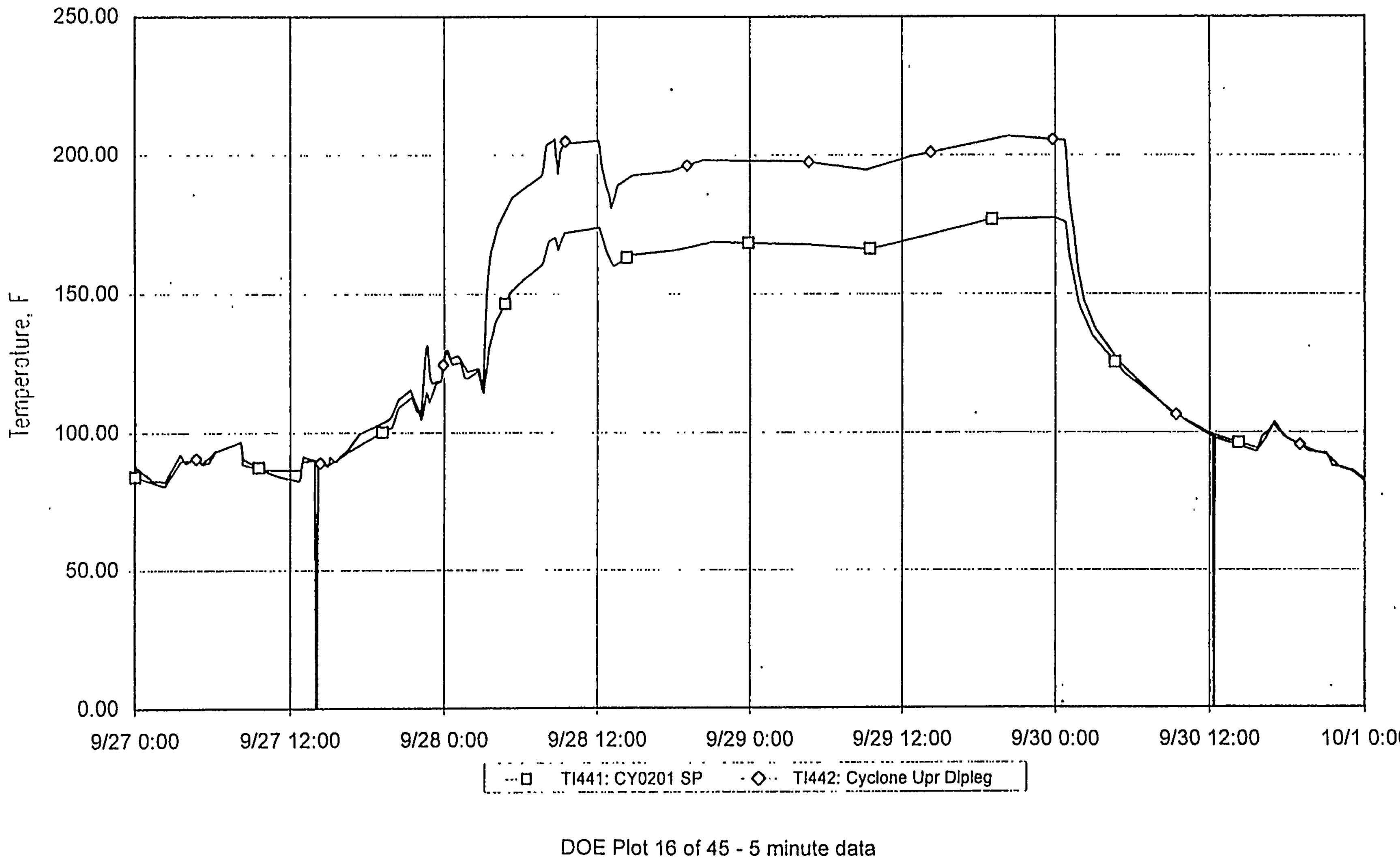


Figure 5.1.8-5 Cyclone Dipleg Temperatures for September 27 through September 30, 1996

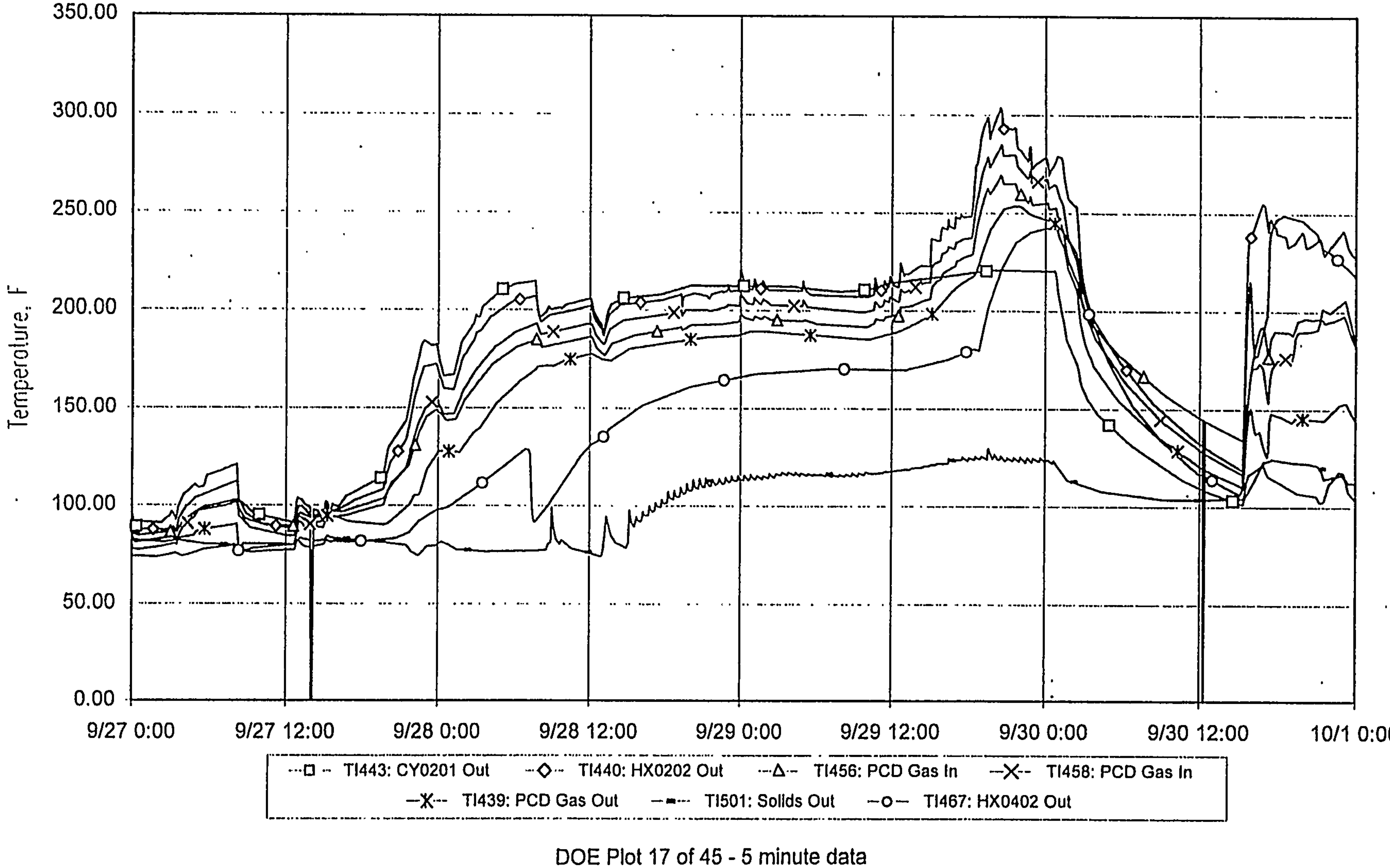
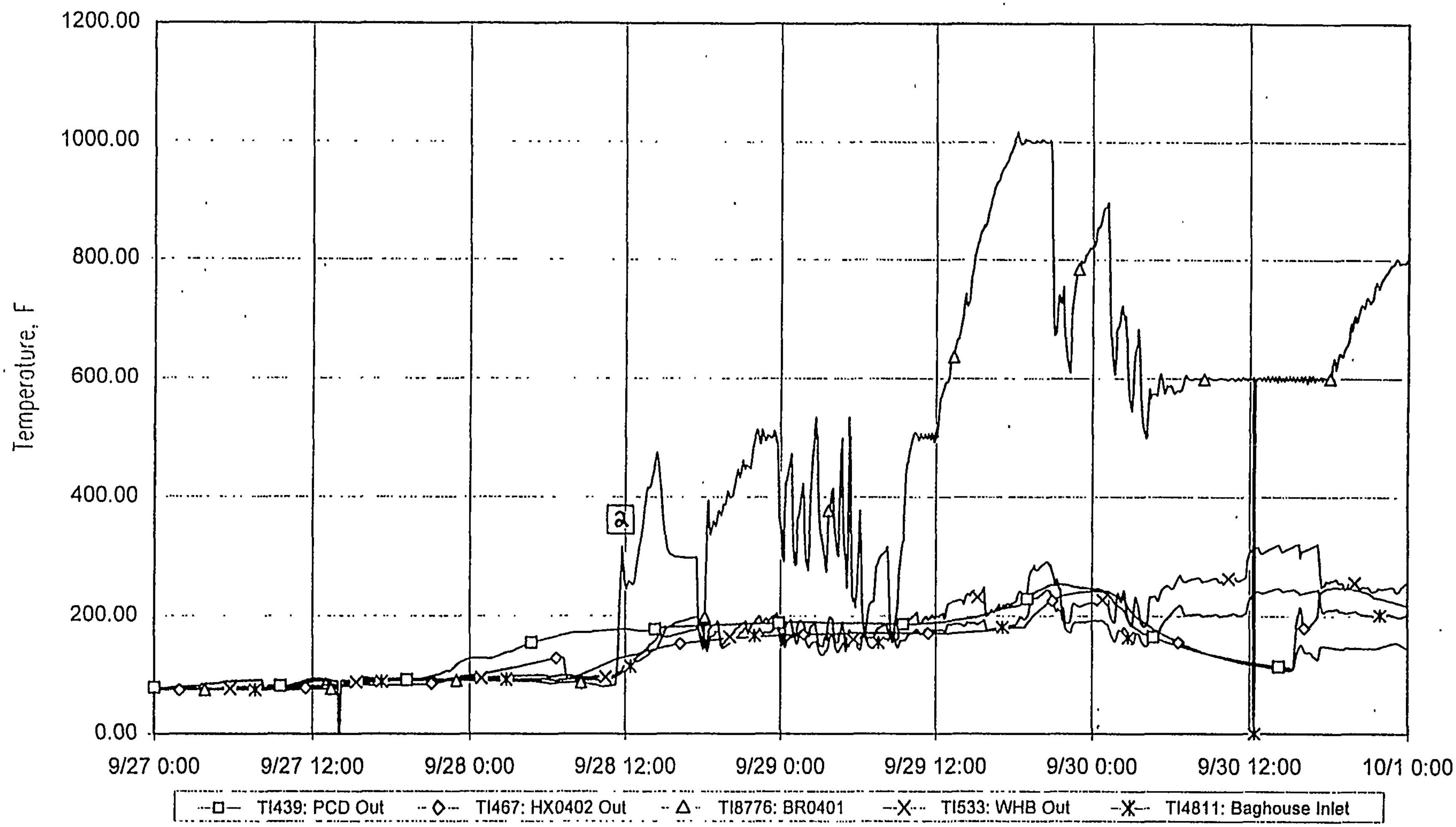
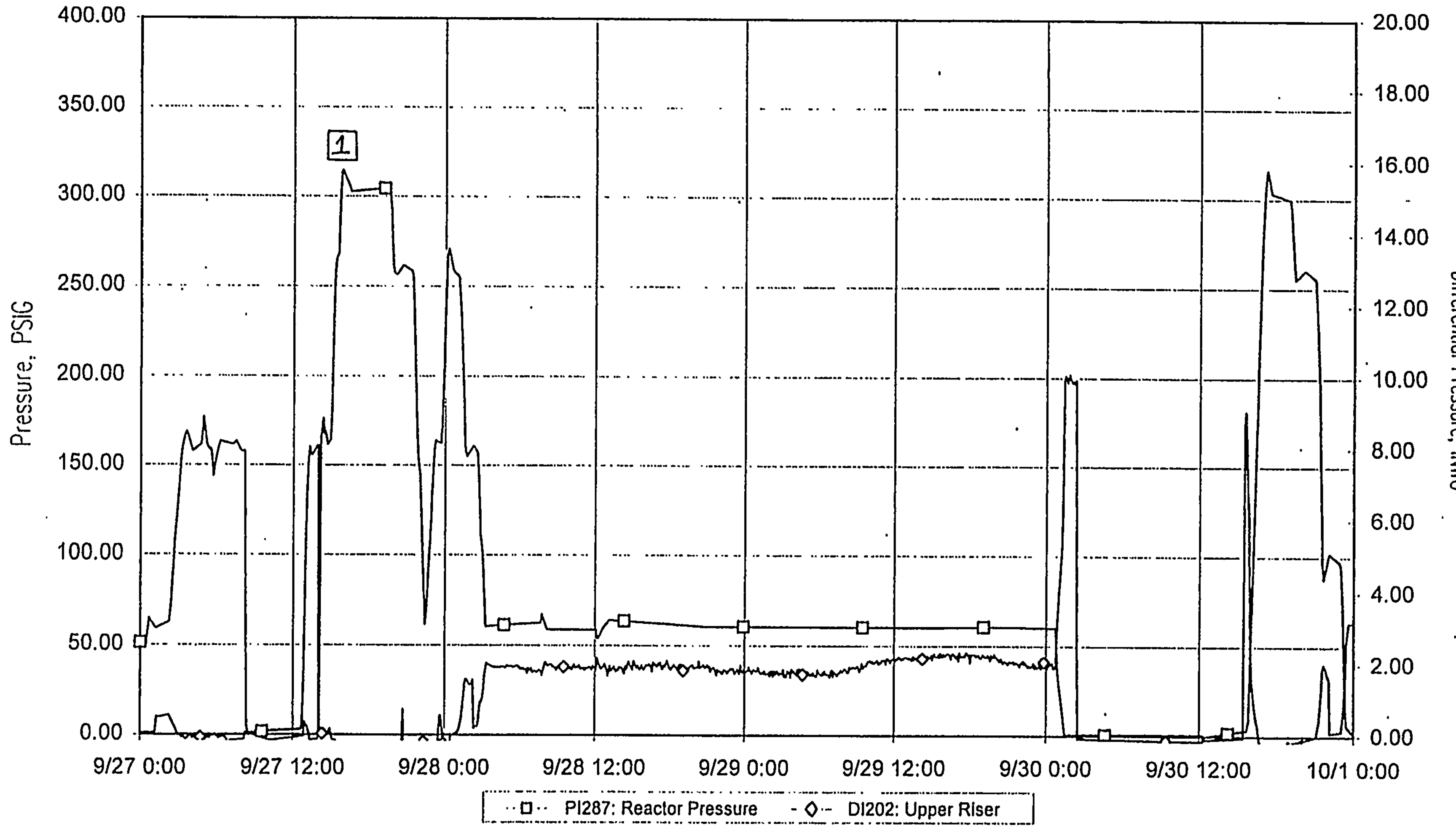


Figure 5.1.8-6 Temperature Profiles Downstream of Reactor for September 27 through September 30, 1996



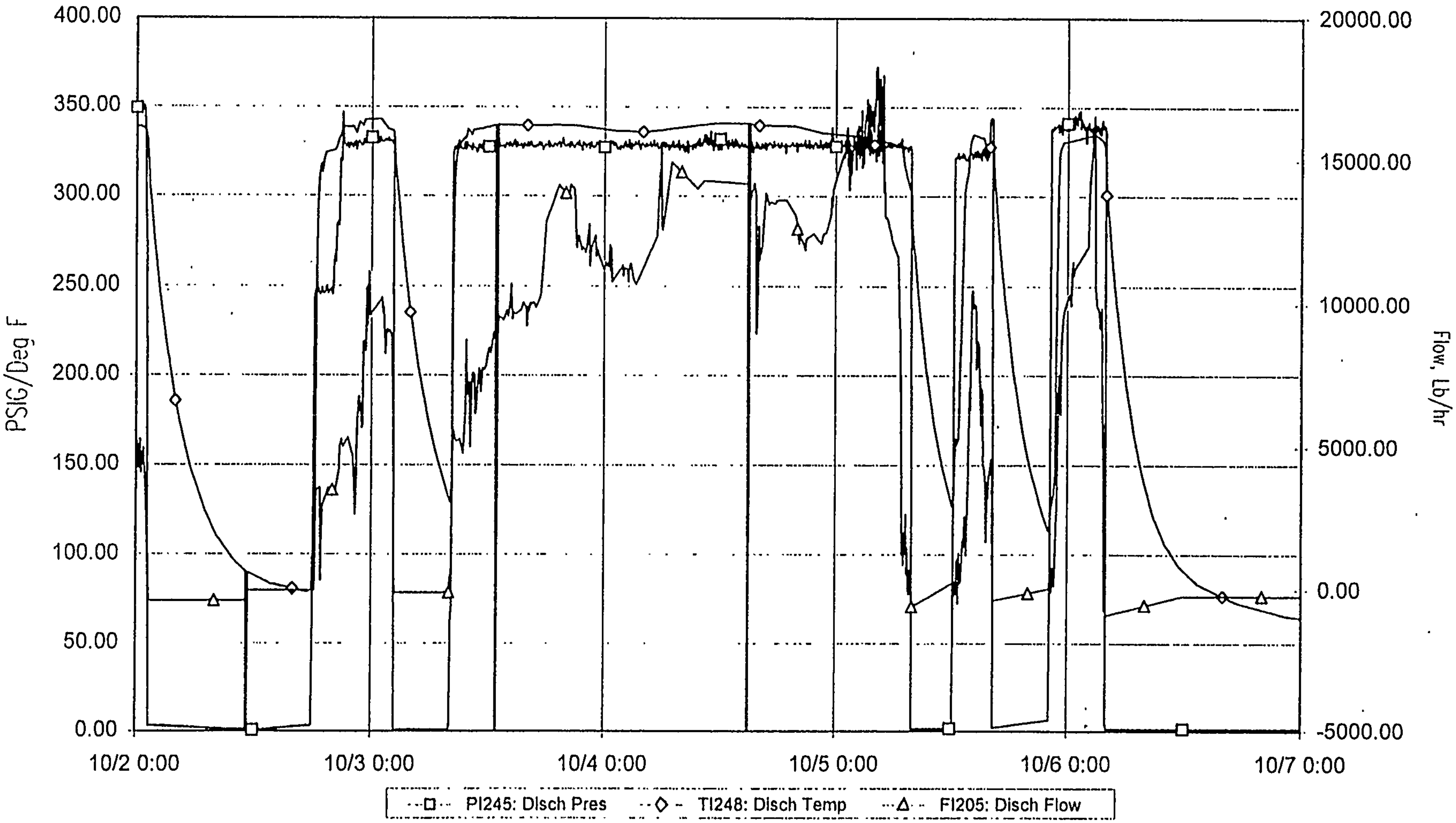
DOE Plot 19 of 45 - 5 minute data

Figure 5.1.8-7 System Temperatures Downstream of PCD for September 27 through September 30, 1996



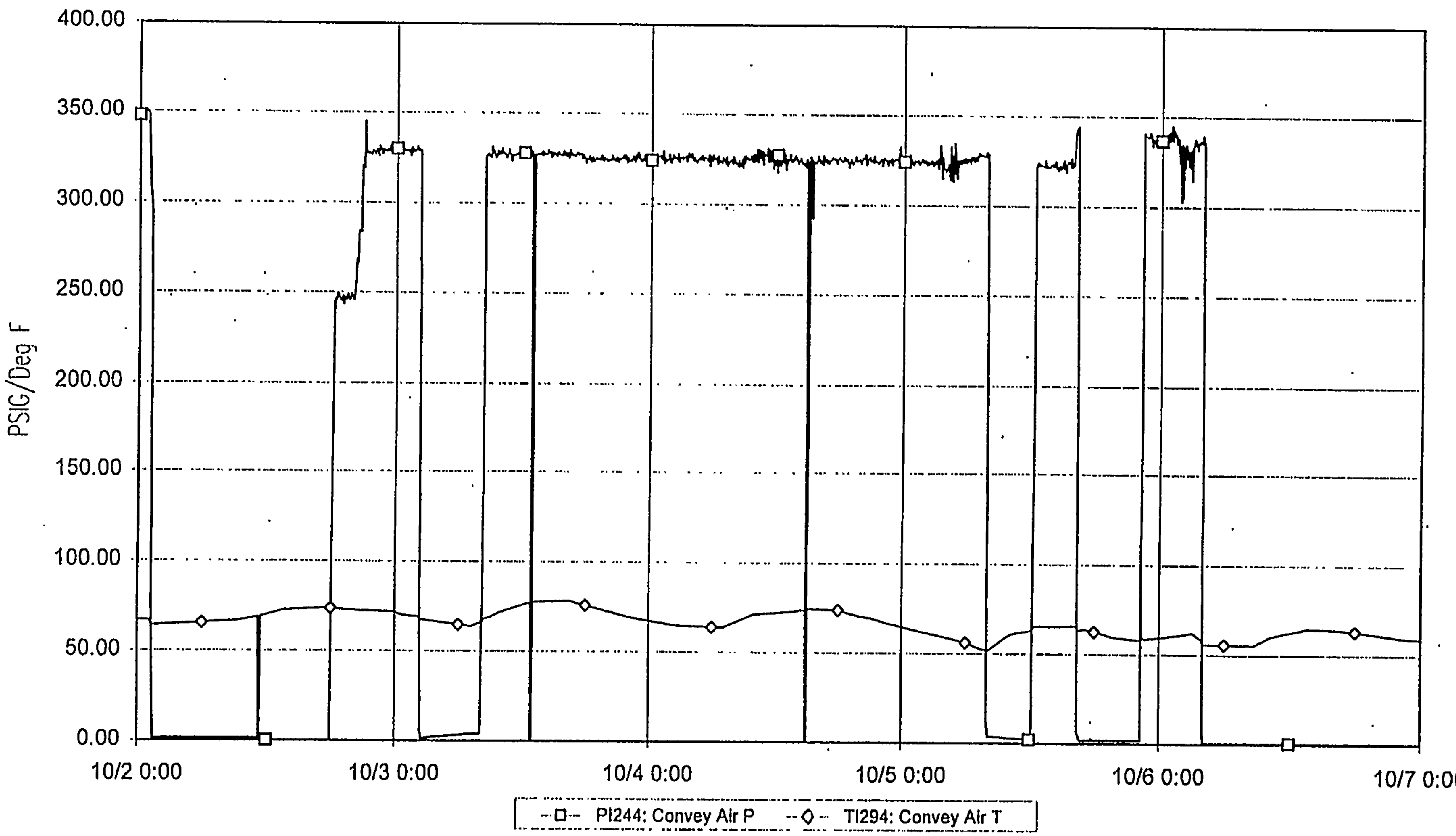
DOE Plot 21 of 45 - 5 minute data

Figure 5.1.8-8 Reactor Pressure/Riser DP Profiles for September 27 through September 30, 1996



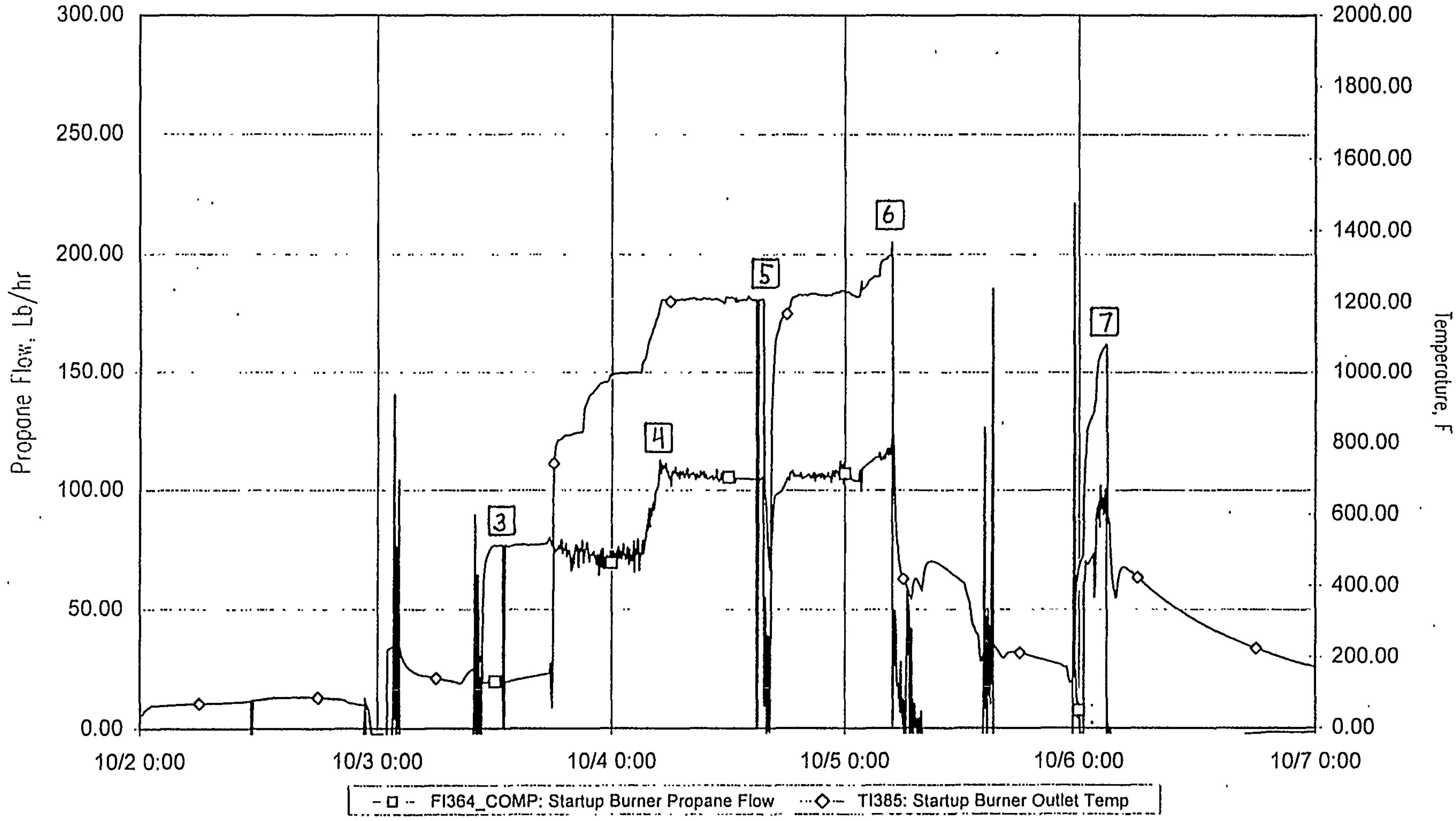
DOE Plot 1 of 45 - 5 minute data

Figure 5.1.8-9 C00201 System Profile for October 2 through October 6, 1996



DOE Plot 5 of 45 - 5 minute data

Figure 5.1.8-10 Transport Air System for October 2 through October 6, 1996



DOE Plot 11 of 45 - 5 minute data

Figure 5.1.8-11 Start-Up Burner Flow Temperature for October 2 through October 30, 1996

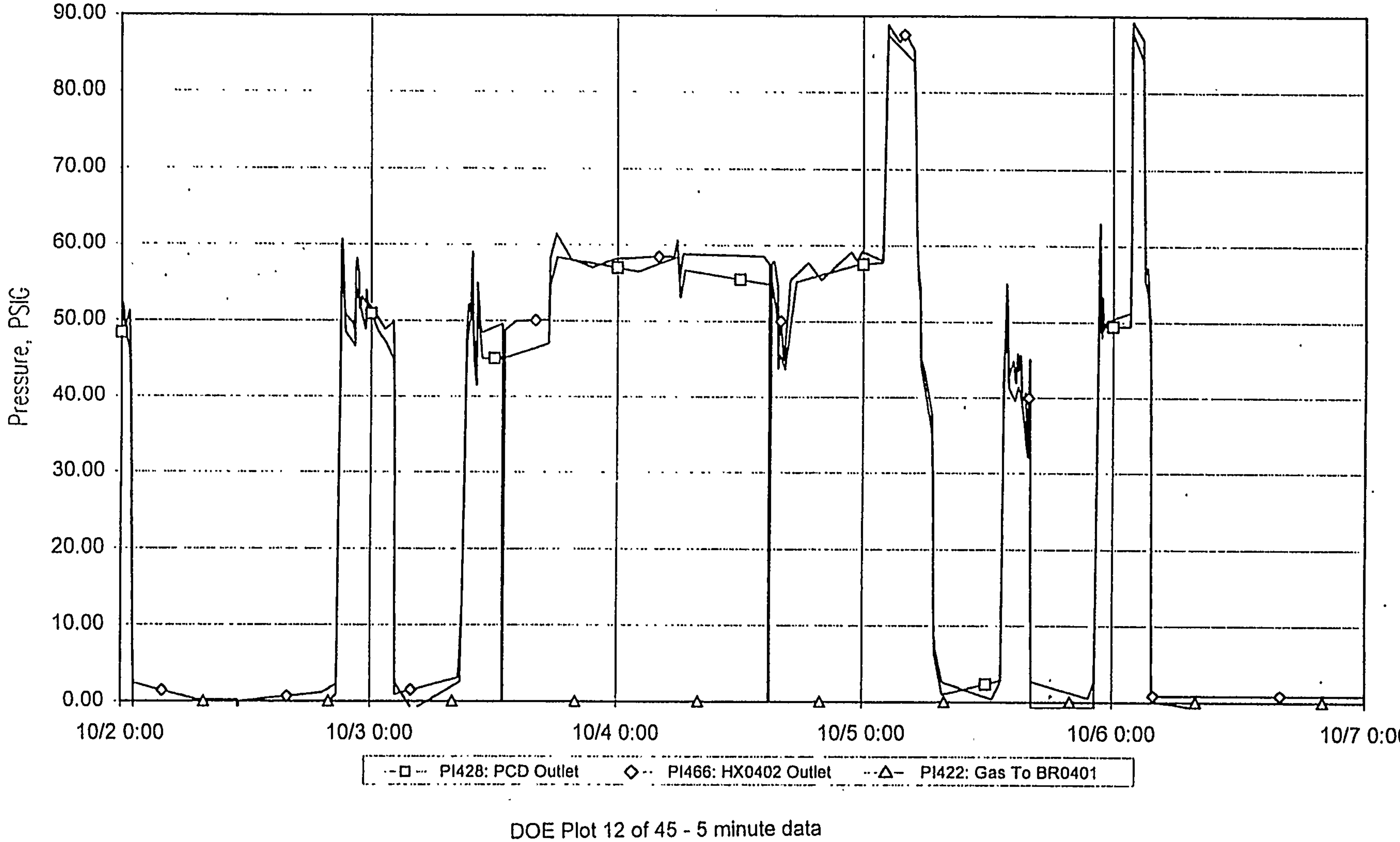
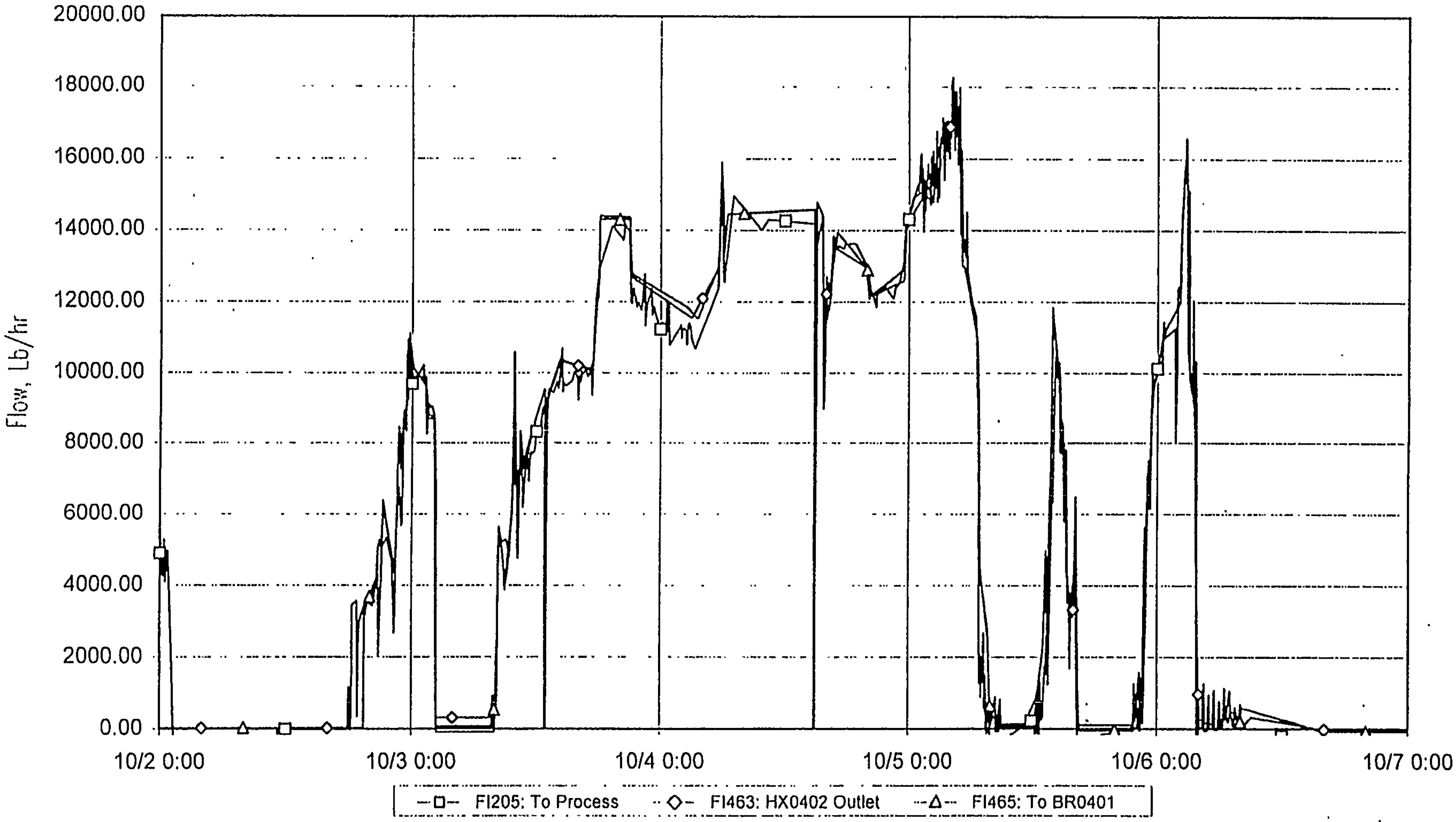


Figure 5.1.8-12 System Pressures Downstream of PCD for October 2 through October 30, 1996



DOE Plot 13 of 45 - 5 minute data

Figure 5.1.8-13 Total Gas In/Out Flow Rates for October 2 through October 6, 1996

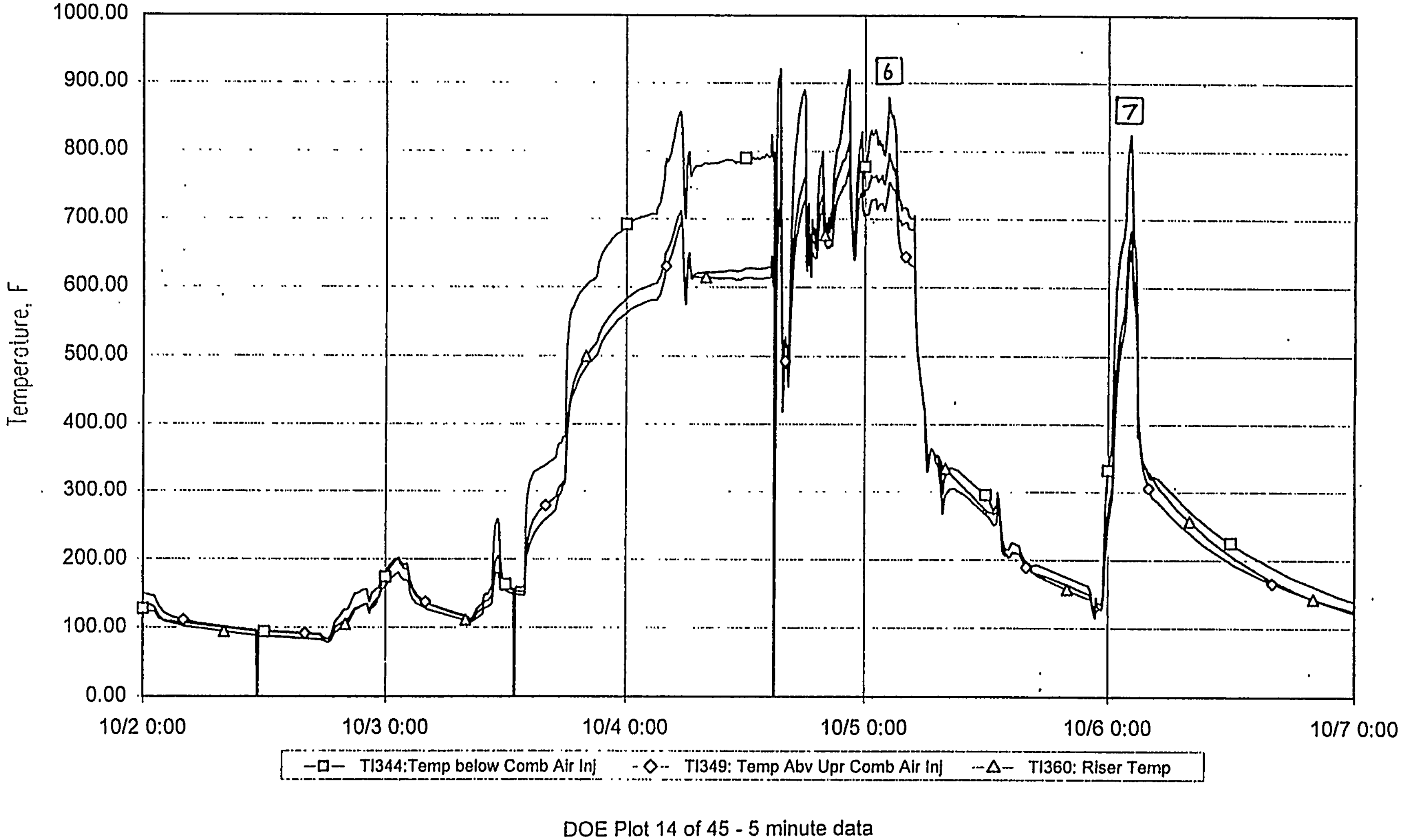


Figure 5.1.8-14 Reactor Mixing Zone and Riser Temperatures for October 2 through October 6, 1996

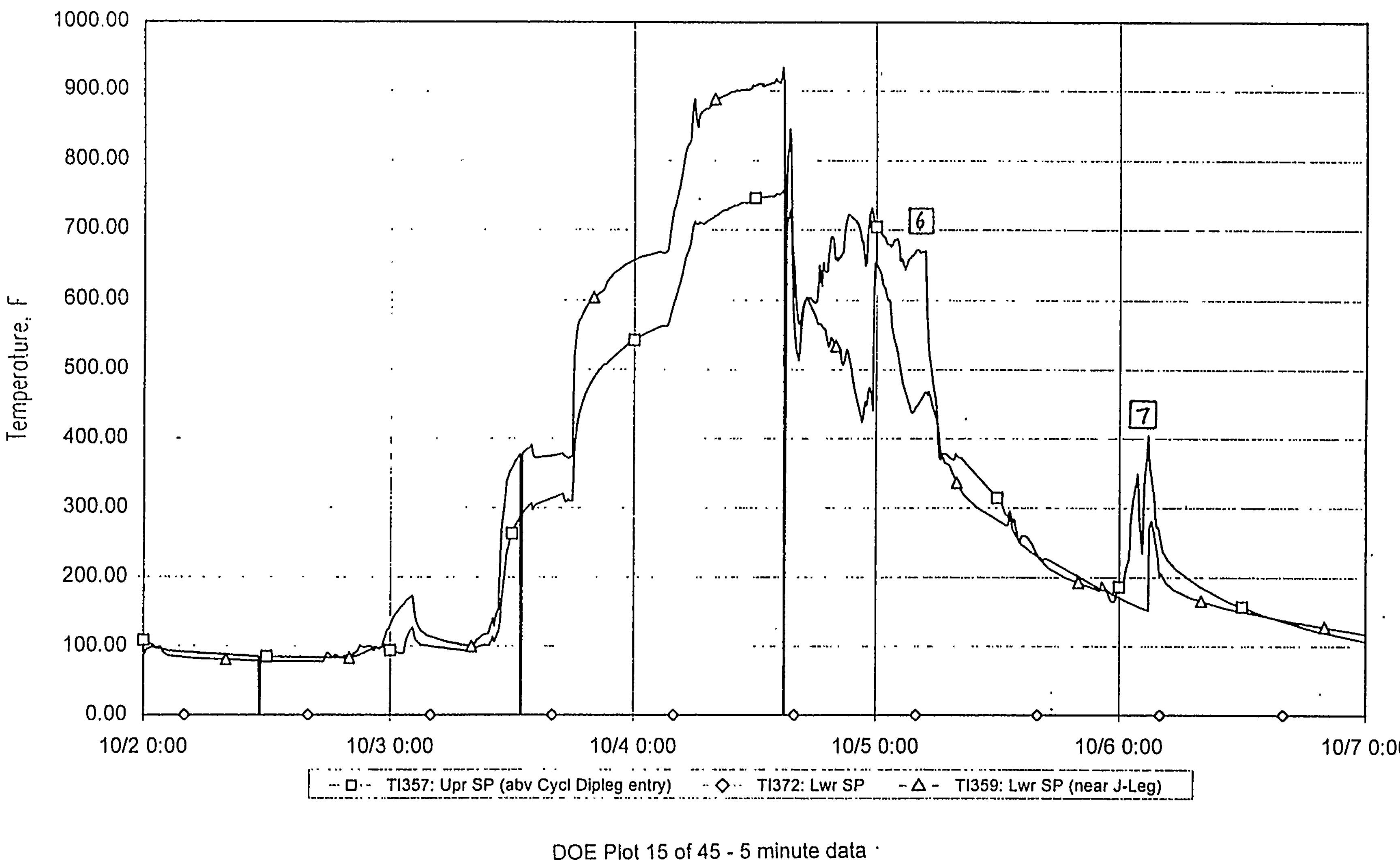
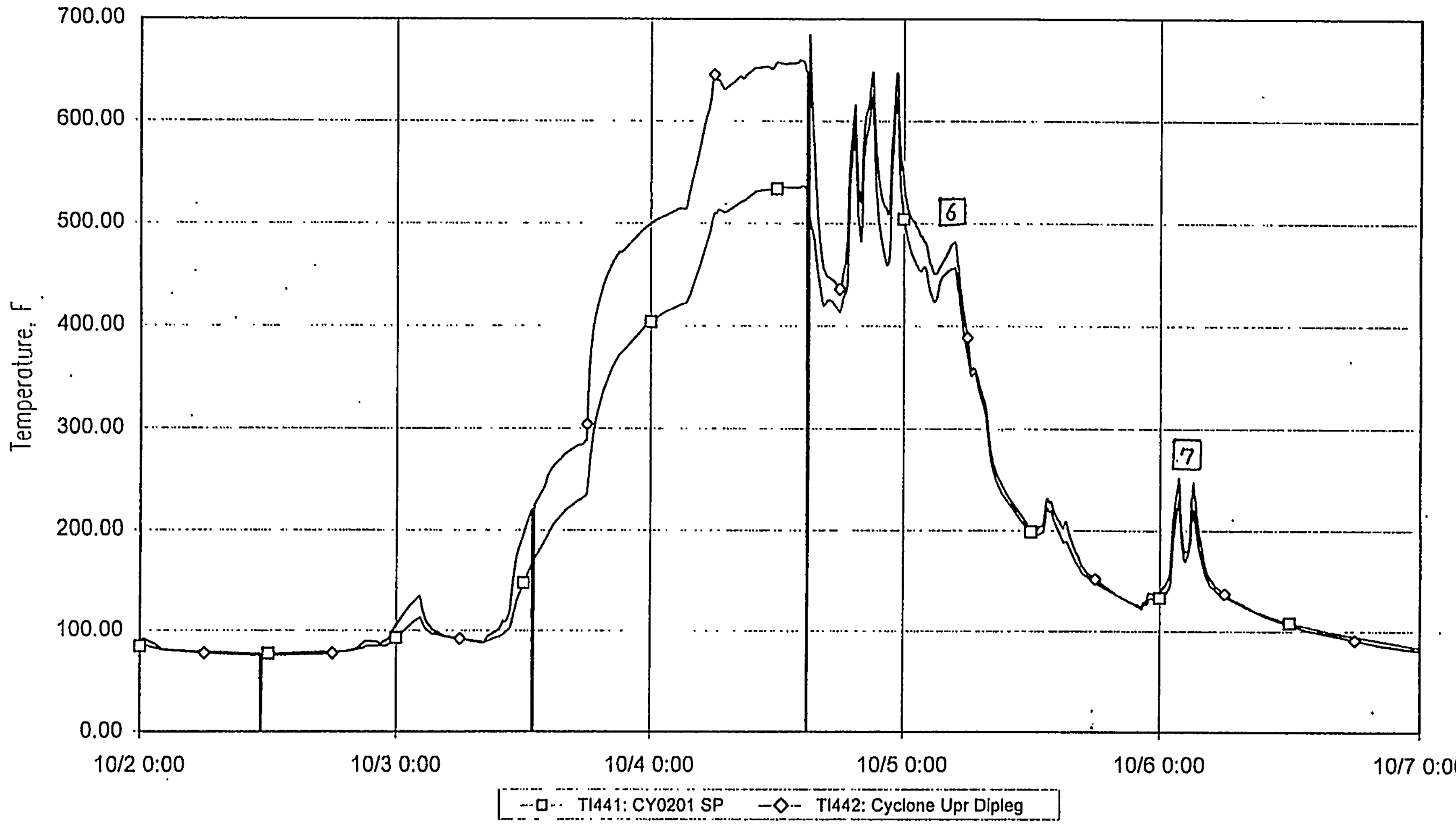


Figure 5.1.8-15 Standpipe Temperatures for October 2 through October 6, 1996



DOE Plot 16 of 45 - 5 minute data

Figure 5.1.8-16 Cyclone Dipleg Temperatures for October 2 through October 6, 1996

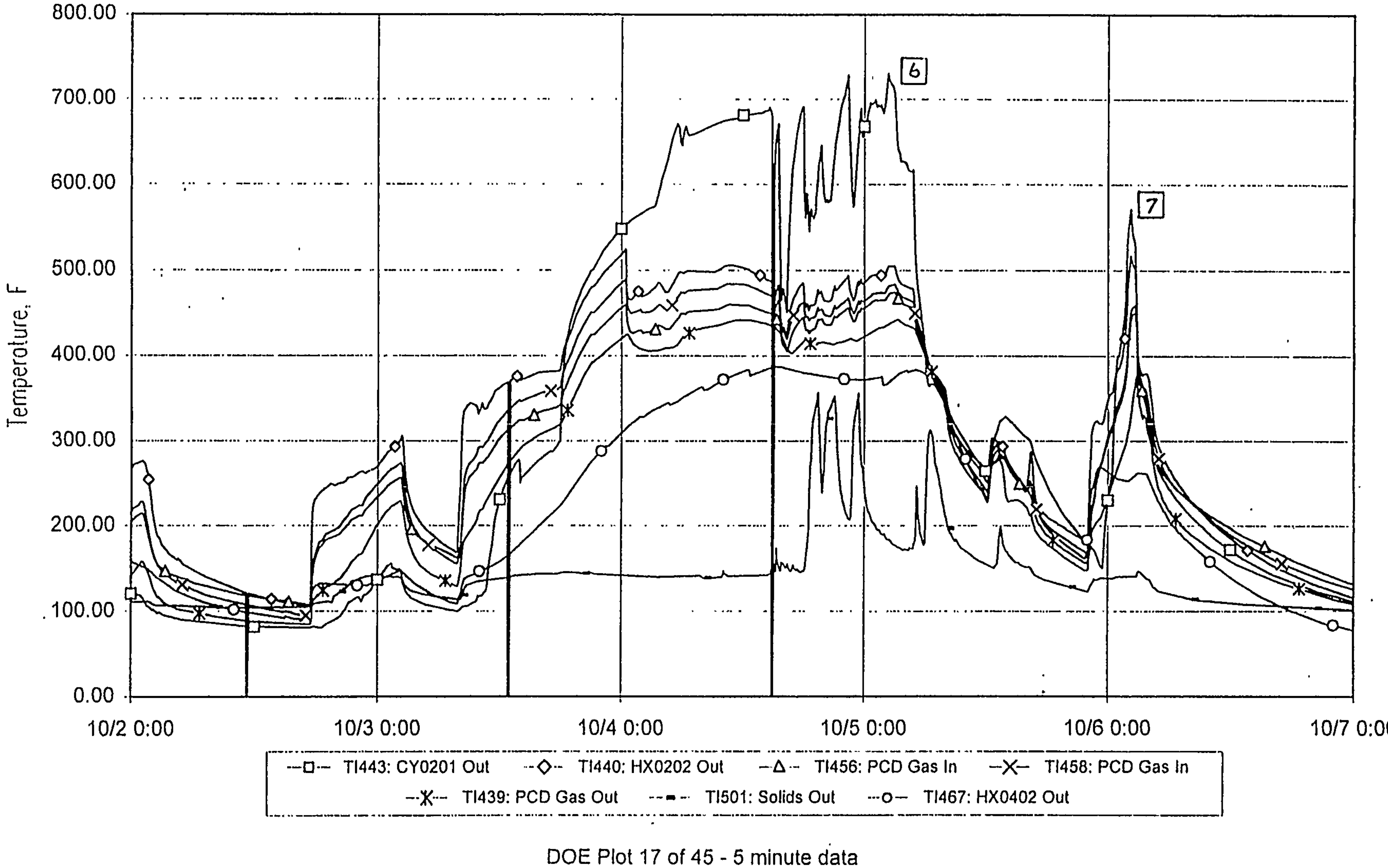


Figure 5.1.8-17 Temperature Profiles Downstream of Reactor for October 2 through October 6, 1996