From: <larry.swanson@ps.ge.com>
To: <aaron-n@ipsc.com>, <garry-c@ipsc.com>, <jim-n@ipsc.com>
Date: 1/10/03 11:48AM
Subject: Recent Boiler Thermal Modeling Results and Estimates of Tube Temperatures

IPP Team,

Conference Call

Attached are recent documents showing the boiler thermal modeling results and estimates of the exchanger and waterwall tube temperatures. Please review this information for our meeting next Monday 13-Jan-03 at 11:00 mountain time. I am also going to send you a power point presentation with the latest baseline and 10% OFA CFD results for uprated nominal load conditions.

- thermal model due today. Postponed one week.
- 1st week in February for a site visit February 4.

CFD work done by the end of the month.

Notes on the tables showing thermal modeling results:

(1) These are thermal modeling results without additional platen exchanger area.
(2) 75% load case - we dialed in this case without changing waterwall fouling conditions from the original full load case (875 MW). To achieve the required steam rate and steam temperatures, the oxygen was increased from a projected 4.75% wet (from the design spec. O2 vs. load figure) to 5.25% wet. The original burner out of service (BOOS) configuration was also changed from a staggered arrangement (DACBG), recommended by Gary, to all burners in the top rows (EDAHF). Moving the burners arrangement to the top rows allowed us to reduce the steam generation rate enough to recover the steam temperatures and superheat attemperation.

We'll discuss this further during the meeting.

for conference call
The meeting number and code are: 1-800-830-0630 and SWANSONL.

Talk to you Monday.

<<Results III 01-07-2003.xls>> <<Results VIII 01-08-2003.xls>> <<Results X .xls>> <<Exchanger Wall Temperatures.xls>> <<WW Tube Temperatures.xls>>

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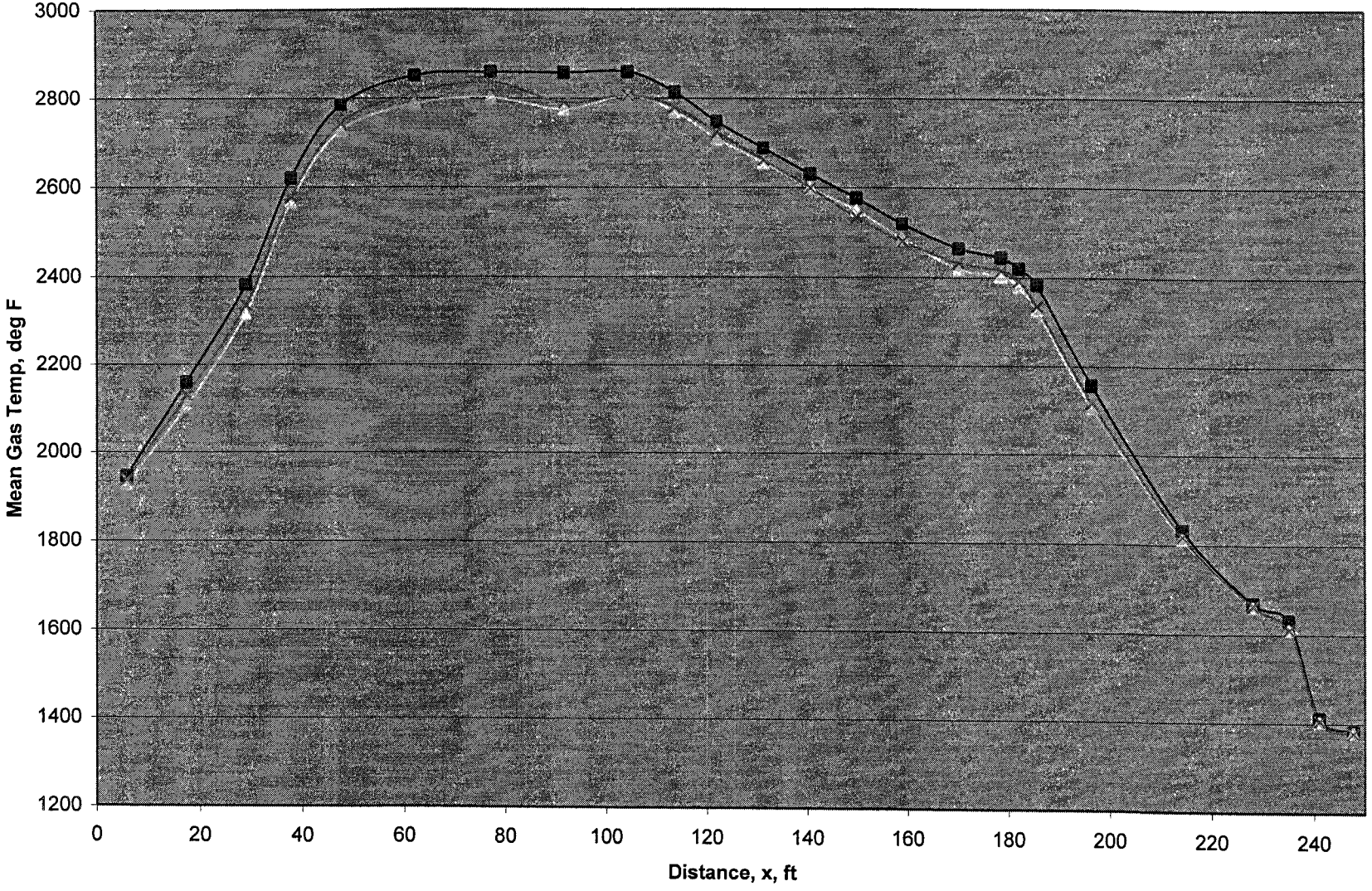
TABLE . COMPARISON BASELINE PERFORMANCE PREDICTIONS AT ORIGINAL FULL LOAD (875 MW)

IPP - Utah Unit 2 No additional Platen Area.

	Unit 1 875MW 7-Dec-02	Uprated Nominal (950 MW)	Original Full Load (875 MW) Initial	Original Full Load (875 MW) (Dirty WWalls) by 7.7%
Flue Gas O_2 (% dry)	3.30	2.50	3.30	3.30
Fuel Flow Rate (1000 lb/hr)	778	679	660	651
Flue gas Temperature (°F) Leaving				
FEGT	2,159	2,374	2,360	2,350
Backpass Inlet	1,453	1,384	1,380	1,378
Pri RH	740	759	740	735
Economizer	764	735	751	757
Air Preheater				
Mixing cup temperature (°F) leaving				
Backpass	756	746	746	748
Flow Rates (1000 lb/hr)				
Main Steam	6,426	6,664	6,537	6,445
Reheat Steam	5,249	5,501	5,340	5,265
Attemperation flow (1000 lb/hr)				
Superheater	42	26	0	26
Reheater	1	0	0	0
Flue gas split in Backpass (%)				
Pri RH	32.81	43.95	40.91	39.84
Pri SH / Econ	67.19	56.05	59.09	60.16
Water/Steam Temperatures (°F)				
Economizer In	551	549	551	551
Economizer Out	580	581	585	586
Waterwall Out	679	678	679	679
Pri SH Out	725			
Platen SH Out	775	781	781	783
SH-Int Out	892			
SH-Out Out	1,001	999	999	1,001
Cold RH In	628	630	628	628
Cold RH Out	804	816	816	812
Hot RH Out	1,005	1,005	1,011	1,005
Percent Carbon in ash	n/a	0.446	0.220	0.199
Heat Absorption (kW)				
Economizer	69,283	78,934	83,544	83,344
Waterwall	910,602	950,152	919,472	901,625
Primary SH	248,610	245,115	245,652	241,174
Platen SH	143,498	155,815	148,803	150,734
SH Int	205,935	242,479	234,385	232,347
SH Out	152,835	119,782	115,380	118,242
Pri RH	157,188	175,308	165,243	163,294
RH Out	168,278	166,082	168,960	161,958
Total Heat Absorption (kW)	2,056,229	2,133,667	2,081,439	2,052,718
ASME Heat Loss Efficiency (%)		89.12	88.19	88.20

Mean Gas Temperature Profile - IPP-Utah



IP7_036406

TABLE . COMPARISON BASELINE PERFORMANCE PREDICTIONS AT 75% OF ORIGINAL FULL LOAD (875 MW)

IPP - Utah Unit 2

	Original Full Load (875 MW)	75% Load Initial	75% Load Increase %O2	75% Load Increase %O2 Change burner arrgmt & FG split
Flue Gas O_2 (% dry)	3.30	4.75	5.25	5.25
Fuel Flow Rate (1000 lb/hr)	651	488	488	488
Flue gas Temperature (°F) Leaving				
FEGT	2,350	2,132	2,133	2,210
Backpass Inlet	1,378	1,306	1,303	1,328
Pri RH	735	742	740	737
Economizer	757	761	757	770
Air Preheater				
Mixing cup temperature (°F) leaving				
Backpass	748	753	751	758
Flow Rates (1000 lb/hr)				
Main Steam	6,445	5,081	5,010	4,817
Reheat Steam	5,265	4,151	4,093	3,935
Attemperation flow (1000 lb/hr)				
Superheater	26	0	0	27
Reheater	0	0	0	0
Flue gas split in Backpass (%)				
Pri RH	39.84	39.84	39.84	38.36
Pri SH / Econ	60.16	60.16	60.16	61.64
Water/Steam Temperatures (°F)				
Economizer In	551	551	551	551
Economizer Out	586	583	584	588
Waterwall Out	679	679	679	679
Pri SH Out				
Platen SH Out	783	767	771	784
SH-Int Out				
SH-Out Out	1,001	945	960	1,001
Cold RH In	628	628	628	628
Cold RH Out	812	797	805	814
Hot RH Out	1,005	969	982	1,006
Percent Carbon in ash	0.199	0.027	0.019	0.026
Heat Absorption (kW)				
Economizer	83,344	60,570	62,530	65,626
Waterwall	901,625	719,108	706,290	669,385
Primary SH	241,174	178,206	180,193	182,073
Platen SH	150,734	106,327	107,340	112,432
SH Int	232,347	162,437	165,190	176,111
SH Out	118,242	77,014	79,590	85,901
Pri RH	163,294	115,728	119,040	120,230
RH Out	161,958	112,973	114,277	119,212
Total Heat Absorption (kW)	2,052,718	1,532,363	1,534,450	1,530,970
ASME Heat Loss Efficiency (%)	88.20	87.70	87.50	87.50

Mean Gas Temperature Profile - IPP-Utah

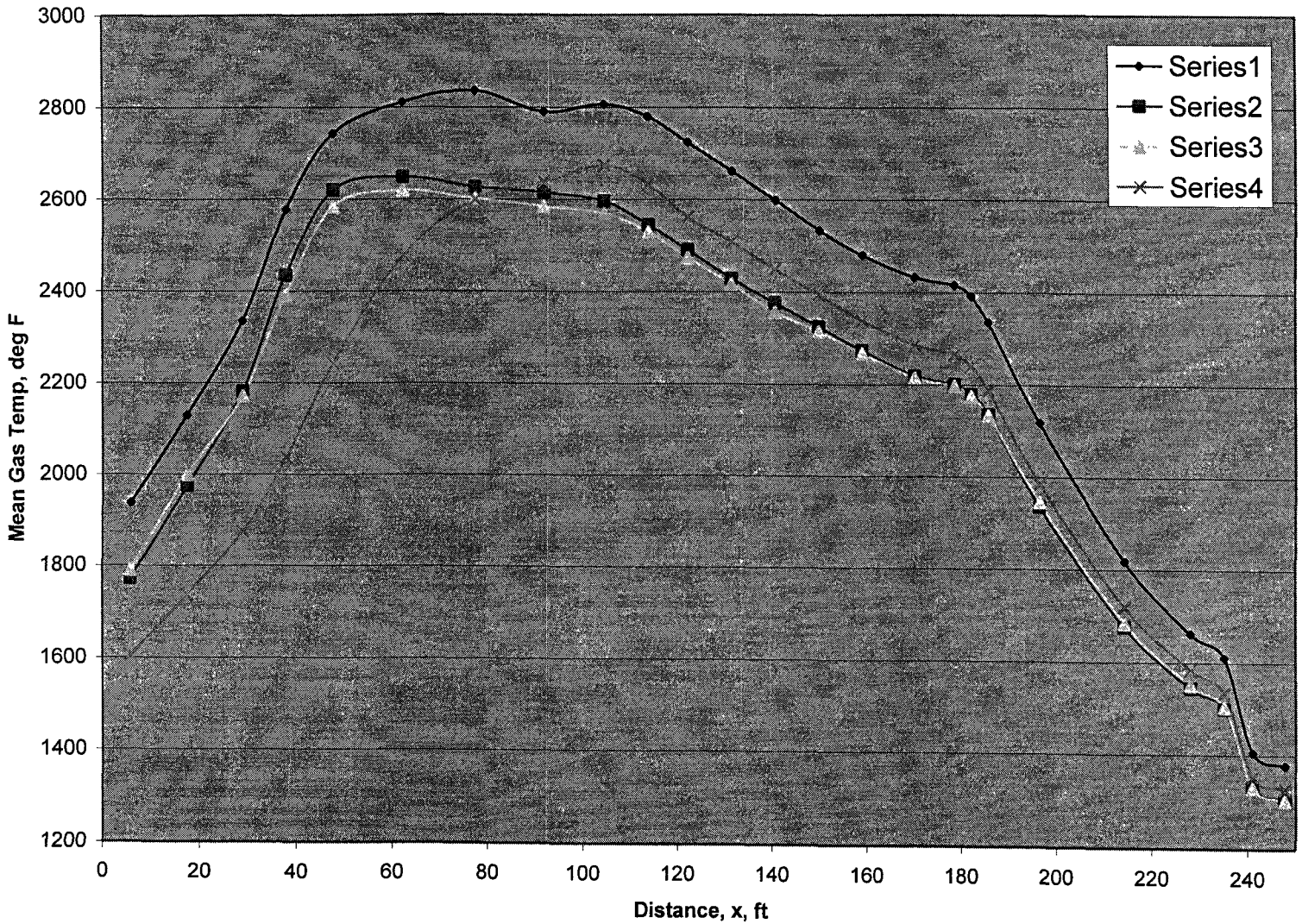
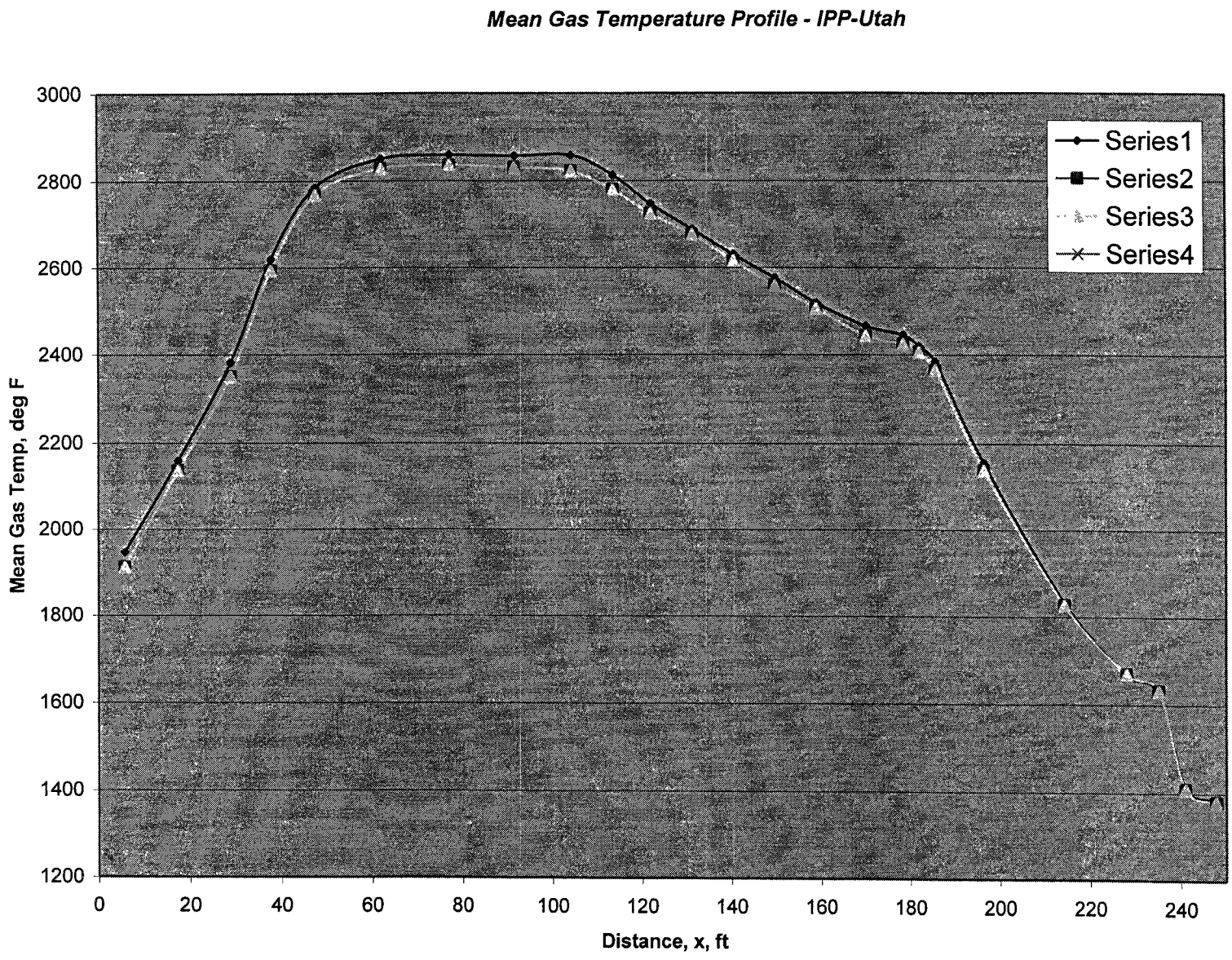


TABLE . COMPARISON BASELINE PERFORMANCE PREDICTIONS AT UPRATED NOMINAL FULL LOAD

No Platen Considered

IPP - Utah Unit 2

	Uprated Nominal	Uprated Nominal Excess O_2	Uprated Nominal Excess O_2 Change FG split
Flue Gas O_2 (% wet)	2.50	3.00	3.00
Fuel Flow Rate (1000 lb/hr)	679	679	679
Flue gas Temperature (°F) Leaving			
FEGT	2,374	2,387	2,387
Backpass Inlet	1,384	1,381	1,381
Pri RH	759	757	743
Economizer	735	732	745
Air Preheater			
Mixing cup temperature (°F) leaving			
Backpass	746	743	744
Flow Rates (1000 lb/hr)			
Main Steam	6,664	6,634	6,657
Reheat Steam	5,501	5,476	5,496
Attemperation flow (1000 lb/hr)			
Superheater	26	56	56
Reheater	0	0	0
Flue gas split in Backpass (%)			
Pri RH	43.95	43.95	41.42
Pri SH / Econ	56.05	56.05	58.58
Water/Steam Temperatures (°F)			
Economizer In	549	549	549
Economizer Out	581	582	583
Waterwall Out	678	678	678
Pri SH Out			
Platen SH Out	781	786	786
SH-Int Out			
SH-Out Out	999	999	999
Cold RH In	630	630	630
Cold RH Out	816	821	814
Hot RH Out	1,005	1,011	1,005
Percent Carbon in ash	0.446	0.283	0.283
Heat Absorption (kW)			
Economizer	78,934	80,965	84,570
Waterwall	950,152	938,757	938,757
Primary SH	245,115	247,600	250,283
Platen SH	155,815	158,080	158,080
SH Int	242,479	240,284	240,284
SH Out	119,782	120,368	120,368
Pri RH	175,308	179,573	172,953
RH Out	166,082	168,351	168,351
Total Heat Absorption (kW)	2,133,667	2,133,978	2,133,646
ASME Heat Loss Efficiency (%)	89.15	89.00	89.00


Mean Gas Temperature Profile - IPP-Utah
Mean Gas Temp, deg F
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
0
20
40
60
80
100
120
140
160
180
200
220
240
Distance, x, ft
Series1
Series2
Series3
Series4

IP7_036410

TABLE . INTERMEDIATE SUPERHEATER THERMAL CHARACTERISTICS FOR DIFFERENT PROCESS CONDITIONS

	Uprated Nominal (950 MW)	Uprated Nominal 5% OFA Dirty WW 6.4%	Uprated Nominal 10% OFA Dirty WW 10.25%	Uprated Nominal 15% OFA Dirty WW 5% Clean PSH 15%	Uprated Nominal Add Pl SH Area Dirty WW 3.33%	Uprated Nominal Add Pl SH Area 10% OFA Dirty WW 10%
Heat Duty (kW)	242,480	237,084	237,965	234,218	234,501	232,710
Exchanger Surface Area (m^2)	3956.66	3956.66	3956.66	3956.66	3956.66	3956.66
Heat Flux (kW/m^2)	61.28	59.92	60.14	59.20	59.27	58.81
Heat Flux ($kBtu/hr\text{-}ft^2$)	19.43	19.00	19.07	18.77	18.79	18.65
Tube Outer Diameter (m)	0.0508	0.0508	0.0508	0.0508	0.0508	0.0508
Tube Thickness (m)	0.0089	0.0089	0.0089	0.0089	0.0089	0.0089
Tube Wall Thermal Conductivity (kW/m-K)	0.0228	0.0227	0.0227	0.0227	0.0228	0.0228
Tube Wall Thermal Conductance ($kW/m^2\text{-}K$)	2.08	2.08	2.08	2.08	2.08	2.08
Temperatures (^oF)						
Platen SH Out	781	781	781	782	790	791
SH Int. Out	916	914	917	915	918	918
Steam Average	849	848	849	849	854	855
Estimated Ave. Tube Wall	902	899	901	900	905	905
Estimated Max. Tube Wall	969	966	969	966	969	969

IP7_036411

TABLE . FINAL SUPERHEATER THERMAL CHARACTERISTICS FOR DIFFERENT PROCESS CONDITIONS

	Uprated Nominal (950 MW)	Uprated Nominal 5% OFA Dirty WW 6.4%	Uprated Nominal 10% OFA Dirty WW 10.25%	Uprated Nominal 15% OFA Dirty WW 5% Clean PSH 15%	Uprated Nominal Add Pl SH Area Dirty WW 3.33%	Uprated Nominal Add Pl SH Area 10% OFA Dirty WW 10%
Heat Duty (kW)	119,782	122,817	119,047	120,714	116,390	117,214
Exchanger Surface Area (m^2)	4215.54	4215.54	4215.54	4215.54	4215.54	4215.54
Heat Flux (kW/m^2)	28.41	29.13	28.24	28.64	27.61	27.81
Heat Flux ($kBtu/hr\text{-}ft^2$)	9.01	9.24	8.95	9.08	8.76	8.82
Tube Outer Diameter (m)	0.0445	0.0445	0.0445	0.0445	0.0445	0.0445
Tube Thickness (m)	0.0076	0.0076	0.0076	0.0076	0.0076	0.0076
Tube Wall Thermal Conductivity (kW/m-K)	0.0239	0.0239	0.0239	0.0239	0.0239	0.0239
Tube Wall Thermal Conductance ($kW/m^2\text{-}K$)	2.56	2.56	2.56	2.56	2.56	2.56
Temperatures (°F)						
SH Int. Out	916	914	917	915	918	918
SH-Out Out	999	999	999	999	999	999
Steam Average	958	957	958	957	959	959
Estimated Ave. Tube Wall	977	977	978	977	978	978
Estimated Max. Tube Wall	1,019	1,020	1,019	1,019	1,018	1,019

IP7_036412

TABLE . REHEATER THERMAL CHARACTERISTICS FOR DIFFERENT PROCESS CONDITIONS

	Uprated Nominal (950 MW)	Uprated Nominal 5% OFA Dirty WW 6.4%	Uprated Nominal 10% OFA Dirty WW 10.25%	Uprated Nominal 15% OFA Dirty WW 5% Clean PSH 15%	Uprated Nominal Add Pl SH Area Dirty WW 3.33%	Uprated Nominal Add Pl SH Area 10% OFA Dirty WW 10%
Heat Duty (kW)	166,083	167,107	164,609	154,258	163,794	161,979
Exchanger Surface Area (m^2)	7893.54	7893.54	7893.54	7893.54	7893.54	7893.54
Heat Flux (kW/m^2)	21.04	21.17	20.85	19.54	20.75	20.52
Heat Flux ($kBtu/hr\text{-}ft^2$)	6.67	6.71	6.61	6.20	6.58	6.51
Tube Outer Diameter (m)	0.0508	0.0508	0.0508	0.0508	0.0508	0.0508
Tube Thickness (m)	0.0089	0.0089	0.0089	0.0089	0.0089	0.0089
Tube Wall Thermal Conductivity (kW/m-K)	0.0231	0.0231	0.0232	0.0231	0.0232	0.0232
Tube Wall Thermal Conductance ($kW/m^2\text{-}K$)	2.11	2.11	2.12	2.11	2.12	2.12
Temperatures (^oF)						
Cold RH Out	816	815	818	813	819	818
Hot RH Out	1,005	1,004	1,005	1,006	1,005	1,005
Steam Average	911	910	912	910	912	912
Estimated Ave. Tube Wall	928	928	929	926	930	929
Estimated Max. Tube Wall	1,023	1,022	1,023	1,023	1,023	1,022

IP7_036413

		Estimated Water Wall Tube Temperature (°F)					
	Increment Number	Uprated Nominal (950 MW)	Uprated Nominal 5% OFA Dirty WW 6.4%	Uprated Nominal 10% OFA Dirty WW 10.25%	Uprated Nominal 15% OFA Dirty WW 5% Clean PSH 15%	Uprated Nominal Add Pl SH Area Dirty WW 3.33%	Uprated Nominal Add Pl SH Area 10% OFA Dirty WW 10%
Hopper	1	7.87E+02	7.92E+02	7.94E+02	7.97E+02	7.88E+02	8.04E+02
Hopper	2	8.07E+02	8.22E+02	8.24E+02	8.27E+02	8.08E+02	8.19E+02
Hopper	3	8.42E+02	8.49E+02	8.52E+02	8.56E+02	8.44E+02	8.49E+02
	4	8.96E+02	9.15E+02	9.04E+02	9.10E+02	8.91E+02	9.07E+02
Burner	5	9.24E+02	9.29E+02	9.42E+02	9.48E+02	9.24E+02	9.36E+02
Burner	6	9.48E+02	9.52E+02	9.55E+02	9.63E+02	9.43E+02	9.52E+02
Burner	7	9.42E+02	9.48E+02	9.49E+02	9.58E+02	9.47E+02	9.53E+02
Burner	8	9.45E+02	9.42E+02	9.39E+02	9.46E+02	9.47E+02	9.41E+02
OFA	9	9.31E+02	9.24E+02	9.07E+02	8.98E+02	9.25E+02	9.05E+02
	10	9.26E+02	8.99E+02	9.03E+02	8.86E+02	9.26E+02	9.06E+02
	11	9.05E+02	8.95E+02	8.90E+02	8.75E+02	9.05E+02	8.94E+02
	12	8.93E+02	8.85E+02	8.75E+02	8.72E+02	8.89E+02	8.76E+02
	13	8.73E+02	8.67E+02	8.66E+02	8.65E+02	8.80E+02	8.67E+02
	14	8.63E+02	8.66E+02	8.56E+02	8.56E+02	8.66E+02	8.62E+02
Nose	15	8.48E+02	8.50E+02	8.43E+02	8.40E+02	8.54E+02	8.45E+02
	16	8.29E+02	8.29E+02	8.29E+02	8.20E+02	8.30E+02	8.28E+02
cavity	17	8.26E+02	8.16E+02	8.21E+02	8.24E+02	8.24E+02	8.14E+02
cavity	18	8.22E+02	8.17E+02	8.10E+02	8.13E+02	8.18E+02	8.07E+02
cavity	19	8.05E+02	8.10E+02	7.96E+02	8.01E+02	8.06E+02	8.06E+02
Platen SH	20	7.41E+02	7.38E+02	7.39E+02	7.37E+02	7.40E+02	7.30E+02
SH Int	21	7.03E+02	7.06E+02	7.05E+02	7.07E+02	7.05E+02	7.04E+02
SH Out	22	7.02E+02	6.98E+02	7.02E+02	6.96E+02	6.97E+02	6.97E+02
Sc 1	23	7.03E+02	7.02E+02	7.01E+02	7.04E+02	7.04E+02	7.00E+02
RH Out	24	6.86E+02	6.84E+02	6.87E+02	6.85E+02	6.85E+02	6.86E+02
Sc 2	25	6.91E+02	6.95E+02	6.92E+02	6.90E+02	6.90E+02	6.93E+02

Tube outer diameter (m)	0.0610
Tube thickness (m)	0.0089
Thermal Conductivity (kW/m-K)	0.0190
Water Saturation Temp. (K)	631.86

IP7_036414

From: <larry.swanson@ps.ge.com>
To: <aaron-n@ipsc.com>, <garry-c@ipsc.com>, <jim-n@ipsc.com>
Date: 1/10/03 3:23PM
Subject: Baseline and 10% OFA CFD Results

IPP Team,

Attached is a power point file with the CFD results for uprated full load baseline and 10% OFA conditions. We'll discuss the details during our meeting on Monday. This case is for fully open damper settings with the air uniformly distributed over the entire duct cross-section.

Notable items:

(1) page 4, CO concentration in the lower furnace for 10% OFA relative to baseline conditions.
(2) pages 6-9, O2 mixing/stratification during 10% OFA operation and it's affect on CO production/distribution, especially at the exit plane.

Talk to you Monday.

<<IPP-CFD.ppt>>

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g

GE Power Systems

IPP Boiler

Baseline and 10% SOFA CFD Results

1/08/2003

GE EER
18 Mason, Irvine, CA 92618

IP7_036416

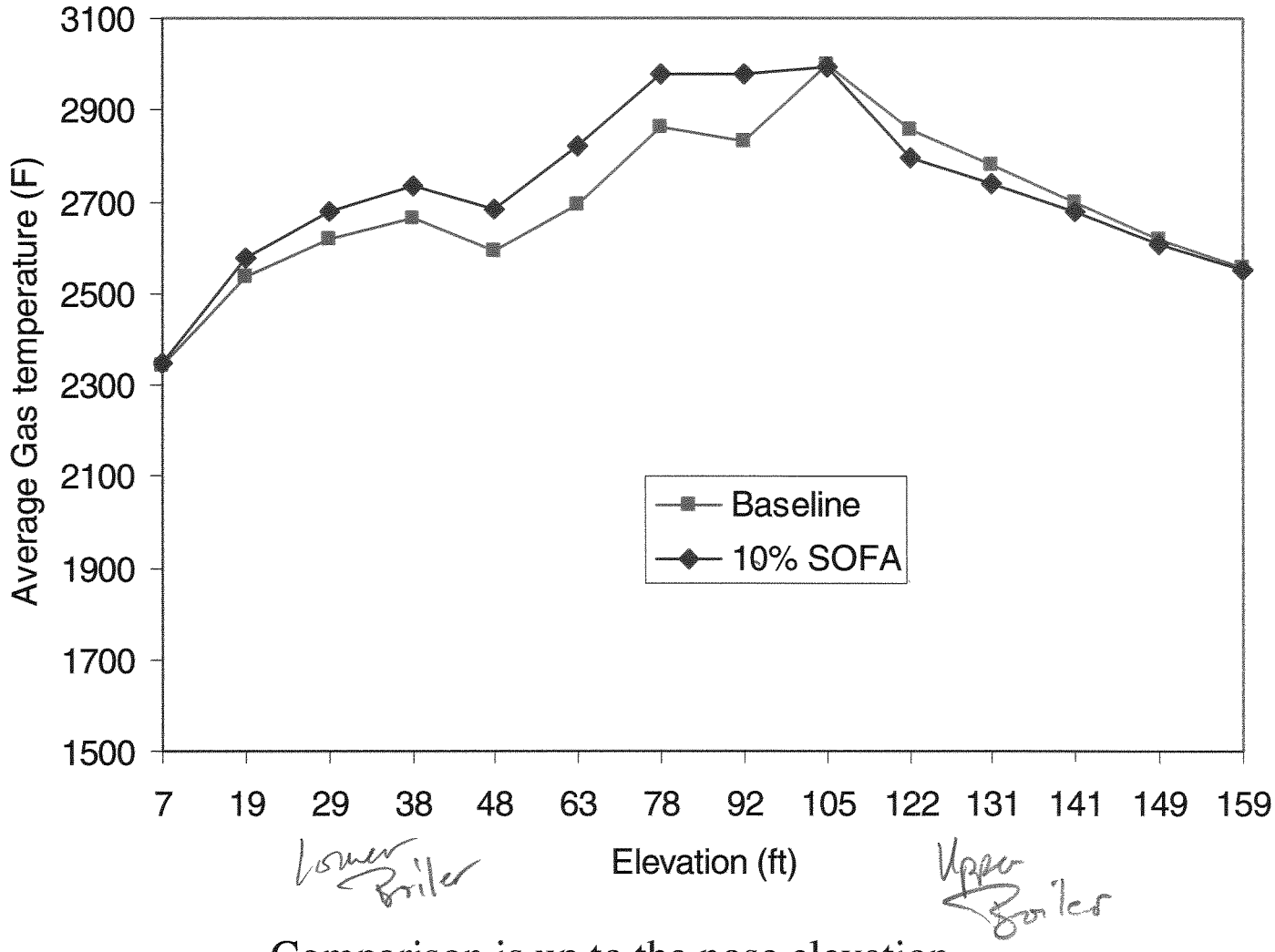
g Model Outputs Comparison

Input		Baseline	10% SOFA
Primary Air	lb/hr	1,249,539	1,249,539
Secondary Air	lb/hr	5,692,320	4,998,120
SOFA	lb/hr	0	694,200
Coal Flow	lb/hr	679,000	679,000
Output			
Exit O2 (wet)	%	2.56	2.57
Exit CO (wet)	ppm	59	~~95~~ 132

IP7_036417

9 Average gas temperature along boiler

GE Optimization Solutions

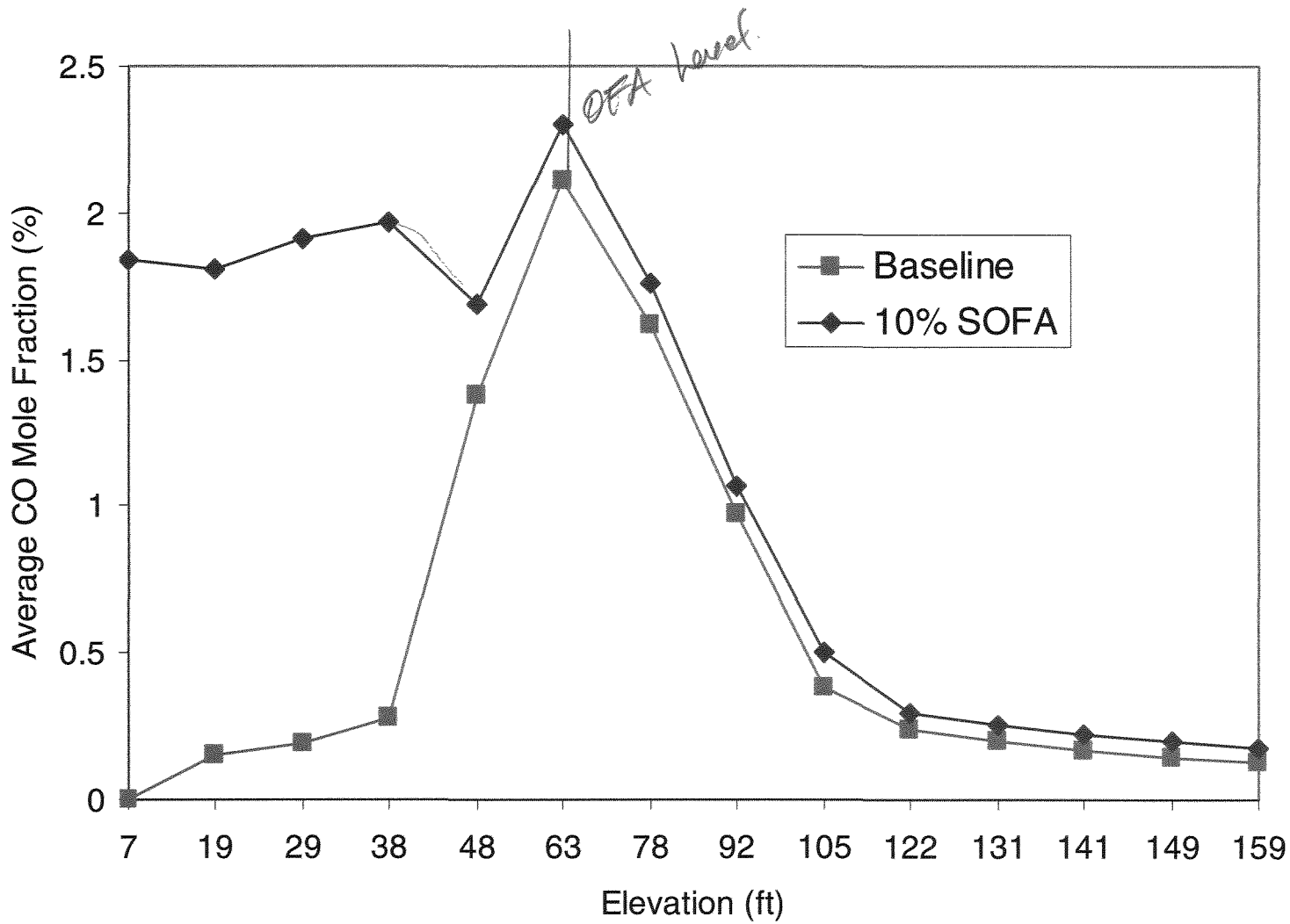


Comparison is up to the nose elevation.

IP7_036418

9 Average CO mole fraction along boiler

GE Optimization Solutions

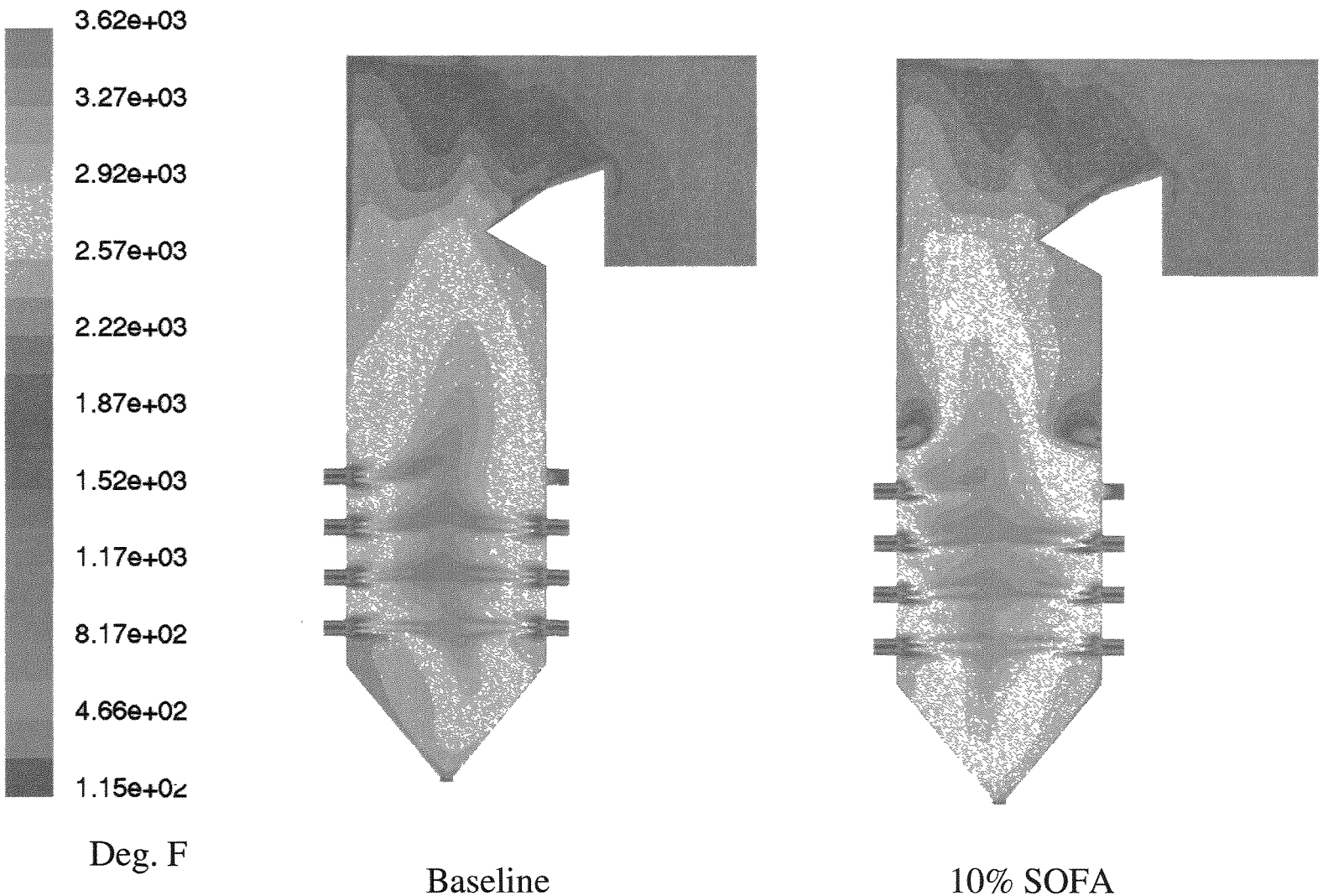


Comparison is up to the nose elevation.

IP7_036419

9 Side view of temperature contour

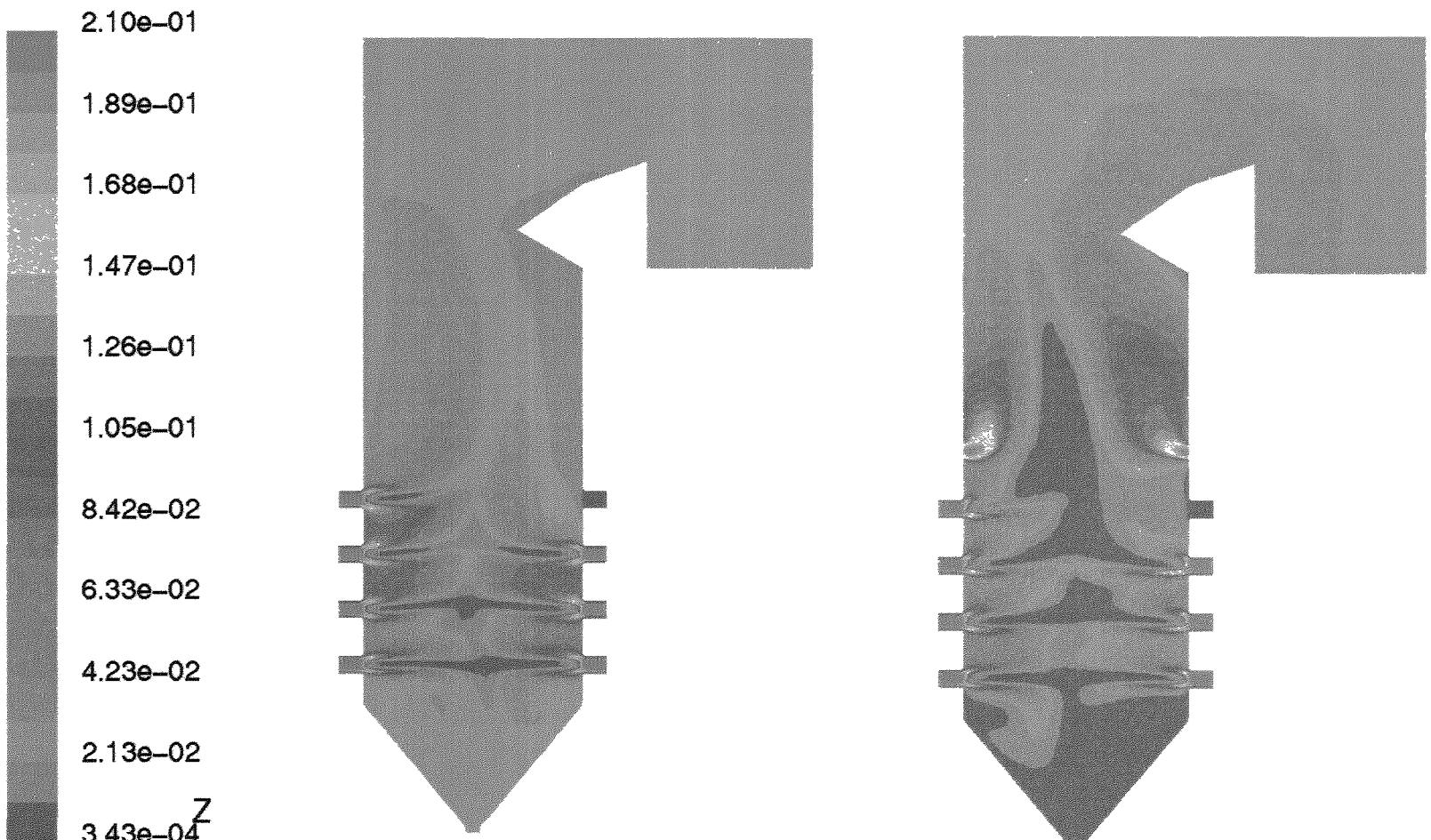
GE Optimization Solutions



IP7_036420

9 Side view of O_2 mole fraction contour

GE Optimization Solutions



Mole fraction

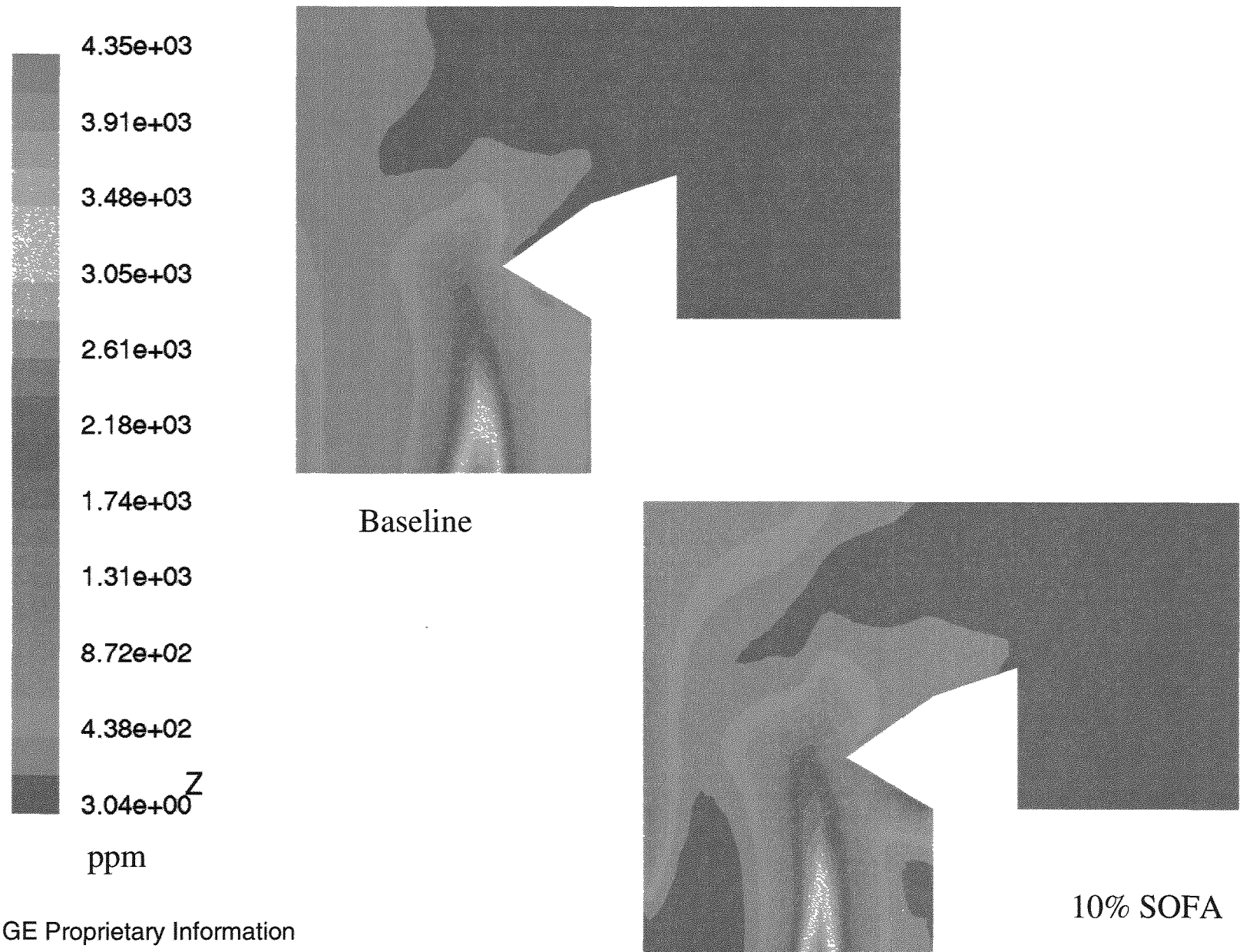
Baseline

10% SOFA

IP7_036421

9 Side view of CO concentration (ppm) above SOFA elevation

GE Optimization Solutions

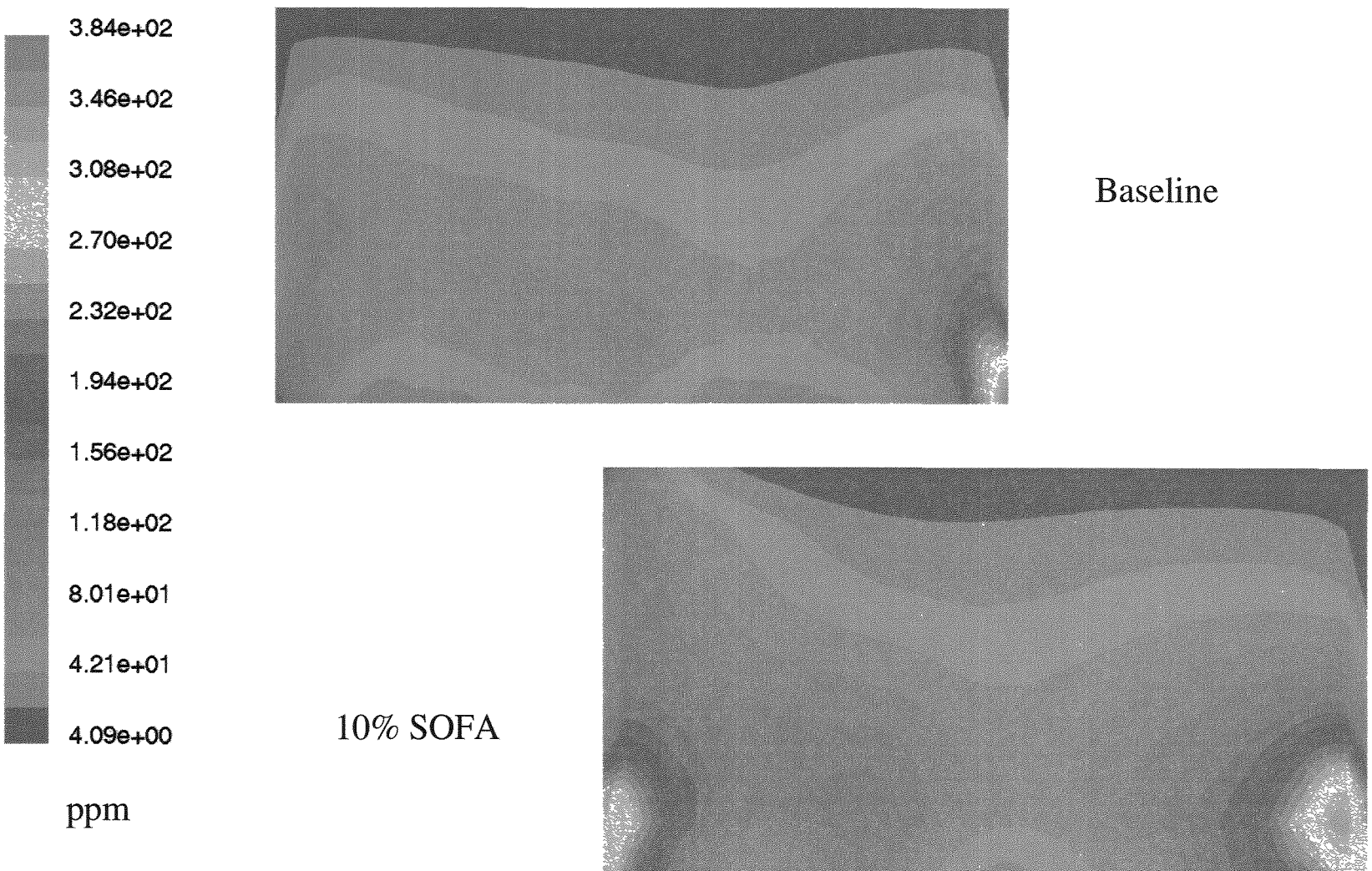


GE Proprietary Information

IP7_036422

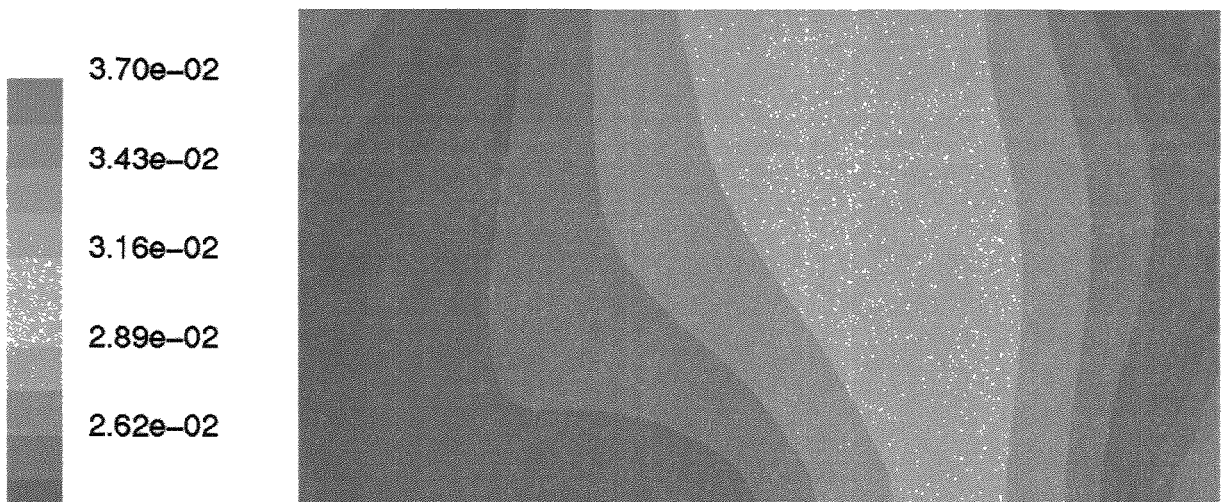
g Top view of concentration (ppm) at model exit

GE Optimization Solutions

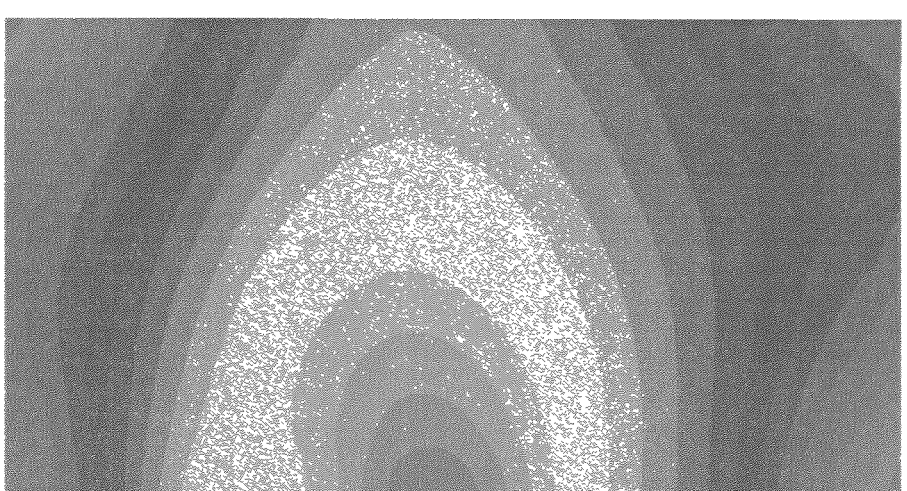


IP7_036423

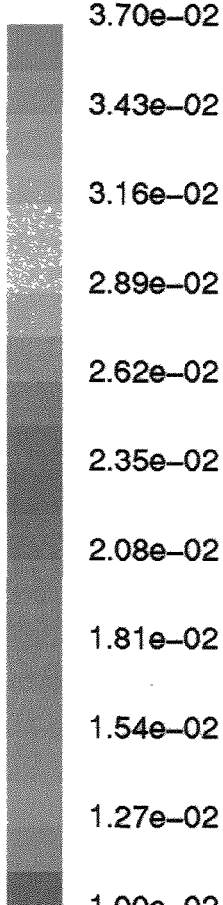
9 Top view of O2 mole fraction at model exit



Baseline



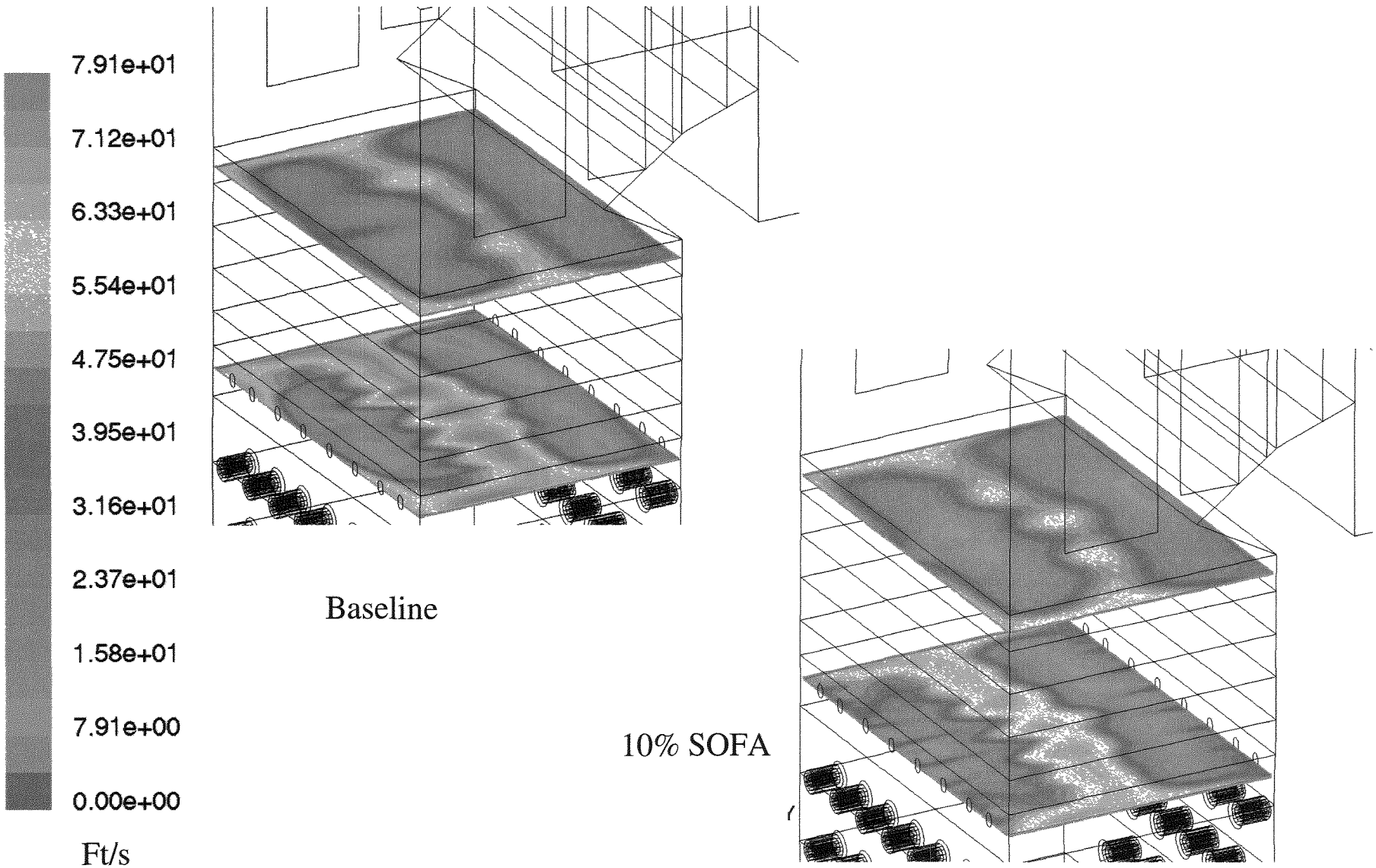
10% SOFA



Mole fraction

IP7_036424

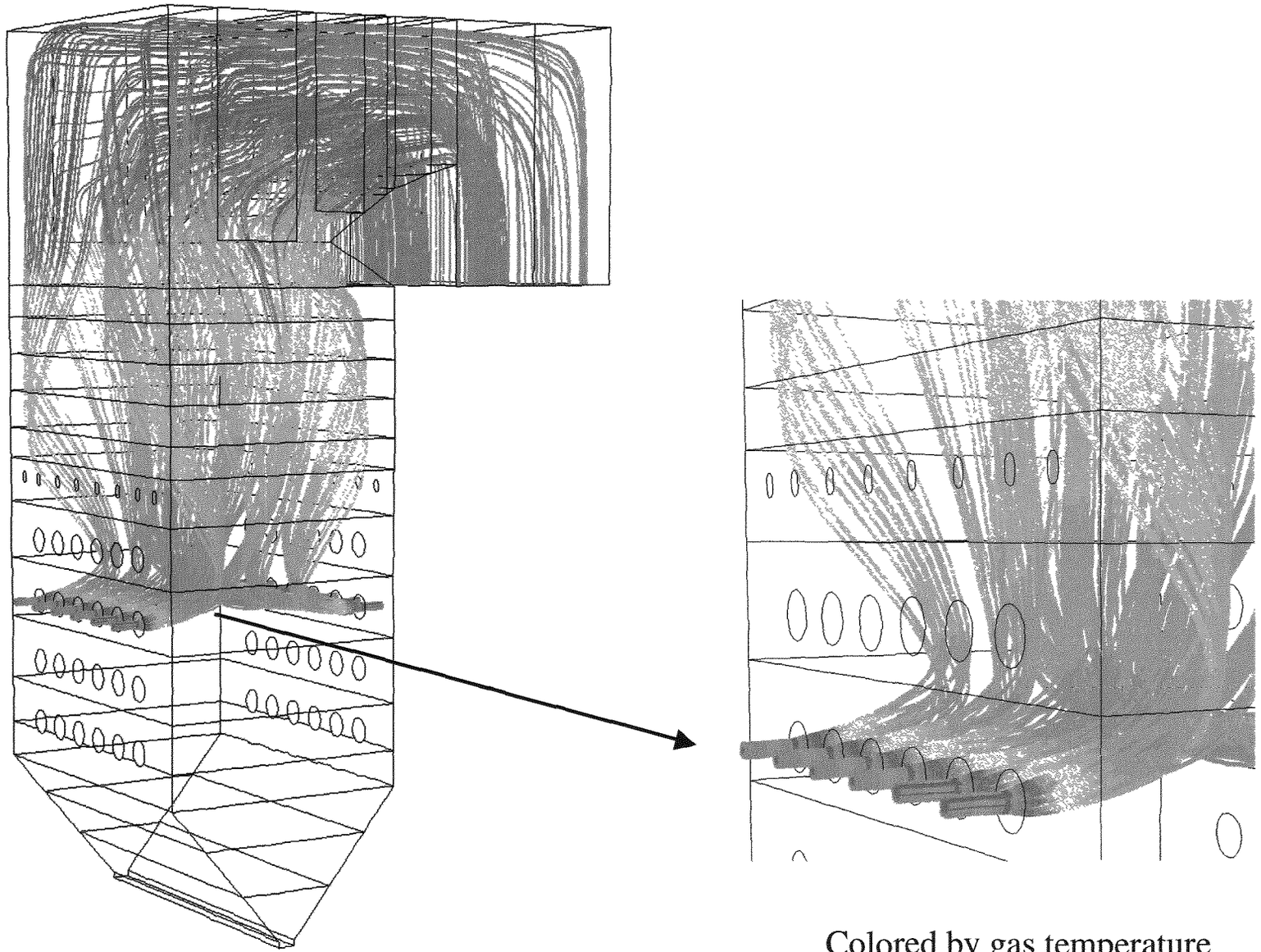
9 Velocity magnitude



IP7_036425

g Path lines released from the burners at baseline

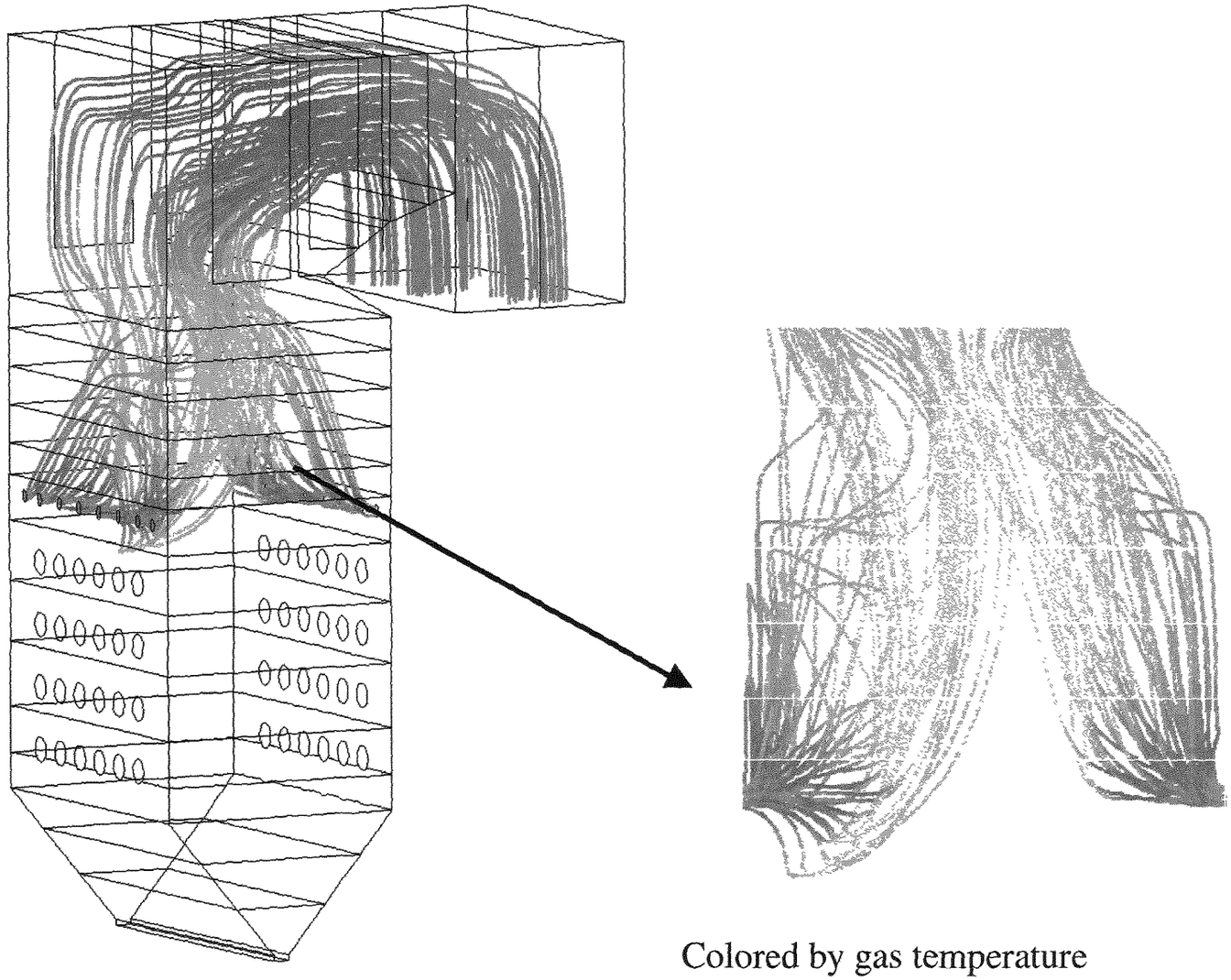
GE Optimization Solutions



Colored by gas temperature

IP7_036426

g Path lines released from SOFA nozzles



Colored by gas temperature

IP7_036427