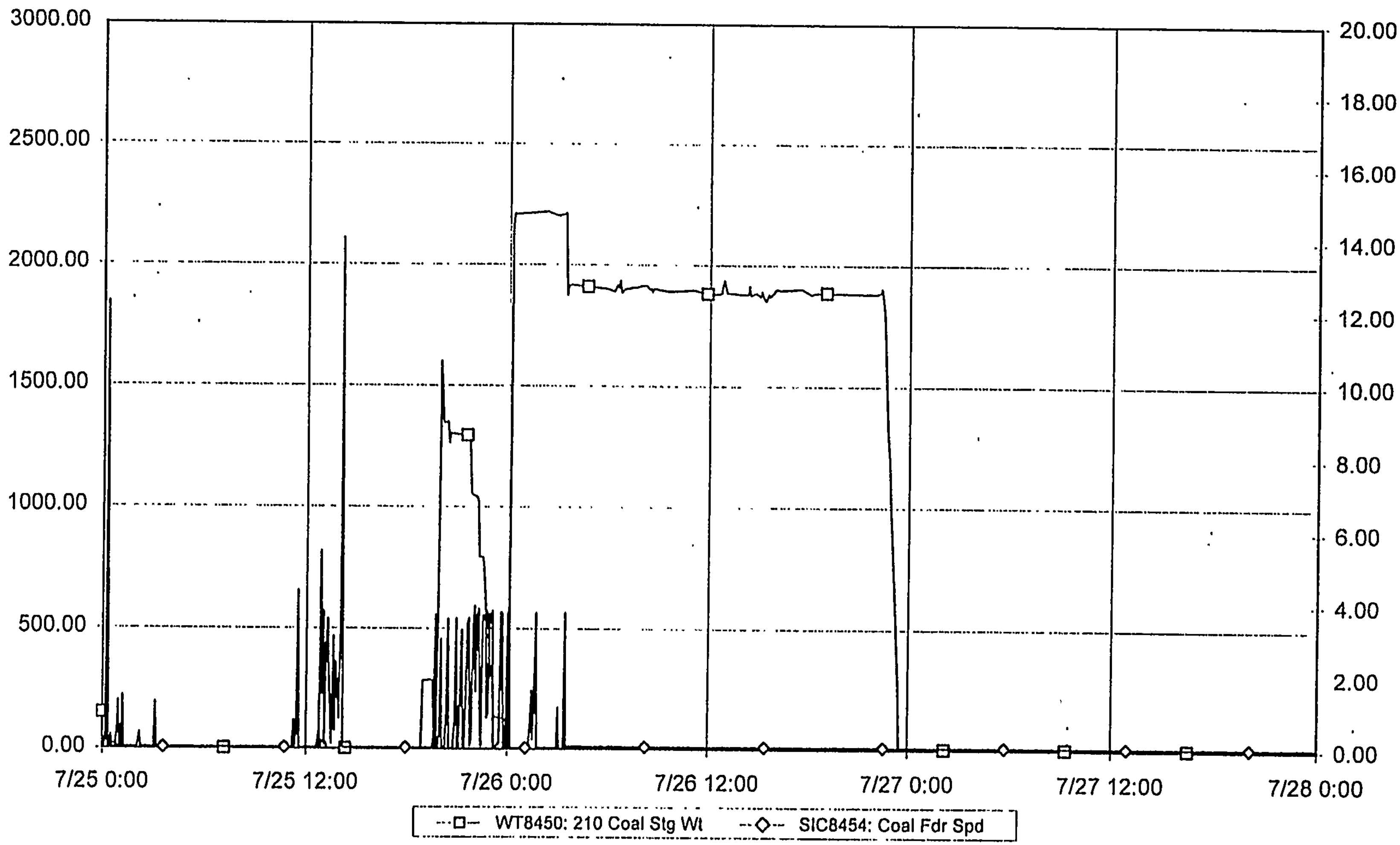
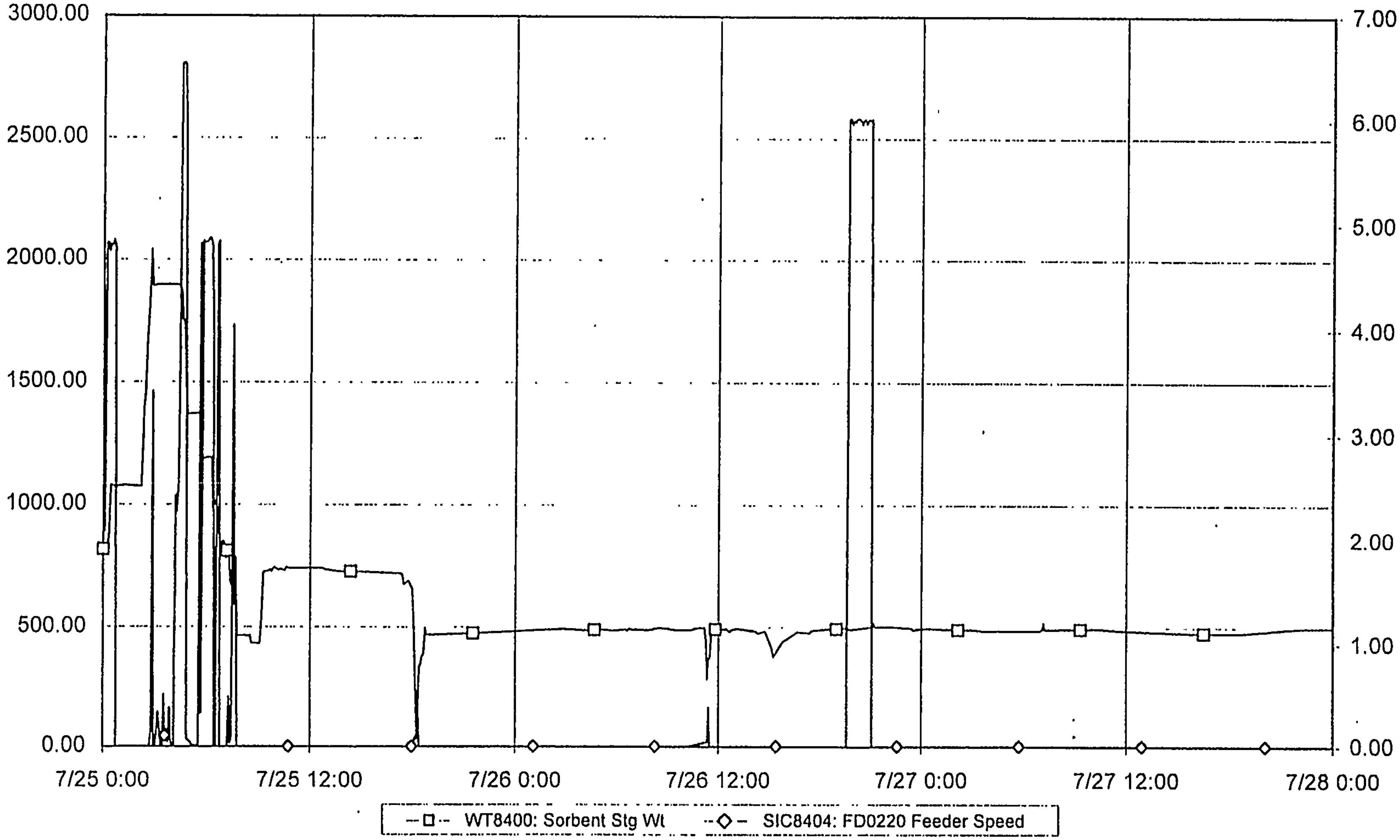


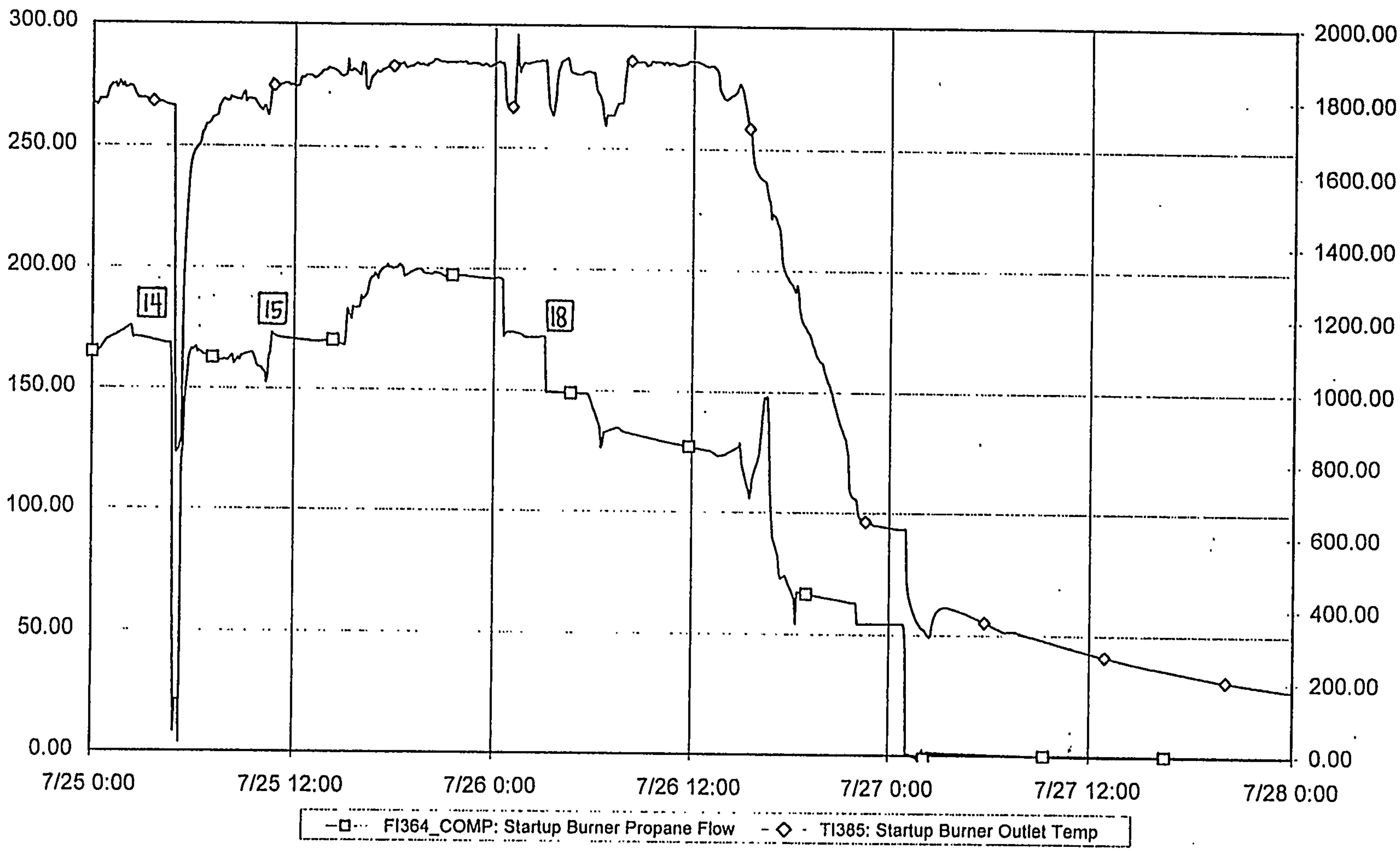
DOE Plot 7 of 45 - 5 minute data

Figure 5.1.5-21 Coal Feed for July 25 Through July 27, 1996



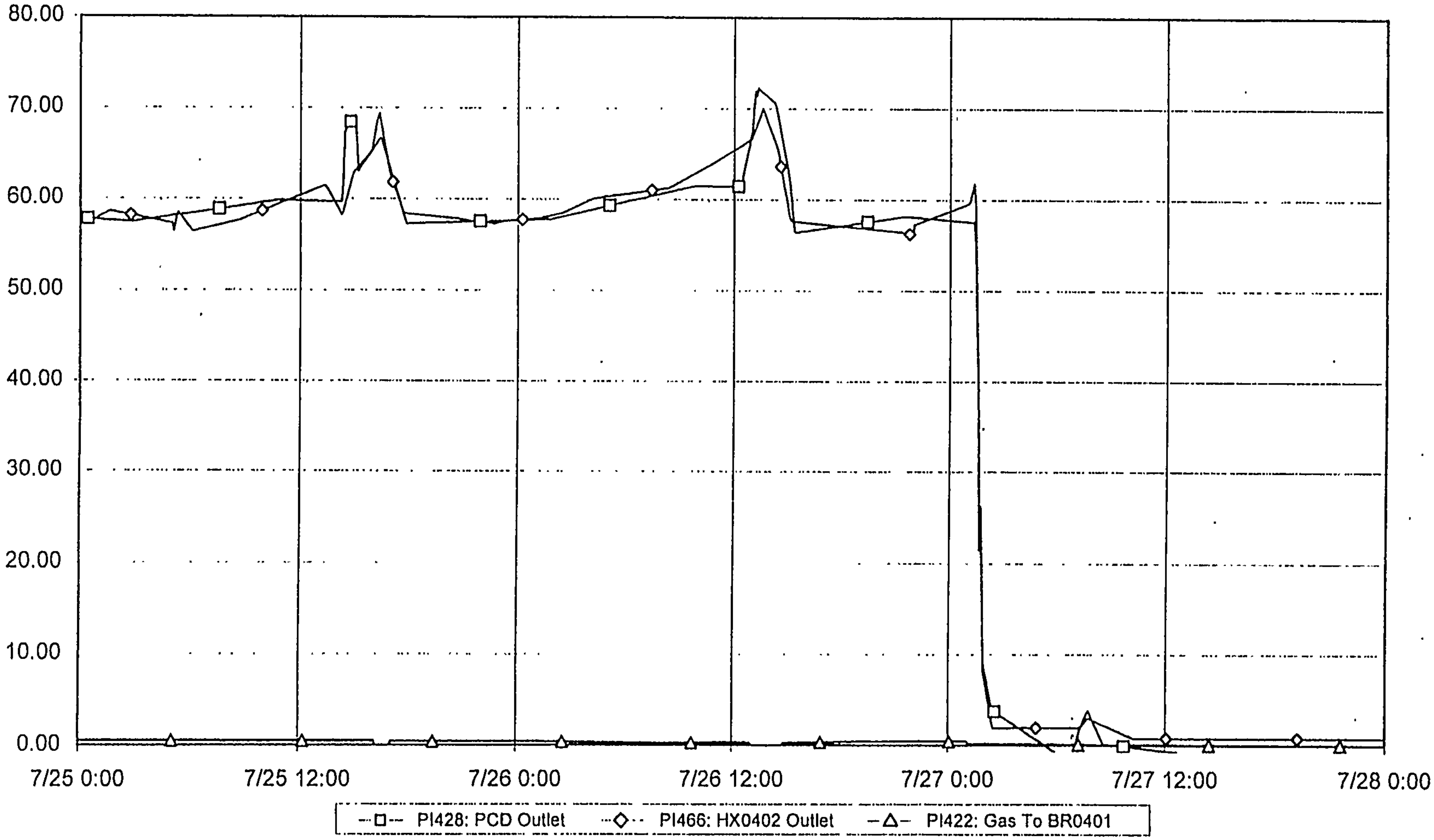
DOE Plot 9 of 45 - 5 minute data

Figure 5.1.5-22 Sorbent Feed for July 25 Through July 27, 1996



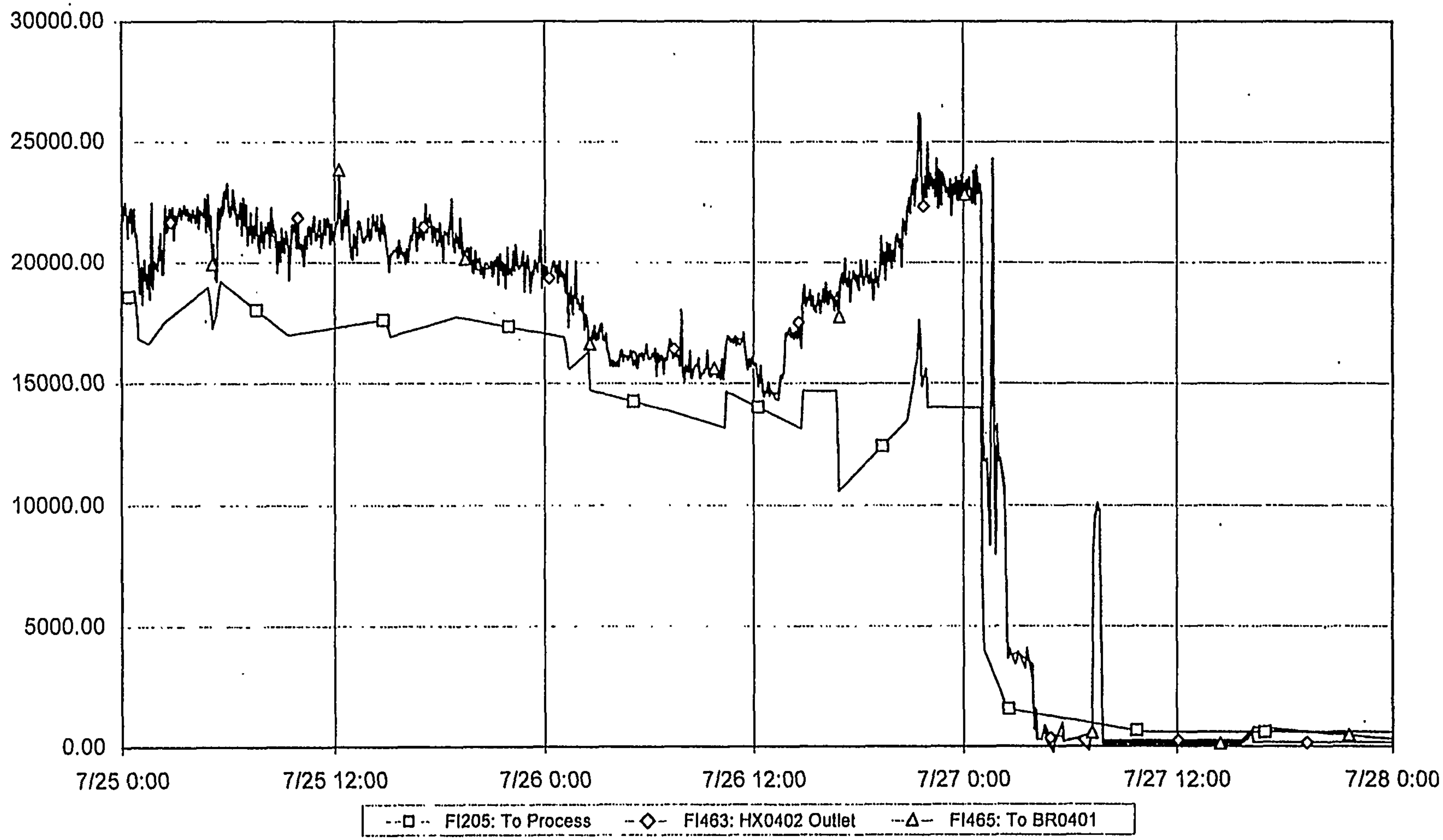
DOE Plot 11 of 45 - 5 minute data

Figure 5.1.5-23 Start-Up Burner Flow/Temperature for July 25 Through July 27, 1996



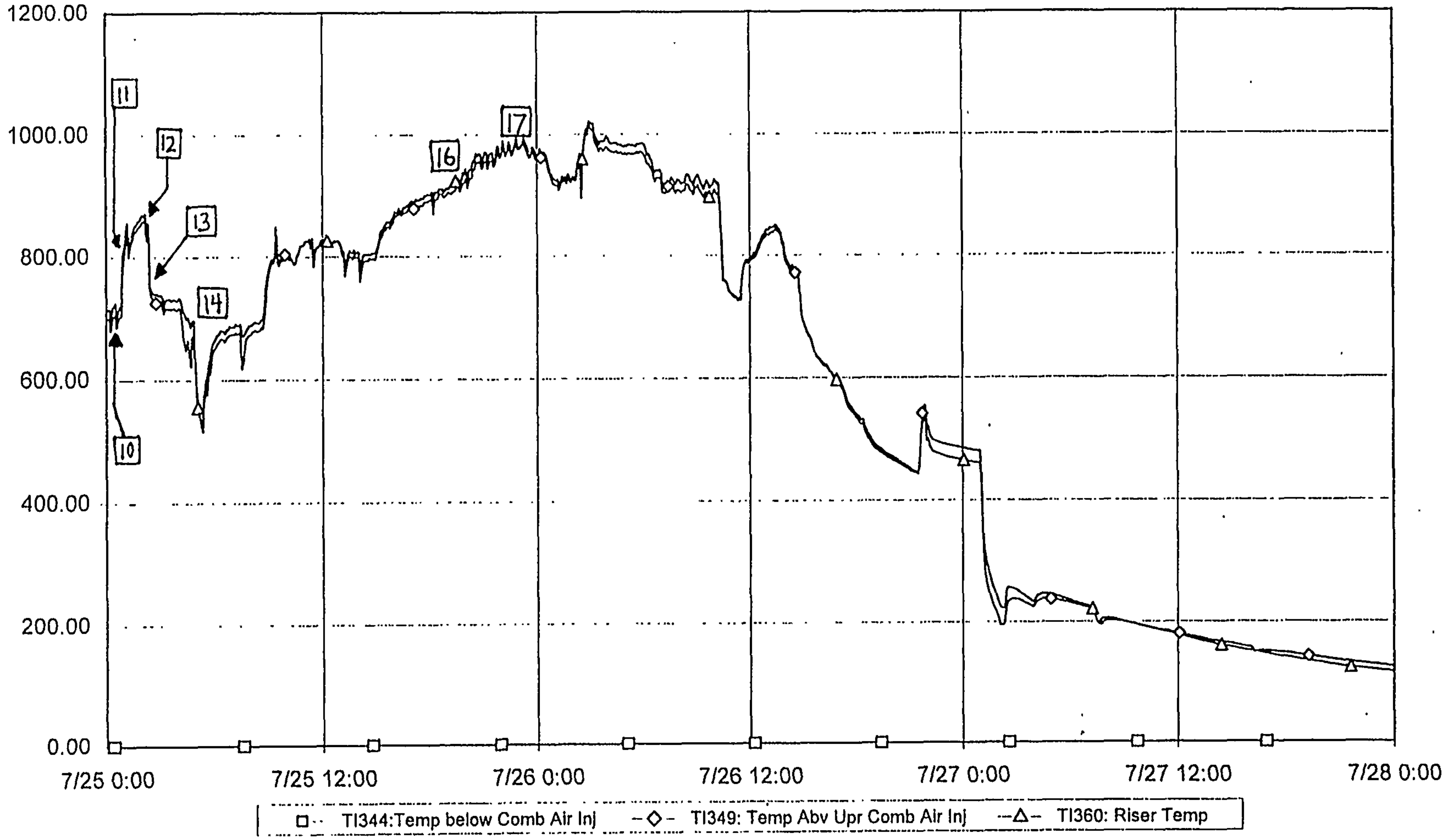
DOE Plot 12 of 45 - 5 minute data

Figure 5.1.5-24 System Pressures Downstream of PCD for July 25 Through July 27, 1996



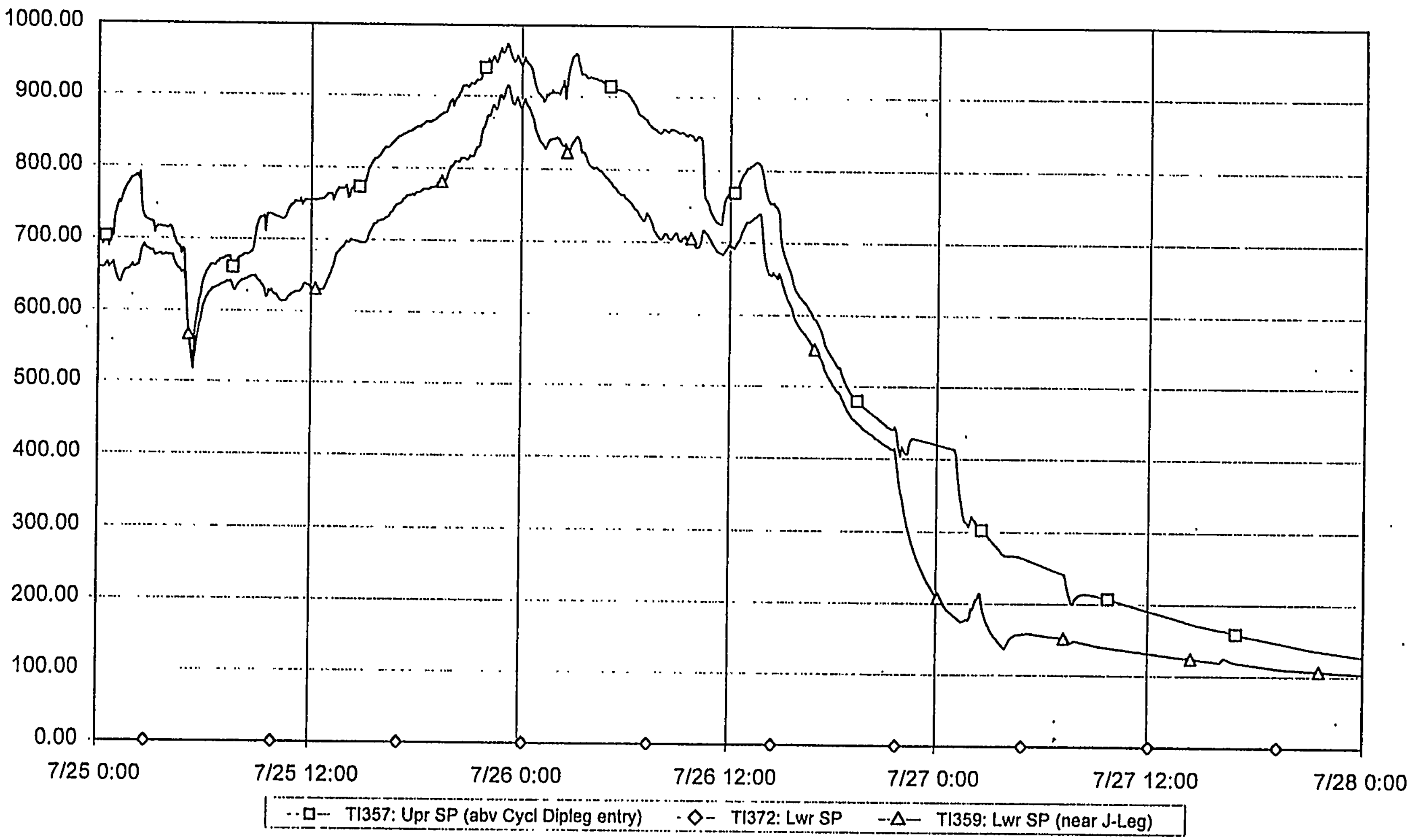
DOE Plot 13 of 45 - 5 minute data

Figure 5.1.5-25 Total Gas In/Out Flow Rates for July 25 Through July 27, 1996



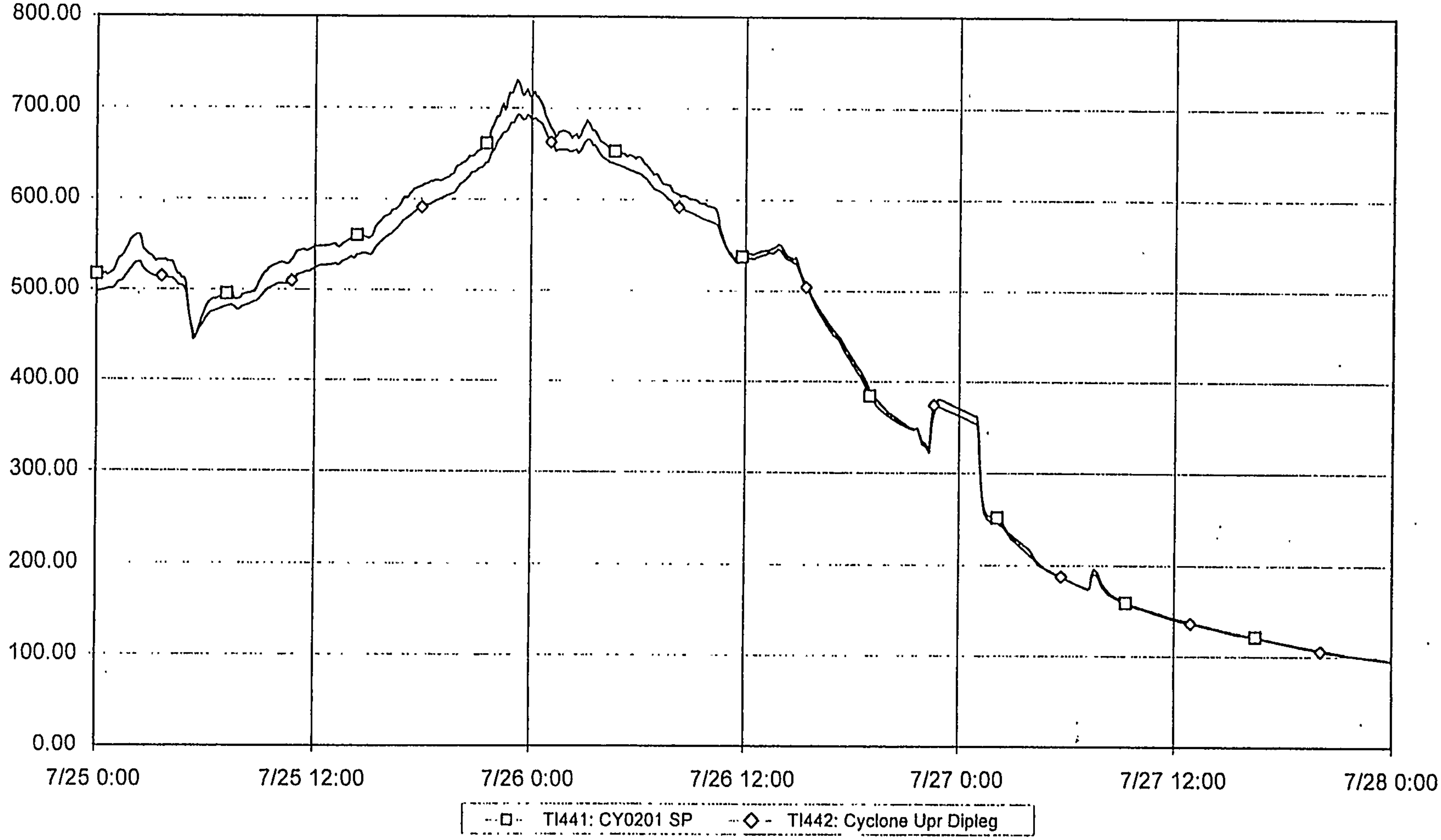
DOE Plot 14 of 45 - 5 minute data

Figure 5.1.5-26 Reactor Mixing Zone and Riser Temperatures for July 25 Through July 27, 1996



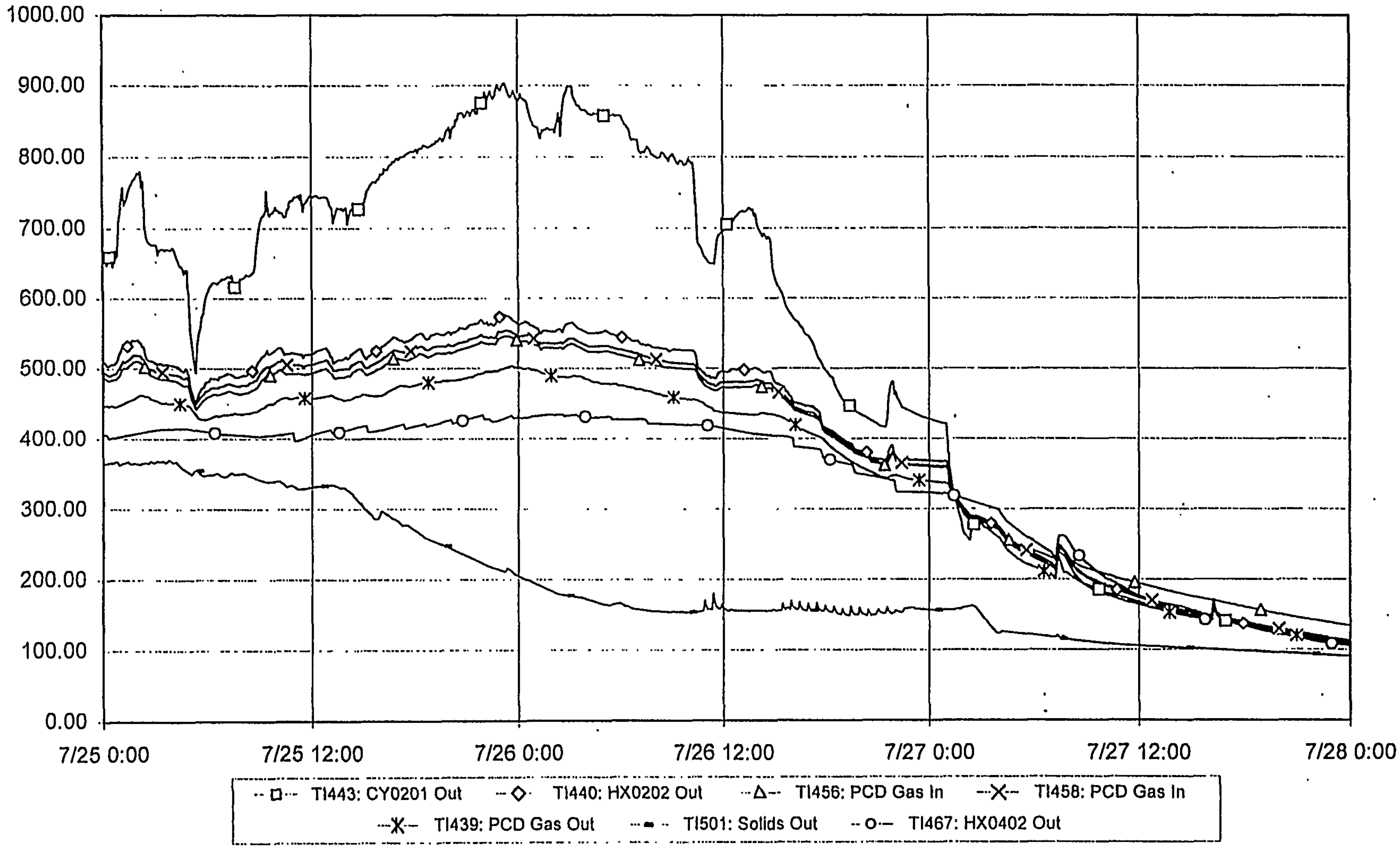
DOE Plot 15 of 45 - 5 minute data

Figure 5.1.5-27 Standpipe Temperatures for July 25 Through July 27, 1996



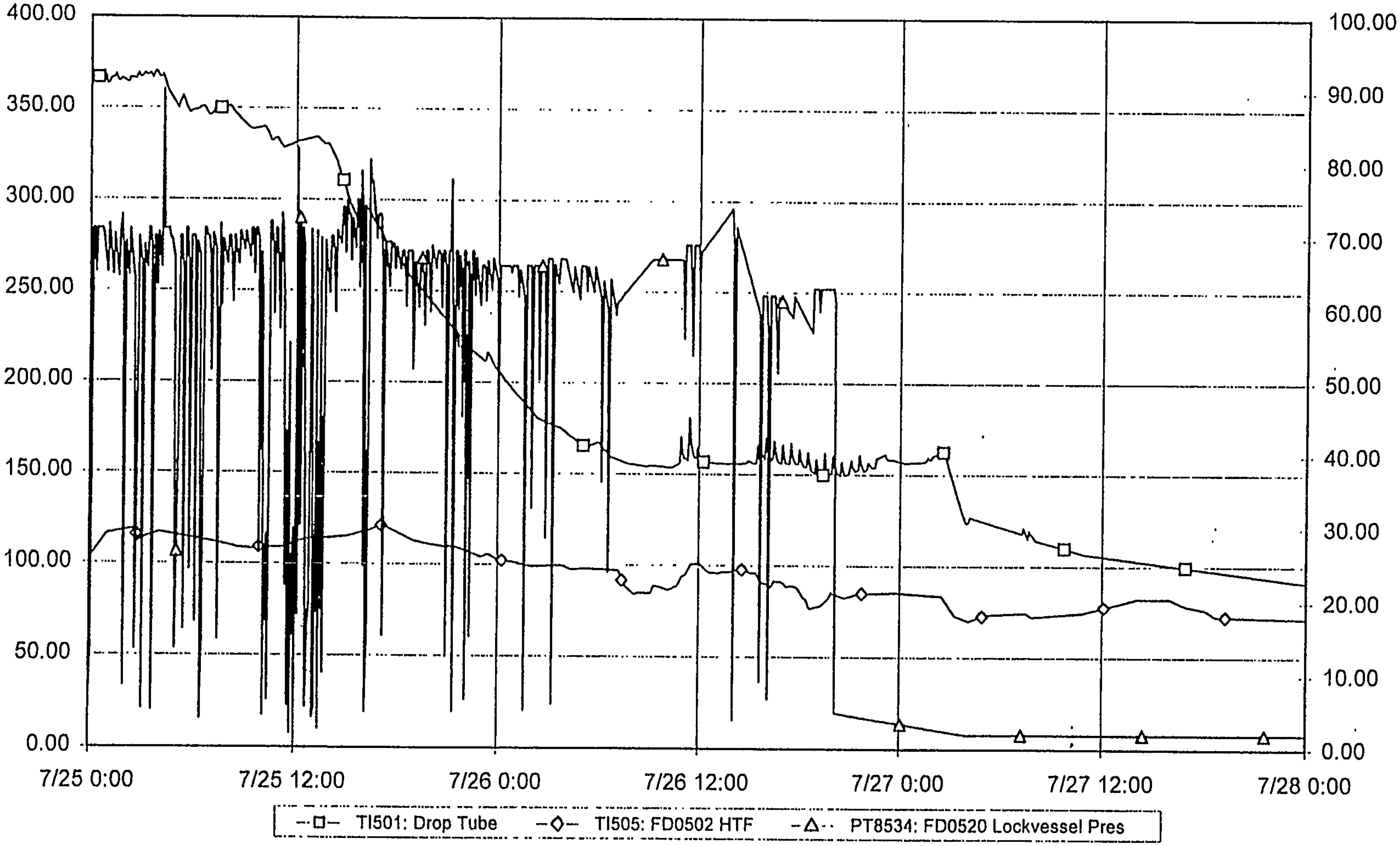
DOE Plot 16 of 45 - 5 minute data

Figure 5.1.5-28 Cyclone Dipleg Temperatures for July 25 Through July 27, 1996



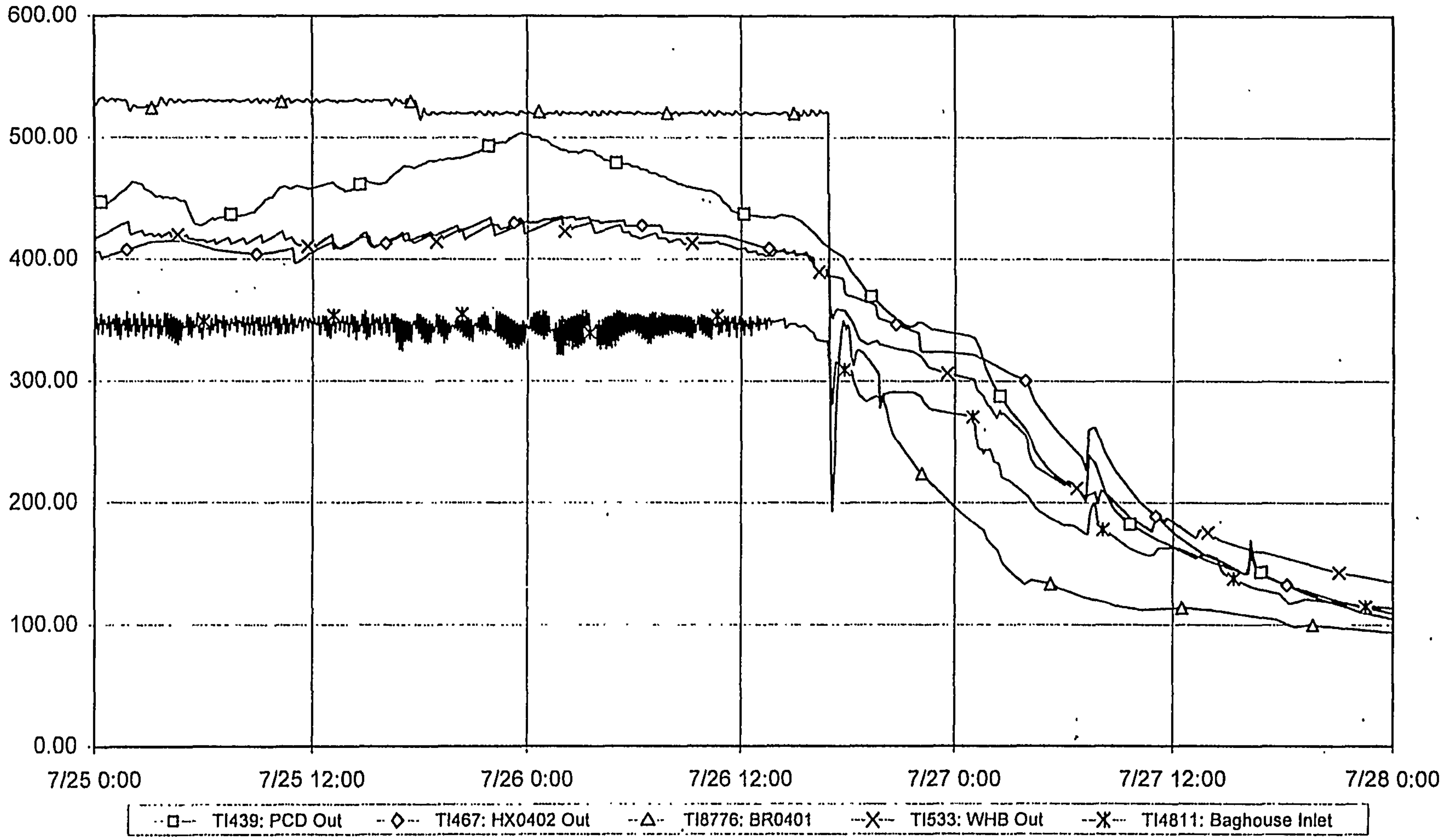
DOE Plot 17 of 45 - 5 minute data

Figure 5.1.5-29 Temperature Profiles Downstream of Reactor for July 25 Through July 27, 1996



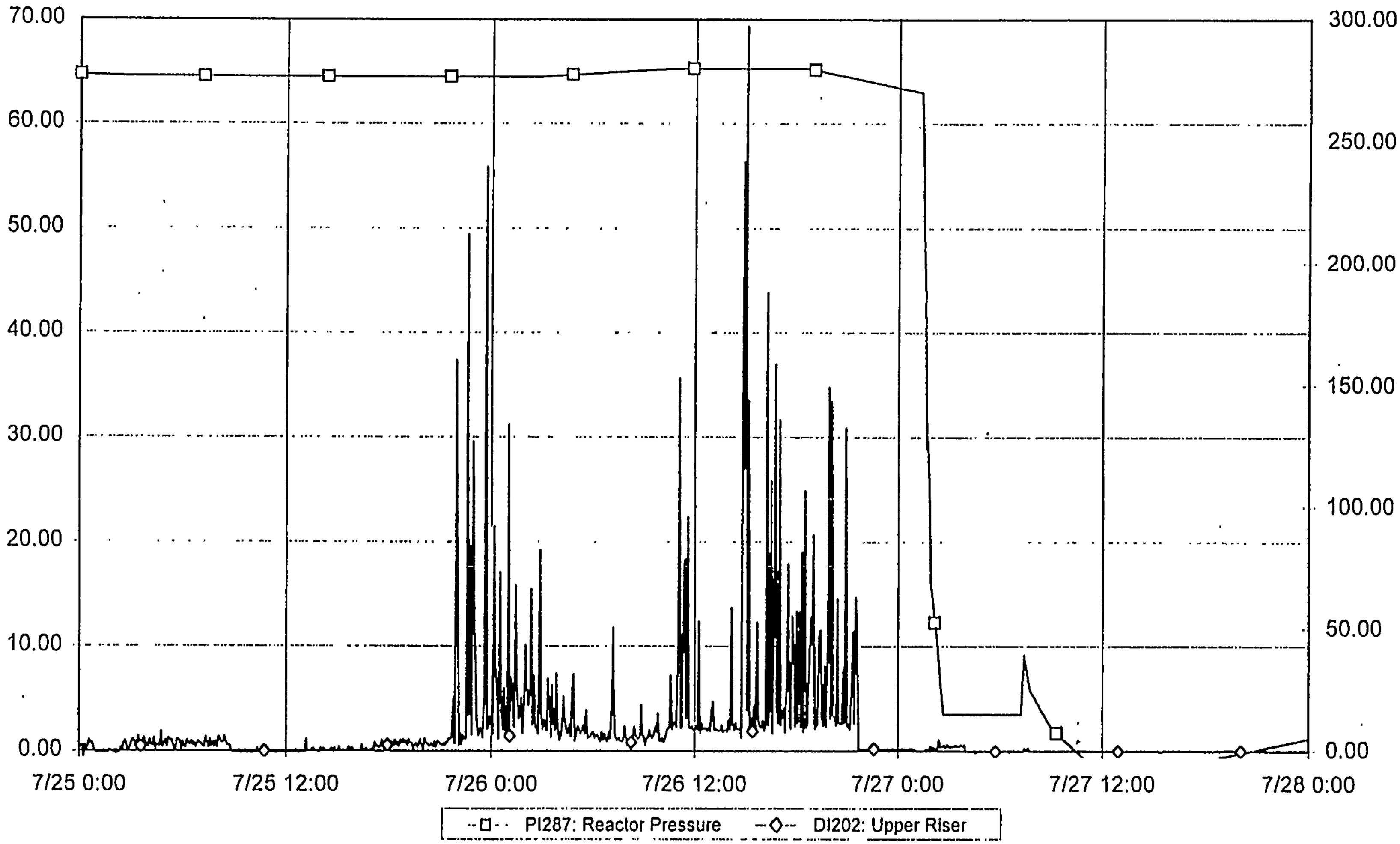
DOE Plot 18 of 45 - 5 minute data

Figure 5.1.5-30 PCD Ash Temperatures for July 25 Through July 27, 1996



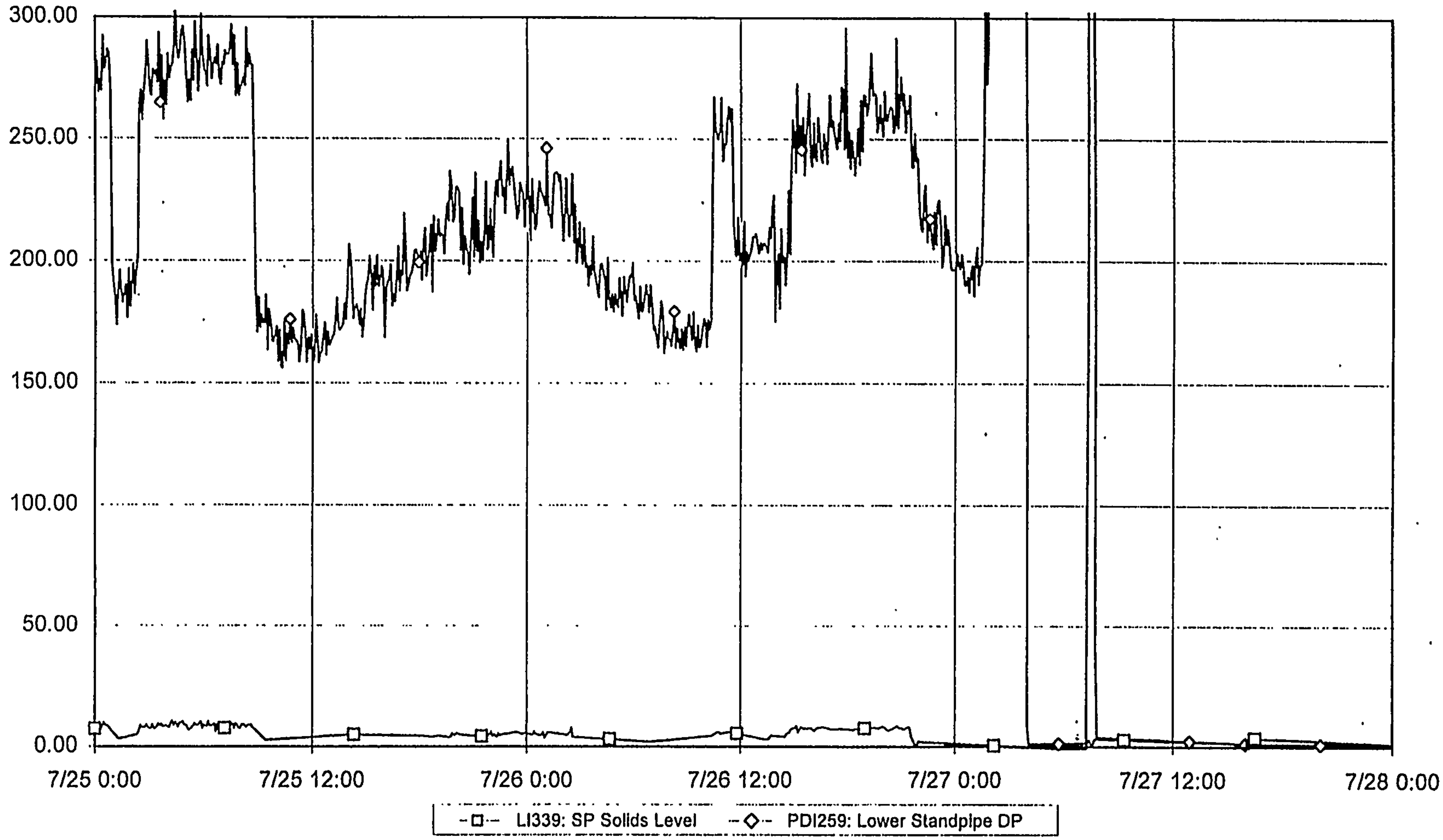
DOE Plot 19 of 45 - 5 minute data

Figure 5.1.5-31 System Temperatures Downstream of PCD for July 25 Through July 27, 1996



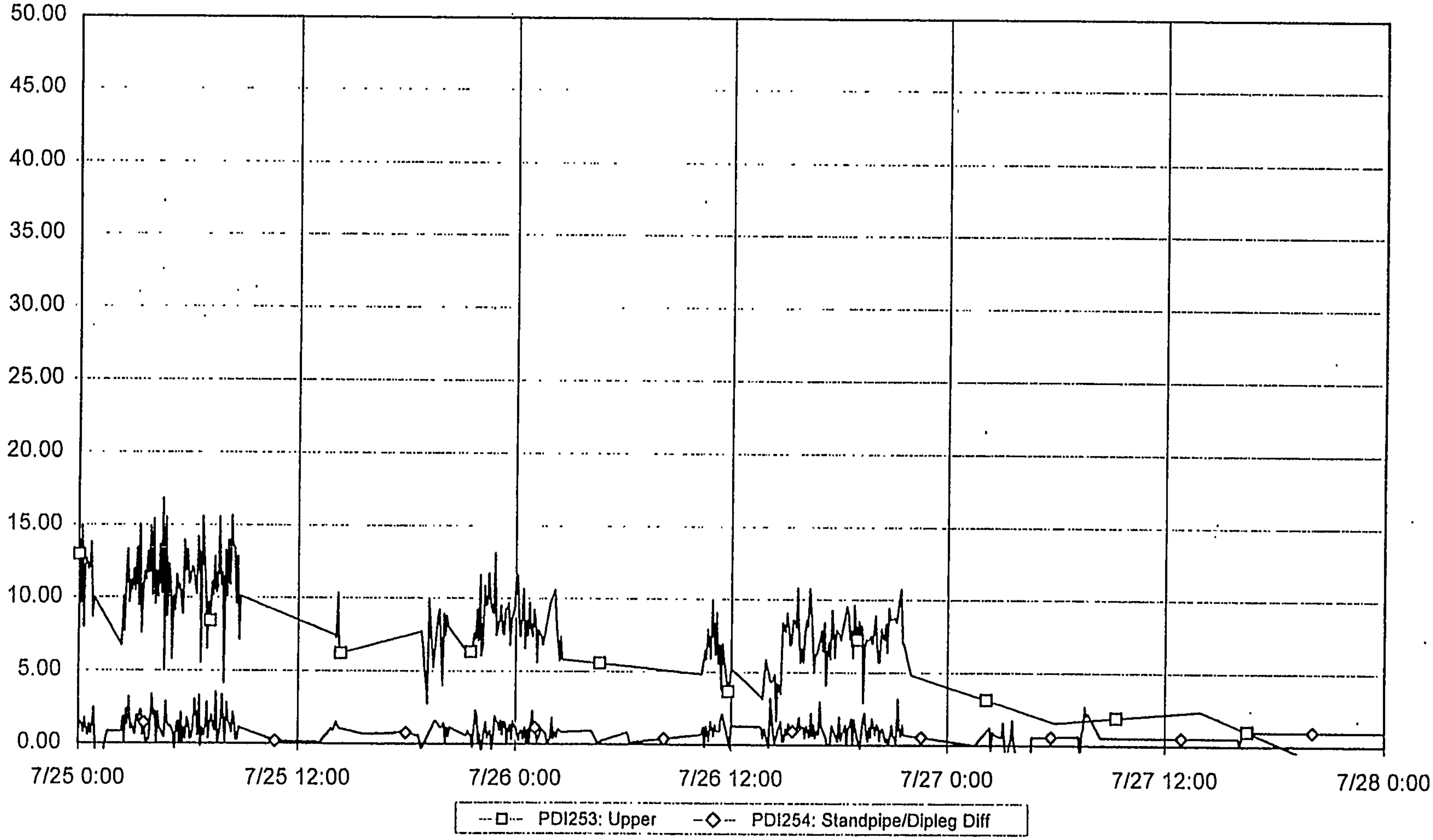
DOE Plot 21 of 45 - 5 minute data

Figure 5.1.5-32 Reactor Pressure/Riser DP Profiles for July 25 Through July 27, 1996



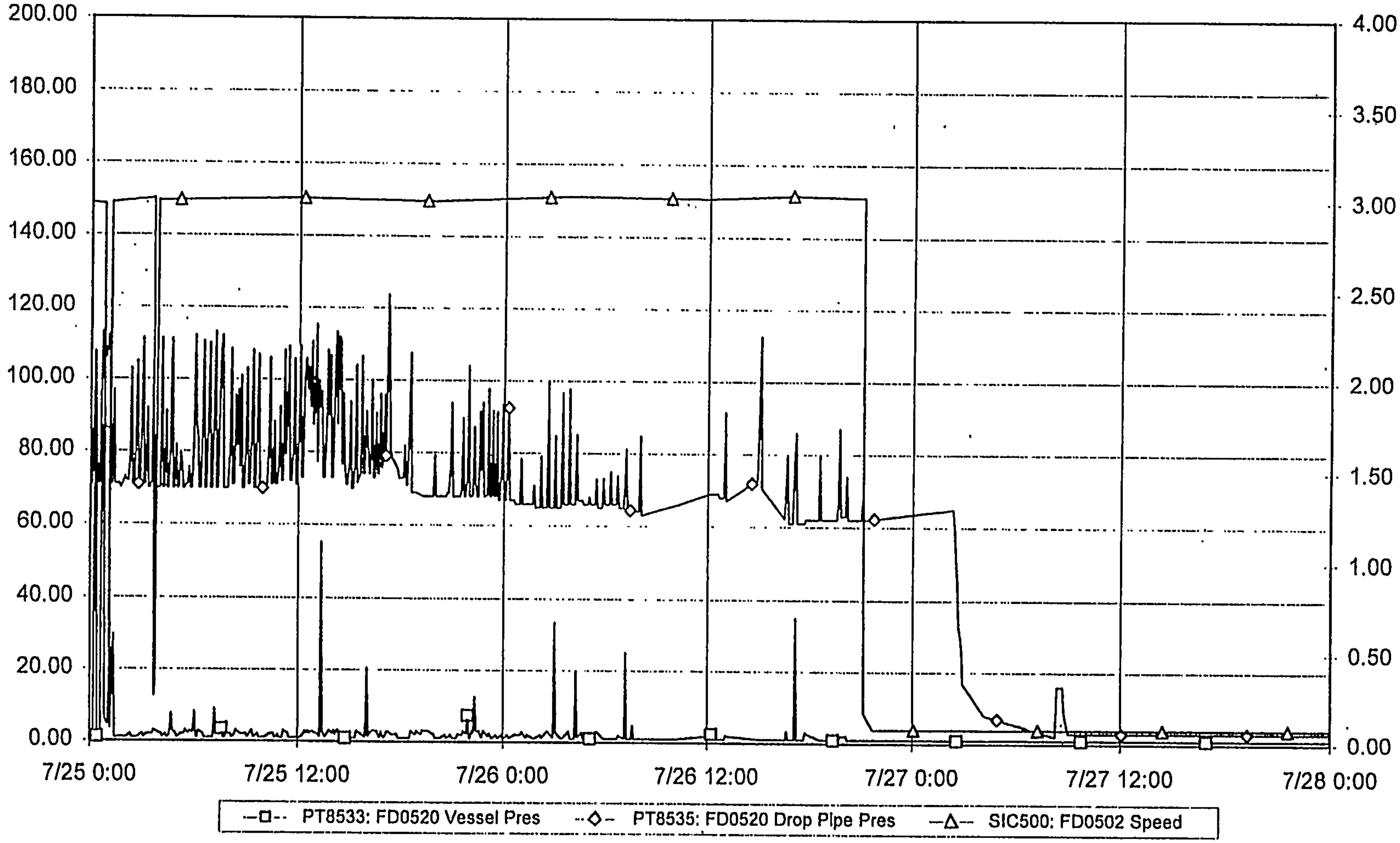
DOE Plot 22 of 45 - 5 minute data

Figure 5.1.5-33 Standpipe DP Profiles for July 25 Through July 27, 1996



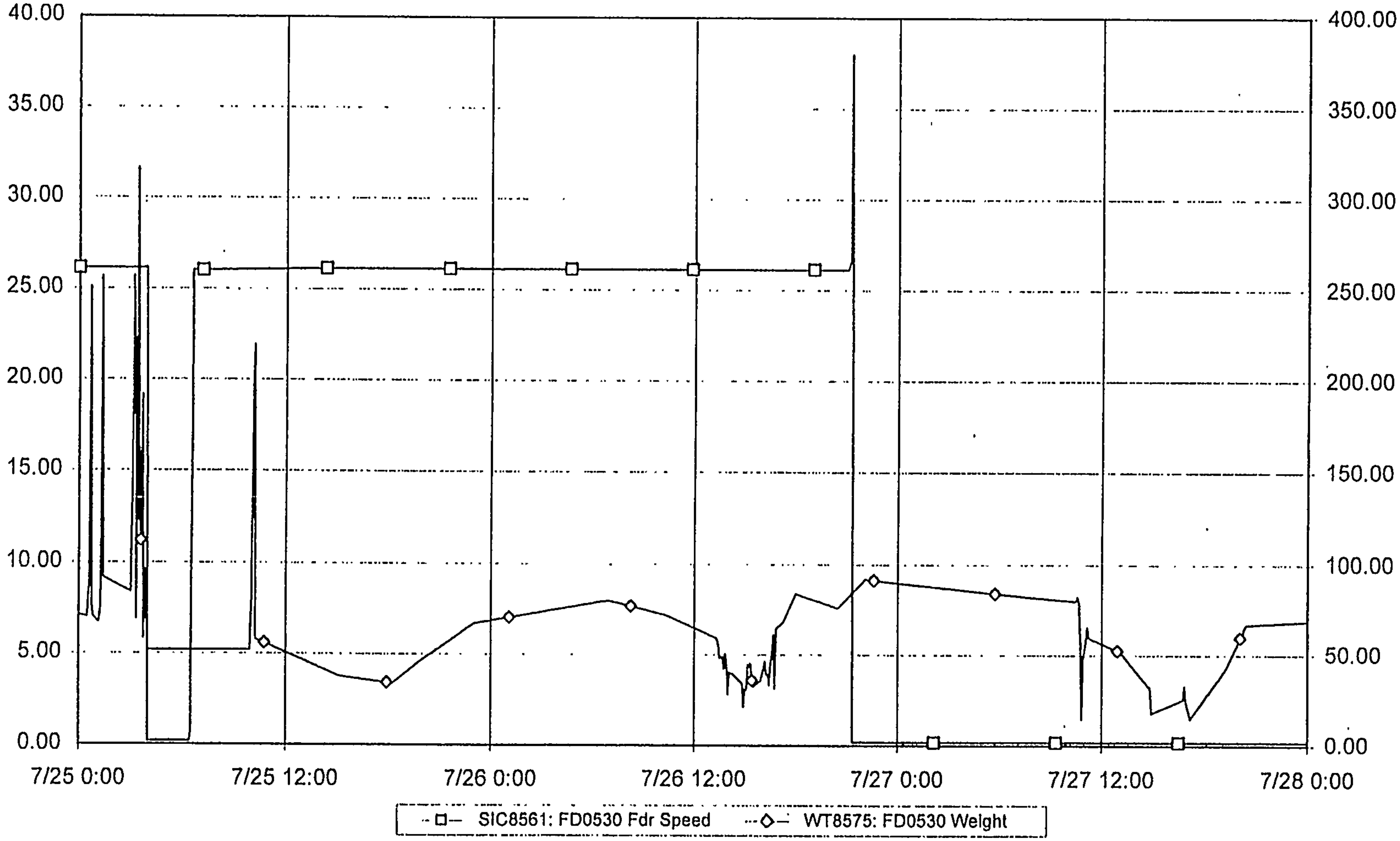
DOE Plot 23 of 45 - 5 minute data

Figure 5.1.5-34 CY0201 Dipleg DP Profiles for July 25 Through July 27, 1996



DOE Plot 30 of 47 - 5 minute data

Figure 5.1.5-35 FD0520 Pressures for July 25 Through July 27, 1996



DOE Plot 31 of 47 - 5 minute data

Figure 5.1.5-36 FD0530 Feeder for July 25 Through July 27, 1996

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5.1.6 Characterization Test Run CCT1B

5.1.6.1 Introduction and Test Objective

The objective of this test run was to circulate sand for the first time in the reactor loop and to achieve coal combustion. As a prerequisite, the reactor loop was pressure tested to 200 psig to check and fix any leaks. Test run CCT1B started on July 31 and was completed on August 6, 1996. Figures 5.1.6-1 through 5.1.6-19 show the operating graphs for this time period.

The main air compressor (CO0201) was started and the reactor pressurization began. At approximately 178 psig reactor pressure, it was noticed that the reactor pressure could not be increased any further though the control valve (PV287) was closed down as much as possible (event 1, figure 5.1.6-6). The reactor loop was then depressurized and the control valve was visually inspected. The valve was opened and the trim assembly was found to be severely eroded by solids. The worn out trim was replaced by a new trim. Prior to the trim replacement, it was hypothesized that the solids that collected inside the refractory pipe prior to routing the gas through the Westinghouse PCD caused the erosion. The piping from Westinghouse PCD to PV287 was therefore blown through with compressed air for 12 hours to remove suspect alumina from piping. After the blow through was completed, selected sections of the refractory piping downstream of the PCD where solids could accumulate were inspected with a borescope and found clean. The bottom nozzle of HX0402 was opened and approximately 50 lb of alumina were drained from the heat exchanger.

For this test run, on-stream oxygen analysis capability was provided while the sampling system heat tracing was being installed. At the end of the previous run (CCT1A) the solids were drained from the reactor standpipe and J-leg. The HX0203 loop was not drained. The PCD and initial reactor loop preheat philosophy used for this run was different from the previous run. The reactor/PCD system (after air drying using CO0201) would be heated up using the start-up burner (BR0201) to as high a temperature as possible. In the reactor, the hot combustion gases would flow through the mixing zone upwards through the riser, through the reactor J-leg, and up the standpipe and cyclone. In this manner, the refractory would be heated up first before solids were loaded into the standpipe. This was done to shorten the reactor preheat time. Because solids sealed the HX0203 J-leg, this loop was not preheated.

5.1.6.2 Test Chronology

The test run began on August 2, 1996, after all the ancillary equipment such as boiler feed pumps, demin pumps, and HTF system were put in service. At 16:39 the main air compressor was started and the reactor loop was successfully pressure tested to 200 psig (event 2, figures 5.1.6-1 and -6). After the leak test was completed at 21:20, the reactor loop was depressurized to 160 psig (set pressure for coal combustion) to determine the instrument purge flow settings for this pressure. The reactor loop was depressurized to 60 psig and the PDT/PT instrument purge flows set. At 02:30 on August 3, 1996, the thermal oxidizer firing rate was increased to increase the steam drum pressure to 400 psig.

At 0630 on August 3, 1996, the spent solids transport system was lined up to convey fines collected by the PCD into the limestone feeder (FD0220) for subsequent feeding into the reactor. This recycle system ensures that the solid inventory in the reactor system remains essentially constant. While this was being done, the HTF system was put in service with heat transfer fluid flowing to the spent solids screw cooler (FD0206) and the fines screw cooler (FD0502).

Opening of block valves on all the aeration/process nozzles that were closed during the shutdown to prevent plugging by solids began at 09:00 and ended at 13:00. After the block valves were opened, the aeration flows were set to standby flows. Some of the nozzles were found plugged with solids. These were cleared later when the compressor discharge pressure was greater than 250 psig. The reactor pressure was reduced from 60 to 50 psig in preparation towards lighting of BR0201 pilot. At 13:20 the downcomers of HX0202 and HX0402 that were inadvertently left open were closed.

After air drying for approximately 21 hours the start-up burner (BR0201) pilot was successfully lit (after a few attempts) to begin reactor refractory and PCD preheat. The propane flow rate was adjusted to 21 lb/hr, the combustion air and quench air flows were set to begin a 2-hour hold at burner exit temperature of approximately 500°F. At the end of the 2-hour hold, the burner pilot flame was lost but was quickly lit back.

In preparation for raising the reactor pressure from 50 to 65 psig, CO0201 discharge pressure was increased to 330 psig. After the reactor pressure was increased to 65 psig at 19:00, the propane flow to BR0201 pilot was increased to 22 lb/hr to maintain flame stability, keeping 13 psid between the pilot propane supply pressure at the burner skid and the burner chamber pressure. The combustion air (FIC365) and the propane flow rates were adjusted to raise the burner exit temperature. At 19:45 the propane pump was started before the main burner gun was lit at 20:35. The burner exit temperature immediately increased from 635 to 860°F (event 3 figure 5.1.6-11). The cold-shot injection to HX0203, which was started earlier in the run to help maintain the steam drum pressure, was discontinued at 21:57 because the steam drum pressure became stable.

To ensure that the solids injected from FD0210 would be carried upwards through the riser and separated in the cyclones, and then drop into the standpipe, the reactor J-leg was first filled by transferring solids from HX0203 (event 4, figure 5.1.6-15). This was accomplished through manipulation of FIC680. Meanwhile, the starting bed material was transferred from FD0140 into FD0210. The FD0502, FD0520, and FD0530 systems were started and the FD0530 was lined up to FD0220 so that any material captured by the PCD during the previous run and any subsequent material captured by the PCD during the present run would be returned into the reactor. After the reactor J-leg was sealed, solids feeding from FD0210 into the reactor was attempted at 01:10 on August 4, 1996. The FD0210 rotor feeder problems delayed the injection of bed material from FD0210 into the reactor. Meanwhile, FD0220 was started at 08:15 to inject material that was transferred from FD0530. At 13:40 the FD0210 rotofeeder was opened for inspection. Foreign debris such as pieces of welding rods, grating, nails etc., was found at the discharge of the feeder. After the debris was removed, the inside of the rotor feeder was inspected with a borescope and was found to be clean. The feeder was reassembled at 17:45 and bed material transferred into FD0210 was successfully transferred into the reactor (event 5, figure 5.1.6-19).

It was discovered at 09:00 (while FD0210 was being serviced) that the gas coolers HX0202 and HX0402 were not put into steam production service as planned. To prevent damage to the coolers, the downcomers were closed for 40 minutes to condense steam on the shell side to cool the heat exchangers. At 09:56 the downcomers of the coolers were opened. This caused the water level in the steam drum to fall below the LSLL level and resulted in the shutdown of the thermal oxidizer. After 4 minutes the thermal oxidizer was relit at 10:14. The downcomer valves on the coolers were then closed. At 12:27 solids circulation through HX0203 was initiated first followed by reactor J-leg circulation to reduce the riser exit gas temperature to HX0202. At this time, the inlet gas temperature to HX0402 had dropped sufficiently to allow its downcomer to be closed (event 6, figure 5.1.6-14). At 14:20 HX0202 downcomer was opened and the heat exchanger was placed in steam producing mode.

After HX0202 was successfully put in service, the burner firing was increased and the reactor heat-up continued. At 21:25 the MWK cooling water pump tripped causing CO0201 to trip on a high inlet air temperature to the third stage. The start-up burner also tripped. At 21:45 the problem with the cooling water system was solved and the operation resumed by starting CO0201 and then the start-up burner to continue with reactor heat up. During this upset condition, nitrogen was supposed to flow into the reactor upon loss of CO0201. However, this did not happen because the block valve on the supply line was manually closed. The effect of the loss of the main air compressor on reactor operation is provided as event 7, figures 5.1.6-12, -13, and -15.

Throughout the reactor preheat period, solids circulation through HX0203 and the reactor J-leg were optimized to achieve as high refractory heat-up rate as possible. When necessary, solids circulation through HX0203 was reduced to a minimum reducing the heat input that was being transferred from the burner to cooling water. Periodic reactor loop skin temperature profiles were taken to ensure that the differential thermal growths between the various reactor legs were within the allowable range.

At 2235 the burner firing rate was increased while keeping the burner exit temperature at 1,750°F by raising the quench air supply to 170 lb/hr propane flow. After half an hour, the propane flow began to decrease. The flow dropped to 160 lb/hr in about 10 minutes. The propane vaporizer system was checked. The propane pump was running. The propane supply pressure and temperature were found to have dropped to 133 psig and 77°F, respectively. After 3 minutes, the propane supply pressure came back to 181 psig and the supply temperature increased to 99°F. The propane flow rate started increasing and after 5 minutes settled at 176 lb/hr. At approximately 23:55, the start-up burner propane flow dropped slowly from 176 lb/hr to 166 lb/hr. The propane vaporizer temperature controller setpoint was increased, increasing steam flow to the vaporizer and causing the vaporizer temperature to increase to 194°F. The propane supply pressure increased from 123 to 182 psig. The propane flow rate settled at 176 lb/hr at the same valve opening. Reductions in propane flow rate were experienced several times during the preheat period. Each time, the propane flow was increased by intensifying its supply pressure and/or the vaporizer temperature. The responses of burner exit temperatures to the irregular propane flow are shown as event 8, figure 5.1.6-11.

Start-up of the spent solids screw cooler (FD0206) and the spent solids dense-phase conveyor (FD0510) began at 00:30 on August 5. However, start-up was delayed due to logic problems. Once the logic problems were solved both FD0206 and FD0510 were started at 01:15. From this time forward, FD0206 was run periodically for a brief period to prevent it from jamming. Five minutes prior to starting the transporter system, the riser exit temperature was 780°F. The reactor pressure was increased from 60 to 72 psig to reduce the riser superficial velocity without reducing burner firing rate as the riser exit temperature increased (event 9, figure 5.1.6-15).

At 0625 the burner firing was increased from 180 to 184 lb/hr and the burner exit temperature increased to 1,900°F, which is the targeted set point. Shortly afterwards, the top FD0510 spheri valve refused to close. At 07:15 the problem with FD0510 was solved and it was placed in service.

At 14:00 approximately 1,000 lb of coke breeze was inventoried into FD0210 in preparation for coke breeze combustion preheat. After about 30 minutes the aeration flows to HX0203 were readjusted to optimize solids circulation through the heat exchanger. The HX0203 standpipe differential pressure increased after the adjustment.

At approximately 15:00, a leak developed in the body of the backpressure control valve (PV287) which spewed dark clouds of coke breeze/alumina mixture. The reactor operation was prematurely terminated and the coke breeze was not fed into the reactor.

5.1.6.3 Post Test Activities

PV287

The valve was disassembled and the internal components were found to be severely eroded by solids as shown in figures 5.1.6-20 to -23. The bottom flange of HX0402 was opened and visually inspected for evidence of solids. There was no carbon-laden dust similar to the dust that blew out of the PV287 body. The bottom flange was covered with rust dust with spots of white alumina sprinkled over it. The source of the dust (particles) was traced to the vent systems on FD0220 and FD210 dispense vessels. The vents from these two vessels are combined and exhausted a few feet upstream of PV287. The vent valves were removed and inspected. The vent valve on FD0220 plug and stem were completely eroded away as shown in figure 5.1.6-24. Those of FD0210 (see figure 5.1.6-25) also showed considerable erosion. The dust cloud observed was a mixture of alumina and coke breeze that was present in FD0220. The vent lines from the feeders to upstream of PV287 were blown clear of solids. A new valve body and the original whisper trim (which was modified by Fisher to allow high gas flow operation at 50 psig) were installed.

Start-up Burner

To increase the heat input into the reactor from the start-up burner and at the same time not operate at high riser superficial velocities, it was necessary to operate the reactor at a higher pressure than 75 psig. To increase the maximum operating pressure to 100 psig, some of the instrumentation on the burner system was upgraded for high-pressure operation. A new differential pressure controller was installed on pilot gas to BR0201 to increase pilot gas pressure and maintain pilot flame length as reactor pressure is increased. The propane system regulator was also replaced.

A new burner pilot assembly and main burner tip were received from John Zink. After some modifications the new pilot assembly was successfully hydro tested at 380 psi. After hydro testing, a trial run was made to show proper actuator movement under pressure. Proper actuation was shown with the vessel at pressure and the cylinder using 110 psig air pressure. The cylinder cycled properly. The old main burner gun tip was replaced with the new main burner gun tip to increase the firing rate to 5 MBtu/hr. The new burner tip was also redesigned to prevent carbon deposition that plagued the old burner gun tip. The new main burner gun tip was provided with a smaller port drilling, and smaller port circle with the tip end closer to the end of the cone.

After review by MWK, the maximum burner exit temperature was increased from 1,900 to 2,100°F to shorten the reactor preheat period and reach the mixing zone temperature of greater than 1,250°F needed for coke breeze combustion.

Solids Feeder Systems

Construction scrap was found in FD0210 feeder valve. It was suspected that it came through FD0140 feed hopper. A 16-mesh screen was placed over FD0140 to prevent foreign debris from entering the feeder when material is transferred from FD0140 into either FD0220 or FD0210.

The feeder dispense vessel vent problems were discussed in a teleconference between Clyde, Kellogg, and SCS. Alternative solutions were developed; however, these were not implemented for the next run. Rather, the vent valves were repaired and reinstalled.

Double block valves were installed downstream of the dispense vessel vent lines from FD0220 and FD0210 (close to the feeders). The block valves were to be closed during the next run, ensuring no venting from FD0210 or FD0220 to PV287. Two PDV valves were installed on nitrogen supply to FD0220 and FD0210 dispense vessels to be used in reducing the aeration and hopper pressurization flows.

Reactor Loop

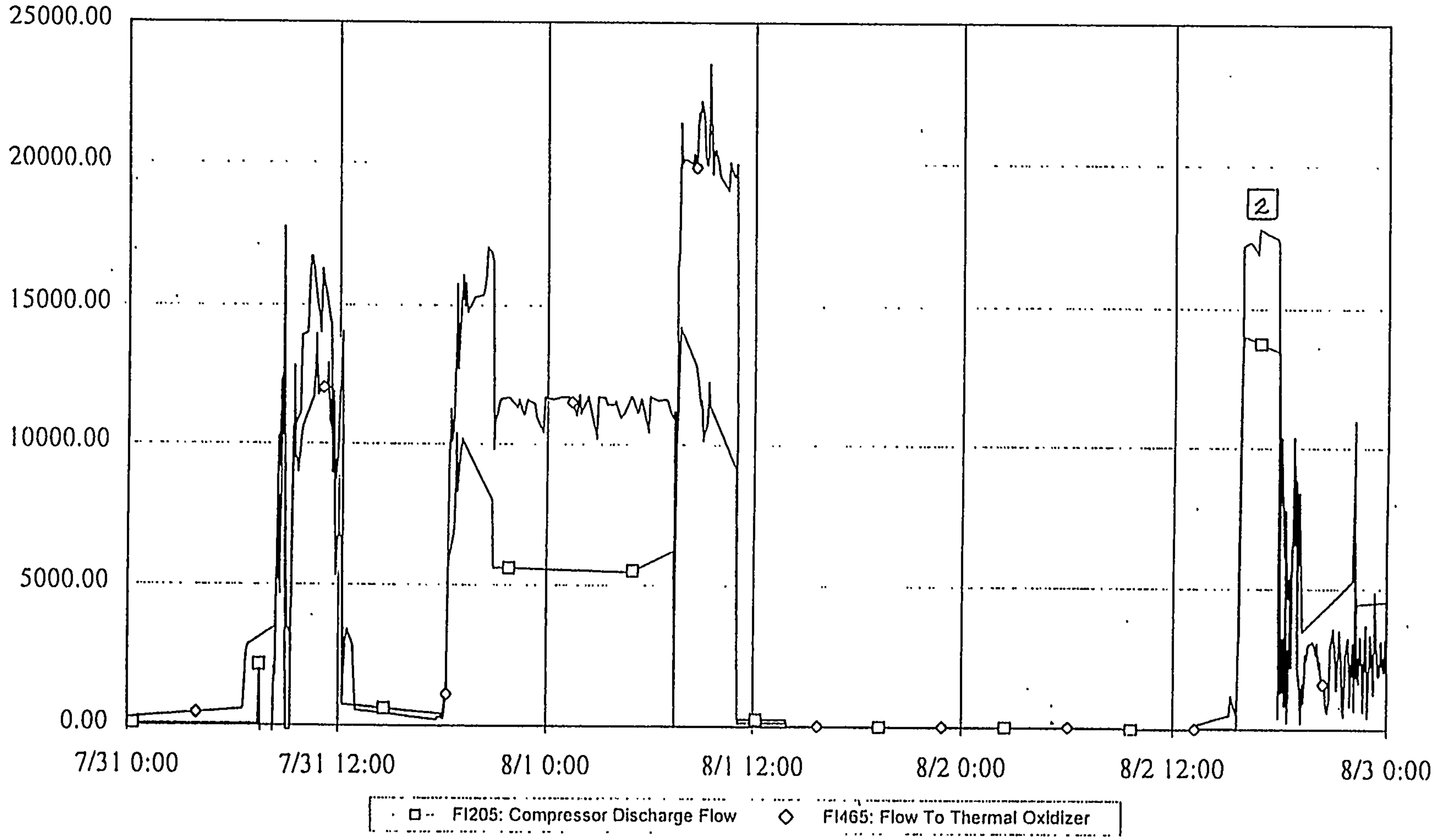
The riser and its associated crossover refractory piping were inspected with a borescope. Some erosion on top of crossover near riser outlet was observed. The pressure transmitter (PI287) was found to be faulty and was replaced with a new one.

Miscellaneous

D0206 screw cooler shaft was repacked, and tubing changes made to bring seal and bellows purge in compliance with design. The 100-ton/day N_2 plant was placed in service, producing sufficient nitrogen to satisfy the present needs. The facility was no longer dependent on truck nitrogen delivery.

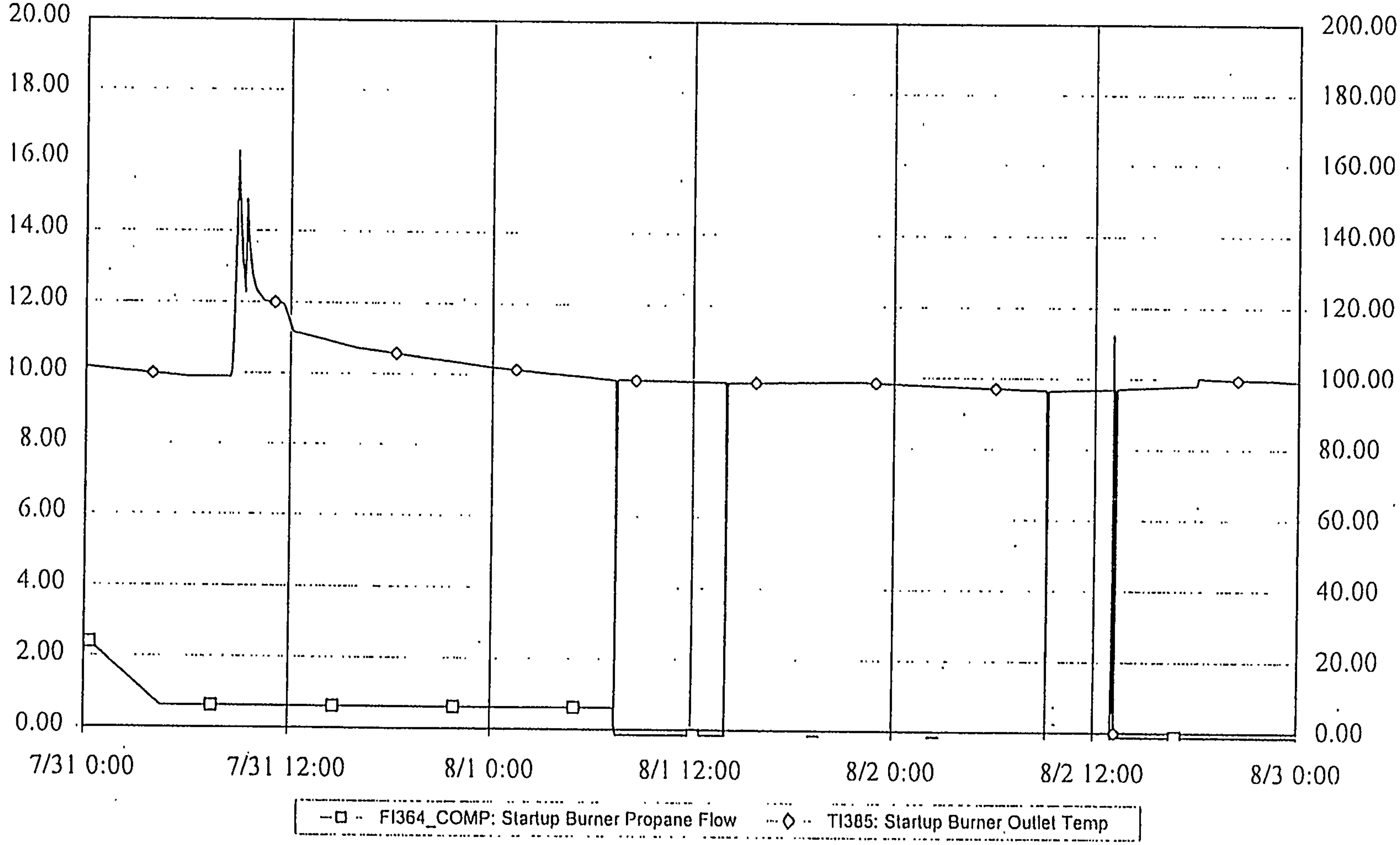
5.1.6.4 Test Run CCT1B Observations

Sand was added to the reactor at 65 psig and circulation was established. The circulation through the HX0203 J-leg was controlled through aeration to achieve faster heat-up of the reactor loop. The superficial riser gas velocities during heat up were high, and as a result, the burner and reactor were operated at higher pressures. The source of particles eroding the pressure letdown valve was found to be the vent systems on the FD0210 and FD0220 dispense vessels.



Non Proprietary Plot1 of 9 - 5 minute data

Figure 5.1.6-1 Reactor Flows for July 31 Through August 2, 1996



Non Proprietary Plot2 of 9 - 5 minute data

Figure 5.1.6-2 Start-Up Burner Flow/Temperature for July 31 Through August 2, 1996

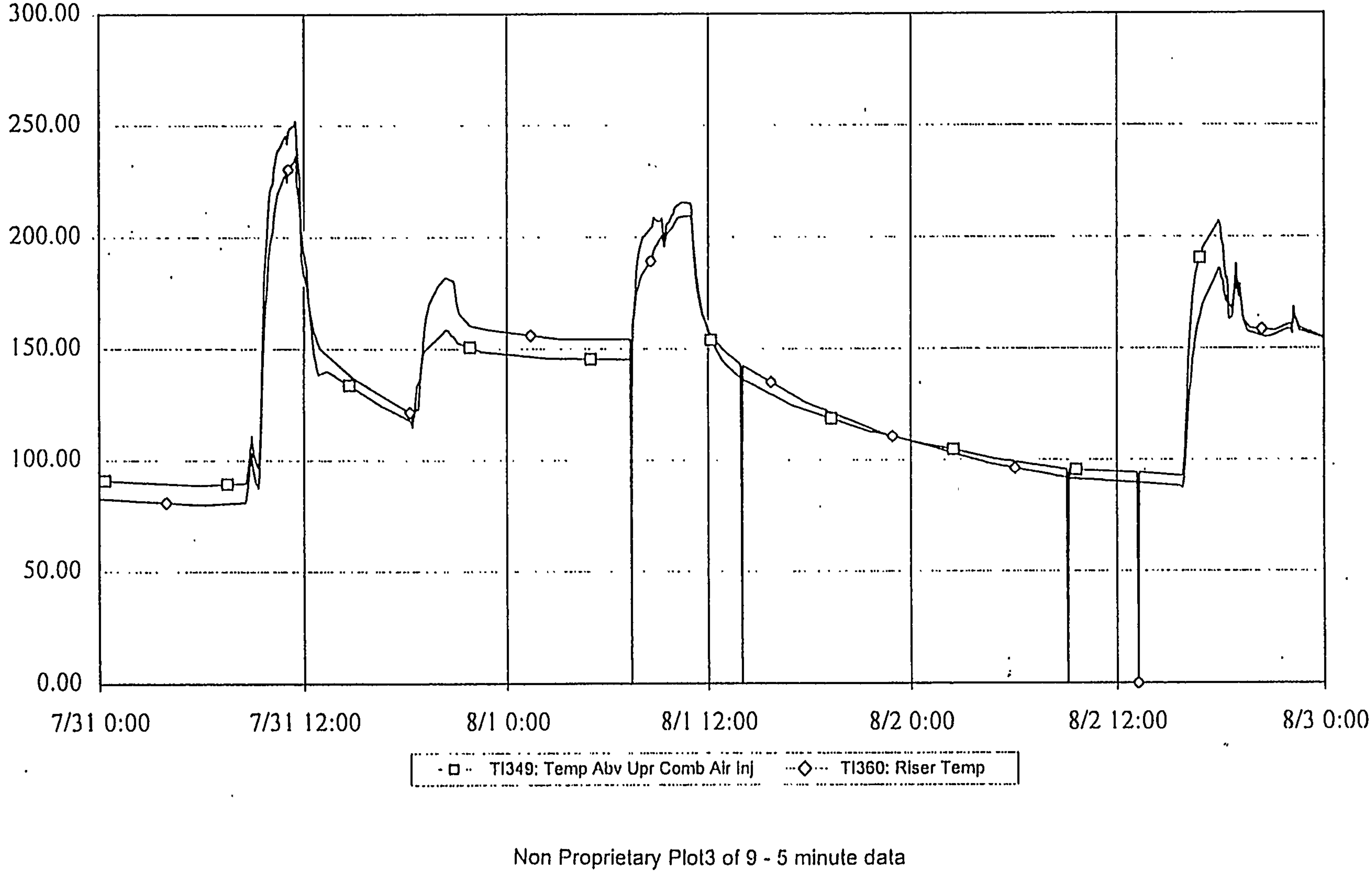
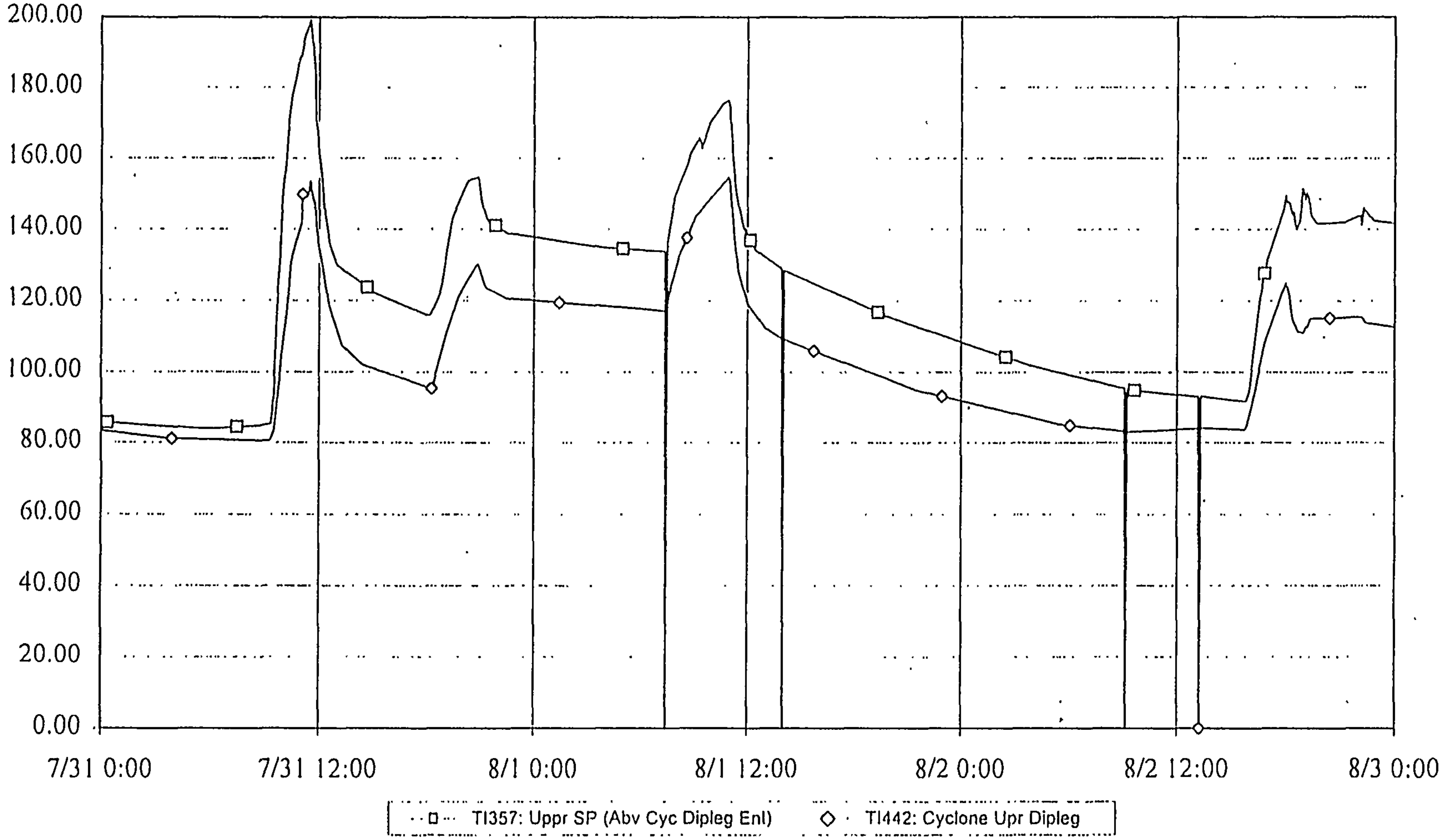
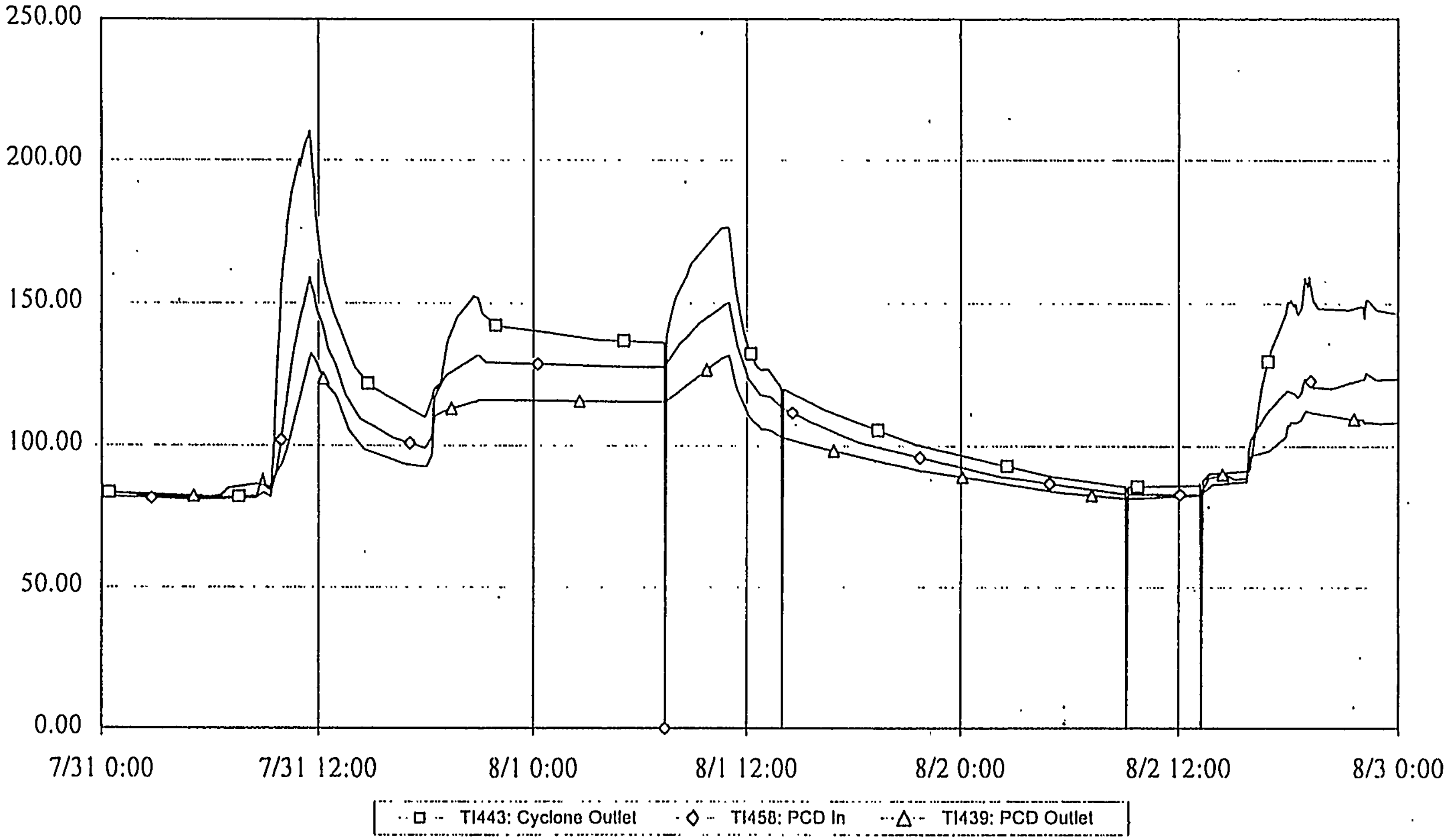


Figure 5.1.6-3 Reactor Mixing Zone and Riser Temperatures for July 31 Through August 2, 1996



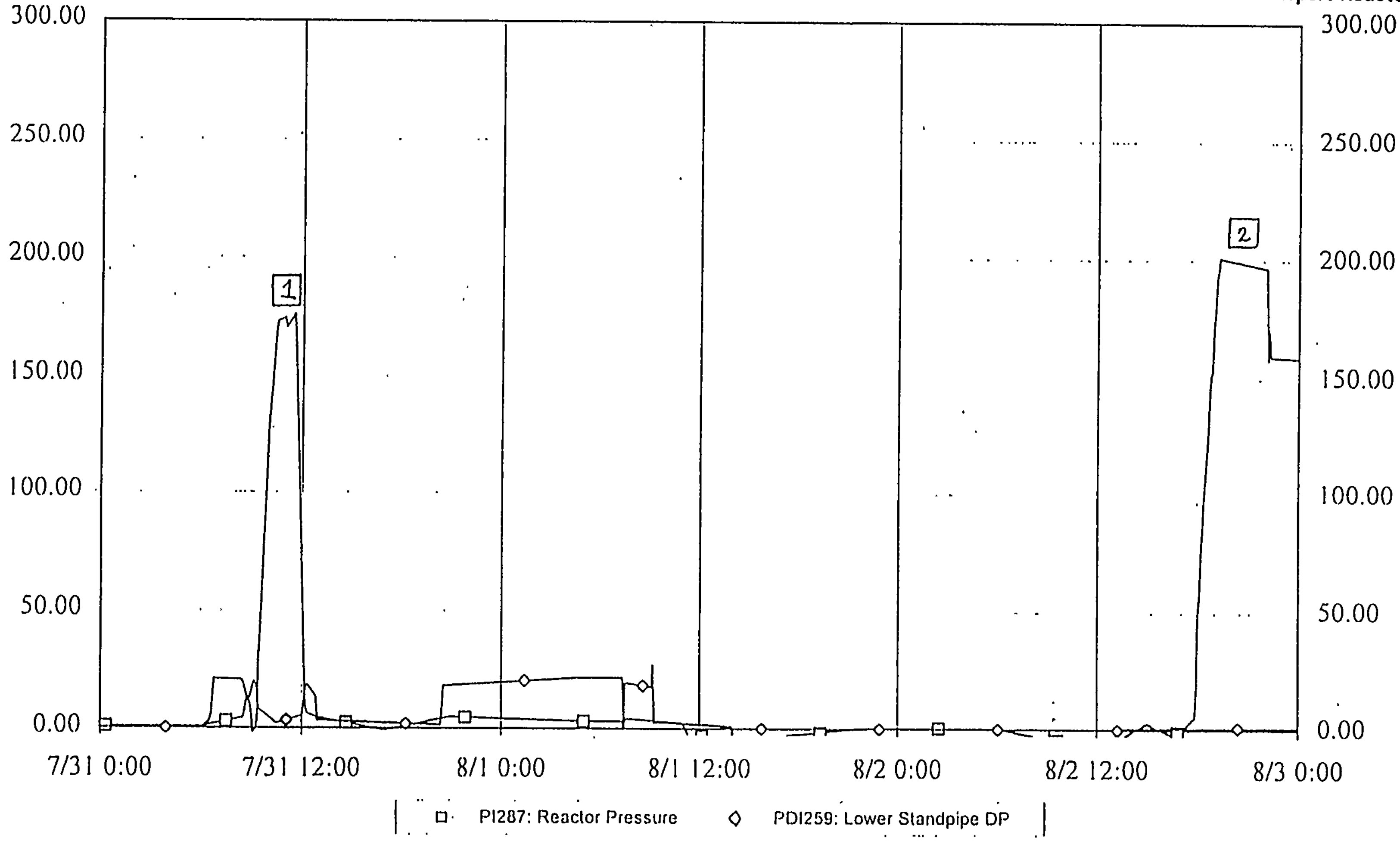
Non Proprietary Plot4 of 9 - 5 minute data

Figure 5.1.6-4 Standpipe/Dipleg Temperatures for July 31 Through August 2, 1996



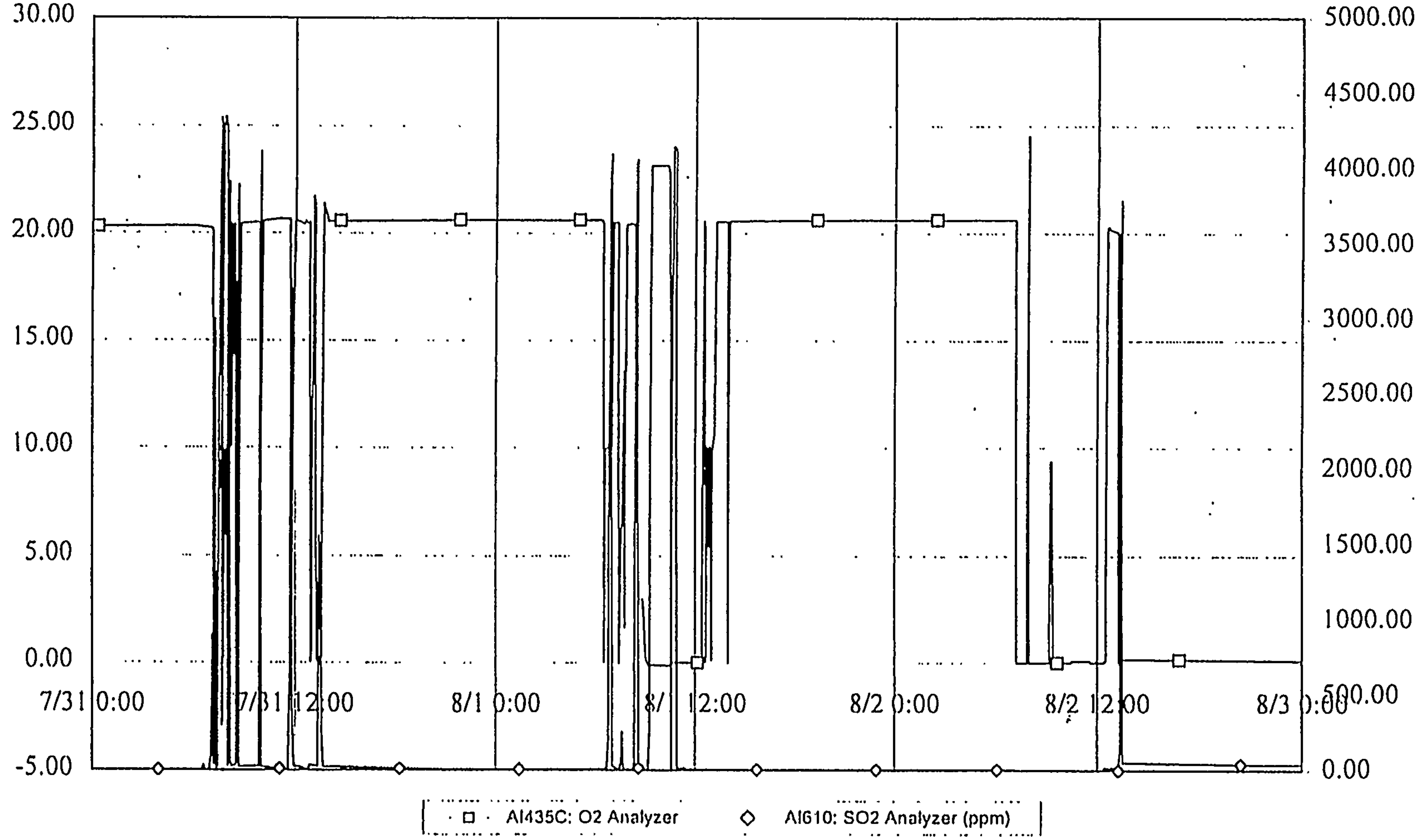
Non Proprietary Plot5 of 9 - 5 minute data

Figure 5.1.6-5 PCD Temperatures for July 31 Through August 2, 1996



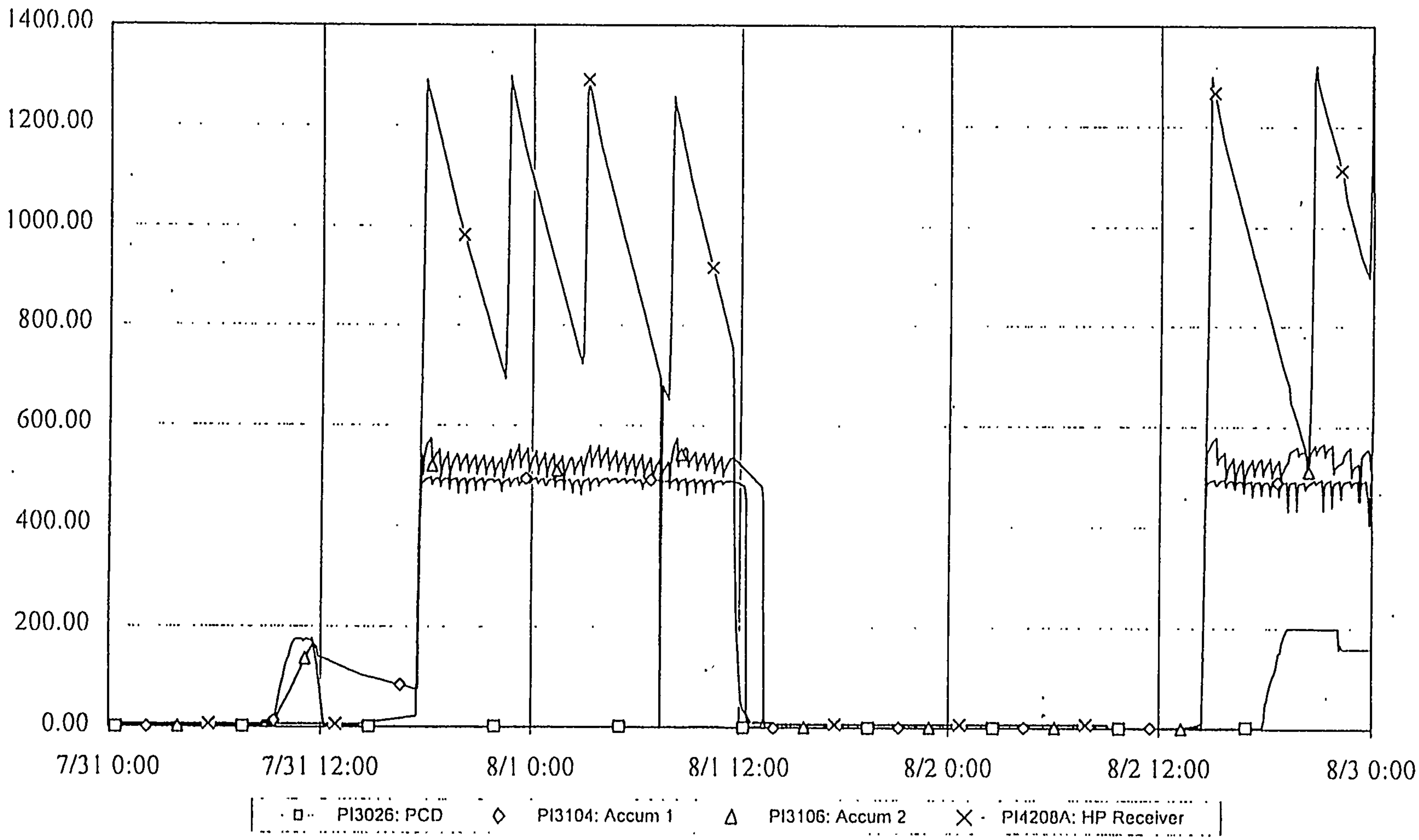
Non Proprietary Plot6 of 9 - 5 minute data

Figure 5.1.6-6 Reactor Pres/Standpipe DP for July 31 Through August 2, 1996



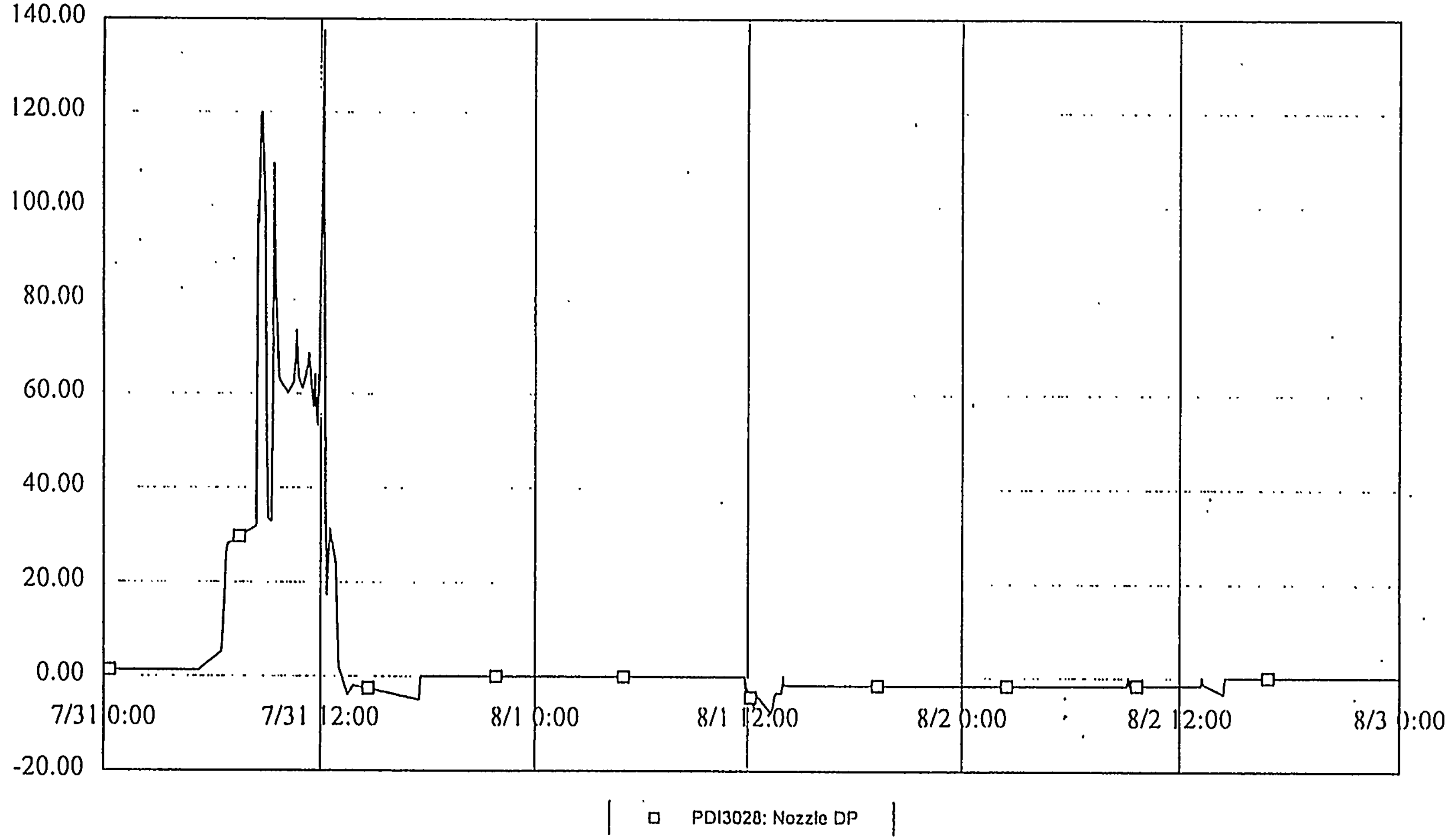
Non Proprietary Plot7 of 9 - 5 minute data

Figure 5.1.6-7 Outlet Gas Compositions for July 31 Through August 2, 1996



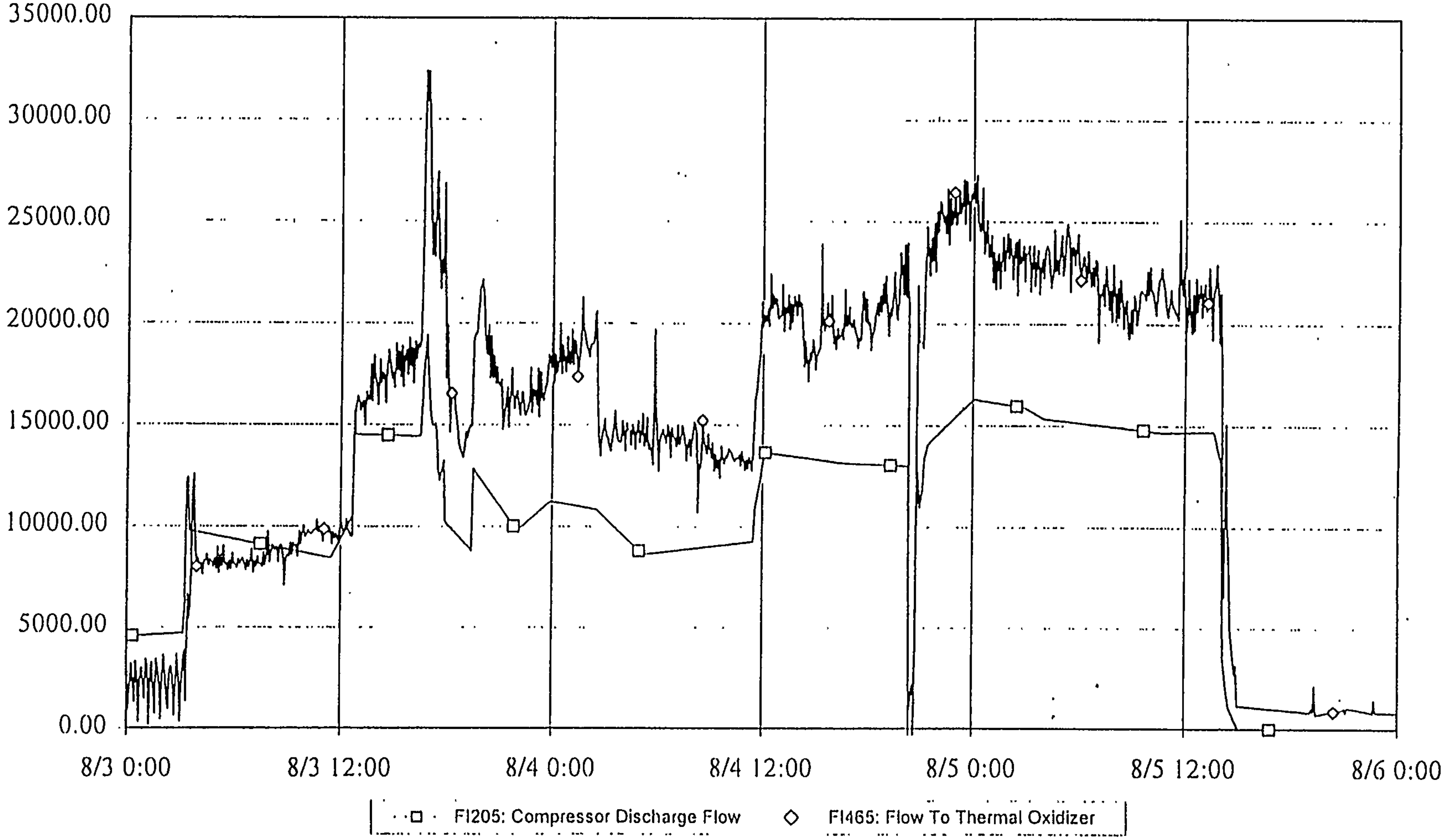
Non Proprietary Plot8 of 9 - 5 minute data

Figure 5.1.6-8 PCD Pulse System Pressures for July31 Through August 2, 1996



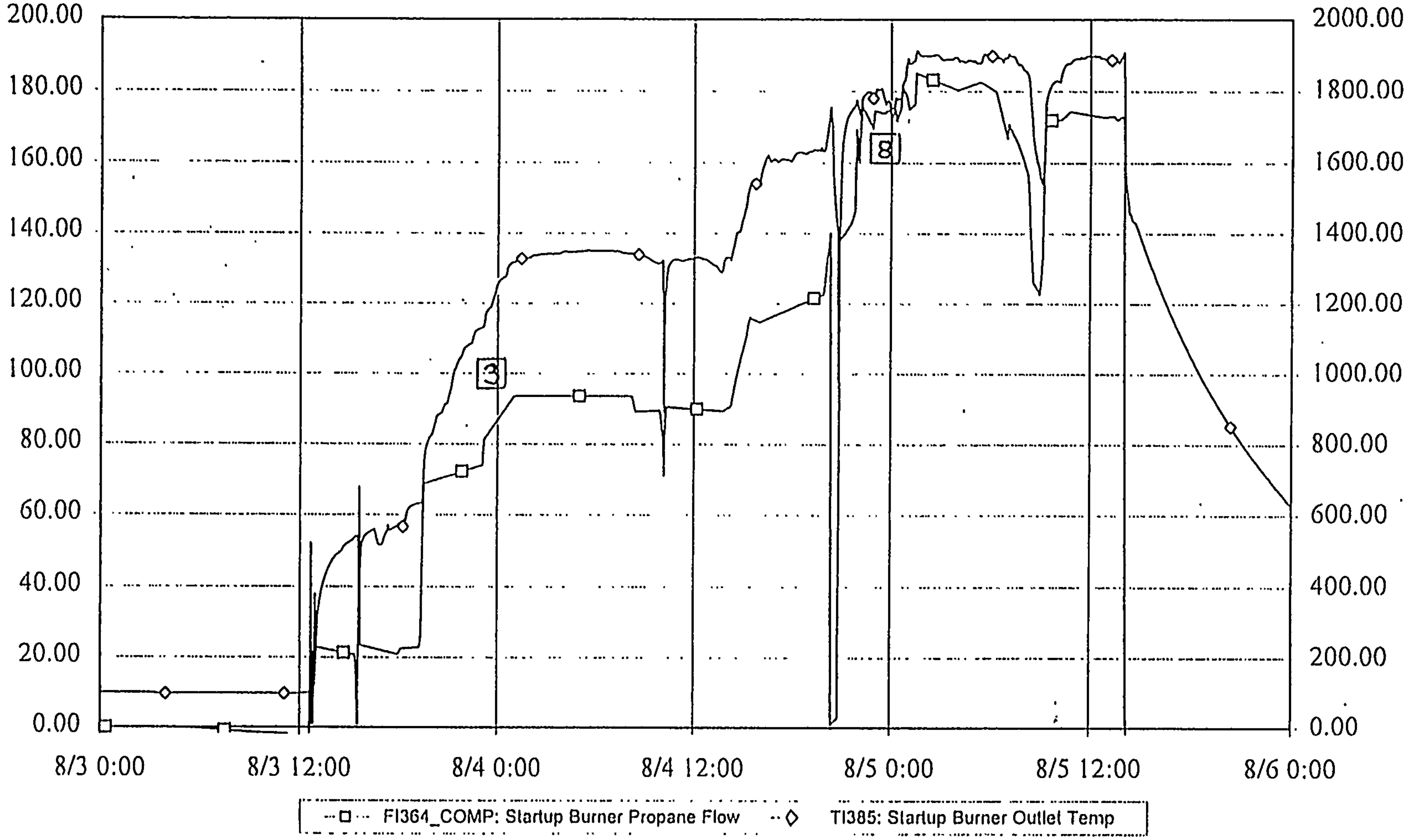
Non Proprietary Plot9 of 9 - 5 minute data

Figure 5.1.6-9 PCD Differential Pressures for July 31 Through August 2, 1996



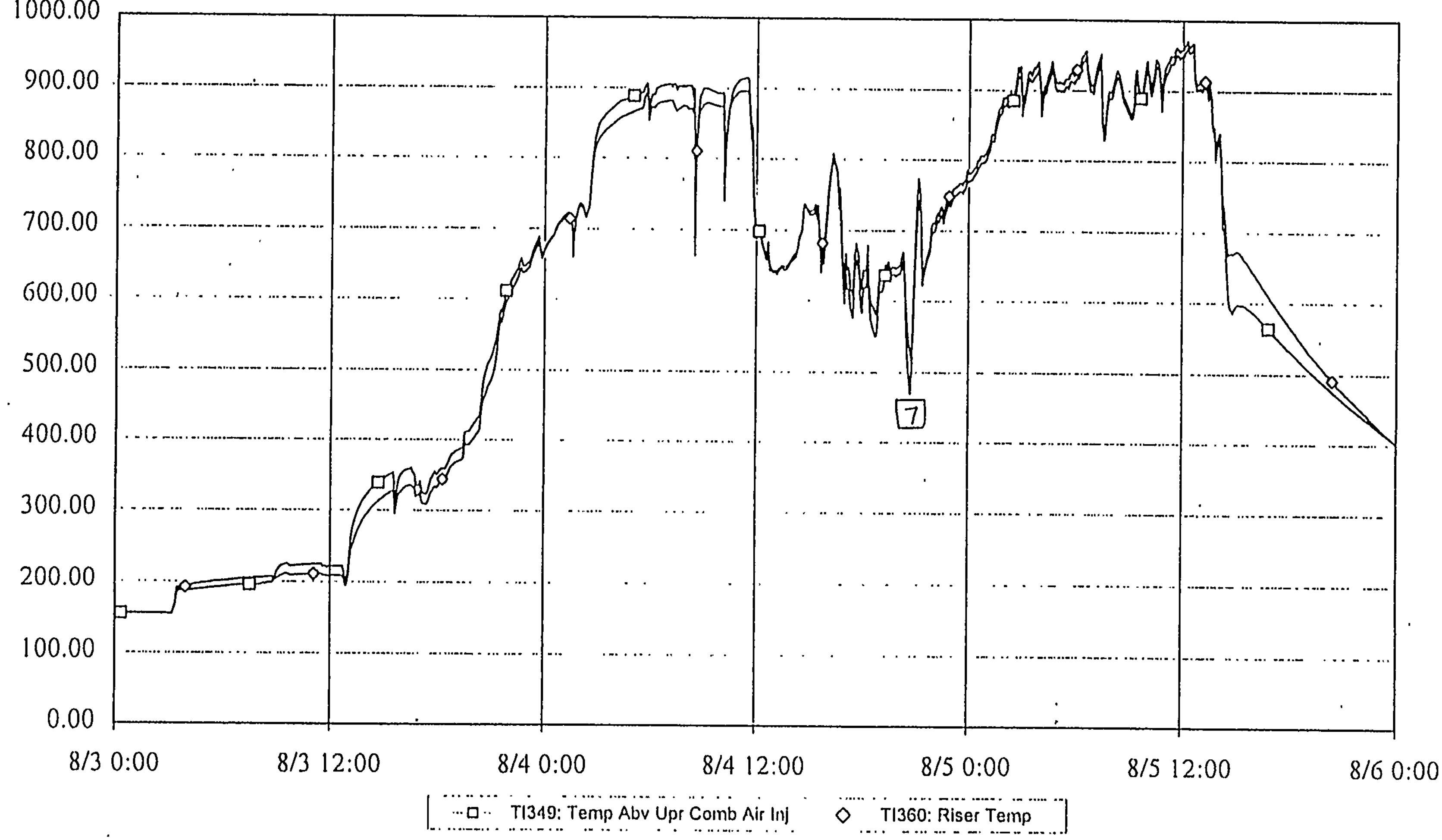
Non Proprietary Plot1 of 9 - 5 minute data

Figure 5.1.6-10 Reactor Flows for August 3 Through August 5, 1996



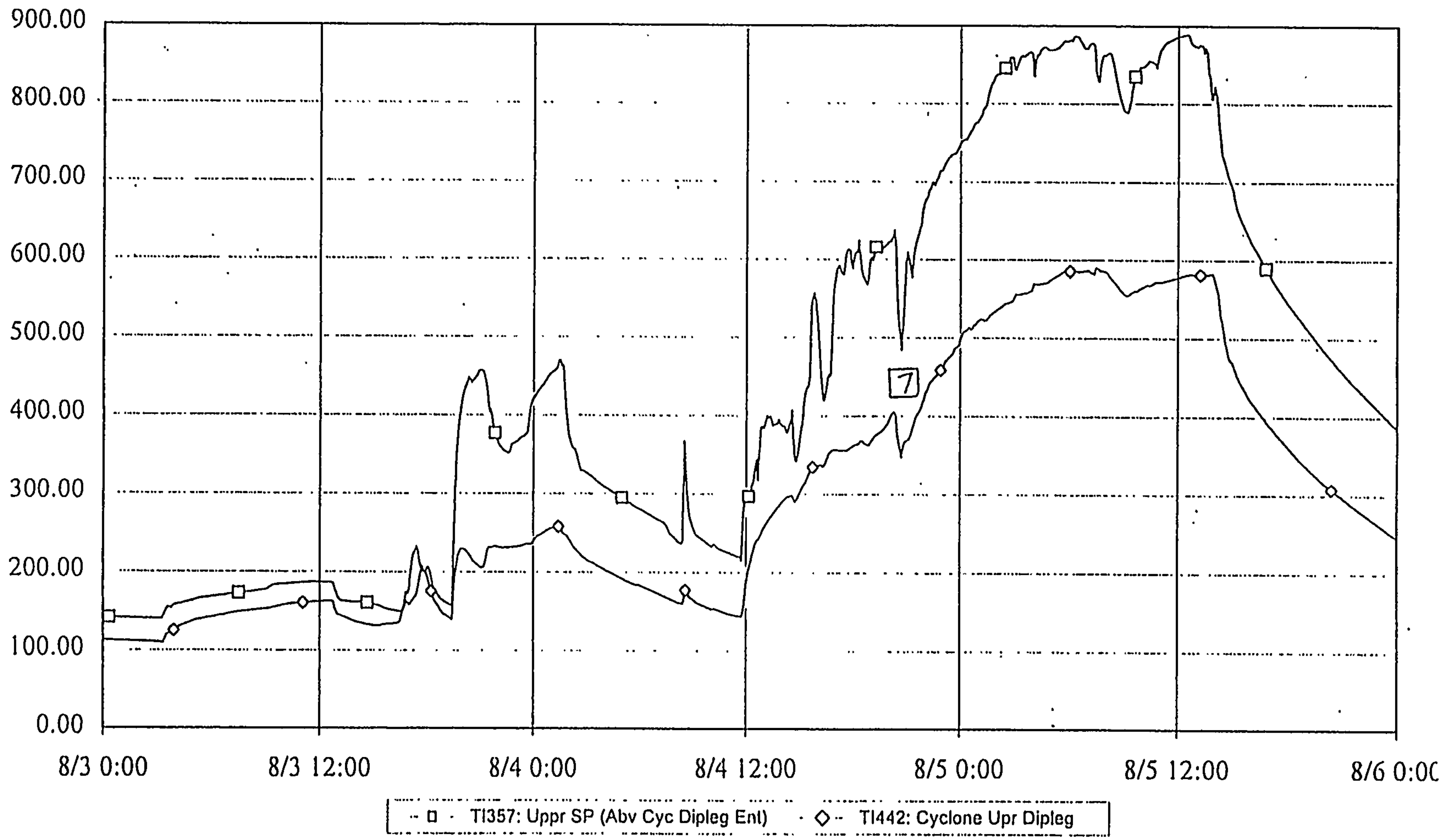
Non Proprietary Plot2 of 9 - 5 minute data

Figure 5.1.6-11 Start-Up Burner Flow/Temperatures for August 3 Through August 5, 1996



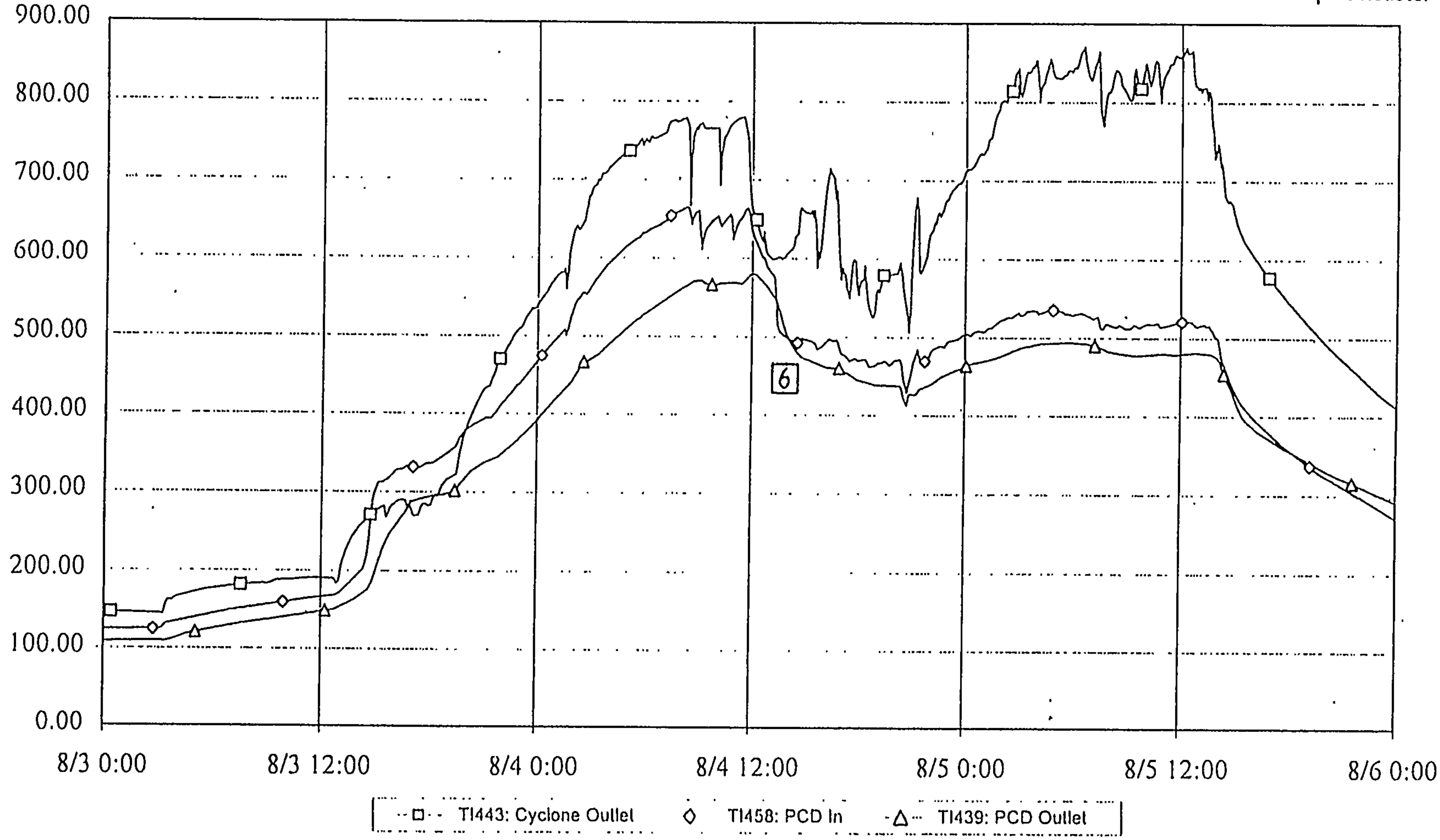
Non Proprietary Plot3 of 9 - 5 minute data

Figure 5.1.6-12 Reactor Mixing Zone and Riser Temperatures for August 3 Through August 5, 1996



Non Proprietary Plot4 of 9 - 5 minute data

Figure 5.1.6-13 Standpipe/Dipleg Temperatures for August 3 Through August 5, 1996



Non Proprietary Plot5 of 9 - 5 minute data

Figure 5.1.6-14 PCD Temperatures for August 3 Through August 5, 1996

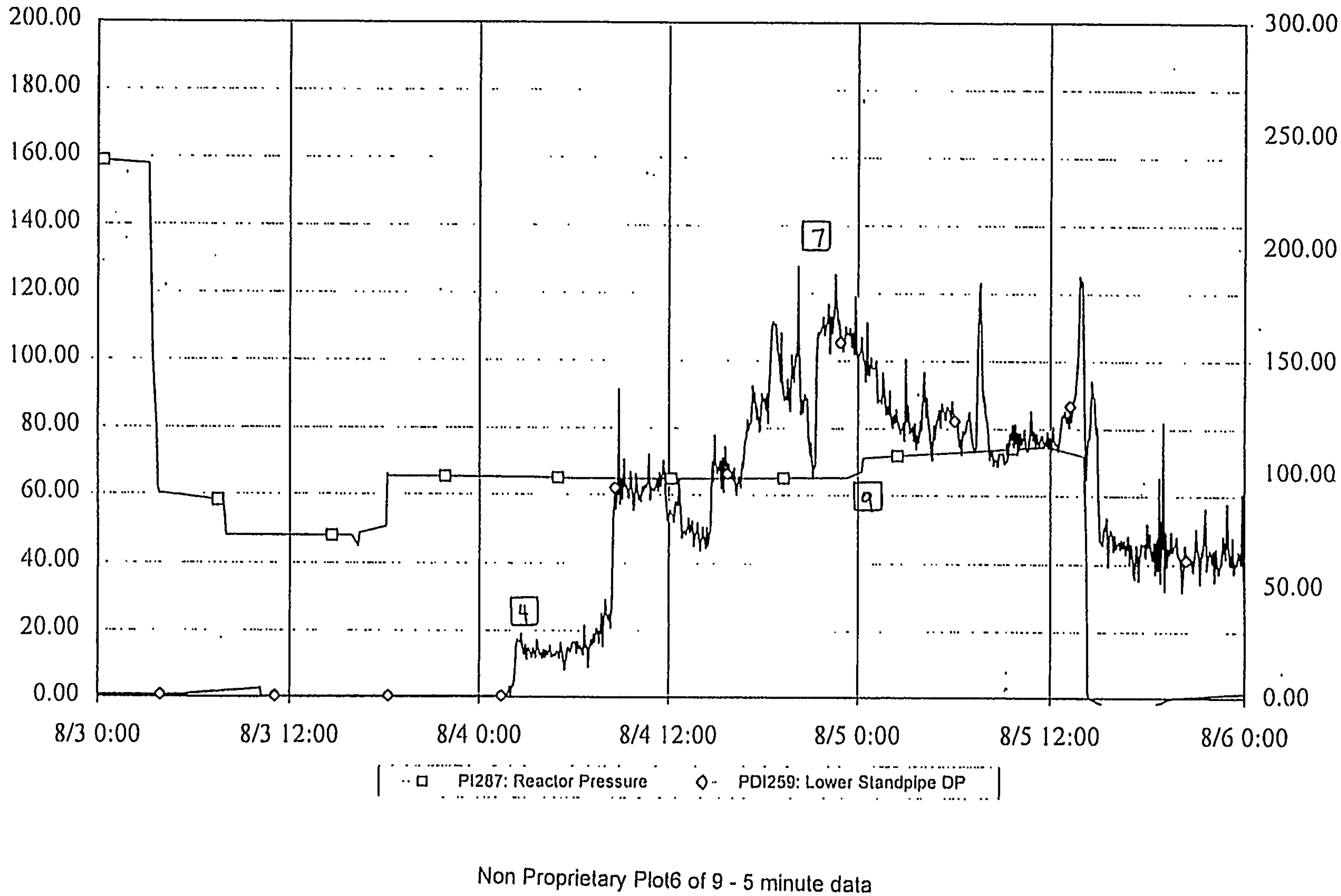
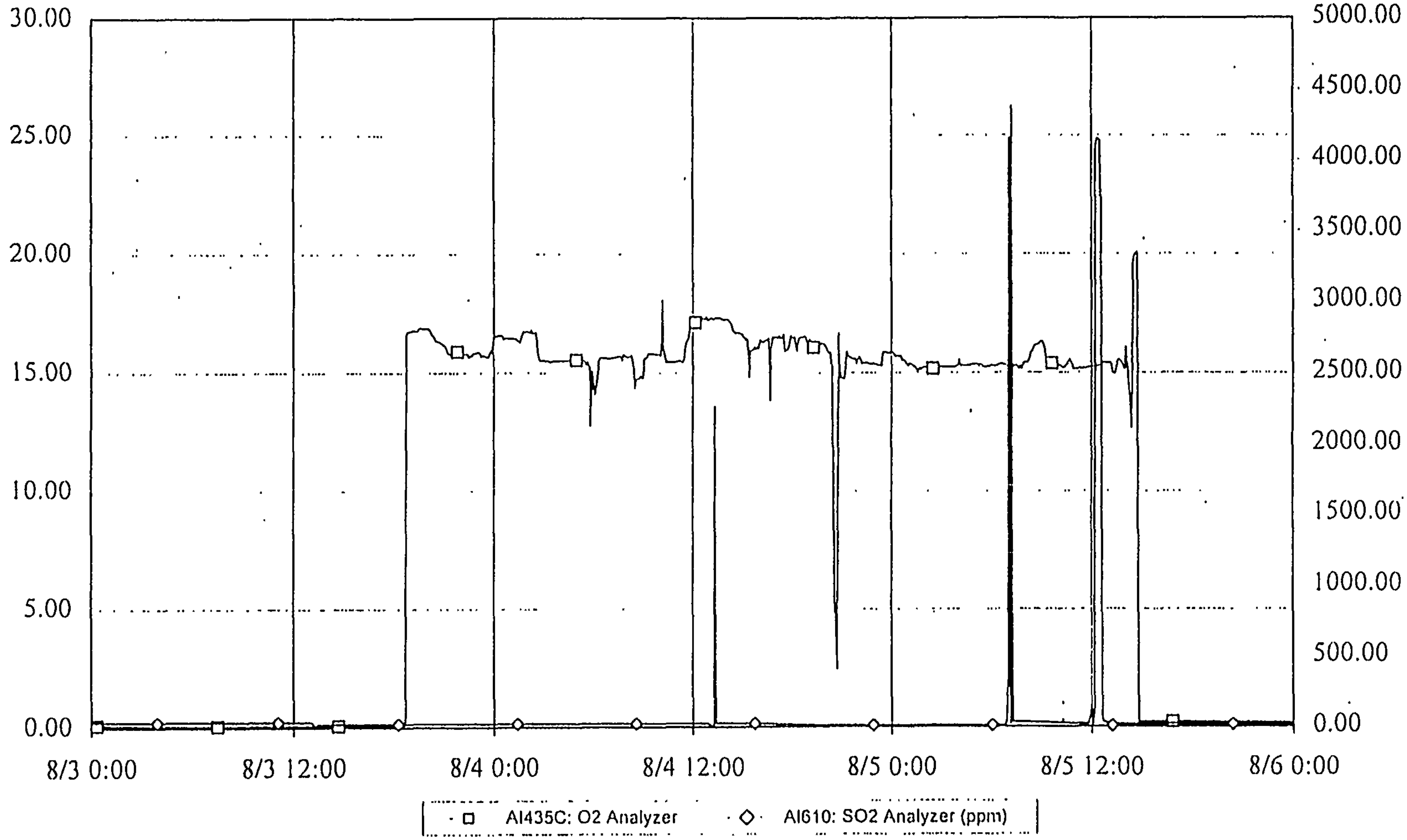


Figure 5.1.6-15 Reactor Pres/Standpipe DP for August 3 Through August 5, 1996



Non Proprietary Plot7 of 9 - 5 minute data

Figure 5.1.6-16 Outlet Gas Compositions for August 3 Through August 5, 1996

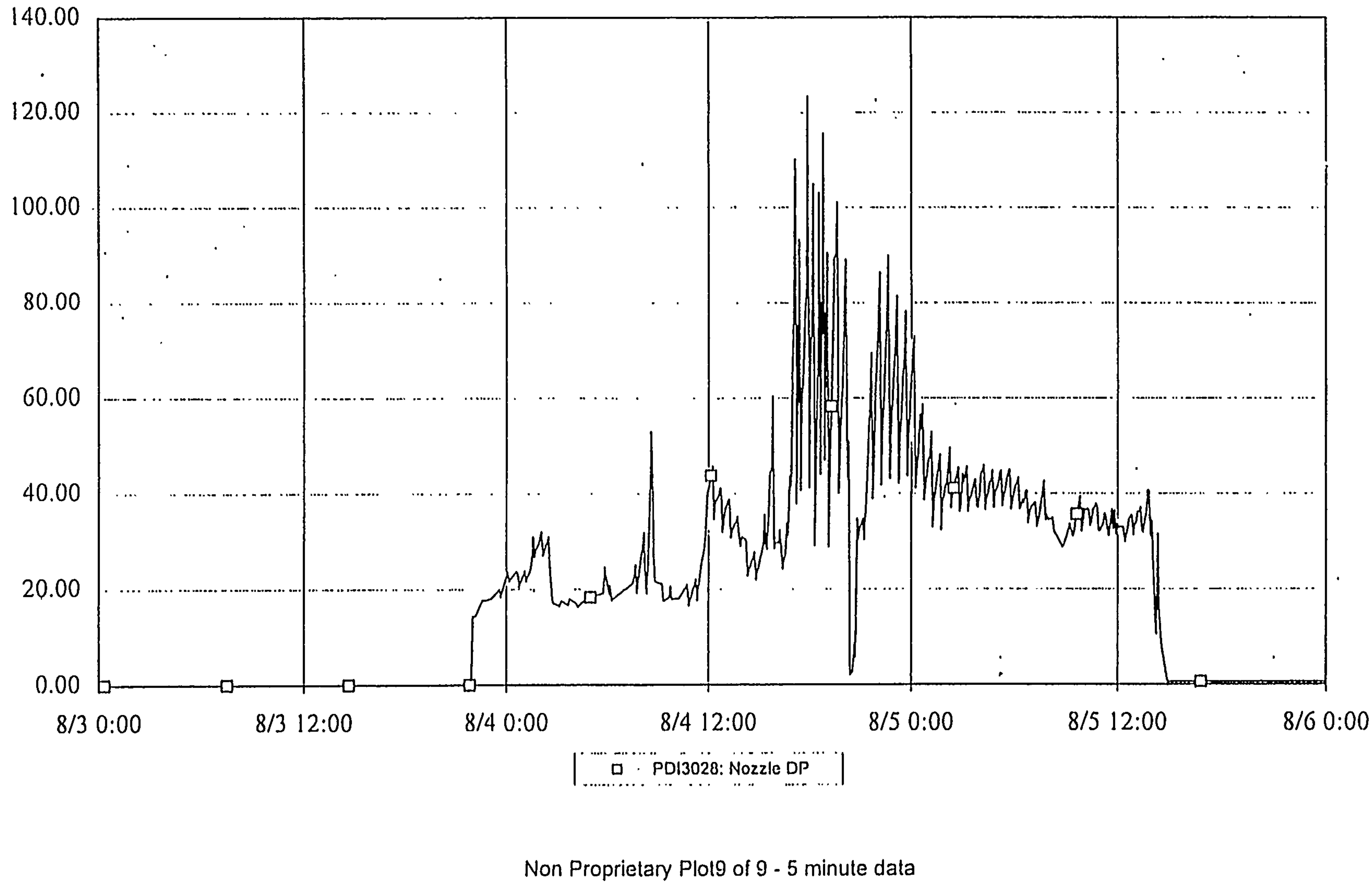
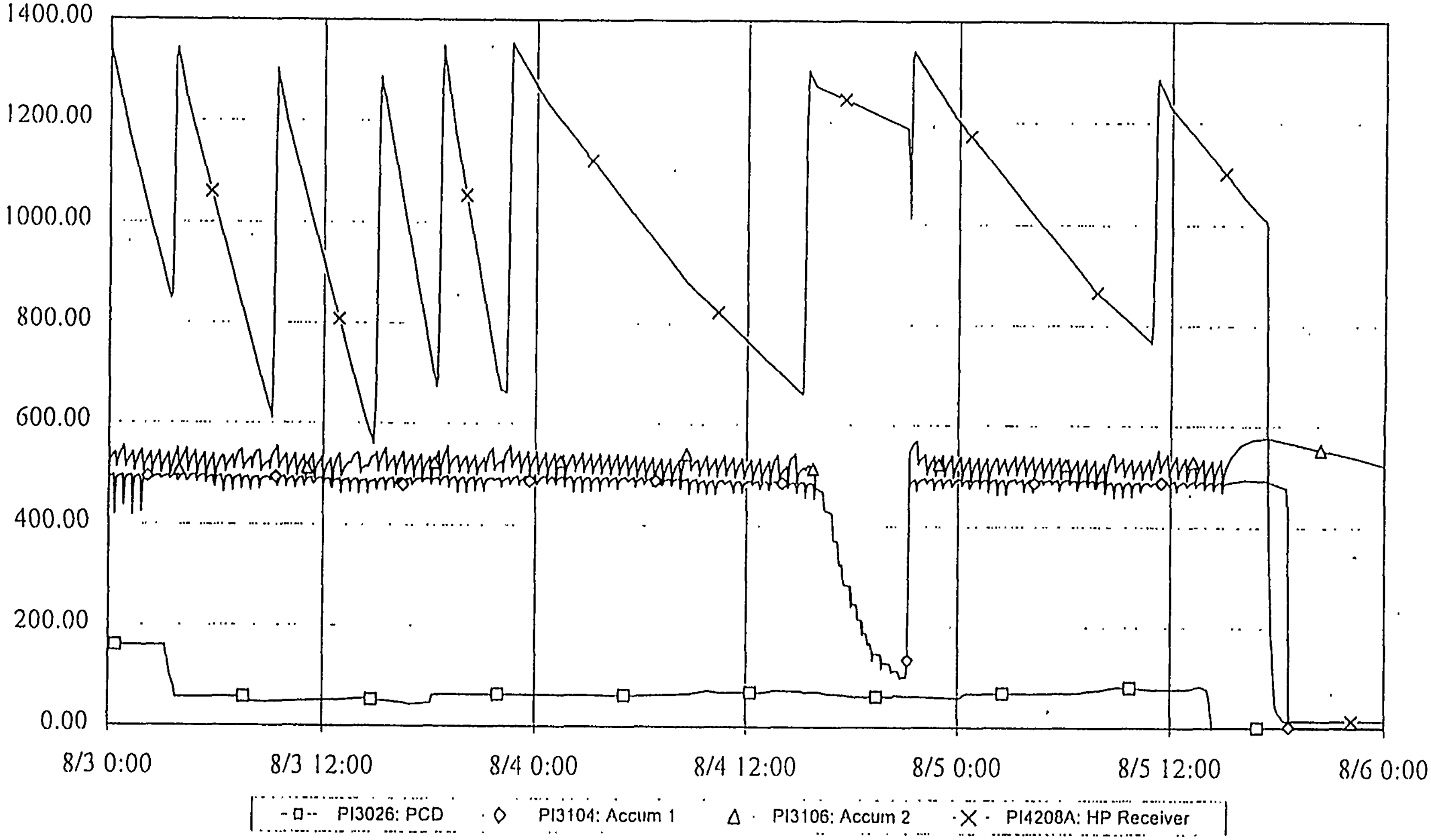
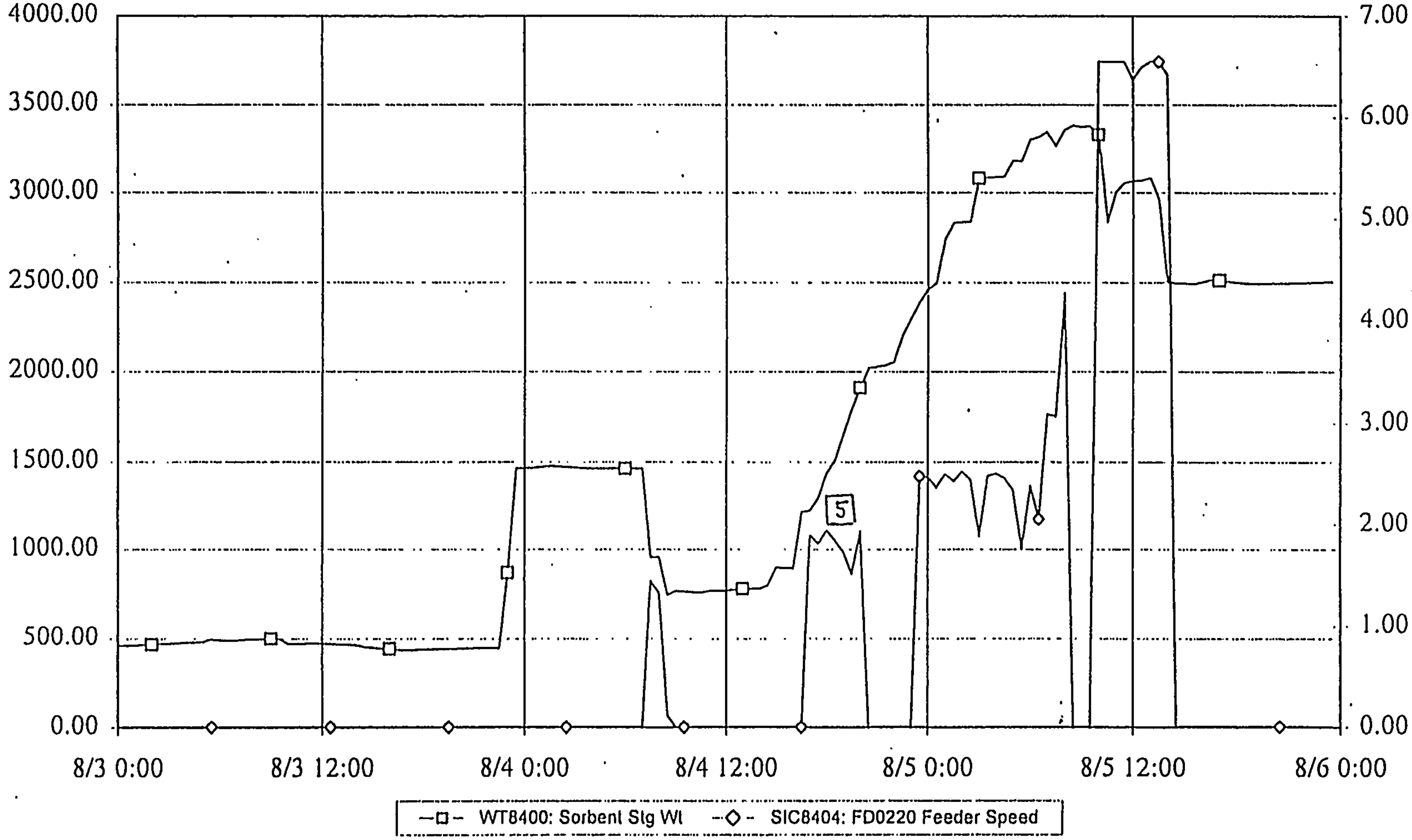


Figure 5.1.6-17 PCD Differential Pressures for August 3 Through August 5, 1996



Non Proprietary Plot8 of 9 - 5 minute data

Figure 5.1.6-18 PCD Pulse System Pressures for August 3 Through August 5, 1996



MWK Transport Reactor Plot 9 of 75 - 30 minute data

Figure 5.1.6-19 Sorbent Feed for August 3 Through August 5, 1996

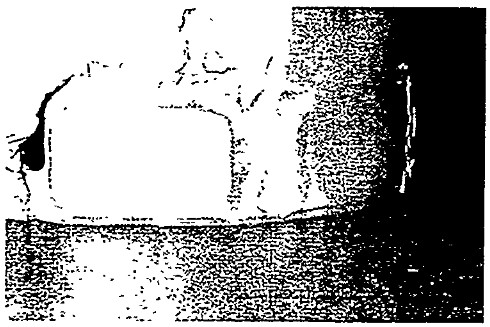


Figure 5.1.6-20 PV287 Erosion

Figure 5.1.6-21 PV287 Erosion

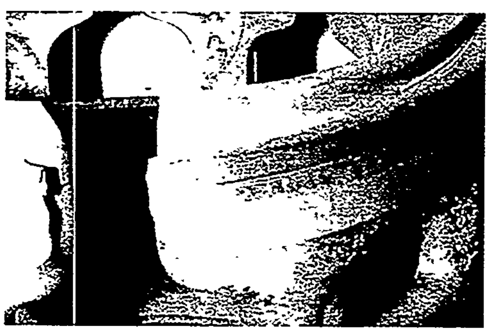


Figure 5.1.6-22 PV287 Erosion

Figure 5.1.6-23 PV287 Erosion

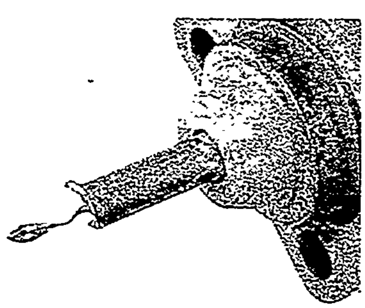


Figure 5.1.6-24 FD0220 Vent Valve

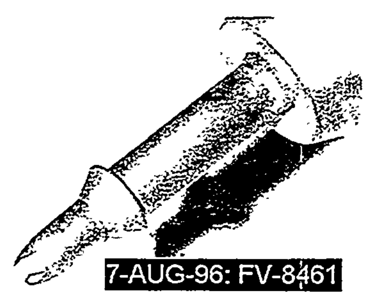


Figure 5.1.6-25 FD0210 Vent Valve

5.1.7 Characterization Test Run CCT1C

5.1.7.1 Introduction and Test Objective

The objective of the CCT1C test run was to perform coal combustion shakedown tests on the transport reactor loop. Shakedown tests were performed August 14 through 21, 1996. Figures 5.1.7-1 through 5.1.7-81 show the operating graphs for this time period.

Pretest Activities

Start-up Burner

A new redesigned pilot assembly for BR0201 with a retractable ignitor was successfully hydrotested at 380 psig at John Zink. The coking problem experienced during the last test was also discussed with John Zink. John Zink agreed to supply a new redesigned main burner gun tip with smaller port sizes and port circle. The new burner gun increased the maximum firing rate from 3.6 to 5 MBtu/hr. The new main burner gun tip was installed and used during this run.

Operationally, it was decided to increase the burner firing and burner exit temperature to 2,000°F to raise the heat input into the system so that the mixing zone temperature could exceed 1,000°F to initiate coke breeze assist preheat. In the previous test, the maximum mixing zone temperatures attained were between 850 and 950°F, which were inadequate to initiate coke breeze combustion. The operating procedure for the burner was also revised to operate the burner up to 90 psig instead of 50 psig during preheat.

Clyde Feeder Systems

The PDVs of the Clyde coal and sorbent feeders were taken apart and inspected. The plug and seat of the limestone dispense vessel PDV were completely eroded away; the PDV for the coal dispense vessel was eroded to a lesser extent. The Clyde feed system problems were discussed at length and solutions were identified to prevent the reoccurrence and extend the life of the control valve. As an interim solution, the vent lines were capped off and a pressure control valve was installed on the lower fluidization line to regulate nitrogen flow rate into each of the dispense vessels. In this way particulate-laden gas is not vented upstream of the pressure letdown valve. Discussions were also held between MWK and SCS on methods to extend the life of the pressure letdown valve (PV287). As an interim solution, a whisper trim with modified cage was installed and, as standard practice with this type of conversion, and the valve body was rotated so gas would flow in from the outlet port and out through the inlet port.

Miscellaneous

Minor erosion marks were observed when the top of the riser and the riser crossover were borescoped. The FD0206 screw feeder shaft was repacked and tubing changes were made to bring its seal and bellows purge in compliance with design. The 100-ton/day nitrogen plant was put into service, satisfying all plant nitrogen needs.

5.1.7.2 Test Chronology

Alumina was used as start-up bed material for this test. The inventory of alumina in stock was not adequate to fill the reactor standpipe and HX0203 to the desired level. The HX0203 and reactor standpipe had bed material left in them from the previous test which had not been drained. The bed material was a mixture of alumina and coke breeze.

Preparation for the run started on August 13, 1996, by starting up the thermal oxidizer and the steam system. By 0800 on August 13, 1996, the steam drum pressure was at 400 psig. On August 14, 1996, the reactor loop was successfully leak tested at 200 psig, and HX0202 and HX0402 were placed in the prewarming mode by closing their downcomers, opening their risers, and cracking open their blowdown valves. This allowed steam to condense inside the heat exchanger, preheating the air stream flowing through the tubes. The reactor pressure was approximately 50 psig.

The first attempt to light the start-up burner early on the morning of August 15, 1996, after the PCD exit temperature reached 240°F was aborted because of leaks in the propane supply line. The blow down valves on HX0202 and HX0402 were throttled down to conserve steam while the operation was put on hold to fix the propane leak. The leak in the propane system was fixed at about 08:30 and the burner pilot was lit an hour later. The burner flue gas exit temperature was maintained at 548°F (TI385). The burner combustion air flow was increased to 4,800 lb/hr and the main burner gun was lit at 10:30 after the reactor pressure was increased from 50 to 60 psig. The propane flow rate was 51 lb/hr (FIC364).

Solids circulation was started through HX0203 at 10:50 and was reduced 2 hours later to reduce the solids carryover to the PCD while troubleshooting was being conducted on FD0530. To achieve this, the reactor J-leg fluidization (FIC681) and HX0203 J-leg fluidization (FIC680) flows were reduced. At approximately 12:30, alumina feeding into the reactor was initiated. After approximately 600 lb of alumina was fed into the reactor the coal feeder (FD0210) tripped because the nitrogen fluffing gas was inadvertently not turned on. At 13:20, FD0530 was fixed and the propane firing rate was increased to continue with reactor and PCD preheat. The reactor pressure was also increased from 60 to 65 psig.

Solids circulation through the reactor was reduced further while FD0210 was being worked on. At approximately 15:00, FD0210 was placed back in service and the balance of the alumina inventoried (1,400 lb) in it was transferred into the reactor. The FD0220 was still plugged; however, solids captured by the PCD was recycled back into its surge bin. At approximately 16:00 feeding from FD0220 into the reactor was initiated but the feeder became plugged again and the conveying line pressure shot up from 70 to 300 psig. The sudden increase in pressure occurred because the vent valves were capped off. A plug in the conveying line or the rotary feeder caused the vessel pressure to increase to near the nitrogen supply pressure because the nitrogen entering the dispense vessel could not be vented. To reduce the dispense vessel pressure the vessel was manually vented through a bypass valve. The FD0220 was serviced and put back in operation at around 17:00, and approximately 1,200 lb of material stored in the surge bin were transferred into the reactor between 17:00 and 20:00. At 16:25 the temperature at the exit of HX0202 reached 480°F and the primary heat exchanger was placed in steam production mode by closing the blow down and opening the downcomer.

The burner tripped at 17:00 but was quickly relit. The propane flow was reset to 133 lb/hr; the burner exit temperature was 1,350°F. The mixing zone temperatures ranged from 560 to 630°F, standpipe temperatures were between 450 and 550°F. The spent solids screw cooler (FD0206) was run continually to prevent moisture condensation inside the screw.

At 19:40 the reactor pressure was increased to 80 psig while maintaining the burner pilot propane supply differential pressure of 21 psig. At this time the propane flow rate was 169 lb/hr and the burner exit temperature as measured by TI385 was 1,650°F. The mixing zone temperatures increased to between 685 and 785°F and the standpipe temperatures were between 562 and 676°F.

It was observed during the run that anytime solids circulation was increased through HX0203, the riser solids circulation rate increased and at the same time the solid carryover to the PCD also increased. To reduce excessive loss of bed material from the reactor loop, periodic solids circulation through the HX0203 was started. This was also done to maintain the differential loop skin temperature difference between HX0203 and the rest of the reactor within the desired limits and to convey material into the standpipe when the standpipe level dropped to an unacceptable level. The HX0203 contained approximately 10 times as much solids as the reactor standpipe.

While continuing to increase the burner firing to raise the heat input into the system at 22:40, approximately 270 lb of coke breeze were inventoried into FD0210 for batch feeding when the mixing zone temperatures were high enough to sustain its ignition. The burner exit temperature was 2,000°F at 22:55. At this time, the reactor pressure was 100 psig and the propane flow was 229 lb/hr (firing rate of ~4.6 MBtu/hr). The burner combustion air flow was high with 100-percent excess air to ensure sufficient flow to the pilot through the index holes in the pilot guide tube. At 23:55 the temperature at the exit of HX0402 reached 400°F and it was cut-in to generate steam. The temperature profiles around the reactor loop are presented in figures 5.1.7-9, -10 and -11. The reactor differential pressures are plotted in figure 5.1.7-15 and the standpipe in figure 5.1.7-16. The primary cyclone dipleg pressure drop shown in figure 5.1.7-17 indicated that the cyclone was collecting solids which continually drained into the standpipe.

On August 16, 1996, reactor preheat continued. Solids in HX0203 were continually circulated. The Clyde feeders FD0220 and FD0210 tripped a few times. The FD0210 was opened up and the conveying line was plugged by epoxy coatings which apparently fell off the surge bin wall. Several propane flow problems were experienced. At 03:45 the propane firing rate was increased from 240 to 250 lb/hr. Ten minutes later, the propane flow began to steadily drop while the burner exit temperature held steady at 2,000°F. The propane vaporizer was found to be operating at the expected temperature and pressure of 121°F and 190 psig respectively. The flow transmitter was suspected to be faulty.

At 06:00 a reactor loop skin temperature survey was started and detected no abnormalities in the differential loop skin temperatures. The survey results for the entire test period are summarized in table 5.1.7-1. The propane flow as measured by FIC364 continued to show a steady drop. The flow transmitter was taken off line and found faulty. The run continued with the propane flow being estimated from the valve position (percent open). The FD0210 conveying air flange was found to be leaking at the bottom of the feeder at 08:30 and was repaired. While this was being done the FD0220 line became plugged. At 10:40 the pressure sensing hose to FD0220 cabinet blew out and had to be replaced. The FD0210 work was completed at 13:50 and (during testing) some of the coke breeze inventoried in the surge bin was inadvertently fed into the reactor.

Between 14:00 and 16:30, coke breeze was intermittently fed into the reactor. The reactor temperatures increased in response to coke breeze injection (event 1, figure 5.1.7-9). The primary cyclone dipleg temperatures also increased indicating that the cyclone was collecting hot particles (event 1, figure 5.1.7-11).

At approximately 15:00 the propane flow to the burner dropped and after 5 minutes the flow recovered. Upon investigation, it was found that the drop in the propane supply pressure was caused by the propane delivery truck driver who failed to equalize the pressure between the propane tank and the truck prior to transfer of propane. Feeding of recycled material from the PCD into the reactor was resumed at approximately 15:30, after FD0220 was repaired.

Batch feeding of coke breeze into the reactor was started again at 17:15 and stopped 3 minutes later. At 17:30 the propane flow to the burner was lost and the burner tripped. The pilot was relit but tripped 4 minutes later, and after that all attempts to light the burner failed. The reactor pressure was reduced from 100 to 60 psig but the burner failed to light. At 20:38 the reactor loop was shutdown and the burner flame rod was removed and found to be faulty. A new flame rod was installed and after several unsuccessful attempts to light the burner the reactor was shutdown and the pilot assembly was pulled out at 00:00 on August 17, 1996.

The pilot tip was replaced with a new one and the pilot assembly was installed. The main air compressor was started and the burner pilot flange was successfully leak tested to 200 psig. The leak test was completed at 14:25 on August 17, 1996. After the leak test, the reactor pressure was reduced from 200 to 50 psig in preparation for burner pilot light off. After a few unsuccessful trials, the pilot was lit at 15:22. The reactor pressure was increased to 60 psig and the main burner gun was successfully lit.

Preheat of the reactor continued as the burner firing was rapidly brought back to preshutdown conditions, since the refractory was already hot. Also, the reactor pressure was rapidly increased from 60 to 100 psig. The burner exit temperature reached 1,966°F at 23:10. To prevent burner pilot tip burn through the pilot differential pressure was increased to 60 psig at reactor pressure of 100 psig. Injection of material collected by the PCD into the reactor through FD0220 was resumed at approximately 17:00.

The riser differential pressure profile after restart is shown on figure 5.1.7-42 (event 2). Throughout the run, the disengager differential pressure was always higher than the cyclone differential pressure drop. The temperature profiles around the reactor loop are presented in figure 5.1.7-36 for the riser, figure 5.1.7-39 for the cyclone exit, and figure 5.1.7-37 for the reactor standpipe. Solids were continually circulated through HX0203 as required to maintain a reasonable differential temperature between it and the rest of the loop. The FD0206 was also run periodically for 2 minutes throughout the preheat period. Around midnight the mixing zone temperatures were above 1,000°F and preparation was made to start coke breeze injection. This injection will accelerate the reactor preheat to 1,400°F, which is necessary for injection of coal.

Batch coke breeze injection into the reactor was started approximately 5 minutes past midnight on August 18, 1996. Coke breeze was fed for approximately 5 to 10 minutes at a time. Every time coke breeze was injected (except for a few trials at the beginning) the reactor temperature increased (event 3, figures 5.1.7-36, -37, and –38). This mode of operation was continued until approximately 05:00 when the FD0210 was stopped. The reactor temperatures began to rapidly increase above 1,200°F in the mixing zone because the circulating material contained a high amount of carbonaceous material. As the reactor temperature began to rise, the devolatilized coke breeze particles began to ignite resulting in an additional heat kick. Coke breeze combustion also started in the standpipe (event 4, figure 5.1.7-37) which was fluidized with air. To reduce the impact of the residual carbon, the burner firing rate was reduced by 50 percent and continuous coke breeze injection at a low feed rate was resumed at 05:36. At 05:00 FD0220 tripped because the conveying line plugged. The plug was removed and the feeder was put back in service at 05:25. Solids circulation through the reactor J-leg was manipulated to even out the temperature in the standpipe and solids circulation through HX0203 was also adjusted to control reactor temperature.

The reactor temperature began to steadily increase as continuous coke breeze feeding was maintained. The burner firing rate was reduced gradually to reduce the total heat input and control reactor temperature. At the same time, preparation was made to begin feeding coal into the reactor. At 08:30 coal was inventoried on top of the coke breeze in the FD0210 surge bin. The coal and dolomite particle size distributions used during this run are shown in figure 5.1.7-82. Prior to this, the oxygen concentration in the flue gas was 12.08 percent. Coal feeding into the reactor started at around 09:00, constituting the first coal feed at the PSDF. Once combustion was established the start-up burner was weaned off. The combustion air flow to the burner was reduced while the quench air flow was slightly increased to cool the refractory and provide fluidization at the bottom of the mixing zone. The quench air flow was later shutdown but some air flow was left through the combustion air nozzle. When the burner was shutdown and the flows were reduced, bed material migrated into the burner duct and the differential pressure between the burner and the mixing zone increased.

Due to high carbon concentration in the circulating material (estimated to be greater than 30-wt percent), the reactor temperature in the riser and standpipe periodically overshot the desired set point of 1,600°F by 200°F. The coal feed rate was reduced and solids circulation through the heat exchanger was increased as a response to lower reactor temperature to within the desired set point. Because HX0203 solids contain the same concentration of carbonaceous material as the reactor standpipe, the cooling effect of the heat exchanger was offset somewhat by additional combustion of carbon from the heat exchanger solids in the riser. The operation was carefully controlled and included increased nitrogen injection into the reactor standpipe to reduce the oxygen concentration until the carbon level in the system was low. It took approximately 6 hours to burn off the carbon present in the circulating material (event 5, figure 5.1.7-36 and -37). At 09:00 when the HX0203 circulation was significantly increased the bed level in the heat exchanger began to drop until it stabilized at a lower level. Some of these solids were transferred into the standpipe (event 6, figure 5.1.7-43), some were lost to the PCD, and the rest being carbonaceous were consumed in the riser.

Cold shot injection into HX0203 was stopped about 11:30 and the heat exchanger was put in steam production mode for the first time. The flue gas composition was as follows: oxygen, 8.28 percent; moisture, 4.87 percent; SO_2, 242 ppm; and CO_2, 11.4 percent.

Recycling of PCD solids was stopped and dolomite was briefly fed through FD0220 into the reactor as make up solids to build back solids level in the reactor loop since the alumina inventory was depleted. Dolomite was also injected to observe its effect on SO_2 emission. The SO_2 concentration (which was 251 ppm) decreased to 46 ppm in approximately 1 hour. Dolomite was added to the reactor again at 23:20 to build up bed level because the recycled solids were too fine to be captured by the solids separation system. When dolomite feeding was resumed, the SO_2 concentration decreased from 170 to 50 ppm.

Steady reactor operation was maintained until 18:40 when the reactor pressure was increased from 100 to 110 psig and eventually increased to 140 psig at 21:20. The coal feeder tripped a few times. Coal and spent solids/sorbent feeding history for August 18, 1996, is shown in figures 5.1.7-31 and -32 respectively.

Reactor operation was held essentially steady throughout August 19, 1996. The reactor pressure was increased to 160 psig to reduce the riser superficial velocity to approximately 35 ft/s or less. The FD0210 feeder operated well with few feed interruptions. Dolomite feeding continued as a means to maintain bed level in the reactor (no fresh alumina was available). Between 12:00 and 14:00 after the inventoried dolomite transfer was completed, the feeder was connected to FD0140 to permit material transfer from FD0140 into FD0220. The FD0220 was lined up to receive recycled PCD catch, and injection of the PCD fines into the reactor was initiated. However, after feeding for a short period, the conveying line became plugged by pieces of epoxy coating. The FD0220 was put back in service at about 20:10. Feeding resumed but the line quickly plugged again. Material recycling from the PCD was stopped and the material inside FD0220 was drained and drummed. Dolomite was inventoried into FD0220 and fed into the reactor.

The firing rate of the thermal oxidizer was continuously reduced as more steam was generated from HX0203, HX0202, and HX0402 and the steam requirement for the plant dropped. The thermal oxidizer exit temperature was reduced to 500°F. The PCD inlet and outlet temperatures steadied out at 674 and 629°F respectively. The mixing zone temperatures and riser temperatures (figure 5.1.7-36) as well as cyclone exit temperatures (figure 5.1.7-39) all remained steady during reactor operation on August 19, 1996. The oxygen concentration in the flue gas was also reasonably steady at around 10 percent. The SO_2 concentration varied between 40 and 50 ppm. The transfer of PCD catch solids from FD0530 to either FD0220 or ash silo is shown in figure 5.1.7-51.

On August 20, 1996, the reactor operated at essentially steady state with minor adjustments made to the flows and coal feed rate to control reactor temperature and velocity. Dolomite feeding into the reactor for bed makeup was continued. Up until 15:30 on August 20, 1996, approximately 7 tons of coal and 8 tons of dolomite were processed in the reactor. The cyclone exit temperature was maintained between 1,400 and 1,500°F. The mixing zone temperature profiles are given in figure 5.1.7-63. The PCD inlet and outlet temperatures were near steady at 680 and 650°F respectively.

Approximately 3.4 tons of ash were drummed out of the ash silo. The ash had a light brown color and visually appeared to contain very little carbon. At about 12:40 the gas analyzers were reading: O_2-7.12 percent, CO-0 percent, SO_2-32 ppm and moisture-2.9 percent. The reactor pressure was increased from 160 to 170 psig in an attempt to reduce the solids carryover to the PCD. The particle size distribution of alumina (starting bed material) material lost to PCD and the standpipe drain at the end of the run are shown in figure 5.1.7-83 for test dates from August 16, 1996, to August 19, 1996. The size distributions of the solids lost to the PCD on August 20 and August 21, 1996, are plotted in figure 5.1.7-84.

At approximately 22:40, the reactor pressure increased very rapidly to 260 psig in just a few minutes (event 7, figure 5.1.7-69). This caused momentary stoppage of solids circulation through the reactor. The mixing zone and riser temperatures increased suddenly to approximately 1,900°F before coal feed was reduced (event 7, figure 5.1.7-63) and then stopped causing the reactor temperatures to drop. After that, the air flows to the reactor were reduced to minimum. Dolomite feeding and solids transporters were also stopped. The back pressure control valve (PV287) was placed in manual and the reactor pressure was reduced to 100 psig. During problem troubleshooting, the thermal oxidizer firing was increased in preparation for restart, if required. The problem was diagnosed to be caused by a broken positioner on PV287.

At approximately 23:30 the mixing zone temperatures had dropped to between 700 and 820°F. Coal feeding was started for heat maintenance. Because solids circulation was not established (event 8, figure 5.1.7-69) before coal injection was begun, both mixing zone and riser temperatures increased very rapidly (event 8, figure 5.1.7-63). The coal feed was quickly stopped and the reactor temperatures dropped. During this time, PDV287 was manually controlled. The positioner arm was replaced at approximately 23:50 and the operation was resumed with PV287 in automatic control. The reactor pressure was increased back to 170 psig and the air and coal feed rates were increased to their steadystate values. Between 23:50 and approximately 01:00, solids circulation through the reactor was low and dilute-phase combustion occurred in the mixing zone and the riser. The solids level in the standpipe dropped, indicating loss of solids from the reactor. The coal feed rate was subsequently reduced to lower and control reactor temperature. After approximately 01:00 on August 21, 1996, solids circulation rate through the reactor was higher after dolomite injection resumed.

Reactor operation was continued, holding conditions at steady state and making minor adjustments to coal feed rate and air flow to the reactor to maintain reactor temperature. Dolomite feeding was continued to keep the standpipe solids level within the operating range. Since there was no fresh alumina in storage and the recycling of fines captured by the PCD was discontinued, keeping reactor solids inventory at minimum level required that coal combustion was done with dolomite injection rates higher than that required for sulfur capture. The solids separating system did not effectively capture the ash generated from the coal. Approximately 29.2 tons of coal was burned in the reactor from start of coal combustion to 11:40 on August 21, 1996.

A PCD filter baseline pressure drop increased and continued to rise at approximately 11:30. The supply pressure of the blowback gas was increased from 500 to 700 psig to increase the cleaning efficiency of the filter elements. Both coal and dolomite feeding to the reactor were reduced to allow the PCD to recover. Despite this, the pressure drop across the PCD continued to increase. Dolomite feeding was stopped shortly after and the coal feed rate was further reduced to a minimum for heat maintenance. The air flow to the system was then reduced at 14:20 to reduce solids carryover to PCD while the candles were being cleaned.

At approximately 15:22, it was decided to shut the reactor down since the PCD candles could not be effectively cleaned to bring the baseline pressure drop to within acceptable limits. All reactor flows were reduced to conserve heat after coal feeding was stopped. The PCD was pulsed every 5 minutes and at approximately 17:50 it was decided to continue with the run after the baseline pressure drop was within acceptable range.

Coal feeding into the reactor resumed before high air flow and solids circulation (event 9, figure 5.1.7-69) through the reactor were established. This caused dilute-phase combustion of the coal in the riser and post combustion in the disengager and cyclone. The reactor temperature increased very quickly and temperatures of 1,900°F were observed in the riser (event 9, figure 5.1.7-63). After reactor flows and solids circulation through the reactor were reestablished the combustion front was contained in the riser and the reactor temperatures were within the expected range. Solids circulation through the reactor was, however, low as shown by PDI202 in figure 5.1.7-69 since dolomite feeding was discontinued. The PCD baseline pressure drop began to increase again so coal feed rate was first reduced to minimum required for heat maintenance.

Coal feeding was resumed at 20:45. Although at this time the air flows were set at proper levels, the riser PDIs indicated that there was very little solids circulation through the reactor (event 10, figure 5.1.7-69). The standpipe solids level was also low as shown in figure 70 (event 10). Consequently, dilute-phase combustion of coal took place in the riser with post combustion occurring after the riser. This time temperatures in the mixing zone and riser were close to and exceeded 1,700°F (event 10, figure 5.1.7-63). The reactor was shutdown and the run was prematurely terminated because of low reactor solids inventory after approximately 80 hours of coal combustion feeding a total of approximately 32.2 tons of coal.

5.1.7.3 Infrared Scan

An infrared scan of the transport reactor loop was taken on August 21, 1997. When the scan began, the riser exit temperature was 1,679°F and the primary cyclone inlet was 1,644°F. The results showed no unexpected hot spots. Most of the reactor skin temperatures were around 230 to 270°F, with some areas in the piping (mainly at the weld joints) approaching 300°F. A discussion of major observations from infrared scan on this and other test runs is presented in section 9.2.3.

5.1.7.4 Test Run CCT1C Observations

A. The start-up sequence, namely propane preheat, coke breeze-assisted preheat, and coal combustion were demonstrated.

B. The ease and flexibility of reactor temperature control with HX0203 were demonstrated.

C. The burner can be operated at a higher outlet temperature and operating pressure than design. However, at high pressures adequate propane flow must be established through the pilot to avoid flame flashback.

D. Recycling of fines from the PCD into the reactor was stopped.

E. Coke breeze will ignite above 1,000°F in the transport reactor, not at 800°F as previously thought. A mixture of coke breeze and subbituminous coal would be used for subsequent start-ups. The subbituminous coal will increase the volatile content of the coke breeze mixture.

F. Carbon content of bed during coke breeze-assisted preheat should be limited.

G. Deposits/agglomerates formation is dependent on temperature. It is important to control reactor temperature to avoid agglomeration of ash.

H. Proper flow levels and solids circulation must be established before injecting coal during restart after a hot standby.

I. The riser crossover should be blown clear of solids after shutdown.

J. Dolomite injection for bed makeup should be avoided. Dolomite should be used for sulfur capture only.

K. The fines screw cooler should be run at maximum speed to convey the ash from the PCD filter vessel as soon as it collected.

5.1.7.5 Post Test Activities

When the outlet elbow was removed from the Westinghouse PCD head, corrosion was seen on the four flanges associated with the elbow. The rust was ground off the flanges and they were painted.

Pieces of broken PCD candle were found in the outlet of the fines transporter (FD0502). The Westinghouse PCD head was pulled and the filter vessel was found to be approximately one-third full of ash/dolomite fines. Thirteen candles out of 36 were broken from the top tier; only 1 candle survived out of 55 candles in the bottom tier. Overall, only 14 candles out of a total of 91 survived. The rest were broken. The Westinghouse PCD vessel was recandled with new candles and the head buttoned back up.

The reactor loop was extensively borescoped. There were extensive agglomerates/clinkers found in the riser disengager crossover, the top of the riser and pillow-top, down inside the standpipe below the disengager, the upper portion of the burner J-leg, and the mixing zone. The disengager/cyclone crossover was pulled (and cleaned), showing minimal deposits. The cyclone appeared clean but the disengager had solids buildup surrounding inlet pipe (above exit). The deposits were cleaned. Coal combustion operations from the test run were discussed. Several theories were proposed as the cause of agglomerate formation in the reactor. The underlining factor was high-temperature excursions.

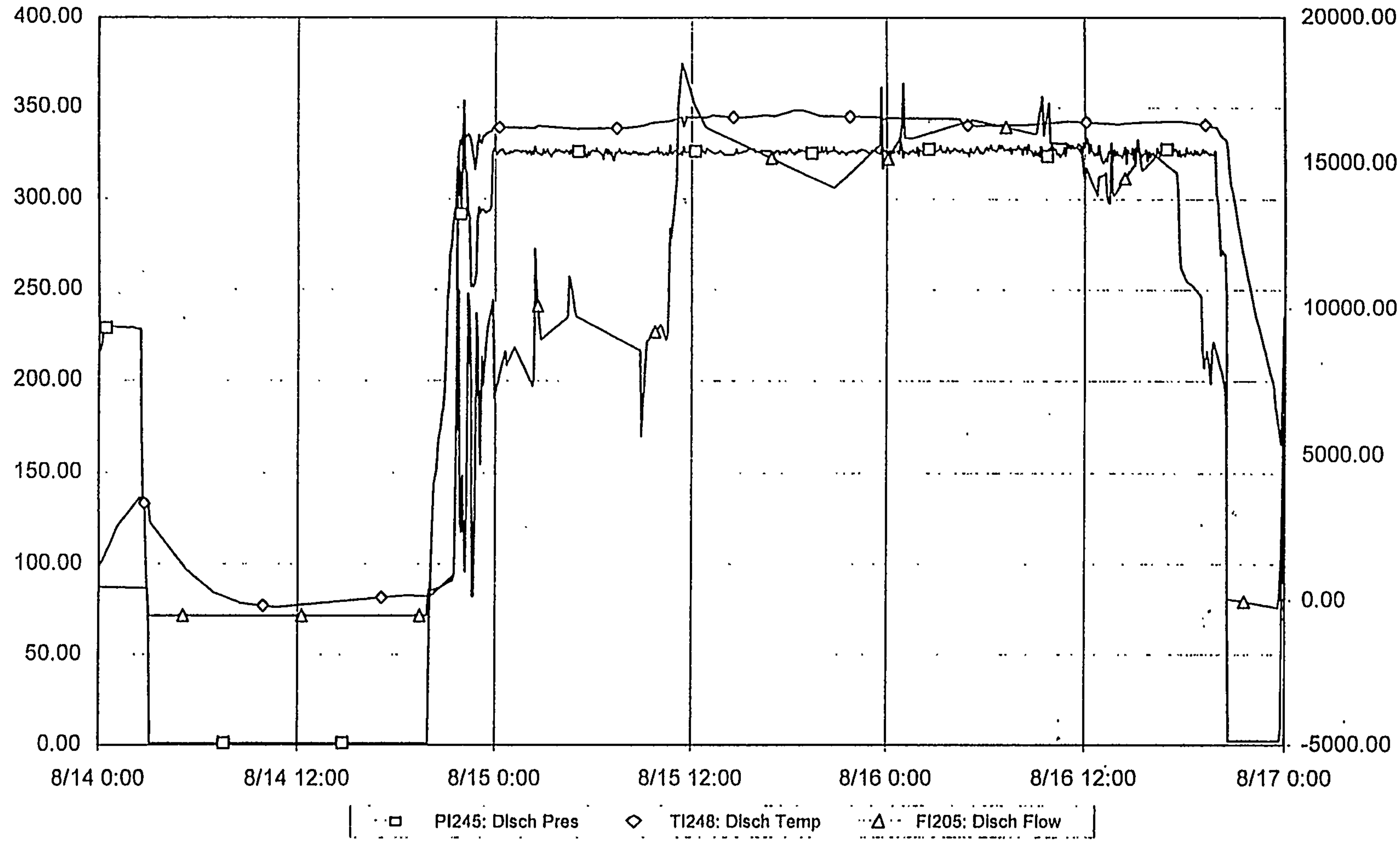
BR0201 was pulled, inspected, and no coke depositions were found. Some burn marks were seen around the edge of the pilot tip. The backpressure control valve (PV287) was inspected. The whisper trim was lightly coated with dust and did not show any visible wear marks. The valve body was in good shape.

Approximately 48,000 lb of sand were purchased for use as start-up bed material instead of alumina. Sand is less expensive than alumina although its fluidization properties are poorer than that of alumina. The sulfator blower motor vibrated intensely during its initial commissioning run. The motor was repaired and reinstalled. The operations of all Clyde units were tested and repaired as necessary.

Table 5.1.7-1

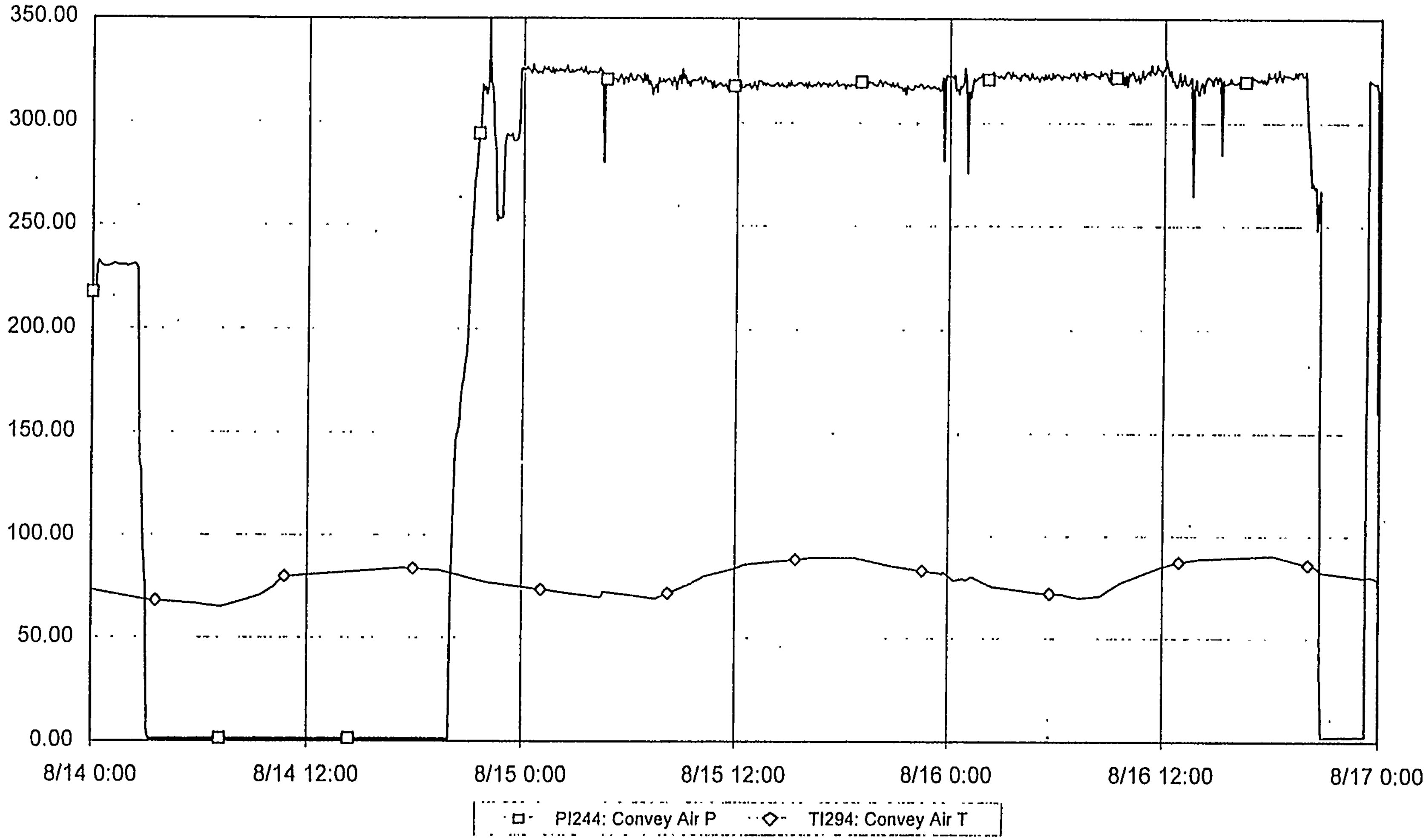
Results From Reactor Loop Skin Temperature Surveys

Date	8/16	8/16	8/17	8/18	8/18	8/19	8/20	8/21
Start Time	06;00	13:30	---	05:00	08:49	04:00	---	02:30
End Time	08:45	---	---	---	---	07:15	---	03:15
Riser Exit Temp, °F	1,212	1,200	703	1,200	1,596	---	---	1,661
Average Riser/ Mixing Zone Skin Temp., °F	165	225	127	173	218	233	250	229
Average Standpipe Skin Temp., °F	158	218	119	159	217	235	253	237
Average Cyclone Skin Temp., °F	158	210	118	161	210	222	237	217
Average HX0203 Loop Skin Temp., °F	124	158	105	122	158	179	184	175
Differential Temperatures °F								
Riser/Mixing Zone and Standpipe	7	7	8	14	1	-2	-3	-8
Standpipe and Cyclone	0	8	1	-1	7	13	16	20
Standpipe and HX0203 Loop	35	60	14	37	58	55	69	62
Riser/Mixing Zone and HX0203 Loop	42	67	22	51	60	54	66	53



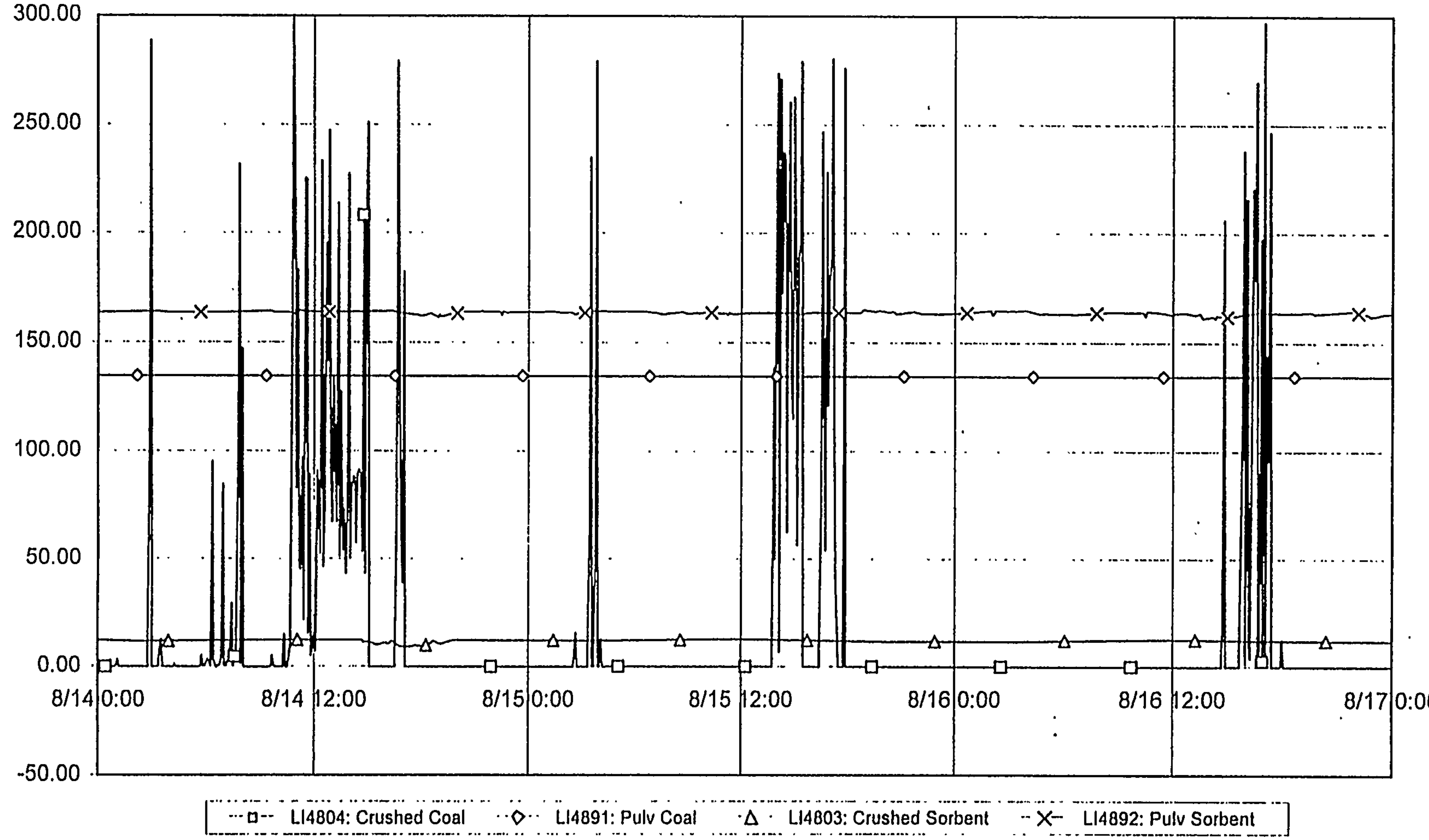
DOE Plot 1 of 47 - 5 minute data

5.1.7-1 C00201 System Profile for August 14 Through August 16, 1996



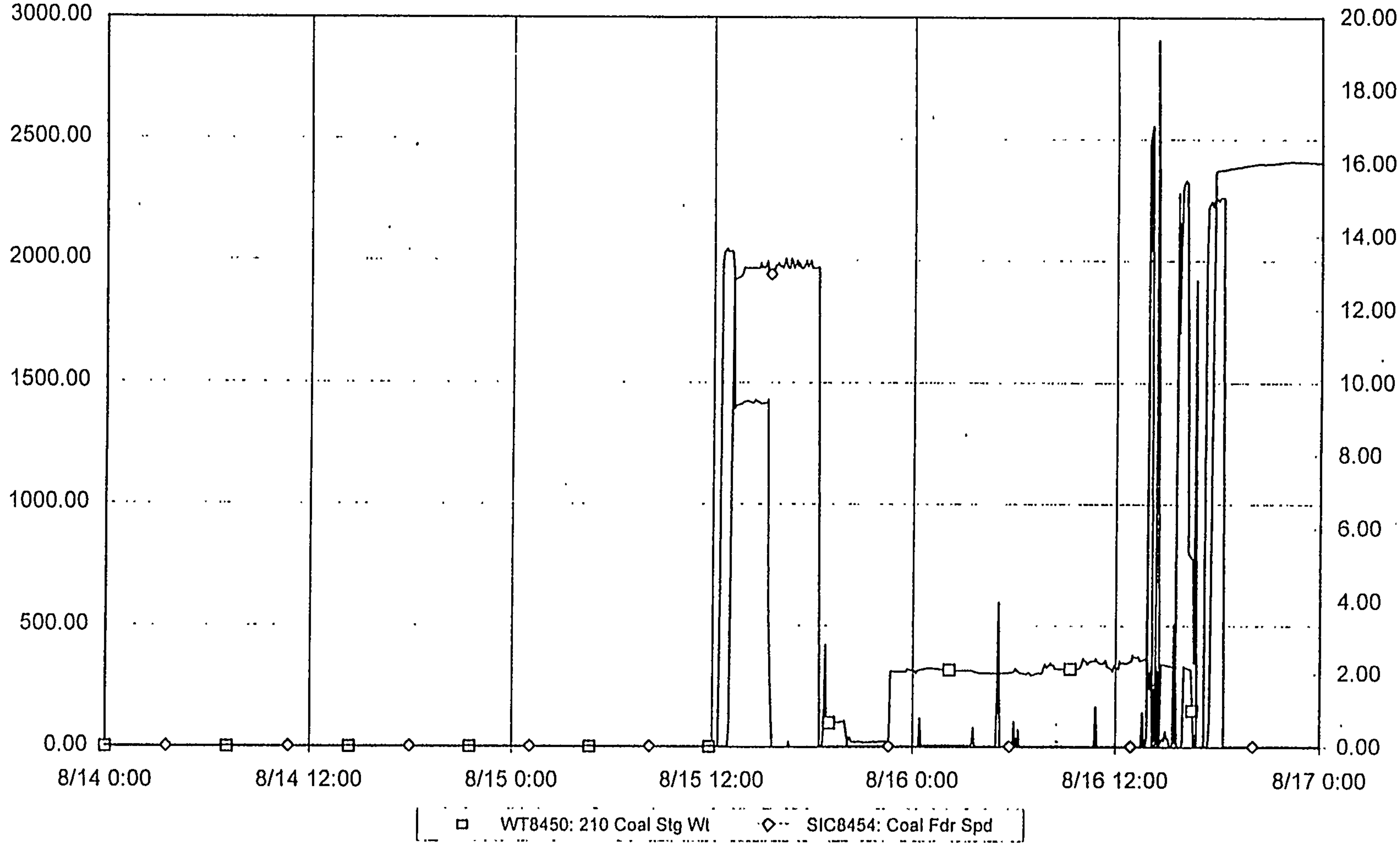
DOE Plot 5 of 47 - 5 minute data

5.1.7-2 Transport Air System for August 14 Through August 16, 1996



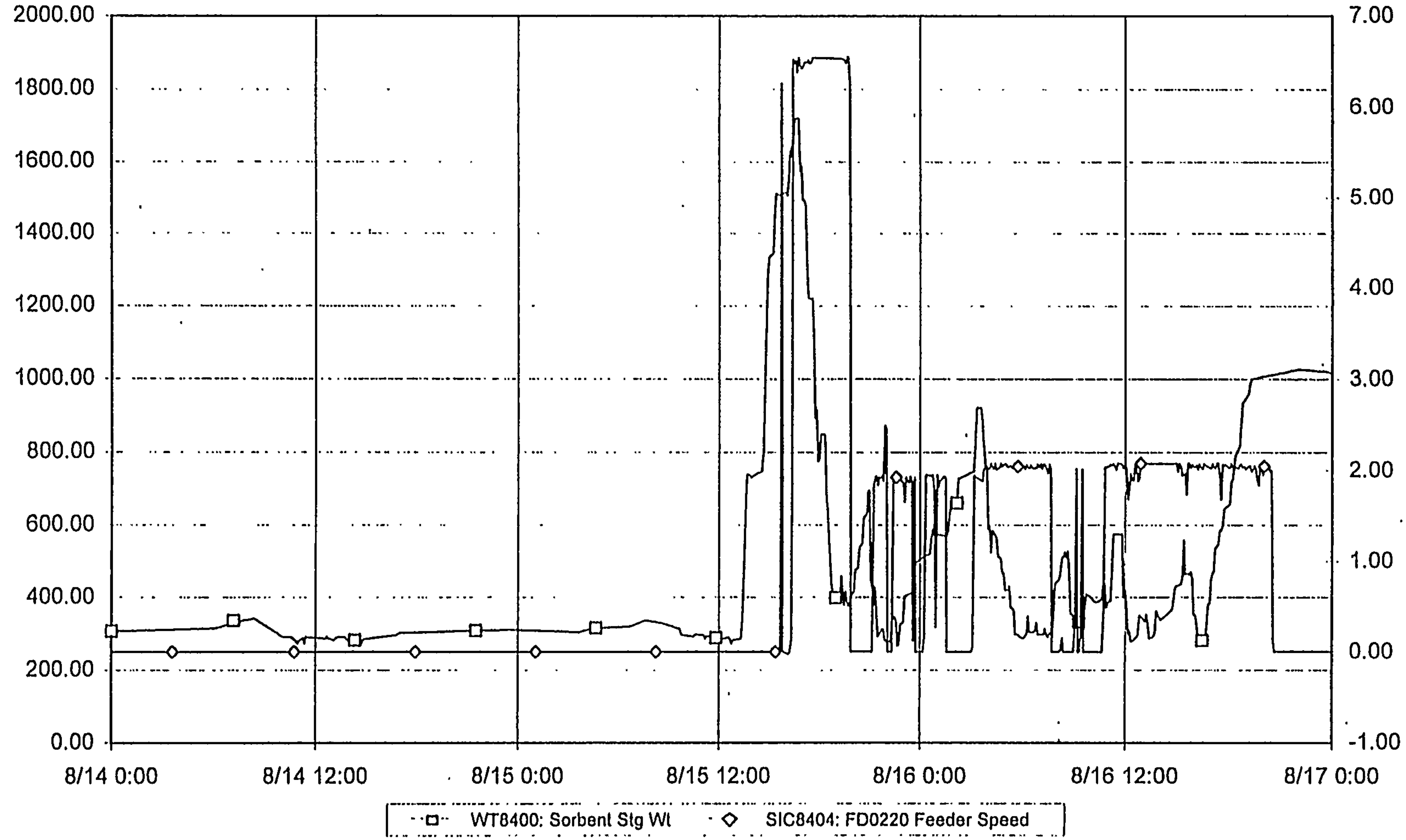
DOE Plot 6 of 47 - 5 minute data

5.1.7-3 Coal and Sorbent Silo Levels for August 14 Through August 16, 1996



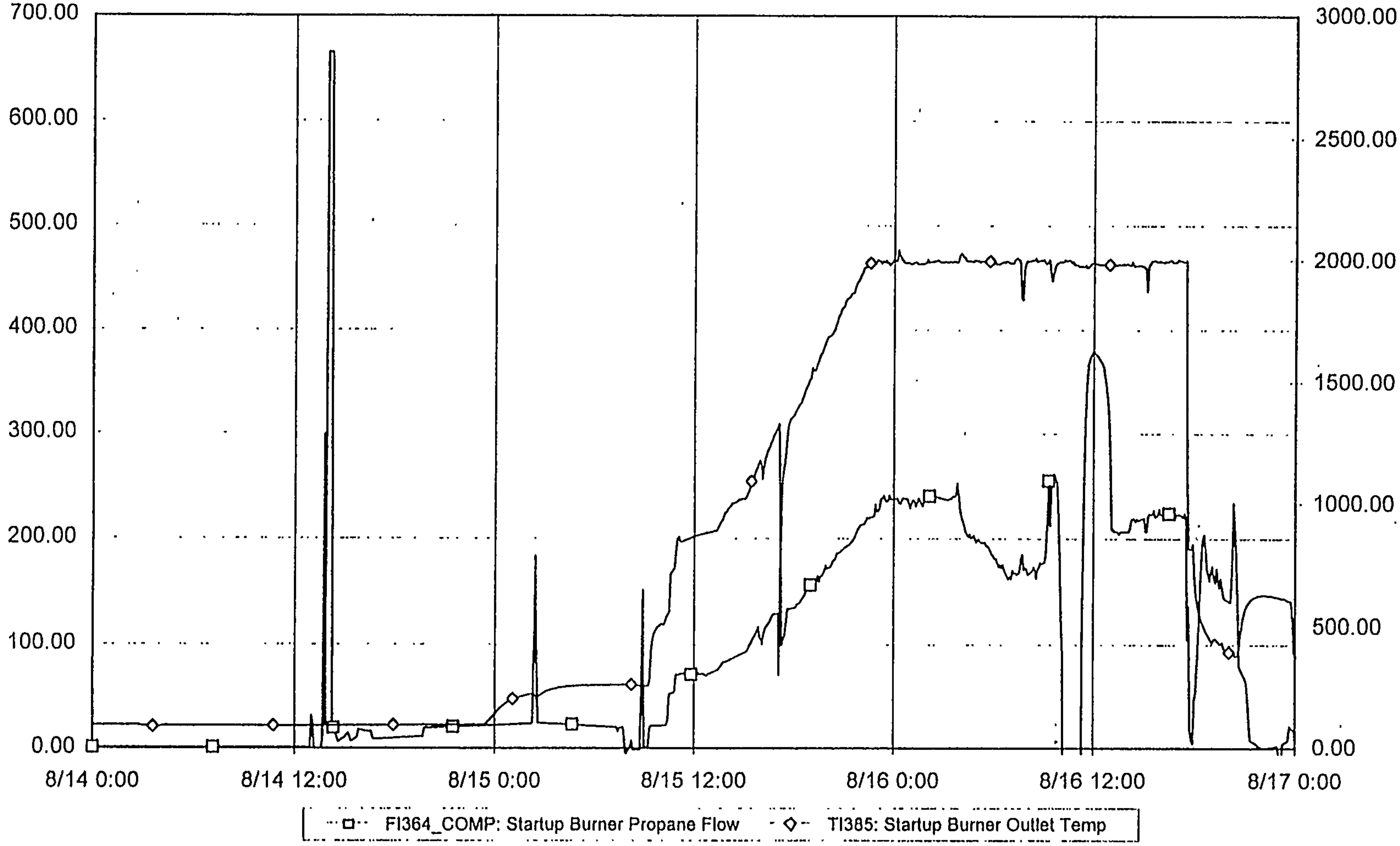
DOE Plot 7 of 47 - 5 minute data

5.1.7-4 Coal Feed for August 14 Through August 16, 1996



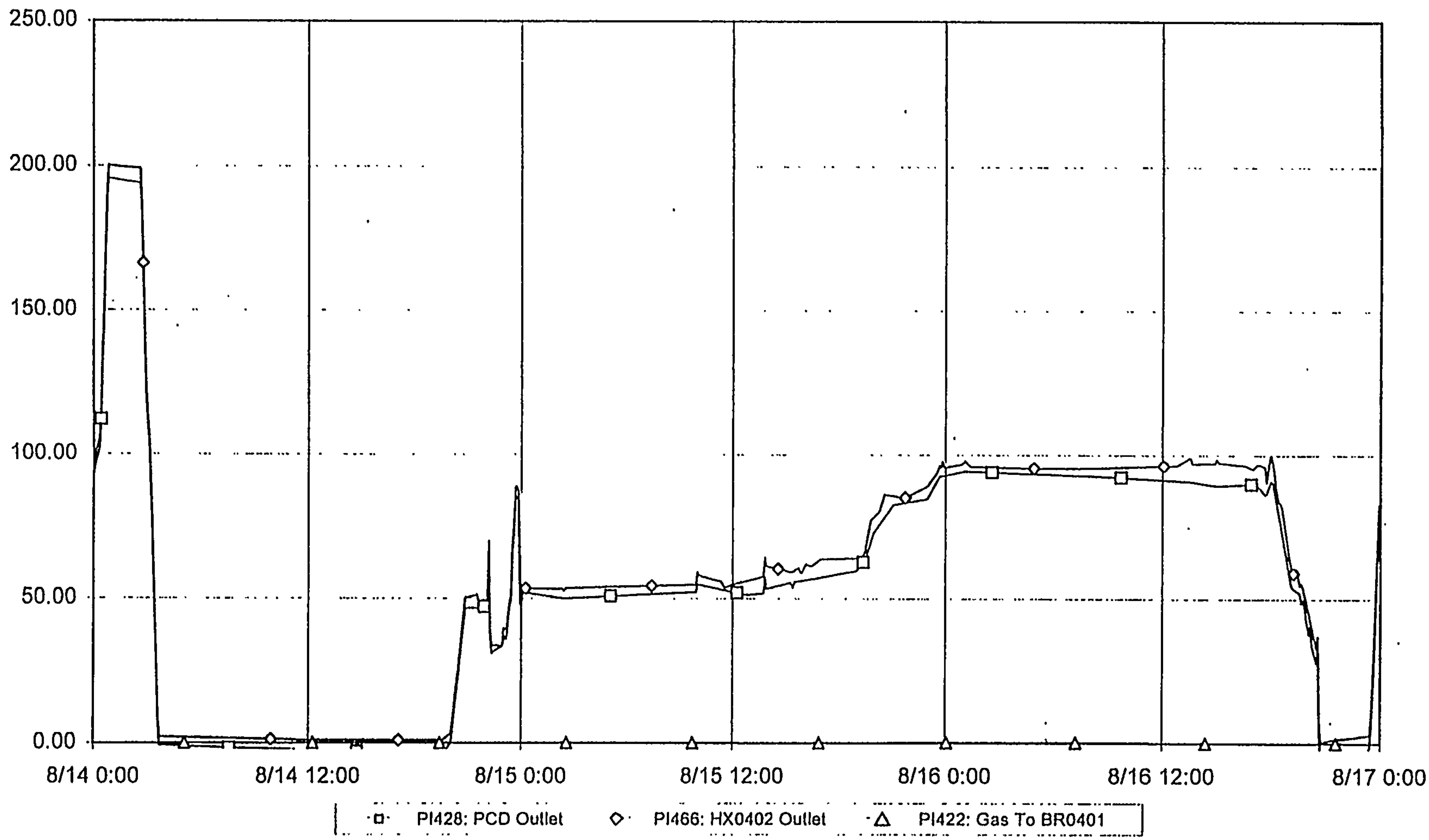
DOE Plot 8 of 47 - 5 minute data

5.1.7-5 Sorbent Feed for August 14 Through August 16, 1996



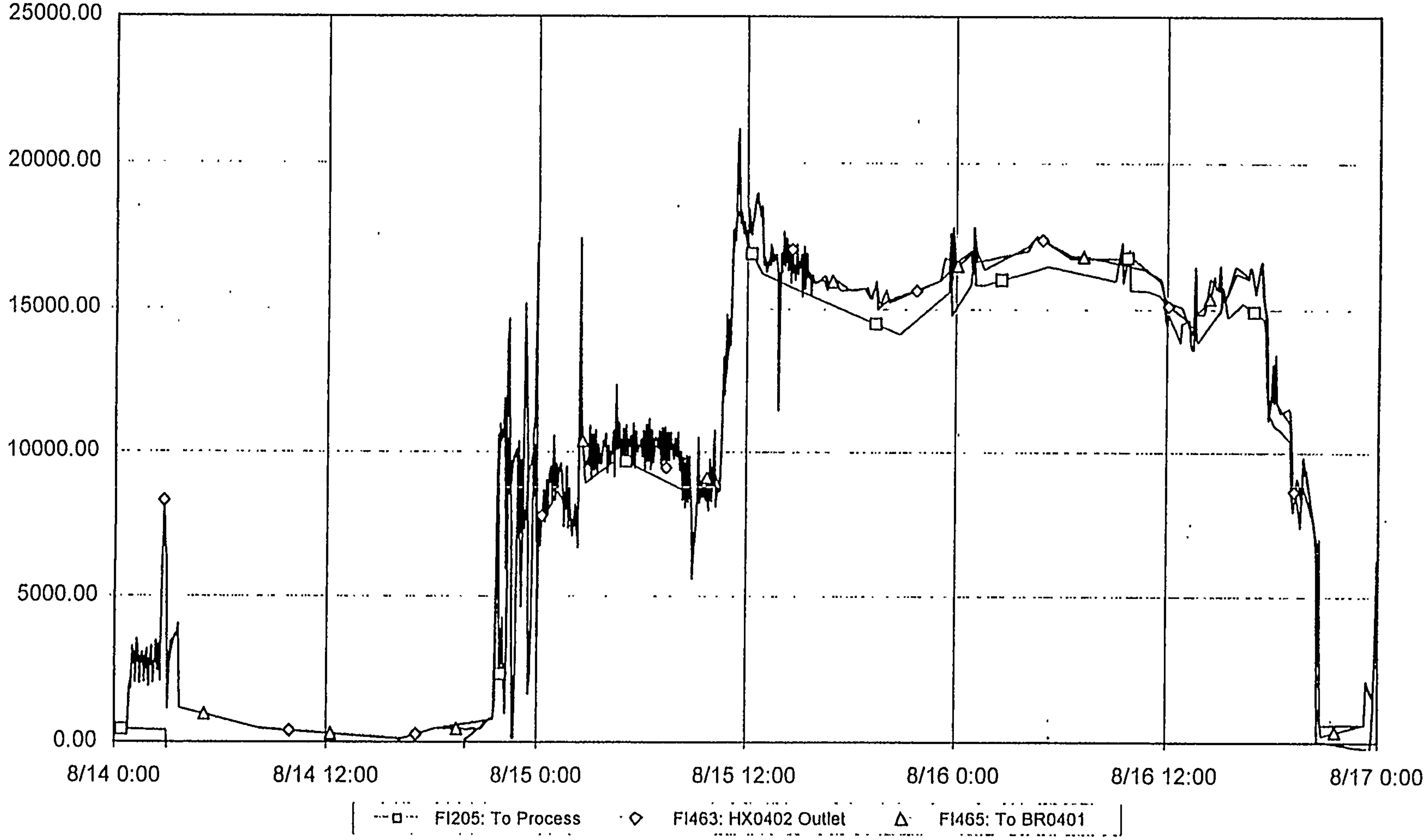
DOE Plot 9 of 47 - 5 minute data

5.1.7-6 Start-Up Burner Flow/Temperature for August 14 Through August 16, 1996



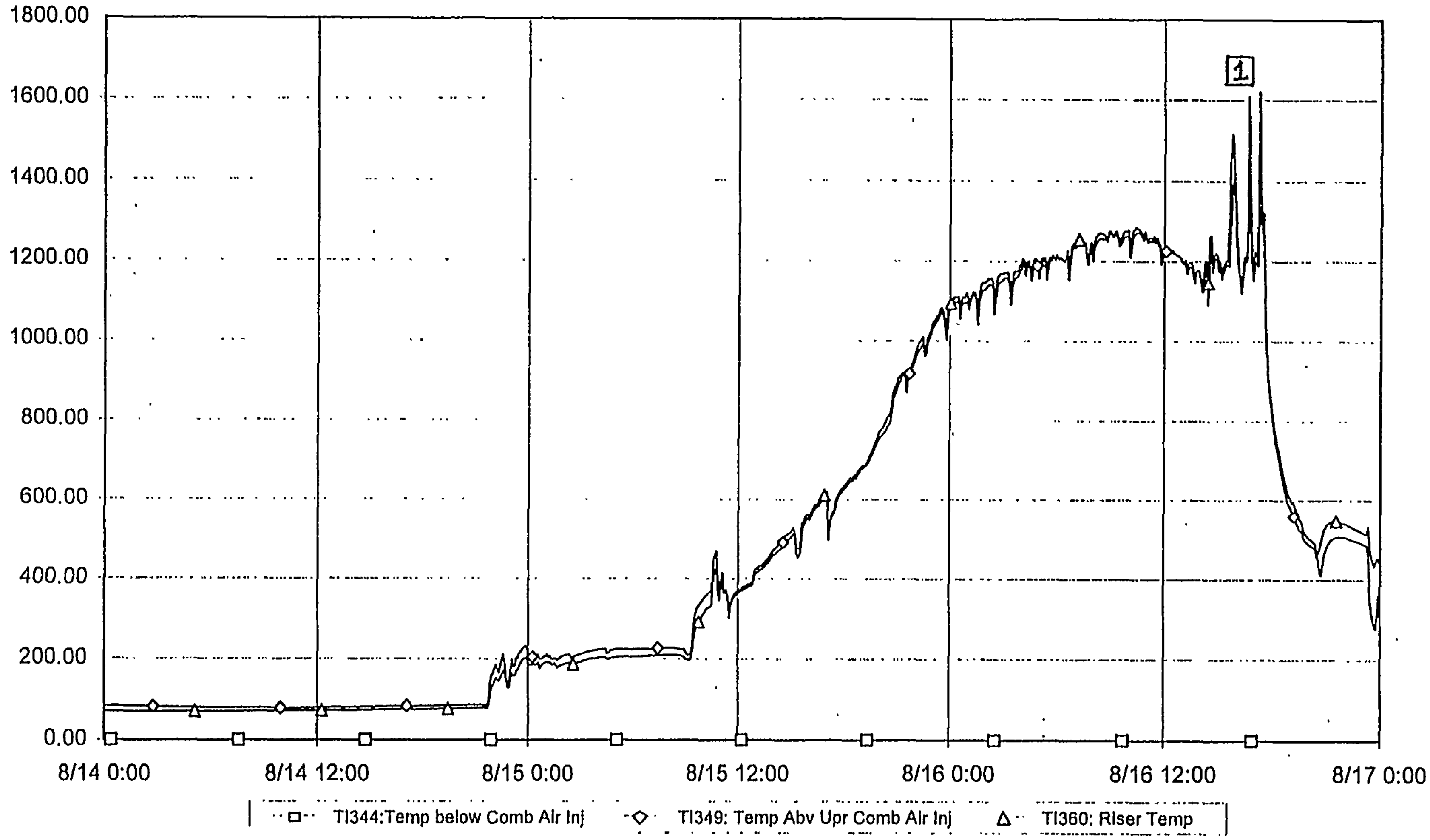
DOE Plot 10 of 47 - 5 minute data

5.1.7.7 System Pressures Downstream of PCD for August 14 Through August 16, 1996



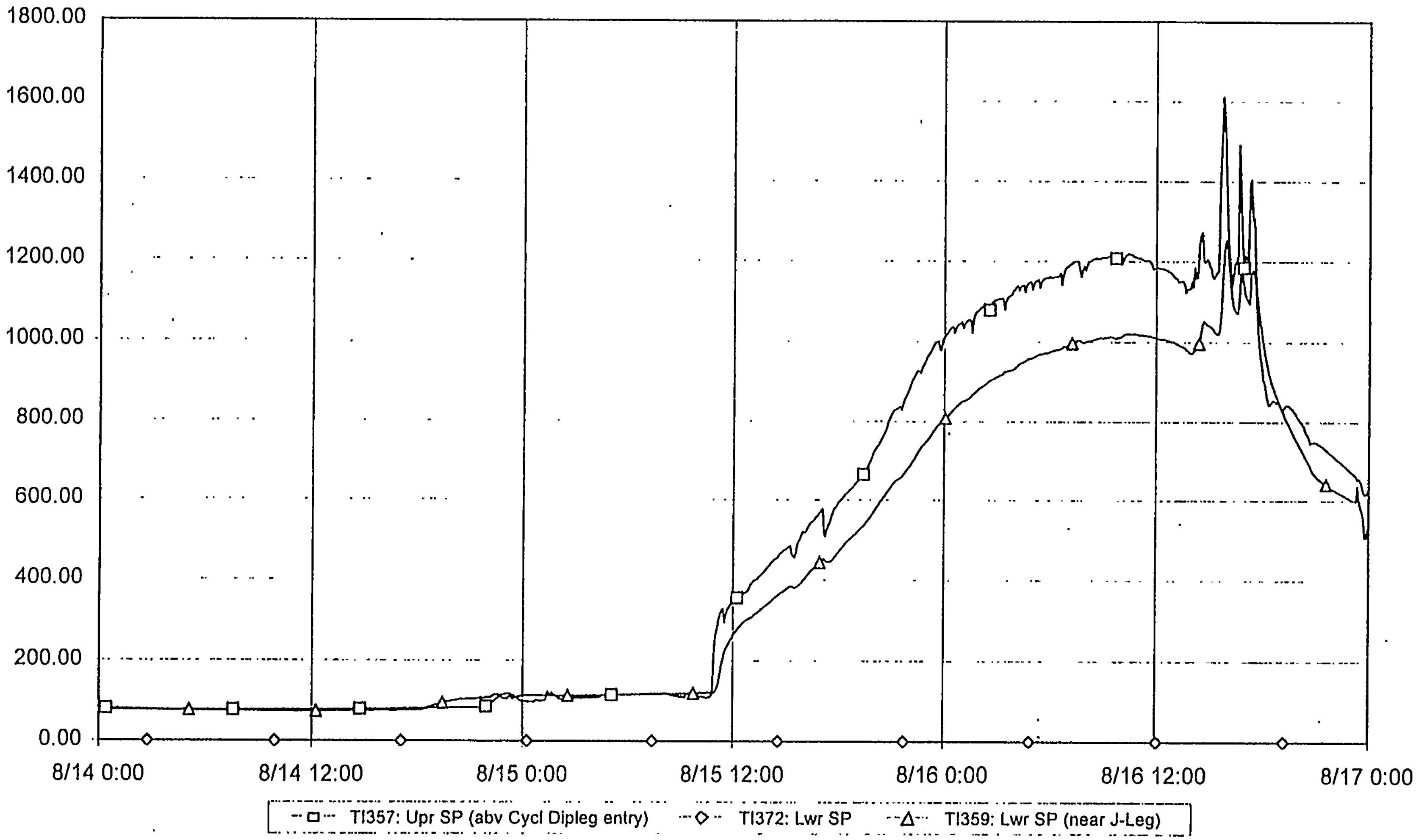
DOE Plot 11 of 47 - 5 minute data

5.1.7.8 Total Gas In/Out Flow Rates for August 14 Through August 16, 1996



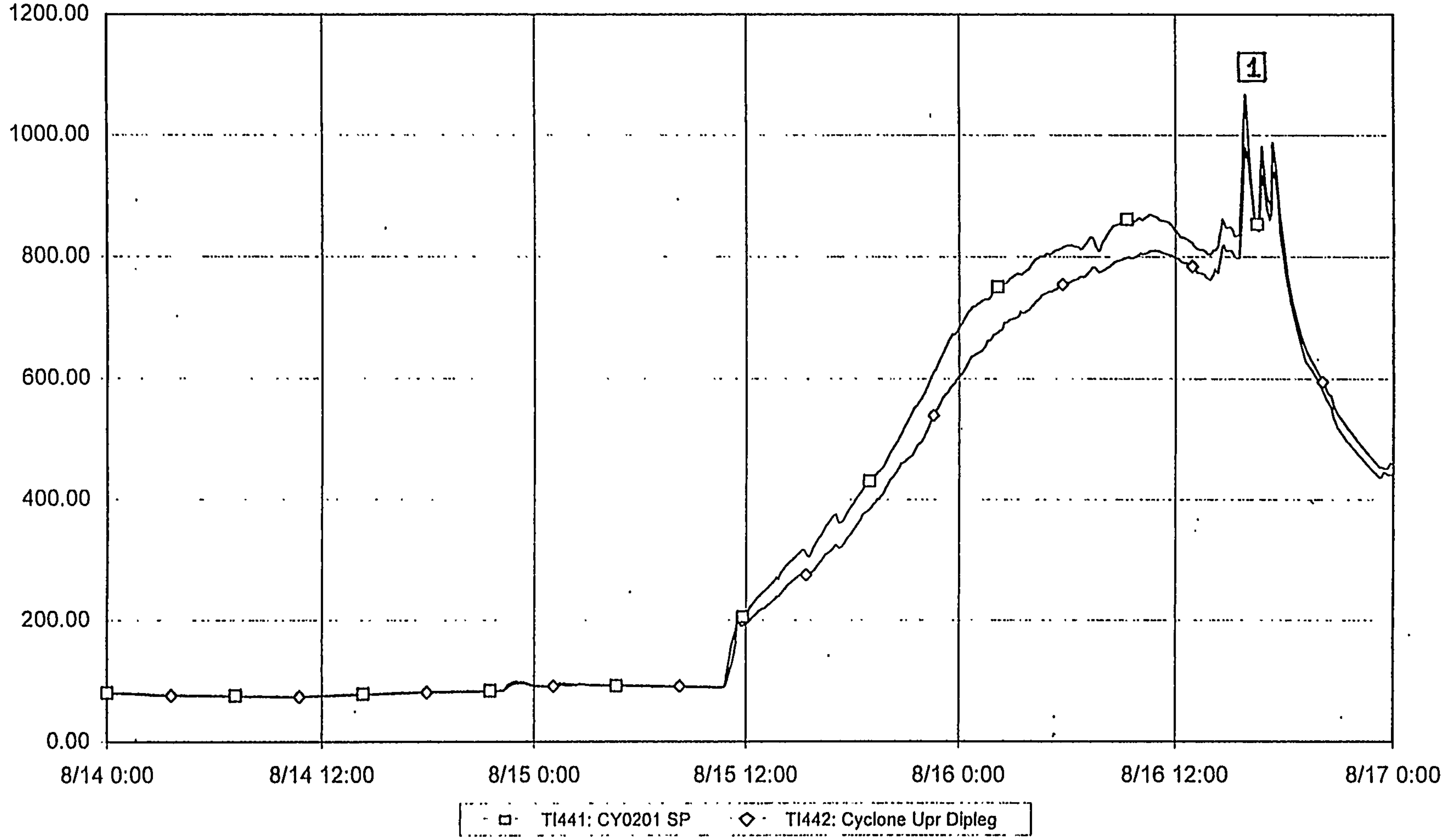
DOE Plot 12 of 47 - 5 minute data

5.1.7-9 Reactor Mixing Zone and Riser Temperatures for August 14 Through August 16, 1996



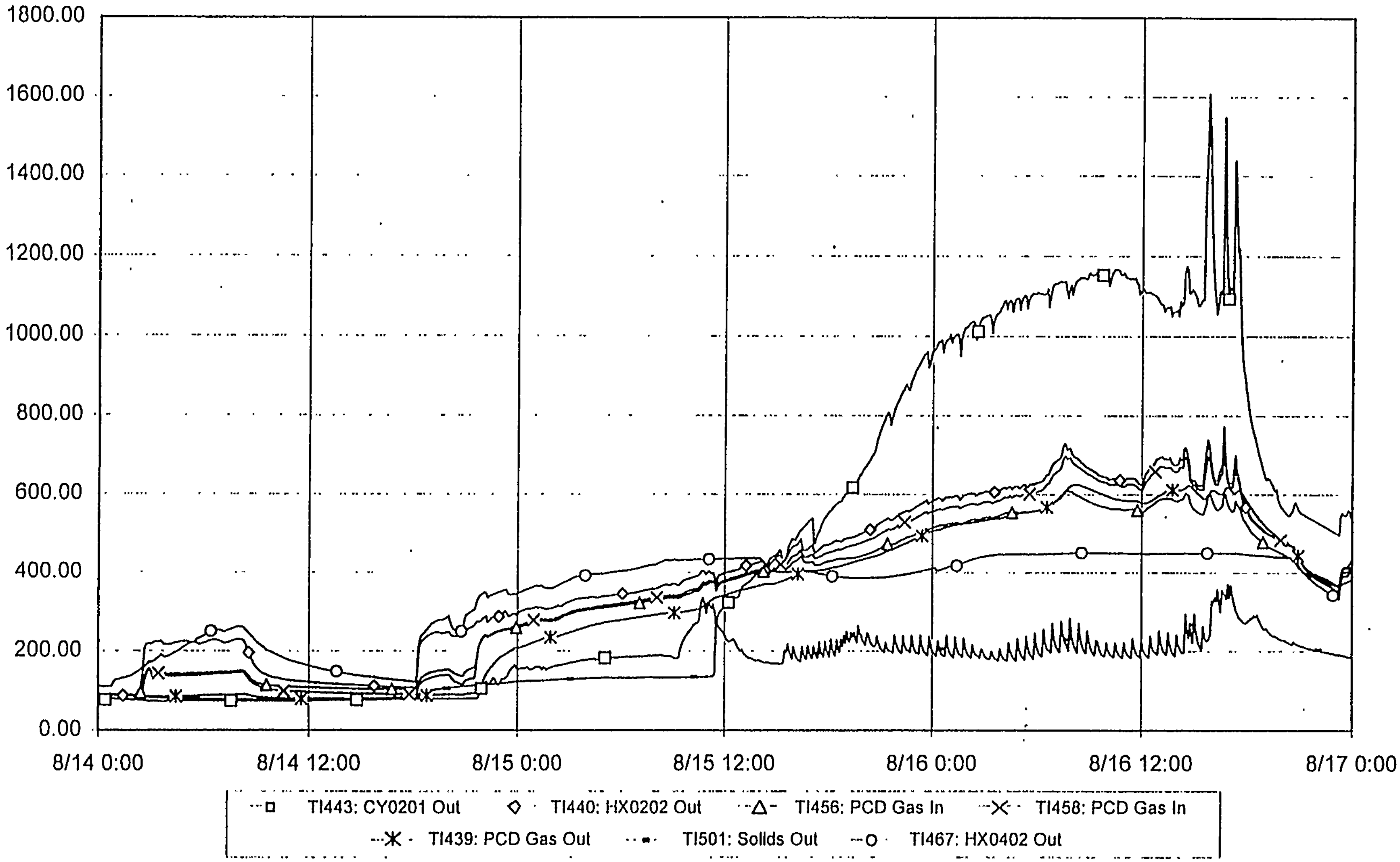
DOE Plot 13 of 47 - 5 minute data

5.1.7-10 Standpipe Temperatures for August 14 Through August 16, 1996



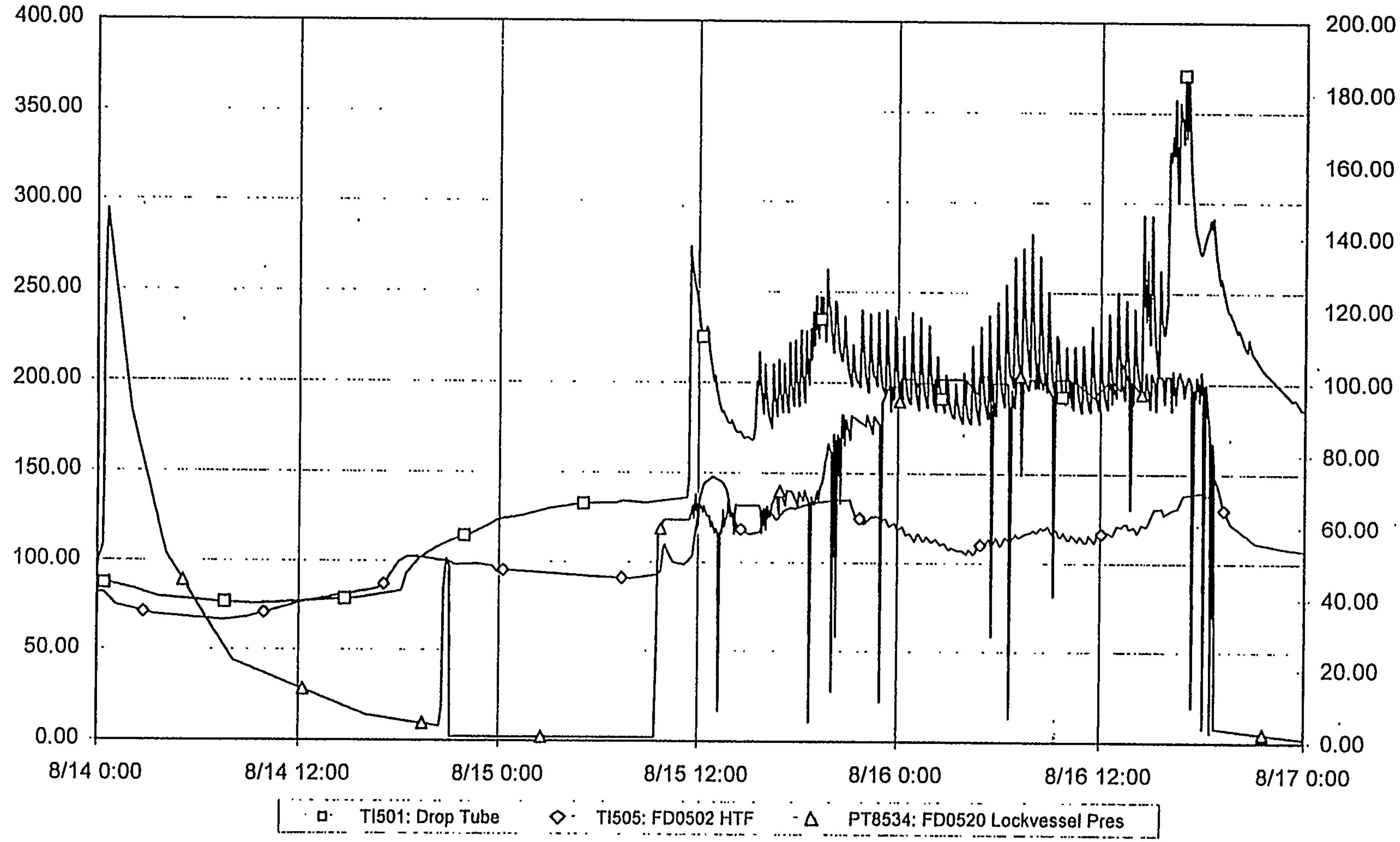
DOE Plot 14 of 47 - 5 minute data

5.1.7-11 Cyclone Dipleg Temperatures for August 14 Through August 16, 1996



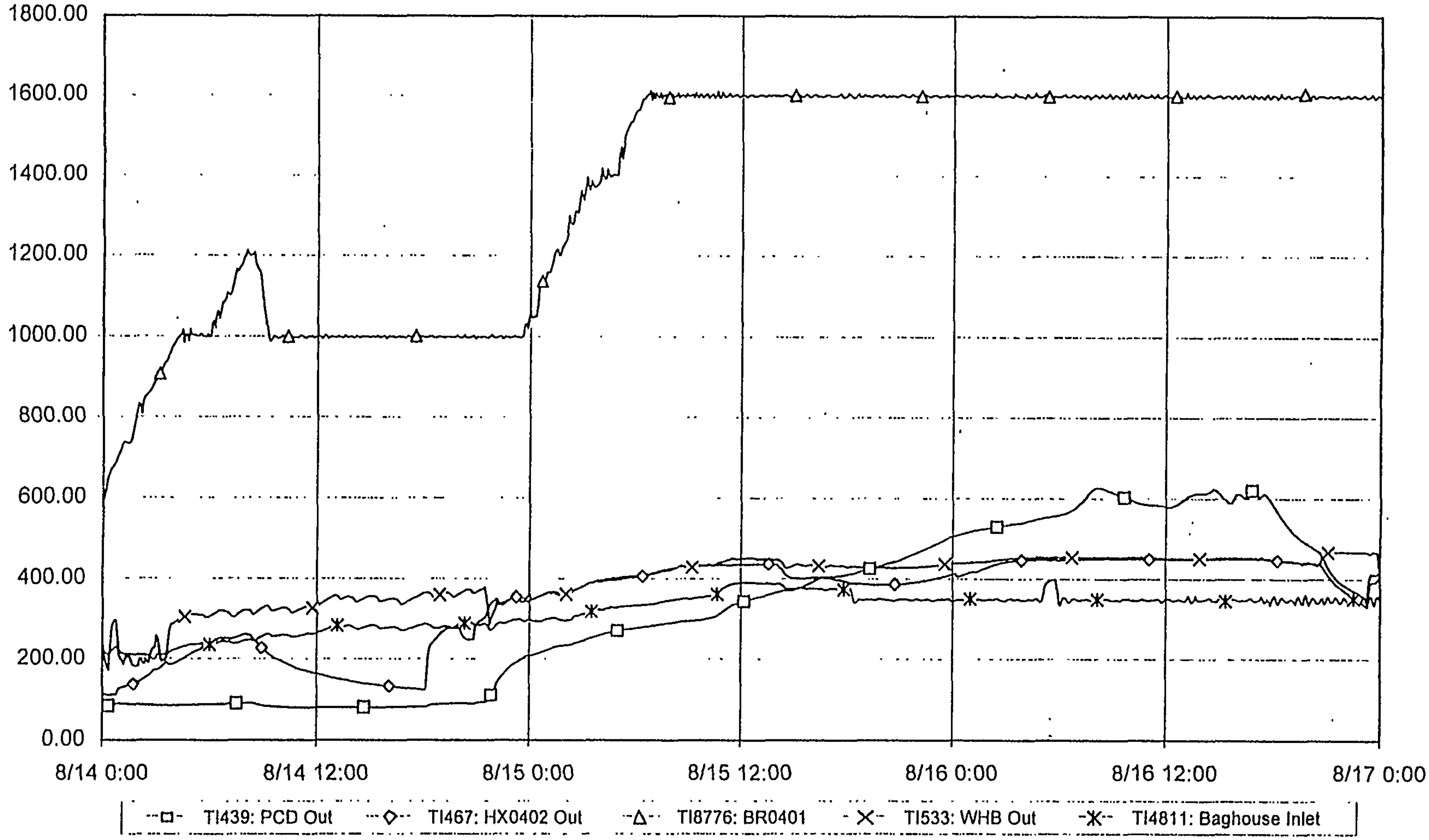
DOE Plot 15 of 47 - 5 minute data

5.1.7-12 Temperature Profiles Downstream of Reactor for August 14 Through August 16, 1996



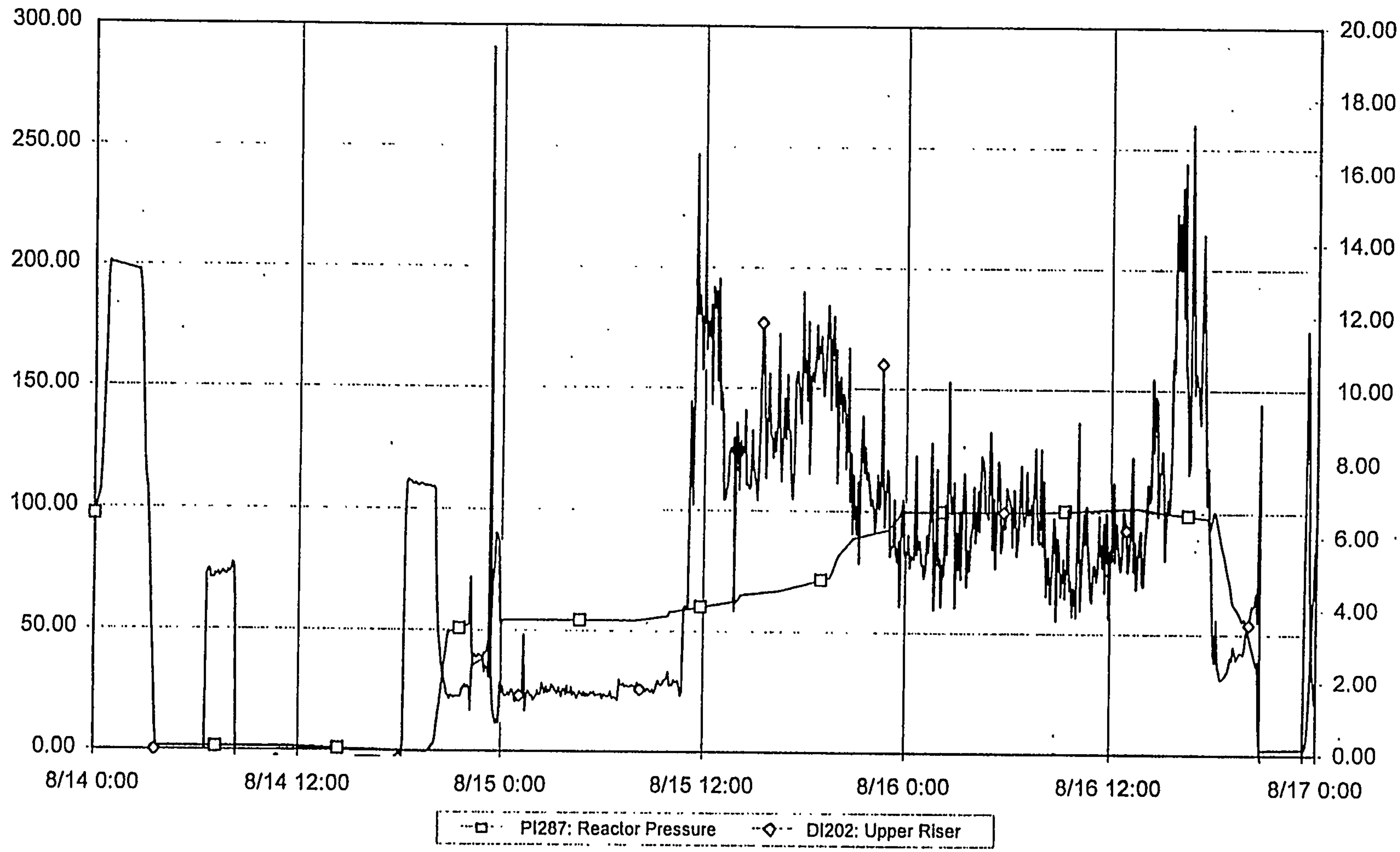
DOE Plot 16 of 47 - 5 minute data

5.1.7-13 PCD Ash Temperatures for August 14 Through August 16, 1996



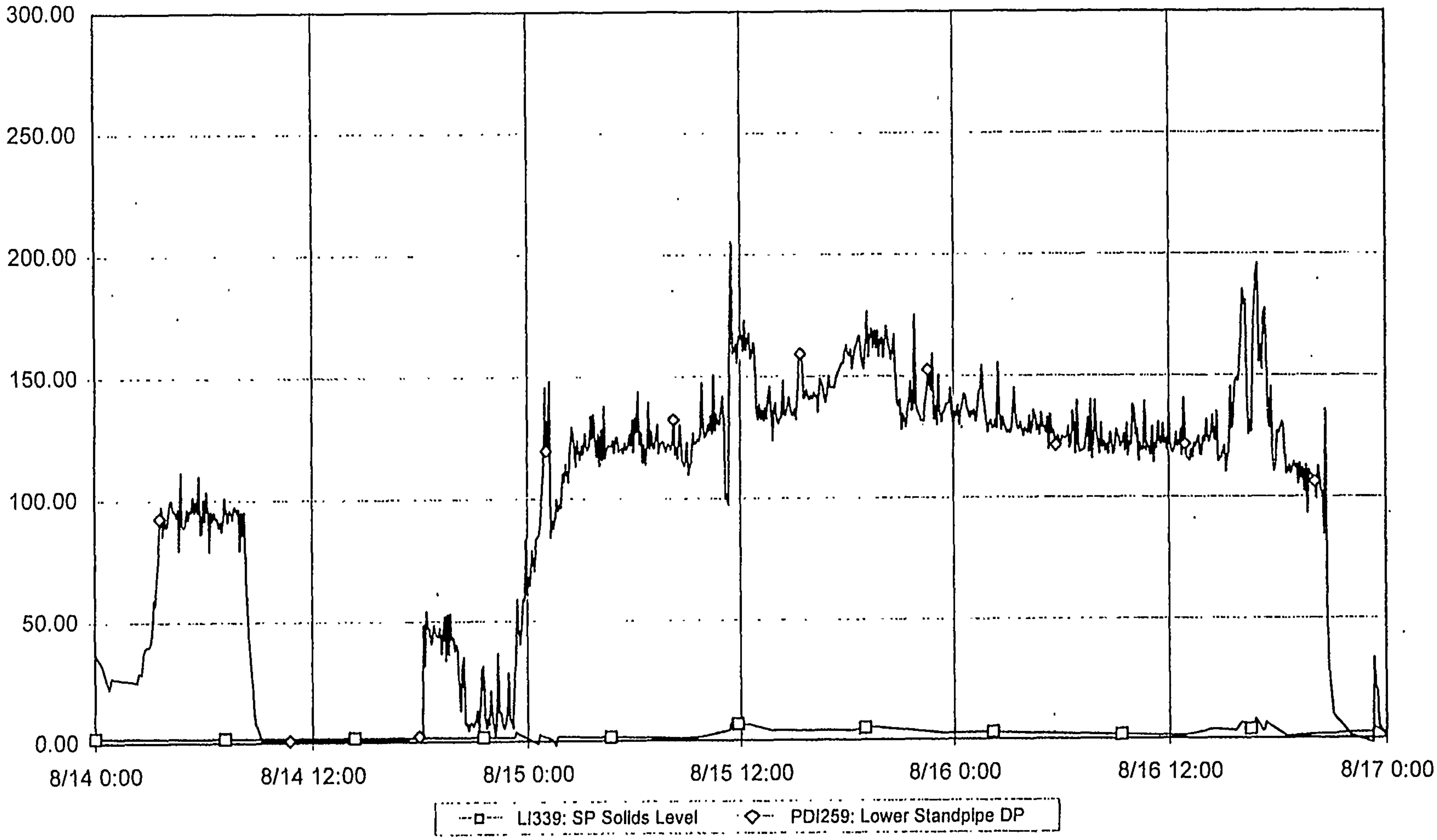
DOE Plot 17 of 47 - 5 minute data

5.1.7-14 System Temperatures Downstream of PCD for August 14 Through August 16, 1996



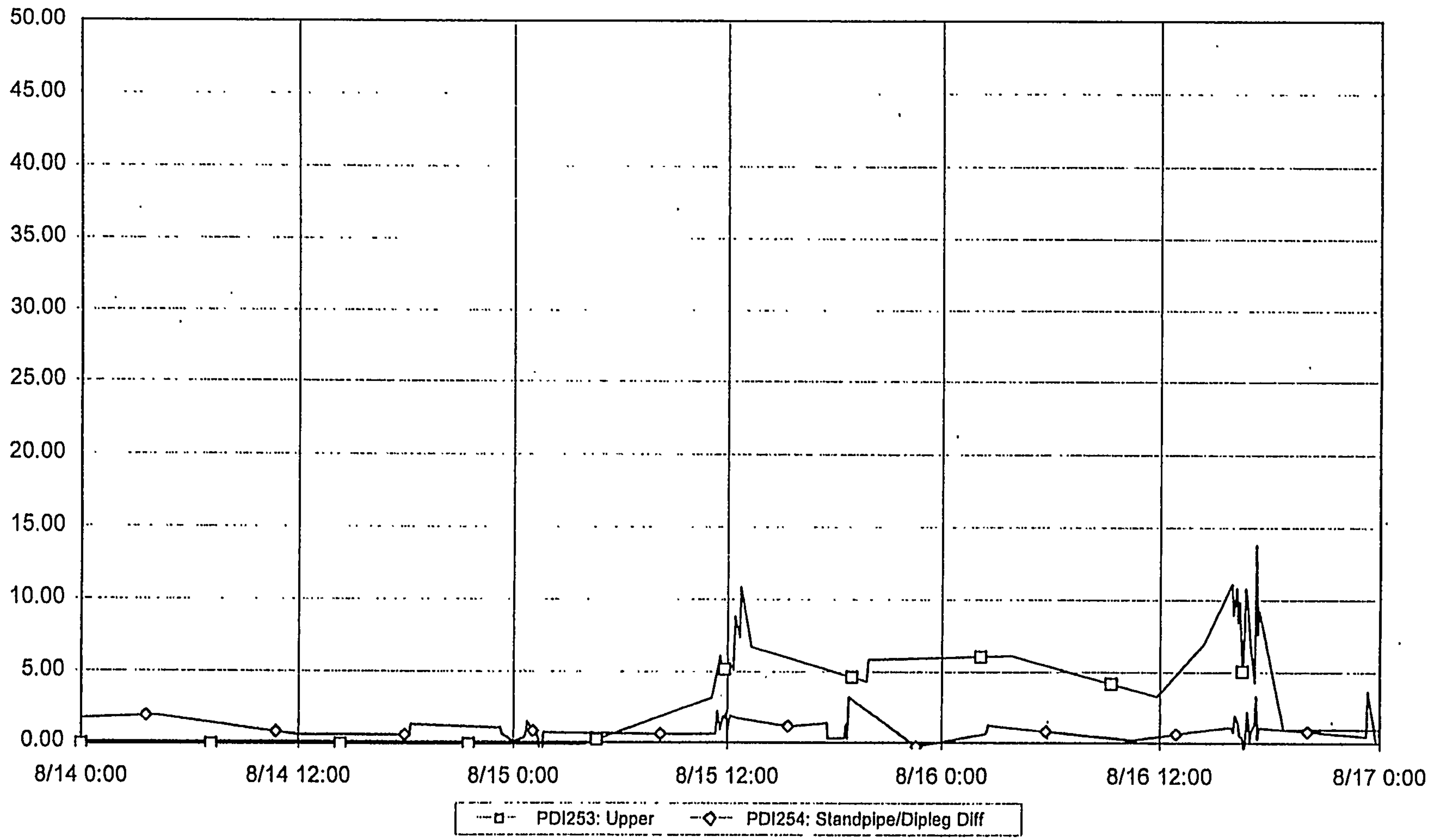
DOE Plot 19 of 47 - 5 minute data

5.1.7-15 Reactor Pressure/Riser DP Profiles for August 14 Through August 16, 1996



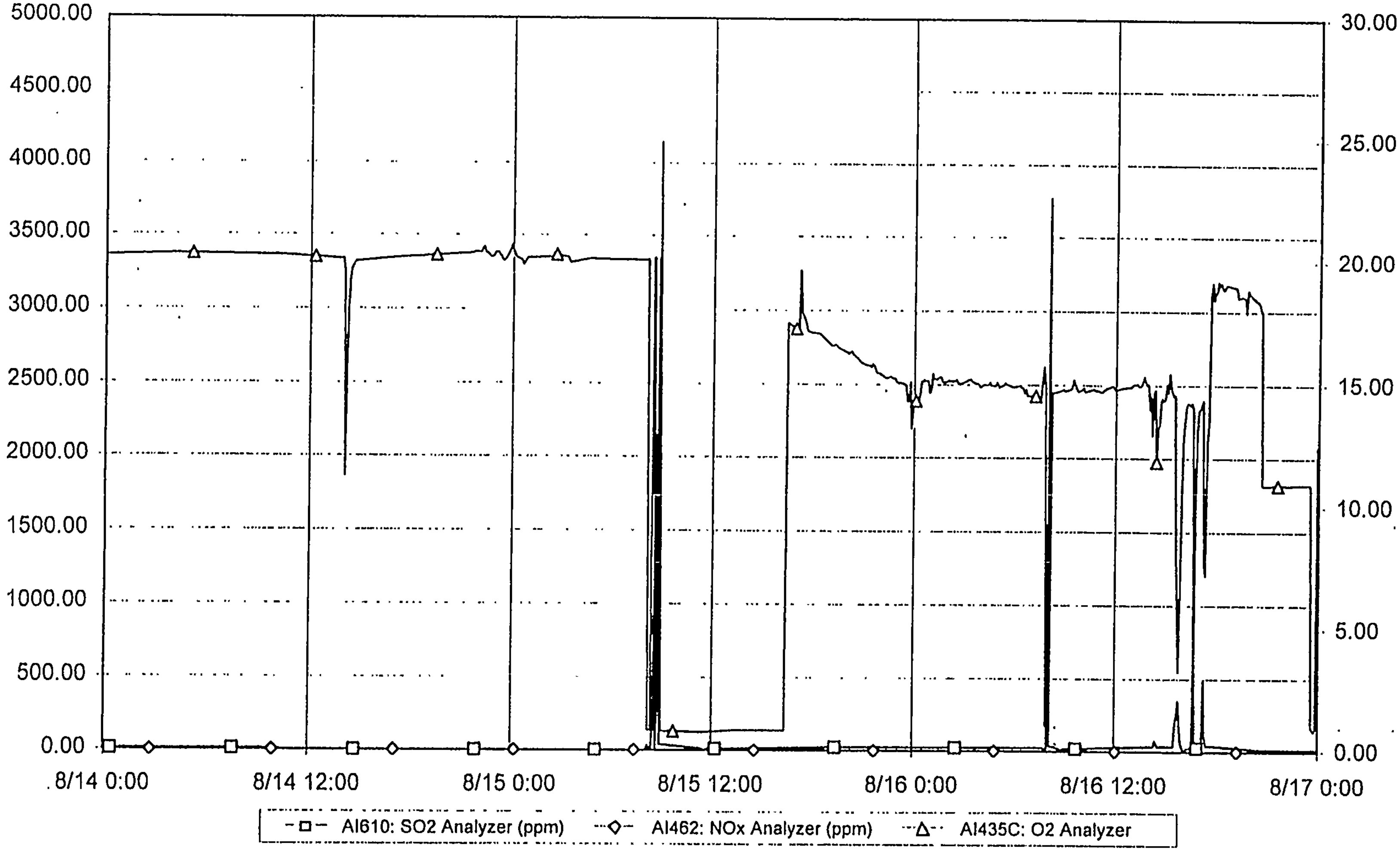
DOE Plot 20 of 47 - 5 minute data

5.1.7-16 Standpipe DP Profiles for August 14 Through August 16, 1996



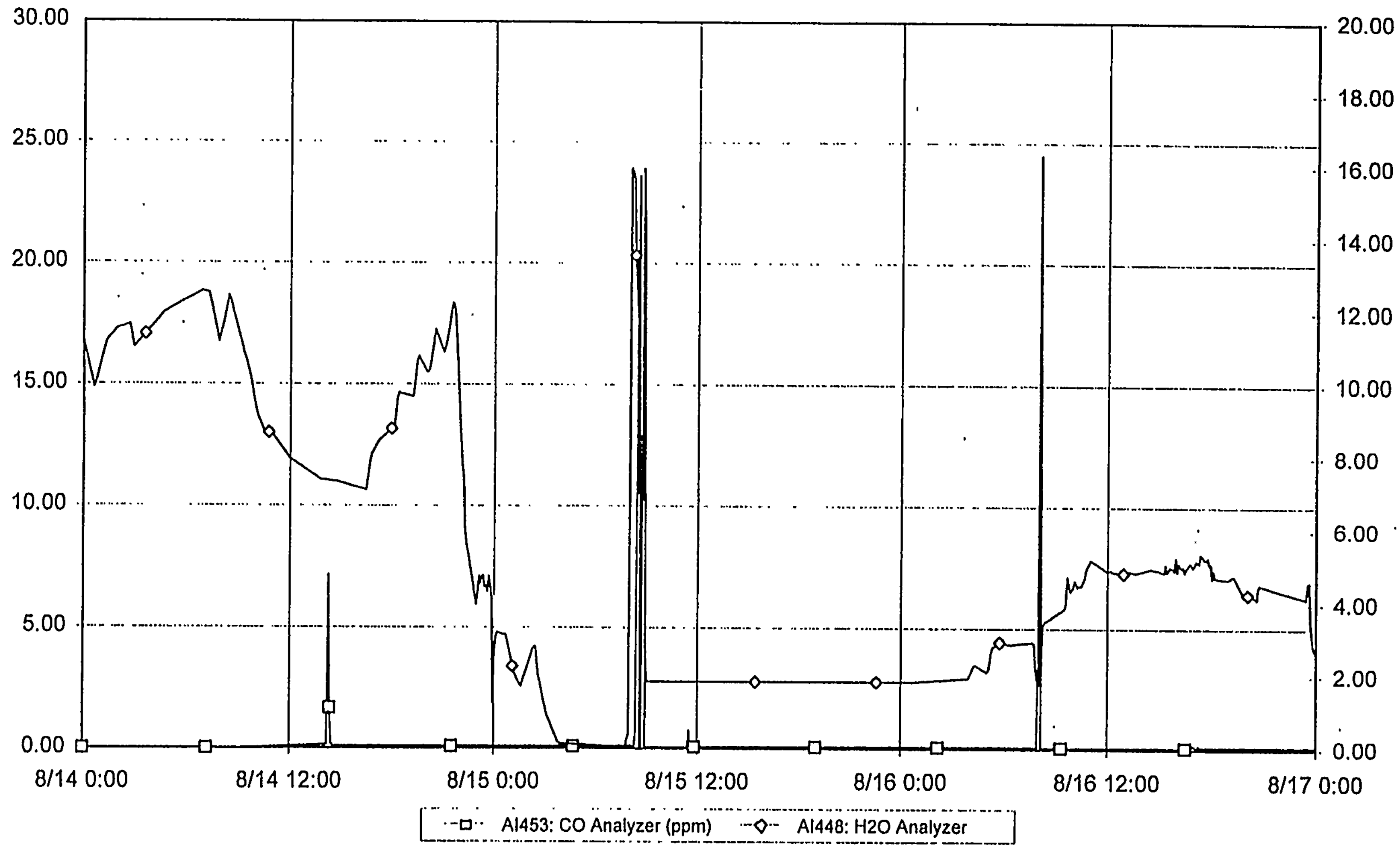
DOE Plot 21 of 47 - 5 minute data

5.1.7-17 CY0201 Dipleg DP Profiles for August 14 Through August 16, 1996



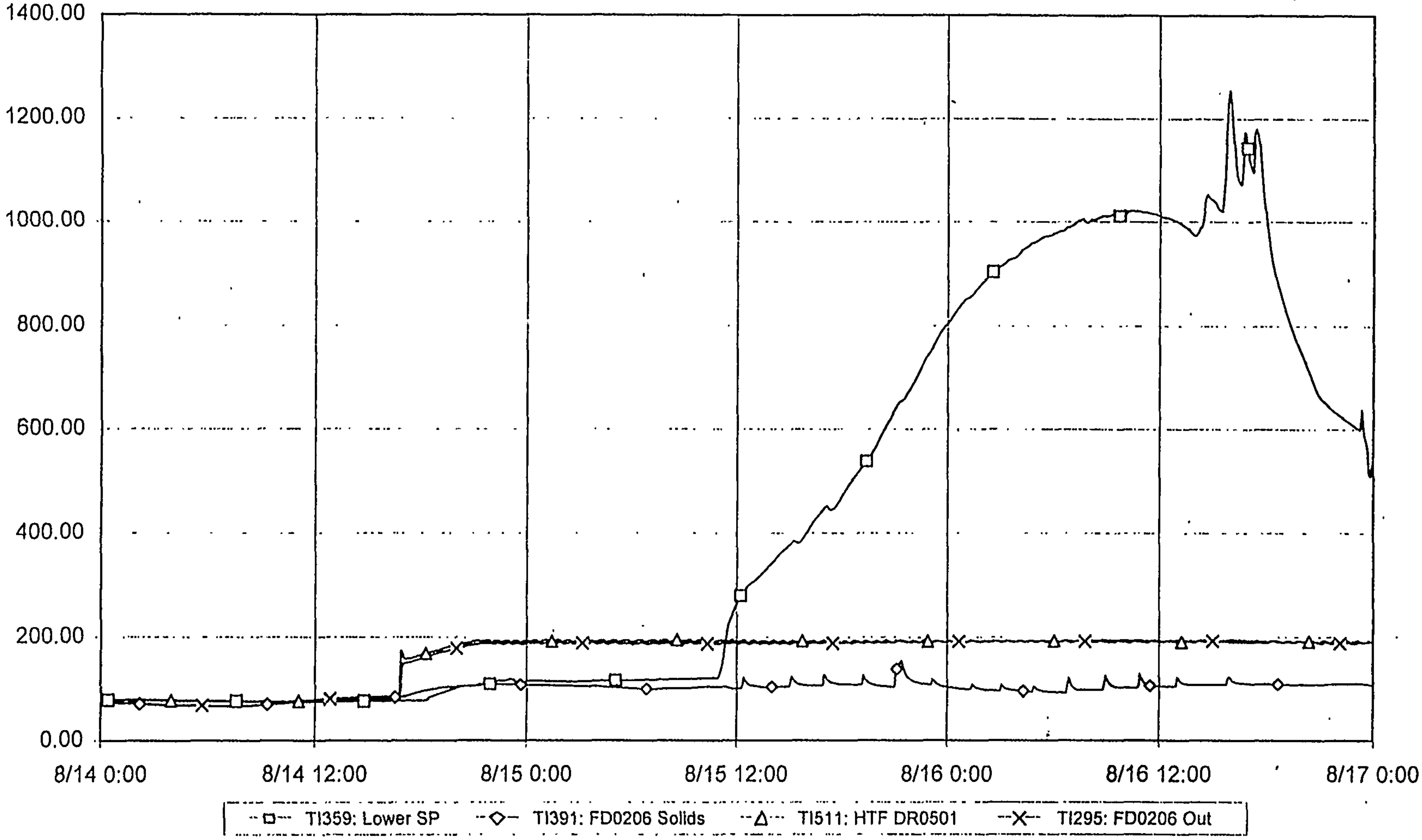
DOE Plot 23 of 47 - 5 minute data

5.1.7-18 O_2, SO_2, and NO_x Analyzers for August 14 Through August 16, 1996



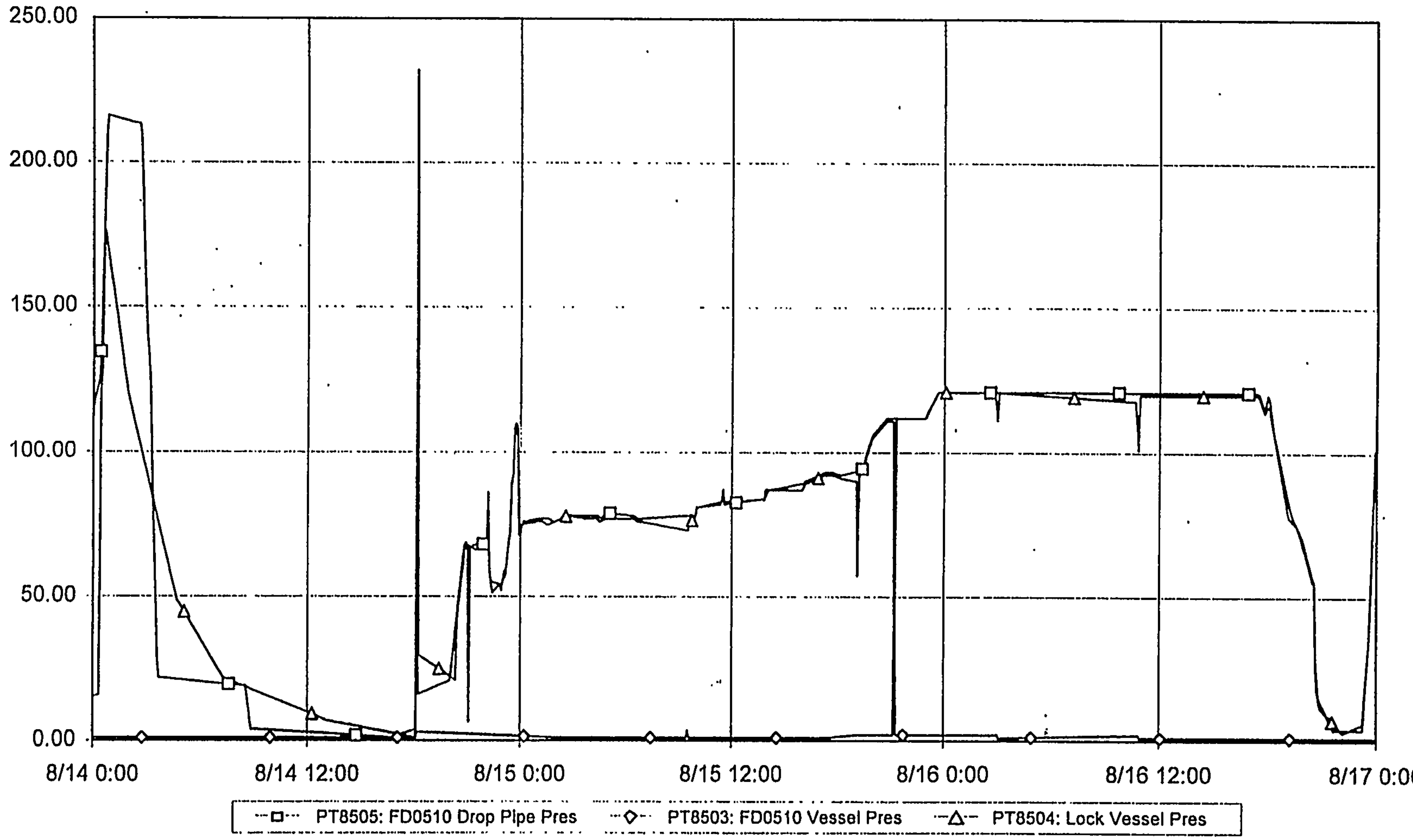
DOE Plot 24 of 47 - 5 minute data

5.1.7-19 CO and H_2O Analyzer for August 14 Through August 16, 1996



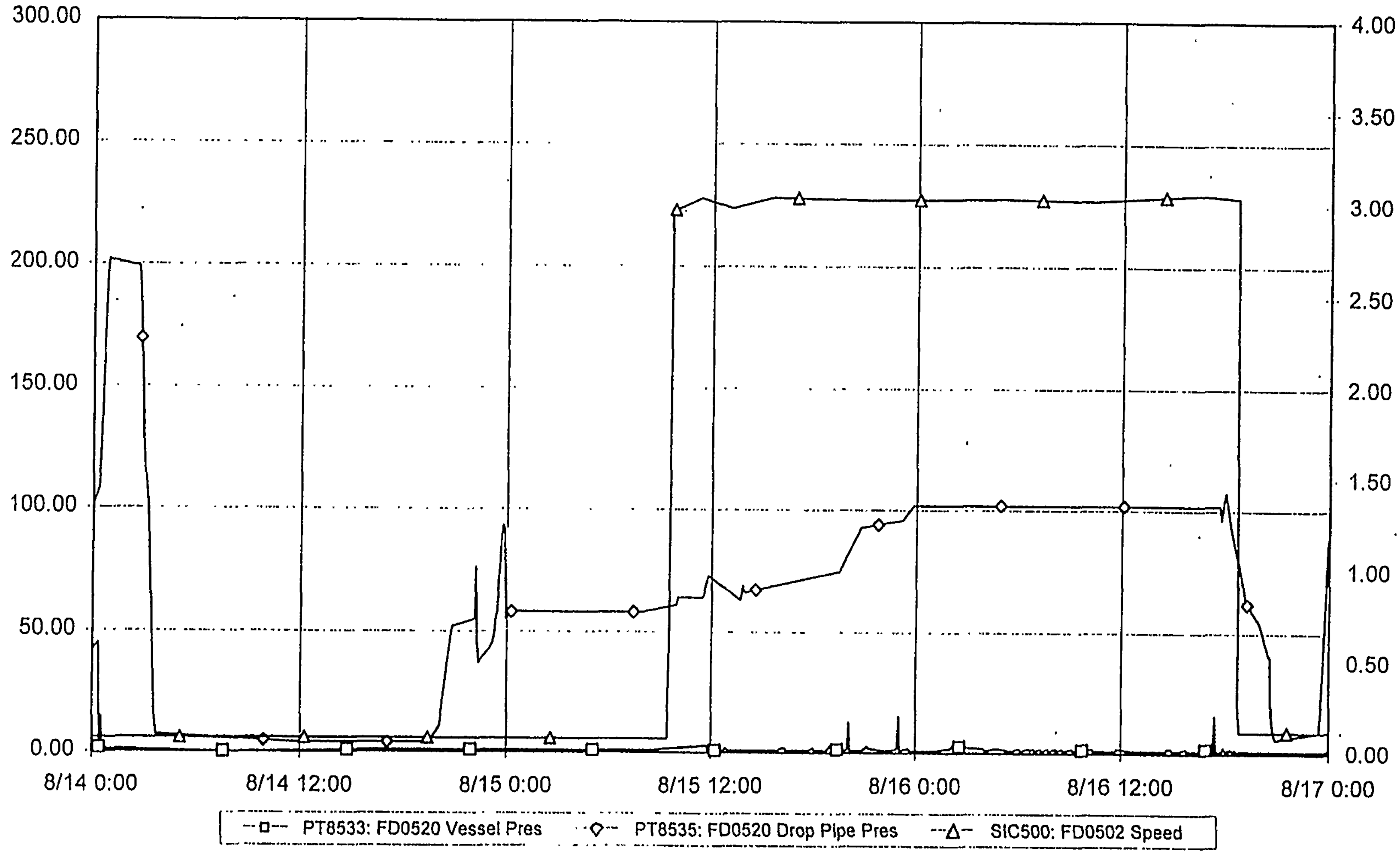
DOE Plot 28 of 47 - 5 minute data

5.1.7-20 FD0510 Temperature Profiles for August 14 Through August 16, 1996



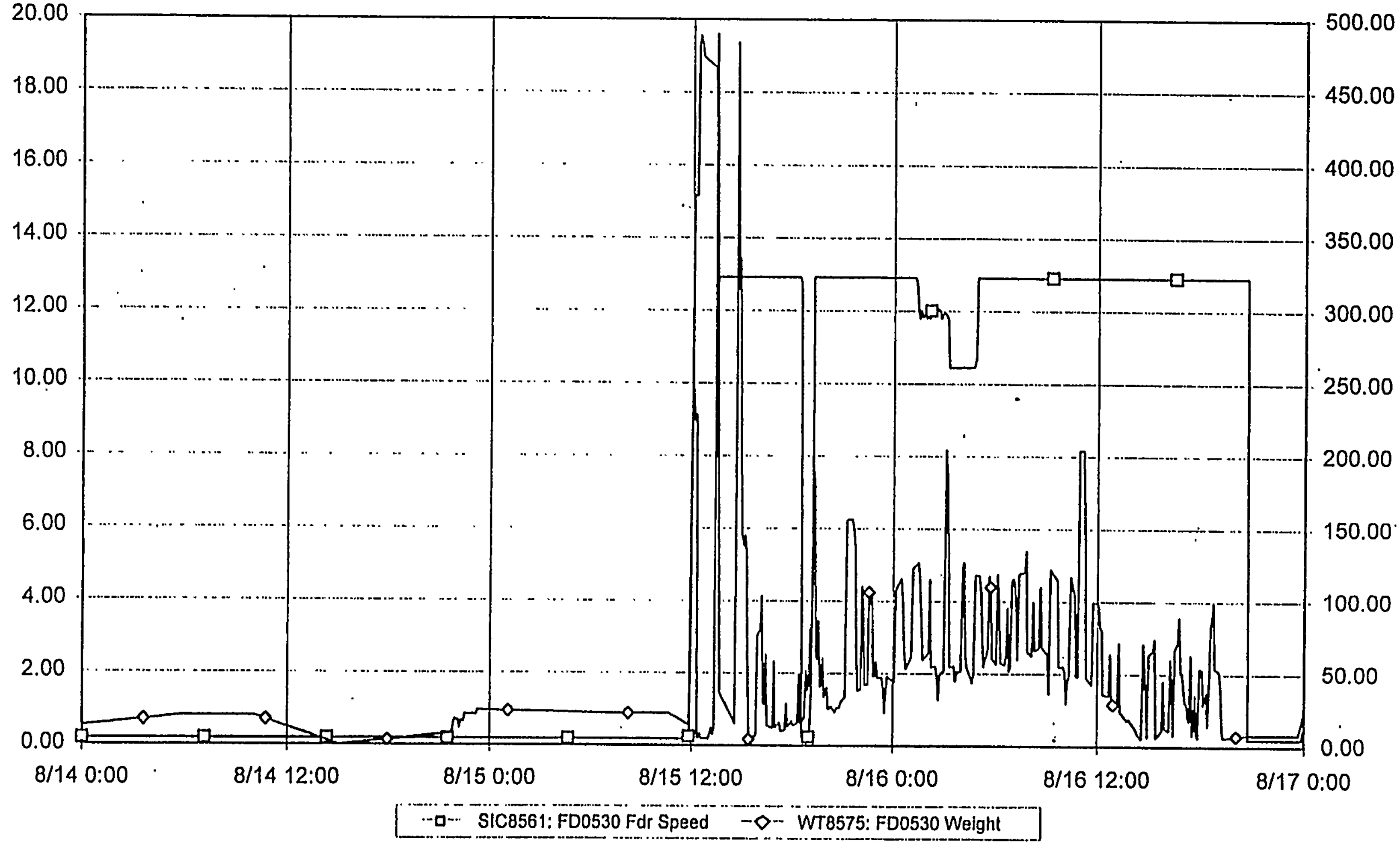
DOE Plot 29 of 47 - 5 minute data

5.1.7-21 FD0206 Pressure Profiles for August 14 Through August 16, 1996



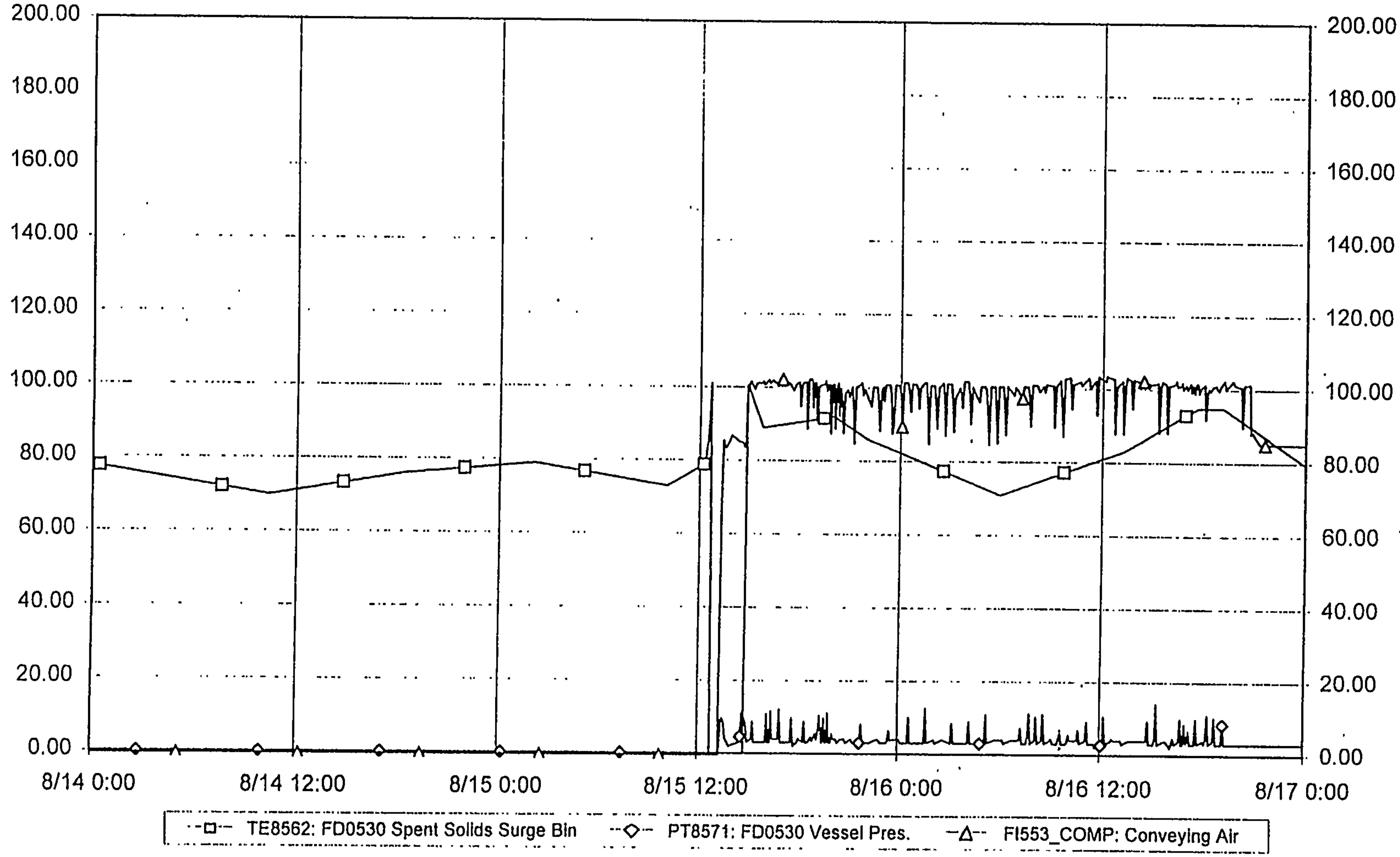
DOE Plot 30 of 47 - 5 minute data

5.1.7-22 FD0520 Pressures for August 14 Through August 16, 1996



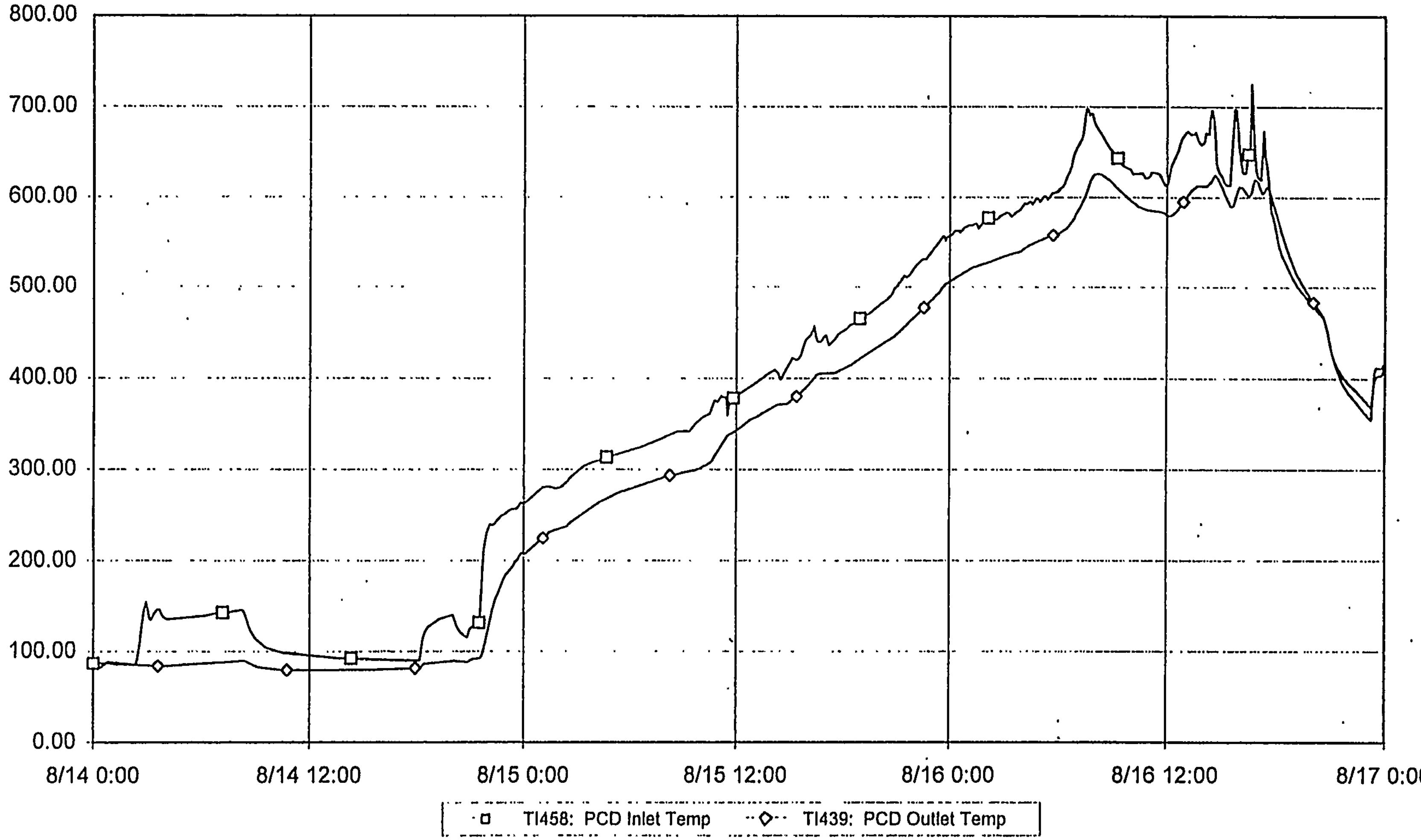
DOE Plot 31 of 47 - 5 minute data

5.1.7-23 FD0530 Feeder for August 14 Through August 16, 1996



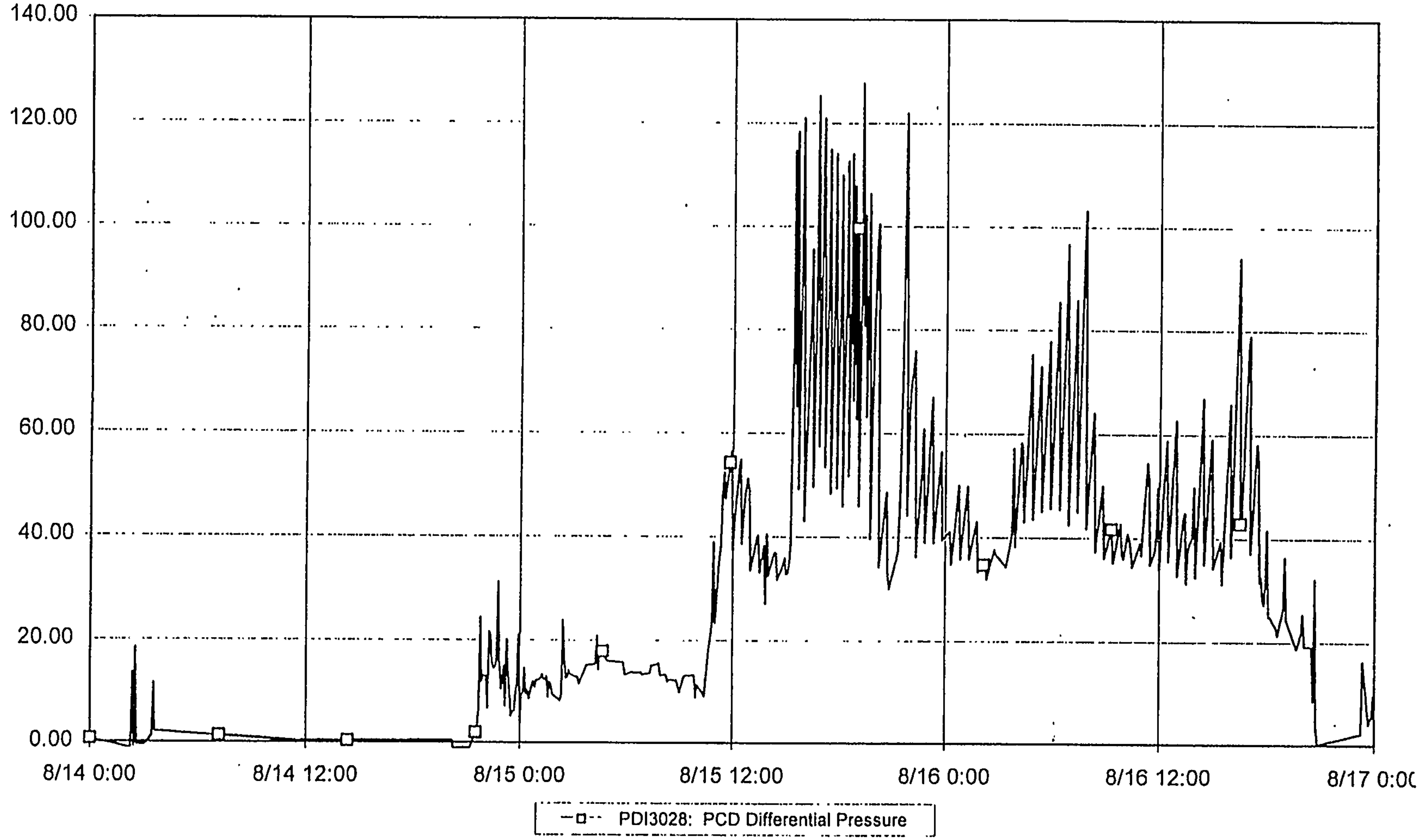
DOE Plot 32 of 47 - 5 minute data

5.1.7-24 FD0530 Feeder for August 14 Through August 16, 1996



DOE Plot 44 of 47 - 5 minute data

5.1.7-25 PCD Temperatures for August 14 Through August 16, 1996



DOE Plot 45 of 47 - 5 minute data

5.1.7-26 PCD Differential Pressures for August 14 Through August 16, 1996