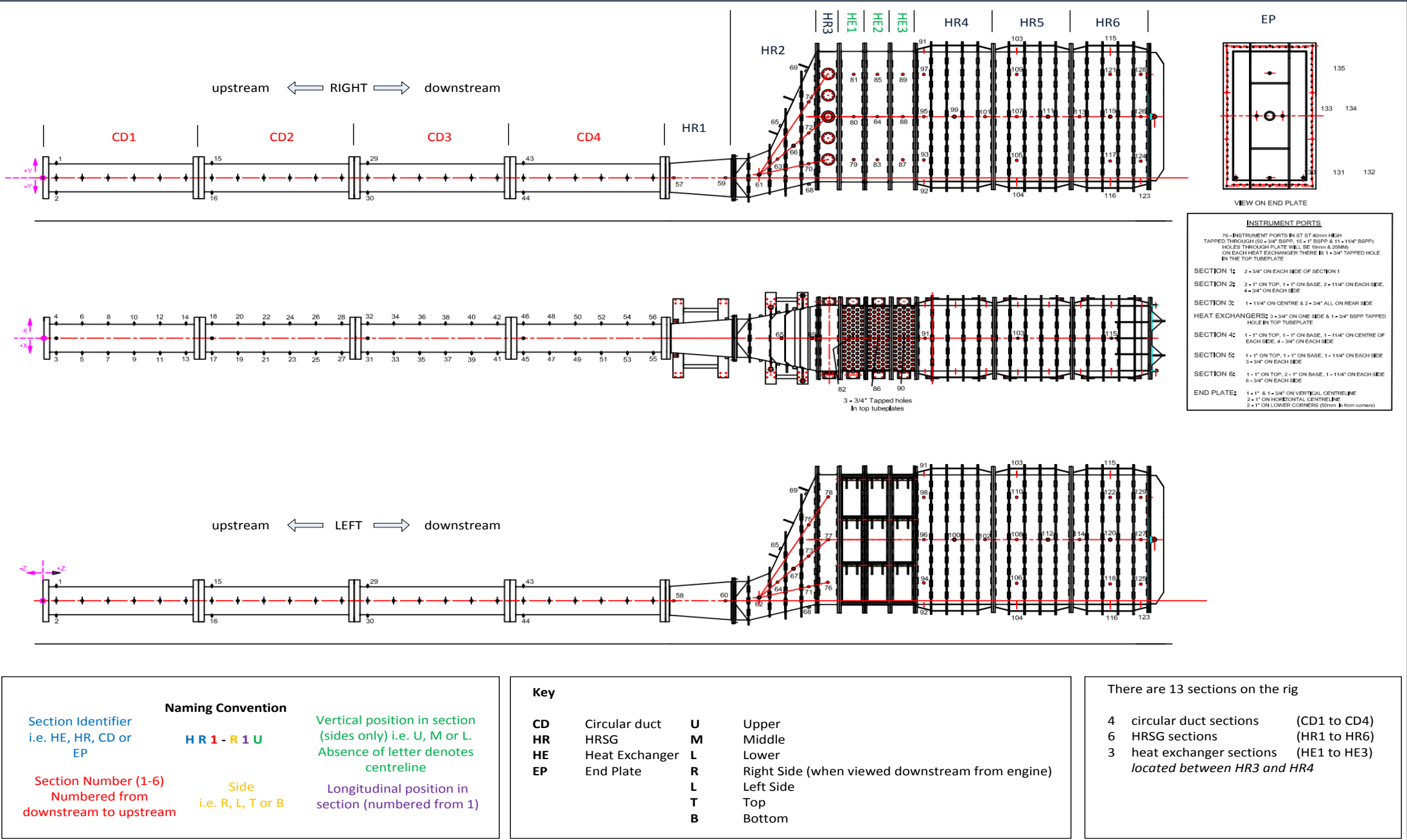


Date	05 March 2016	General Comments: (weather, rig configuration) Weather: Cold and sunny with a light North breeze. Sunny intervals with some snow. Rig configuration: 4 x 3m circular duct; expansion section and HRSG attached. End Plate attached. igniter 258mm from beginning of 2nd circular duct section Engine Speed: 40%; 11,800 rpm 1st test with end plate and mixture composition 100% H2 at an EQR of 0.45 The test gave a moderate combustion event and all sensors (except IP rakes) provided a good response. There is a reasonable correlation between flame speeds from both wall IPs and OPs with both showing values of around 370-400 m/s immediately after the HE, although the OP shows higher flame speeds of 552 m/s inside the HE. The rake IP data was less easily analysed and gave limited information on flame speeds. Maximum overpressures of 621mbar were seen in the duct with the next highest being at or near the end plate - KU5 (521mbar) and PCB (565mbar) giving good correlation
Time	15:13:54	
Test Number	9	
Mixture Composition	100% H2	
Ambient Temperature	20C	
Ambient Pressure	954	
Wind Speed	4.5 m/s	
Wind direction	N	
Relative Humidity	86.00%	
Mass Flow	9.6010 kg/s	
Equivalence Ratio	0.47	

		Ionisation Probes		Ionisation Rakes		Optical Probes	
Max overpressure		Max. temperature		Max. flame speed		Max. flame speed	
621 mbar		827 °C		379 m/s		173 m/s	
		Initial Temperature				552 m/s	
		453 °C					
Location of Max. Overpressure		Location of Max. Temperature		Location of Max. Flame Speed		Location of Max. Flame Speed	
sensor	KU6	sensor	TC7	sensor	IP20	sensor	OP3
label	CD3-R5	label	CD3-R2	label	HR6-L5L	label	HE1-T1
distance	8258 mm	distance	6758 mm	distance	21165 mm	distance	15600 mm

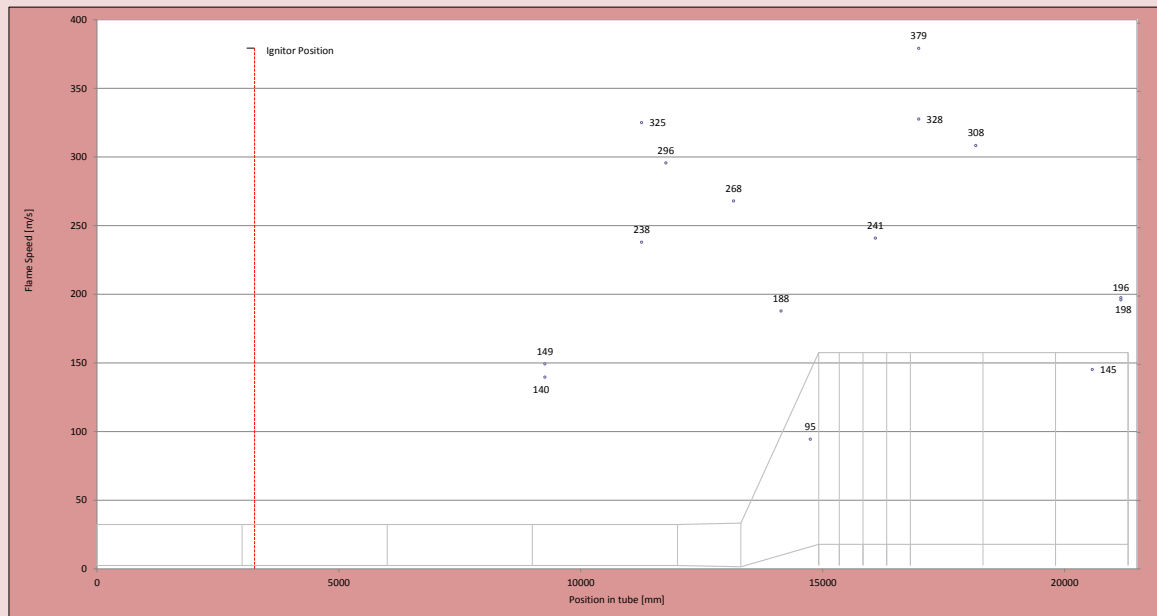


0	3000	6000	9000	12000	13310	14920	15345	15835	16325	16815	18315	19815	21315	21315	19815	16815	16325	15835	15345	14920	13310	12000	9000	6000	3000	0
600	600	600	600	600	620	3120	3120	3120	3120	3120	3120	3120	3120	310	310	310	310	310	310	310	-20	0	0	0	0	0

Location of igniter 3258 mm Time of ignition 25.7321 seconds

IP Number	Location label	Data Name	Position in tube (mm)	Flame arrival time (s)	Avg Flame speed from last sensor (m/s)
IP4	CD4-L1	Flameion_4	9258	25.7723	149
IP5	CD4-R1	Flameion_5	9258	25.7750	140
IP2	CD4-L5	Flameion_2	11258	25.7807	238
IP3	CD4-R5	Flameion_3	11258	25.7812	325
IP0	CD4-L6	Flameion_0	11758		
IP1	CD4-R6	Flameion_1	11758	25.7829	296
IP6	HR1-R2	Flameion_6	13160	25.7881	268
IP7	HR2-R3M	Flameion_7	14140	25.7956	188
IP8	HR2-R5M	Flameion_8	14745	25.8020	95
IP10	HE2-R1M	Flameion_10	16090	25.8036	241
IP12	HR4-R1M	Flameion_12	16985	25.8031	379
IP13	HR4-L1L	Flameion_13	16985	25.8042	328
IP14	HR4-R5M	Flameion_14	18165	25.8086	308
IP15	HR5-R2M	Flameion_15	18775	25.8064	-271
IP16	HR5-L2L	Flameion_16	18775	25.8032	
IP17	HR6-R1M	Flameion_17	19985	25.8037	
IP19	HR6-L3L	Flameion_19	20575	25.8156	145
IP18	HR6-R5M	Flameion_18	21165	25.8097	198
IP20	HR6-L5L	Flameion_20	21165	25.8154	196
IP9	#N/A	Flameion_9	#N/A		
IP11	#N/A	Flameion_11	#N/A		
IP21	#N/A	Flameion_21	#N/A		
IP22	#N/A	Flameion_22	#N/A		
IP23	#N/A	Flameion_23	#N/A		

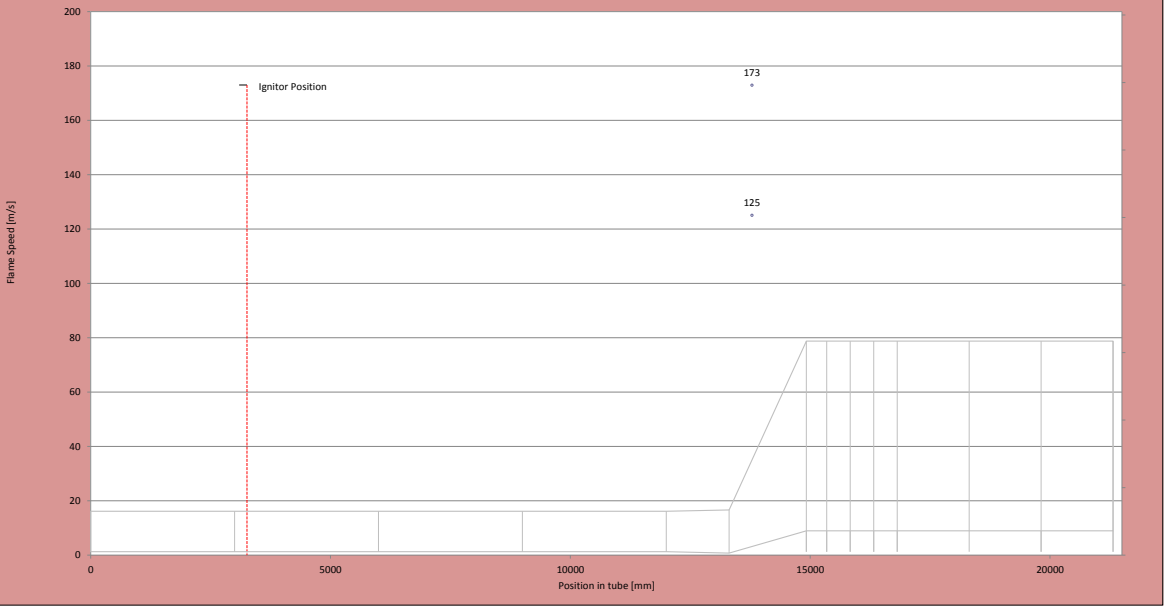
The behaviour of the flame after the HE is complex and the flame speeds are indicative values.e.g. flame apparently arrives at IP15 ahead of IP14, which is further upstream



Location of igniter 3258 mm Time of ignition 25.7321 seconds

Rake Number	IP Number	Location label	Data Name	Position in tube (mm)	Flame arrival time (s)	Avg Flame speed from last sensor (m/s)
RA1	IP24	HR2-R2M	IP24	13785	25.7930	173
RA1	IP25	HR2-R2M	IP25	13785	ND	
RA1	IP26	HR2-R2M	IP26	13785	25.8162	125
RA2	IP27	HR2-R4M	IP27	14475	ND	
RA2	IP28	HR2-R4M	IP28	14475	ND	
RA2	IP29	HR2-R4M	IP29	14475	ND	
RA3	IP30	HR4-R3M	IP30	17575	ND	
RA3	IP31	HR4-R3M	IP31	17575	ND	
RA3	IP32	HR4-R3M	IP32	17575	ND	
RA4	IP33	HR5-R4M	IP33	19375	ND	
RA4	IP34	HR5-R4M	IP34	19375	ND	
RA4	IP35	HR5-R4M	IP35	19375	ND	

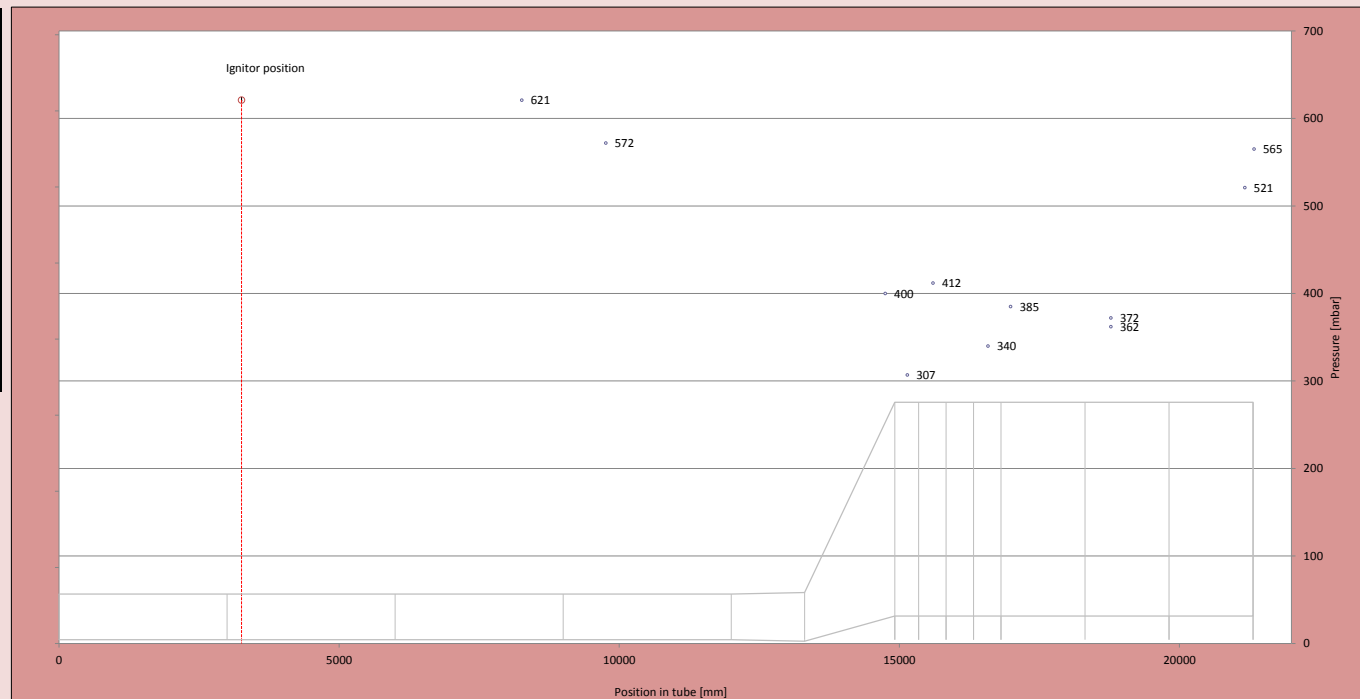
RA2 was not working. None of the working rakes gave signals that were easily analysed.



Location of igniter

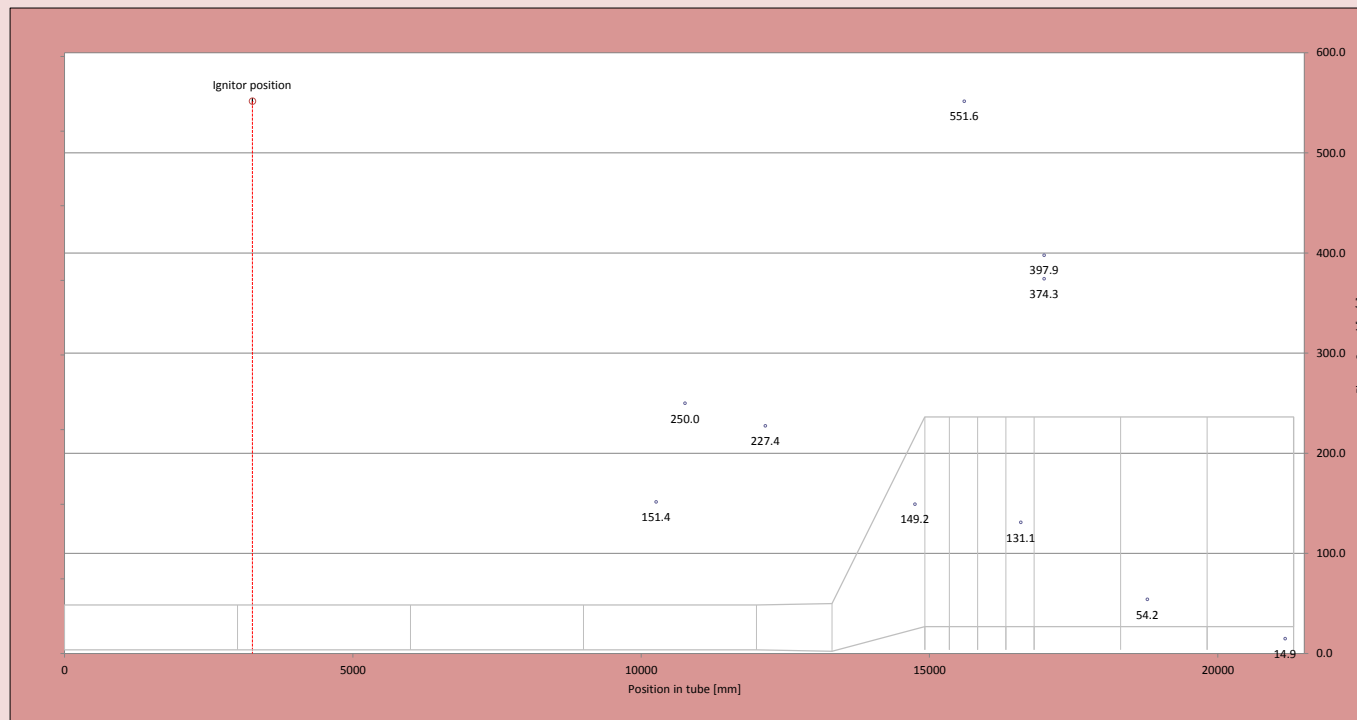
3258 mm

Transducer number	Location	Position in tube [mm]	ΔP_{max} [mbar]	Time ΔP_{max} [mbar]
KU6	CD3-R5	8258	621	25.8324
KU7	CD4-R2	9758	572	25.8083
KU8	HR2-T5	14745	400	25.8251
KU9	HR3-L1L	15140	307	25.8260
KU0	HE1-R1U	15600	412	25.8051
KU1	HE3-R1L	16580	340	25.8056
KU2	HR4-R1U	16985	385	25.8101
KU3	HR5-R2L	18775	372	25.8176
KU4	HR5-L2M	18775	362	25.8174
KU5	HR6-L5M	21165	521	25.8158
PCB	EP-1M	21330	565	25.8156
KU10	#N/A	#N/A		
KU11	#N/A	#N/A		



Location of igniter mm Time of ignitio seconds

OP Number	Location label	Position in tube (mm)	Flame arrival time (s)	Average flame speed (m/s)
OP11	CD4-L3	10258	25.7783	151.4
OP10	CD4-R4	10758	25.7803	250.0
OP0	HR1-R1	12152	25.7865	227.4
OP1	HR2-T3	14215	25.8026	
OP2	HR2-LSM	14745	25.8038	149.2
OP3	HE1-T1	15600	25.8054	551.6
OP4	HE3-T1	16580	25.8178	131.1
OP5	HR4-R1L	16985	25.8095	397.9
OP6	HR4-T1	16985	25.8091	374.3
OP7	HR5-T2	18775	25.8421	54.2
OP8	HR6-T3	20575		
OP9	HR6-RSU	21165	26.0020	14.9
OP12	#N/A	#N/A		
OP13	#N/A	#N/A		
OP14	#N/A	#N/A		
OP15	#N/A	#N/A		

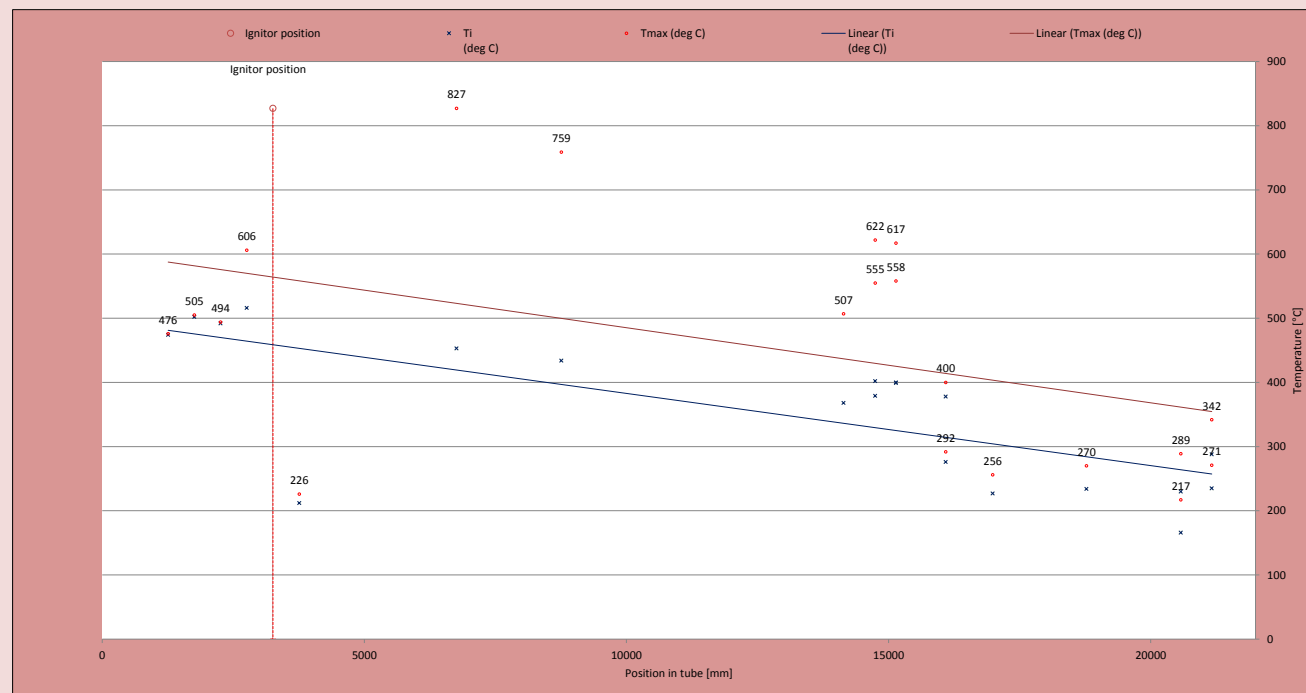


Location of igniter 3258 mm

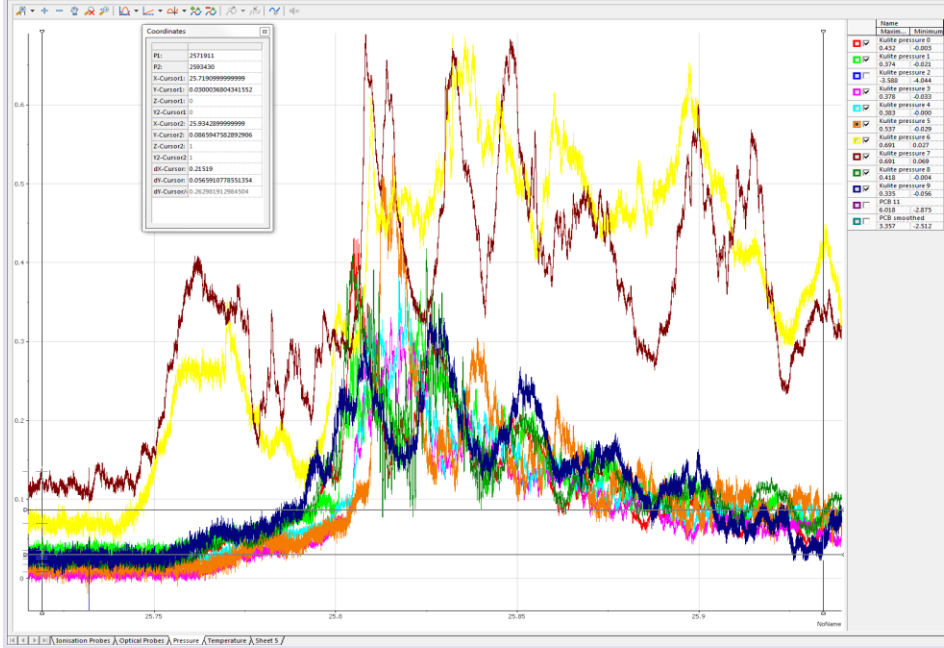
Thermocouple number	Location	Position in tube (mm)	T _{max} (deg C)	T _i (deg C)
TC0	CD1-R3	1258	476	474
TC2	CD1-R4	1758	505	502
TC3	CD1-R5	2258	494	492
TC4	CD1-R6	2758	606	516
TC5	CD2-R2	3758	226	212
TC7	CD3-R2	6758	827	453
TC9	CD3-R6	8758	759	434
TC11	#N/A	#N/A		
TC12	#N/A	#N/A		
TC13	#N/A	#N/A		
TC14	#N/A	#N/A		
TC15	#N/A	#N/A		
TC16	HR2-R5L	14745	622	402
TC17	HE2-R1U	16090	292	276
TC18	HR6-R3L	20575	217	166
TC19	#N/A	#N/A		
TC20	HE2-R1L	16090	400	378
TC22	#N/A	#N/A		
TC23	HR6-R5L	21165	271	235
TC24	HR2-L3M	14140	507	368
TC25	HR2-L5L	14745	555	379
TC26	HR3-L1M	15140	617	399
TC27	HR3-L1U	15140	558	400
TC28	HR4-L1M	16985	256	227
TC29	HR5-L2U	18775	270	234
TC30	HR6-L3U	20575	289	230
TC31	HR6-L5U	21165	342	288

surface thermocouples [not plotted]

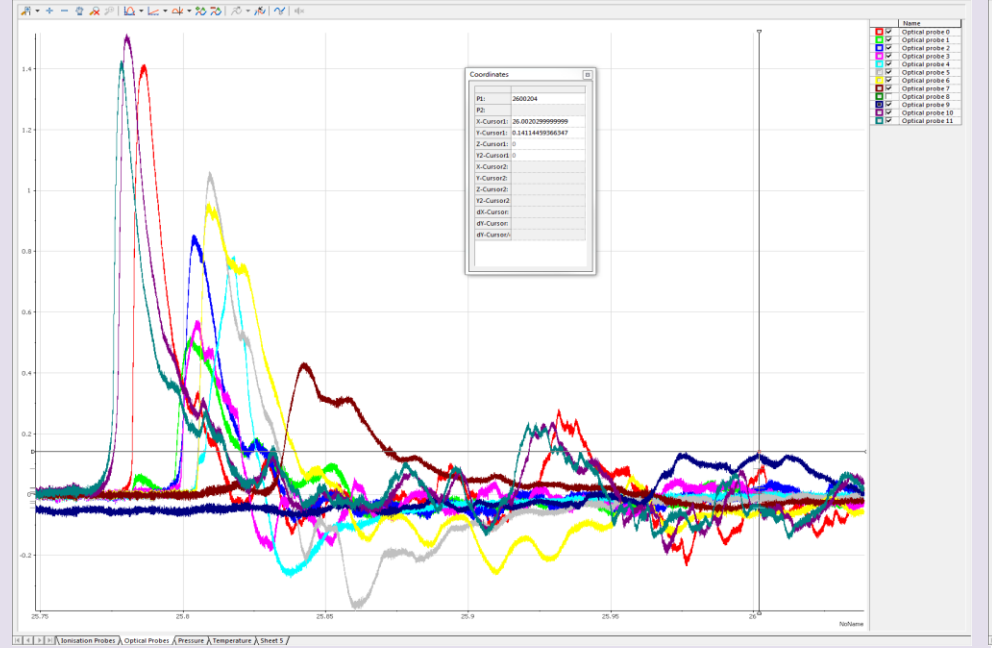
TC1	CD1-T2	1508		
TC6	CD2-T2	4508	196	185
TC8	CD3-T2	7508	221	210
TC10	CD4-T2	10508	183	176
TC21	HRS-R1M	18455	44	42



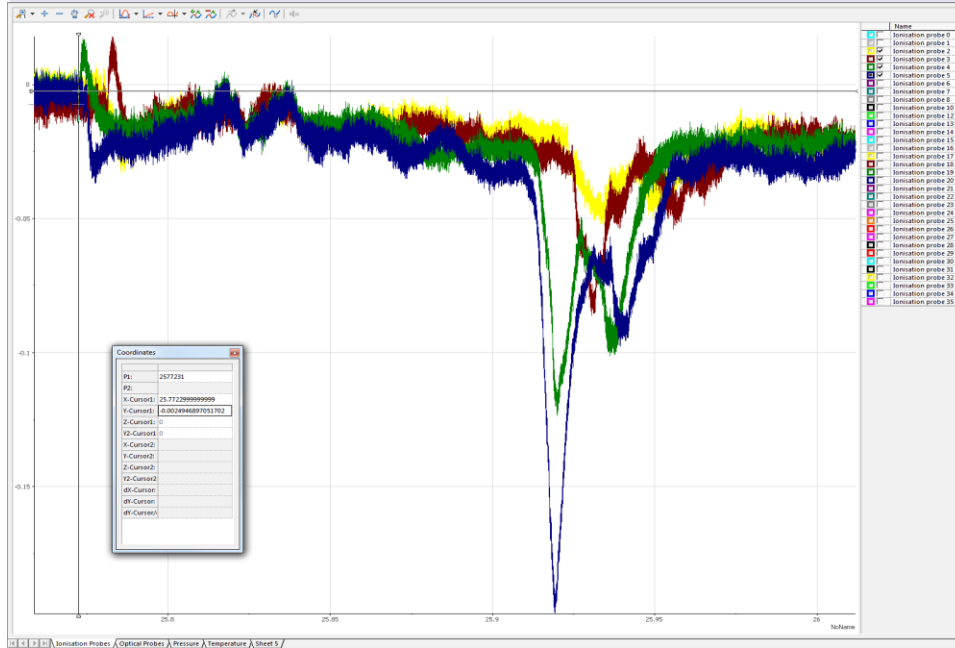
Pressure



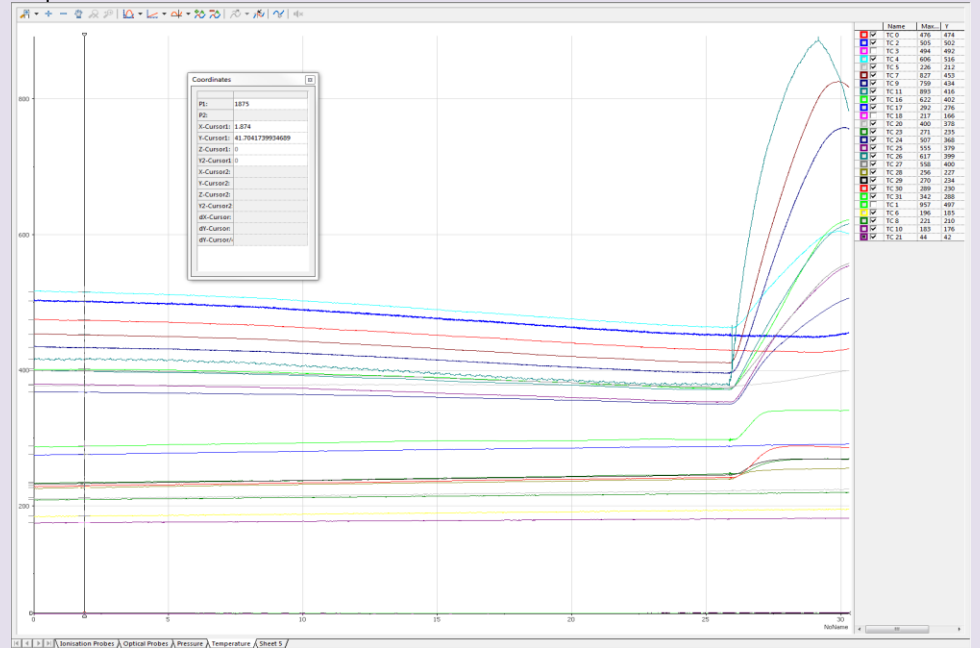
Optical Probes



Ionisation Probes



Temperature



Sensor	OLD DESIGNATION	NEW DESIGNATION	Section	Section Number	Side	Horizontal Location	Vertical Location	PORT REF	SIZE	"X"	"Y"	"Z"
-		CD1-T1	CD	1	T	1		1	1" BSPP	0	298	258
TC1	TS1-1	CD1-T2	CD	1	T	2		NA	SURFACE	0	298	1508
-		CD1-B1	CD	1	B	1		2	1" BSPP	0	-298	258
-	NS1-1	CD1-R1	CD	1	R	1		3	3/4" BSPP	298	0	258
-	FS1-1	CD1-L1	CD	1	L	1		4	3/4" BSPP	-298	0	258
-	NS1-2	CD1-R2	CD	1	R	2		5	3/4" BSPP	298	0	758
-	FS1-2	CD1-L2	CD	1	L	2		6	3/4" BSPP	-298	0	758
TC0	NS1-3	CD1-R3	CD	1	R	3		7	3/4" BSPP	298	0	1258
-	FS1-3	CD1-L3	CD	1	L	3		8	3/4" BSPP	-298	0	1258
TC2	NS1-4	CD1-R4	CD	1	R	4		9	3/4" BSPP	298	0	1758
-	FS1-4	CD1-L4	CD	1	L	4		10	3/4" BSPP	-298	0	1758
TC3	NS1-5	CD1-R5	CD	1	R	5		11	3/4" BSPP	298	0	2258
-	FS1-5	CD1-L5	CD	1	L	5		12	3/4" BSPP	-298	0	2258
TC4	NS1-6	CD1-R6	CD	1	R	6		13	3/4" BSPP	298	0	2758
-	FS1-6	CD1-L6	CD	1	L	6		14	3/4" BSPP	-298	0	2758
IGN		CD2-T1	CD	2	T	1		15	1" BSPP	0	298	3258
TC6	TS2-1	CD2-T2	CD	2	T	2		NA	SURFACE	0	298	4508
-		CD2-B1	CD	2	B	1		16	1" BSPP	0	-298	2358
-	NS2-1	CD2-R1	CD	2	R	1		17	3/4" BSPP	298	0	3258
-	FS2-1	CD2-L1	CD	2	L	1		18	3/4" BSPP	-298	0	3258
TC5	NS2-2	CD2-R2	CD	2	R	2		19	3/4" BSPP	298	0	3758
-	FS2-2	CD2-L2	CD	2	L	2		20	3/4" BSPP	-298	0	3758
-	NS2-3	CD2-R3	CD	2	R	3		21	3/4" BSPP	298	0	4258
-	FS2-3	CD2-L3	CD	2	L	3		22	3/4" BSPP	-298	0	4258
-	NS2-4	CD2-R4	CD	2	R	4		23	3/4" BSPP	298	0	4758
-	FS2-4	CD2-L4	CD	2	L	4		24	3/4" BSPP	-298	0	4758
-	NS2-5	CD2-R5	CD	2	R	5		25	3/4" BSPP	298	0	5258
-	FS2-5	CD2-L5	CD	2	L	5		26	3/4" BSPP	-298	0	5258
-	NS2-6	CD2-R6	CD	2	R	6		27	3/4" BSPP	298	0	5758
-	FS2-6	CD2-L6	CD	3	L	6		28	3/4" BSPP	-298	0	5758
-		CD3-T1	CD	3	T	1		29	1" BSPP	0	298	6258
TC8	TS1-1	CD3-T2	CD	3	T	2		NA	SURFACE	0	298	7508
-		CD3-B1	CD	3	B	1		30	1" BSPP	0	-298	6258
-	NS3-1	CD3-R1	CD	3	R	1		31	3/4" BSPP	298	0	6258
-	FS3-1	CD3-L1	CD	3	L	1		32	3/4" BSPP	-298	0	6258
TC7	NS3-2	CD3-R2	CD	3	R	2		33	3/4" BSPP	298	0	6758
-	FS3-2	CD3-L2	CD	3	L	2		34	3/4" BSPP	-298	0	6758
-	NS3-3	CD3-R3	CD	3	R	3		35	3/4" BSPP	298	0	7258
-	FS3-3	CD3-L3	CD	3	L	3		36	3/4" BSPP	-298	0	7258
-	NS3-4	CD3-R4	CD	3	R	4		37	3/4" BSPP	298	0	7758
-	FS3-4	CD3-L4	CD	3	L	4		38	3/4" BSPP	-298	0	7758
KU6	NS3-5	CD3-R5	CD	3	R	5		39	3/4" BSPP	298	0	8258
-	FS3-5	CD3-L5	CD	3	L	5		40	3/4" BSPP	-298	0	8258
TC9	NS3-6	CD3-R6	CD	3	R	6		41	3/4" BSPP	298	0	8758
-	FS3-6	CD3-L6	CD	3	L	6		42	3/4" BSPP	-298	0	8758
-		CD4-T1	CD	4	T	1		43	1" BSPP	0	298	9258
TC10	TS1-1	CD4-T2	CD	4	T	2		NA	SURFACE	0	298	10508
-		CD4-B1	CD	4	B	1		44	1" BSPP	0	-298	9258
IP5	NS4-1	CD4-R1	CD	4	R	1		45	3/4" BSPP	298	0	9258
IP4	FS4-1	CD4-L1	CD	4	L	1		46	3/4" BSPP	-298	0	9258
KU7	NS4-2	CD4-R2	CD	4	R	2		47	3/4" BSPP	298	0	9758
-	FS4-2	CD4-L2	CD	4	L	2		48	3/4" BSPP	-298	0	9758
-	NS4-3	CD4-R3	CD	4	R	3		49	3/4" BSPP	298	0	10258
OP11	FS4-3	CD4-L3	CD	4	L	3		50	3/4" BSPP	-298	0	10258
OP10	NS4-4	CD4-R4	CD	4	R	4		51	3/4" BSPP	298	0	10758
-	FS4-4	CD4-L4	CD	4	L	4		52	3/4" BSPP	-298	0	10758
IP3	NS4-5	CD4-R5	CD	4	R	5		53	3/4" BSPP	298	0	11258
IP2	FS4-5	CD4-L5	CD	4	L	5		54	3/4" BSPP	-298	0	11258
IP1	NS4-6	CD4-R6	CD	4	R	6		55	3/4" BSPP	298	0	11758

Sensor	OLD DESIGNATION	NEW DESIGNATION	Section	Section Number	Side	Horizontal Location	Vertical Location	PORT REF	SIZE	"X"	"Y"	"Z"
IP0	FS4-6	CD4-L6	CD	4	L	6		56	3/4" BSPP	-298	0	11758
OP0		HR1-R1	HR	1	R	1		57	3/4" BSPP	308	0	12152
-		HR1-L1	HR	1	L	1		58	3/4" BSPP	-308	0	12152
IP6		HR1-R2	HR	1	R	2		59	3/4" BSPP	393	0	13160
-		HR1-L2	HR	1	L	2		60	3/4" BSPP	-393	0	13160
RA1		HR2-R2M	HR	2	R	2	M	61	11/4" BSPP	448	70	13785
RA1		HR2-L2M	HR	2	L	2	M	62	11/4" BSPP	-448	70	13785
IP7		HR2-R3M	HR	2	R	3	M	63	3/4" BSPP	528	410	14140
TC24		HR2-L3M	HR	2	L	3	M	64	3/4" BSPP	-528	410	14140
OP1		HR2-T3	HR	2	T	3		65	1" BSPP	0	1122	14215
RA2		HR2-R4M	HR	2	R	4	M	66	11/4" BSPP	598	700	14475
RA2		HR2-L4M	HR	2	L	4	M	67	11/4" BSPP	-598	700	14475
-		HR2-B5	HR	2	B	5		68	1" BSPP	0	-100	14745
KU8		HR2-T5	HR	2	T	5		69	1" BSPP	0	2315	14745
TC16		HR2-R5L	HR	2	R	5	L	70	3/4" BSPP	662	310	14745
TC25		HR2-L5L	HR	2	L	5	L	71	3/4" BSPP	-662	310	14745
IP8		HR2-R5M	HR	2	R	5	M	72	3/4" BSPP	662	975	14745
OP2		HR2-L5M	HR	2	L	5	M	73	3/4" BSPP	-662	975	14745
-		HR2-R5U	HR	2	R	5	U	74	3/4" BSPP	662	1660	14745
-		HR2-L5U	HR	2	L	5	U	75	3/4" BSPP	-662	1660	14745
KU9		HR3-L1L	HR	3	L	1	L	76	3/4" BSPP	-700	400	15140
TC26		HR3-L1M	HR	3	L	1	M	77	11/4" BSPP	-700	1335	15140
TC27		HR3-L1U	HR	3	L	1	U	78	3/4" BSPP	-700	2270	15140
-		HE1-R1L	HE	1	R	1	L	79	3/4" BSPP	700	400	15600
-		HE1-R1M	HE	1	R	1	M	80	3/4" BSPP	700	1335	15600
KU0		HE1-R1U	HE	1	R	1	U	81	3/4" BSPP	700	2270	15600
TC20		HE2-R1L	HE	2	R	1	L	83	3/4" BSPP	700	400	16090
IP10		HE2-R1M	HE	2	R	1	M	84	3/4" BSPP	700	1335	16090
TC17		HE2-R1U	HE	2	R	1	U	85	3/4" BSPP	700	2270	16090
KU1		HE3-R1L	HE	3	R	1	L	87	3/4" BSPP	700	400	16580
-		HE3-R1M	HE	3	R	1	M	88	3/4" BSPP	700	1335	16580
-		HE3-R1U	HE	3	R	1	U	89	3/4" BSPP	700	2270	16580
OP3		HE1-T1	HE	1	T	1		82	3/4" BSPP HOLE	-47	2735	15600
-		HE2-T1	HE	2	T	1		86	3/4" BSPP HOLE	0	2735	16090
OP4		HE3-T1	HE	3	T	1		90	3/4" BSPP HOLE	-47	2735	16580
OP6		HR4-T1	HR	4	T	1		91	1" BSPP	0	2735	16985
-		HR4-B1	HR	4	B	1		92	1" BSPP	0	-65	16985
OP5		HR4-R1L	HR	4	R	1	L	93	3/4" BSPP	700	400	16985
IP13		HR4-L1L	HR	4	L	1	L	94	3/4" BSPP	-700	400	16985
IP12		HR4-R1M	HR	4	R	1	M	95	3/4" BSPP	700	1335	16985
TC28		HR4-L1M	HR	4	L	1	M	96	3/4" BSPP	-700	1335	16985
KU2		HR4-R1U	HR	4	R	1	U	97	3/4" BSPP	700	2270	16985
-		HR4-L1U	HR	4	L	1	U	98	3/4" BSPP	-700	2270	16985
RA3		HR4-R3M	HR	4	R	3	M	99	11/4" BSPP	700	1335	17575
RA3		HR4-L3M	HR	4	L	3	M	100	11/4" BSPP	-700	1335	17575
IP14		HR4-R5M	HR	4	R	5	M	101	3/4" BSPP	700	1335	18165
-		HR4-L5M	HR	4	L	5	M	102	3/4" BSPP	-700	1335	18165
TC21		HR5-R1M	HR	5	R	1	M	NA	SURFACE	700	1200	18455
OP7		HR5-T2	HR	5	T	2		103	1" BSPP	0	2735	18775
-		HR5-B2	HR	5	B	2		104	1" BSPP	0	-65	18775
KU3		HR5-R2L	HR	5	R	2	L	105	3/4" BSPP	700	400	18775
IP16		HR5-L2L	HR	5	L	2	L	106	3/4" BSPP	-700	400	18775
IP15		HR5-R2M	HR	5	R	2	M	107	3/4" BSPP	700	1335	18775
KU4		HR5-L2M	HR	5	L	2	M	108	3/4" BSPP	-700	1335	18775
-		HR5-R2U	HR	5	R	2	U	109	3/4" BSPP	700	2270	18775
TC29		HR5-L2U	HR	5	L	2	U	110	3/4" BSPP	-700	2270	18775
RA4		HR5-R4M	HR	5	R	4	M	111	11/4" BSPP	700	1335	19375
RA4		HR5-L4M	HR	5	L	4	M	112	11/4" BSPP	-700	1335	19375
IP17		HR6-R1M	HR	6	R	1	M	113	3/4" BSPP	700	1335	19985

Sensor	OLD DESIGNATION	NEW DESIGNATION	Section	Section Number	Side	Horizontal Location	Vertical Location	PORT REF	SIZE	"X"	"Y"	"Z"
-		HR6-L1M	HR	6	L	1	M	114	3/4" BSPP	-700	1335	19985
OP8		HR6-T3	HR	6	T	3		115	1" BSPP	0	2735	20575
-		HR6-B3	HR	6	B	3		116	3/4" BSPP	0	-65	20575
TC18		HR6-R3L	HR	6	R	3	L	117	3/4" BSPP	700	400	20575
IP19		HR6-L3L	HR	6	L	3	L	118	3/4" BSPP	-700	400	20575
-		HR6-R3M	HR	6	R	3	M	119	11/4" BSPP	700	1335	20575
-		HR6-L3M	HR	6	L	3	M	120	11/4" BSPP	-700	1335	20575
-		HR6-R3U	HR	6	R	3	U	121	3/4" BSPP	700	2270	20575
TC30		HR6-L3U	HR	6	L	3	U	122	3/4" BSPP	-700	2270	20575
-		HR6-B5	HR	6	B	5		123	1" BSPP	0	-65	21165
TC23		HR6-R5L	HR	6	R	5	L	124	3/4" BSPP	700	400	21165
IP20		HR6-L5L	HR	6	L	5	L	125	3/4" BSPP	-700	400	21165
IP18		HR6-R5M	HR	6	R	5	M	126	3/4" BSPP	700	1335	21165
KU5		HR6-L5M	HR	6	L	5	M	127	3/4" BSPP	-700	1335	21165
OP9		HR6-R5U	HR	6	R	5	U	128	3/4" BSPP	700	2270	21165
TC31		HR6-L5U	HR	6	L	5	U	129	3/4" BSPP	-700	2270	21165
-		EP-1L	EP			1	L	130	1" BSPP	650	-15	21330
-		EP-2L	EP			2	L	131	1" BSPP	0	-15	21330
-		EP-3L	EP			3	L	132	1" BSPP	-650	-15	21330
PCB		EP-1M	EP			1	M	133	1" BSPP	250	1335	21330
-		EP-2M	EP			2	M	134	1" BSPP	-250	1335	21330
-		EP-1U	EP			1	U	135	3/4" BSPP	0	2270	21330