Day 1 Monday	Day 2 Tuesday	Day 3 Wednesday	Day 4 Thursday	Day 9 Tuesday	Day 10 Wednesday
Arrive 7.30. Setting up systems, checking. End of day 1800	AM50 680 SF6 HFE Novec. Gas ring with SO2 in air has been in use over night, and extensive oxidation/fire has taken place. Cleaned up but surface still somewhat oxidised. Alloyed with Al1%Be alloy to get 8ppm Be. After alloying and and drossing, we run 0.7%So2 in air at approx 6.9 l/min for 15 min. With Novec612 400ppm HF evolved. No explanations for the high concentrations. Hypotesis from Dean: MgF2 = (MgF4 2-)(Mg 2+) = (MgF2)x, propelled by Novec. When ketone is removed, reaction goes backwards, producing F-. End of day 1830.	Calibrating FTIR. Ready 0922. Running HFC/air at 680. HFC/air at 710. Metal sample taken. End of day 1600.	Metal topped with Be. Calibrating FTIR. Ready 0840	Optimising cover gas.	Long term exposure SF6, HFC and HFE.
Tests	SF6, HFE and Novec in air, 680C.	HFC/air 680C and 710C. Novec, HFE and SF6 in air 710.	SF6, HFC, Hfe, Novec in CO2air 680C, Novec and HFE in CO2air 710C.	HFC/SF6 CO2air 710C	

Procedure:
0: Gas on.
1: Wait for furnace atmosphere to stabilize (10, 10, 15 and 30 min).
2: Dross carefully.
3: Wait 10 min.
4:Collect sample, dross.
5: Change gas flow.

Cover gas concentration is kept constant at 0.05%
Workers safety measurements (operator zone) are taken at lowest protecting flow + at flow above lowest. Also after open lid and drossing

Observations IMA Pilot testing Porsgrunn, 242295.11

AM50,10 l/min SF_6 in CO_2/5%air, 680°C.

11-Sep day 10, Wednesday.

Procedure casting trials.

1) Start off melt with drossing and exposure to optional flow rate and carrier gas for replacement of atmosphere (10 - 30 min). Oxide and metal sample.
2) Expose for 2.5 hours. Record visual appearance of surface. Sample surface and metal (as before exposure).
3) Turn off gas, open hatch, and provoke a fire. Lance gas, high concentration to quench fire. Pure SF6, 7 l/min. Video.
4) Die cast 20*3 test pieces. Add ingot. Dross, and wait 10 min for surface to even.
5) Test single point gas inlet with a lance. Record surface appearance regular for up to 30 min.
6) Switch cover gas.

The Long term exposure is performed with a standard lid accepting the pump for die casting. It differs from the custom lid in two ways:
a) The cover gas distribution ring do not have traversing tube, and the distribution holes in the ring has a diameter of ca 2 mm.
b) One of the hatches are bigger (ca 40 cm diameter) in order to accommodate the pump.

Trial and observations:

0810	SF6 on, 10 l/min.
0820	Drossing picture and video, surface and metal sample. Start lon term test.
1050	End exposure. Sampling surface and metal.
1051	Shut off cover gas, open hatch.
	1:30 white oxide flowers
	2:15 spot fires
	ca 4 min smoke evolving.
	7:00 quenching with pure SF6. OK.
1100	Preparing for die casting.
1125	20 ingots casted.
1138	Switch to single point gas inlet (lance). 500ppm 10 l/min. Drossing.
1152	Evaluate single inlet. No difference. Quit and change gas

Observations from optimizing trials.

Gas flow	**Uniform gas distribution**			**Mono-point gas distribution**
(l/min)	Gas set	Response to first drossing	Post exposure sampling and drossing	Reduction until protection failure.
10	At 11.00 start flush with SO2, 11.30 start the SF6 stream. 75/25 CO2/air due to problems with pure SF6. We have some problems with SF6 conc and wait until we get down to 500 ppm before doing a first dross	At 11.57 we do a first dross as concentration down to 500 ppm. The surface looks good without too many balls The black dross smolders a little when exposed	12.07 Sampling and drossing. Surface has a streched appeance but seems well protected. A few smaller meatballs. Slight discoloration	

Observations IMA Pilot testing Porsgrunn, 242295.11

AM50, 5 l/min HFC134a in CO_2/5%air, 680°C.

11-Sep day 10, Wednesday.
Procedure casting trials.

1) Start off melt with drossing and exposure to optional flow rate and carrier gas for replacement of atmosphere (10 - 30 min). Oxide and metal sample.
2) Expose for 2.5 hours. Record visual appearance of surface. Sample surface and metal (as before exposure).
3) Turn off gas and provoke a fire. Lance gas, high concentration to quench fire. (max conc. of cover gas at 20 l/min. (HFC straight from the bottle). Video.
4) Die cast 20*3 test pieces. Add ingot. Dross, and wait 10 min for surface to even.
5) Test single point gas inlet with a lance. Record surface appearance regular for up to 30 min.
6) Switch cover gas.

The Long term exposure is performed with a standard lid accepting the pump for die casting. It differs from the custom lid in two ways:
a) The cover gas distribution ring do not have traversing tube, and the distribution holes in the ring has a diameter of ca 2 mm.
b) One of the hatches are bigger (ca 40 cm diameter) in order to accommodate the pump.

Trial and observations:

1210	HFC 134a on. 530ppm 5 l/min
1225	Drossing picture and video, surface and metal sample. Start long term test.
1455	End exposure. Sampling surface and metal.
1456	Shut off cover gas, open hatch.
	1:30 Oxide roses with/sparks. Similar to SF6 in the start.
	2:00 Smoke and some spot fire.
1504	8:00 Quenching with Concentrated HFC. Smoke stops immideately.
	General impression: sparks/smoke start as early as with SF6, but increases more slowly.
1508	Preparing for die casting.
1510	Casting started
1514	Ingot added.
1524	Ingot added.
1529	Casting completed.
1534	Single point lance 517ppm 5 l/min. Drossing.
1549	Evaluate single inlet. No difference. Quit and change to SO2

Observations from optimizing trials.

Gas flow	**Uniform gas distribution**			**Mono-point gas distribution**	
(l/min)	Gas set	Response to first drossing	Post exposure sampling and drossing	Comparison with optimal flow using ring	Fire Extinguish
5	9.48 decrease flow	10.03 Drossing. Still very shiny and smooth. A few oxide roses.	10.13 Very good and stable conditions. Some small black oxide build-ups. Acceptable level. We observe that the film is much more elastic than air film.		

Observations IMA Pilot testing Porsgrunn, 242295.11

AM50, 2,5 l/min HFE7100 in CO_2/5%air, 680°C.

11-Sep day 10, Wednesday.
Procedure casting trials.

1) Start off melt with drossing and exposure to optional flow rate and carrier gas for replacement of atmosphere (10 - 30 min). Oxide and metal sample.
2) Expose for 2.5 hours. Record visual appearance of surface. Sample surface and metal (as before exposure).
3) Turn off gas and provoke a fire. Lance gas, high concentration to quench fire. (max conc. of cover gas at 20 l/min. (HFC straight from the bottle). Video.
4) Die cast 20-50 test pieces. Add ingot. Dross, and wait 10 min for surface to even.
5) Test single point gas inlet with a lance. Record surface appearance regular for up to 30 min.
6) Switch cover gas.

The Long term exposure is performed with a standard lid accepting the pump for die casting. It differs from the custom lid in two ways:
a) The cover gas distribution ring do not have traversing tube, and the distribution holes in the ring has a diameter of ca 2 mm.
b) One of the hatches are bigger (ca 40 cm diameter) in order to accommodate the pump.

Trial and observations:

1559	HFE 7100 500ppm 10 l/min to change atmosphere.
1609	HFE 7100 498ppm 2.5 l/min Sampling and drossing. Start long exposure.
1839	End exposure. Sampling surface and metal.
1839	Shut off cover gas, open hatch.
	1:15 Old meatballs starts to glow. Melt passive.
	4:00 Meatballs starts to smoke, and is growing.
	4:30 Meatballs start to burn. Smoke slowly getting more severe. Pretty similar to HFC.
1847	8:00 Quenching with 1.7% HFE 7100in 50:50 CO2/air. Calms immideately. Large meatballs glow for 15 sec.
1850	Prepare to die casting.
1852	Ingot added.
1912	Ingot added.
1912	Casting completed.
1918	Single point lance 520ppm 2.5 l/min. Drossing.
1933	Evaluate single inlet. No difference. Shiny metallic surface. End of day.

Observations from optimizing trials.

Gas flow	Uniform gas distribution			Mono-point gas distribution
(l/min)	Gas set	Response to first drossing	Post exposure sampling and drossing	Reduction until protection failure.
2.5	14.22 Flow decreased 524 ppm	14.52 Drossing. Some large meatballs, otherwise exemplary.	15.02 Sampling and drossing. Some large meatballs, otherwise exemplary	

Observations IMA Pilot testing Porsgrunn, 242295.11

AM50, 2,5 l/min Novec612 in CO_2/5%air, 680°C.

12-Sep day 11, Thursday.
Procedure casting trials.

1) Start off melt with drossing and exposure to optional flow rate and carrier gas for replacement of atmosphere (10 - 30 min). Oxide and metal sample.
2) Expose for 2.5 hours. Record visual appearance of surface. Sample surface and metal (as before exposure).
3) Turn off gas and provoke a fire. Lance gas, high concentration to quench fire. (max conc. of cover gas at 20 l/min. (HFC straight from the bottle). Video.
4) Die cast 20-50 test pieces. Add ingot. Dross, and wait 10 min for surface to even.
5) Test single point gas inlet with a lance. Record surface appearance regular for up to 30 min.
6) Switch cover gas.

The Long term exposure is performed with a standard lid accepting the pump for die casting. It differs from the custom lid in two ways:
a) The cover gas distribution ring do not have traversing tube, and the distribution holes in the ring has a diameter of ca 2 mm.
b) One of the hatches are bigger (ca 40 cm diameter) in order to accommodate the pump.

Trial and observations:

0815 Novec 612, 500ppm 10 l/min to change atmosphere.
0833 Novec 612, 550ppm 2.5 l/min Sampling and drossing. Start long exposure.
1103 End exposure. Sampling surface and metal.
0:00 Shut off cover gas, open hatch. A few old meatballs. Satin metallic surface, indicating that it is thicker than for the other cover gases.
2:00 Film still passive.
3:00 Meatballs starts to form at the film rift where the sample was taken.
3:30 Meatballs start to glow.
4:00 Meatballs starts to grow slowly.
5:30 Still very low activity. Some smoke starting to evolve
11:00 Activity is gradually increasing, and smoke is more and more pronounced.
11:00 Quenching with 1.7% Novec 612 in 50:50 CO2/air. Calms immideately. Large meatball at fire quenched after 15 sec.
11:00 Compared to HFC and HFE, Novec is performing significantly better. Film appearance also differs, in being satin metallic (looks relatively thicker).
1125 Ingot added.
1157 Prepare to die casting. Ad to wait some time fir tubes to reach temperature.
1205 Ingot added.
1220 Casting completed.
1222 Single point lance 520ppm 2.5 l/min. Drossing.
1237 Evaluate single inlet. No difference. Shiny metallic surface. Directly under the lance, the film starts to become satin, building up thickness.

Extended trial: 10 l/min, 125 ppm (similar delivery of cover gas, but more diluted and higher speed.

1238 SO2 while setting up the gas
1246 Gas on, Novac 10 l/min, 108 ppm.
1301 Drossing
1311 Film sample, video. Shiny metallic. Passive surface. Exemplary. End test
1315 End trial.

Observations from optimizing trials.

Gas flow		**Uniform gas distribution**		**Mono-point gas distribution**
(l/min)	Gas set	Response to first drossing	Post exposure sampling and drossing	Reduction until protection failure.
2.5	15.51 flow turned down	16.21 Drossing. Exemplary	16.32 Sampling and drossing. Sample film very thin but still exemplary.	

Observations IMA Pilot testing Porsgrunn, 242295.11
AM50, SF_6 in air, 680°C.
9/3/2002 day 2, Tuesday.

Gas flow	Uniform gas distribution			Mono-point gas distribution	Comments
(l/min)	Gas set	Response to first drossing	Post exposure sampling and drossing	Reduction until protection failure.	
20	9.42 Change from SO2 to testgas 500 ppm (not measured)		09.55 Normal response, no fire or excessive oxidation. FTIR acquisition starts at dross start. 10.05 observation is slightly yellow surface. Sample taken. Conditions stable.		Premixed 0.2SF6 in air used. Mixed with net air to 500 ppm
10	10.07 gas change 500 ppm (not measured)	Dross burns	10.19 More oxidised surface. No fire or smoking but less attractive surface and oxide build-ups. At 10.29 sample taken and surface drossed. Significant oxide buildup. Switch to SO2 gas		
5	Not done due to 10 l/min response				
2.5					

Procedure:
0: Gas on.
1: Wait for furnace atmosphere to stabilize (10, 10, 15 and 30 min).
2: Dross carefully.
3: Wait 10 min.
4:Collect sample, dross.
5: Change gas flow.
Cover gas concentration is kept constant at 0.05%

Observations IMA Pilot testing Porsgrunn, 242295.11
AM50, SF_6 in CO_2/5%air, 680°C.
5-Sep day 4, Thursday.

Gas flow (l/min)	Uniform gas distribution: Gas set	Uniform gas distribution: Response to first drossing	Uniform gas distribution: Post exposure sampling and drossing	Mono-point gas distribution: Reduction until protection failure.
20	Skip due to experience with HFC			
10	At 11.00 start flush with SO2, 11.30 start the SF6 stream. 75/25 CO2/air due to problems with pure SF6. We have some problems with SF6 conc and wait until we get down to 500 ppm before doing a first dross	At 11.57 we do a first dross as concentration down to 500 ppm. The surface looks good without too many balls The black dross smolders a little when exposed	12.07 Sampling and drossing. Surface has a streched appeance but seems well protected. A few smaller meatballs. Slight discoloration	
5	12.10 turn down flow 500 ppm (not measured.)	12.26. Drossing. Pea sized black balls on surface (~20). More sticky film with acceptable protection	12.36 Sampling and drossing. More meatballs. Surface starting to smoke upon drossing. Protection not OK. Stop sequence.	
2.5				

Procedure:
0: Gas on.
1: Wait for furnace atmosphere to stabilize (10, 10, 15 and 30 min).
2: Dross carefully.
3: Wait 10 min.
4:Collect sample, dross.
5: Change gas flow.
Cover gas concentration is kept constant at 0.05%

Observations IMA Pilot testing Porsgrunn, 242295.11
AM50, SF_6 in air, 710°C.

4-Sep day 3, Wednesday

Gas flow (l/min)	**Uniform gas distribution** Gas set	Response to first drossing	Post exposure sampling and drossing	**Mono-point gas distribution** Reduction until protection failure.
20	At 15.10, SF6 turned on after 20 minutes purging with SO2. Drossing. 500 ppm (not measured).	15.22 Continous smoulder, smoke and reformation of white oxide when drossing.	15.28 Sampling. Very strong smoking. Thick white oxide layer. Hardly any protective layer.	
10				
5				
2.5				

Procedure:
0: Gas on.
1: Wait for furnace atmosphere to stabilize (10, 10, 15 and 30 min).
2: Dross carefully.
3: Wait 10 min.
4:Collect sample, dross.
5: Change gas flow.
Cover gas concentration is kept constant at 0.05%

Observations IMA Pilot testing Porsgrunn, 242295.11
AM50, SF_6 in CO_2/5%air, 710°C.

10-Sep day 9, Tuesday.

Gas flow (l/min)	Uniform gas distribution: Gas set	Uniform gas distribution: Response to first drossing	Uniform gas distribution: Post exposure sampling and drossing	Mono-point gas distribution: Reduction until protection failure.
20	Not tested.			
10	Gas set 1246 500 ppm (not measured)	1256 Drossing. Passive surface, a few meatballs, golden metallic appearance. Dross burns.	1306 Sampling and drossing. Passive surface, golden metallic appearance. Dross burns. Protection just OK.	
5	1308 Reduce flow	1323 Drossing. Meatballs, golden appearance, very thin oxide film, but no smoke. Dross burns.	1333 Drossing and sampling. Meatballs, very thin oxide film, a little smoke and some smoulder during drossing. Not quite OK.	
2.5				

Procedure:
0: Gas on.
1: Wait for furnace atmosphere to stabilize (10, 10, 15 and 30 min).
2: Dross carefully.
3: Wait 10 min.
4:Collect sample, dross.
5: Change gas flow.
Cover gas concentration is kept constant at 0.05%

Observations IMA Pilot testing Porsgrunn, 242295.11
AM50, HFC134a in air, 680°C.

4-Sep day 3, Wednesday.

Gas flow (l/min)	**Uniform gas distribution** Gas set	Response to first drossing	Post exposure sampling and drossing	**Mono-point gas distribution** Reduction until protection failure.
20	10.47 Surface drossed and new gas turned on. Deans portable gas analyser shows 500ppm ok but pressure unstable and switch back to SO_2. New turnon of gas at 10.59. Still problems so back on SO_2. We start here 4/9 0924 HFC 496 (24) ppm. Drossing.	0934 Drossing. Surface looks nice and shiny, calm.	0944 Sample catch fire due to oxide roses. Thin oxide layer, oxide roses abundant. No spot fires upon drossing. Protection inferior compared to HFE/Novec/SF_6. Protection nearly failed.	
10	0950: Gas set, HFC 446 (334) ppm.	10.00 Drossing. Very large build-up of oxide roses. Smoke (white) and spot burning. Impossible to clean surface properly.	10.11 Lots of oxide roses. Continously smolulder/smoke evolving before and during drossing. Protection failed.	
5				
2.5				

Procedure:
0: Gas on.
1: Wait for furnace atmosphere to stabilize (10, 10, 15 and 30 min).
2: Dross carefully.
3: Wait 10 min.
4:Collect sample, dross.
5: Change gas flow.
Cover gas concentration is kept constant at 0.05%

Cover gas flow meter 3 (CO) setting:
20 l/min : 24.9
10 " : 12.4
5 " : 4.0 (calibrated)
2.5 " : 2.3 (calibrated)

Cross section lid holes 0.17 cm2, 1/4"tube 0.31 cm2, 3/8"tube 0.65cm2.

Observations IMA Pilot testing Porsgrunn, 242295.11
AM50, HFC134a in CO_2/5%air, 680°C.

5-Sep

Gas flow (l/min)	**Uniform gas distribution** Gas set	Response to first drossing	Post exposure sampling and drossing	**Mono-point gas distribution** Comparison with optimal flow using ring	Fire Extinguish
20	9.00 Drossing and turn over to HFC from the SO2. We have also alloyed up with Be back up to ~8ppm. The HFC conc 583 (62) ppm.	9.10 Surface very calm and smooth, no oxide or smoke.	9.23 Sampling and drossing. Considerably better surface under CO2 than air. Smooth and covering film without visible signs of oxidation. Film a little multicoloured indicating relative thiness.		
10	9.26 decrease flow. HFC 502 (40) ppm.	9.36 Drossing. Still very shiny and smooth surface without indications of oxidation. Exemplary.	9.47 Very good and stable conditions. No signs of oxidation at all.		
5	9.48 decrease flow. HFC 505 (36) ppm.	10.03 Drossing. Still very shiny and smooth. A few oxide roses.	10.13 Very good and stable conditions. Some small black oxide build-ups. Acceptable level. We observe that the film is much more elastic than air film.		
2.5	10.15 decrease flow. HFC 537 (74) ppm.	10.44. Drossing. Shiny surface without white oxide but some buildup of black oxide balls (meatballs) approx 1 cm diameter	10.55 Sampling and drossing. Fine stable surface. But with "meatball" size black oxide lumps in a few places. Sten considers it still acceptable. Dross burns All taken into account, we still consider it borderline		

Procedure:
0: Gas on.
1: Wait for furnace atmosphere to stabilize (10, 10, 15 and 30 min).
2: Dross carefully.
3: Wait 10 min.
4:Collect sample, dross.
5: Change gas flow.
Cover gas concentration is kept constant at 0.05%

Cover gas flow meter 3 (CO) setting:
20 l/min : 24.9
10 " : 12.4
5 " : 4.0 (calibrated)
2.5 " : 2.3 (calibrated)

Observations IMA Pilot testing Porsgrunn, 242295.11
AM50, HFC134a in air, 710°C.
4-Sep day 3, wednesday.

Gas flow (l/min)	**Uniform gas distribution** Gas set	Response to first drossing	Post exposure sampling and drossing	**Mono-point gas distribution** Reduction until protection failure.
20	1123 gas on. HFC 583 (22) ppm.	1133 Drossing. Significant amount of oxide roses, smoke, little fire. Significant worse than 680. Video.	1143 Extensive roses, smoke, some fire. Protection failed.	
10				
5				
2.5				

Procedure:
0: Gas on.
1: Wait for furnace atmosphere to stabilize (10, 10, 15 and 30 min).
2: Dross carefully.
3: Wait 10 min.
4:Collect sample, dross.
5: Change gas flow.
Cover gas concentration is kept constant at 0.05%

Cover gas flow meter 3 (CO) setting:
20 l/min : 24.9
10 " : 12.4
5 " : 4.0 (calibrated)
2.5 " : 2.3 (calibrated)

Observations IMA Pilot testing Porsgrunn, 242295.11
AM50, HFC134a in CO_2/5%air, 710°C.
10-Sep day 9, Tuesday.

Gas flow (l/min)	Gas set	Uniform gas distribution Response to first drossing	Post exposure sampling and drossing
20	Not tested		
10	Gas set 1107, HFC 548 (14) ppm	1117 Drossing. Exemplary. Passive surface, shiny metallic.	1127 Sampling and drossing. Exemplary. Passive surface, shiny metallic.
5	Decrease flow 1130 HFC 604 (16) ppm	1145 Drossing. Exemplary. Passive surface, coloured shiny metallic (thinner oxide skin).	1155 Sampling and drossing. Exemplary. Passive surface, coloured shiny metallic.
2.5	Decrease flow 1158 HFC 650 (9) ppm	1228 Drossing. Some meatballs, but no smoke. Metallic coloured appearance (thin film).	1238 Sampling and drossing. Meatballs, no smoke. Golden film OK protection. Dross burns.

Barely OK at 680 (yellow). Reasons: Small leakage in the hatch; residuaal effect?

0: Gas on.
1: Wait for furnace atmosphere to stabilize (10, 10, 15 and 30 min).
2: Dross carefully.
3: Wait 10 min.
4:Collect sample, dross.
5: Change gas flow.

Cover gas concentration is kept constant at 0.05%

Observations IMA Pilot testing Porsgrunn, 242295.11
AM50, HFE7100 in air, 680°C.

3-Sep day 2, Tuesday.

Gas flow	Uniform gas distribution			Mono-point gas distribution
(l/min)	Gas set	Response to first drossing	Post exposure sampling and drossing	Reduction until protection failure.
20	1029: HFE 538 (3) ppm on	1140: No fire, no smoke, stable. Residues of oxide from earlier when HFC was tried.	1150: Sampling. Very smooth and shiny surface, no smoke or fire. Dross is burning.	
10	11.53 Flow turned down. At 12.01, HFE 547 (6) ppm	12.11: No fire, no smoke, Stable. Some dark oxide at crucible sides. Dross is burning.	12.22: Sampling and drossing. Roses of oxide present but not significantly worse than previous. Dross still burning	
5	12.24 turn down gas. 12.28 at 571 (27) ppm	12.44: No fire or smoke stable and only a few small oxide roses	12.54: No fires, very little smoke but a a few more white oxie roses. A little more reactive	
2.5	12.56 turn gas down. 12.58 at 497 (13) ppm, some smoke out of lid	1226: Small spotfires and whiteish surface. Considerably worse protection, not sufficient, some smoke.	12.37 sampling and drossing. White smoke. Lot of white oxide on surface. Small spotfires when sampling	

We run an extra experiment on Thursday 5/9 to try gas.

Gas on 1641.

Procedure:
0: Gas on.
1: Wait for furnace atmosphere to stabilize (10, 10, 15 and 30 min).
2: Dross carefully.
3: Wait 10 min.
4:Collect sample, dross.
5: Change gas flow.
Cover gas concentration is kept constant at 0.05%

Observations IMA Pilot testing Porsgrunn, 242295.11
AM50, HFE7100 in CO_2/5%air, 680°C.

5-Sep day 4, Thursday.

Gas flow	Uniform gas distribution			Mono-point gas distribution
(l/min)	Gas set	Response to first drossing	Post exposure sampling and drossing	Reduction until protection failure.
20	1240: SO2 on. 12.55 Switch to HFE and dross. 557 (29) ppm conc.NB, Photo says 10l/min	13.05 Drossing. Very nice looking film without tendencies to oxidation. Film quite elastic.	13.17 Sampling and drossing. Very smooth and pretty surface without any oxidation or discoloration. Exemplary.NB, Photo says 10l/min	
10	13.19 Flow decreased. HFE 467 (8) ppm	13.34 Drossing. Very nice smooth surface and no tendencies whatsoever for oxidation. Still exemplary	13.47 Sampling and drossing. Still exemplary. NB, Photo says 5l/min	
5	13.53 Flow decreased. HFE 463 (9) ppm.	14.08 Drossing. Exemplary	14.21 Sampling and drossing. Still exemplary.	
2.5	14.22 Flow decreased. HFE 515 (4) ppm	14.52 Drossing. Some large meatballs, otherwise exemplary.	15.02 Sampling and drossing. Some large meatballs, otherwise exemplary	

Procedure:
0: Gas on.
1: Wait for furnace atmosphere to stabilize (10, 10, 15 and 30 min).
2: Dross carefully.
3: Wait 10 min.
4:Collect sample, dross.
5: Change gas flow.
Cover gas concentration is kept constant at 0.05%

Observations IMA Pilot testing Porsgrunn, 242295.11
AM50, HFE7100 in air, 710°C.
4-Sep day 3, Wednesday.

Gas flow	Uniform gas distribution			Mono-point gas distribution
(l/min)	Gas set	Response to first drossing	Post exposure sampling and drossing	Reduction until protection failure.
20	SO2 flushed for 15 min. At. 13.55 HFE turned on and surface drossed from lots of fine white oxide. HFE 490 (15) ppm.	14.08 Drossing. Very similar respons as Novec. Stable surface with a few oxide roses.	14.19 Sampling and drossing. Surface stable and not burning. Some roses but no white oxide. Film looks thin and multicoloured. Sten' comment that this looks like Novec at 10l/min.	
10	14.22 Flow decreased. HFE 512 (4) ppm	14.32. Drossing. A thin layer of oxide on top. Difficult to dross as white oxide film regenerates. Some smoke and spot fires.	14.45 Sampling and drossing. Relatively thick white loose oxide layer. Some burning	
5				
2.5				

Procedure:

1: Wait for furnace atmosphere to stabilize (10, 10, 15 and 30 min).
2: Dross carefully.
3: Wait 10 min.
4:Collect sample, dross.
5: Change gas flow.
Cover gas concentration is kept constant at 0.05%

Observations IMA Pilot testing Porsgrunn, 242295.11
AM50, HFE7100 in CO_2/5%air, 710°C.
5-Sep day 4, Thursday.

Gas flow (l/min)	Uniform gas distribution: Gas set	Uniform gas distribution: Response to first drossing	Uniform gas distribution: Post exposure sampling and drossing	Mono-point gas distribution: Reduction until protection failure.
20	Skipped			
10	Skipped			
5	Gas set 1702, while furnace heating to 710C. 1712 up. HFE 441 (45) ppm.	1717 Drossing. No smoke or spot fire, but some meat balls. Concentration notched up to 475ppm.	1727 sampling and drossing. Better result than first drossing! A few small meatballs, otherwise exemplary.	
2.5	Gas set 1729. HFE 524 (4) ppm.	1801 Drossing. A few meatballs, otherwise exemplary.	1811 Sampling and drossing. Exemplary.	

Procedure:
0: Gas on.
1: Wait for furnace atmosphere to stabilize (10, 10, 15 and 30 min).
2: Dross carefully.
3: Wait 10 min.
4:Collect sample, dross.
5: Change gas flow.
Cover gas concentration is kept constant at 0.05%

Observations IMA Pilot testing Porsgrunn, 242295.11
AM50, Novec612 in air, 680°C.
3-Sep day 2, Tuesday.

Gas flow	Uniform gas distribution			Mono-point gas distribution
(l/min)	Gas set	Response to first drossing	Post exposure sampling and drossing	Reduction until protection failure.
20	1407: Novec on (After 20 min of SO2 flush at standard conditions). Start conc 630 ppm. Predross. Some black lumps and dis coloration of surface. Novec (505 (5) ppm	14.17 Surface is very stable. No oxidation or fires. Dross burns	14.49 Sampling and drossing. Very pretty surface and no fires/smoke. Dross does **not** burn. 14.52 switch to SO2 for dry air IR cell calibration. (1cm pathlength). At 15.45,. We generate HF so take surface sample (under SO2) + metal sample. 15.46 we change back to Novec at 20l/min. At 15.56 drossing. Dross does not burn. At 16.08, sampling of surface and dross again. Dross burns.	
10	16.10 flow lowered. Novec 494 (2) ppm	1620: Drossing, very stable surface and pretty surface. Dross burns	16.31 Sampling and dross, very stable and shiny surface. Dross burns.	
5	16.34 flow lowered. Novec (484 (5) ppm.	16.50 Stable surface but some oxide roses appears. Vidar assess it as being too thin. Dross burns.	17.01 Sample and drossing. Sample still looks shiny but a tendency towards small white oxide film building up. The sampled film looks very thin and protection seems a little inadeqate	
2.5	17.04 flow lowered. Novec 609 (27) ppm.	17.34. Oxide build up in furnace worse with a little white smoke coming off. Small spike flames. Looks a little better than HFE at same flow.	17.45 Sampling and drossing. Bad cover and white smoke, white oxide build-up, burning sample and dross.	

Procedure:
0: Gas on.
1: Wait for furnace atmosphere to stabilize (10, 10, 15 and 30 min).
2: Dross carefully.
3: Wait 10 min.
4:Collect sample, dross.
5: Change gas flow.
Cover gas concentration is kept constant at 0.05%

Observations IMA Pilot testing Porsgrunn, 242295.11
AM50, Novec612 in CO_2/5%air, 680°C.

5-Sep day 4, Thursday.

Gas flow (l/min)	Uniform gas distribution Gas set	Response to first drossing	Post exposure sampling and drossing	Mono-point gas distribution Reduction until protection failure.
20	skipped			
10	skipped			
5	SO2 turned on at 15.04. Novec turned on 1523. Onc. 521 (31) ppm.	1537 Drossing. Exemplary, film a little elastic.	1547 Sampling and drossing. Exemplary	
2.5	15.51 flow turned down. Novec 725 (62).	16.21 Drossing. Exemplary	16.32 Sampling and drossing. Sample film very thin but still exemplary.	

Procedure:
0: Gas on.
1: Wait for furnace atmosphere to stabilize (10, 10, 15 and 30 min).
2: Dross carefully.
3: Wait 10 min.
4:Collect sample, dross.
5: Change gas flow.
Cover gas concentration is kept constant at 0.05%

Observations IMA Pilot testing Porsgrunn, 242295.11
AM50, Novec612 in air, 710°C.
4-Sep day 3, Wednesday.

Gas flow (l/min)	**Uniform gas distribution** Gas set	Response to first drossing	Post exposure sampling and drossing	**Mono-point gas distribution** Reduction until protection failure.
20	1206: Gas on. Novec 514 (3)ppm. Drossing	1216 Drossing.Calm. No smoke or fire. Flexible, moderately thick oxide skin.	12.27 Sampling and drossing. Only a few scattered oxide roses. Easy sampling. Visibly thicker film than HFC.	
10	12.30 Reduced to 10 l/min. Novec 551 (8). Increasing FTIR sampling tube bore, which used to keep clogging.	12.59 Drossing. Some roses have appeared but melt is still very calm. No smoke or white oxide	13.09 Sampling and drossing. Sample ok but surface has some white oxide and somewhat unattractive. Still no fires.	
5	13.11 Gas flow reduced. Novec 519 (8) ppm.	12.29 Drossing. Fine layer of white oxide, some roses but no fire. Oxide does not burn	12.40 Sampling and drossing. Fine layer of white oxide and some smoke. Some roses and scattered burning oxide on surface. Film on surface thinner and multi coloured.	
2.5				

Procedure:
0: Gas on.
1: Wait for furnace atmosphere to stabilize (10, 10, 15 and 30 min).
2: Dross carefully.
3: Wait 10 min.
4:Collect sample, dross.
5: Change gas flow.
Cover gas concentration is kept constant at 0.05%

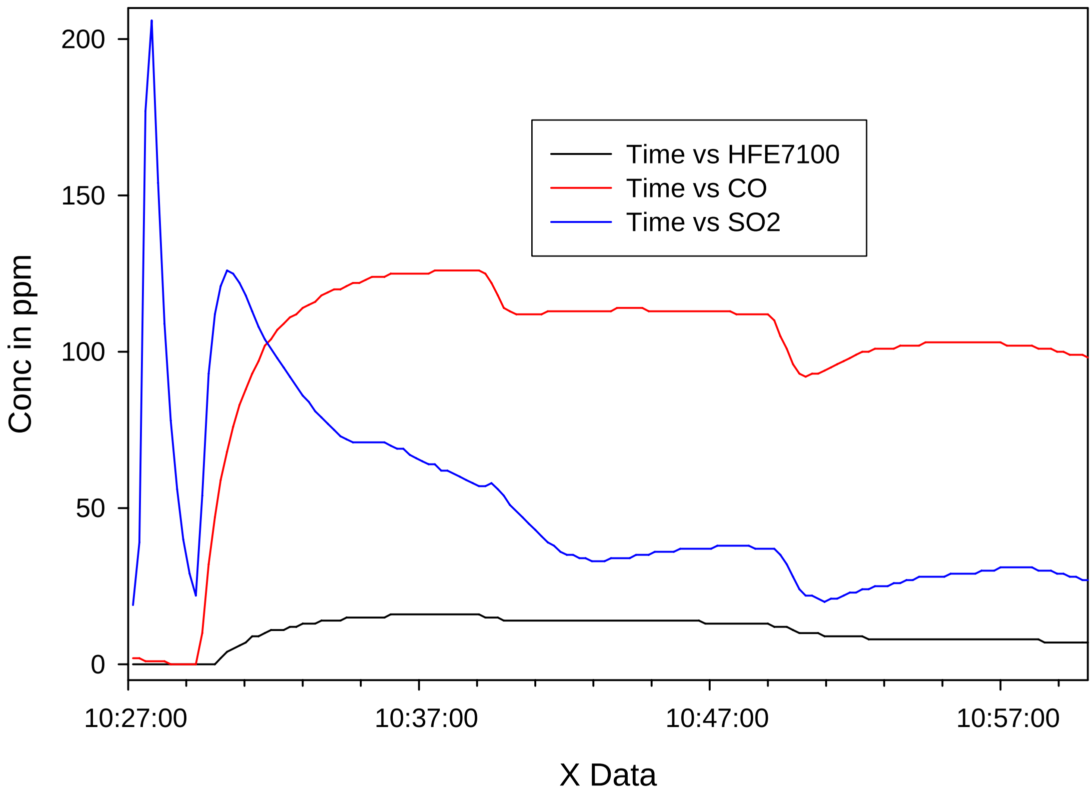
Observations IMA Pilot testing Porsgrunn, 242295.11
AM50, Novec612 in CO_2/5%air, 710°C.

5-Sep day 4, Thursday.

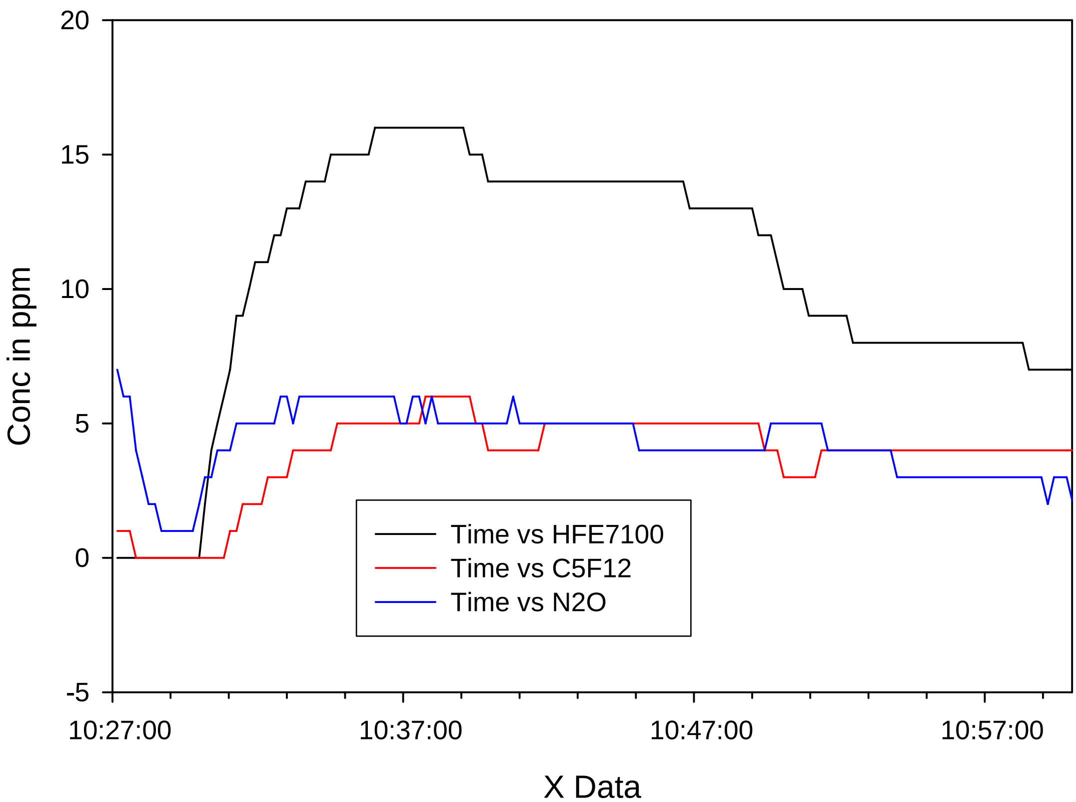
Gas flow	Uniform gas distribution			Mono-point gas distribution
(l/min)	Gas set	Response to first drossing	Post exposure sampling and drossing	Reduction until protection failure.
20				
10				
5	Gas set 1828. Novec 581 ppm (not recorded).	1838. Drossing. Exemplary.	1848. Sampling and drossing. A few meat balls, otherwise exemplary.	
2.5	Gas set 1851. Novec 659 (12) ppm.	1921 Drossing. A few meat balls an one tiny spot fire, otherwise exemplary.	1931. Sampling and drossing. A few meat balls, otherwise exemplary.	

Procedure:
0: Gas on.
1: Wait for furnace atmosphere to stabilize (10, 10, 15 and 30 min).
2: Dross carefully.
3: Wait 10 min.
4:Collect sample, dross.
5: Change gas flow.
Cover gas concentration is kept constant at 0.05%

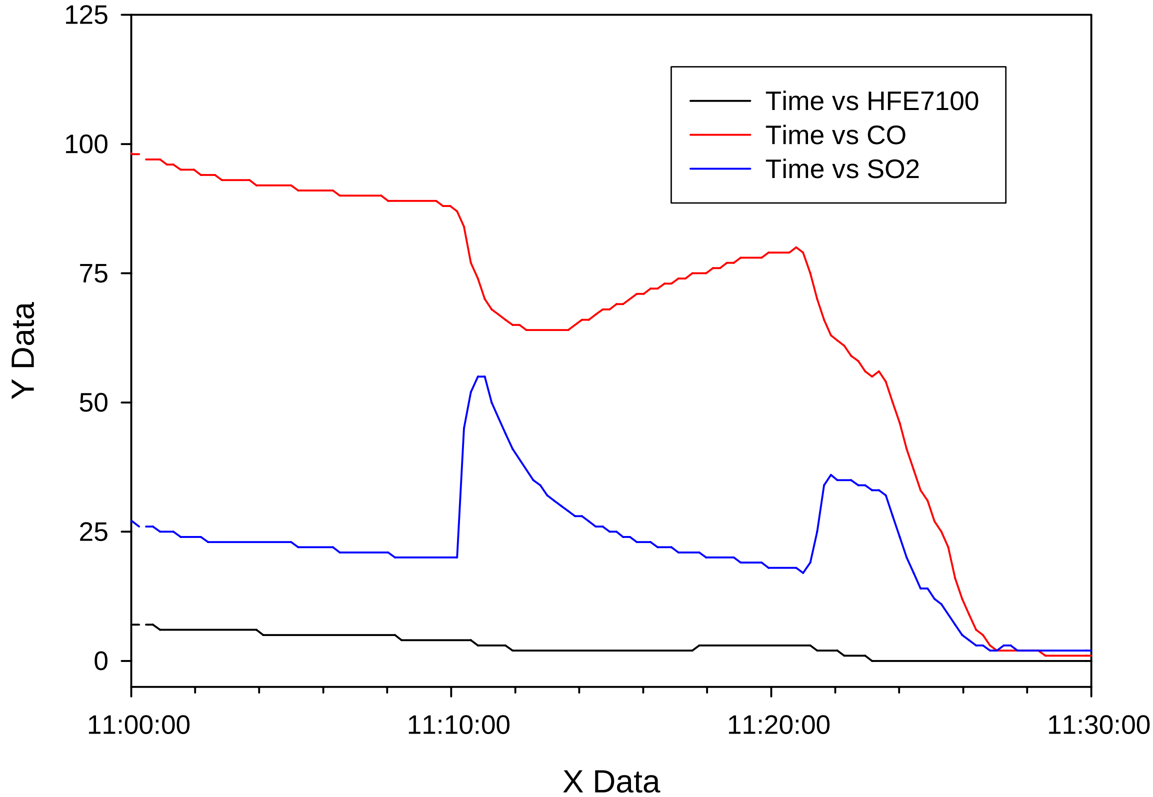
Experiment 1: Plot of HFE-7100, CO and SO2



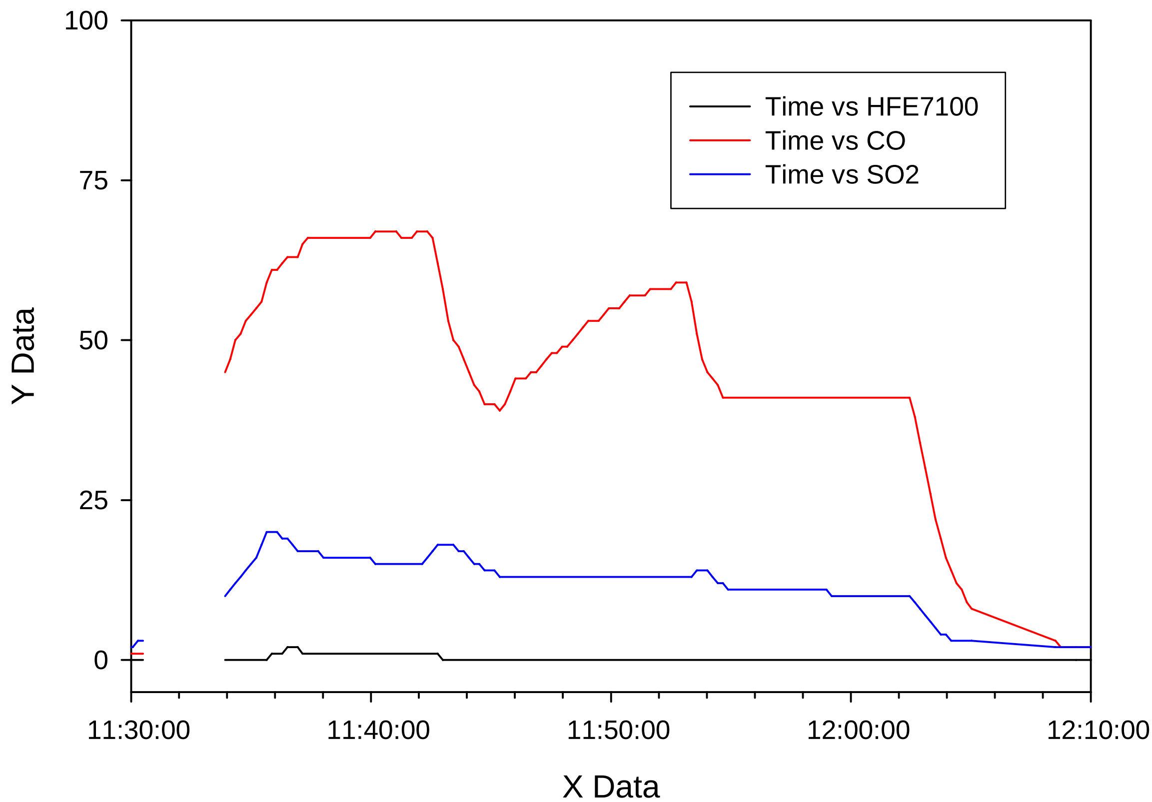
Experiment 1: Plot of HFE-7100, C5F12 and N2O

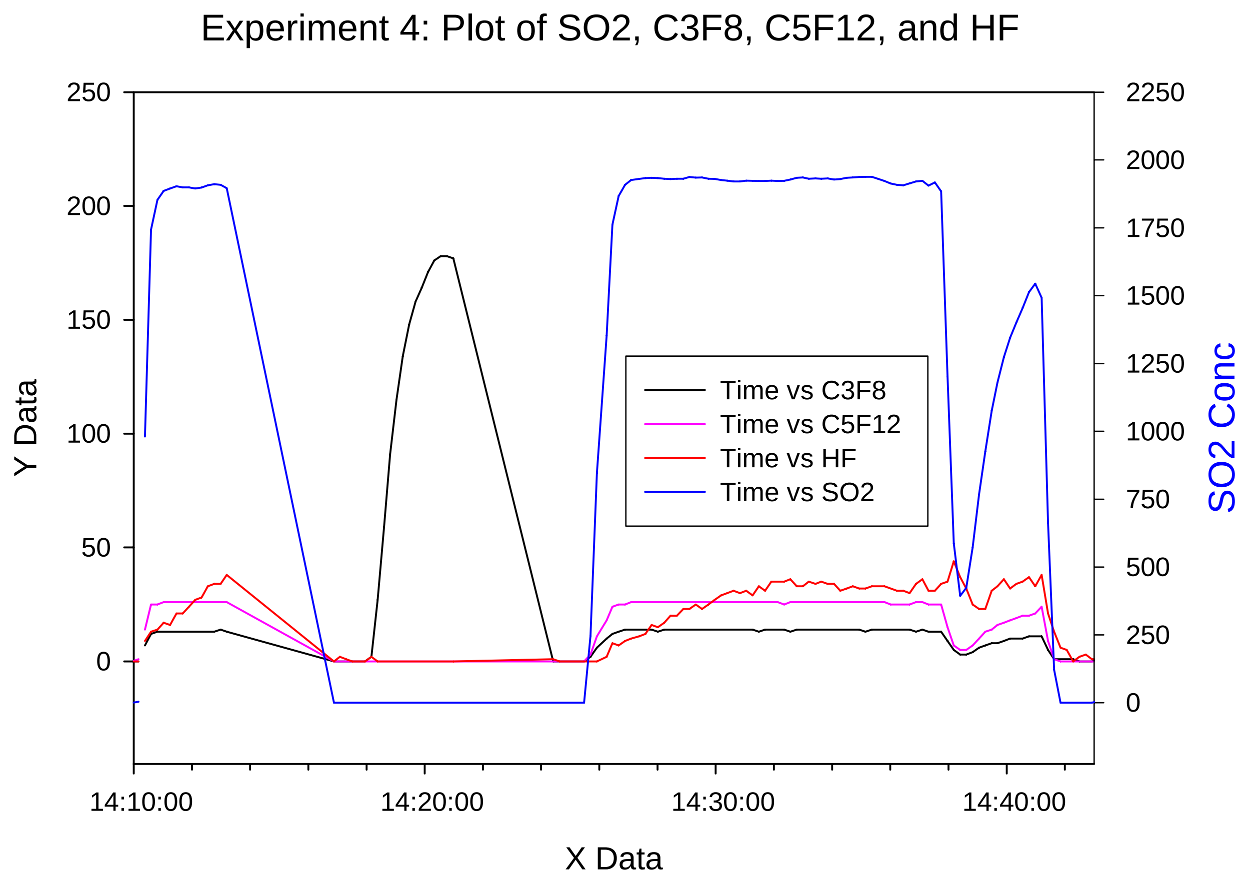


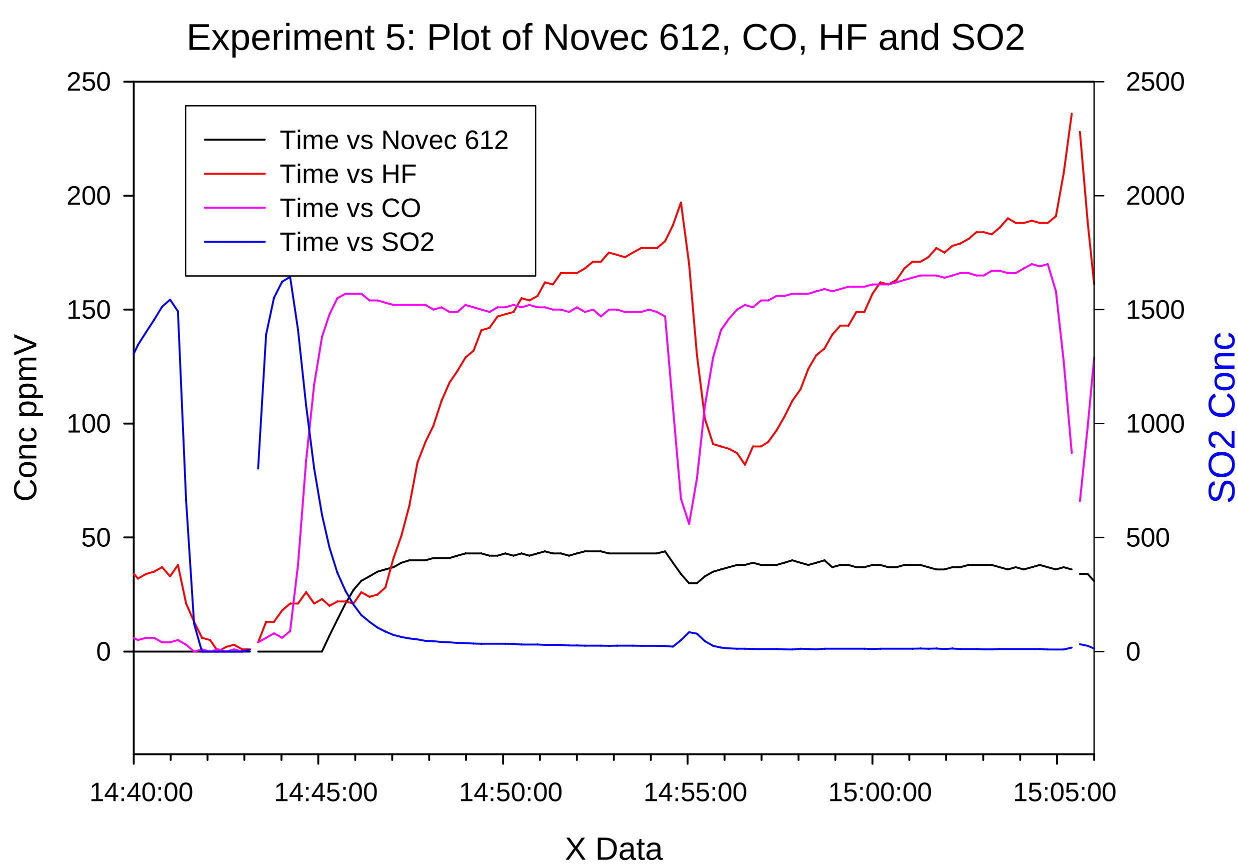
Experiment 2: Plot of HFE-7100, CO and SO2



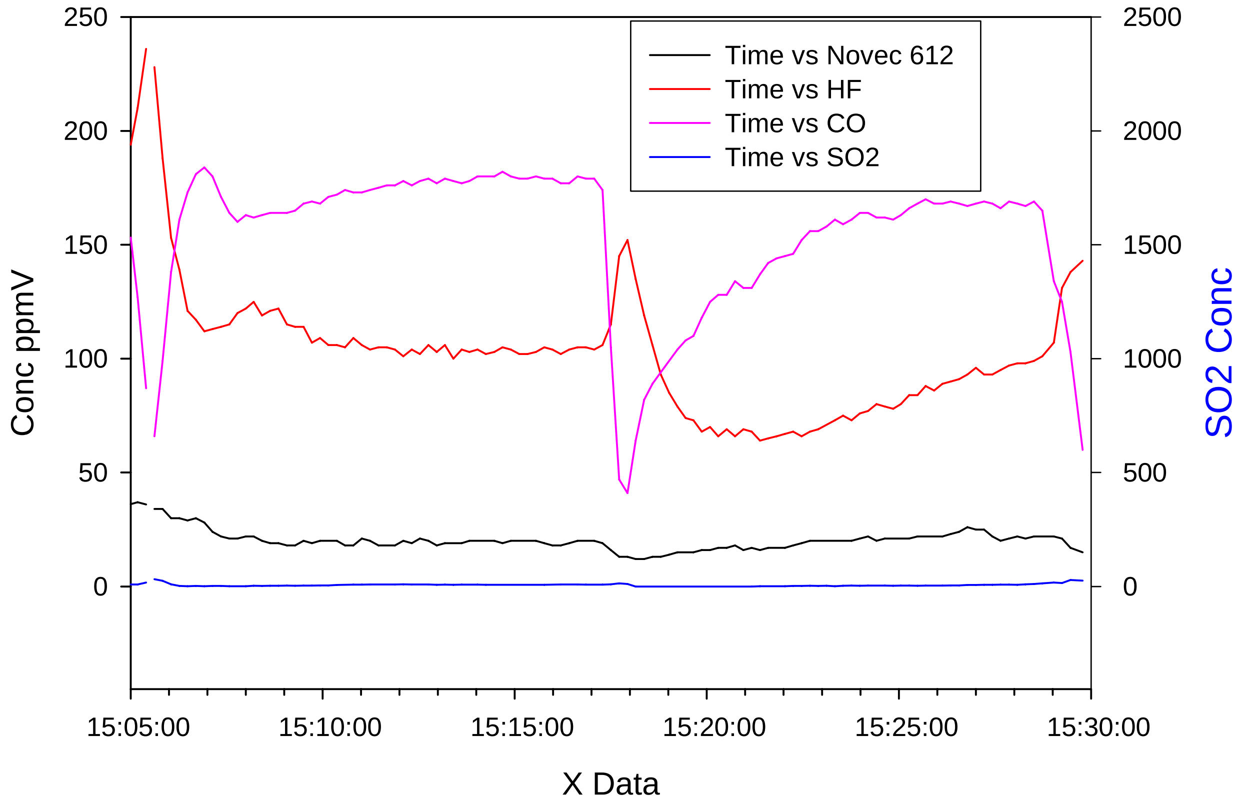
Experiment 3: Plot of HFE-7100, CO and SO2



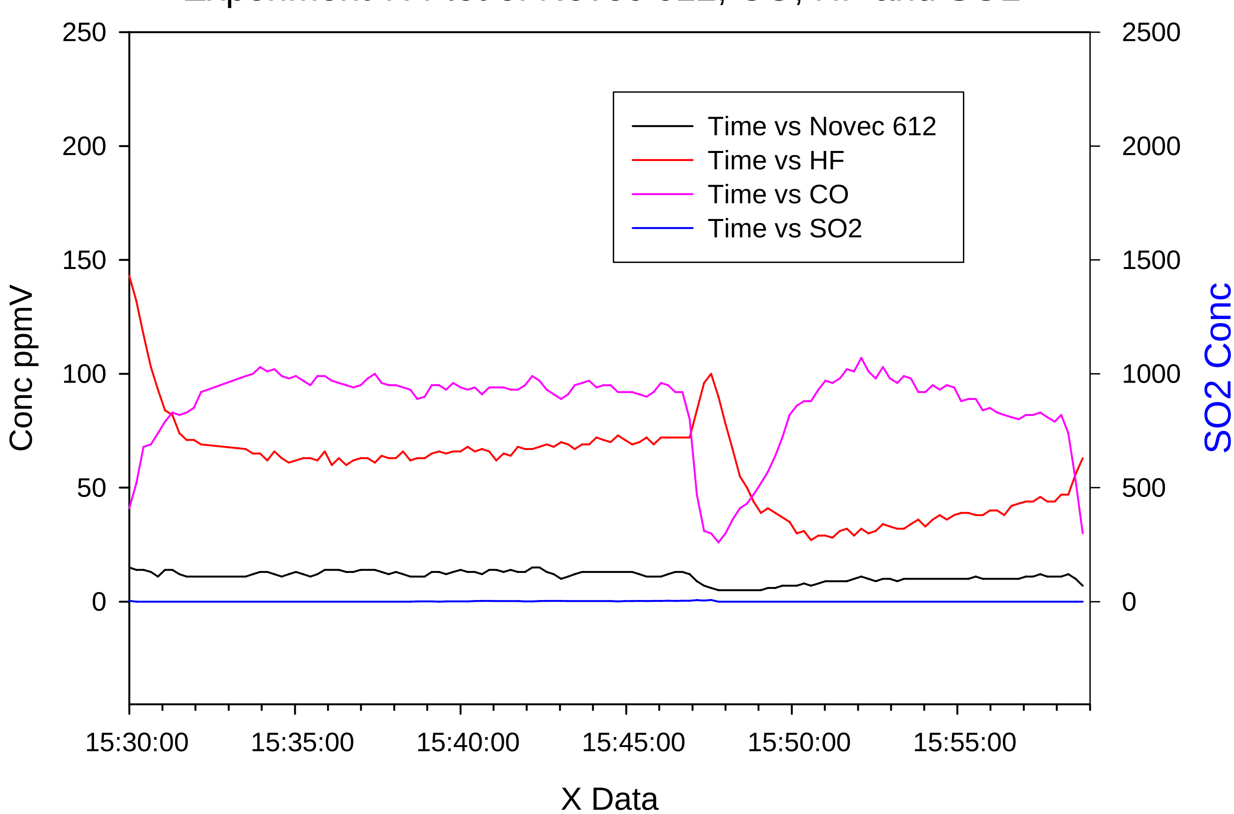

Experiment 4: Plot of SO2, C3F8, C5F12, and HF
Y Data
SO2 Conc
X Data
Time vs C3F8
Time vs C5F12
Time vs HF
Time vs SO2
250
200
150
100
50
0
2250
2000
1750
1500
1250
1000
750
500
250
0
14:10:00
14:20:00
14:30:00
14:40:00

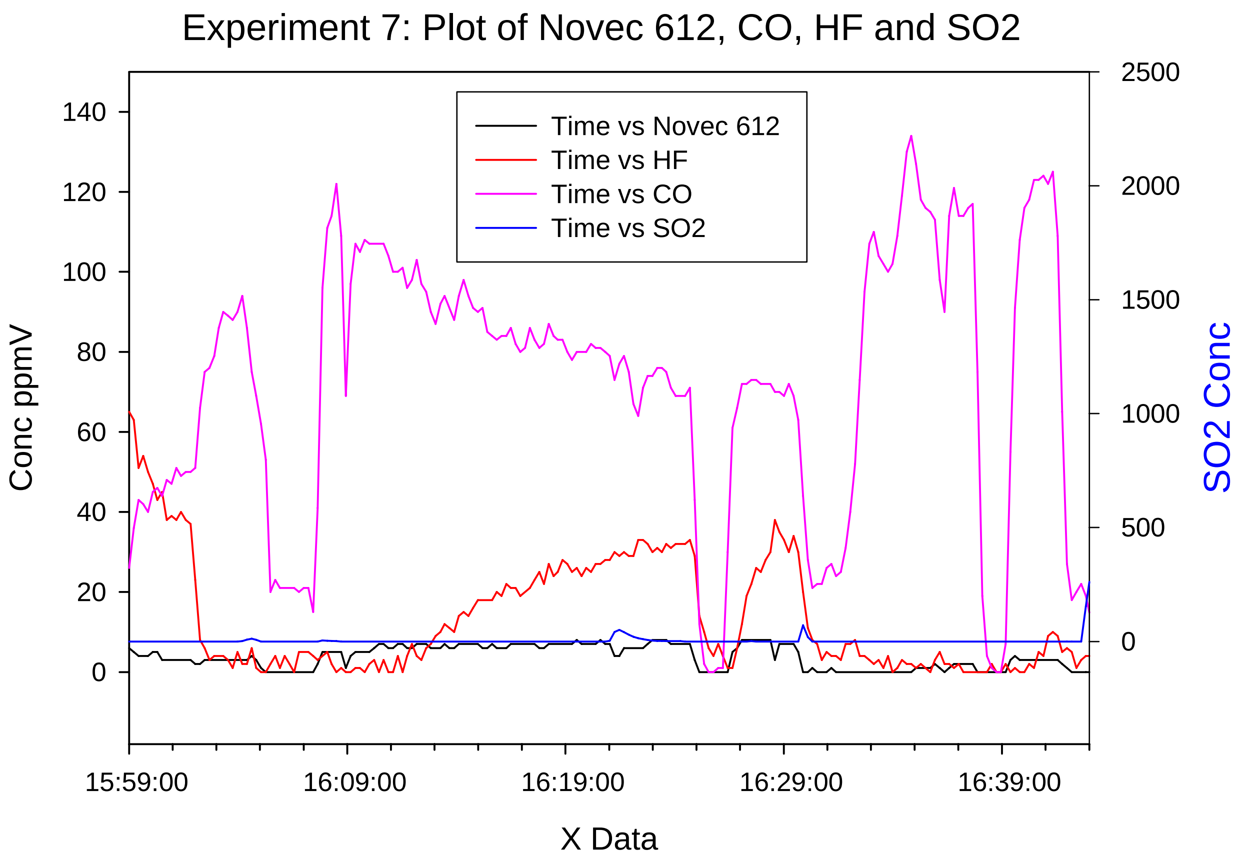

Experiment 5: Plot of Novec 612, CO, HF and SO2
Conc ppmV
SO2 Conc
X Data
Time vs Novec 612
Time vs HF
Time vs CO
Time vs SO2
250
200
150
100
50
0
2500
2000
1500
1000
500
0
14:40:00
14:45:00
14:50:00
14:55:00
15:00:00
15:05:00

Experiment 6: Plot of Novec 612, CO, HF and SO2

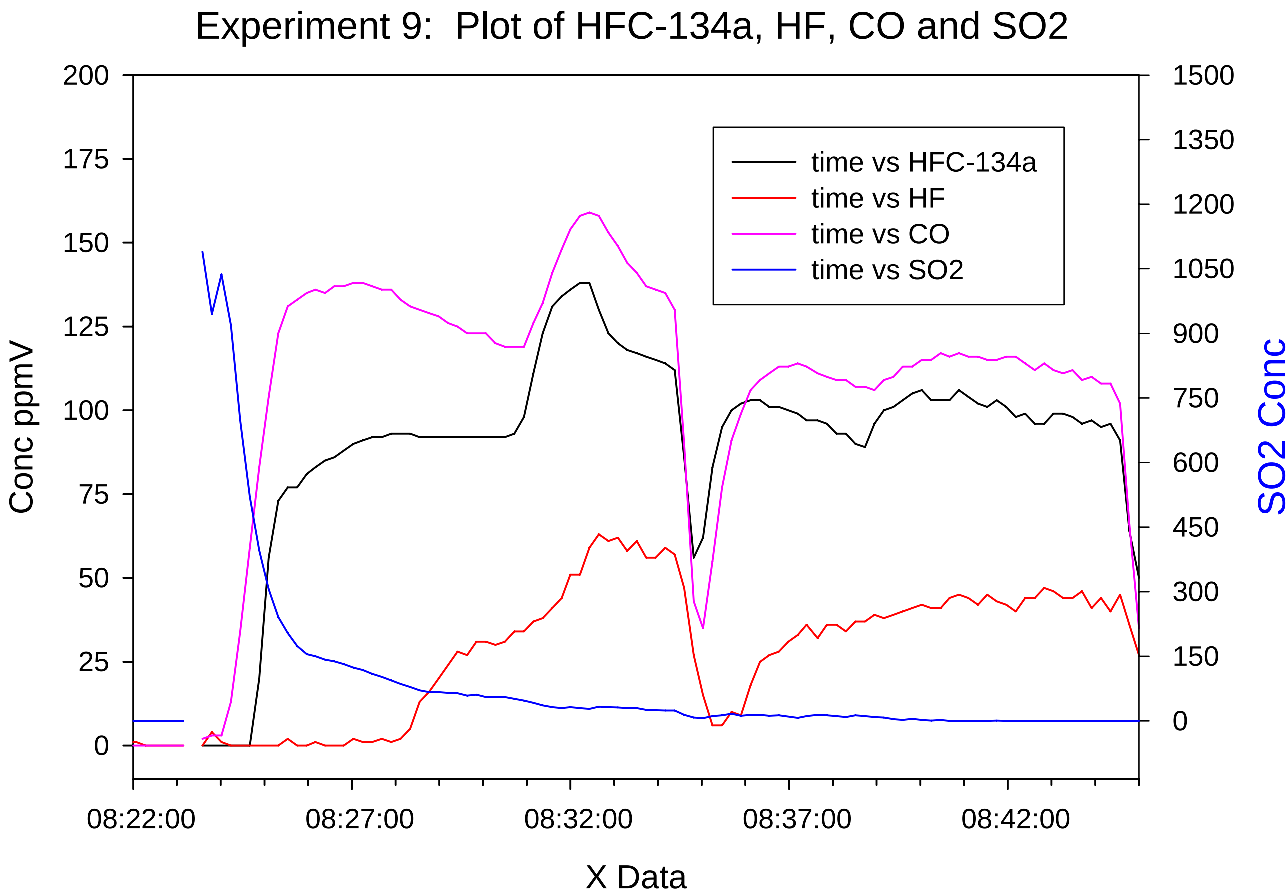


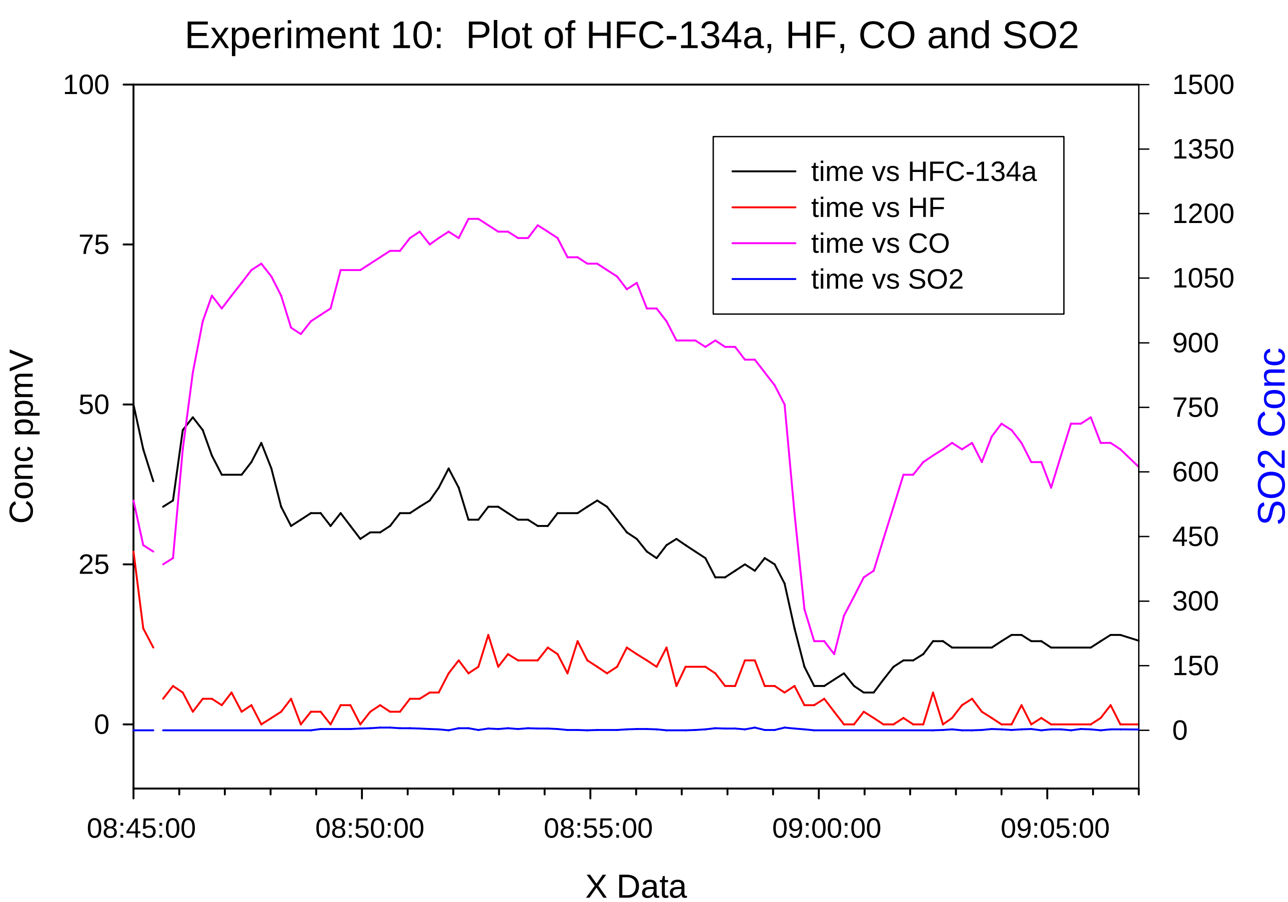
Experiment 7: Plot of Novec 612, CO, HF and SO2

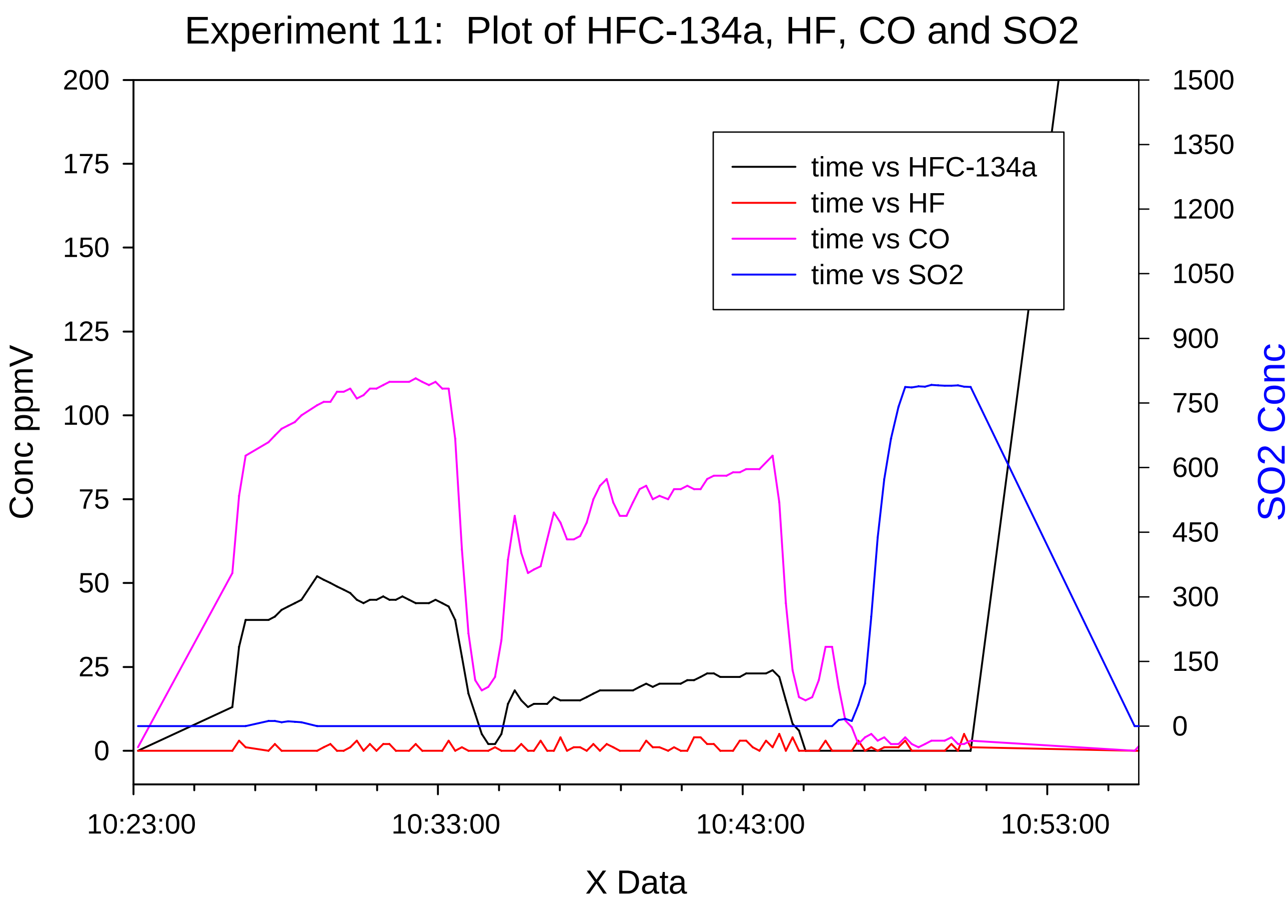


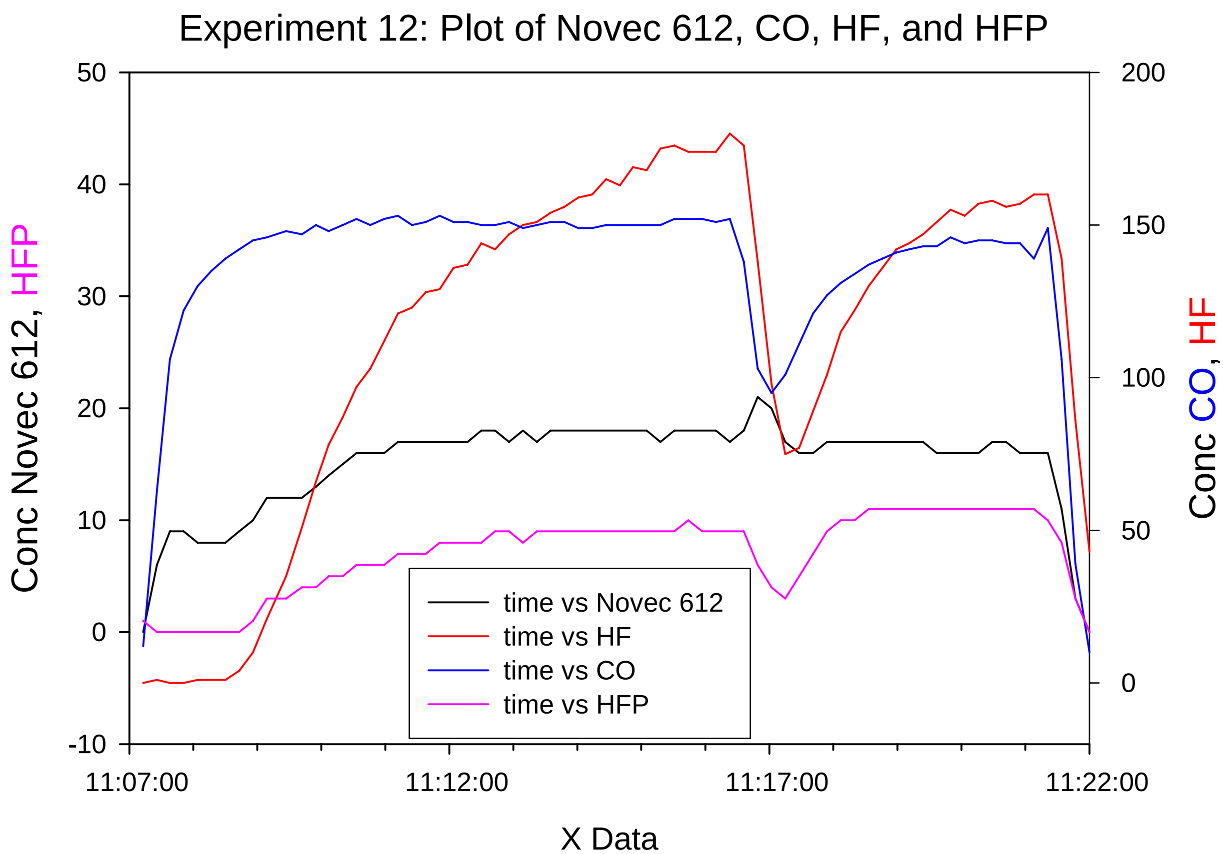


Experiment 7: Plot of Novec 612, CO, HF and SO2
Time vs Novec 612
Time vs HF
Time vs CO
Time vs SO2
Conc ppmV
SO2 Conc
X Data
140
120
100
80
60
40
20
0
2500
2000
1500
1000
500
0
15:59:00
16:09:00
16:19:00
16:29:00
16:39:00

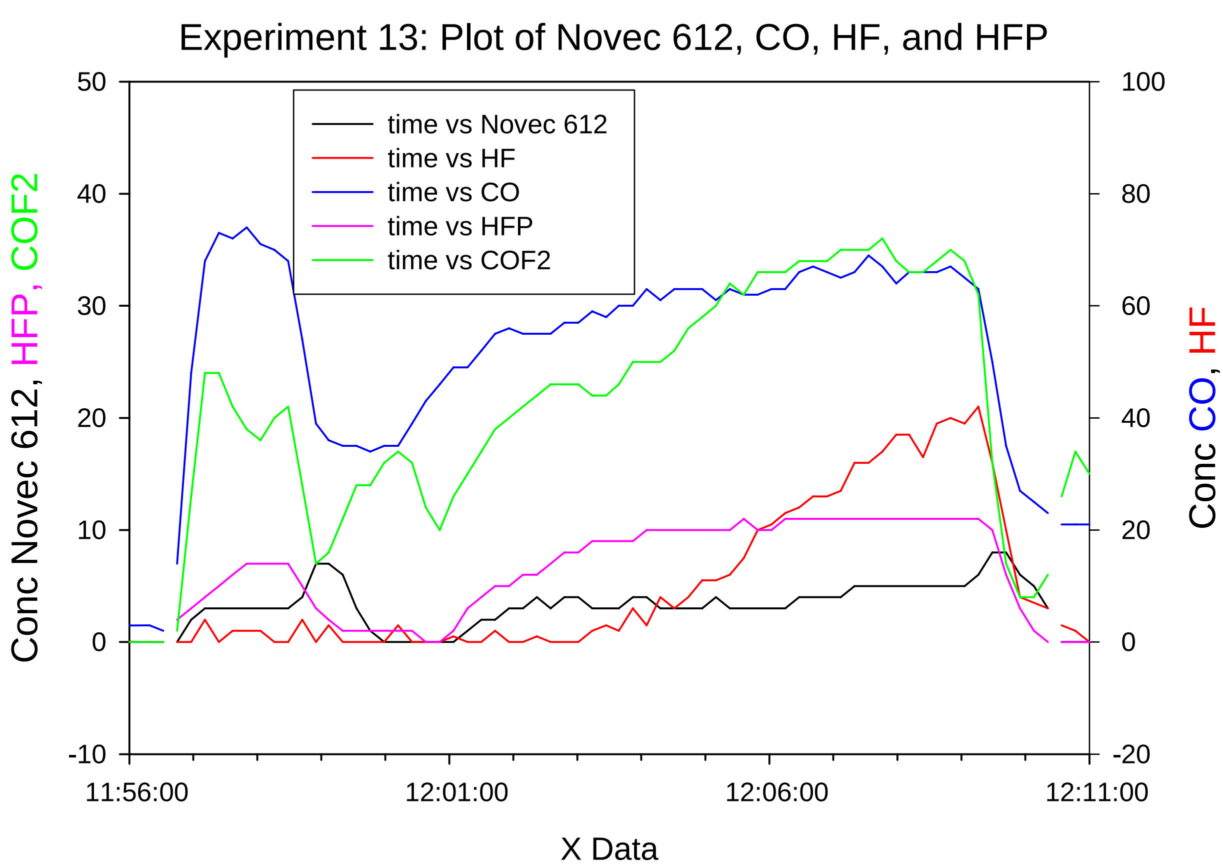

Experiment 9: Plot of HFC-134a, HF, CO and SO2
Conc ppmV
SO2 Conc
X Data
time vs HFC-134a
time vs HF
time vs CO
time vs SO2
0
25
50
75
100
125
150
175
200
0
150
300
450
600
750
900
1050
1200
1350
1500
08:22:00
08:27:00
08:32:00
08:37:00
08:42:00


Experiment 10: Plot of HFC-134a, HF, CO and SO2
Conc ppmV
SO2 Conc
X Data
time vs HFC-134a
time vs HF
time vs CO
time vs SO2
0
25
50
75
100
0
150
300
450
600
750
900
1050
1200
1350
1500
08:45:00
08:50:00
08:55:00
09:00:00
09:05:00


Experiment 11: Plot of HFC-134a, HF, CO and SO2
Conc ppmV
SO2 Conc
X Data
0
25
50
75
100
125
150
175
200
0
150
300
450
600
750
900
1050
1200
1350
1500
10:23:00
10:33:00
10:43:00
10:53:00
time vs HFC-134a
time vs HF
time vs CO
time vs SO2

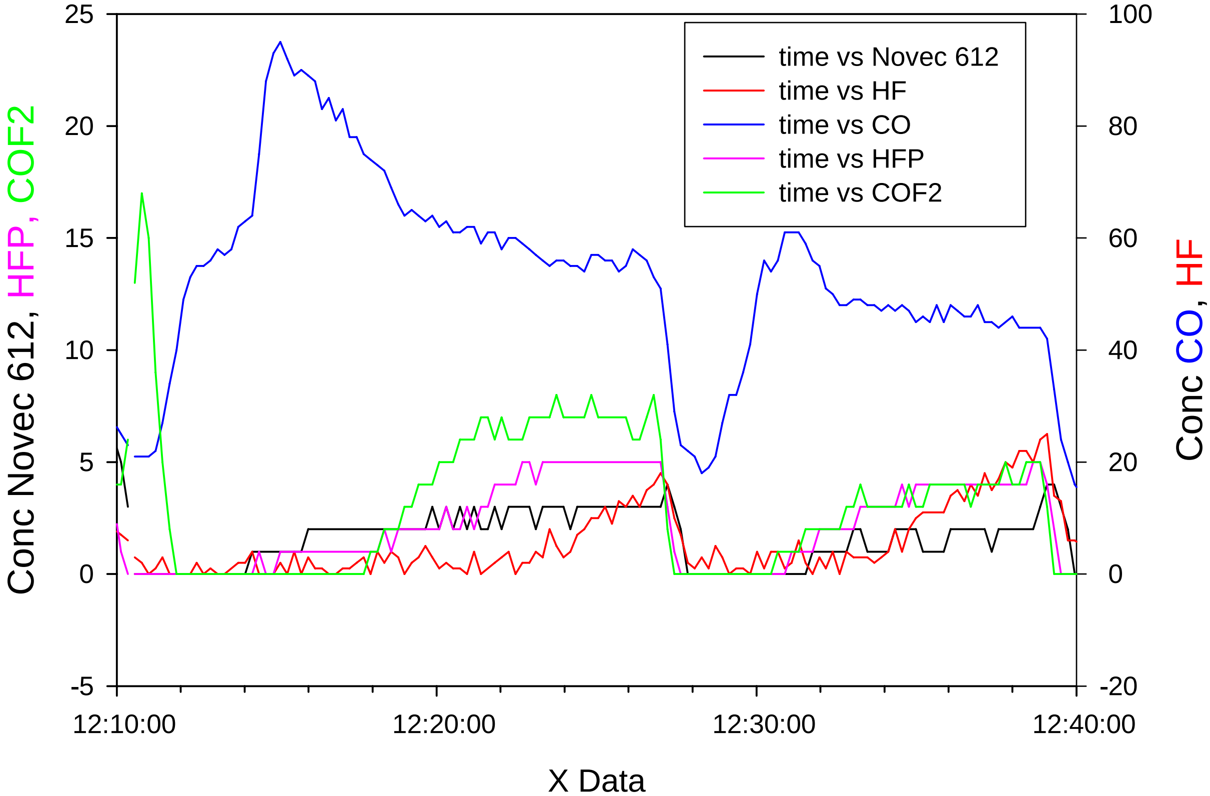


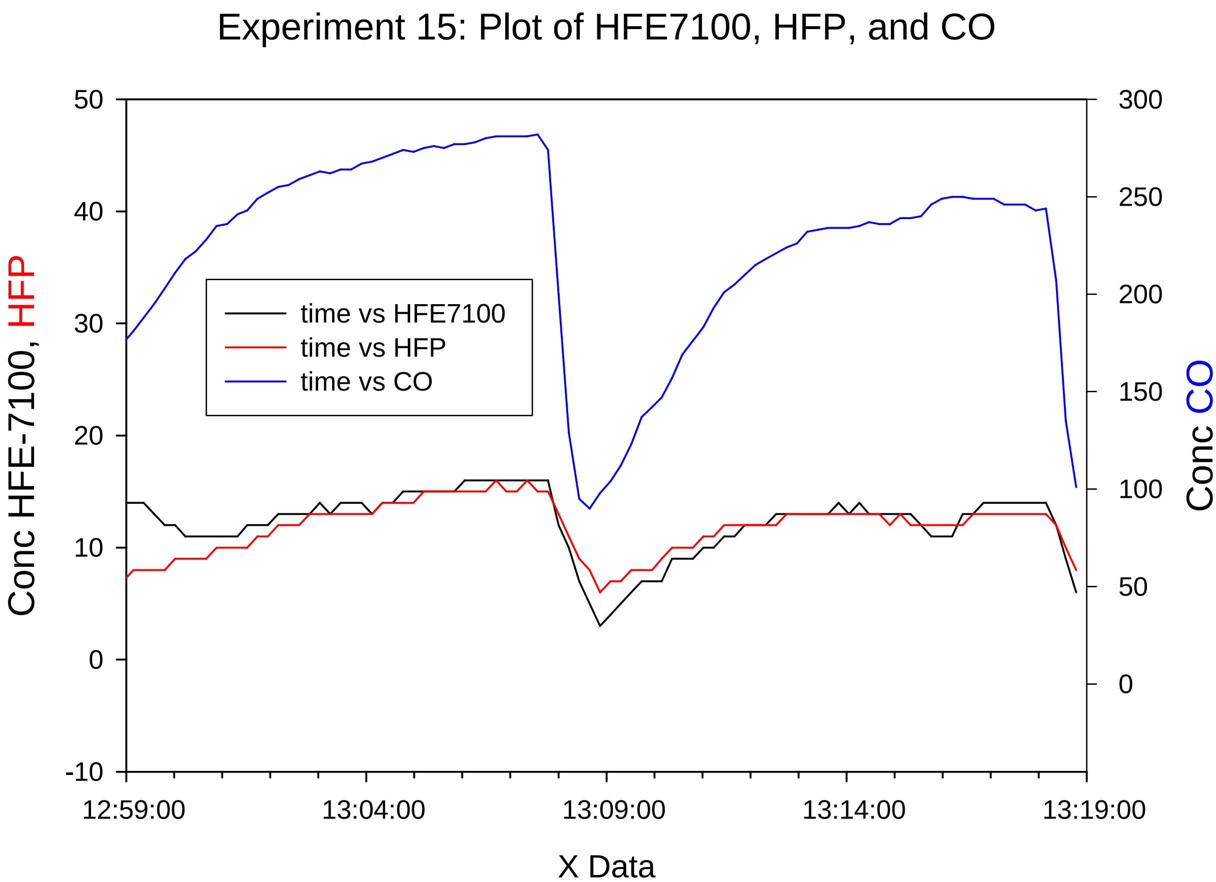
Experiment 12: Plot of Novec 612, CO, HF, and HFP
Conc Novec 612, HFP
Conc CO, HF
time vs Novec 612
time vs HF
time vs CO
time vs HFP
50
40
30
20
10
0
-10
200
150
100
50
0
11:07:00
11:12:00
11:17:00
11:22:00
X Data

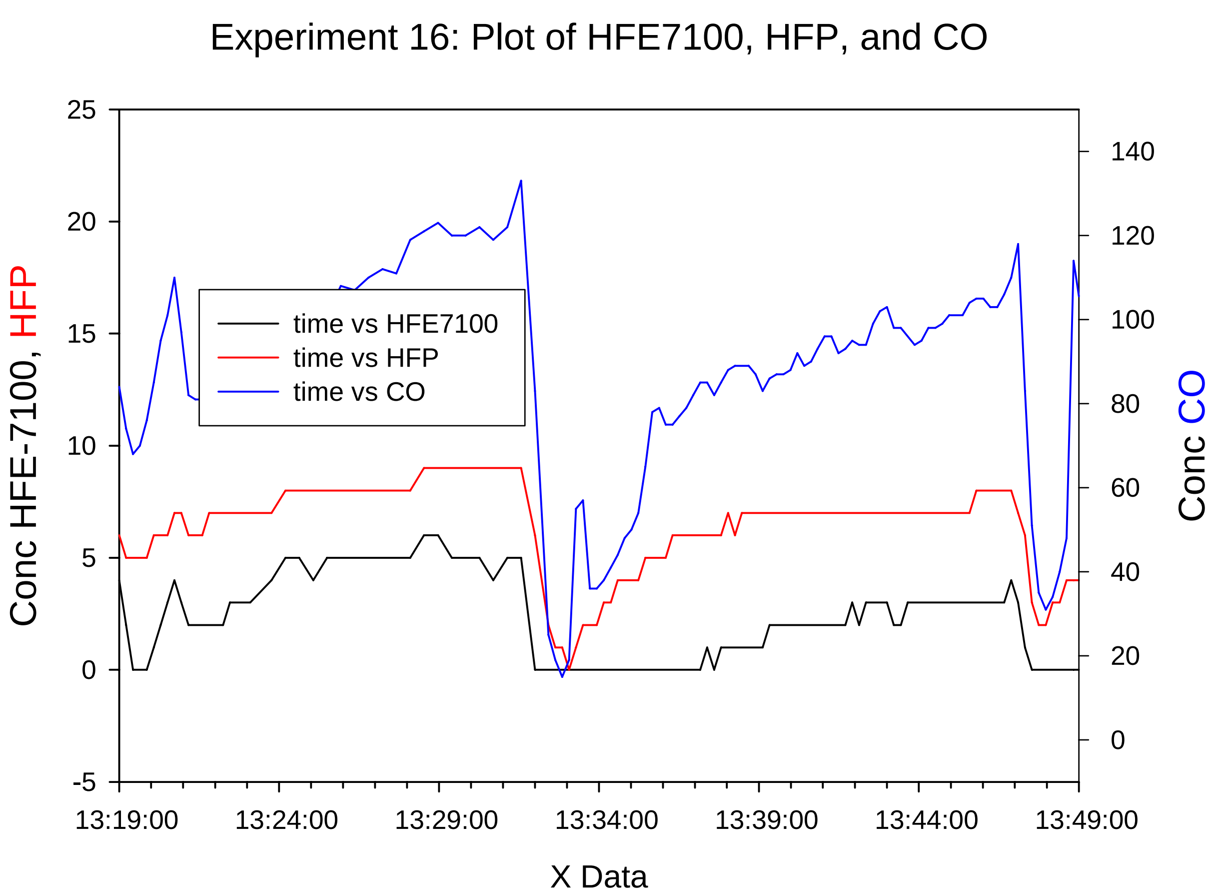


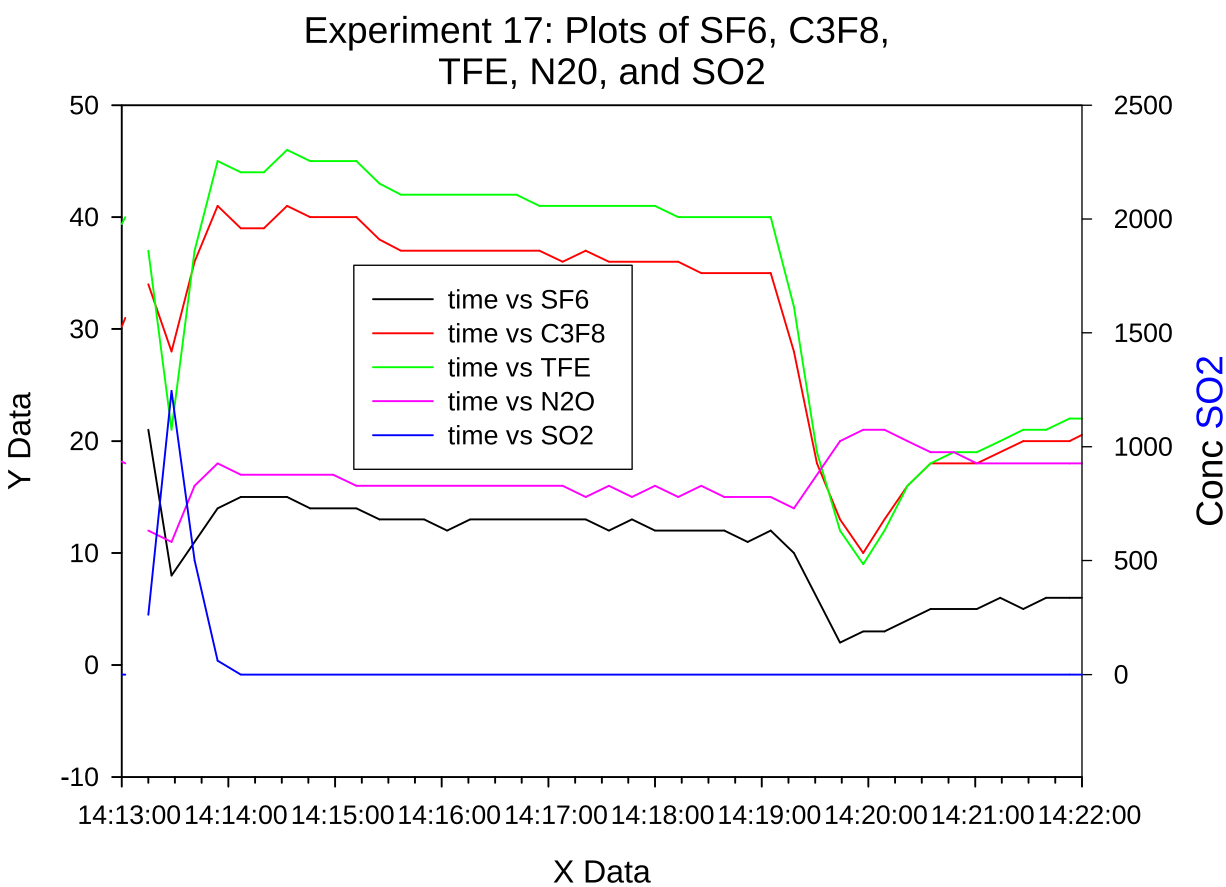
Experiment 13: Plot of Novec 612, CO, HF, and HFP
Conc Novec 612, HFP, COF2
Conc CO, HF
time vs Novec 612
time vs HF
time vs CO
time vs HFP
time vs COF2
50
40
30
20
10
0
-10
100
80
60
40
20
0
-20
11:56:00
12:01:00
12:06:00
12:11:00
X Data

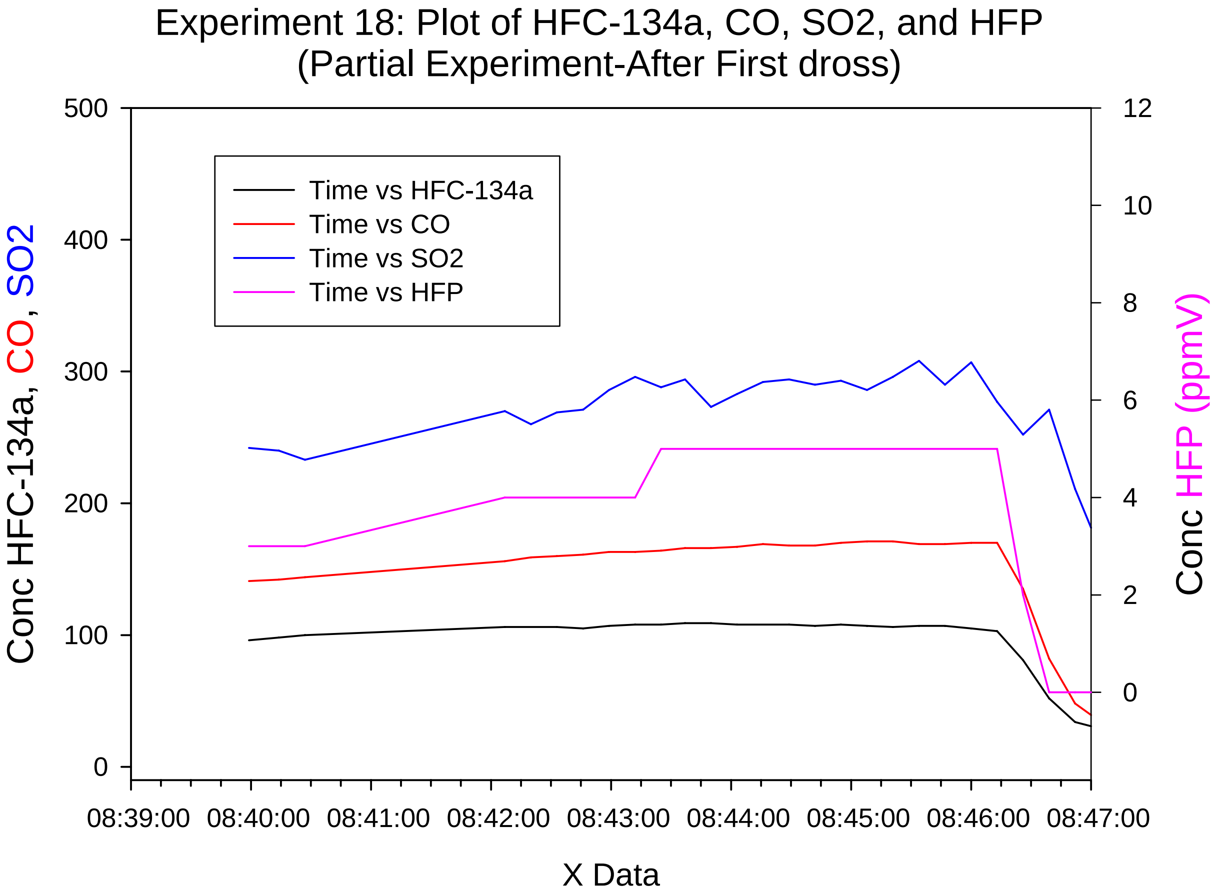
Experiment 14: Plot of Novec 612, CO, HF, and HFP



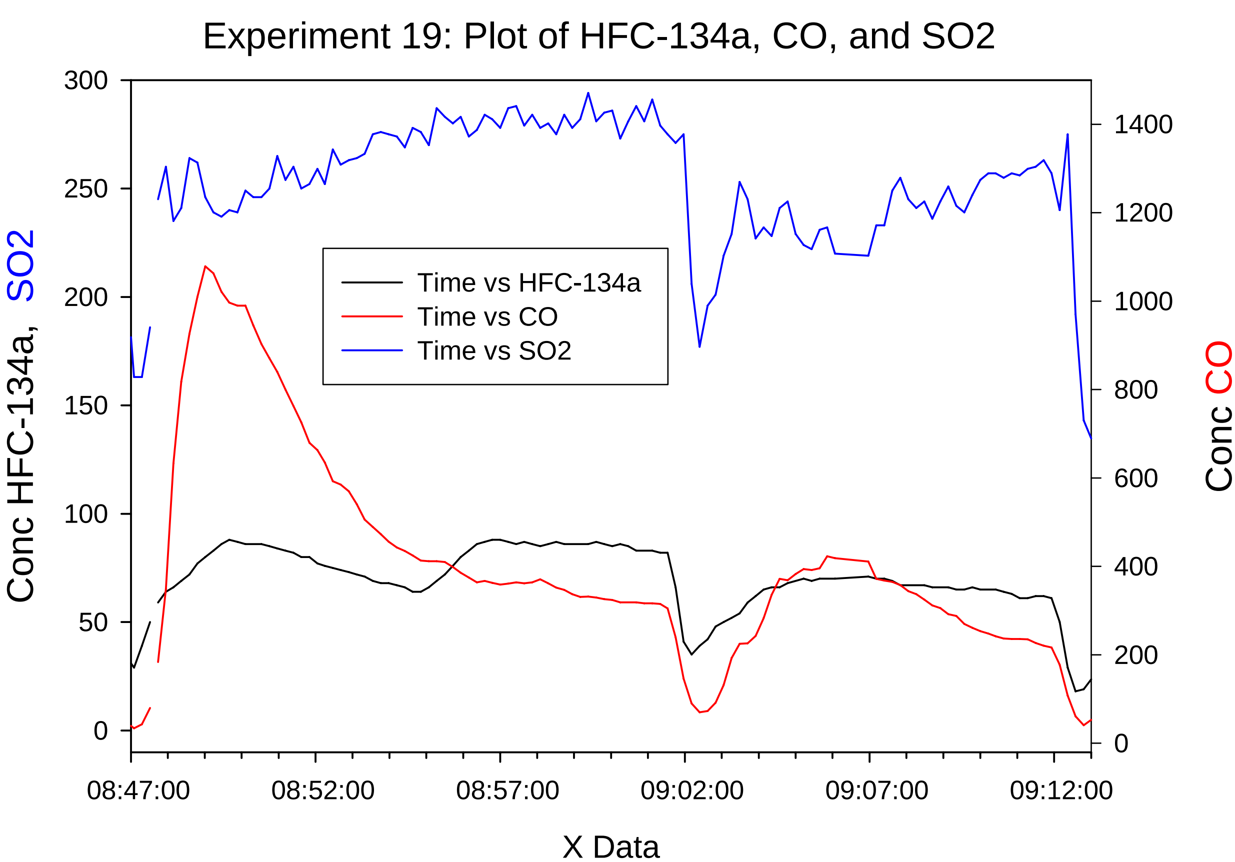

Experiment 15: Plot of HFE7100, HFP, and CO
Conc HFE-7100, HFP
Conc CO
time vs HFE7100
time vs HFP
time vs CO
50
40
30
20
10
0
-10
300
250
200
150
100
50
0
12:59:00
13:04:00
13:09:00
13:14:00
13:19:00
X Data


Experiment 16: Plot of HFE7100, HFP, and CO
Conc HFE-7100, HFP
Conc CO
time vs HFE7100
time vs HFP
time vs CO
25
20
15
10
5
0
-5
140
120
100
80
60
40
20
0
13:19:00
13:24:00
13:29:00
13:34:00
13:39:00
13:44:00
13:49:00
X Data

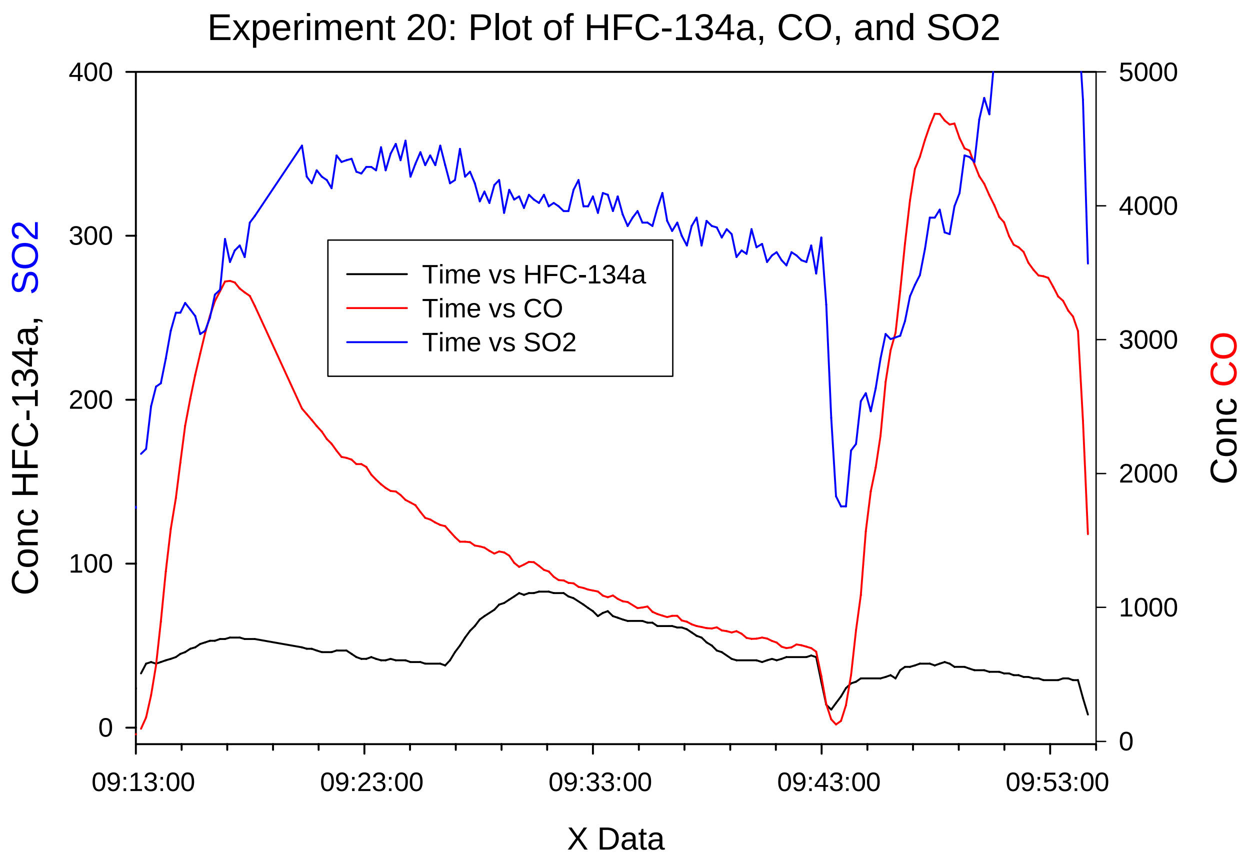

Experiment 17: Plots of SF6, C3F8,
TFE, N20, and SO2
Y Data
Conc SO2
X Data
time vs SF6
time vs C3F8
time vs TFE
time vs N2O
time vs SO2
50
40
30
20
10
0
-10
2500
2000
1500
1000
500
0
14:13:00
14:14:00
14:15:00
14:16:00
14:17:00
14:18:00
14:19:00
14:20:00
14:21:00
14:22:00



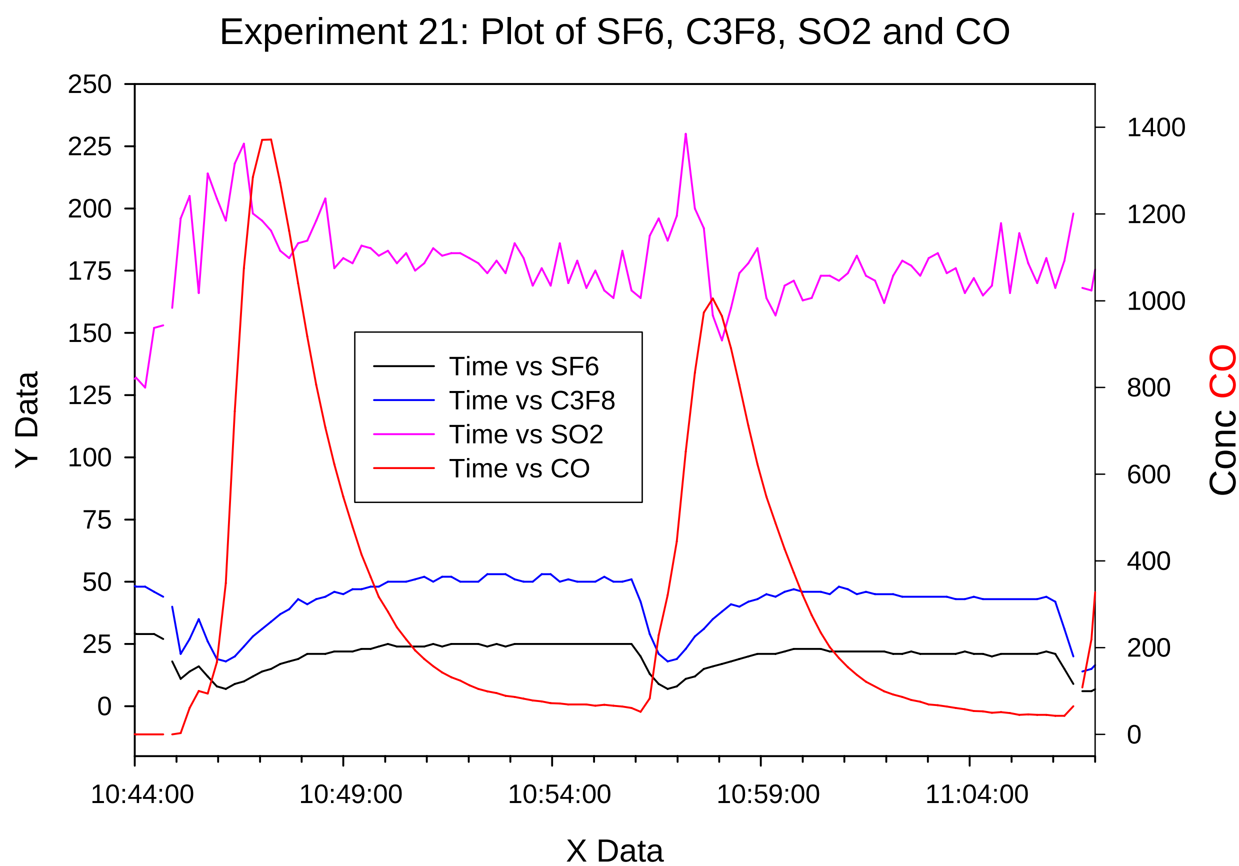
Experiment 18: Plot of HFC-134a, CO, SO2, and HFP
(Partial Experiment-After First dross)
Time vs HFC-134a
Time vs CO
Time vs SO2
Time vs HFP
Conc HFC-134a, CO, SO2
Conc HFP (ppmV)
0
100
200
300
400
500
0
2
4
6
8
10
12
08:39:00
08:40:00
08:41:00
08:42:00
08:43:00
08:44:00
08:45:00
08:46:00
08:47:00
X Data



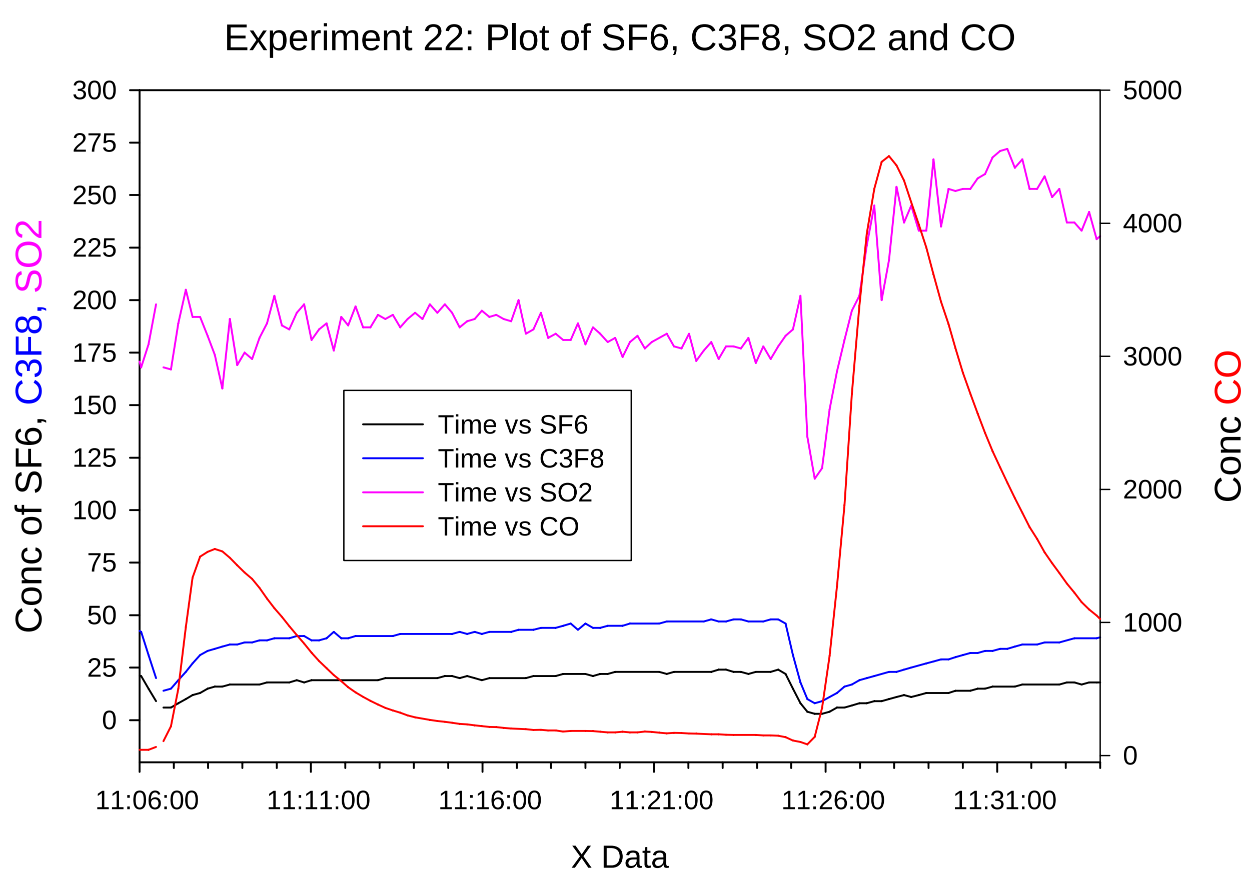
Experiment 19: Plot of HFC-134a, CO, and SO2
Time vs HFC-134a
Time vs CO
Time vs SO2
Conc HFC-134a, SO2
Conc CO
0
50
100
150
200
250
300
0
200
400
600
800
1000
1200
1400
08:47:00
08:52:00
08:57:00
09:02:00
09:07:00
09:12:00
X Data



Experiment 20: Plot of HFC-134a, CO, and SO2
Conc HFC-134a, SO2
Conc CO
X Data
Time vs HFC-134a
Time vs CO
Time vs SO2
0
100
200
300
400
0
1000
2000
3000
4000
5000
09:13:00
09:23:00
09:33:00
09:43:00
09:53:00

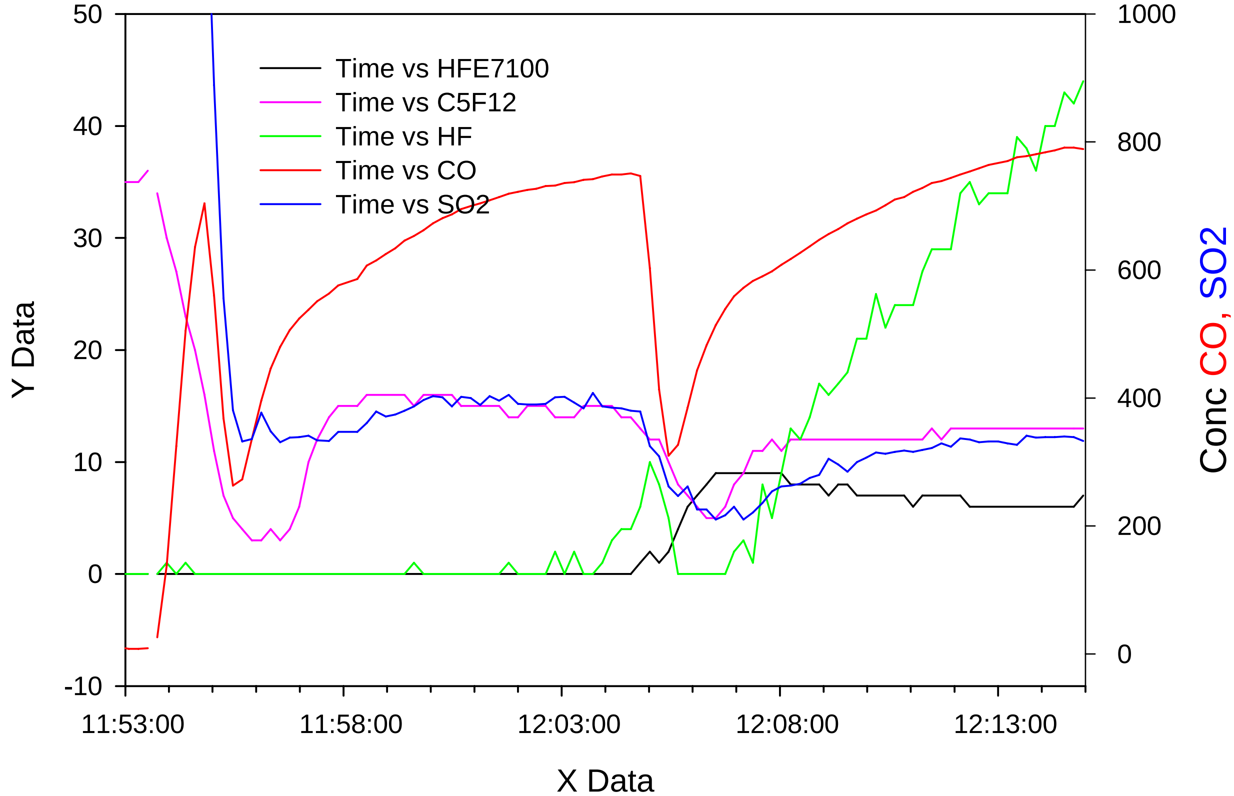


Experiment 21: Plot of SF6, C3F8, SO2 and CO
Y Data
Conc CO
X Data
Time vs SF6
Time vs C3F8
Time vs SO2
Time vs CO
250
225
200
175
150
125
100
75
50
25
0
1400
1200
1000
800
600
400
200
0
10:44:00
10:49:00
10:54:00
10:59:00
11:04:00

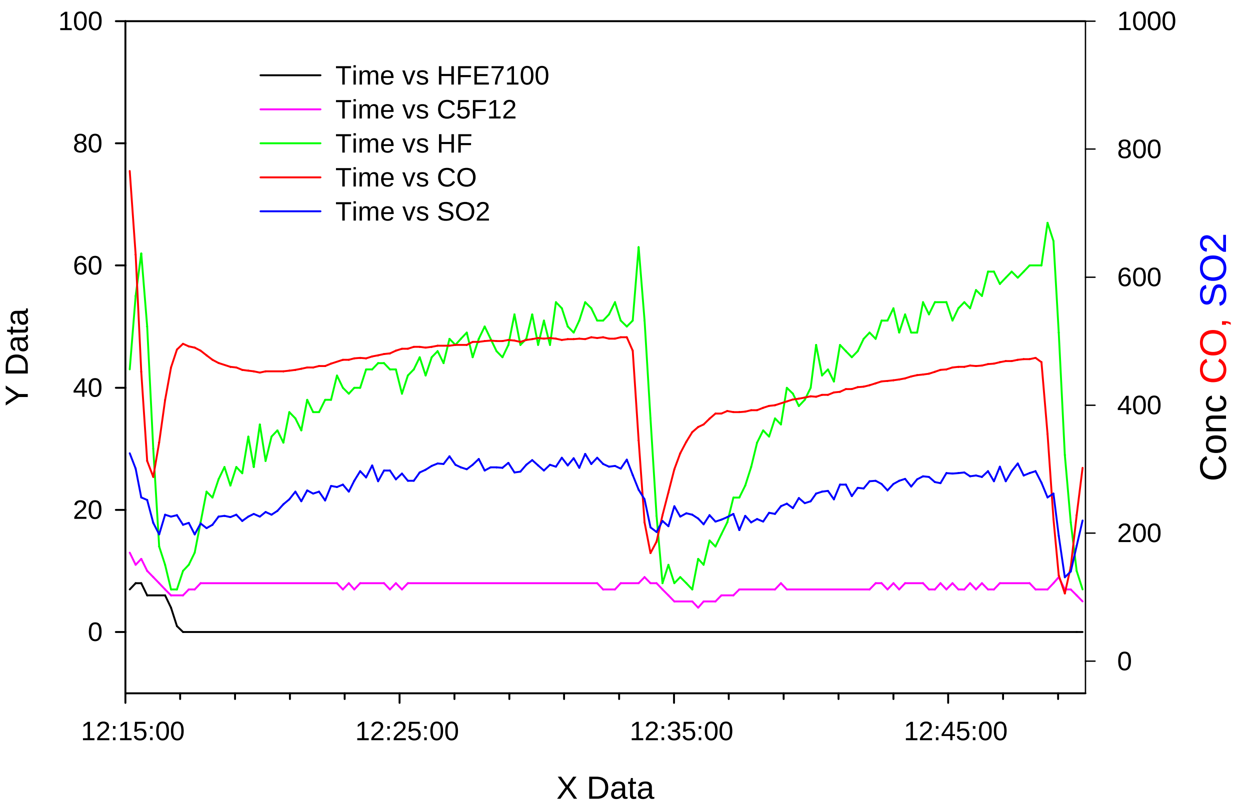


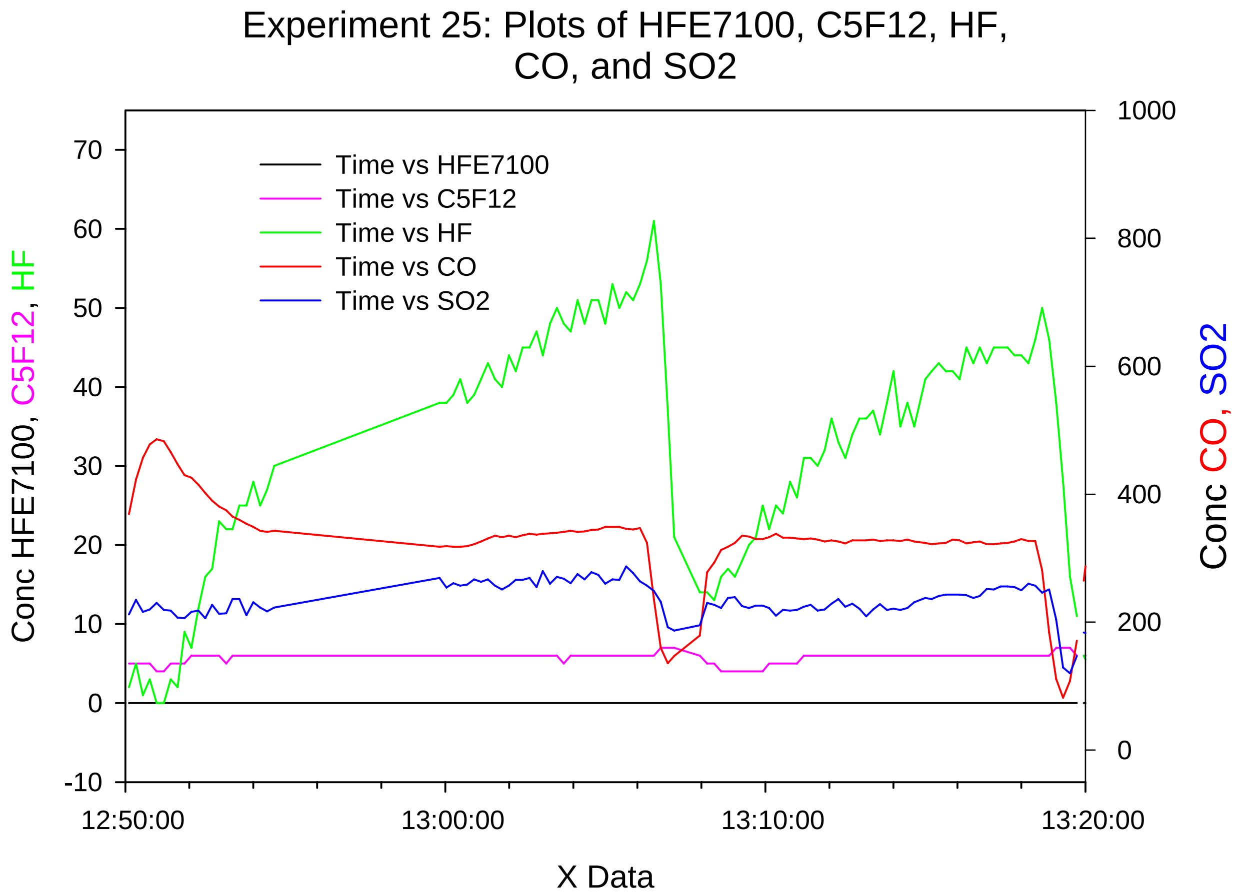
Experiment 22: Plot of SF6, C3F8, SO2 and CO
Conc of SF6, C3F8, SO2
Conc CO
X Data
Time vs SF6
Time vs C3F8
Time vs SO2
Time vs CO
300
275
250
225
200
175
150
125
100
75
50
25
0
5000
4000
3000
2000
1000
0
11:06:00
11:11:00
11:16:00
11:21:00
11:26:00
11:31:00

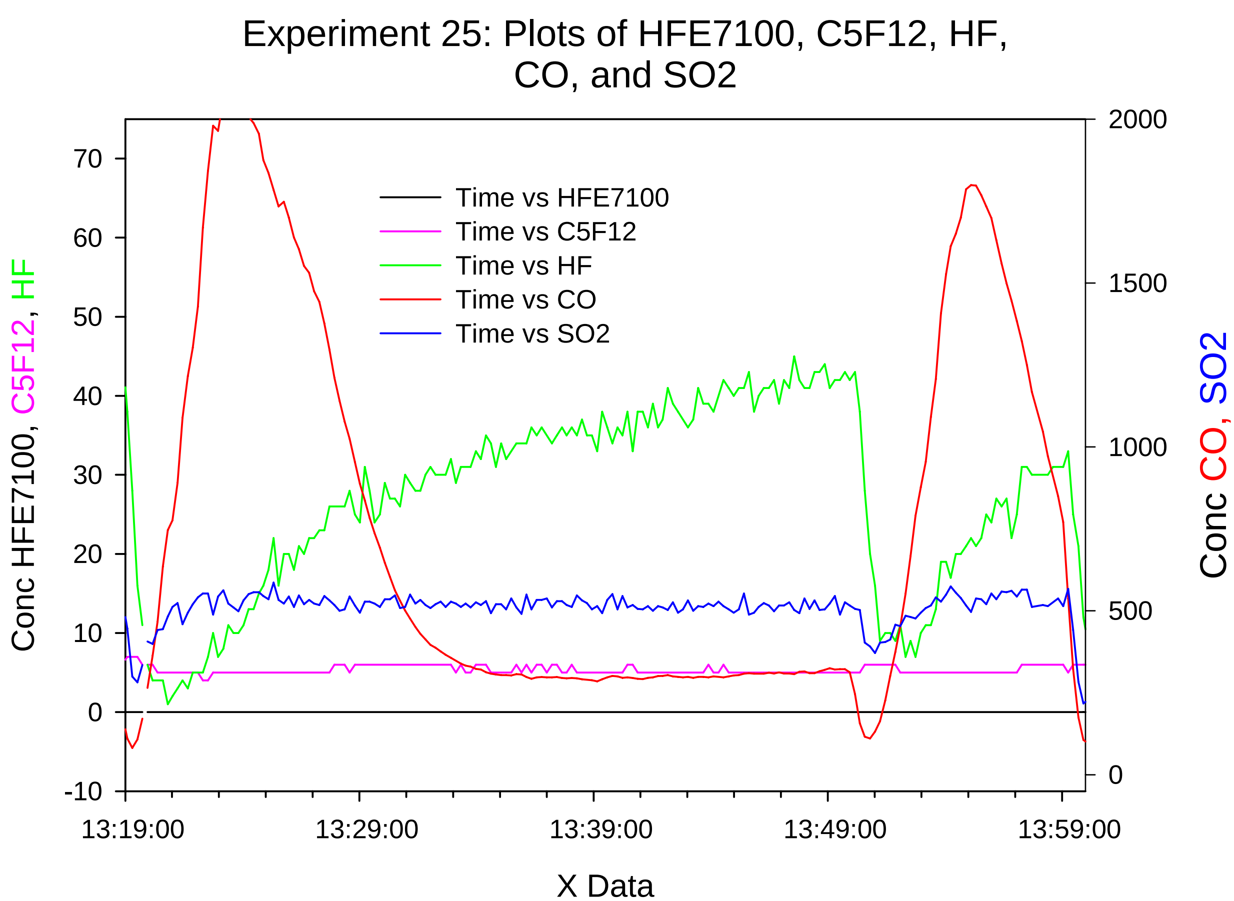
Experiment 23: Plots of HFE7100, C5F12, HF, CO, and SO2



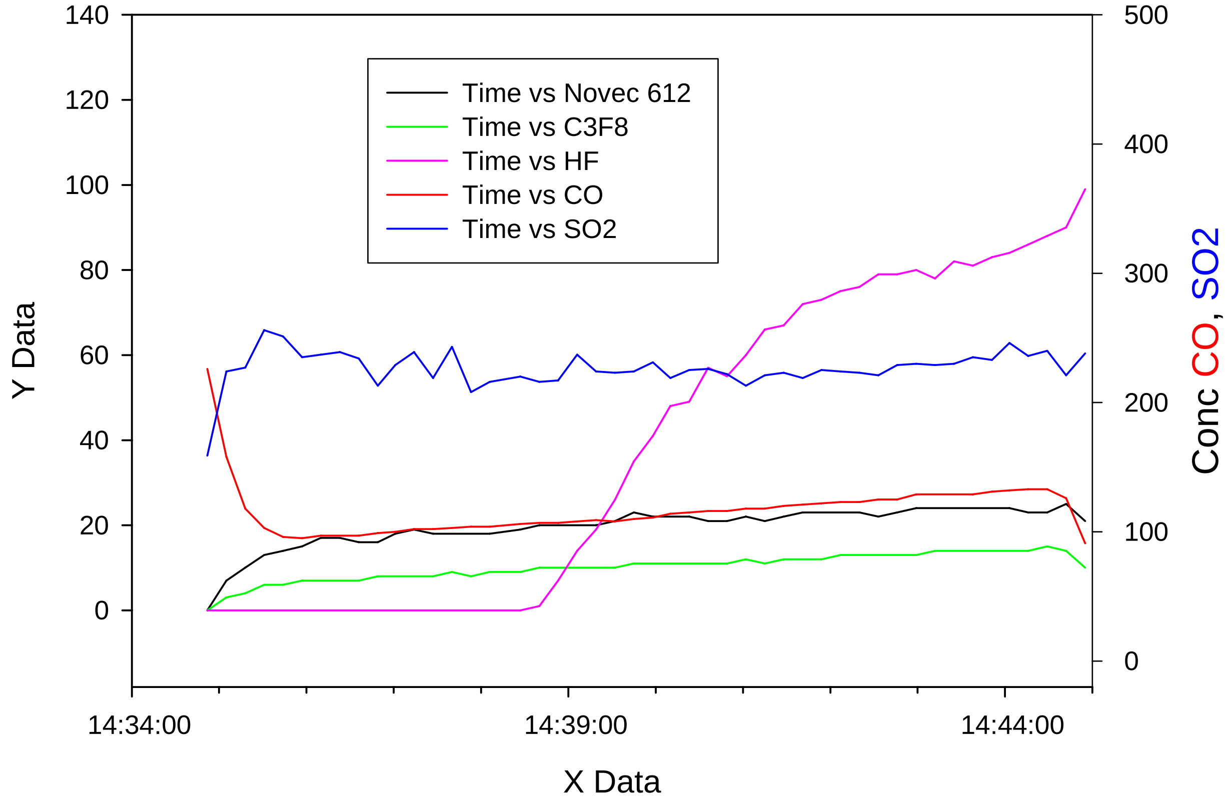
Experiment 24: Plots of HFE7100, C5F12, HF, CO, and SO2



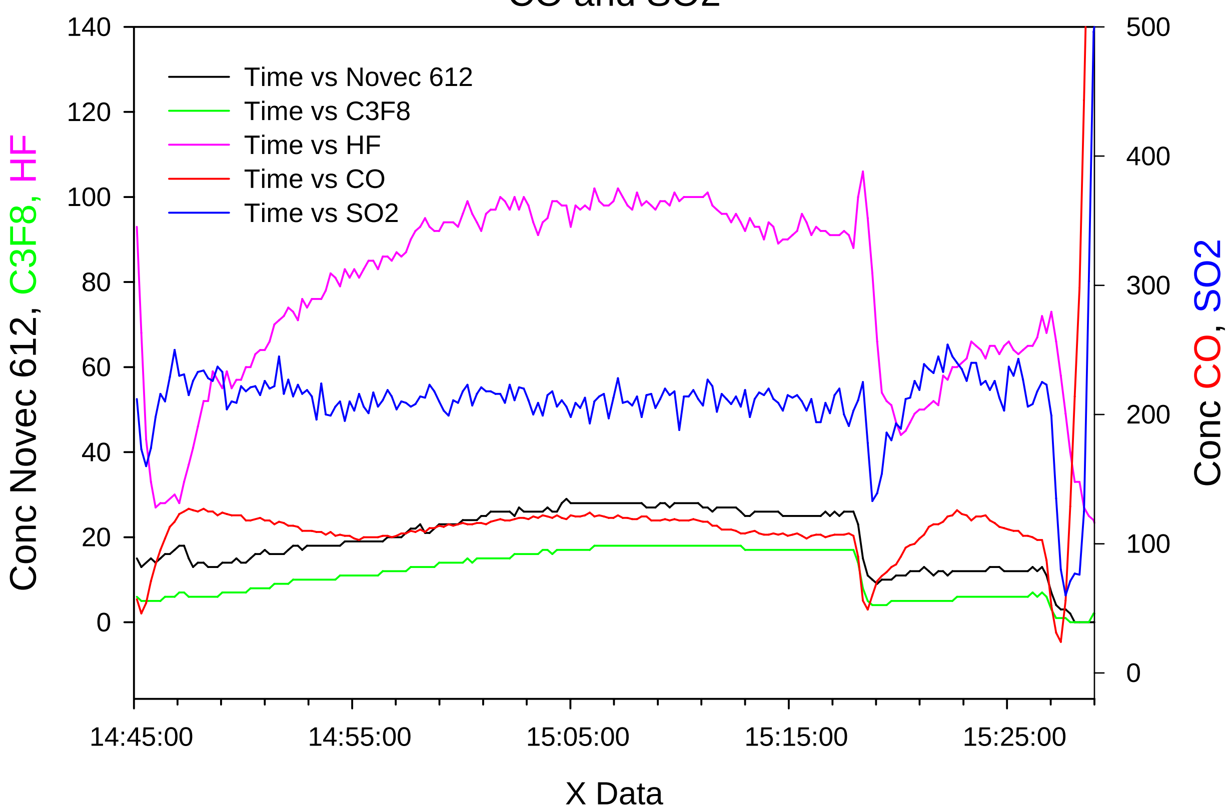

Experiment 25: Plots of HFE7100, C5F12, HF, CO, and SO2
Time vs HFE7100
Time vs C5F12
Time vs HF
Time vs CO
Time vs SO2
Conc HFE7100, C5F12, HF
Conc CO, SO2
X Data
12:50:00
13:00:00
13:10:00
13:20:00
70
60
50
40
30
20
10
0
-10
1000
800
600
400
200
0


Experiment 25: Plots of HFE7100, C5F12, HF, CO, and SO2
Time vs HFE7100
Time vs C5F12
Time vs HF
Time vs CO
Time vs SO2
Conc HFE7100, C5F12, HF
Conc CO, SO2
X Data
13:19:00
13:29:00
13:39:00
13:49:00
13:59:00
70
60
50
40
30
20
10
0
-10
2000
1500
1000
500
0

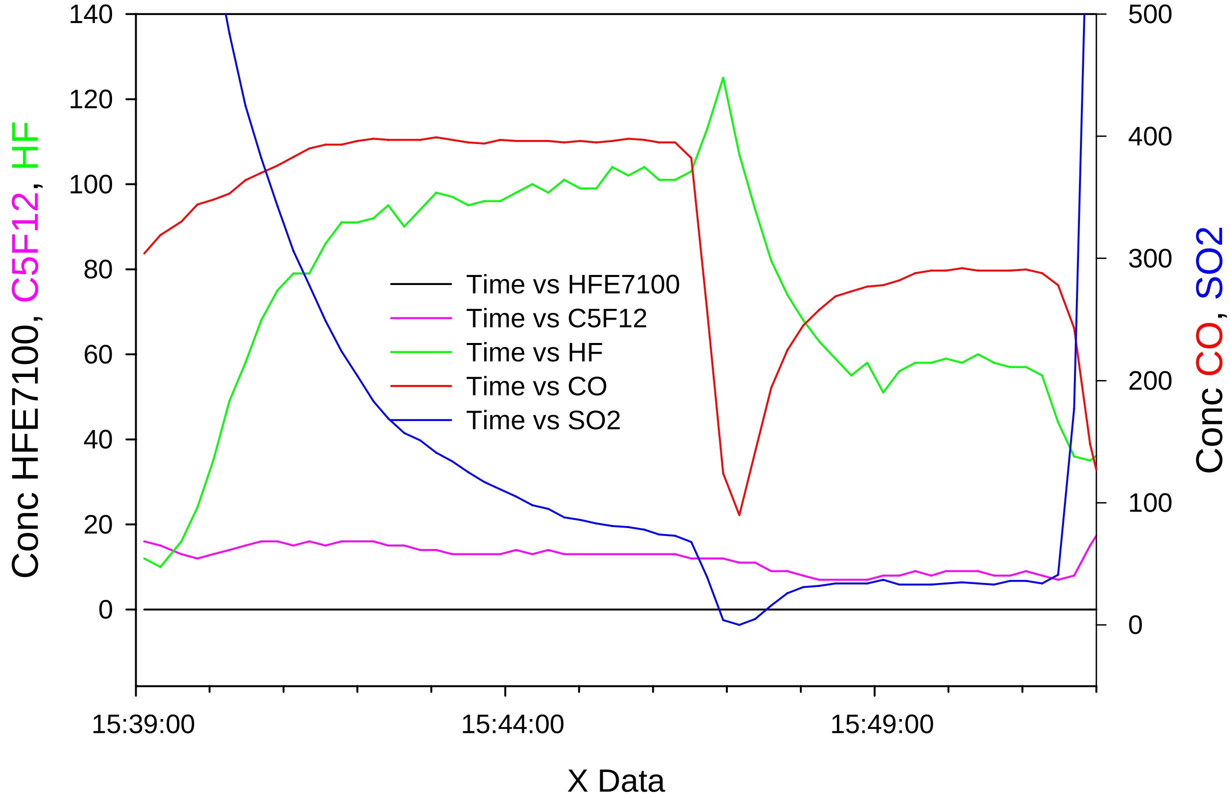
Experiment 27: Plot of Novec 612, C3F8, HF, CO and SO2
Partial Data After First Dross

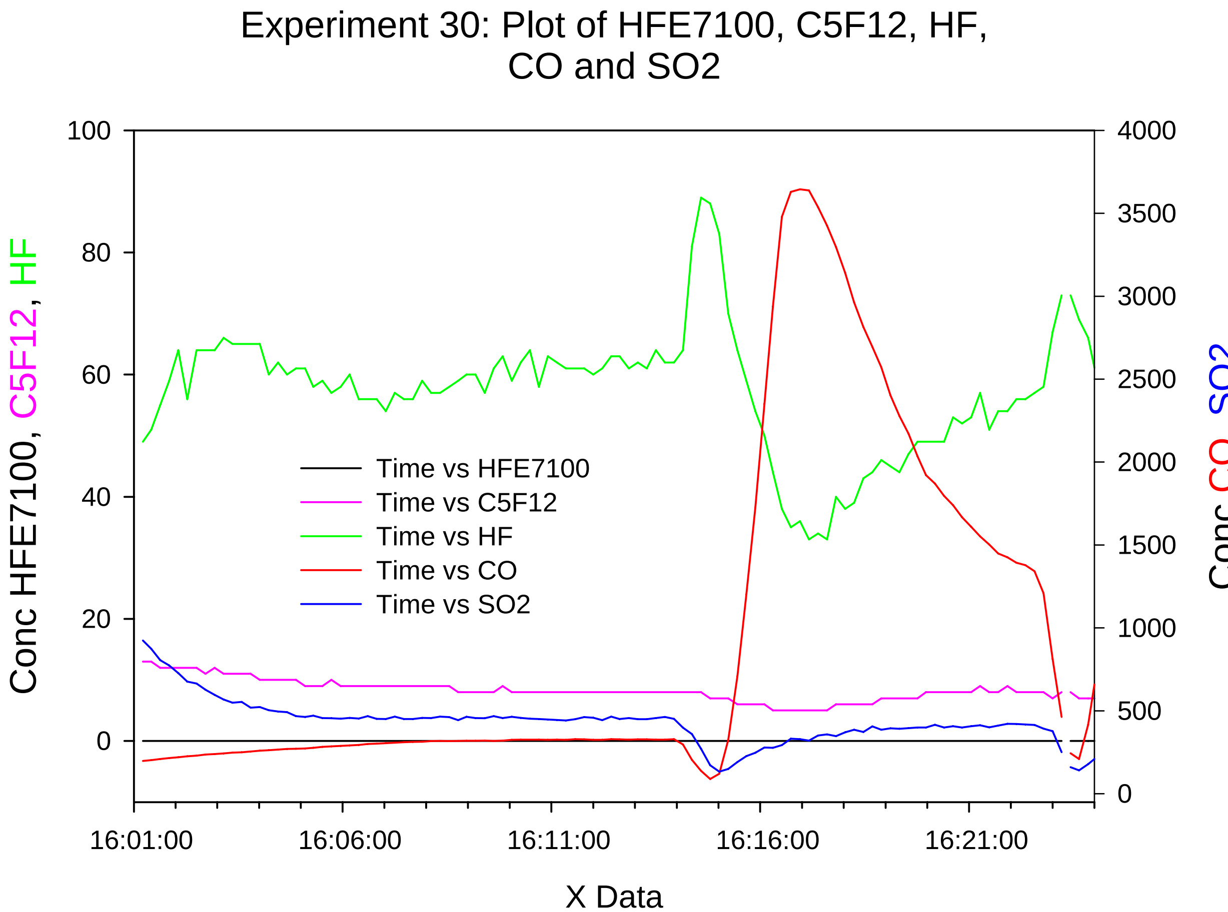


Experiment 28: Plot of Novec 612, C3F8, HF, CO and SO2

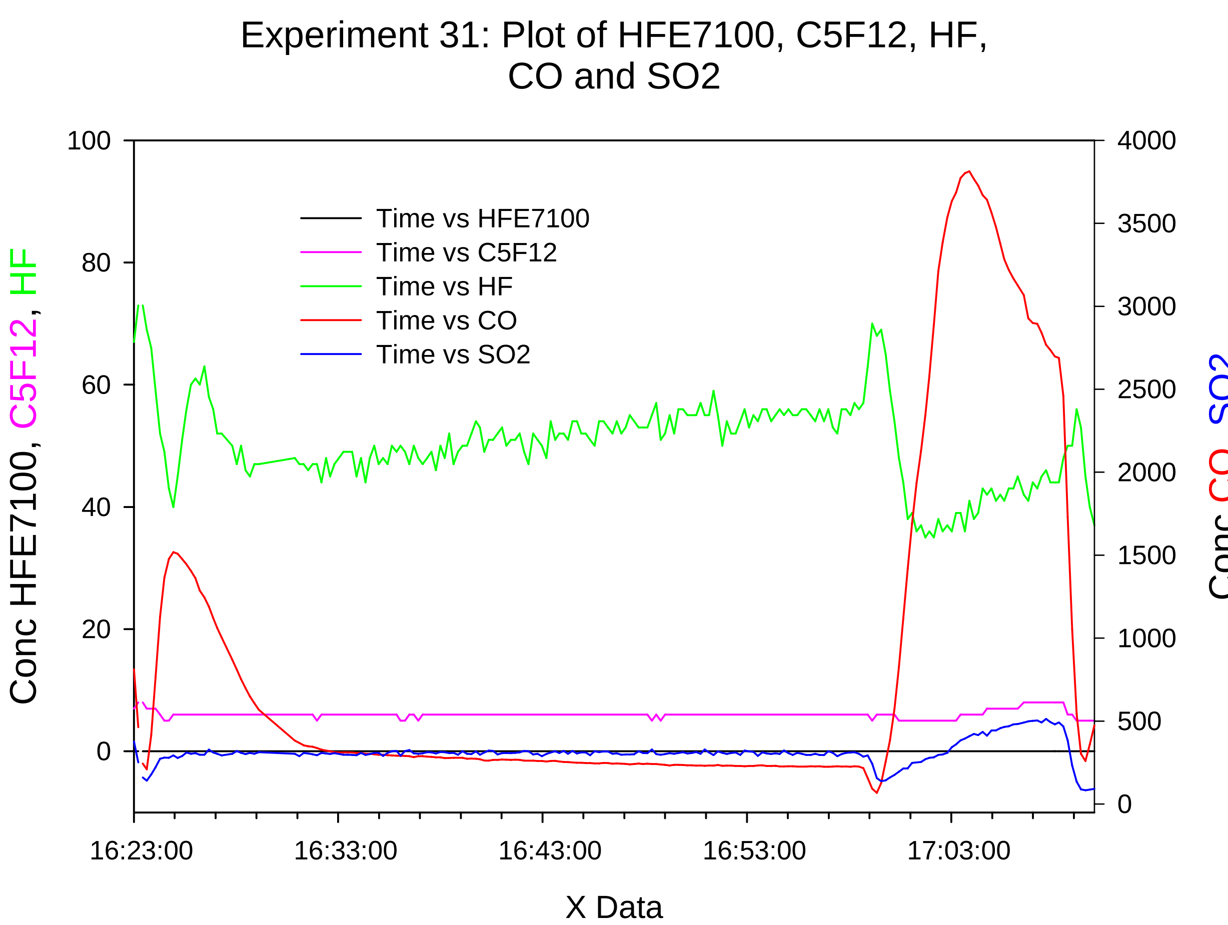


Experiment 29: Plot of HFE7100, C5F12, HF,
CO and SO2

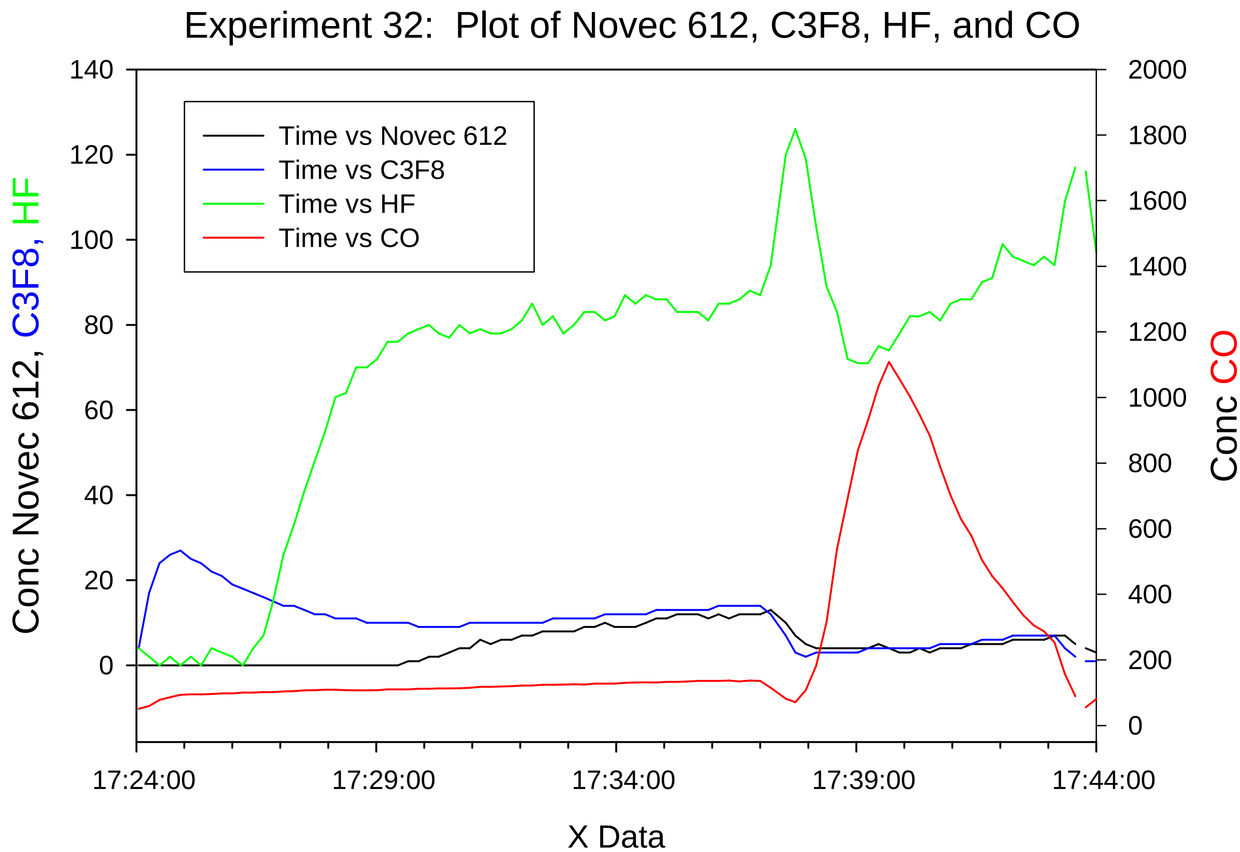


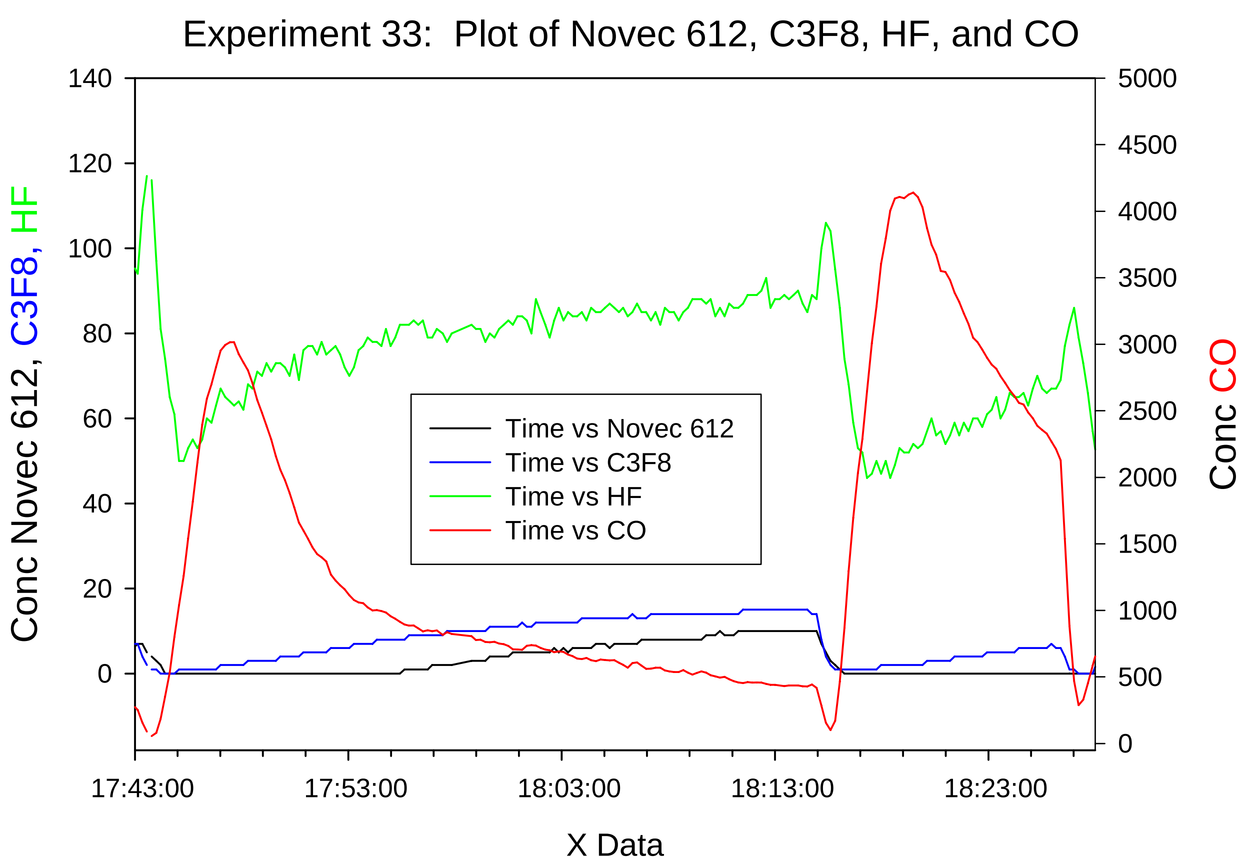


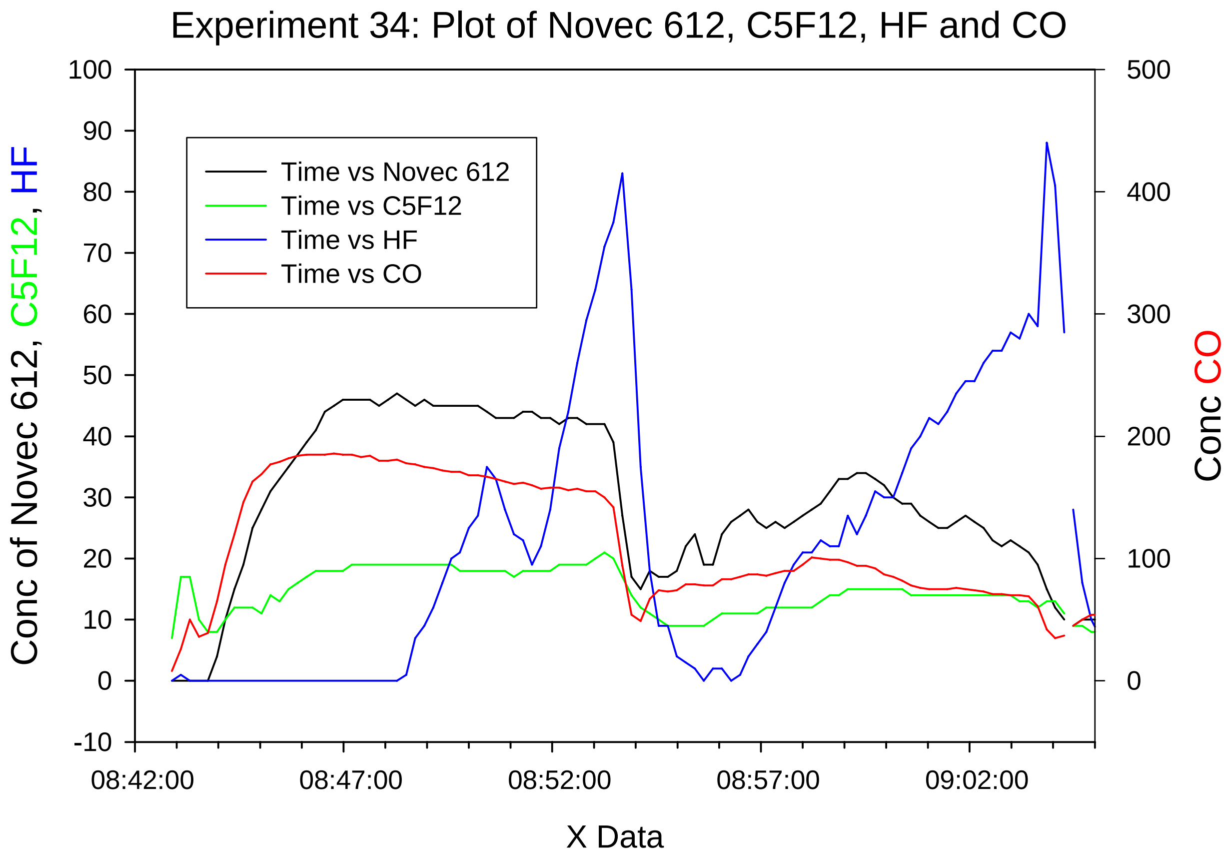
Experiment 30: Plot of HFE7100, C5F12, HF, CO and SO2
Conc HFE7100, C5F12, HF
Conc CO, SO2
100
80
60
40
20
0
4000
3500
3000
2500
2000
1500
1000
500
0
Time vs HFE7100
Time vs C5F12
Time vs HF
Time vs CO
Time vs SO2
16:01:00
16:06:00
16:11:00
16:16:00
16:21:00
X Data

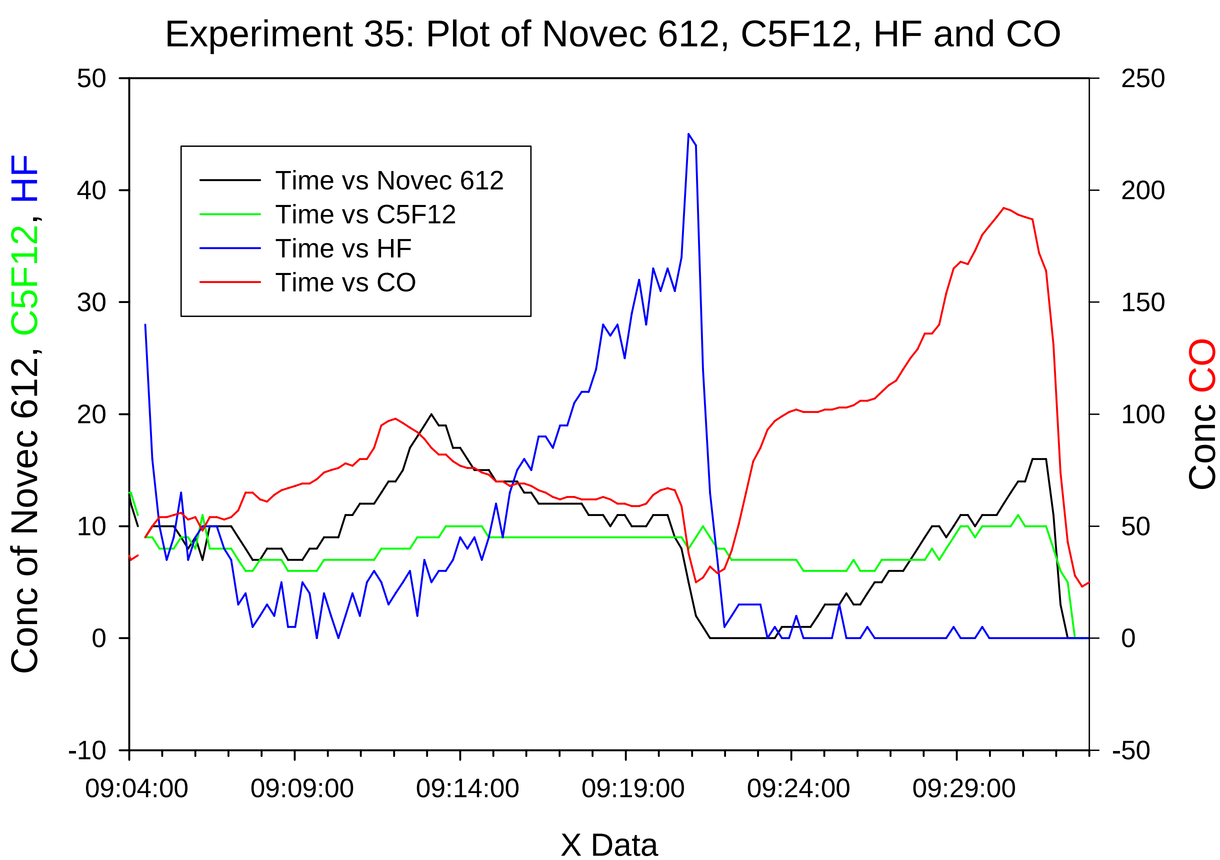


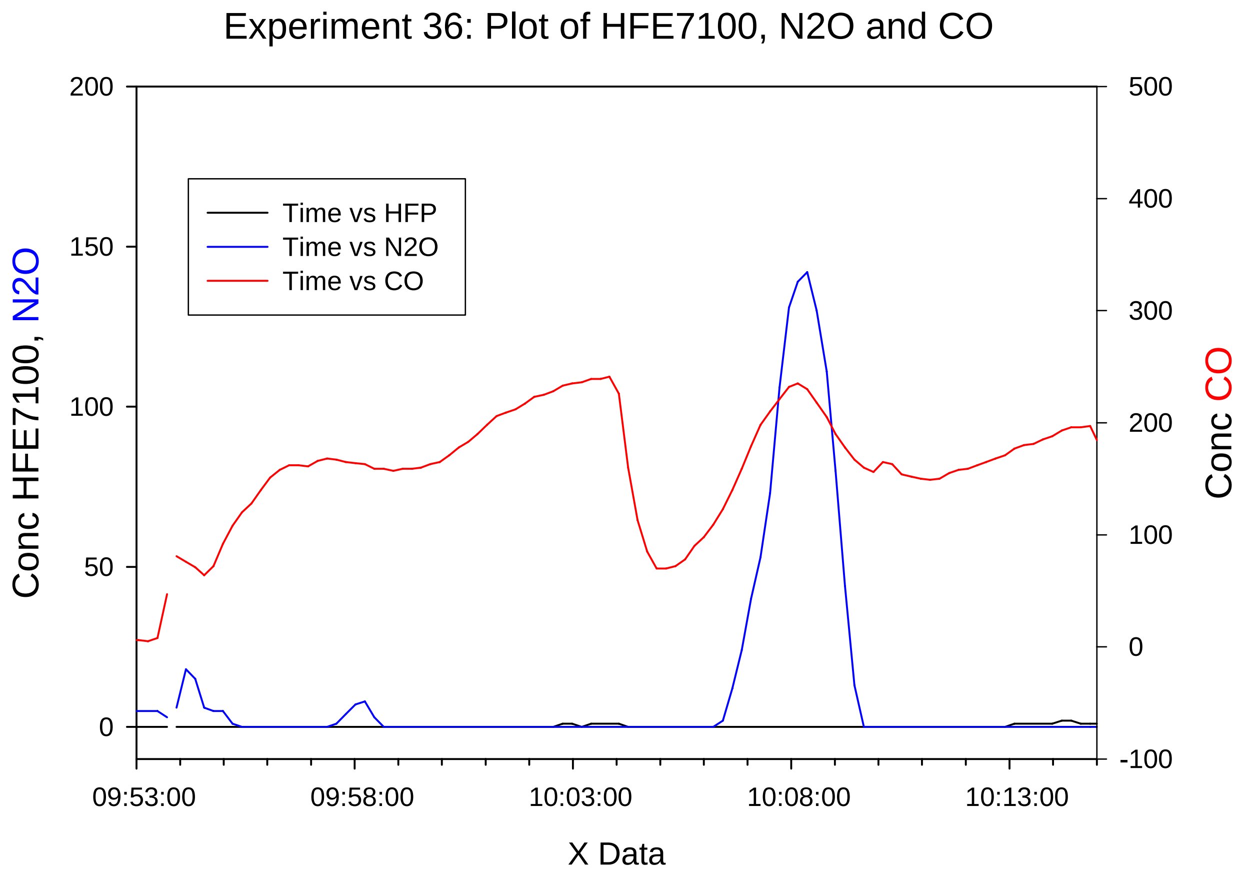
Experiment 31: Plot of HFE7100, C5F12, HF, CO and SO2
Conc HFE7100, C5F12, HF
Conc CO, SO2
100
80
60
40
20
0
4000
3500
3000
2500
2000
1500
1000
500
0
Time vs HFE7100
Time vs C5F12
Time vs HF
Time vs CO
Time vs SO2
16:23:00
16:33:00
16:43:00
16:53:00
17:03:00
X Data


Experiment 32: Plot of Novec 612, C3F8, HF, and CO
Conc Novec 612, C3F8, HF
Conc CO
Time vs Novec 612
Time vs C3F8
Time vs HF
Time vs CO
140
120
100
80
60
40
20
0
2000
1800
1600
1400
1200
1000
800
600
400
200
0
17:24:00
17:29:00
17:34:00
17:39:00
17:44:00
X Data

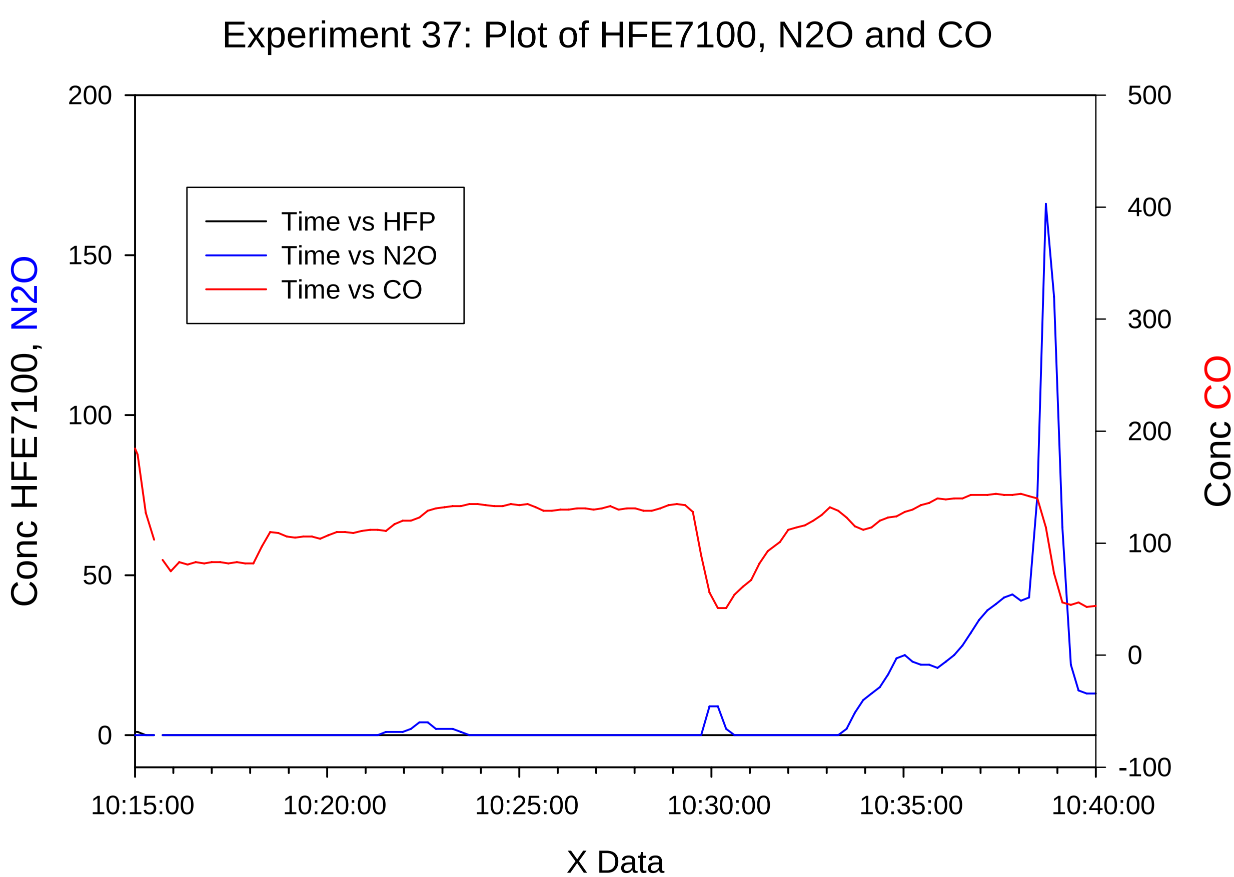

Experiment 33: Plot of Novec 612, C3F8, HF, and CO
Conc Novec 612, C3F8, HF
Conc CO
Time vs Novec 612
Time vs C3F8
Time vs HF
Time vs CO
140
120
100
80
60
40
20
0
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
17:43:00
17:53:00
18:03:00
18:13:00
18:23:00
X Data


Experiment 34: Plot of Novec 612, C5F12, HF and CO
Conc of Novec 612, C5F12, HF
Conc CO
X Data
Time vs Novec 612
Time vs C5F12
Time vs HF
Time vs CO
100
90
80
70
60
50
40
30
20
10
0
-10
500
400
300
200
100
0
08:42:00
08:47:00
08:52:00
08:57:00
09:02:00


Experiment 35: Plot of Novec 612, C5F12, HF and CO
Conc of Novec 612, C5F12, HF
Conc CO
X Data
Time vs Novec 612
Time vs C5F12
Time vs HF
Time vs CO
50
40
30
20
10
0
-10
250
200
150
100
50
0
-50
09:04:00
09:09:00
09:14:00
09:19:00
09:24:00
09:29:00

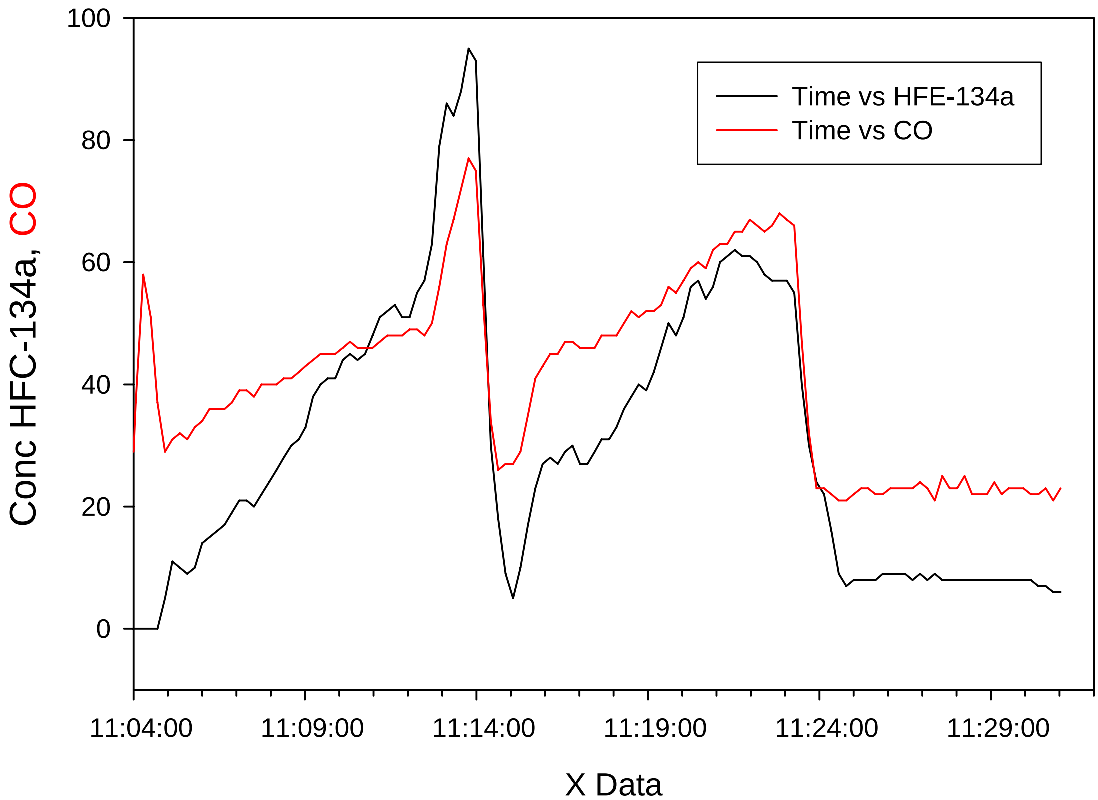


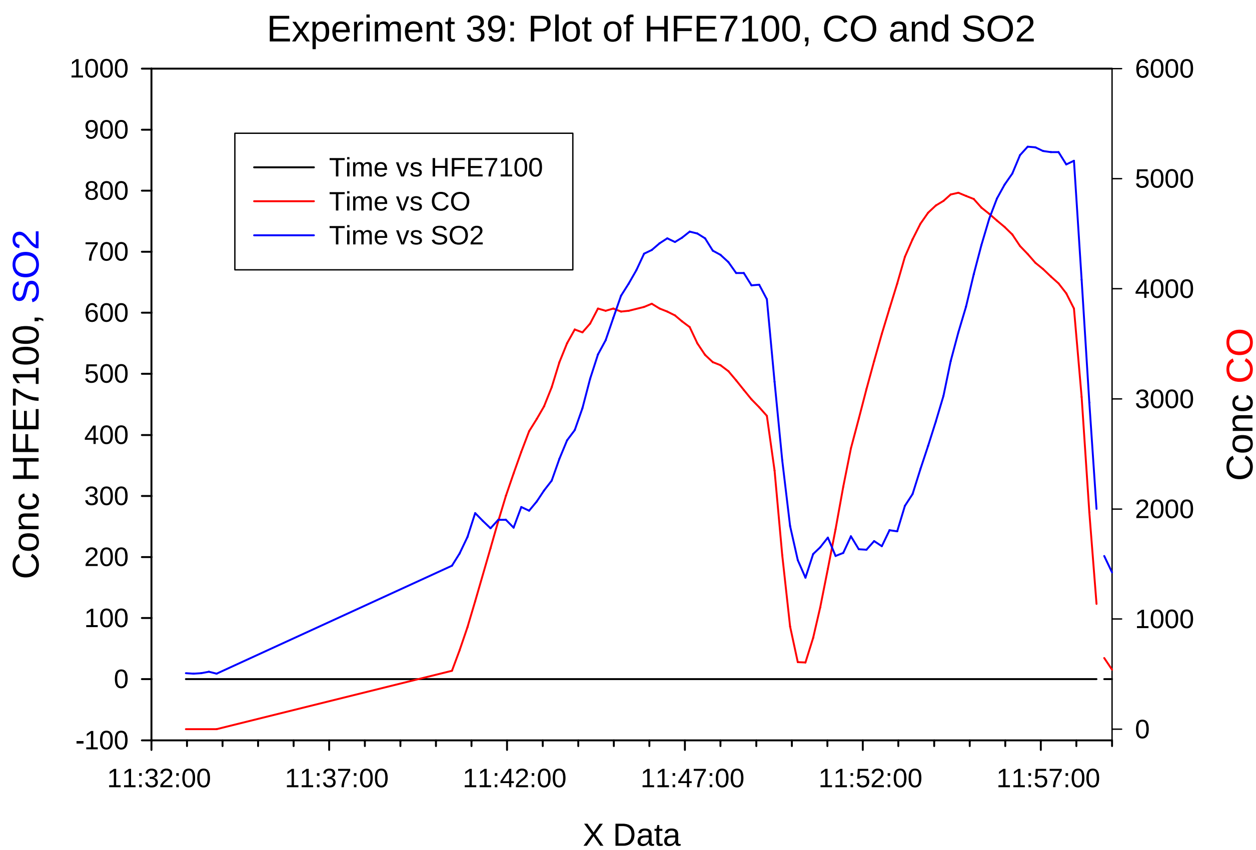
Experiment 36: Plot of HFE7100, N2O and CO
Time vs HFP
Time vs N2O
Time vs CO
Conc HFE7100, N2O
Conc CO
X Data
0
50
100
150
200
-100
0
100
200
300
400
500
09:53:00
09:58:00
10:03:00
10:08:00
10:13:00



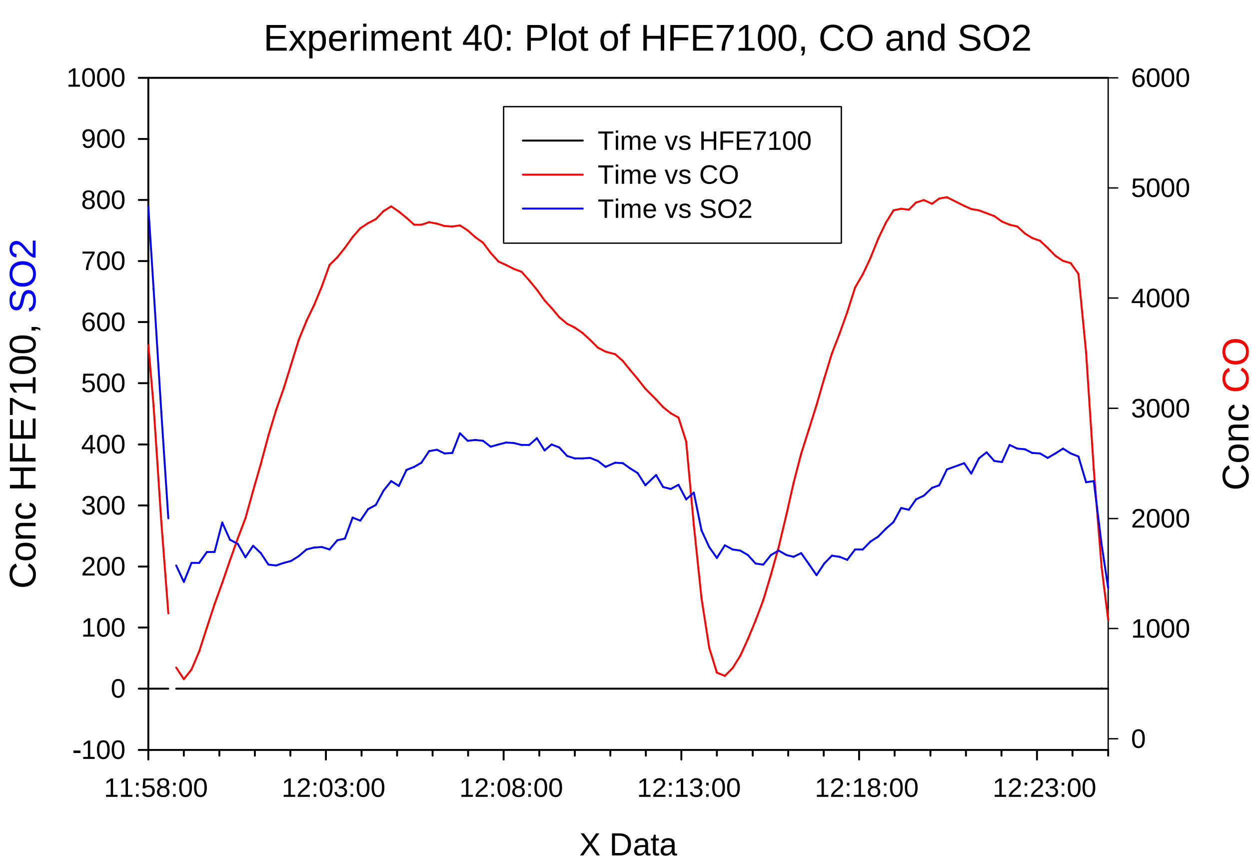
Experiment 37: Plot of HFE7100, N2O and CO
Time vs HFP
Time vs N2O
Time vs CO
Conc HFE7100, N2O
Conc CO
X Data
0
50
100
150
200
-100
0
100
200
300
400
500
10:15:00
10:20:00
10:25:00
10:30:00
10:35:00
10:40:00

Experiment 38: Plot of HFC-134a, CO

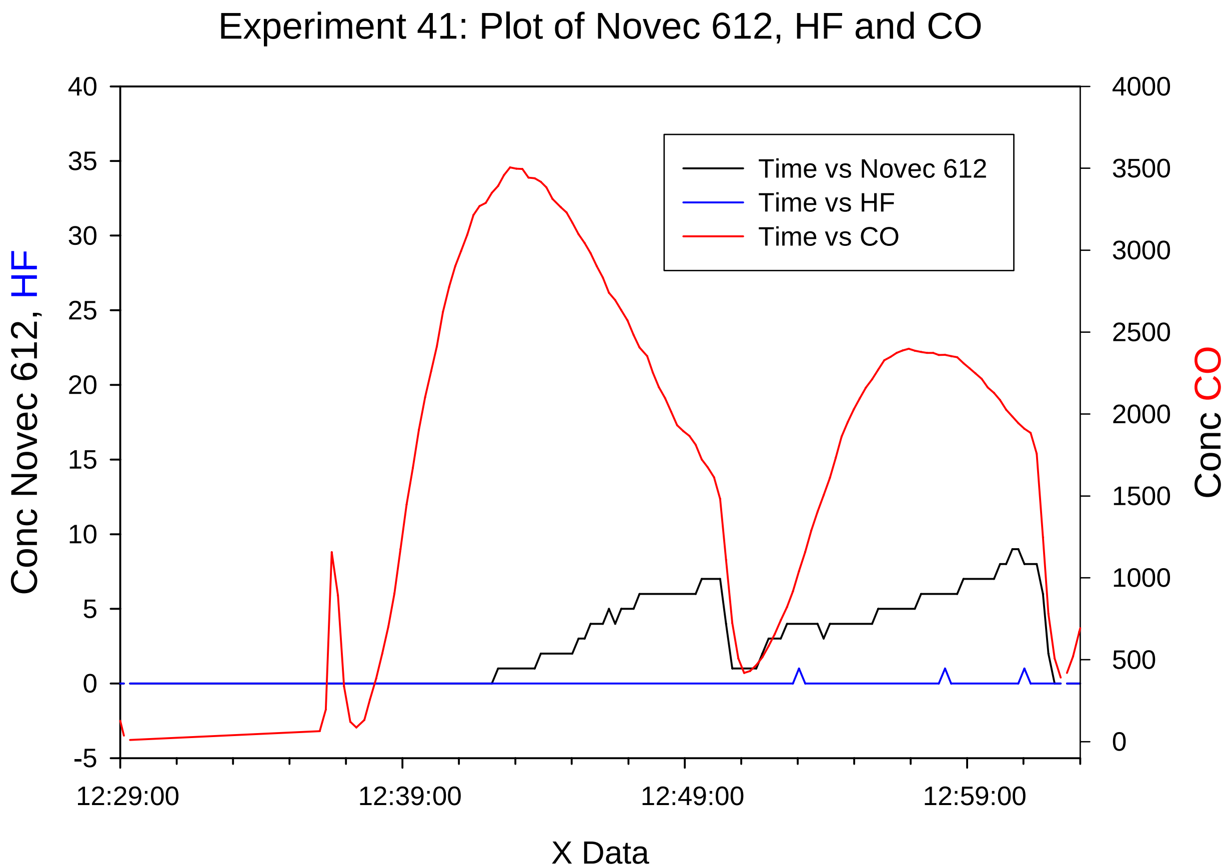


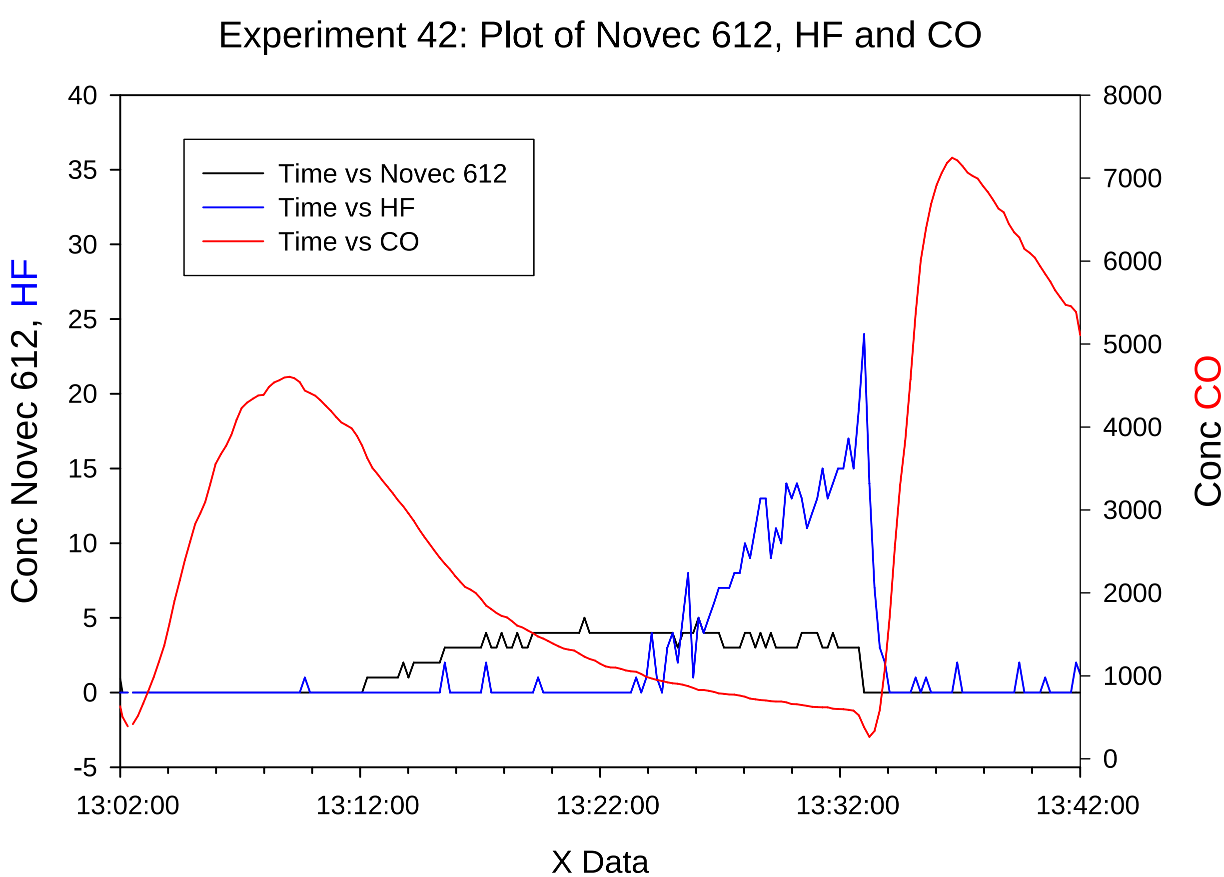


Experiment 39: Plot of HFE7100, CO and SO2
Time vs HFE7100
Time vs CO
Time vs SO2
Conc HFE7100, SO2
Conc CO
X Data
1000
900
800
700
600
500
400
300
200
100
0
-100
6000
5000
4000
3000
2000
1000
0
11:32:00
11:37:00
11:42:00
11:47:00
11:52:00
11:57:00



Experiment 40: Plot of HFE7100, CO and SO2
Time vs HFE7100
Time vs CO
Time vs SO2
Conc HFE7100, SO2
Conc CO
X Data
1000
900
800
700
600
500
400
300
200
100
0
-100
6000
5000
4000
3000
2000
1000
0
11:58:00
12:03:00
12:08:00
12:13:00
12:18:00
12:23:00


Experiment 41: Plot of Novec 612, HF and CO
Time vs Novec 612
Time vs HF
Time vs CO
Conc Novec 612, HF
Conc CO
40
35
30
25
20
15
10
5
0
-5
4000
3500
3000
2500
2000
1500
1000
500
0
12:29:00
12:39:00
12:49:00
12:59:00
X Data


Experiment 42: Plot of Novec 612, HF and CO
Time vs Novec 612
Time vs HF
Time vs CO
Conc Novec 612, HF
Conc CO
40
35
30
25
20
15
10
5
0
-5
8000
7000
6000
5000
4000
3000
2000
1000
0
13:02:00
13:12:00
13:22:00
13:32:00
13:42:00
X Data

Experiment 43: Plot of Novec 612, HF and CO