NFPA 286

STANDARD METHODS OF FIRE TESTS FOR EVALUATING CONTRIBUTION OF WALL AND CEILING INTERIOR FINISH TO ROOM FIRE GROWTH

Contego Latex Fire Barrier Intumescent

(Also marketed in Canada by Pyrologistics, Inc. as Fire Barrier Intumescent Latex)

Project No. 16539-111931

August 22, 2002

Prepared for:

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ABSTRACT

This report describes the results obtained when a thin film, water-based latex intumescent paint submitted by Contego International tested in accordance with the NFPA 286 Standard Methods of Fire Tests for Evaluating Contribution of Wall and Ceiling Interior Finish to Room Fire Growth. The intumescent paint was identified by the client as "Contego Latex Fire Barrier Intumescent" and was sprayed on the rear, left, right walls as well as the ceiling of the test room. The sample did not spread flames to the ceiling during the 40 kW exposure, nor did the flames spread to the extremities of the 12 foot walls during the 160 kW exposure. The sample did not exhibit flashover conditions at any time during the test.

Signed:

Majid Mehrafza

Majid Mehrafza
Manager, Research and Special Projects

Date: 8-12-02

Reviewed and approved:

William E. Fitch, P.E. No. 55296

Date: 8-12-02

OMEGA POINT LABORATORIES

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INTRODUCTION[1]

This standard describes a method for determining the contribution of interior finish materials to room fire growth during specified fire exposure conditions. This method is not intended to evaluate the fire endurance of assemblies, nor is it able to evaluate the effect of fires originating within the wall assembly. The method is not intended for the evaluation of floor finishes.

This method is to be used to evaluate the flammability characteristics of interior finish materials when such materials constitute the exposed interior surfaces of buildings. This test method specifies three types of specimen mounting, depending on the application of the interior finish material, as follows:

1) Three walls (for interior finish to be used on walls only)
2) Three walls and the ceiling (for interior finish to be used on the walls and ceilings)
3) The ceiling alone (for interior finish to be used on ceilings only)

This fire test measures certain fire performance characteristics of interior finish materials in an enclosure under specified fire exposure conditions. It determines the extent to which the interior finish materials may contribute to fire growth in a room and the potential for fire spread beyond the room under the particular conditions simulated. The test indicates the maximum extent of fire growth in a room, the rate of heat release, and if they occur, the time to flashover and the time to flame extension beyond the doorway following flashover. It does not measure the fire growth in, or the contribution of, the room contents. Time to flashover is defined herein as either the time when the radiant flux onto the floor reaches 20 kW/m^2, the temperature of the upper air reaches 600°C, the heat release rate exceeds 1 MW or flames exit the doorway. A crumpled single sheet of newspaper shall be placed on the floor 4 feet out from the center of the rear wall and 4 ft. in from the center of the front wall. The spontaneous ignition of this newspaper provides the visual indication of flashover.

The potential for spread of fire to other objects in the room, remote from the ignition source, is evaluated by measurements of:

1. The total heat flux incident on the center of the floor.
2. A characteristic upper-level gas temperature in the room.
3. Instantaneous net peak rate of heat release.

The potential for the spread of fire to objects outside the room of origin is evaluated by the measurement of the total heat release of the fire.

TEST EQUIPMENT AND INSTRUMENTATION

IGNITION SOURCE

The ignition source for the test is a gas burner with a nominal 12- by 12-inch porous top surface of a refractory material. The burner used at this laboratory is filled with a minimum 4-inch layer of Ottawa sand.

The top surface of the burner is positioned 12 inches above the floor, and the burner enclosure is located such that the edge of the diffusion surface is located 1 inch from both walls in the left corner of the room opposite from the door.

The gas supply to the burner is C.P. grade propane (99 percent purity). The burner is capable of producing a gross heat output of 40 ± 1 kW (.92 scfm propane flow) for five minutes followed by a 160 ± 5 kW (3.44 scfm propane flow) for ten minutes. The flow rate is metered throughout the test. The design of the burner controls is such that when one quarter-turn ball valve is opened, the flow of gas to the burner produces 40 kW and when a second quarter-turn valve is opened the combined flow produces 160 kW.

COMPARTMENT GEOMETRY AND CONSTRUCTION

The interior dimensions of the floor of the fire room, when the specimens are in place, measures 8 feet ± 2 inches by 12 feet ± 2 inches. The finished ceiling is 8 feet ± 2.0 inches above the floor. The four walls are at right angles defining the compartment. The compartment contains a 30.75 ± 0.75 by 79.5 ± 0.75 inches doorway in the center of one of the 8- by 8-foot walls. No other openings are present to allow ventilation. The test room is lined with 5/8 in. type X gypsum wall board.

TOTAL HEAT FLUX GAUGE

A gauge shall be mounted a maximum of 1.1 ± 0.9 inches above the floor surface, facing upward in the geometric center of the test room. The gauge shall be of the Schmidt-Boelter type, with a flat black surface, and a 180 degree view angle. In operation, it shall be maintained at a constant temperature (within ± 5% °F) above the dew point by water supplied at a temperature from 122° to 149°F.

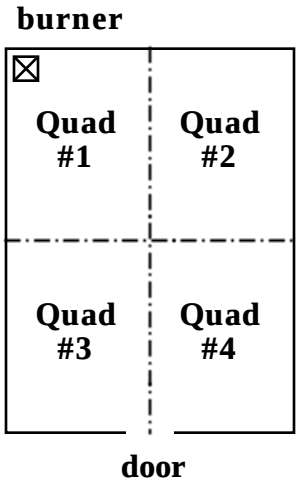
THERMOCOUPLES

Bare chromel-alumel thermocouples 20 mil in diameter (24 GA. Type K, Chromel-Alumel, Special Limits of Error: ±1.1°C, purchased with Lot Traceability and with 5-point calibrations at each end of the Lot Purchase), with electrically welded thermojunctions shall be used at each required location. The thermocouple wires, within 0.5 inches of the thermojunction, shall be run along expected isotherms to minimize conduction errors. The insulation between the wires shall be stable to at least 2000°F or the wires shall be separated.

THERMOCOUPLE LOCATIONS

LOCATION	DESCRIPTION OF PLACEMENT
DOORWAY	A thermocouple is located in the interior plane of the door opening on the door centerline, 4 inches down from the top.
ROOM	Thermocouples are located 4 inches below the ceiling at the center of the ceiling, the center of each of the four ceiling quadrants and directly over the center of the ignition burner.
HOOD EXHAUST DUCT	One pair of thermocouples is placed in the duct, 8 duct diameters downstream of the entrance to the horizontal duct.

The placement of the Quadrant Thermocouples is as shown in the drawing below. All plots and data tables follow this format.



Room Quadrant Thermocouple Locations (Plan View)

CANOPY AND EXHAUST DUCT

A hood is installed immediately adjacent to the door of the fire room. The bottom of the hood is level with the top surface of the room. The face dimensions of the hood are 10- by 10-feet, with a depth of 3.5 feet. The hood feeds into a plenum having a 3- by 3-foot cross section and a height of 3 feet. The exhaust duct connected to the plenum is 24 inches in diameter, horizontal, and has a circular aperture of 16 inches at its entrance.

DUCT GAS VELOCITY

A bi-directional probe is used to measure gas velocity in the duct. The probe consists of a short stainless steel cylinder 1.75 inches long and 0.875 inches inside diameter, with a solid diaphragm in the center. The pressure taps on either side of the diaphragm support the probe. The axis of the probe is along the centerline of the duct, 9 duct diameters downstream from the entrance. The pressure taps are connected to a pressure transducer capable of resolving pressure differences of 0.001 inches W.C.

OXYGEN MEASUREMENTS

A stainless steel gas sampling tube is located 10 duct diameters downstream from the entrance to the duct at the geometric center of the duct ±1/2 inch to obtain a continuously flowing sample for determining the oxygen concentration of the exhaust gas as a function of time. The oxygen content of the duct exhaust gas is determined by an oxygen analyzer with a relative accuracy of ±2% in the concentration range from 15 to 21% oxygen. The signal from the oxygen analyzer is within 5% of its final value within 30 seconds following a step change in the composition of the gas stream flowing past the sampling tube inlet.

CARBON MONOXIDE AND CARBON DIOXIDE

The gas sampling system described above is also routed through a dual gas analyzer which determines the concentrations of CO and CO_2 in the duct gases. The range of the analyzer is 0 - 1% CO and 0 - 10% CO_2.

PHOTOGRAPHIC RECORDS

Digital color photographs and VHS or 8-mm video taping are both used to record and document the test. Care is taken to position the photographic equipment so as to not to interfere with the smooth flow of air into the test room.

PROCEDURE

SUMMARY OF METHOD

A calibration test is run within 30 days of testing any material as specified in the standard. All instrumentation is zeroed, spanned and calibrated prior to testing. The specimen is installed and the diffusion burner is placed. The collection hood exhaust duct blower is turned on and an initial flow is established. The gas sampling pump is turned on and the flow rate is adjusted. When all instruments are reading steady state conditions, the computer data acquisition system and video equipment is started. Ambient data is taken then the burner is ignited at a fuel flow rate that is known to produce 40 kW of heat output. This level is maintained for five minutes at which time the fuel flow is increased to the 160 kW level for a 10-minute period. During the burn period, all temperature, heat release and heat flux data is being recorded every 6 seconds. At the end of the 15-minute burn period, the burner is shut off and all instrument readings are stopped. Posttest observations are made and this concludes the test.

All damage is documented after the test is over, using descriptions, photographs and drawings, as is appropriate.

ACCEPTANCE CRITERIA

Currently, there is no acceptance criteria listed in the NFPA 286, either in the mandatory text of the document nor within the informational appendices.

TEST SPECIMEN

The product was identified as Contego Latex Fire Barrier Intumescent. The product is a thin film, water-based lax intumescent paint. The paint was sprayed onto the three walls and the ceiling of the test room. Two coats of paint were applied to the walls and the ceiling. Each coat consisted of wet mil thickness of 11 that dried to a 7-mil thickness for a total thickness of 14 mils. The second coat was applied over the first coat when the first coat was dry to the touch. For this test, the first coat was allowed to dry for 24 hours. Testing was performed after the second coat had dried for 72 hours.

TEST RESULTS

The test was begun at 10:30 a.m., August 6, 2002. The ambient temperature was 87°F with a relative humidity of 48%. The thermocouples and other instrumentation were positioned in accordance with the standard and their outputs verified after connection to the data acquisition system. The data acquisition system was started and allowed to collect ambient data prior to igniting the burner and establishing a gas flow equivalent to 40 kW. Events during the test are described below:

TIME (min:sec)	OBSERVATION
0:00	Ignition of 40 kW burner.
1:38	Left wall discoloration
1:50	Back wall discoloration.
2:30	Charring on the back wall, above the burner.
5:00	Burner increased to 160 kW output.
6:00	Charring at the 6-ft level on the left and back wall.
7:55	Discoloration of the ceiling.
8:14	Charring on the ceiling above the burner.
15:00	End test.

Post Test Observations:

Left Wall: Charring and discoloration directly above the burner area.
Back Wall: Charring and discoloration directly above the burner area.
Right Wall: No change.
Ceiling: Some charring and discoloration directly above the burner area.

See photos in the appendix for more detailed evidence.

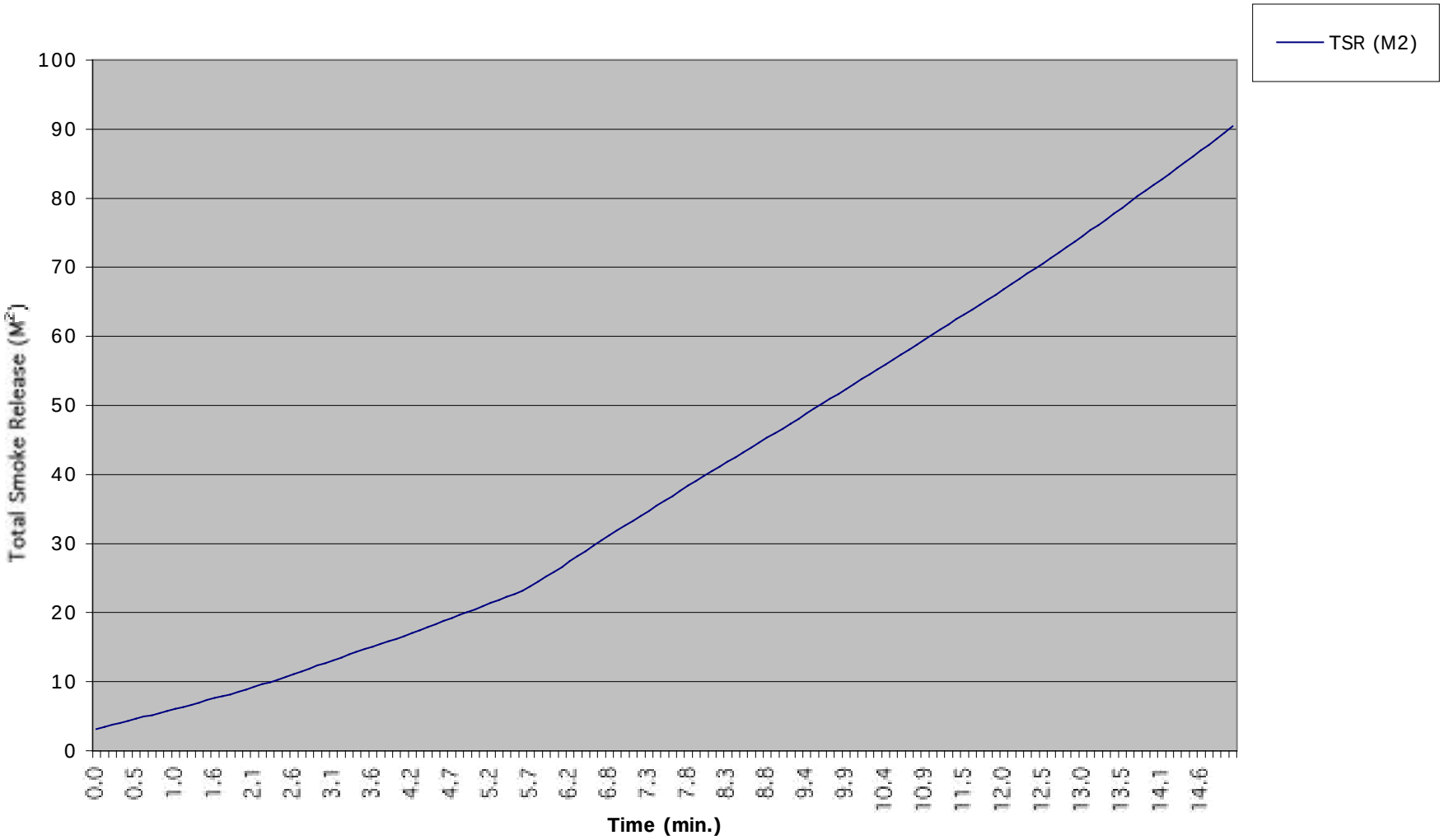
CONCLUSION

For this test, the net heat release rate was within typical limits of acceptability. Limited Smoke Release Rate values and the damage to the specimen were not indicative of flame spread outside the general area of the ignition source.

APPENDIX A

DATA

Contego International Inc.
Project # 111931 NFPA 286
August 22, 2002
Total Smoke Release Data



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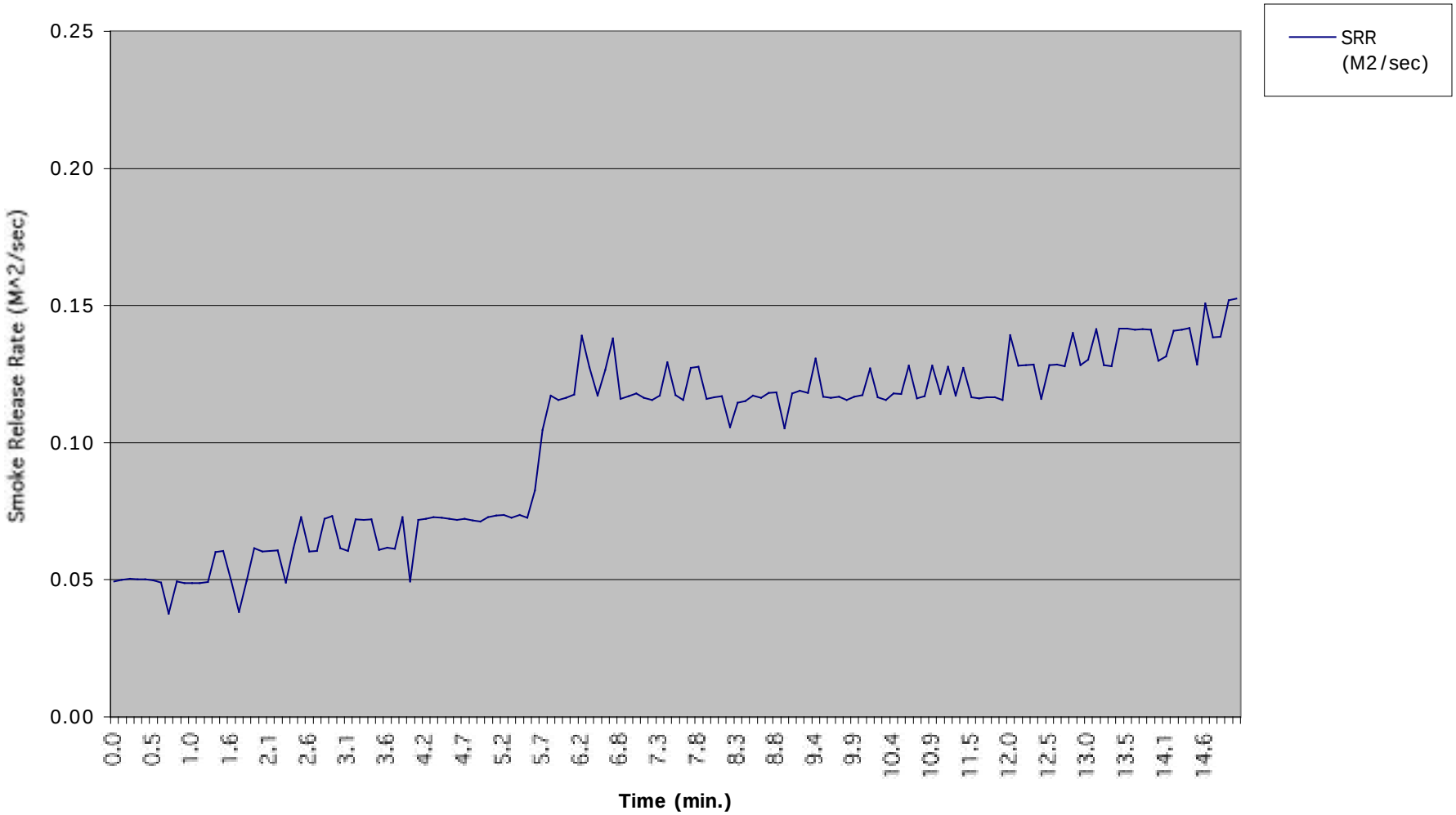
Smoke Release Data



Contego International Inc.
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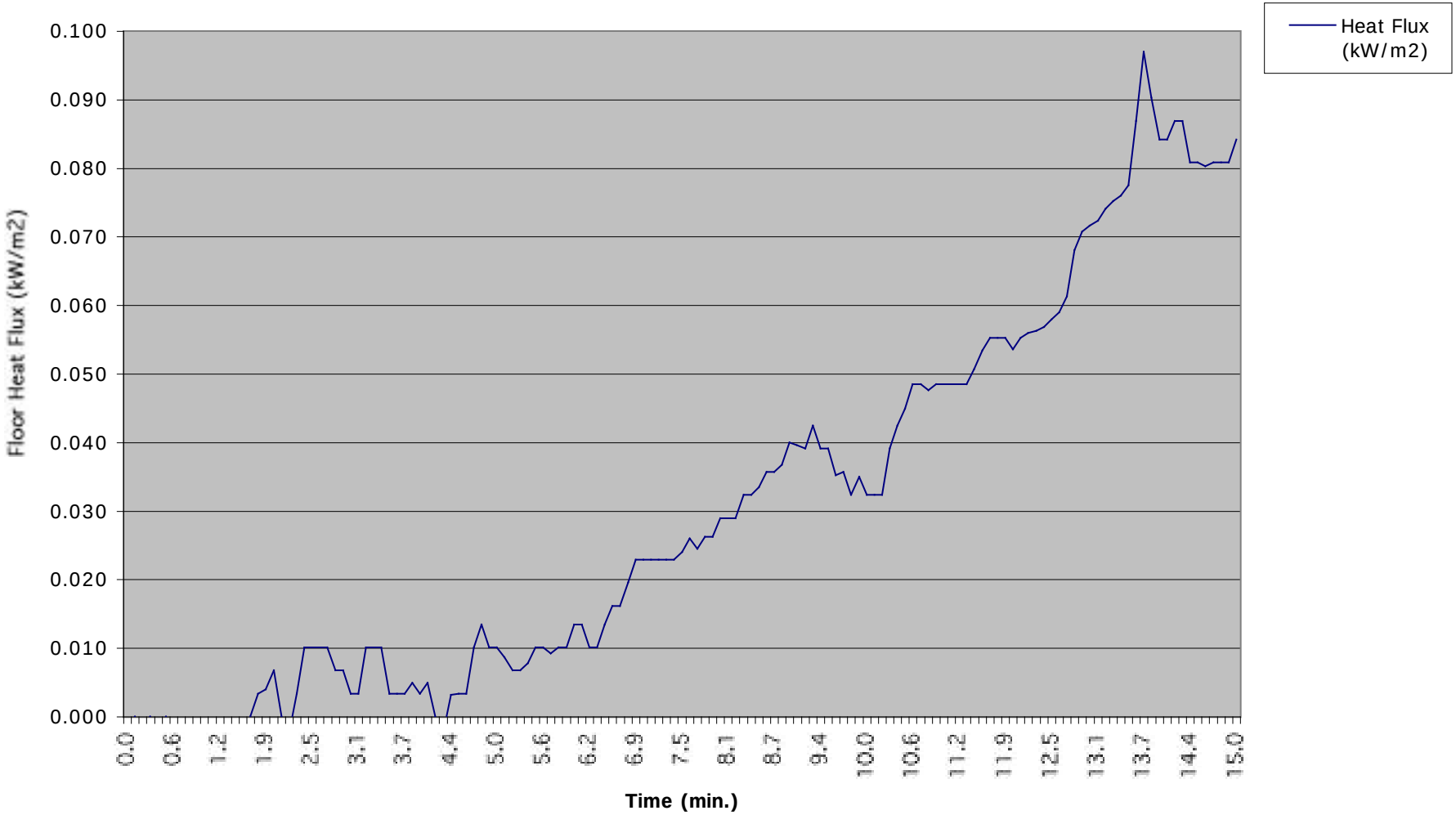
Floor Heat Flux Data



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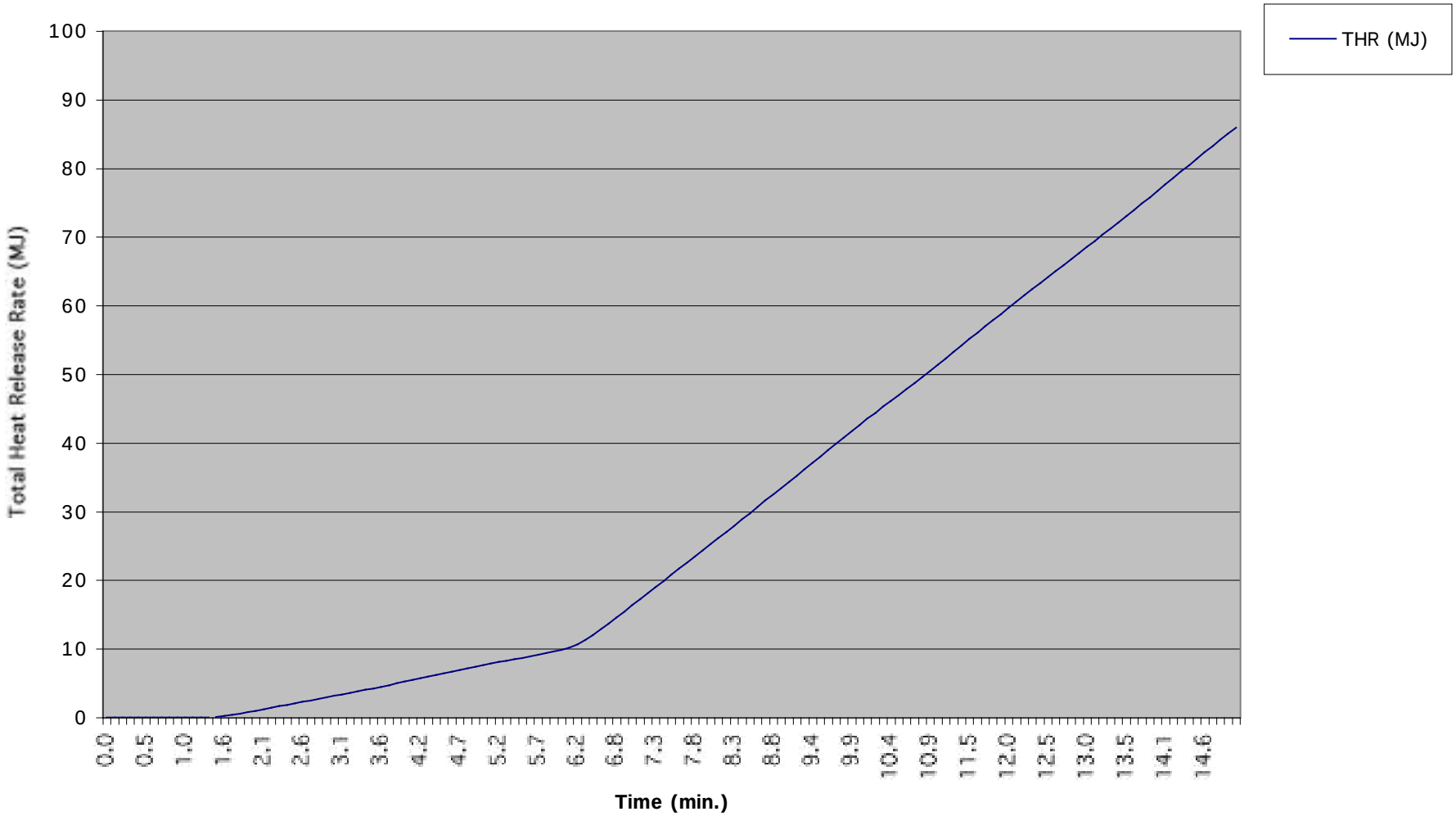
August 22, 2002
Totat Heat Release Data



Contego International Inc.
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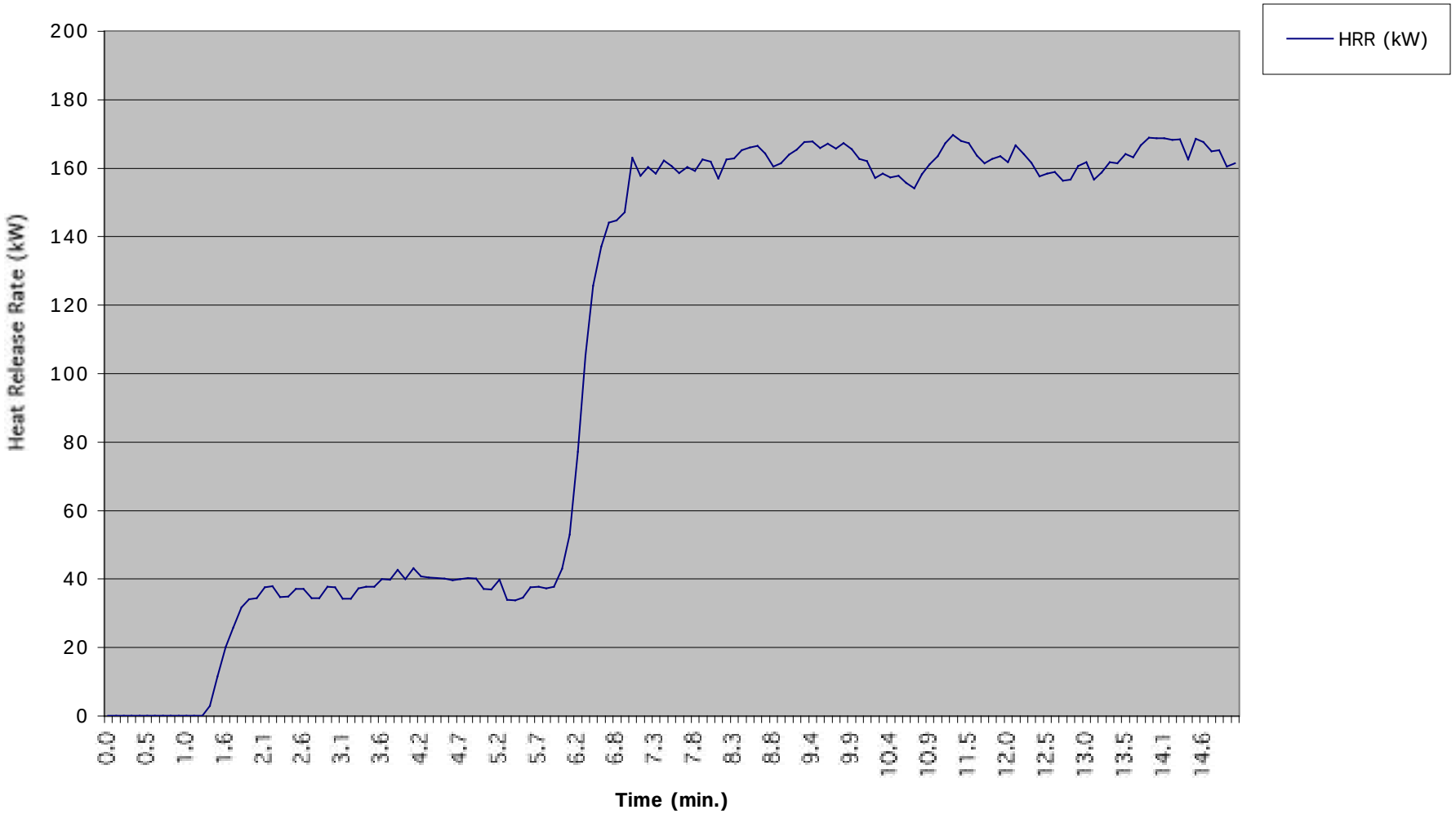
August 22, 2002
Heat Release Data



Contego International Inc.
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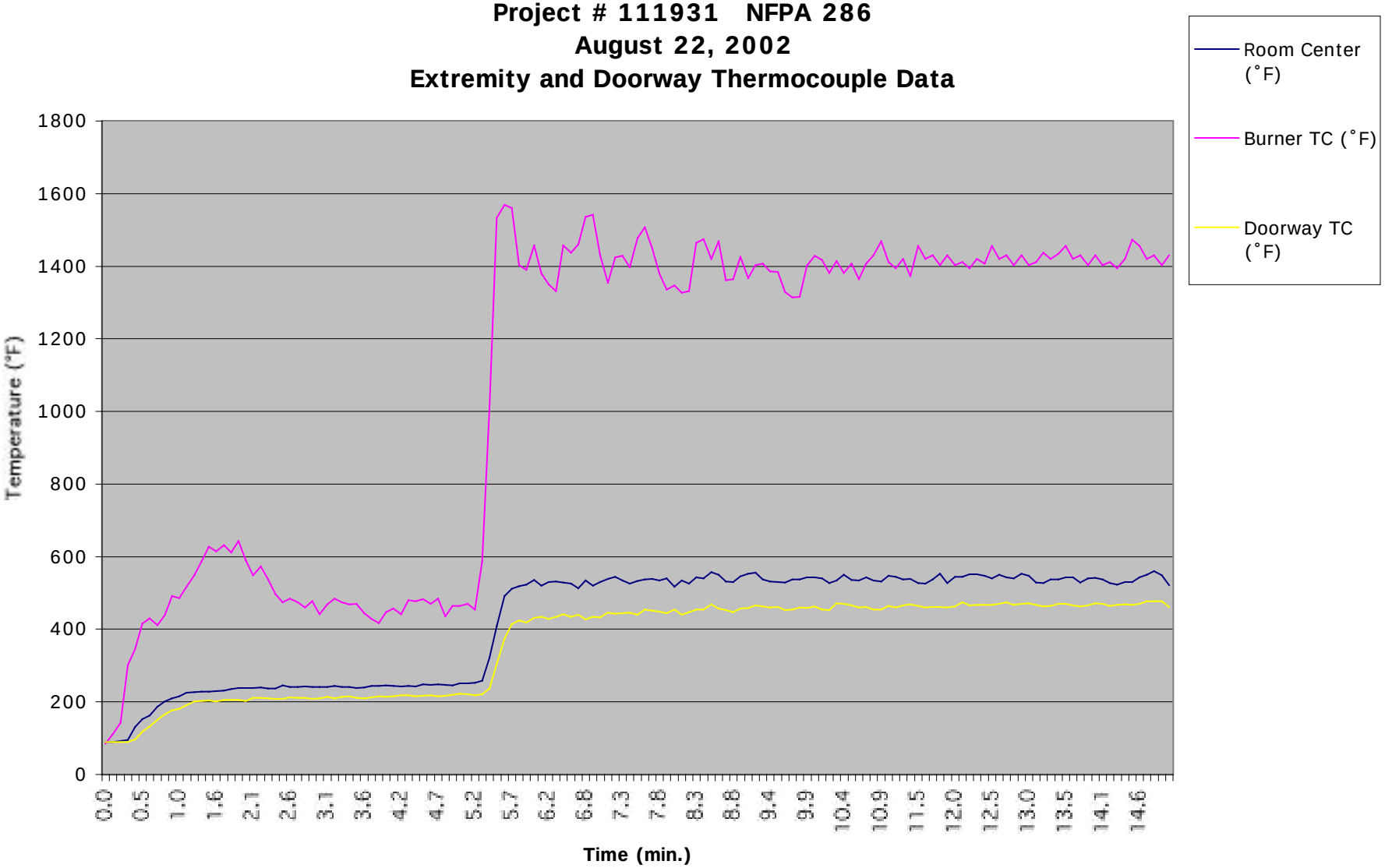
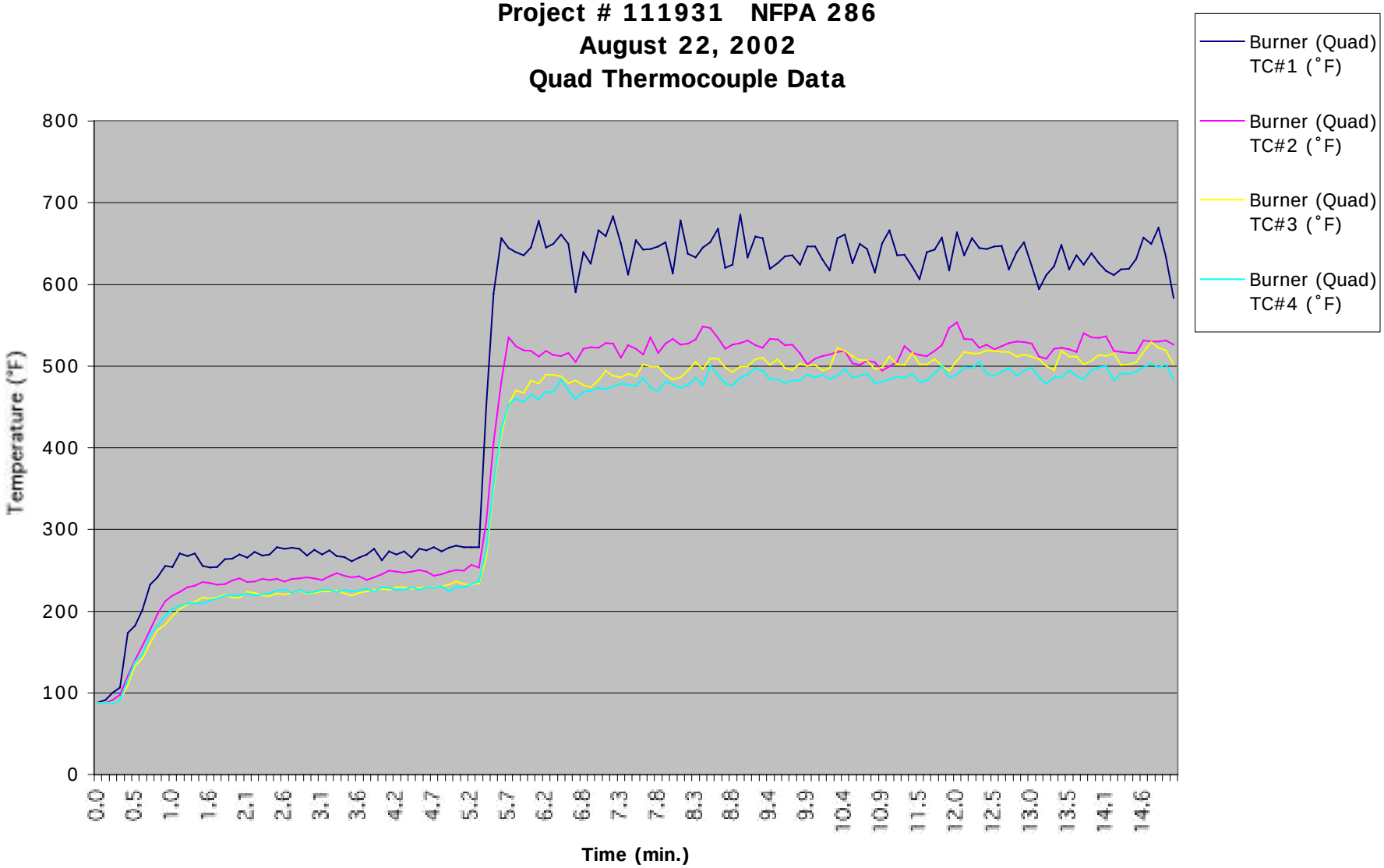
August 22, 2002
Extremity and Doorway Thermocouple Data



Contego International Inc.
Project # 111931 NFPA 286
August 22, 2002
Quad Thermocouple Data



Time (min)	Burner (Quad) TC#1 (˚F)	Burner (Quad) TC#2 (˚F)	Burner (Quad) TC#3 (˚F)	Burner (Quad) TC#4 (˚F)	Room Center (˚F)	Burner TC (˚F)
0.0	88	87	87	87	88	85
0.1	91	87	87	87	88	110
0.2	100	91	88	87	91	142
0.3	106	97	91	91	94	301
0.4	173	120	109	116	130	345
0.5	182	140	133	138	151	415
0.6	201	157	142	146	162	429
0.7	232	177	160	171	186	410
0.8	241	196	176	182	200	438
0.9	255	212	183	194	209	491
1.0	254	219	194	202	215	485
1.1	270	223	202	206	224	517
1.2	267	229	208	209	226	548
1.2	270	231	211	209	228	587
1.5	255	235	216	209	227	626
1.6	253	234	215	213	229	614
1.7	254	232	216	215	230	631
1.8	263	233	220	219	235	611
1.9	264	237	216	219	237	642
2.0	269	240	216	219	237	590
2.1	265	235	223	221	237	548
2.2	272	236	222	219	239	573
2.3	268	239	219	220	236	537
2.4	269	238	218	221	236	497
2.5	278	239	221	225	244	474
2.6	276	236	220	226	241	484
2.7	277	239	222	222	241	474
2.8	276	240	225	226	242	459
2.9	268	241	221	222	241	476
3.0	275	240	222	223	240	441
3.1	269	238	224	226	240	468
3.2	274	242	224	226	243	483
3.3	267	246	225	223	241	474
3.4	266	243	221	226	240	468
3.5	261	241	219	224	237	470
3.6	265	242	222	225	239	444
3.7	269	238	224	227	243	428
3.9	276	241	226	224	243	417
4.0	262	245	227	229	245	446
4.1	273	249	226	228	243	457
4.2	269	248	229	226	242	441
4.3	273	247	229	226	243	479
4.4	265	248	227	229	242	476
4.5	276	250	228	226	248	482
4.6	274	248	229	229	246	469
4.7	278	243	229	228	248	483
4.8	273	245	230	230	246	435
4.9	277	248	232	224	245	463
5.0	280	250	236	229	250	463
5.1	278	249	233	229	251	469

Time (min)	Burner (Quad) TC#1 (˚F)	Burner (Quad) TC#2 (˚F)	Burner (Quad) TC#3 (˚F)	Burner (Quad) TC#4 (˚F)	Room Center (˚F)	Burner TC (˚F)
5.2	278	256	232	233	252	453
5.3	278	253	234	236	258	586
5.4	451	309	265	274	320	1008
5.5	588	406	350	354	408	1533
5.6	656	481	416	422	491	1568
5.7	644	535	453	453	511	1560
5.8	639	524	470	460	518	1402
5.9	635	519	467	456	522	1389
6.0	645	518	482	464	535	1457
6.1	677	511	478	459	520	1380
6.2	645	518	489	468	530	1349
6.3	649	513	489	468	531	1331
6.5	661	512	487	483	528	1457
6.6	649	516	479	470	525	1436
6.7	590	505	482	460	512	1459
6.8	639	521	476	468	533	1536
6.9	625	523	474	469	520	1541
7.0	666	522	482	473	529	1429
7.1	659	528	494	471	538	1354
7.2	683	527	488	475	544	1424
7.3	650	510	486	478	534	1428
7.4	612	525	490	477	525	1397
7.5	654	521	487	475	532	1477
7.6	642	514	502	485	537	1507
7.7	643	535	499	473	538	1450
7.8	646	516	499	469	533	1380
7.9	651	527	489	481	540	1335
8.0	613	533	483	477	517	1346
8.1	678	526	486	473	533	1326
8.2	637	527	494	476	525	1330
8.3	633	532	505	485	542	1464
8.4	645	548	496	476	539	1474
8.5	651	546	509	500	557	1420
8.6	668	534	509	489	549	1468
8.7	620	521	498	478	531	1361
8.8	624	526	492	476	529	1363
9.0	685	528	499	485	545	1425
9.1	633	531	499	489	552	1367
9.2	658	525	508	497	555	1402
9.3	656	522	510	494	537	1406
9.4	619	533	501	483	531	1385
9.5	626	532	508	483	529	1384
9.6	634	525	497	479	528	1328
9.7	635	526	495	482	537	1314
9.8	624	515	503	482	537	1315
9.9	646	502	500	489	543	1401

Time (min)	Burner (Quad) TC#1 (˚F)	Burner (Quad) TC#2 (˚F)	Burner (Quad) TC#3 (˚F)	Burner (Quad) TC#4 (˚F)	Room Center (˚F)	Burner TC (˚F)
10.0	646	509	501	486	542	1428
10.1	630	512	494	489	540	1416
10.2	617	514	497	484	527	1381
10.3	656	517	522	488	534	1414
10.4	661	518	518	496	549	1381
10.5	626	503	512	486	535	1407
10.6	649	501	507	488	534	1363
10.7	643	506	507	490	543	1407
10.8	614	504	496	479	533	1429
10.9	650	494	498	481	531	1468
11.0	666	499	511	483	547	1411
11.1	635	505	502	487	544	1394
11.2	636	524	501	485	536	1420
11.3	621	516	516	490	538	1372
11.5	606	513	502	480	527	1455
11.6	639	512	502	482	525	1420
11.7	642	518	508	491	537	1429
11.8	657	525	500	500	552	1402
11.9	617	546	494	486	527	1429
12.0	663	553	506	489	544	1402
12.1	635	533	517	498	544	1411
12.2	656	532	515	497	551	1394
12.3	644	522	515	505	551	1420
12.4	643	526	519	490	546	1407
12.5	646	520	518	488	540	1455
12.6	647	524	517	493	549	1420
12.7	618	528	517	497	542	1429
12.8	639	530	511	488	539	1402
12.9	651	529	514	494	553	1429
13.0	622	527	511	498	547	1402
13.1	594	511	508	486	528	1411
13.2	611	509	500	478	526	1437
13.3	622	521	495	486	537	1420
13.4	648	522	518	486	536	1433
13.5	618	520	511	494	542	1455
13.6	635	517	511	488	543	1420
13.7	624	540	502	484	528	1429
13.8	638	535	506	495	539	1402
14.0	626	534	513	498	541	1429
14.1	616	536	512	499	537	1402
14.2	611	518	515	482	527	1411
14.3	618	517	501	490	522	1394
14.4	619	516	502	490	530	1420
14.5	631	516	504	493	530	1472
14.6	657	531	517	498	543	1455
14.7	649	530	529	503	549	1420
14.8	669	530	522	498	560	1429
14.9	634	531	519	502	548	1402
15.0	583	526	502	483	521	1429

Doorway TC (˚F)	Stack TC#1 (deg F)	Stack TC#2 (deg F)	Heat Flux (kW/m^2)	Stack CO (frac)	Stack CO2 (frac)	Stack O2 (frac)	Stack P. (Pa)
88	89	90	-0.006	0.000021	0	0.2095	188.47
89	90	90	0.000	0.000021	0	0.2095	193.1154
89	90	90	-0.003	0.00002	0	0.2095	196.7653
89	90	90	0.000	0.000023	0	0.2095	194.7744
96	90	90	-0.006	0.000026	0	0.2095	193.779
118	90	90	0.000	0.000027	0	0.2095	191.4563
132	90	90	-0.003	0.000021	0	0.2095	184.82
150	90	90	-0.009	0.00002	0	0.2095	186.4791
165	90	91	-0.013	0.000021	0	0.2095	188.47
176	91	91	-0.015	0.000034	0	0.2095	182.8291
181	91	91	-0.013	0.000075	0	0.2095	183.8246
191	91	92	-0.013	0.000136	0	0.2095	183.8246
200	92	92	-0.009	0.000223	0	0.2095	186.4791
202	92	92	-0.009	0.000324	0	0.209469	181.8337
203	92	93	-0.009	0.000436	0	0.209375	184.4882
201	92	93	-0.006	0.00053	0	0.209281	187.4745
205	93	93	0.000	0.00059	0	0.209219	190.7927
205	93	94	0.003	0.000637	0	0.209156	188.47
204	93	94	0.004	0.000673	0	0.209125	190.7927
202	93	94	0.007	0.000706	0	0.209125	183.8246
210	94	94	0.000	0.000726	0	0.209094	184.1564
210	94	94	-0.003	0.000731	0	0.209094	185.4837
209	94	94	0.003	0.000732	0	0.209125	184.4882
207	94	95	0.010	0.000754	0	0.209125	190.129
207	94	95	0.010	0.000759	0	0.209094	188.47
212	94	95	0.010	0.000759	0	0.209094	183.4928
211	94	95	0.010	0.00076	0	0.209125	183.8246
211	94	95	0.007	0.000766	0	0.209125	185.4837
208	94	95	0.007	0.000765	0	0.209094	189.7972
209	95	96	0.003	0.000772	0	0.209094	189.7972
213	95	96	0.003	0.00078	0	0.209125	184.1564
209	95	96	0.010	0.00078	0	0.209125	183.161
213	95	96	0.010	0.000772	0	0.209094	182.8291
214	95	96	0.010	0.000765	0	0.209094	184.1564
210	95	96	0.003	0.000766	0	0.209094	186.4791
209	95	96	0.003	0.00078	0	0.209063	190.7927
212	95	96	0.003	0.000794	0	0.209063	189.1336
214	96	97	0.005	0.000794	0	0.209031	187.4745
213	96	97	0.003	0.00078	0	0.209063	186.1473
214	96	97	0.005	0.00078	0	0.209031	182.1655
218	96	97	0.000	0.00078	0	0.209063	184.1564
218	96	97	-0.003	0.000772	0	0.209063	187.1427
215	96	97	0.003	0.000772	0	0.209063	186.4791
216	96	97	0.003	0.000772	0	0.209063	184.82
218	96	97	0.003	0.000772	0	0.209063	182.1655
215	97	97	0.010	0.000772	0	0.209063	183.8246
216	97	97	0.013	0.000779	0	0.209063	180.8383
219	97	97	0.010	0.000786	0	0.209063	179.1792
222	97	97	0.010	0.000786	0	0.209094	187.4745
221	97	98	0.009	0.000786	0	0.209094	190.129

Doorway TC (˚F)	Stack TC#1 (deg F)	Stack TC#2 (deg F)	Heat Flux (kW/m^2)	Stack CO (frac)	Stack CO2 (frac)	Stack O2 (frac)	Stack P. (Pa)
217	97	98	0.007	0.00078	0	0.209063	190.7927
221	97	98	0.007	0.000772	0	0.209125	186.1473
236	97	98	0.008	0.000766	0	0.209125	190.7927
303	98	98	0.010	0.000772	0.000003	0.209125	186.1473
374	99	100	0.010	0.000779	0.000003	0.209094	177.852
413	101	101	0.009	0.000779	0	0.209094	173.8702
424	102	103	0.010	0.000794	0	0.209094	176.5247
418	103	104	0.010	0.001061	0.000006	0.209094	171.8793
430	104	105	0.013	0.001612	0.000006	0.209031	173.8702
433	104	105	0.013	0.002078	0.000022	0.208906	177.5201
428	105	106	0.010	0.002393	0.000041	0.208625	172.5429
433	106	107	0.010	0.002535	0.000041	0.208312	172.2111
440	107	108	0.013	0.002609	0.000041	0.208063	175.1974
434	107	108	0.016	0.002629	0.000041	0.207938	169.2248
439	108	109	0.016	0.002696	0.000037	0.207875	169.2248
426	108	109	0.020	0.002748	0.000034	0.207844	171.2157
434	109	110	0.023	0.002764	0.000041	0.207813	173.8702
432	109	110	0.023	0.00275	0.000041	0.207781	176.8565
445	110	111	0.023	0.00277	0.000041	0.207813	172.2111
442	110	112	0.023	0.002796	0.000019	0.207781	169.8884
444	111	112	0.023	0.00277	0.000022	0.207813	173.8702
445	111	112	0.023	0.002741	0.000019	0.207781	175.5292
439	112	112	0.024	0.002741	0.000019	0.207813	174.202
454	112	113	0.026	0.002763	0.000019	0.207813	168.893
451	112	113	0.025	0.002755	0.000019	0.207781	169.5566
448	113	113	0.026	0.002756	0.000006	0.207813	170.5521
444	113	114	0.026	0.002769	0.000003	0.207781	169.8884
453	113	113	0.029	0.002763	0.000003	0.207781	171.5475
439	113	114	0.029	0.002764	0.000006	0.207813	172.5429
447	113	114	0.029	0.002796	0.000003	0.20775	173.8702
453	114	115	0.032	0.00281	0.000022	0.20775	165.5749
454	114	115	0.032	0.002756	0.000022	0.207719	167.5657
468	114	115	0.034	0.002736	0.000006	0.207719	173.2066
457	114	115	0.036	0.002721	0.000003	0.207719	170.5521
452	115	115	0.036	0.002736	0.000022	0.20775	175.8611
447	115	115	0.037	0.002756	0.000022	0.20775	176.1929
456	115	116	0.040	0.002756	0.000022	0.20775	171.8793
458	116	116	0.040	0.002769	0.000019	0.20775	174.8656
465	116	116	0.039	0.002802	0.000019	0.207719	177.852
462	116	117	0.042	0.002815	0.000019	0.207719	175.5292
459	116	117	0.039	0.00279	0.000022	0.207719	177.5201
461	116	117	0.039	0.00279	0.000006	0.207719	171.2157
452	117	117	0.035	0.002822	0.000003	0.207719	169.8884
454	117	118	0.036	0.002824	0.000006	0.20775	170.8839
460	117	117	0.032	0.002801	0.000009	0.207719	167.5657
458	117	118	0.035	0.002796	0.000006	0.20775	171.2157

Doorway TC (°F)	Stack TC#1 (deg F)	Stack TC#2 (deg F)	Heat Flux (kW/m^2)	Stack CO (frac)	Stack CO2 (frac)	Stack O2 (frac)	Stack P. (Pa)
462	117	118	0.032	0.002809	0.000003	0.20775	172.5429
453	117	118	0.032	0.002822	0.000003	0.20775	167.5657
452	118	118	0.032	0.00281	0.000006	0.207813	170.2202
471	118	118	0.039	0.002783	0.000003	0.207781	167.5657
469	118	118	0.042	0.002776	0.000006	0.207813	174.202
465	118	118	0.045	0.00275	0.000006	0.207813	173.5384
460	118	119	0.049	0.002735	0.000003	0.207813	169.8884
461	118	119	0.049	0.002756	0.000006	0.207844	169.2248
454	118	119	0.048	0.002783	0.000003	0.207781	171.2157
454	118	119	0.049	0.002824	0.000006	0.207781	169.8884
463	118	119	0.049	0.002858	0.000022	0.20775	173.8702
460	119	119	0.049	0.00285	0.000003	0.207688	168.893
465	119	119	0.049	0.002828	0.000003	0.207656	171.8793
468	119	120	0.049	0.00277	0.000006	0.207688	167.5657
464	119	120	0.051	0.002723	0.000006	0.207688	169.8884
460	119	120	0.053	0.002729	0.000006	0.20775	168.893
461	120	120	0.055	0.002756	0.000006	0.20775	169.5566
461	120	120	0.055	0.002795	0.000006	0.20775	169.5566
460	120	121	0.055	0.002809	0.000003	0.207719	166.5703
462	120	120	0.054	0.002796	0.000006	0.20775	168.5612
474	120	121	0.055	0.002815	0.000003	0.207688	169.5566
465	120	121	0.056	0.002815	0.000003	0.207719	169.8884
467	120	121	0.056	0.00281	0.000006	0.20775	170.5521
467	120	121	0.057	0.002796	0.000003	0.207781	167.5657
466	120	120	0.058	0.002789	0.000003	0.207781	169.8884
470	120	121	0.059	0.002829	0.000003	0.207781	170.5521
473	120	121	0.061	0.002858	0.000006	0.207813	169.2248
467	120	121	0.068	0.002837	0.000006	0.207813	170.2202
470	121	121	0.071	0.002775	0.000003	0.20775	169.5566
471	120	121	0.072	0.002769	0.000003	0.20775	175.5292
467	121	121	0.072	0.002776	0.000006	0.207813	173.5384
462	121	121	0.074	0.002796	0.000006	0.207781	169.5566
464	121	122	0.075	0.00279	0.000003	0.20775	168.5612
470	121	122	0.076	0.002764	0.000006	0.20775	173.8702
469	121	122	0.077	0.002804	0.000006	0.20775	173.8702
465	121	122	0.087	0.00283	0.000006	0.20775	172.8748
462	121	122	0.097	0.002816	0.000006	0.207688	173.2066
465	122	122	0.090	0.002822	0.000003	0.207656	172.5429
471	122	122	0.084	0.002851	0.000006	0.207688	173.8702
470	122	122	0.084	0.002842	0.000003	0.207688	177.852
464	122	122	0.087	0.00279	0.000006	0.207688	171.8793
467	122	123	0.087	0.002783	0.000006	0.207688	172.5429
468	122	122	0.081	0.002836	0.000006	0.20775	173.8702
466	122	122	0.081	0.002822	0.000003	0.207688	169.8884
470	122	123	0.080	0.002796	0.000006	0.207719	167.5657
477	122	123	0.081	0.002783	0.000006	0.207719	165.9067
476	122	123	0.081	0.002769	0.000003	0.207719	166.2385
477	122	123	0.081	0.00277	0.000006	0.207781	170.2202
461	122	123	0.084	0.002829	0.000003	0.20775	171.5475

Stack Smoke (%)	HRR (kW)	THR (MJ)	SRR (M^2/sec)	TSR (M^2)	Stack Vel. (m^3/s)
1.393731	0	0.017685	0.049249	3.105105	4.605166
1.393731	0	0.017685	0.049898	3.404491	4.665821
1.393731	0	0.017685	0.050367	3.706692	4.709707
1.393731	0	0.017685	0.050111	4.00736	4.68582
1.393731	0	0.017685	0.049983	4.30726	4.673831
1.393731	0	0.017685	0.049683	4.605356	4.645735
1.393731	0	0.017685	0.048814	4.898241	4.56451
1.045293	0	0.017685	0.03753	5.123418	4.584951
1.393731	0	0.017685	0.049294	5.419181	4.609361
1.393731	0	0.017685	0.048595	5.710748	4.543986
1.393731	0	0.017685	0.048727	6.003109	4.55634
1.393731	0	0.017685	0.048727	6.295469	4.55634
1.393731	0	0.017685	0.049122	6.5902	4.593284
1.742159	2.899246	0.035081	0.059926	6.949754	4.535712
1.742159	11.409004	0.103535	0.060362	7.311923	4.568699
1.393731	20.016299	0.223632	0.049253	7.60744	4.605528
1.045293	25.73326	0.378032	0.038065	7.835827	4.650315
1.393731	31.644684	0.5679	0.049428	8.132396	4.621922
1.742159	34.087251	0.772424	0.06144	8.501035	4.650315
1.742159	34.335162	0.978434	0.060307	8.862879	4.564606
1.742159	37.494503	1.203402	0.060416	9.225378	4.572855
1.742159	37.790623	1.430145	0.060634	9.58918	4.589305
1.393731	34.672298	1.638179	0.048947	9.882864	4.576973
1.742159	34.885293	1.847491	0.061388	10.251194	4.646418
2.090597	37.094116	2.070055	0.072809	10.688047	4.626101
1.742159	37.094036	2.29262	0.060307	11.049892	4.564608
1.742159	34.365434	2.498812	0.060362	11.412063	4.568734
2.090597	34.273094	2.704451	0.07223	11.845441	4.589305
2.090597	37.690761	2.930595	0.073065	12.28383	4.642362
1.742159	37.525956	3.155751	0.06139	12.65217	4.646552
1.742159	34.180505	3.360834	0.060471	13.014996	4.576983
2.090597	34.211397	3.566103	0.071841	13.446041	4.564596
2.090597	37.227468	3.789467	0.071776	13.876695	4.560459
2.090597	37.657858	4.015415	0.072036	14.308909	4.576983
1.742159	37.623898	4.241158	0.060851	14.674015	4.605756
1.742159	39.907753	4.480604	0.061551	15.043321	4.658721
1.742159	39.799748	4.719403	0.061283	15.411017	4.638422
2.090597	42.601928	4.975014	0.072747	15.8475	4.622194
1.393731	39.907753	5.214461	0.049256	16.143035	4.605803
2.090597	43.025072	5.472611	0.07171	16.573294	4.556277
2.090597	40.620448	5.716334	0.072101	17.005897	4.581107
2.090597	40.443451	5.958995	0.072683	17.441995	4.618102
2.090597	40.229431	6.200371	0.072554	17.877318	4.609906
2.090597	40.086772	6.440892	0.07223	18.310701	4.589354
2.090597	39.65572	6.678826	0.07171	18.74096	4.556277
2.090597	39.871829	6.918057	0.0721	19.173562	4.581094
2.090597	40.193814	7.15922	0.071512	19.602637	4.543731
2.090597	40.122484	7.399955	0.071184	20.029738	4.52284
2.090597	37.093877	7.622518	0.072813	20.466614	4.626351
2.090597	36.826532	7.843478	0.073326	20.906573	4.658989

Stack Smoke (%)	HRR (kW)	THR (MJ)	SRR (M^2/sec)	TSR (M^2)	Stack Vel. (m^3/s)
2.090597	39.800097	8.082278	0.073454	21.347298	4.667112
2.090597	33.840814	8.285323	0.072555	21.782625	4.609945
2.090597	33.685223	8.487434	0.073454	22.223351	4.667112
2.090597	34.456151	8.694171	0.07262	22.659069	4.614084
2.439024	37.589066	8.919706	0.082493	23.154027	4.514145
3.13589	37.654609	9.145633	0.104508	23.781077	4.471309
3.484317	37.19338	9.368794	0.116955	24.482805	4.509328
3.484317	37.654609	9.594721	0.115508	25.175855	4.453558
3.484317	42.871	9.851947	0.116279	25.873526	4.483255
3.484317	53.019624	10.170065	0.117493	26.578483	4.530068
4.181183	77.074726	10.632513	0.138976	27.41234	4.47007
3.832755	105.242256	11.263967	0.127426	28.176894	4.469723
3.484317	125.538505	12.017198	0.117032	28.879084	4.512294
3.832755	137.088931	12.839732	0.126428	29.63765	4.434713
4.181183	144.045095	13.704002	0.137998	30.465641	4.438624
3.484317	144.604455	14.571629	0.115796	31.160418	4.464657
3.484317	147.052726	15.453945	0.116793	31.861177	4.503095
3.484317	162.927169	16.359508	0.117792	32.567928	4.541602
3.484317	157.643451	17.233369	0.116337	33.265948	4.485498
3.484317	160.201535	18.122578	0.115549	33.959245	4.455146
3.484317	158.368583	19.00079	0.116998	34.661234	4.511006
3.832755	162.089766	19.901328	0.129215	35.436523	4.532477
3.484317	160.629308	20.793104	0.117212	36.139798	4.519263
3.484317	158.535559	21.672317	0.115413	36.832273	4.449865
3.832755	160.230963	22.561703	0.127109	37.594925	4.458599
3.832755	159.110664	23.444367	0.127593	38.36048	4.475577
3.484317	162.539661	24.347605	0.115853	39.0556	4.466861
3.484317	161.83821	25.246634	0.116418	39.754106	4.488619
3.484317	156.862922	26.115812	0.116755	40.454636	4.501623
3.13589	162.506178	27.018849	0.105621	41.08836	4.518904
3.484317	162.815487	27.923742	0.114473	41.775197	4.413637
3.484317	165.199464	28.842939	0.115159	42.466152	4.440092
3.484317	165.94569	29.766613	0.117081	43.16864	4.514208
3.484317	166.391689	30.692963	0.116181	43.865724	4.479483
3.484317	164.275495	31.606616	0.118078	44.574191	4.552631
3.484317	160.469012	32.49743	0.118189	45.283326	4.556924
3.13589	161.358942	33.393584	0.105197	45.914511	4.500796
3.484317	163.852099	34.304696	0.117846	46.621585	4.543676
3.484317	165.364545	35.224884	0.118848	47.33467	4.582309
3.484317	167.597693	36.15847	0.118069	48.043084	4.552289
3.832755	167.744421	37.092936	0.130514	48.826166	4.578033
3.484317	165.82613	38.015893	0.116609	49.525821	4.496006
3.484317	167.021887	38.946024	0.116257	50.223364	4.482434
3.484317	165.607434	39.867669	0.116597	50.922948	4.495546
3.484317	167.315764	40.799564	0.11546	51.615707	4.451686
3.484317	165.464079	41.720348	0.11671	52.31597	4.499909

Stack Smoke (%)	HRR (kW)	THR (MJ)	SRR (M^2/sec)	TSR (M^2)	Stack Vel. (m^3/s)
3.484317	162.714374	42.624634	0.117162	53.018941	4.517317
3.832755	161.99886	43.524627	0.126912	53.780411	4.451686
3.484317	157.081166	44.395114	0.116472	54.47924	4.490697
3.484317	158.317982	45.273022	0.11556	55.172599	4.455544
3.484317	157.221951	46.144354	0.117826	55.879554	4.542916
3.484317	157.783742	47.019056	0.117601	56.585162	4.534255
3.832755	155.665707	47.881051	0.127899	57.352555	4.486318
3.484317	154.002602	48.733066	0.11613	58.049338	4.477547
3.484317	158.191286	49.610214	0.116812	58.750208	4.503809
3.832755	161.058052	50.504562	0.127899	59.517601	4.486318
3.484317	163.470338	51.413384	0.117714	60.223883	4.538588
3.832755	167.202373	52.344599	0.127634	60.989686	4.477025
3.484317	169.560748	53.289963	0.117139	61.692521	4.516433
3.832755	167.807445	54.224808	0.127131	62.455309	4.459399
3.484317	167.202373	55.156022	0.116459	63.154061	4.4902
3.484317	163.615077	56.065712	0.116117	63.850763	4.477025
3.484317	161.300093	56.961513	0.116445	64.549435	4.489686
3.484317	162.614252	57.865199	0.116445	65.248107	4.489686
3.484317	163.357778	58.773345	0.115415	65.940599	4.449973
4.181183	161.73943	59.671782	0.139176	66.775653	4.476488
3.832755	166.613245	60.599461	0.127995	67.543622	4.489686
3.832755	164.122895	61.512199	0.12812	68.312343	4.494078
3.832755	161.464037	62.408983	0.12837	69.082563	4.502846
3.484317	157.504748	63.282011	0.11576	69.777121	4.46325
3.832755	158.371722	64.160242	0.12812	70.545841	4.494078
3.832755	158.80328	65.041061	0.12837	71.316062	4.502846
3.832755	156.283185	65.90676	0.12787	72.083279	4.485291
4.181183	156.56471	66.774149	0.139859	72.922433	4.498464
3.832755	160.583969	67.665653	0.128105	73.691064	4.493557
3.832755	161.610219	68.563314	0.13023	74.472443	4.568077
4.181183	156.56471	69.430702	0.141337	75.320466	4.546013
3.832755	158.659568	70.31066	0.128105	76.089098	4.493557
3.832755	161.75625	71.209197	0.127729	76.855469	4.480348
4.181183	161.335286	72.105209	0.141472	77.704303	4.550357
4.181183	164.073695	73.017651	0.141472	78.553137	4.550357
4.181183	163.078562	73.924122	0.141067	79.399538	4.537313
4.181183	166.64969	74.85202	0.141202	80.24675	4.541665
4.181183	168.844777	75.793089	0.141053	81.093066	4.536857
3.832755	168.604506	76.732716	0.129836	81.872083	4.554273
3.832755	168.604506	77.672343	0.131314	82.65997	4.606127
4.181183	168.155573	78.609277	0.140781	83.504656	4.528124
4.181183	168.30536	79.547109	0.141053	84.350972	4.536857
4.181183	162.515088	80.450199	0.141594	85.200536	4.554273
3.832755	168.469836	81.389018	0.128341	85.970582	4.501823
4.529621	167.531601	82.322208	0.150589	86.874113	4.470943
4.181183	164.897761	83.239594	0.138313	87.703994	4.448755
4.181183	165.192642	84.15875	0.138452	88.534704	4.453201
4.529621	160.40313	85.049169	0.151777	89.445364	4.506218
4.529621	161.352798	85.945286	0.152367	90.359567	4.523752

APPENDIX B

PHOTOGRAPHS