3.0 CONCLUSIONS

The research work conducted was concentrated on the feasibility of using waste iron oxides in a simultaneous hot gas desulfurization and particulate filtration process. The test results indicated that the very heavy dust loading of iron oxide and coal ash mixture can be successfully dislodges with the use of back pulse cleaning technique. Heavy particulate filtration testing were repeated many times with a concentration more than 100,000 ppmw. The successful dust cake dislodging on very high dust loading and efficient hot gas desulfurization performance with the use of waste iron oxides provided assurance of the feasibility of the use of iron oxides as a disposable sorbent candidate for hot gas desulfurization work.

Based on the parametric test results of particulate filtration, a high efficiency filtration system can be optimized to filtrate particulate and have the dust cake removed with the use back pulse cleaning technology. The sharp increase of dust loading of iron oxides as a disposable sorbent can be successfully managed and cleaned during the particulate filtration process.

An innovative design was completed to evaluate the reaction time and residence time required for iron oxide on hot gas desulfurization at a wide spectrum of temperature. Reducing KRW-Gas stream with 5500 ppm hydrogen sulfide concentration was desulfurized with mixtures of coal ash and waste iron oxides to reduce hydrogen sulfide concentration to a safe level. Different ratio of iron oxides to coal ash mixture (same as the filtration testing) was utilized to evaluate the amount of iron oxides required in the coal ash and iron oxide mixtures (converted to space velocity after post test data analysis) to perform desulfurization task.

Based on the test results of hot gas desulfurization, disposable iron oxide can be injected into a strong reducing KRW gas, to absorb corrosive hydrogen sulfide. The major parameters of hot gas desulfurization include the reaction temperature, space velocity and the reaction time provided for iron oxide to absorb hydrogen sulfide from the hot gas stream. According to the test results of hot gas desulfurization described in section 2.2.6, it is encouraging to find out that waste iron oxides can be served as a disposable sorbent alternative to reduce the concentration level of hydrogen sulfide to a low ppm level, better than 200 ppm goal set for regenerable sorbent. The findings of hot gas desulfurization testing provides a guideline for hot gas desulfurization testing system design. The coordination of space velocity, residence time and reaction temperature could help develop an efficient and economical hot gas desulfurization system.

The particulate filtration testing also indicates that the use of waste iron oxides as sorbent additive could also aid dust cake maintain low differential pressure across the filtration chamber and the filtrated gas stream plenum. The back pulse cleaning technology was also verified to be capable to dislodge dust cake developed by heavy dust loading of mixtures of waste iron oxide and coal ash.

The use of disposable iron oxides as a desulfurization sorbent candidate will mitigate many constraints imposed on current sorbent candidates. Physical attrition and reducing of iron oxides for reducing gas are not issues any more for iron oxides to act as a sorbent candidate.

The less stringent operating temperature requirement of lower operating temperature IGCC and PFBC system will also justify the use of iron oxides as the low cost desulfurization sorbent alternative, because it is efficient for iron oxides for desulfurization application at lower operating temperatures. The use of standard off shelf components for particulate cleanup system will accelerate the realization of new IGCC and PFBC power systems for industries.

The use of disposable sorbent can also eliminate the needs of sorbent regeneration process, saving a lot of initial capital investment and downstream operation and maintenance expenses required for current regenerable sorbent applications.

The very low cost of waste iron oxide material and the elimination of the capital investment on sorbent regeneration system make it attractive to use waste iron oxide as a disposable sorbent alternative to replace the regenerable sorbent candidates developed in the last decade. The additional savings on lower operation and maintenance expenses justify various economical benefits of the use waste iron oxides as the disposable sorbent candidate on the operation of simultaneous hot gas desulfurization and particulate filtration for hot gas cleanup applications.

According to the parametric testing results of particulate filtration and hot gas desulfurization, it concluded that the use of disposable iron oxide as an alternative of desulfurization sorbent during coal combustion or coal Gasification processes is feasible.

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Table 1. Differential Pressure Measurement Data

Time Min	Pr. Diff 1:0 Ratio	Pr. Diff 1:0 Ratio	Pr.Diff 1:0.5 Ratio	Pr.Diff 1:0.5 Ratio	Pr. Diff 1:1 Ratio	Pr.Diff 1:1 Ratio	Pr. diff 1:2 Ratio	Pr.Diff. 1:2 Ratio
0	2.9	3.1	2.97	2.83	3.54	3.18	2.62	2.77
2	7.825	4.76	8.05	7.71	8.59	5.67	5.99	6.19
4	9.32	9.5	9.3	8.67	10.02	6.23	6.47	7.2
6	10.375	10.49	9.79	9.04	10.75	6.52	6.77	7.55
8	10.985	10.9	10.51	9.01	11.25	6.6	6.97	7.7
10	11.545	11.43	11.35		11.62		7.11	
12	12.005	11.75	11.73		11.65			
14		11.96						

Time min	Av. pr. diff 1:0 ratio	Av Pr. diff 1:0.5 ratio	Av. Pr. diff 1:1 ratio	Av. Pr. diff 1:2 ratio
0	2.955	2.9	3.36	2.69
2	6.292	7.88	7.13	6.09
4	9.36	8.98	8.12	6.83
6	10.432	9.41	8.63	7.16
8	10.942	9.76	8.92	7.33
10	11.487			
12	11.877			
14	11.96			

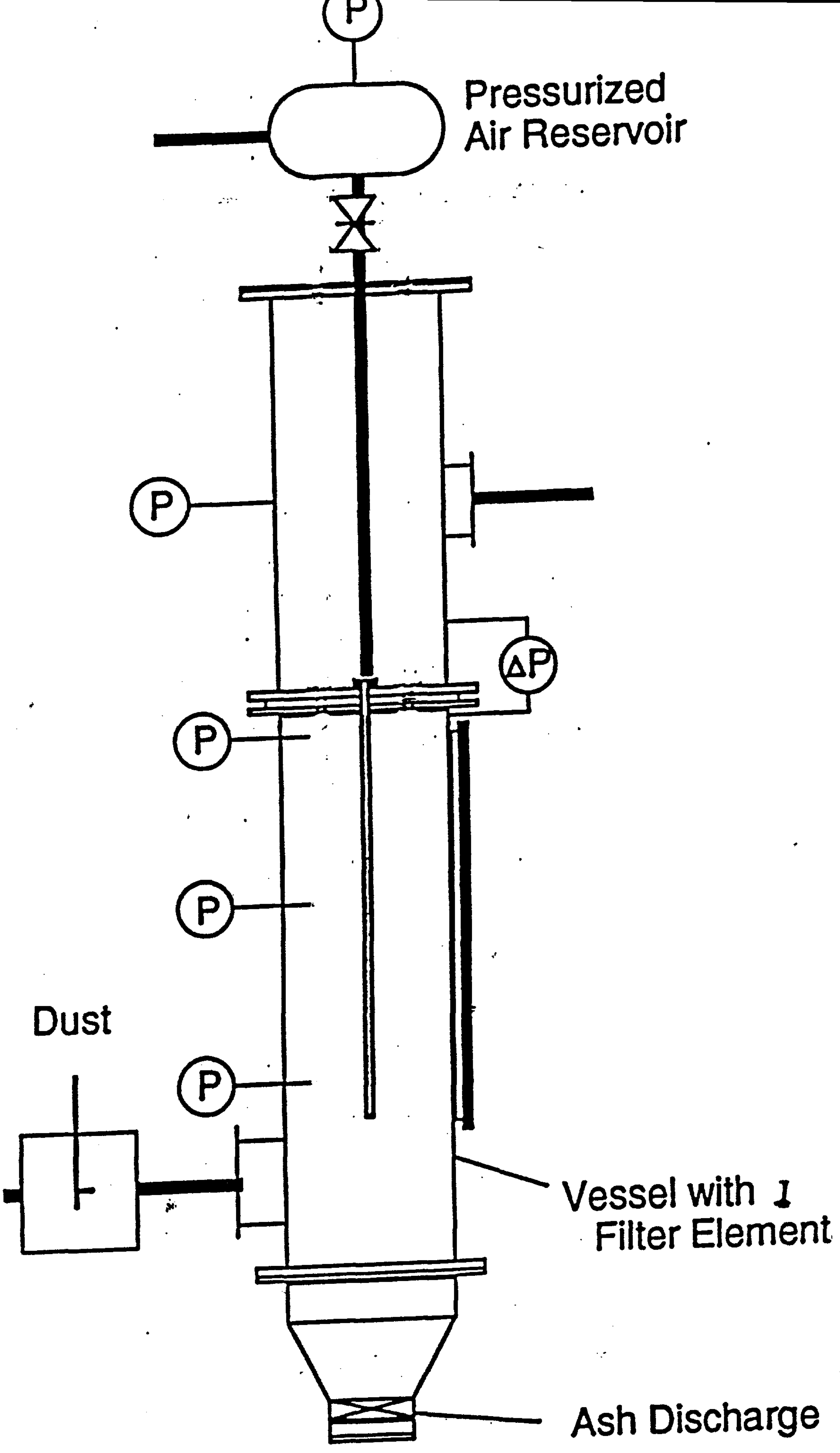


Figure A. Filter Cleaning Test Facility

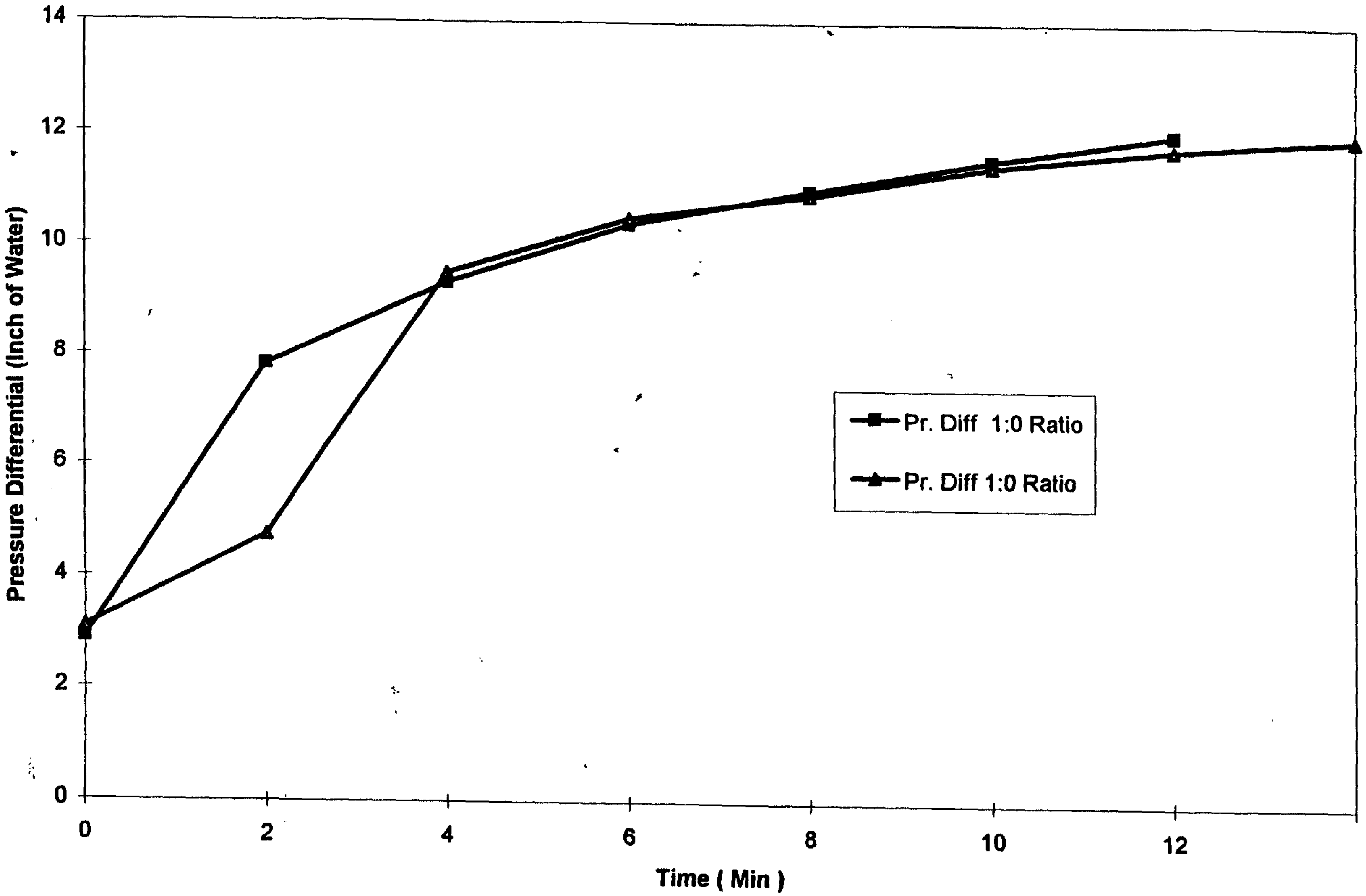


Figure 1 Dust Build up Pattern for 1:0 Ash &Iron Oxide Ratio

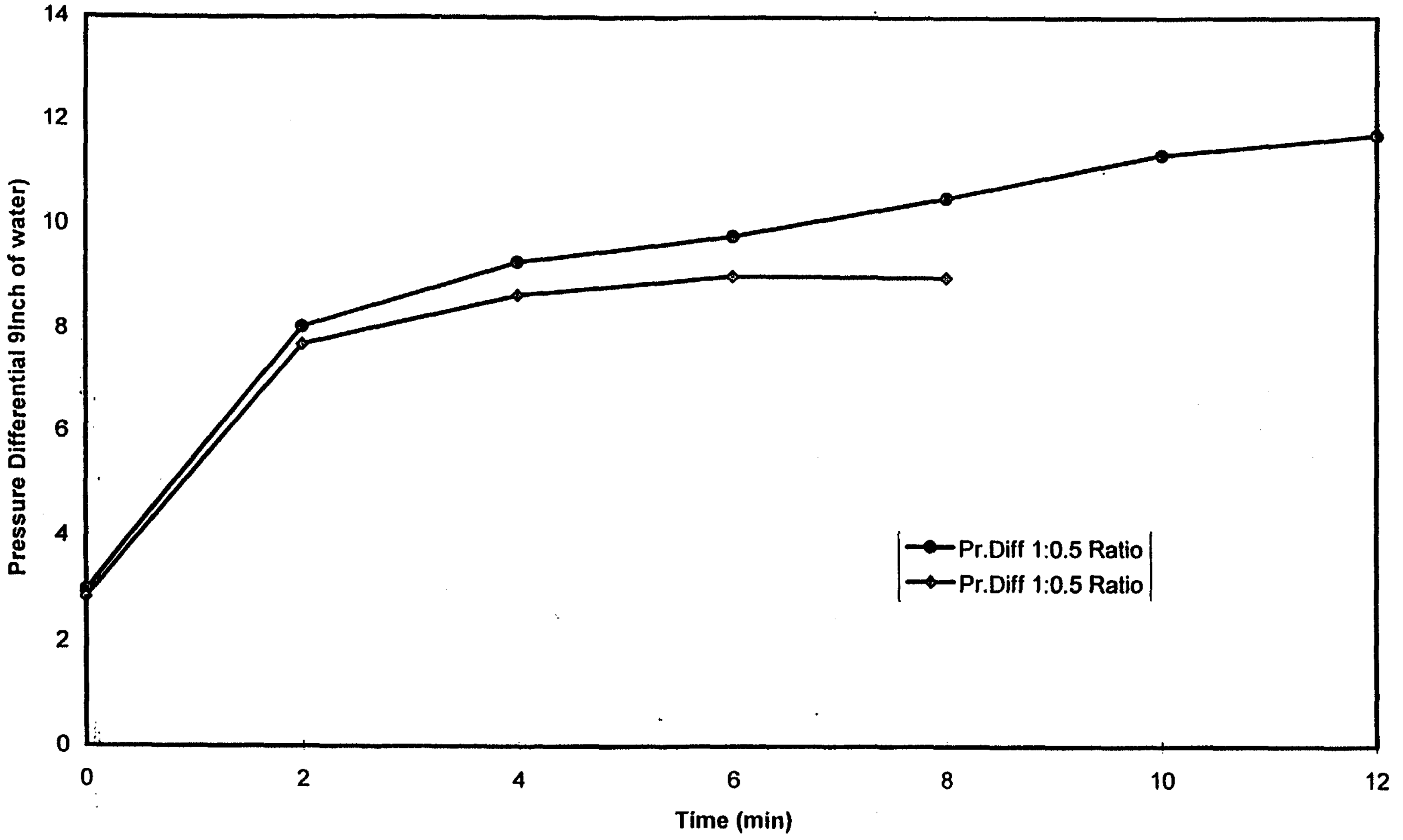


Figure 2. Dust Build up pattern for 1:0.5 Coal Ash & Iron Oxide Ratio

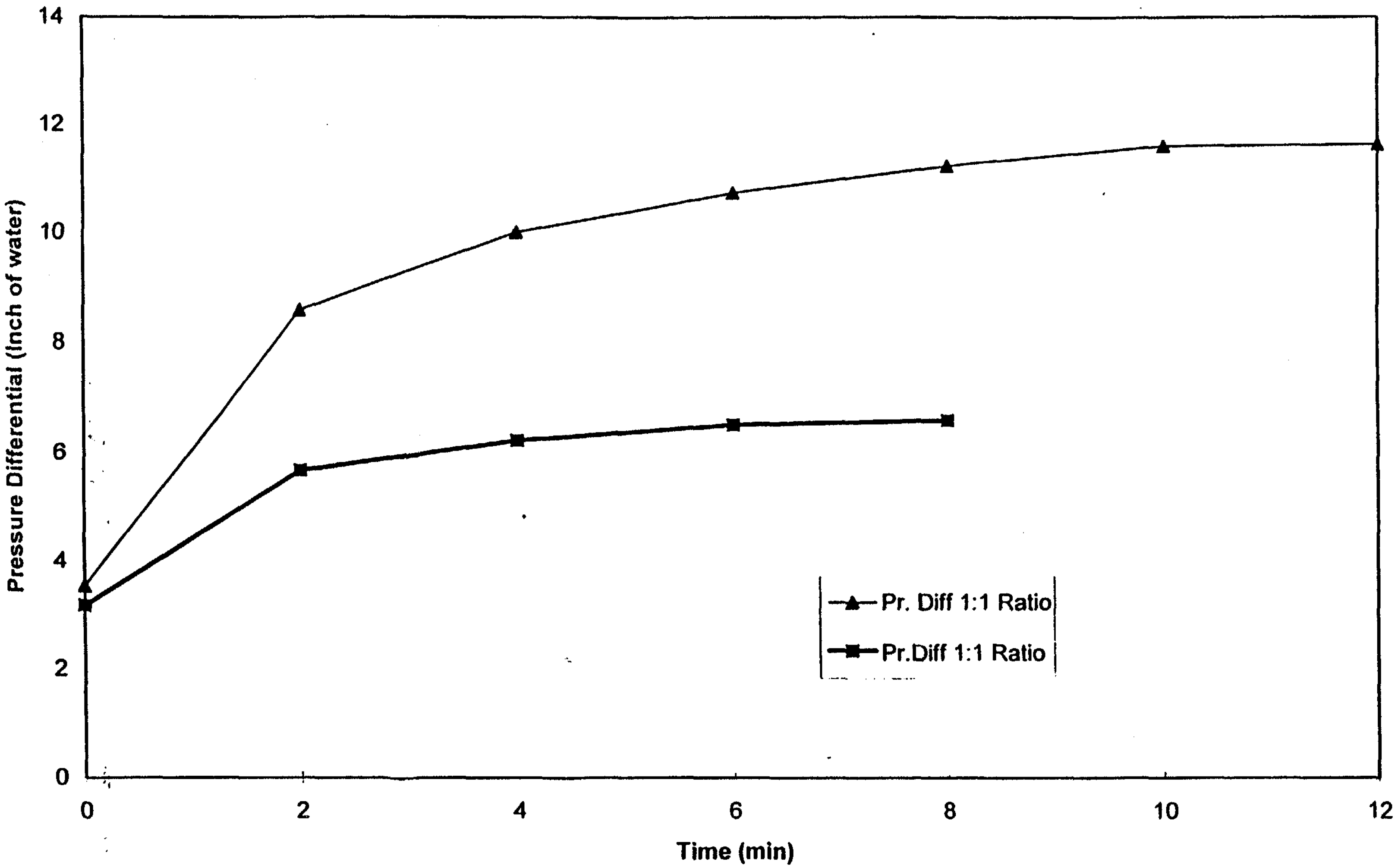


Figure 3 Dust Build up Pattern for 1:1 Coal Ash & Iron Oxide Ratio

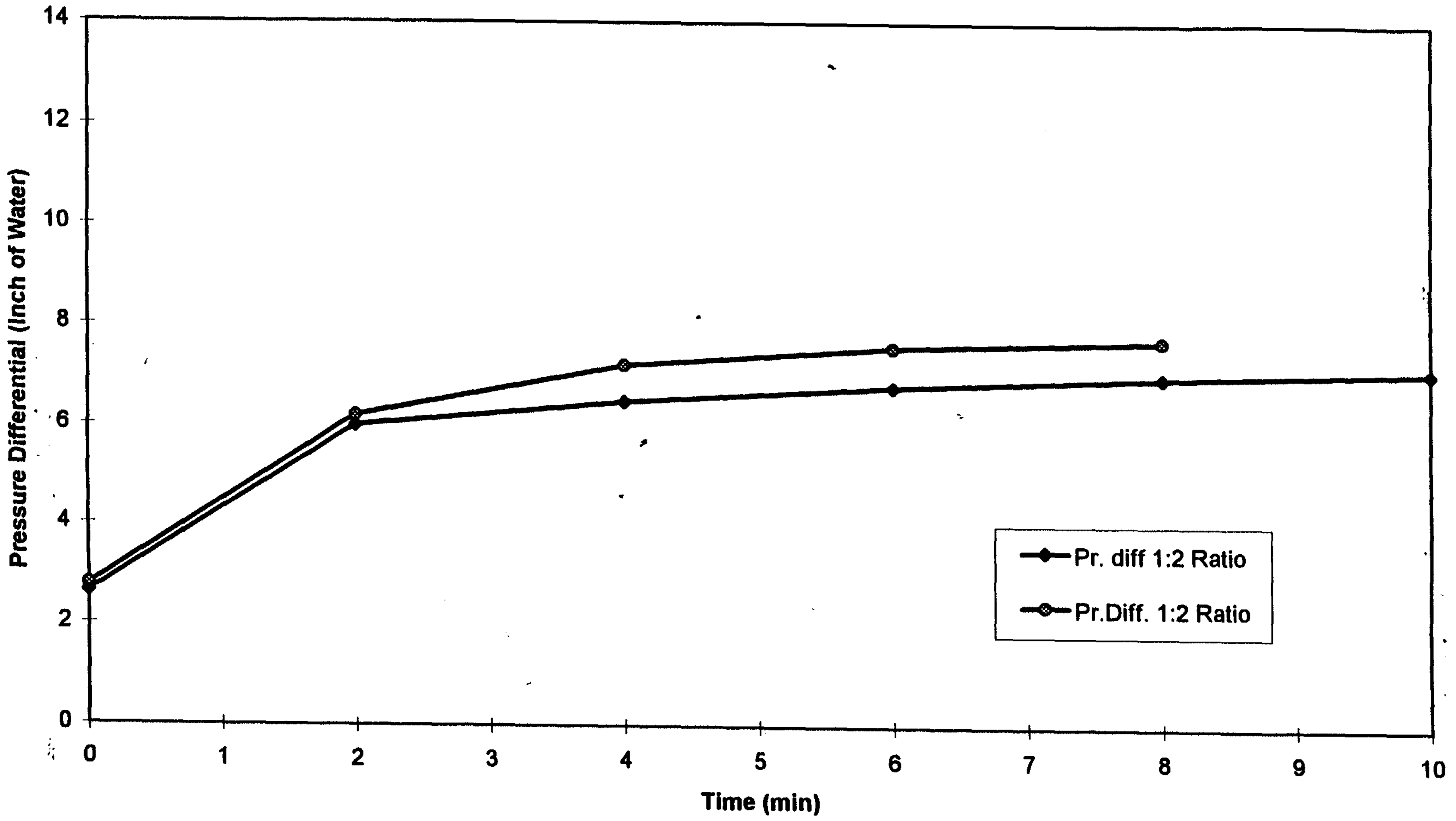


Figure 4. Dust Build up Pattern for 1:2 Coal & Iron Oxide ratio

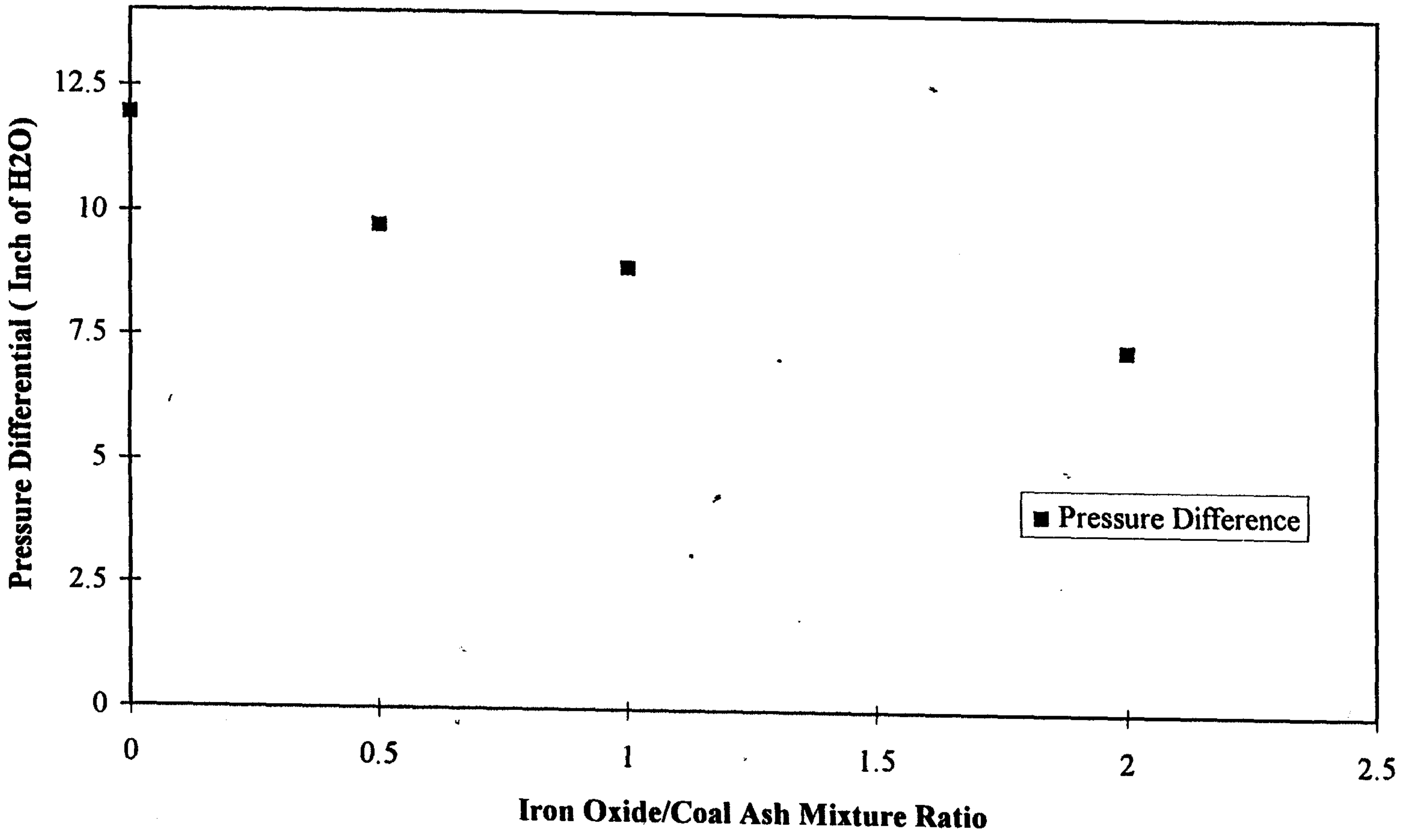


Figure 5. Pressure Difference with Ratio of Iron Oxide to Coal Dust by Weight

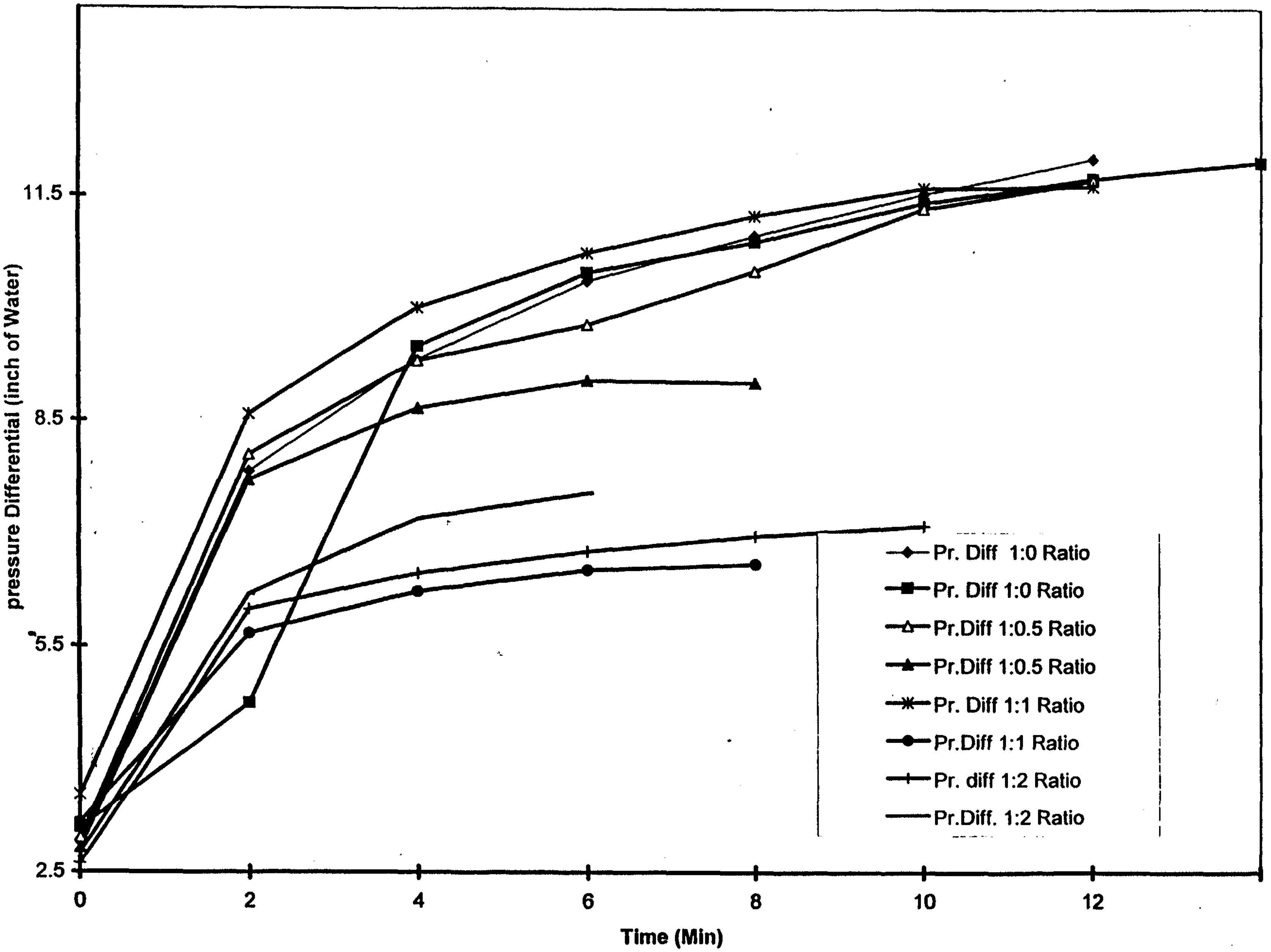


Figure 6a. Dust Build up pattern for different mixture Ratio

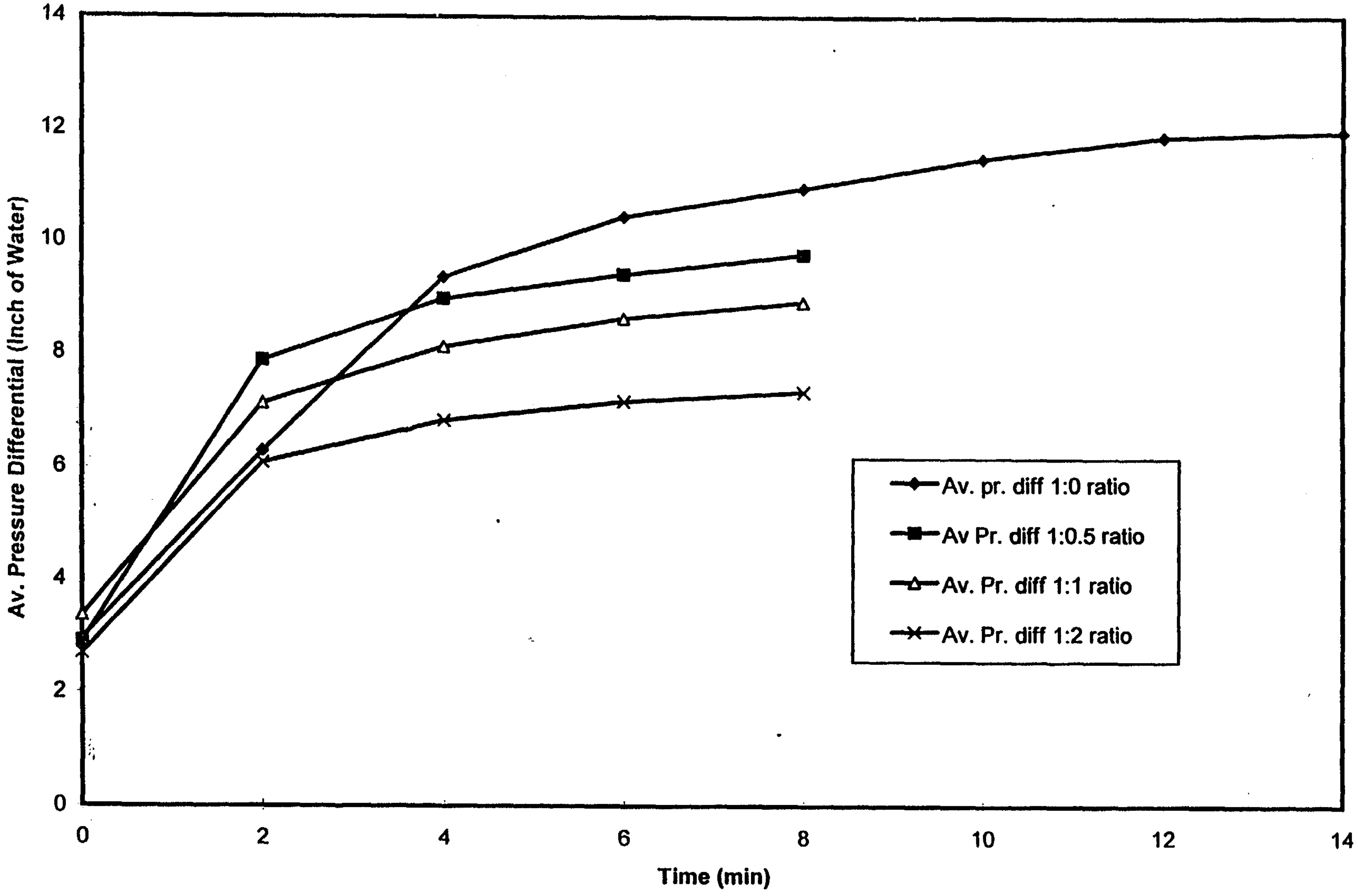


Figure 6b. Dust Build up pattern for Diff. Mixture Ratio

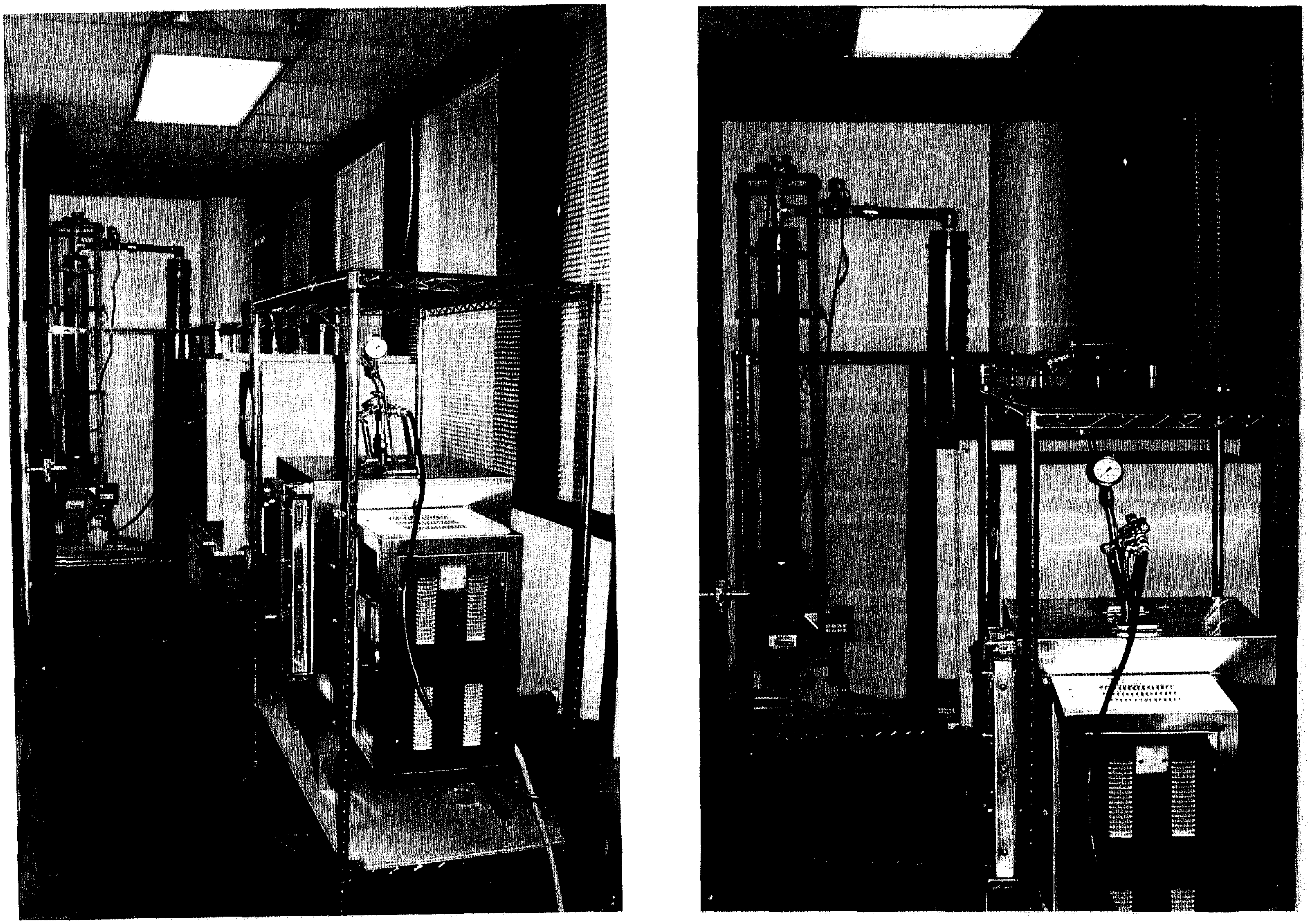


Figure 7. Test Setup

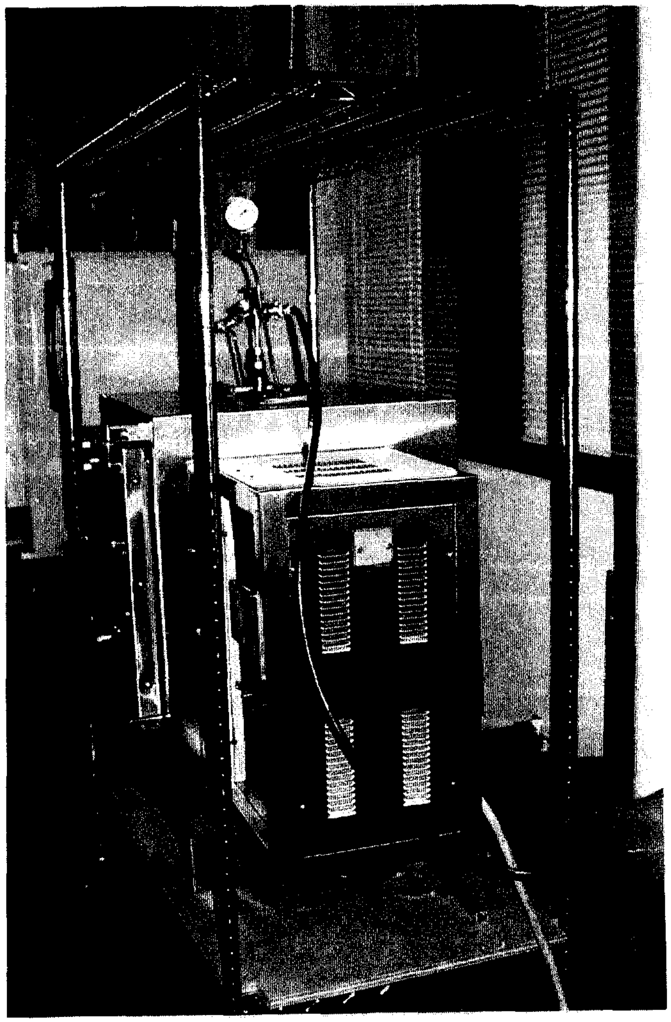


Figure 8a. Sub Assembly of Test Setup
(Preheat and Reactor Ovens)

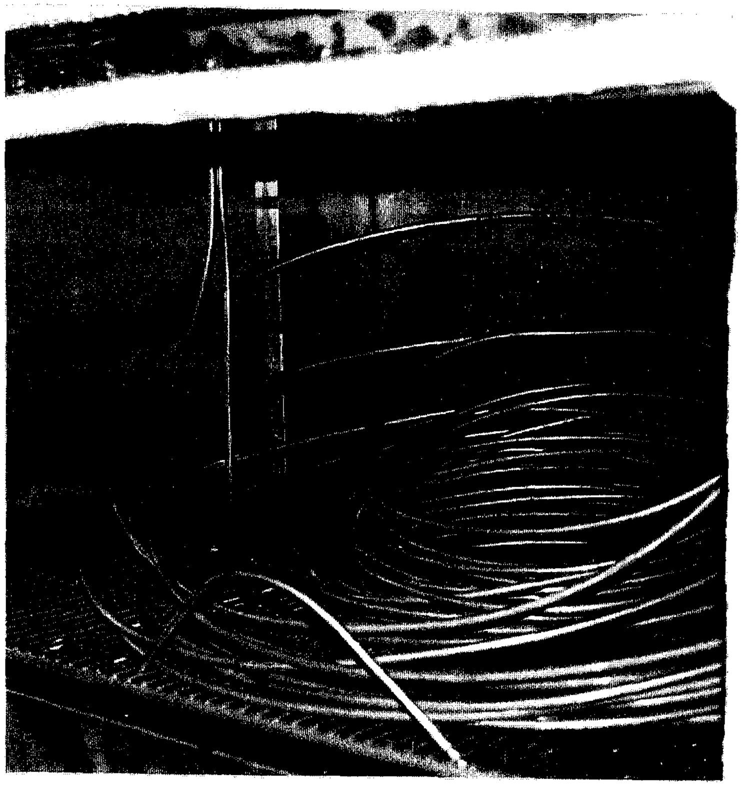


Figure 8b. Sub Assembly of Test Setup
(Coil Tubing Assembly)

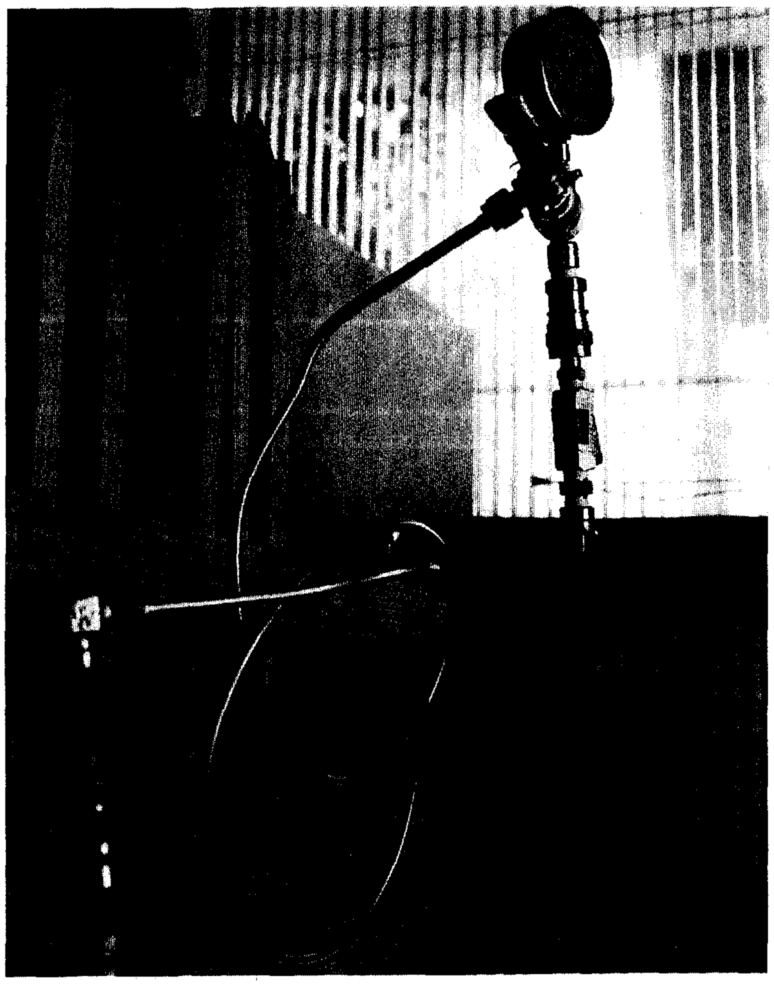


Figure 8c. Sub Assembly of Test Setup
(Reactor Gas Assembly Setup)

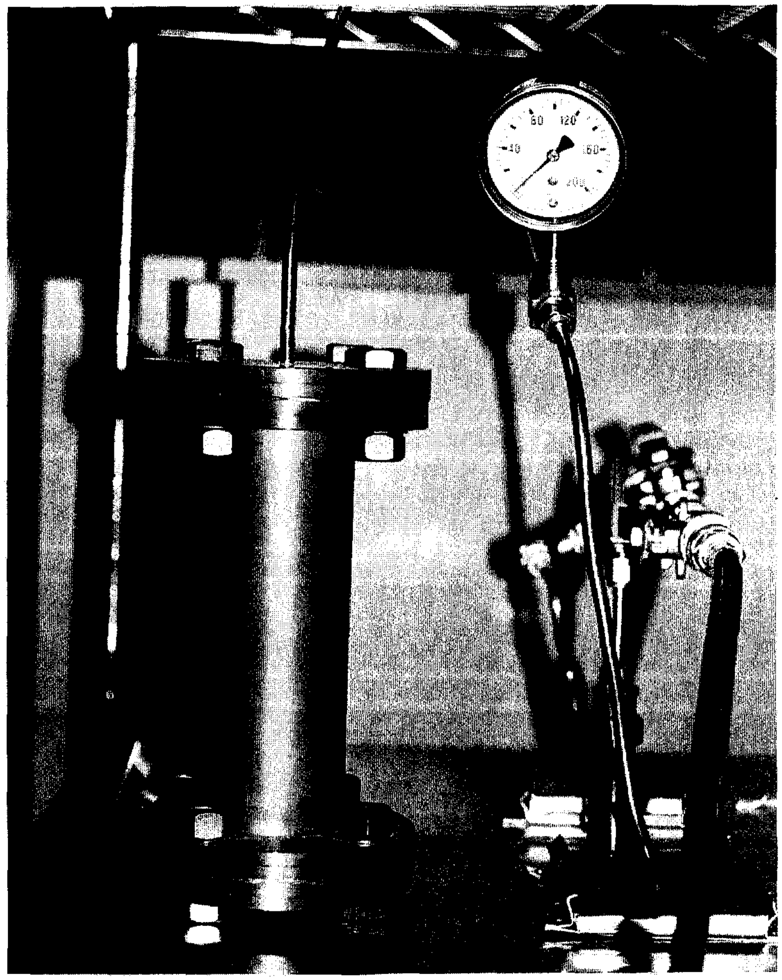


Figure 8d. Sub Assembly of Test Setup
(Reactor Chamber)

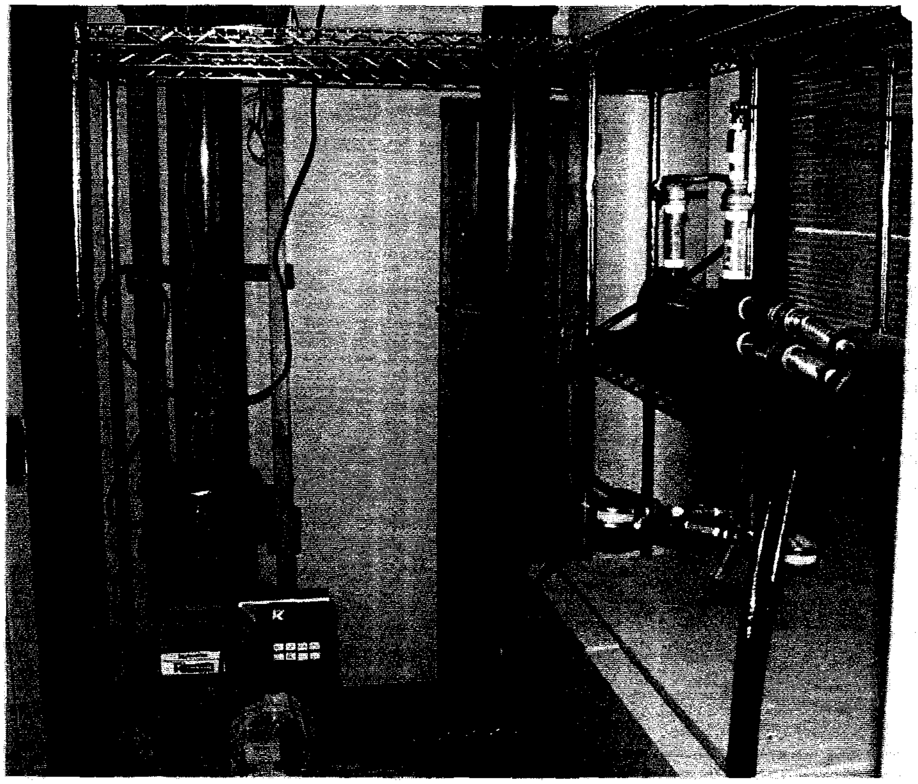


Figure 9a. Heat Exchanger and Particulate Filtration Assembly

Figure 9b. Gas Supply and Post Gas Treatment Assembly

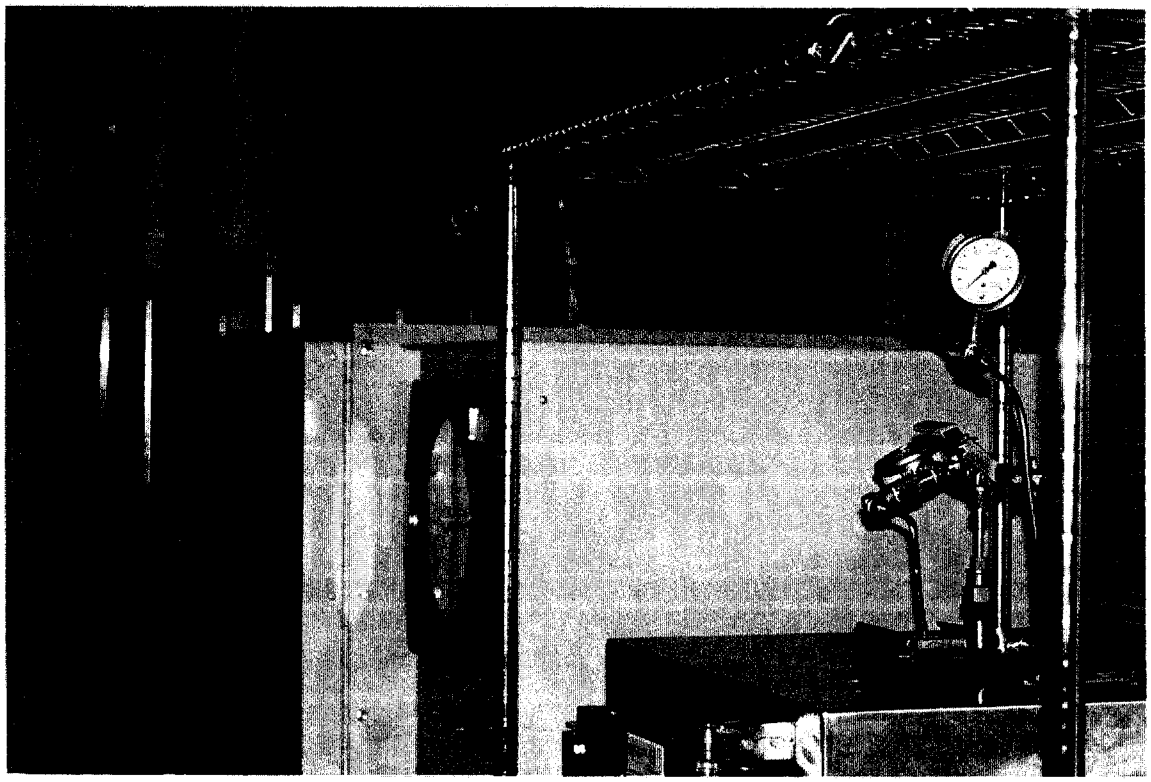


Figure 9c. Reactor Assembly

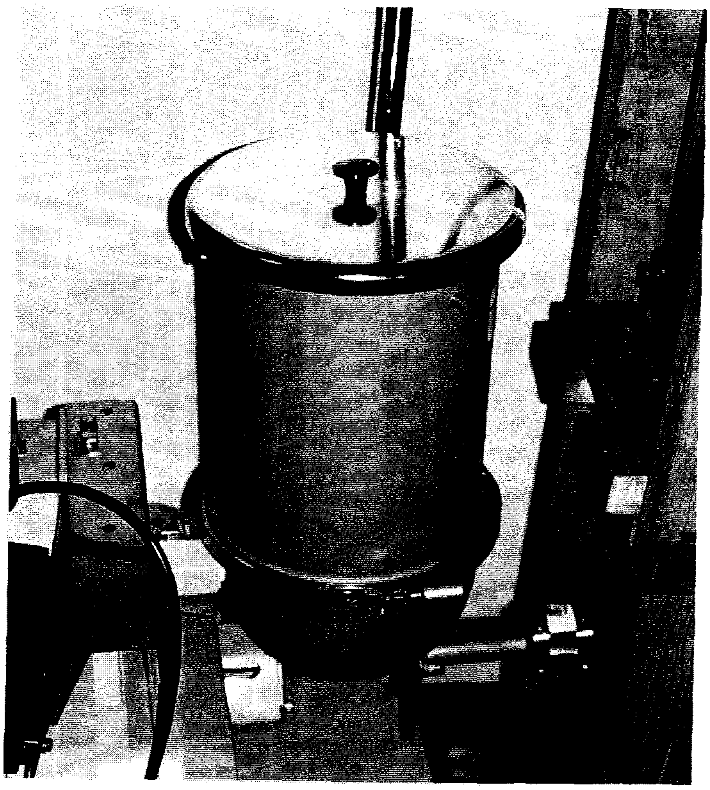


Figure 10a. K-Tron Dust Feeder

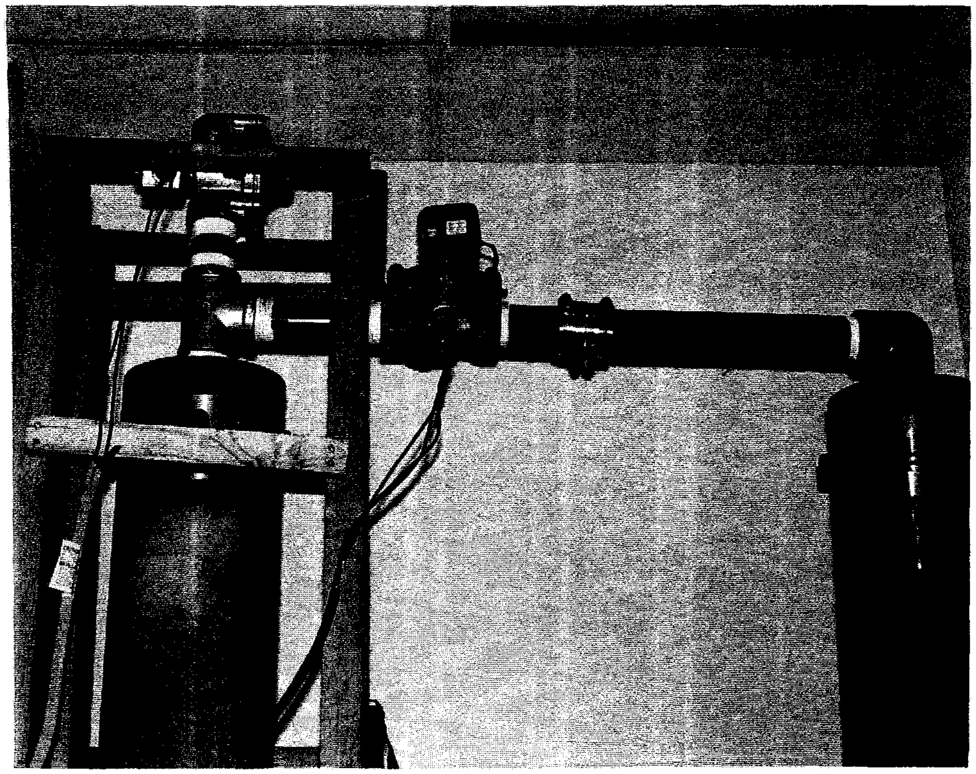


Figure 10b. Fast Response Solenoid Valve

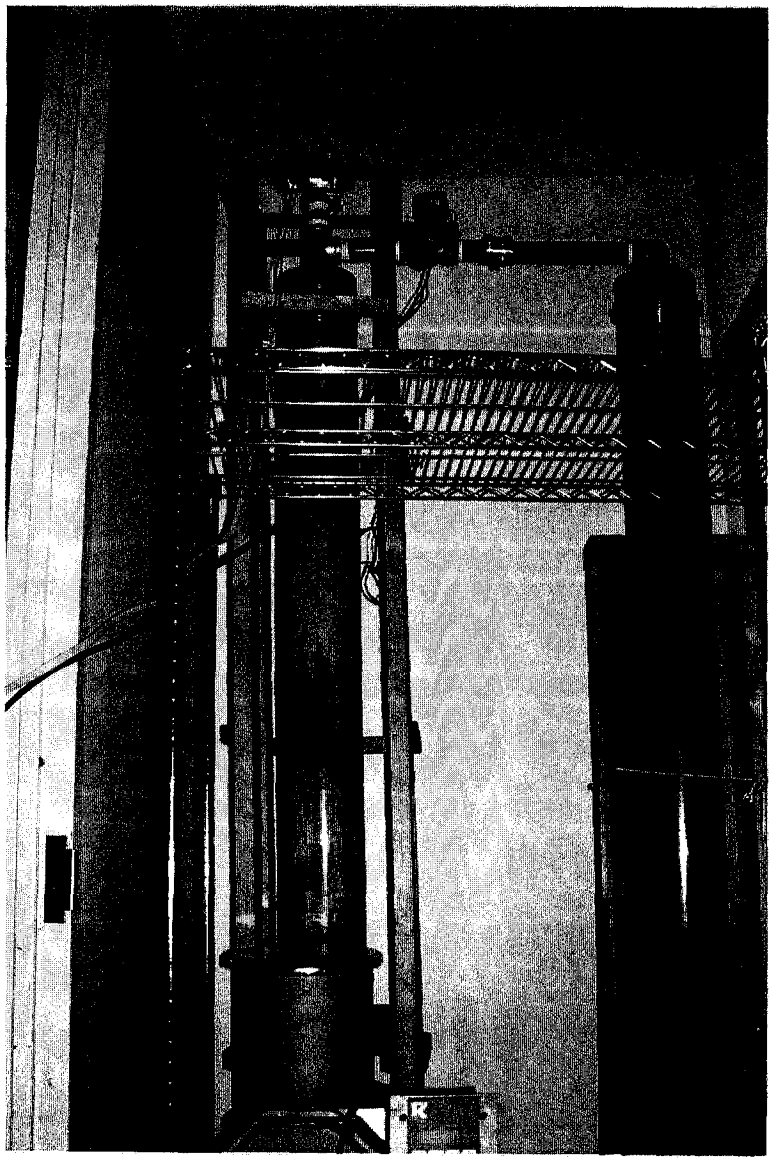


Figure 10c. Fast Response Solenoid Valve

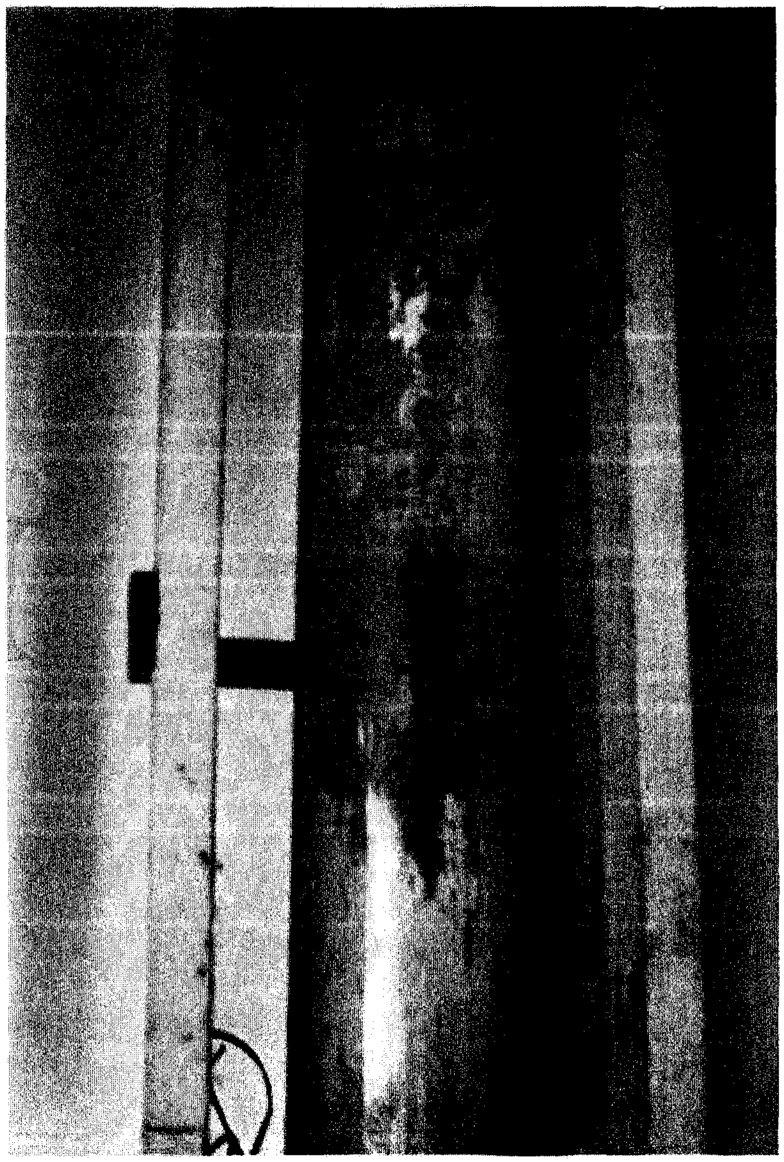


Figure 10d. Candle Filter After Dust Cake Dislodging

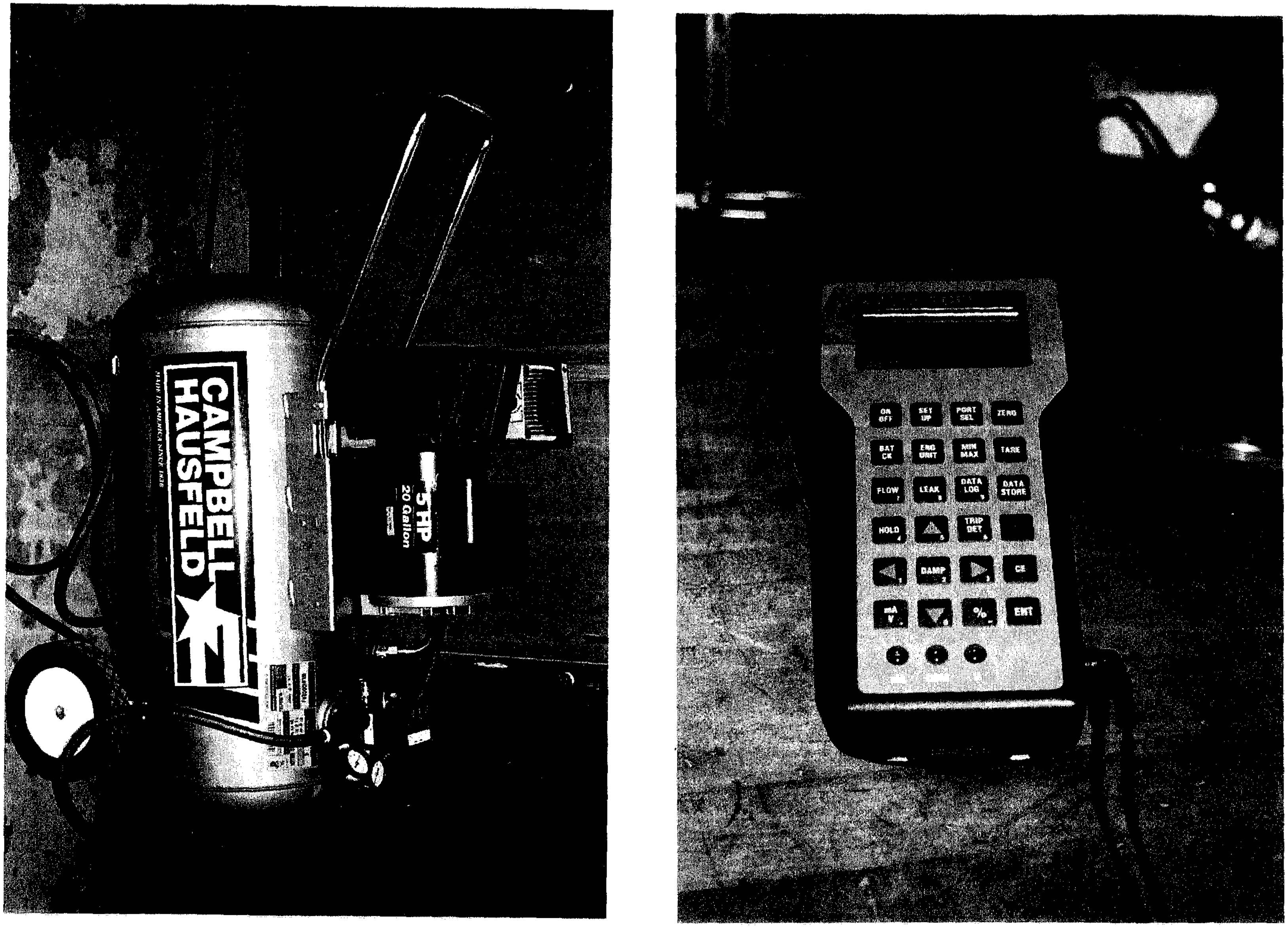


Figure 11. Air Compressor and Ashcroft Delta P Pressure Calibrator

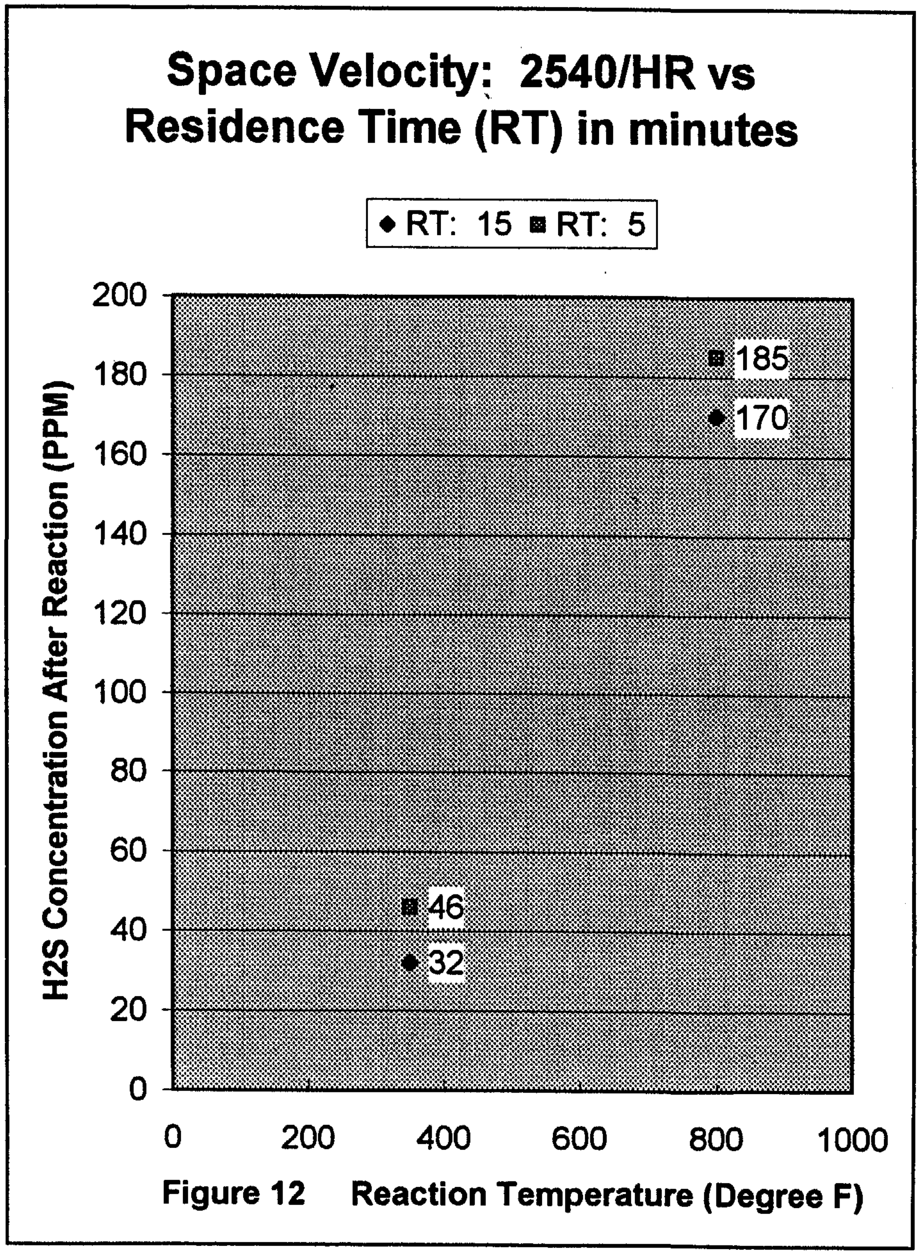

Space Velocity: 2540/HR vs Residence Time (RT) in minutes
◆ RT: 15 ■ RT: 5
H2S Concentration After Reaction (PPM)
200
180
160
140
120
100
80
60
40
20
0
185
170
46
32
0
200
400
600
800
1000
Reaction Temperature (Degree F)

Figure 12

Space Velocity: 4560/HR vs Residence Time (RT) in minutes

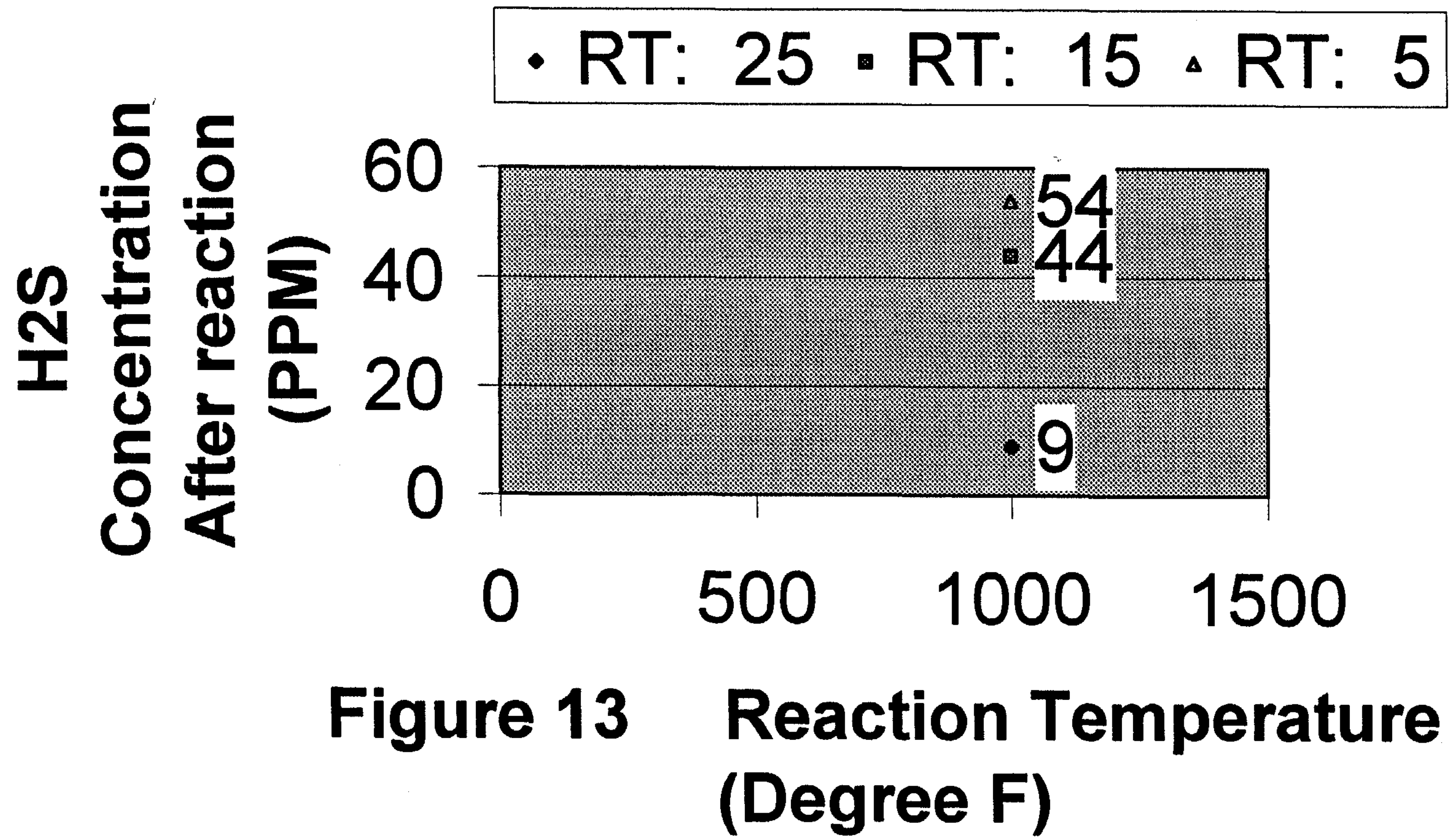


Figure 13

Space Velocity: 5500/HR vs Residence Time (RT) in minutes

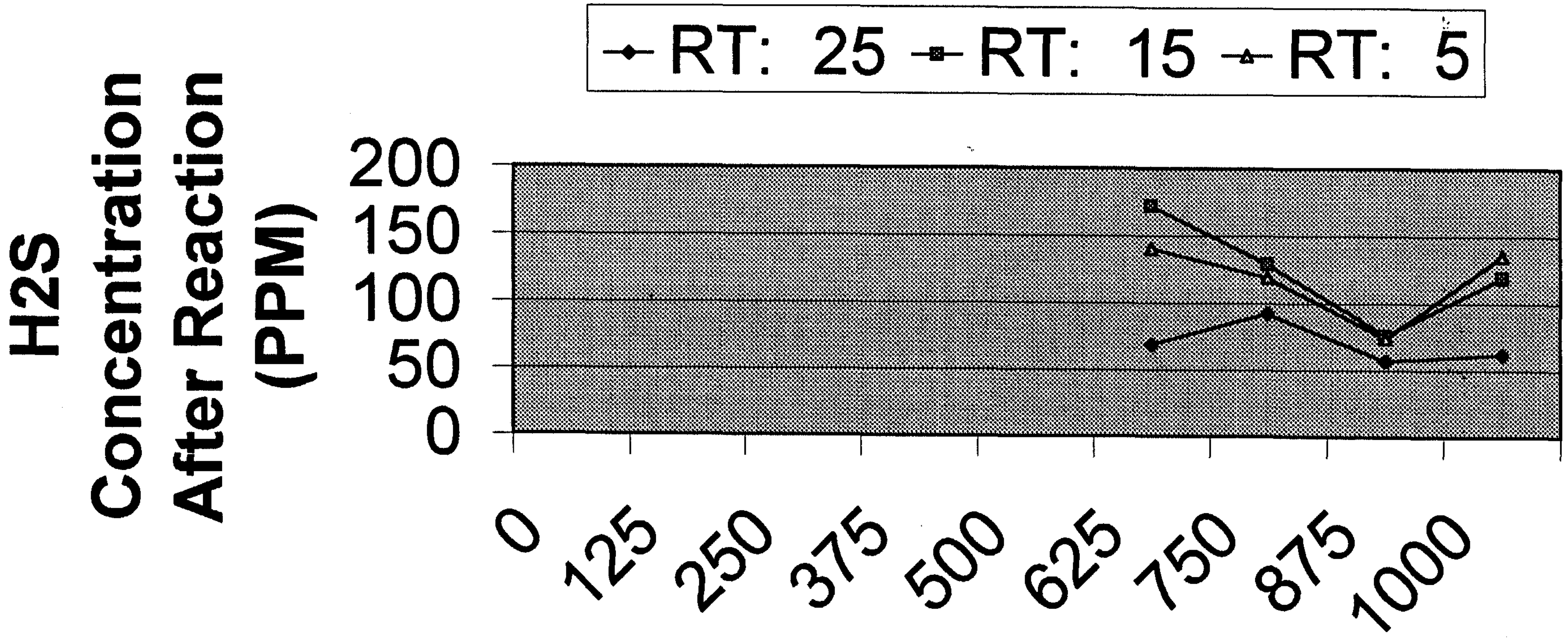


Figure 14 Reaction Temperature (Degree F)

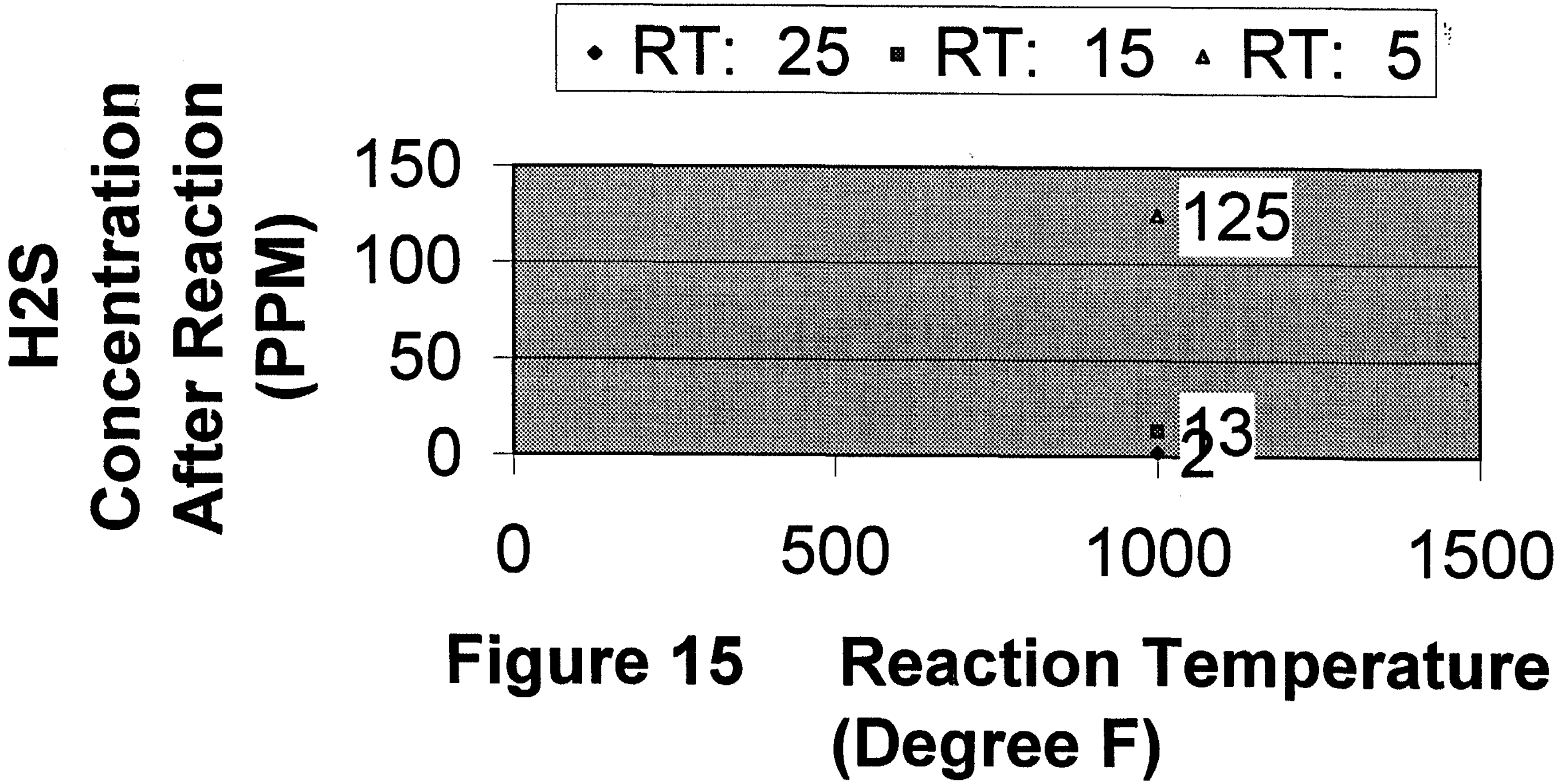

Space Velocity: 9100/HR vs Residence Time (RT) in minutes
◆ RT: 25
■ RT: 15
▲ RT: 5
H2S Concentration After Reaction (PPM)
150
100
50
0
125
13
2
0
500
1000
1500
Reaction Temperature (Degree F)

Figure 15

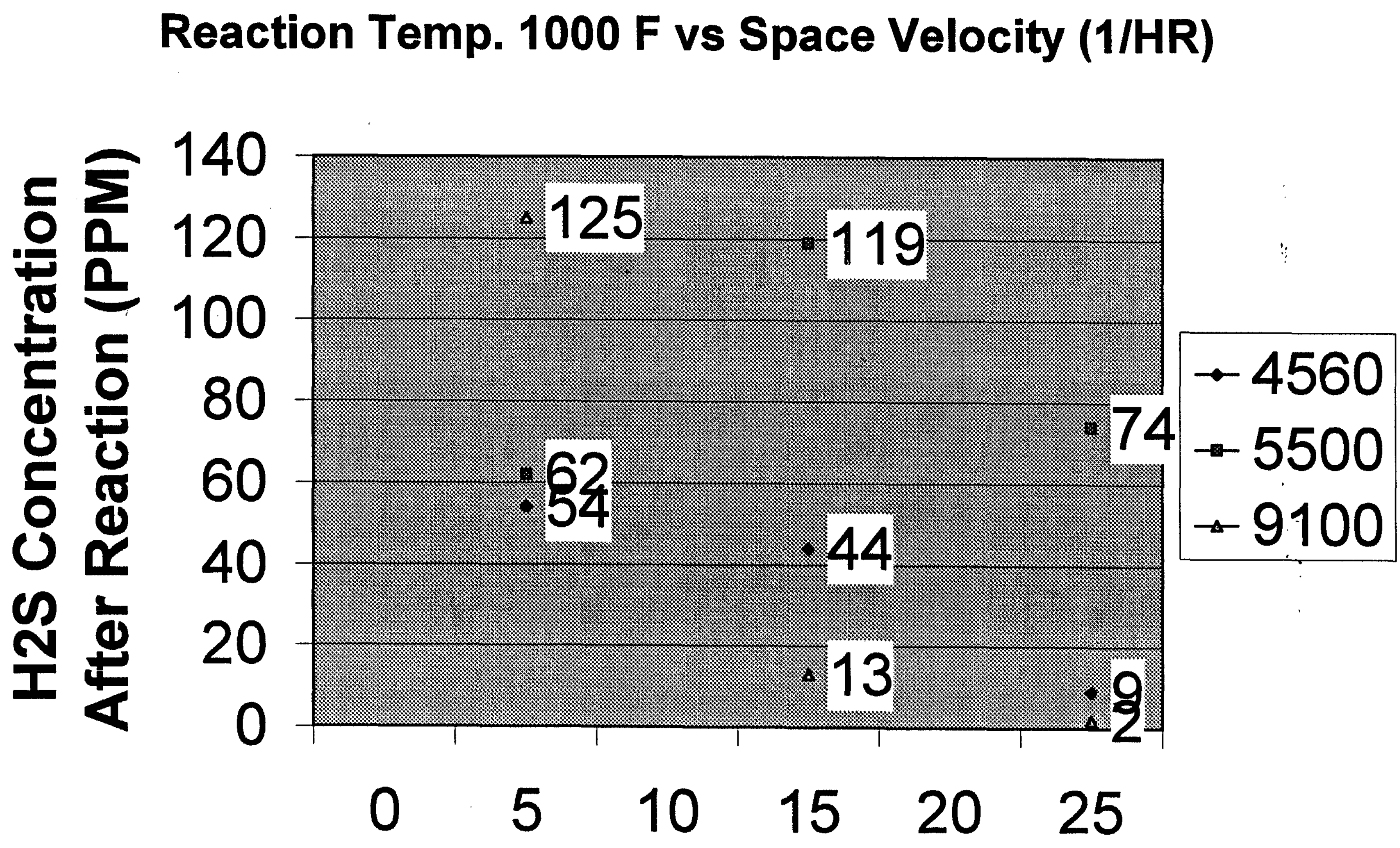

Reaction Temp. 1000 F vs Space Velocity (1/HR)
H2S Concentration After Reaction (PPM)
140
120
100
80
60
40
20
0
0
5
10
15
20
25
Residence Time (minutes)
125
119
62
54
44
13
74
9
2
4560
5500
9100

Figure 16

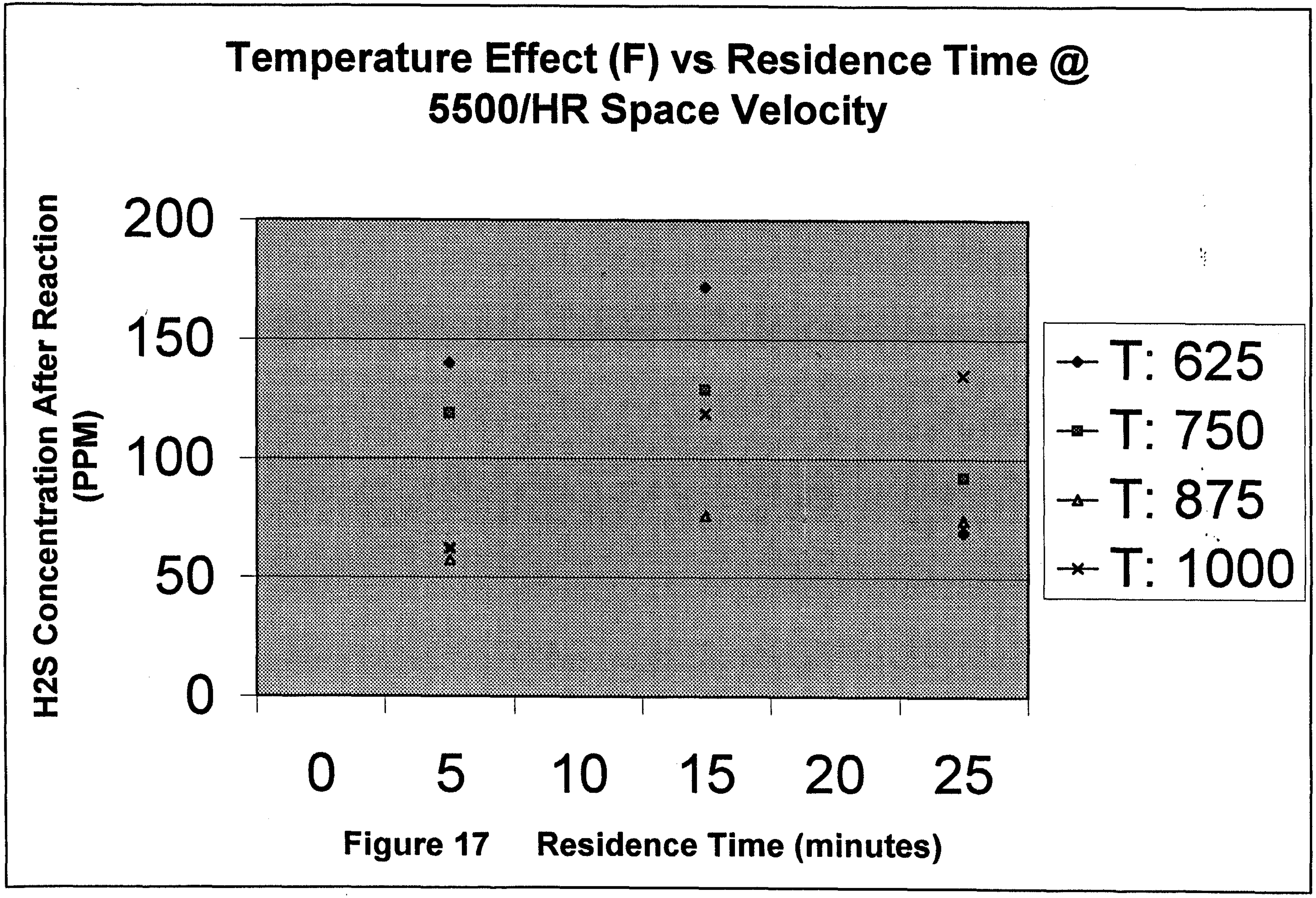

Temperature Effect (F) vs Residence Time @ 5500/HR Space Velocity
H2S Concentration After Reaction (PPM)
200
150
100
50
0
0
5
10
15
20
25
Residence Time (minutes)
T: 625
T: 750
T: 875
T: 1000

Figure 17

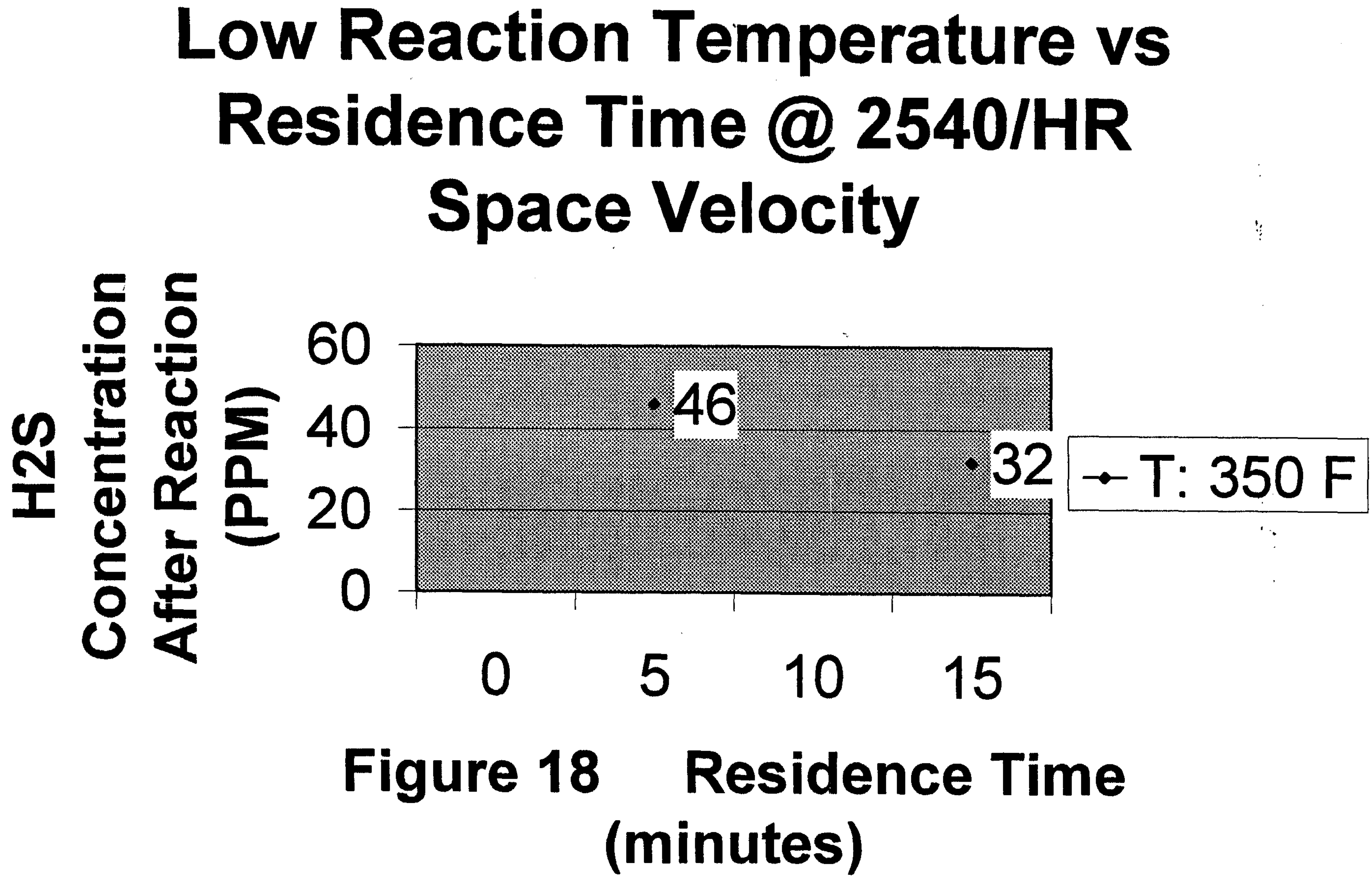
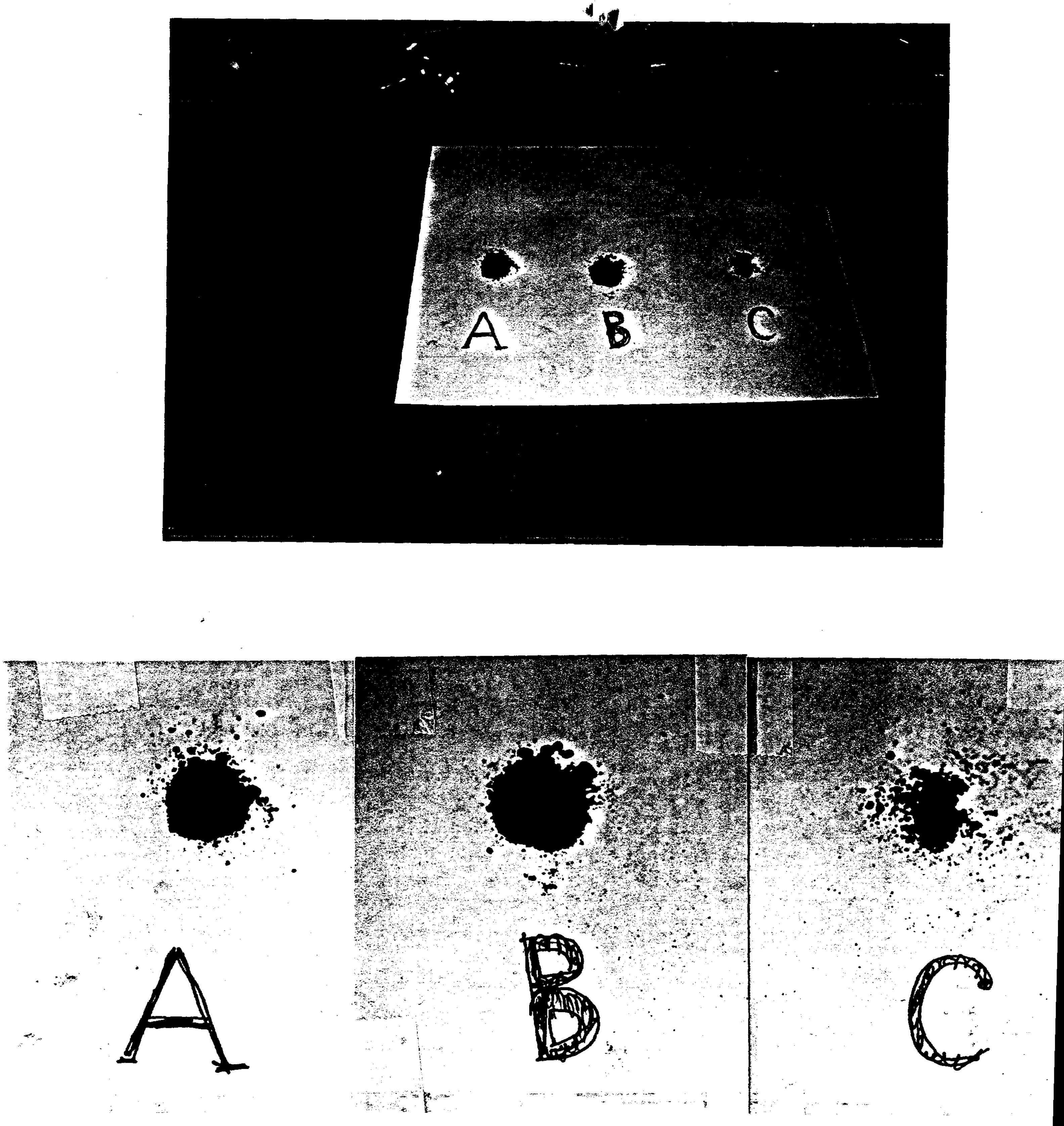

Low Reaction Temperature vs Residence Time @ 2540/HR Space Velocity
H2S Concentration After Reaction (PPM)
60
40
20
0
46
32
T: 350 F
0
5
10
15
Residence Time (minutes)

Figure 18



19 Comparison of wet, dry and reacted mixture of coal ash and iron oxide with H2S