Smurfit-Stone

Containerboard Mill Division

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BUREAU OF AIR REGULATION

November 2, 2005

Mr. Jeff Koerner
Florida Dept. of Environmental Protection
2600 Blair Stone Rd.
MS #5505
Tallahassee, FL, 32399-2400

Re: Request for revision of Permit
Project No. 0050009-021-AC
0050009-022-AC

Dear Mr. Koerner

We request a minor revision of the above permit. The mill needs to revise permit condition #4, "Permitted Capacity". The reasons for this request were previously covered in the comment memo of October 18, 2005, and in various telephone conversations. The mill requests that the current limit of 300,000 pounds per hour, based on a 24 hour average be changed to 330,000 pounds per hour, based on a 24 hour average. This new limit will be allowed only when another boiler is down. During all other periods, the 300,000 pound per hour limit would apply. Summarizing the rational for this request:

1. We have operated this boiler at greater than 300,000 pounds per hour in the past. The last three years of stack testing were conducted at an average of 321,000 pounds per hour. The requested limit does not represent an increase in capacity. A small spreadsheet summarizing the past three years of stack testing is attached, as is additional information.
2. An evaluation of the overfire air system operation (OFA) was attached to the October comment memo. The manufacturer believes that the boiler and the OFA system can function correctly at 330,000 #/hr.
3. Operating with only three boilers is an unusual condition. It generally results in lower production and lower mill wide emissions. Allowing the boiler to operate at a higher production during these periods will have no appreciable impact on emissions as compared to normal operation.
4. We are requesting the lower of 330,000 pounds per hour, or the steaming rate at which we can demonstrate compliance. This provides reasonable assurance of compliance.

Smurfit-Stone Container Corporation
1 Everitt Avenue 32401 P.O. Box 59560 32412-0560 Panama City, FL Phone (850) 785-4311 Fax (850) 763-6290

The permit requires two "pre-construction" items. These are the Computational Fluid Dynamics (CFD) modeling and a summary of the proposed changes. The CFD report is attached. The proposed changes were included in the permit application, and have not been modified as a result of the modeling. Additional information on the changes is also in the CFD report.

Please call Tom Clements at (850) 785-4311 x470 if you have additional questions.

Sincerely

Bobby G. Sammons
General Manager

Shared/IBM/#4 BB permit reply Nov05

Smurfit-Stone Container Corp. Pamama City Mill					
#4 Bark Boiler Stack Test Results					
Date	**Steam flow**	**Particulate**	**SO2**	**TRS**	**VE**
	klbs/hr	**lbs/mmbtu**	**#/hr**	**ppm**	**%**
10/22/2003	317	0.06	2	0.7	12.1
10/8/2004	322	0.05	17	0.01	13.7
10/12/2005*	324	0.04	360	0.8	<15
Limit =	**N/A**	**0.2**	**781**	**5**	**30**
*= preliminary					

11/2/05

2005 Stack Testing Notes

The figures given are preliminary and could change a small amount.

The #4 Combination Boiler was tested on October 12, from approximately 0930 to 1805 hours. The steam flow of 324,000 #/hr was an average across this period.

Individual test results are not yet available. These will be included in the final report, which is expected to be issued by the second week in November. This report will also include the exact test times per run.

The testing service used was ESS of 18631-H Northline Dr., Cornelius, NC, 28031
Phone: (704) 892-4405

The ESS lead tester was Robert Hamlin. The ESS account manager for the mill is Bill Kissel. The mill support team for the testing was T. Clements, L. Thomas, and M. Groome.

SUMMARY OF SMURFIT STONE ON-SITE EMISSION ESTIMATES
OCTOBER 10 - 13, 2005

EMISSION SOURCE	EMISSION LIMIT	POLLUTANT
RECOVERY BOILER	0.044 gr/dscf @ 8% O2	PARTICULATE MATTER
	17.5 ppm @ 8% O2	TRS
	35%	VE
No. 3 BARK BOILER	0.3 lbs/MMBtu BARK	PARTICULATE MATTER
	0.1 lbs/MMBtu OTHER FUELS	PARTICUALTE MATTER
	109.5 lbs/hr	PARTICUALTE MATTER
	887 lbs/hr	SO2
	5 ppm @ 10% O2	TRS
	30%	VE
No. 4 BARK BOILER	0.3 lbs/MMBtu BARK	PARTICULATE MATTER
	0.1 lbs/MMBtu OTHER FUELS	PARTICUALTE MATTER
	86.7 lbs/hr	PARTICUALTE MATTER
	781 lbs/hr WITH NCGs	SO2
	772 lbs/hr WITHOUT NCGs	SO2
	5 ppm @ 10% O2	TRS
	30%	VE
SDTV	0.2 lbs/ton BLS	PARTICUALTE MATTER
	0.048 lbs/3000 lbs BLS	TRS
	20%	VE
LIME KILN	29.83 lbs/hr	PARTICULATE MATTER
	20 ppm @ 10% O2	TRS
	20%	VE
SLAKER	14 lbs/hr	PARTICULATE MATTER
	20%	VE

No. 1SDTV	PM=0.11 lb/tbls	
	TRS= 0.02 lb/3000 lbs BLS	
No. 1A RB	PM=0.004 gr/dscf @ 8% O2	
No. 1B RB	PM=0.002 gr/dscf @ 8% O2	
No. 2A RB	PM=0.005 gr/dscf @ 8% O2	
No. 2B RB	PM=0.006 gr/dscf @ 8% O2	
No. 3 CB	PM=0.063 lb/mmbtu	(Allowable ~ 0.2 lb/mmbtu)
	PM= 41 lbs/hr	
	SO2 = 399 lbs/hr	
	TRS= 1 ppm @ 10% O2	
No. 4 CB	PM= 0.040 lb/mmbtu	(Allowable ~ 0.2 lb/mmbtu)

	PM= 31 lbs/hr SO2 = 360 lbs/hr TRS= 0.8 ppm @ 10% O2
No. 2SDTV	PM= 0.12 lb/tbls TRS= 0.03 lb/3000 lbs BLS
Lime Kiln	PM= 13 lbs/hr TRS= 8 ppm @ 10% O2
Slaker	PM= 1.0 lb/hr

"All VE's of units monitored have been well below the VE limits"

CORRECTED

SMURFIT STONE PANAMA CITY
STACK TEST FLOWRATE DATA
OCTOBER 10-13, 2005

SOURCE	FLOW (ACFM)	FLOW (DSCFM)	FLOW (SCFM)	OXYGEN (%)	TEMP (F)	H2O (%)
COMBO BOILER 3	225,000	151,000	199,472	6.8	139	24.3
COMBO BOILER 4	261,000	180,000	230,769	6.3	141	22.0
LIME KILN	48,590	26,385	41,034	7.6	164	35.7
SLAKER	9,482	5,335	8,023	AMBIENT	164	33.5
NO. 1 SDTV	47,070	29,794	40,371	AMBIENT	156	26.2
NO. 2 SDTV	46,123	28,780	40,028	AMBIENT	152	28.1
NO.1A RECOVERY	157,000	78,606	111,182	5.8	288	29.3
NO. 1B RECOVERY	158,000	79,667	114,960	5.7	268	30.7
NO. 2A RECOVERY	163,000	76,518	111,705	5.9	310	31.5
NO. 2B RECOVERY	175,000	77,145	114,799	7.1	346	32.8

comp

SMURFIT-STONE CONTAINER CORPORATION
NO. 4 BARK BOILER STACK EMISSIONS TEST LOG

DATE: 10-12-05

TEST: ☑ TRS ☑ PARTICULATE

TESTERS: Bob Hamlin

OPERATOR:

comp

TIME	BARK (MMBTU)	FUEL OIL (MMBTU)	COAL (MMBTU)	NATURAL GAS (MMBTU)	TOTAL (MMBTU)	SCRUBBER FLOW (GPM)	SCRUBBER pH	NCG IN/OUT	REMARKS
9:30	75	71	275	43	430	1094	6.9	out	
10:00	103	70	246	43	470	1096	7.0	out	
10:30	95	70	247	40	456	1094	7.0	out	
11:00	99	69	247	38	459	1097	7.0	out	
11:30	97	69	248	37	454	1090	7.0	out	
12:00	96	69	248	40	452	1093	6.9	out	
12:30	95	69	248	40	453	1088	7.0	out	12:55 NCG in #4BB
1:00	93	69	248	40	454	1090	8.6	IN	
1:30	96	69	248	40	458	1089	8.5	IN	
2:00	98	69	248	40	460	1090	8.5	IN	1:55 - Particulates Finished
3:00	100	69	248	40	462	1091	6.7	out	2:06 - NCG out #4 BB
4:00	98	69	248	40	460	1086	6.9	out	
5:00	97	69	248	40	460	1098	6.9	out	
6:00	92	69	248	40	455	1099	7.0	out	
7:00	93	70	248	40	456	1121	7.0	OUT	
8:00	97	70	248	40	459	1124	7.0	OUT	8⁰⁰ pm Stack Test Completed
9:00									

NOTE: TAKE READINGS EVERY 30 MINUTES ON PARTICULATES AND EVERY HOUR ON TRS.

TESTING LIMITS:	TOTAL MMBTU	PERMIT LIMITS:			MIN. LIMITS:	SCRUBBER FLOW
MINIMUM (90%)	491		BARK	474 MMBTU		1096 GPM
TARGET (95%)	518		OIL	472 MMBTU		
PERMIT MAXIMUM (100%)	545		COAL	395 MMBTU		
			GAS	512 MMBTU		
			3&4 BB BARK	501 MMBTU		

Rev. 10/23/02

ESS

ENVIRONMENTAL SOURCE SAMPLERS, INC. — AIR QUALITY CONSULTANTS

SMURFIT-STONE CONTAINER CORPORATION
PANAMA CITY, FLORIDA
PARTICULATE MATTER, SO2, TRS AND VISIBLE EMISSIONS TEST REPORT
COMBO BOILER NO. 4
OCTOBER 8, 2004

Prepared for:
Smurfit-Stone Container Corporation
Panama City, Florida

Prepared by:
Environmental Source Samplers, Inc.
Cornelius, North Carolina

18631-H Northline Drive • Cornelius, NC 28031
Phone 704.892.4405 • Fax 704.892.8127
environmentalsourcesamplers.com

1.0 INTRODUCTION

On October 8, 2004, Environmental Source Samplers, Inc. (ESS) conducted particulate emissions testing for the Smurfit-Stone Container Corporation's mill located in Panama City, Florida. Particulate emissions testing was performed on the stack associated with Combo Boiler No. 4.

A series of three (3) particulate test runs was performed on the stack associated with Combo Boiler No. 4. Particulate emissions sampling was performed as outlined in EPA Method 5. EPA Methods 1-4 were used in support of EPA Method 5.

A series of three (3) TRS test runs were also performed on the stack associated with Combo Boiler No. 4. TRS sampling was performed as outlined in EPA Method 16A.

A series of three (3) SO2 test runs were also performed on the stack associated with Combo Boiler No. 4 in combination with each EPA Method 5 test. SO2 sampling was performed as outlined in EPA Methods 5 and 6.

In addition, ESS conducted visible emission observations simultaneously with each EPA Method 5 PM emission test run in accordance with the procedures outlined in EPA Method 9.

The purpose of the testing was to determine the units' ability to meet particulate, SO2 and TRS emission limits included in the Facility's Air Permit.

Personnel present during the test series included:

Mr. Tom Clements, Smurfit-Stone Container Corporation
Mr. Charlie Garner, Environmental Source Samplers
Mr. Rusty Caton, Environmental Source Samplers
Mr. Matt Graham, Environmental Source Samplers
Mr. Ray Bean, Environmental Source Samplers
Mr. James Burgin, Environmental Source Samplers
Mr. John DeMarinis, Environmental Source Samplers

2.0 SUMMARY AND DISCUSSION OF RESULTS

The test results are summarized on the following pages. Field data sheets are included in Appendix A; calculations in Appendix B; operational data in Appendix C; laboratory data in Appendix D; and calibration data in Appendix E.

The test results and the allowable emission rates are summarized below:

PARTICULATE EMISSIONS SUMMARY

SOURCE	MEASURED
COMBO BOILER NO. 4	38.077 LBS/HR
COMBO BOILER NO. 4	0.0239 GR/DSCF
COMBO BOILER NO. 4	0.0483 LBS/MMBTU

VISIBLE EMISSIONS SUMMARY

SOURCE	MEASURED
COMBO BOILER NO. 4	13.73 %

TRS EMISSIONS SUMMARY

SOURCE	MEASURED
COMBO BOILER NO. 4	0.0153 LBS/HR
COMBO BOILER NO. 4	0.0153 PPM
COMBO BOILER NO. 4	0.0119 PPM@10%O2

SO2 EMISSIONS SUMMARY

SOURCE	MEASURED
COMBO BOILER NO. 4	16.53 LBS/HR

Smurfit-Stone Container Panama City
Bark Boiler 4
8-Oct-04
12:06 PM - 13:15 PM

MIN	0	15	30	45
1	15	15	15	15
2	15	25	20	20
3	20	20	15	15
4	15	15	15	15
5	15	15	15	15
6	15	15	15	15

6 Minute Avg 16.25

MIN	0	15	30	45
7	15	15	15	15
8	15	15	15	15
9	20	20	15	15
10	15	15	15	15
11	15	15	15	15
12	15	25	25	25

6 Minute Avg 16.66667

MIN	0	15	30	45
13	20	20	15	15
14	15	15	15	15
15	15	15	15	15
16	15	15	15	15
17	15	15	15	15
18	15	15	15	15

6 Minute Avg 15.41667

MIN	0	15	30	45
19	15	15	15	15
20	15	15	15	15
21	15	15	15	15
22	15	15	15	15
23	15	15	15	15
24	15	15	15	15

6 Minute Avg 15

MIN	0	15	30	45
25	15	15	20	20
26	20	20	20	20
27	20	20	20	20
28	20	20	20	20
29	20	20	20	20
30	20	20	20	20

6 Minute Avg 19.58333

MIN	0	15	30	45
31	20	20	20	20
32	20	20	20	20
33	15	20	15	15
34	20	20	15	15
35	15	15	15	15
36	15	15	15	20

6 Minute Avg 17.5

MIN	0	15	30	45
37	20	20	15	20
38	10	10	10	10
39	10	10	10	10
40	10	10	10	10
41	10	10	10	10
42	10	10	10	10

6 Minute Avg 11.45833

MIN	0	15	30	45
43	10	10	10	10
44	10	10	10	10
45	10	10	10	10
46	10	10	10	10
47	10	10	10	10
48	10	10	10	10

6 Minute Avg 10

MIN	0	15	30	45
49	10	10	10	10
50	10	10	10	10
51	10	10	10	10
52	10	10	10	10
53	10	10	10	10
54	10	10	10	10

6 Minute Avg 10

MIN	0	15	30	45
55	10	10	10	10
56	10	10	10	10
57	10	10	10	10
58	10	10	10	10
59	10	10	10	10
60	10	10	10	10

6 Minute Avg 10

SMURFIT-STONE PANAMA CITY
COMBO 4 TRS TEST SUMMARY

TITRATION	1A	1B	2A	2B	3A	3B
SAMPLE VOLUME (MLS)	50	50	50	50	50	50
ALIQUOT VOLUME (MLS)	10	10	10	10	10	10
BARIUM PERCHLORATE (MLS)	0.01	0.01	0.01	0.01	0.01	0.01
AVG TITRATION (MLS)	0.01		0.01		0.01	
BLANK TITRATION (MLS)	0.01		0.01		0.01	
METER START (CM)	39.3455		39.6966		40.0497	
METER STOP (CM)	39.6905		40.0455		40.3917	
METER VOLUME (CF)	12.182		12.320		12.076	
METER CORRECTION FACTOR	1.0160		1.0160		1.0160	
BAR. PRESSURE (IN. HG)	30.04		30.04		30.04	
AVG METER TEMP (F)	74.66		78.80		75.38	
AVG METER TEMP (C)	23.70		26.00		24.10	
CORRECTED VOL (DSCF)	12.274		12.317		12.151	
BARIUM PERCHLORATE NORMALITY	0.0128		0.0128		0.0128	
TRS AS SO2 (PPM)	0.015		0.015		0.016	
TRS AS SO2 (10-4 LB/DSCF)	0.0000		0.0000		0.0000	
FLOWRATE (DSCFM)*	186,000		186,000		186,000	
TRS AS H2S (LB/HR)	0.0153		0.0152		0.0154	

*AVERAGE FLOWRATE FROM M5-PM EMISSION TEST RUNS USED

Run 1 - 1000 - 1300

2 - 1300 - 1600

3 - 1610 - 1910

SMURFIT STONE CONTAINER
PANAMA CITY MILL
SO2 EMISSIONS SUMMARY

COMBO BOILER NO. 4

RUN NO.	CATCH WEIGHT (mg)	ALIQUOT RATIO	TOTAL CATCH WEIGHT (mg)	SAMPLE VOL (DSCF)	GRAMS/LB	FLOWRATE (dscfm)	MIN/HR	SO2 (lbs/hr)
1	36.5	2	73.00	38.25	453.5927	188000.00	60	47.46074
2	0.8	2	1.60	38.03	453.5927	189000.00	60	1.049189
3	0.8	2	1.60	36.18	453.5927	183000.00	60	1.067826
AVERAGE	**12.7**		**25.40**	**37.49**		**186667**		**16.53**

Run 1 - 1305 - 1335

2 - 1610 - 1640

3 - 1915 - 1945

SMURFIT STONE
COMBO BLR NO. 4
PARTICULATE EMISSIONS TEST SUMMARY

RUN #	1	2	3	AVG
DATE	10/8/04	10/8/04	10/8/04	
TIME START (EST)	1255	1416	1538	
TIME COMPLETE (EST)	1359	1519	1642	
FLUE GAS TEMP (F)	144.0	145.0	145.3	144.8
FLUE GAS VELOCITY (FPS)	92.89	93.05	93.11	93.02
FLUE GAS FLOWRATE (MM ACFM)	0.271	0.272	0.272	0.272
FLUE GAS FLOWRATE (MM DSCFM)	0.188	0.189	0.183	0.186
VOL OF GAS SAMPLES (DSCF)	38.25	38.03	36.18	37.49
MOISTURE (%)	21.4	21.0	23.3	21.9
ISOKINETIC SAMPLE RATE (%)	93.6	92.6	90.7	92.3
BAROMETRIC PRESSURE (IN HG)	30.04	30.04	30.04	30.04
STACK PRESSURE (IN HG)	30.10	30.10	30.10	30.10
OXYGEN (%)	7.5	6.6	6.5	6.9
CARBON DIOXIDE (%)	12.0	12.4	12.6	12.3
CARBON MONOXIDE (%)	0.0	0.0	0.0	0.0
NITROGEN (%)	80.5	81.0	80.9	80.8
MOLECULAR WEIGHT OF GAS(MOLES)	27.73	27.80	27.54	27.69
PARTICULATE (GR/DSCF)	0.0163	0.0178	0.0377	0.0239
PARTICULATE (LBS/HR)	26.229	28.791	59.212	38.077
PARTICULATE (LBS/MMBTU)	0.0347	0.0355	0.0747	0.0483

SMURFIT-STONE CONTAINER CORPORATION
NO. 4 BARK BOILER STACK EMISSIONS TEST LOG

DATE: 10-8-04

TEST: ✓ TRS ✓ PARTICULATE

TESTERS: CHARlie
OPERATOR: Charlie Scott

TIME	BARK (MMBTU)	FUEL OIL (MMBTU)	COAL (MMBTU)	NATURAL GAS (MMBTU)	TOTAL (MMBTU)	SCRUBBER FLOW (GPM)	SCRUBBER pH	NCG IN/OUT	REMARKS
10:00 AM	78.22	112.07	196.26	40.0	460.21	1121	7.0	out	
10:30 AM	86.88	93.35	236.57	40.0	461.30	1118	7.0	out	
11:00 AM	92.30	70.67	244.94	40.0	452.36	1123	7.0	out	
11:30 AM	93.13	70.22	244.94	40.0	452.78	1121	7.0	out	
12:00 NOON	93.96	73.87	244.93	40.0	452.27	1120	6.9	out	
12:30 Pm	86.83	71.87	244.93	40.0	448.11	1130	8.9	out	NCG IN 12:50 p
1:00 Pm	82.25	69.62	244.93	40.0	446.27	1133	9.8	IN	
1:30 Pm	97.71	66.48	244.94	40.0	453.62	1134	8.7	IN	
2:00 Pm	104.39	66.76	244.94	40.0	460.58	1137	8.5	IN	
2:30 Pm	99.54	66.55	244.93	40.0	455.48	1138	9.2	IN	
3:00 PM	95.33	66.52	244.98	40.0	451.20	1185	8.2	IN	
3:30 PM	93.71	66.69	248.22	40.0	458.97	1104	8.1	IN	
4:00 PM	94.19	66.34	255.18	40.0	460.71	1104	8.6	IN	
4:30 PM	89.57	66.17	263.28	40.0	463.51	1104	8.2	IN	
5:00 PM	92.54	66.67	266.61	40.0	469.21	1104	8.0	IN	
5:30 PM	92.97	65.38	265.23	40.0	467.95	1105	9.1	IN	
6:30 PM	87.18	65.05	269.89	40.0	466.59	1106	10.0	IN	Testing finished 7:10 PM
7:30 PM									

91.60 73.29 246.4 40

NOTE: TAKE READINGS EVERY 30 MINUTES ON PARTICULATES AND EVERY HOUR ON TRS.

TESTING LIMITS:	TOTAL MMBTU	PERMIT LIMITS:			MIN. LIMITS:	SCRUBBER FLOW
MINIMUM (90%)	491		BARK	474 MMBTU		1096 GPM
TARGET (95%)	518		OIL	472 MMBTU		
PERMIT MAXIMUM (100%)	545		COAL	395 MMBTU		
			GAS	512 MMBTU		
			3&4 BB BARK	501 MMBTU		

Work Order No. 03939.009.001

No. 3 and No. 4 Bark Boilers
Compliance Test Report
Smurfit-Stone Container Corporation
Panama City, Florida
22-23 October 2003

Prepared For

SMURFIT-STONE CONTAINER CORPORATION
1 Everett Avenue
Panama City, Florida 32412-0560

Wayne Roberts
Project Manager
Approved for Transmittal

Joseph E. Oven, P.E.
Report Review
Approved for Transmittal

Prepared By

WESTON SOLUTIONS, INC.
1625 Pumphrey Ave.
Auburn, Alabama 36832-4303
Phone: (334) 466-5600 Fax: (334) 466-5660

1 December 2003

SECTION 1
INTRODUCTION

Weston Solutions, Inc. (WESTON®) was retained by Smurfit-Stone Container Corporation (Smurfit-Stone) to conduct particulate matter (PM), sulfur dioxide (SO_2), total reduced sulfur (TRS), and visible emission (VE) testing on the Nos. 3 and 4 Bark Boilers at the mill in Panama City, Florida. The purpose of the testing was to demonstrate compliance with Florida Department of Environmental Protection (FDEP) permit limits.

WESTON performed the emission testing during 22-23 October 2003. The project team was comprised of the following individuals.

Name	Project Role
Wayne Roberts	Project Manager/Test Team Leader
Gary Lloyd	Technical Director/Test Team Member
Jon Howard	Quality Assurance Manager
Landie Fowler	Test Team Member
Paul Green	Test Team Member
Temp Simpkins	Test Team Member
Wayne Childress	Test Team Member
Curtis Cotney	Test Team Member
Cory Landers	Test Team Member
Natalie Hornsby	Report Coordinator

Mr. Tom Clements of Smurfit-Stone coordinated the testing with mill operations and served as WESTON's technical contact throughout the effort. Mr. Richard Brookins of FDEP was present during a portion of the testing.

SECTION 2
RESULTS AND DISCUSSION

Table 2-1 presents the mean results of the emission testing with comparison to the permit limits. The results are less than the applicable standards for each source.

TABLE 2-1
SUMMARY OF EMISSION TEST RESULTS

	Mean Test Value	Permit Limit
No. 3 Bark Boiler		
Particulate Matter, lb/hr	47	109.5
Particulate Matter, lb/MMBtu	0.10	0.3
Sulfur Dioxide, lb/hr	122	485
Total Reduced Sulfur, ppm @ 10% O_2	0.56	5.0
Visible Emissions, %	14.6	30
No. 4 Bark Boiler		
Particulate Matter, lb/hr	26	86.7
Particulate Matter, lb/MMBtu	0.058	0.3
Sulfur Dioxide, lb/hr	<1.7	781
Total Reduced Sulfur, ppm @ 10% O_2	0.67	5.0
Visible Emissions, %	12.1	30

Tables 2-2 through 2-5 provide detailed summaries of the emission results. Any differences between the calculated results presented in the appendices and the results reported in the summary tables are due to rounding for presentation.

TABLE 2-4
NO. 4 BARK BOILER DETAILED
SUMMARY OF PM, SO_2, AND VE EMISSION RESULTS

	Run 1	Run 2	Run 3	Mean
Date	10/22/03	10/22/03	10/22/03	----
Time Began	1106	1339	1517	----
Time Ended	1211	1444	1620	----
Stack Gas Data				
Temperature, °F	145	144	144	144
Velocity, ft/sec	85	87	88	87
Moisture, %	21	21	21	21
CO_2 Concentration. %	15.1	15.1	15.4	15.2
O_2 Concentration, %	6.4	6.4	6.6	6.5
VFR, x 10^5 dscfm	1.70	1.73	1.75	1.73
Particulate Matter				
Isokinetic Sampling Rate, %	103	106	105	105
Concentration, gr/dscf	0.018	0.019	0.017	0.018
Emission Rate, lb/hr	26	28	25	26
Permit Limit, lb/hr	----	----	----	86.7
Emission Factor, lb/MMBtu	0.058	0.062	0.055	0.058
Permit Limit. lb/MMBtu	----	----	----	0.3
Sulfur Dioxide				
Concentration, ppm	<1.0	<1.0	<1.0	<1.0
Emission Rate, lb/hr	<1.7	<1.7	<1.7	<1.7
Permit Limit, lb/hr	----	----	----	781
Visible Emissions[a]				
Mean Opacity %	----	----	----	12.1
Permit Limit %	----	----	----	30.0

[a] The VE observations were made from 1125 to 1225.

Preliminary source evaluation determined that the Slaker exhibited cyclonic flow characteristics. At the direction of Smurfit-Stone, the PM testing was conducted without alignment correction at each traverse point. This approach was consistent with testing performed for previous tests.

TABLE 2-5
NO. 4 BARK BOILER DETAILED SUMMARY OF TRS EMISSION RESULTS

	Run 1	Run 2	Run 3	Mean
Date	10/22/03	10/22/03	10/22/03	----
Time Began	1100	1452	1814	----
Time Ended	1400	1753	2114	----
Stack Gas Data				
O_2 Concentration, %	6.3	6.4	6.5	6.4
Total Reduced Sulfur				
Concentration, ppm	0.74	1.11	0.82	0.89
Concentration, ppm @ 10% O_2	0.55	0.83	0.62	0.67
Permit Limit, ppm @ 10% O_2	----	----	----	5.0

SECTION 3
SOURCE TESTING METHODOLOGY

The emission testing program was conducted in accordance with the U.S. EPA Reference Methods summarized in Table 3-1. Method descriptions and quality assurance data are provided in the referenced appendices.

TABLE 3-1
SOURCE TESTING METHODOLOGY

Parameter	Method Number	Appendix Reference		Comments
		Method Description	Quality Control Data	
Volumetric Flow Rate	1,2,3,4	B.1	E	Note 1
Particulate Matter	5	B.2	E	Note 1
Sulfur Dioxide	6C	B.3	E	Note 2
Visible Emissions	9	B.4	E	Note 3
Total Reduced Sulfur	16	B.5	E	

Note 1: Both the No. 3 and No. 4 Boilers were determined to be cyclonic.

Note 2: Sulfur dioxide interference studies for the Bover Western Research Analyzer used for analysis on Bark Boiler systems are on file at WESTON's Auburn, Alabama office.

Note 3: On the day of testing there was little/no wind, which allowed the tester to differentiate the plumes from the CO-located stacks.

SMURFIT-STONE CONTAINER CORPORATION
NO. 4 BARK BOILER STACK EMISSIONS TEST LOG

DATE: 10-22-03

TEST: ☑ TRS ☑ PARTICULATE

TESTERS:

OPERATOR: Dewberry/Green

Hourly - Pg. 6

TIME	BARK (MMBTU)	FUEL OIL (MMBTU)	COAL (MMBTU)	NATURAL GAS (MMBTU)	TOTAL (MMBTU)	SCRUBBER FLOW (GPM)	SCRUBBER pH	NCG IN/OUT	REMARKS
11^{30}	97	41	286	36	447	1113	9.0	iN	
12^{00}	95	41	286	40	453	1115	9.0	iN	1ST RUN FiNished At 12^{12}
12^{30}	90	40	286	40	454	1118	9.1	iN	
1^{00}	93	40	286	40	457	1129	9.0	iN	
1^{30}	97	40	286	40	460	1122	9.0	iN	2ND RUN STARTED AT 1^{38}
2^{00}	83	40	286	40	450	1122	9.1	iN	1ST 3HR TRS TEST FiNished — 2^{06}
2^{30}	84	39	284	40	452	1122	8.8	iN	2ND RUN TRS STARTED 2^{57}
3^{00}	96	39	286	40	457	1119	9.0	iN	3RD RUN PARTICULATE + TRS START - 3^{12}
3^{30}	90	40	286	40	450	1125	9.0	iN	3RD RUN PART + TRS Finished - 4^{22}
4^{00}	80	40	286	40	457	1116	9.0	iN	
4^{30}	89	40	286	40	457	1125	8.9	iN	
5^{00}	84	39	286	40	452	1119	9.0	iN	
5^{30}	87	39	286	40	453	1120	9.0	iN	
6^{00}	91	39	284	40	462	1120	9.1	iN	
6^{30}	88	39	284	40	456	1125	9.0	iN	
7^{00}	87	39	286	40	457	1124	9.0	iN	
7^{30}	87	39	286	40	455	1125	9.2	iN	
8^{00}	92	39	286	40	459	1122	9.1	iN	

NOTE: TAKE READINGS EVERY 30 MINUTES ON PARTICULATES AND EVERY HOUR ON TRS.

TESTING LIMITS:	TOTAL MMBTU	PERMIT LIMITS:		MIN. LIMITS:	SCRUBBER FLOW
MINIMUM (90%)	491	BARK	474 MMBTU		1096 GPM
TARGET (95%)	518	OIL	472 MMBTU		
PERMIT MAXIMUM (100%)	545	COAL	395 MMBTU		
		GAS	512 MMBTU		
		3&4 BB BARK	501 MMBTU		

SMURFIT-STONE CONTAINER CORPORATION
NO. 4 BARK BOILER STACK EMISSIONS TEST LOG

DATE: 10-22-03

TEST: ☒ TRS ☒ PARTICULATE

TESTERS:

OPERATOR: GREEN

Hourly - Pg. 6

TIME	BARK (MMBTU)	FUEL OIL (MMBTU)	COAL (MMBTU)	NATURAL GAS (MMBTU)	TOTAL (MMBTU)	SCRUBBER FLOW (GPM)	SCRUBBER pH	NEG IN/OUT	REMARKS
8:30pm	88	40	286	40	458	1128	9.1	iN	
9:00pm	87	39	286	40	455	1121	9.1	iN	
9:30pm	91	39	286	40	457	1122	9.0	iN	
10:00pm	88	39	286	40	455	1100	9.0	iN	

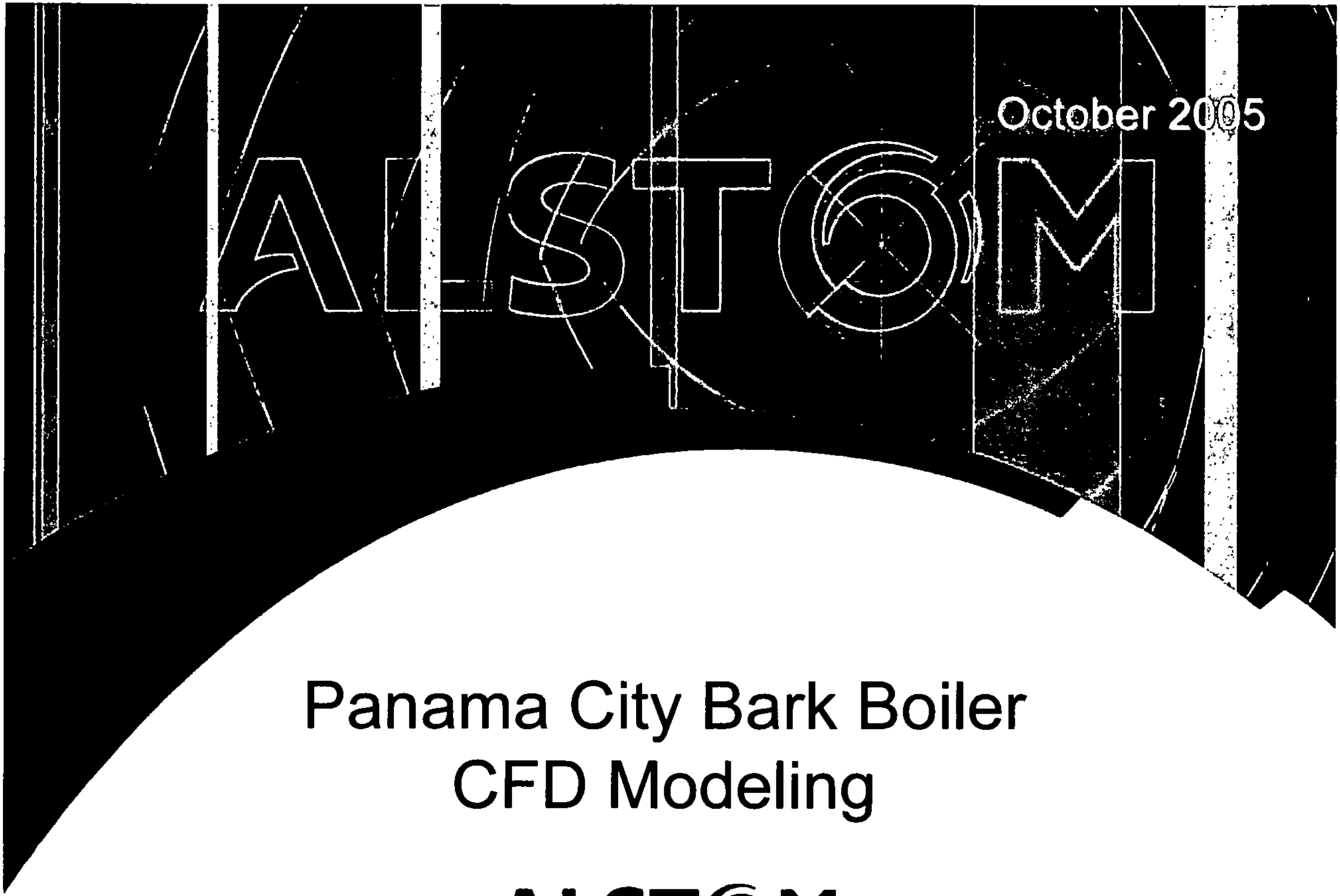
NOTE: TAKE READINGS EVERY 30 MINUTES ON PARTICULATES AND EVERY HOUR ON TRS.

TESTING LIMITS:	TOTAL MMBTU
MINIMUM (90%)	491
TARGET (95%)	518
PERMIT MAXIMUM (100%)	545

PERMIT LIMITS:	
BARK	474 MMBTU
OIL	472 MMBTU
COAL	395 MMBTU
GAS	512 MMBTU
3&4 BB BARK	501 MMBTU

MIN. LIMITS:	SCRUBBER FLOW
	1096 GPM

F-4



October 2005

Panama City Bark Boiler CFD Modeling

ALSTOM

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Technical Report

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Summary: A vintage CE-type power boiler at Smurfit Stone – Panama City FL is being retrofit with a new air system. A CFD study was performed in conjunction with that project to evaluate the new air system relative to the current system. These CFD results suggest that, at the same fuel firing rate, the proposed HMZ air system yields improved performance with lower superheater inlet temperatures, lower CO levels and less unburned carbon. At the tested load point, CO levels at the same bark and total airflow decreased from 1430 to 575 PPM, and the backpass carbon loss decreased from 3.4% to 1.7%. CO and Carbon Loss also dropped significantly, 986 ppm and 1.6% respectively, at lower excess air levels. The improvement was achieved by the combination of an HMZ air system and a fabric stoker seal to reduce infiltration. The Model indicates an increase in carbon loss at the higher bark firing rates as would be expected with the increased load conditions. The series of 8 runs described in this report included bark and bark/coal firing with combinations of reduced leakage, higher loads, and lower excess air levels inline with the anticipated design levels for the upgraded boiler .

1.0 INTRODUCTION

Alstom Power is in the process of upgrading the firing system for a vintage CE-type power boiler for Smurfit Stone Container Corp (SSCC) Panama City, Florida mill, unit #4. Planned modifications to boiler #4 include the installation of a new Overfire Air (OFA) system, a fabric stoker seal to reduce infiltration, and other airflow control equipment. As part of this process, CFD was used to examine the proposed Horizontal Mixing Zone (HMZ) OFA design firing bark as well as coal with bark, for a range of loads.

In order to develop a reasonable representation of the current firing conditions to calibrate the CFD baseline cases, field testing was conducted by Alstom during August 2005 to measure all necessary parameters for steam side boiler performance, as well as other inputs necessary for a CFD model such as specific air flow distribution, fuel composition, and outlet gas compositions for both bark and coal/bark firing. Case load conditions for firing bark +coal + oil were not modeled as this operating condition is not expected to result in higher CO and carbon loss emissions. Based on the test data[1], a FLUENT CFD model was calibrated for both bark, and for bark + coal firing conditions. However, the localized grate combustion and entrainment distribution due to localized bark piles and air streams passing around these piles impact entrainment and ultimately carbon carryover. Representing actual grate bed conditions in a CFD model is difficult, therefore, some assumptions were made for the purpose of modeling. These assumptions impact the specific results, hence quantitative results should be treated on a relative basis only.

The CFD runs examined the proposed new HMZ air system for normal and maximum bark load conditions under the anticipated operating conditions. The CFD modeling described in this report includes the geometry, test conditions, results, and modeling approach used, along with predictions and recommendations. Engineering performance calculations for different operating conditions were used to develop the test matrix. While the engineering performance predictions serve as the basis for the commercial guarantees, the CFD modeling provides insight to the 3-D flow, temperature and mixing patterns for the different options. The CFD predicted results are based on extrapolation of the baseline conditions at the mill. These predictions indicate that the new HMZ air system with a stoker fabric seal provides a significant improvement to the furnace, allowing operation at lower excess air levels with reduced carbon loss and CO emissions.

2.0 Modeled Geometry and Test Conditions

2.1 Furnace Geometry

A three-dimensional model of the boiler arrangement shown in **Fig. 1** was generated from original and proposal drawings. The proposed new HMZ air system will include nozzles on the front and rear wall as shown in **Fig. 2**. The HMZ nozzles are arranged in large vs. small configuration so that on the opposite walls, a large nozzle faces a small nozzle on the opposite wall. A small lateral

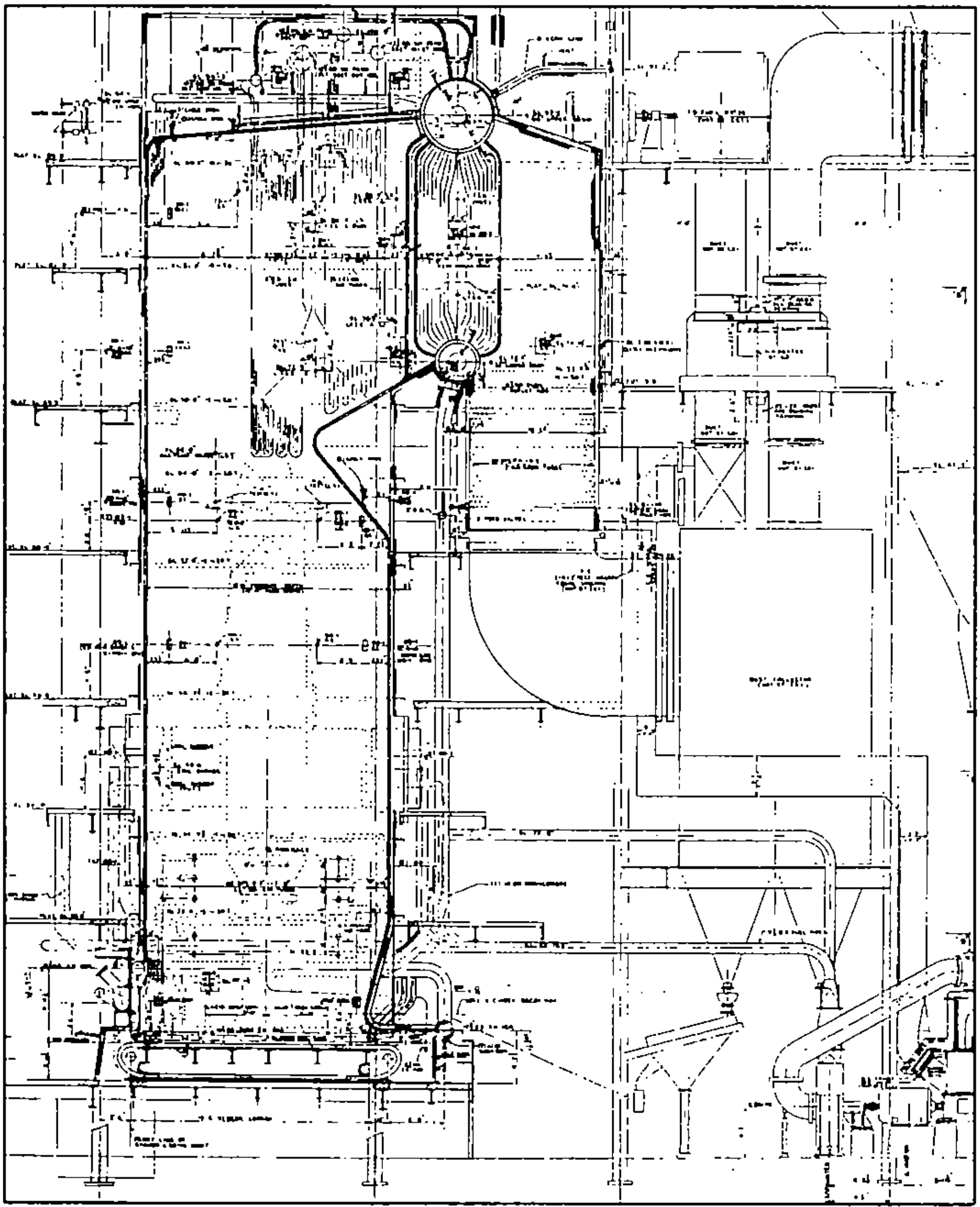


Fig. 1 Side Elevation of Unit #4 at SSCS - Panama City

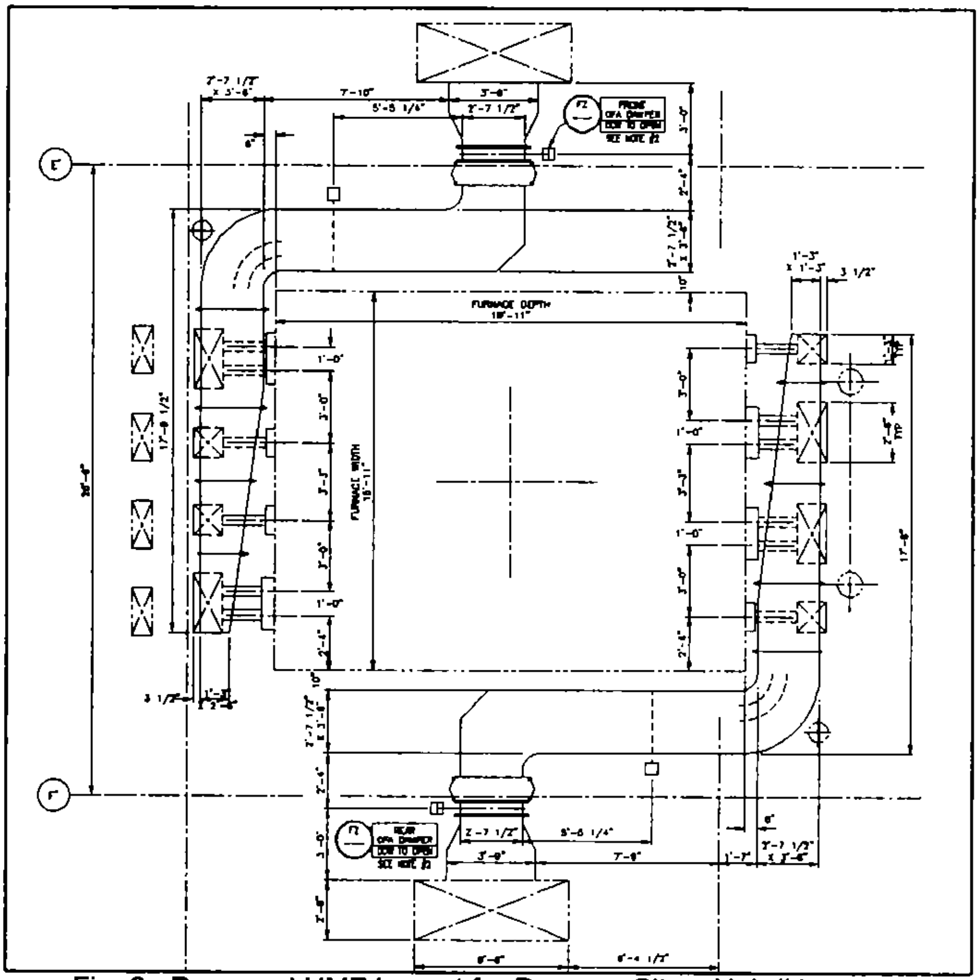


Fig. 2 Proposed HMZ Layout for Panama City – Unit #4.

offset between the nozzle pairs causes increased shear and establishes a preferred trajectory to avoid instability as the jets intersect in the center. This HMZ design concept has been widely applied to ALSTOM boilers of many types. The specific arrangement of the HMZ design is dependent on the boiler size, aspect ratio and other factors. CFD modeling was conducted for this specific arrangement to assist in the performance design evaluation. For this boiler study, the current boiler operation was tested at two firing conditions. The fuel and airflow rates were measured. In combination with the outlet gas sample grid measurements, the CFD model was calibrated with the existing hardware and used to extrapolate performance with the new air system and grate seal. This helps to show that the retrofit design will meet performance targets. The CFD modeling provides useful qualitative 3-D predictions of the flow fields, gas temperatures, and species. The CFD model can be used to screen designs and different operation conditions; however, the CFD predictions are based on extrapolation from the test conditions that may not be fully representative of the new boiler operation.

2.2 Air System Components Modeled

A computational mesh was generated for the Panama City Unit #4 boiler that included components of the current and retrofit air system. The mesh was composed of approximately 750,000 cells, with concentration of the nodes in the lower furnace. The modeled geometry is shown in **Fig. 3**. In addition to the furnace, the model includes a block directly below the stoker that is used in conjunction with a custom heat exchanger model for the grate. This block is used to represent the heating of the undergrate air as it passes through the grate keys based on local combustion and furnace radiation to the grate surface. Other inputs to the furnace model include:

Undergrate air: The total undergrate air is based on process data measurements. Undergrate air was uniformly distributed over the entire surface. In actual operation however, the air will be biased front to rear as necessary.

Stoker Perimeter Leakage: The current stoker is believed to allow a significant amount of infiltration. This leakage into the furnace was provided through a gap between the top of the stoker and the furnace sidewalls. The leakage was uniformly distributed around the stoker for only the baseline runs. For the retrofit cases, the leakage levels are assumed to be much lower. For these cases, the leakage flow was added to the undergrate air in the model. There were no other "holes" in the boiler to allow infiltration.

Bark Distributors: Bark particles were injected through the four compartments. No transport air was used because mechanical distributors spread the bark. The distributors will experience some minor amount of leakage. However for modeling purposes the post-retrofit leakage sources were combined with the undergrate airflow.

Cinder Injection Nozzles: A group of four rear wall cinder injection nozzles were prescribed.

Sidewall OFA Nozzles: There are five levels of sidewall OFA nozzles. The five levels of sidewall tangential air are arranged with an alternating swirl direction. In practice, only five nozzles were found in service – Four nozzles at the middle level and a nozzle at the left front corner of top level. Nozzle stubs were included to allow the nozzle trajectory to be defined by a flow rate at the upstream face. These sidewall OFA nozzles were not in service with the HMZ system active in the model.

HMZ nozzles: The 4 x 4 HMZ nozzles were located on the front and rear walls at an elevation 11 feet above the top of the stoker. The nozzles were arranged such that two individual nozzles were located close together to represent a "large" nozzle. In the model, the constant-velocity dampers that are integral to the OFA design to vary the nozzle area at the furnace plane were represented by selectively turning off portions of the nozzle opening.

Burner/ Coal Windbox: Air to the burner windboxes was provided uniformly to the air compartments with the required direction. With pulverized coal firing, transport air was provided with the coal particles. The flow rates for the primary transport and secondary air were based on the PI-data.

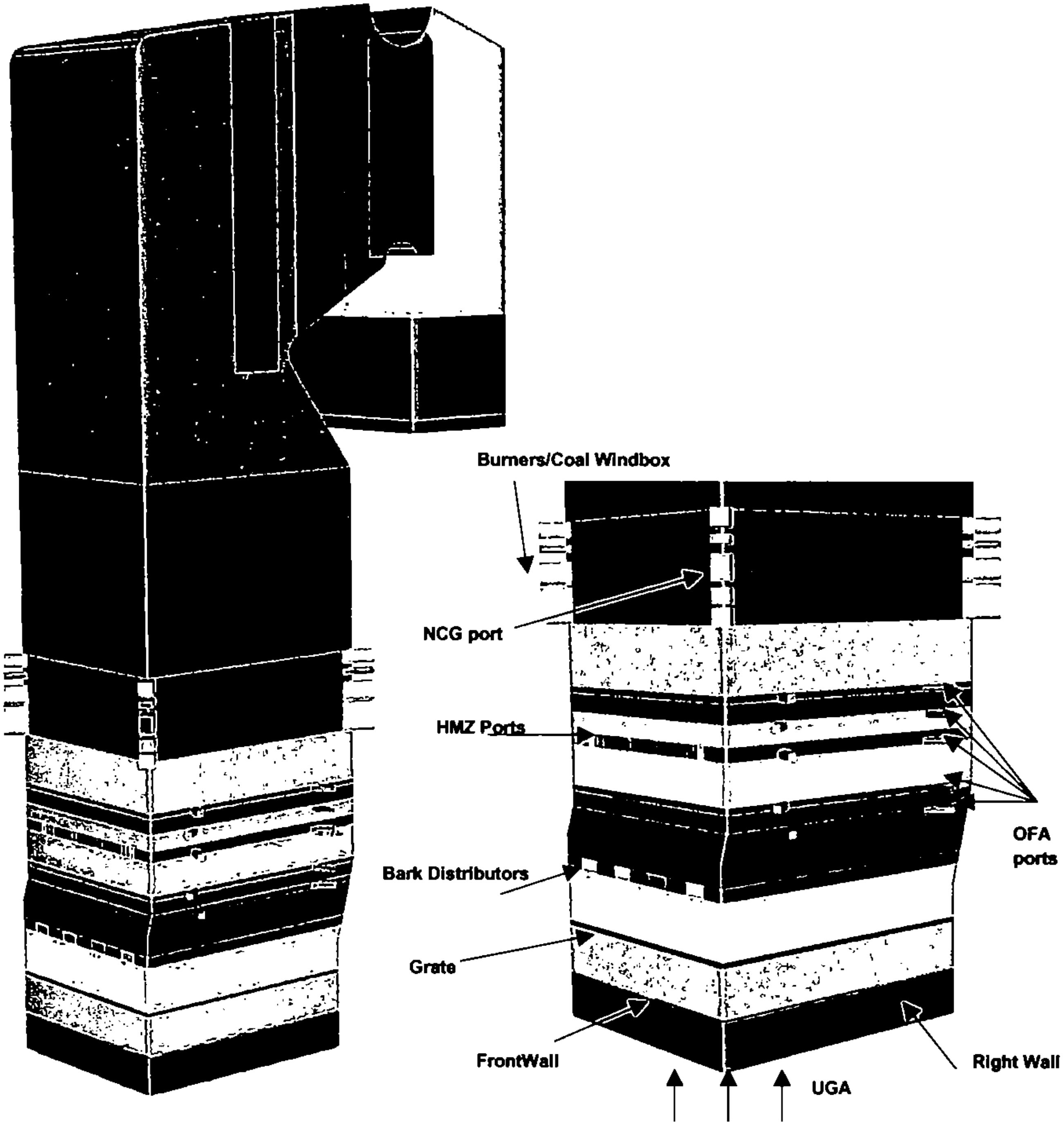


Fig. 3 CFD Model Generated with inlets indicated.

3.2 Matrix and Test Conditions

The objectives of the tests conducted were to calibrate the baseline conditions for both bark and for coal and bark firing, and then extrapolate how the furnace would perform with the new air system and other modifications. The runs are divided between the baseline~~,~~ or existing furnace conditions and the retrofit cases as follows:

3.2.1 Baseline Runs

Two baseline conditions were modeled; bark and coal / bark. Data measurements from the August testing were used to determine the air inputs to the model, along with the net heat input and outlet gas flow. Determination of the total combustion air was based on fuel flow rates and outlet gas O2 levels determined using an economizer-sampling grid. Engineering calculations to measure efficiency also include feedwater flows, steam flows, temperatures and other parameters. These performance engineering calculations were used as a basis for the total combustion airflow rates. Leakage flow rates, or the difference between the total combustion air minus the air to the fans were assumed to be 12% for the baseline case. The leakage flows are difficult to measure. The 2004 outage inspection report indicated several areas of the stoker pier and backstop seal where infiltration was suspected. However these could only be estimated. For the CFD modeling, prescribing where this leakage air actually enters the boiler must be defined. For the baseline runs the 12% leakage airflow of 42,150 lb/hr was admitted through a gap around the perimeter of the stoker. Baseline Case 1 – 100% bark with 45,150 lb/hr of as-fired bark using 354,150 lb/hr of total combustion air for an excess air level of 10.4% O_2. The existing sidewall OFA nozzles were used with five nozzles, four at the middle level, and one additional nozzle from top level on the left front corner. This yields only 5.7% of the combustion air admitted through the sidewall OFA ports, or an OFA/UGA split of 10/90. Consistent with the test conditions, the windbox flow was a substantial 109,000 lb/hr, even with the coal off. The windbox compartment dampers were assumed to be open, and a uniform velocity through the secondary air nozzles was used. The baseline bark test indicated 10.4% O2 at the economizer outlet. The model was set to achieve that level.

For the baseline Case 2 - Bark and Coal , the bark flow was reduced to 26,600 lb/hr, and 22,000 lb/hr coal fired. This CFD run had an O2 level of 3.9% at the economizer outlet, with the total airflow of 388,650 lb/hr. Consistent with coal firing, the burner airflow increased to 168,000 lb/hr.

3.2.2 Retrofit Cases

The upgraded OFA system was modeled in cases 3-8. For the retrofit cases, the existing sidewall OFA nozzles were closed off, and the HMZ nozzles were modeled at design velocities of 230 to 240 ft/second. The objective of Cases 3 and 4 was to model the operation of the boiler as a comparison between the baseline Cases 1 and 2. In essence, runs 3 and 4 have the same steaming conditions and similar air flows as runs 1 and 2, with the exception that the HMZ is installed for runs 3 and 4 with the appropriate OFA/UGA splits. Note that runs 3 and 4 are strictly used for comparison purposes and the boiler is not expected to run under these non-ideal conditions. The objective of runs 5 to 8 was to model the boiler the way it will be operating after the retrofit. For all of the retrofit cases (3-8), the stoker leakage was reduced, because the anticipated tightening up of the stoker/boiler with the seal. Even with the stoker seal, some infiltration into the boiler will occur. Our assumption was to allocate the predicted 5% leakage flow with the undergrate air, since there were no other logical openings to inject this tramp air. This may be valid because infiltration through the stoker hopper may be expected. The retrofit bark cases (3, 5, and 6) also have reduced windbox airflow rates. It was assumed that these flows would be better controlled after the modifications. For a system comparison at high excess air, run 3 was conducted using 10.5% outlet O2 level. It may be more relevant to examine the bark runs (5 and 6) which were run with fuel and air rate equivalent to 6% O2 on a dry basis, presuming the boiler will be able to run with less air and achieve higher efficiency. Case 4 is similar to the conditions of case 2, which was tested at lower than 4.0% outlet O_2.

The HMZ nozzle velocities were set to be approximately 230-240 ft/s by adjusting the fraction of the nozzle open. This allows sufficient jet velocities to provide good mixing performance at different loads. Table 1 below lists the fuel firing rates and outlet O_2 levels for the different CFD runs.

Although the Mill intends to fire oil in combination with bark and coal under certain operating conditions, ALSTOM does not deem it necessary to model this condition using CFD. This is due to the fact that firing oil with bark and coal would essentially reduce CO levels as compared with firing bark and coal alone, and would therefore not represent a worst-case scenario.

Table 1: Test Runs

Run	Condition	Bark lb/hr	Coal lb/hr	Outlet O2 %vol (dry)	Comments
1.	Baseline Bark	45,150	OFF	10.4	Calibrate Bark Firing
2.	Base Coal+Bark	26,600	22,000	3.9	Calibrate Bark and Coal Firing
3.	Retrofit Bark	45,150	OFF	10.3	HMZ System to Baseline Comparison
4.	Retro Coal+Bark	26,380	22,000	3.3	HMZ System to Baseline Comparison
5.	Retrofit Bark	45,150	OFF	5.8	HMZ System with Low Excess Air
6.	Max Bark	69,720	OFF	5.9	HMZ with Max Bark
7.	~~Max~~ Bark/Coal	56,770	14,625	3.9	HMZ with ~~max~~-Coal + Bark
8.	~~Max~~ Bark/Coal	65,200	13,720	6.2	HMZ with ~~max~~ Coal and 50% Moisture Bark

Note: All cases were run with 39.5% moisture bark except Case 8 with 50% moisture.

4.0 Results:

4.1 Summary

The inputs for all of the runs and the performance predicted by these CFD runs appear in Table 2. The retrofit case results are related to the calibration of the baseline condition. In order to calibrate the baseline Case 1, tuning of the bark combustion characteristics was necessary. To achieve similar outlet CO levels in the CFD model which were 1,400 PPM of CO at the furnace outlet running at an outlet O2 level of 10.5%, a significant level of suspension burning and carryover appear to have been present. This was confirmed in discussions about the operation during the model tuning phase. Once the CFD model solid combustion parameters were calibrated for the baseline runs, they were unchanged for the retrofit runs. However, the suspension burning and carryover rates could have been higher in the furnace due to non-uniformities on the grate. The CFD model assumed uniform undergrate air distribution and reasonably uniform combustion on the grate.

With the new upgrade air system, the unburned bark carryover levels dropped significantly. It would be determined that with lower predicted carbon loss, the carryover and particulate loading leaving the boiler would also decrease. For example, entrained carbon loss for Case 3 was approximately half of the baseline Case 1. These two cases are equivalent with respect to bark flow and heat input. CO levels were less than half of the baseline case.

With regard to the tabulated emissions, the carbon loss was expressed as both carbon and entrained solid particulate expressed as a fraction of the gross fuel heat input. There were no direct measurements of the current carbon loss to calibrate the model to, but with these settings in the model, a reasonable match to CO levels for both bark and coal+ bark firing was attained. Heat loss associated with the heat content of CO gas was ignored. Carbon loss from particles remaining on the grate and deposited into the stoker front hopper were also ignored, since operators will likely adjust undergrate airflows and bark distributors to minimize such losses.

4.2 Comparison Plots

The flow distribution, lower furnace combustion and improved mixing for the retrofit design are clearly superior to the current operation. To provide a visual comparison of the baseline bark run 1 to the retrofit case with low excess air, case 5, a series of plots are presented in **Figs 4- 8**. An isosurface plot of velocity equal to 50 ft/s appears in **Fig. 4**. This contour level is just above the vertical velocity range inside the furnace, and highlights the penetration of jets with significant momentum and mixing energy. Inside these surfaces, the velocities increase up to the initial injection velocity, or up to 240 ft/s. For the baseline case, only a small zone of coverage by the sidewall jets can be detected. By contrast, the HMZ air jets spread over most of the cross section above the grate. The strong air jets provide turbulent mixing oxygen to the grate combustion zone for increased heat release in the lower furnace.

The vertical velocity distribution is compared in **Fig. 5**. In this figure, the vertical velocity zones in excess of 40 ft/s appear red. The added energy of the HMZ level drives entrainment of combustible gases leaving the stoker toward the front and rear walls. However, the jets also provide aerodynamic blockage, so the zones between the nozzles have velocities greater than the prescribed 40 ft/s level, while at the center the velocities is downward toward the stoker. By contrast, the current OFA system has insufficient impact on the lower furnace mixing, and a plume of velocity in the center remains untouched. The impact of the HMZ system on lower furnace temperatures is dramatic, as shown by the temperature distribution in **Fig. 6**. The mixing of combustibles with the overfire air accelerates the gas phase reactions and heat radiated to the bed compared to the base case, which has temperatures near the stoker that are several hundred degrees cooler. The baseline case has combustion delayed to the upper furnace, due to the suspension burning fraction and air provided by the tangential windboxes. The stratification of gas temperatures near the coal windboxes is due to the low injection velocities prescribed. It was assumed that the 109,000 lb/hr to the windbox was uniformly distributed to the 5 secondary elevations, with a nozzle velocity of 36 ft/s. The wide color range for this plot does not reveal the fact that the horizontal furnace outlet temperatures were 80F lower for the retrofit.

For the gas mixing distribution, the Oxygen distributions are shown in **Fig. 7**. The baseline case has high O2 levels near the grate due to the delayed combustion compared to retrofit case. Even in the upper furnace, the baseline case shows significant oxygen stratification. In the low O2 zones of the baseline case, entrained char particles will likely pass out of the furnace without fully burning, contributing to carbon loss. By contrast, run 4 has much lower O2 levels in the upper furnace, with little variation below the nose. This improves the char burning efficiency and also the CO burnout, as illustrated in **Fig. 8**. A limited range from 0 to 1,000 PPM was used which is appropriate for the upper furnace and backpass zone. In the lower furnace the CO levels are far in excess of the 1,000 PPM range. In the stoker zone the substoichiometric region can have CO levels of several percent CO, or more. A higher range was used for the detailed plots for each case that appear later in this report. In the upper furnace CO levels are significantly lower for run 4 compared to the baseline case.

In addition to the bark comparison illustrated by these figures, the coal and bark comparison is important. Each of the runs is described in more detail after the modeling approach section. The figures for each of these cases are included in a separate PowerPoint file.

The results for the co-fired Cases 2, 4, and 7 are also important, because coal is frequently used at this unit. While increased bark firing may be possible in the future, the performance of the unit with coal as predicted by the CFD model is discussed here briefly. For the baseline Case 2 with coal, it was noted that the upper furnace combustion levels increase dramatically. The impact on the furnace performance with coal is significant. With coal acting as a significant fuel source, the performance improvement contributed by the HMZ bark OFA system change is relatively modest. However the carbon loss for Case 4 did decrease compared to Case 2. In fact, run 4 had the lowest carbon loss of all 8 runs. The combination of higher gas temperatures with coal, with improved mixing to burn the bark lower due to the HMZ and reduced infiltration all contribute to improved combustion. CO levels are significantly lower for all cases where coal is fired.

Table 2. Summary of Inputs and Results

Table 2 Summary of Inputs and Results		*Baseline*		*Retrofit*		*Retrofit, low excess air*			
		bark	bark & coal	bark	bark & coal	bark	max. bark	bark & coal	50% moisture bark & coal
INPUTS:	Case #	1	2	3	4	5	6	7	8
Steam Flow	Lbs/hr	138,000	267,000	138,000	267,000	138,000	221,000	300,000	300,000
Wood Steam Flow	Lbs/hr	138,000	85,000	138,000	84,500	138,000	221,000	180,000	180,000
Coal Steam Flow	Lbs/hr	0	182,000	0	182,500	0	0	120,000	120,000
Bark Fuel Flow	Lbs/hr	45,150	26,600	45,150	26,380	45,150	69,720	56,770	65,200
Bark Moist. Content	% m.c.	39.5	39.5	39.5	39.5	39.5	39.5	39.5	50.0
Coal Fuel Flow	Lbs/hr	0	22,000	0	22,000	0	0	14,625	13,720
Total Combustion Air	Lbs/hr	354,150	388,650	354,150	379,500	252,100	382,420	442,400	439,000
Total Burner Air	Lbs/hr	109,000	168,000	24,000	239,100	24,000	24,000	158,900	171,000
UGA + OFA	Lbs/hr	203,000	179,000	330,150	121,400	228,100	358,420	261,400	246,050
UGA	Lbs/hr	174,670	150,670	144,375	46,530	107,400	138,530	109,530	114,925
OFA	Lbs/hr	20,230	20,230	165,075	66,770	100,000	192,670	143,770	123,025
OFA / UGA split	% / %	10 / 90	10 / 90	50 / 50	55 / 45	44 / 56	55 / 45	55 / 45	50 / 50
Cinder Reinjection Air	Lbs/hr	8,100	8,100	8,100	8,100	8,100	8,100	8,100	8,100
Coal Transport Air	Lbs/hr	0	41,000	0	36,000	0	0	36,000	36,000
Leakage Air	Lbs/hr	42,150	41,650	12,600	19,000	12,600	19,120	22,100	21,950
Gross Heat Input	MBtu/hr	235.9	401.1	235.9	401.1	235.9	369.2	474.7	488.1
Grate Heat Rate	Btu/hr-ft^2	776,650	452,400	776,650	454,100	776,650	1,200,000	976,900	1,012,000
RESULTS:		1	2	3	5	4	6	7	8
CO at exit of ECON	ppm, dry	1,430	270	575	314	986	1,234	500	302
CO at exit of ECON	Lbs/Mbtu	2.05	0.25	0.83	0.28	1.01	1.23	0.44	0.25
O2 at exit of ECON	%, dry	10.4	3.9	10.3	3.3	5.8	5.9	3.9	6.2
O2 at nose of arch	%, dry	10.8	4.6	10.4	3.9	6.0	6.3	4.4	6.8
Avg. Temperature at arch	F	1,670	2,268	1,541	2,219	1,590	1,825	2,134	2,023
Carbon Loss	%	3.4	1.0	1.7	0.3	1.6	4.2	3.3	2.6
% Loss (Heat Input Basis)	%	1.7	0.6	0.9	0.2	0.8	2.1	1.9	1.3

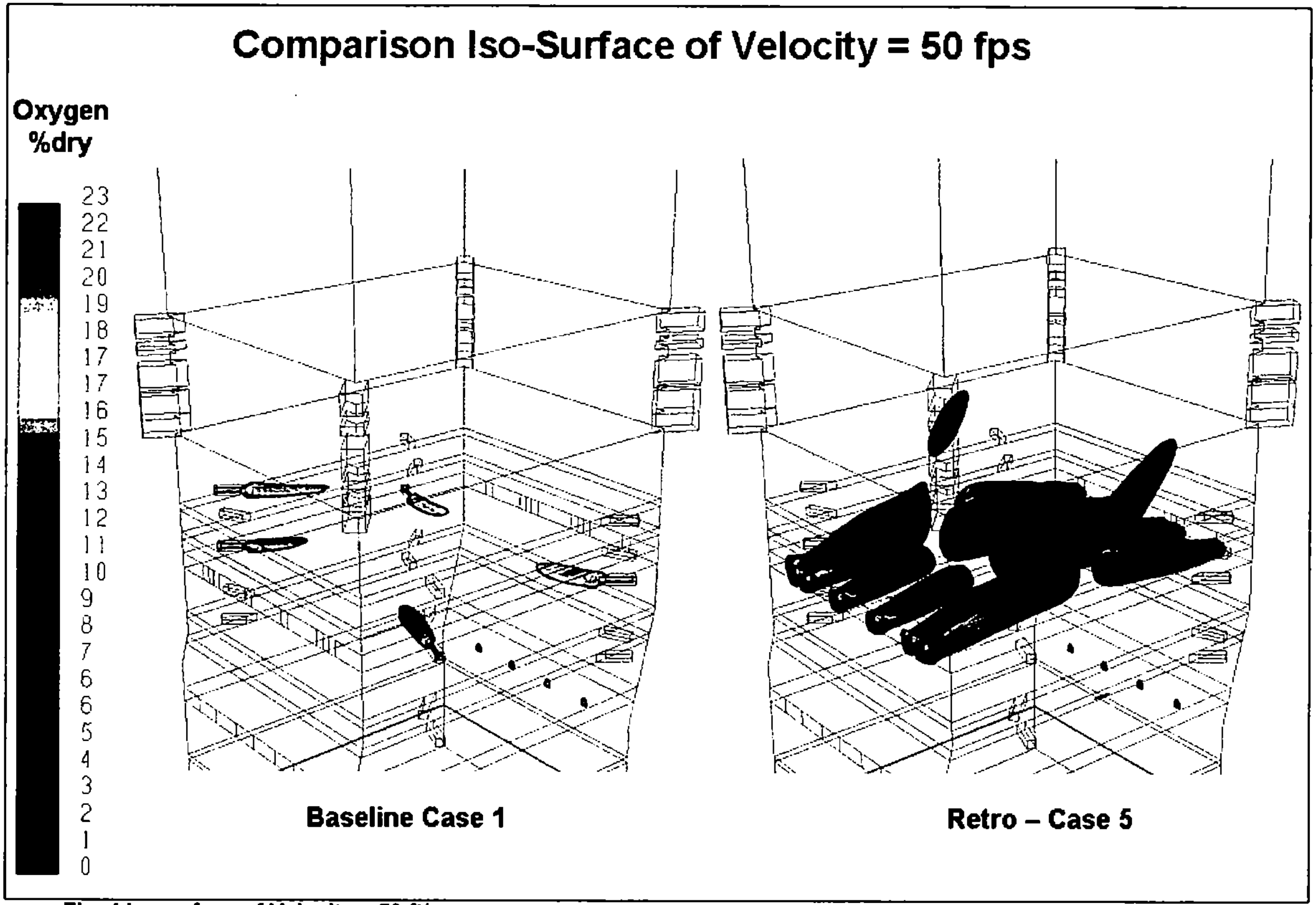


Fig. 4 Isosurface of Velocity – 50 ft/s

Comparison: Vertical Velocity Distribution

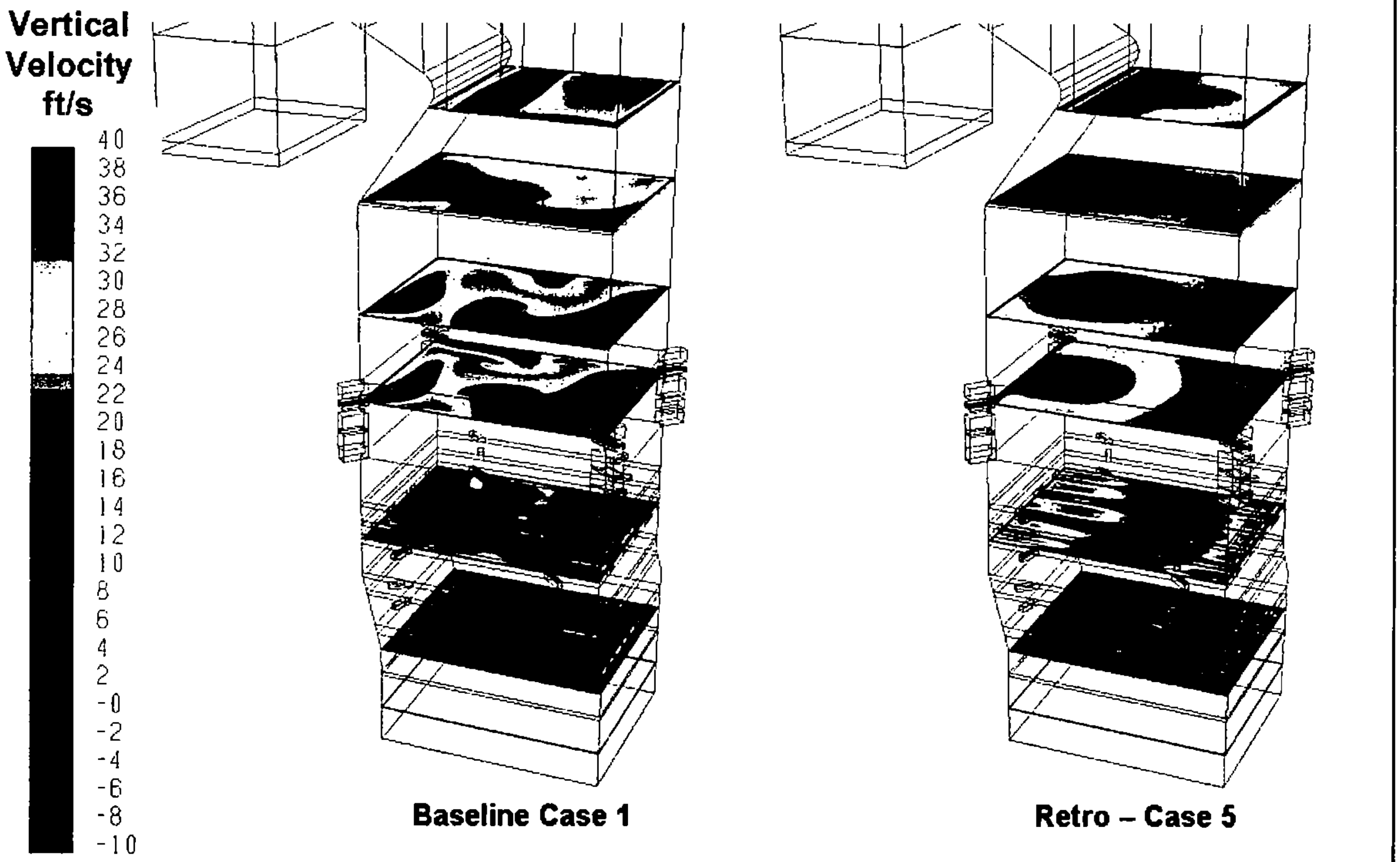


Fig. 5 Vertical Velocity Distribution at Horizontal Planes

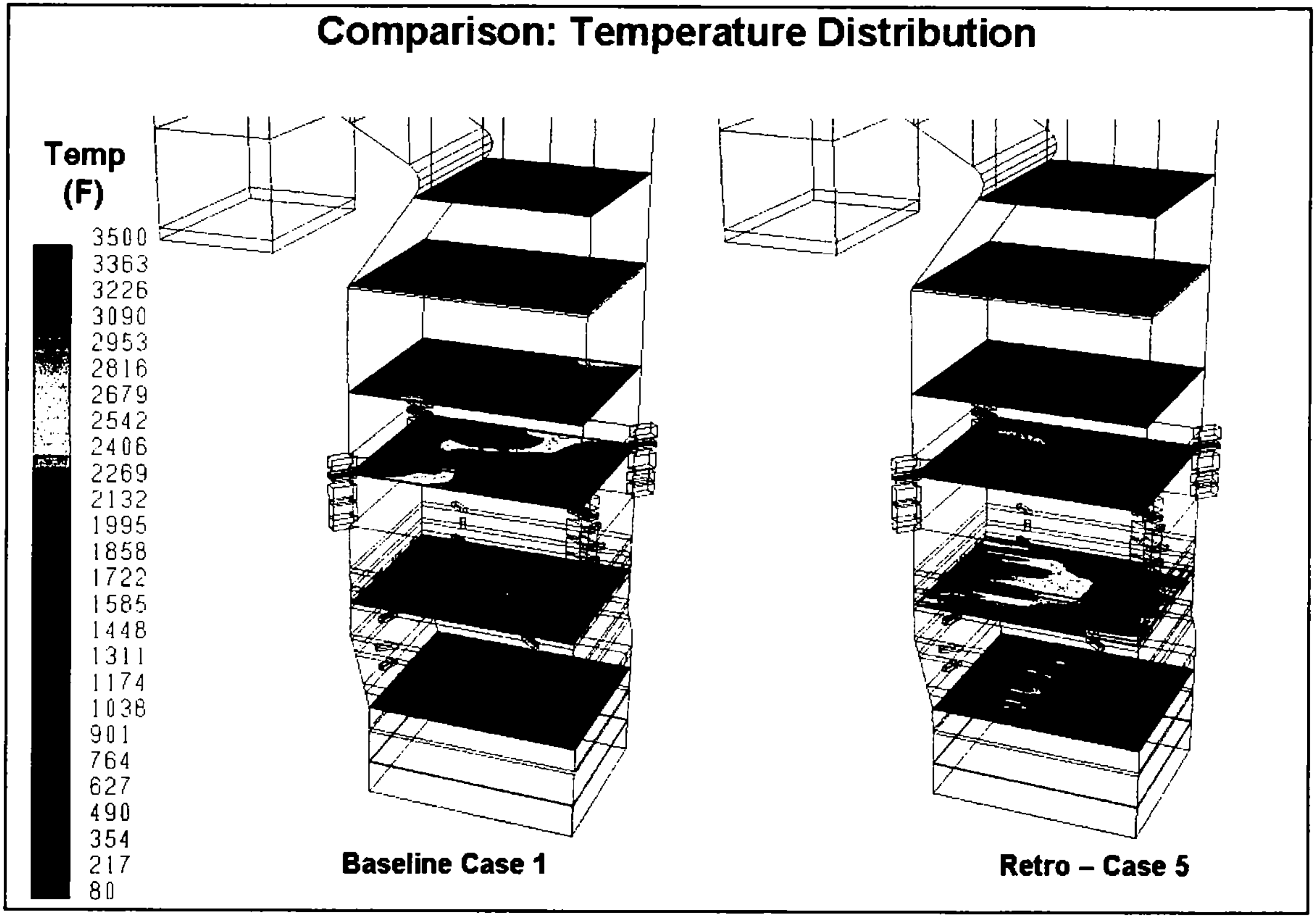


Fig. 6 Temperature Distribution at Horizontal Planes

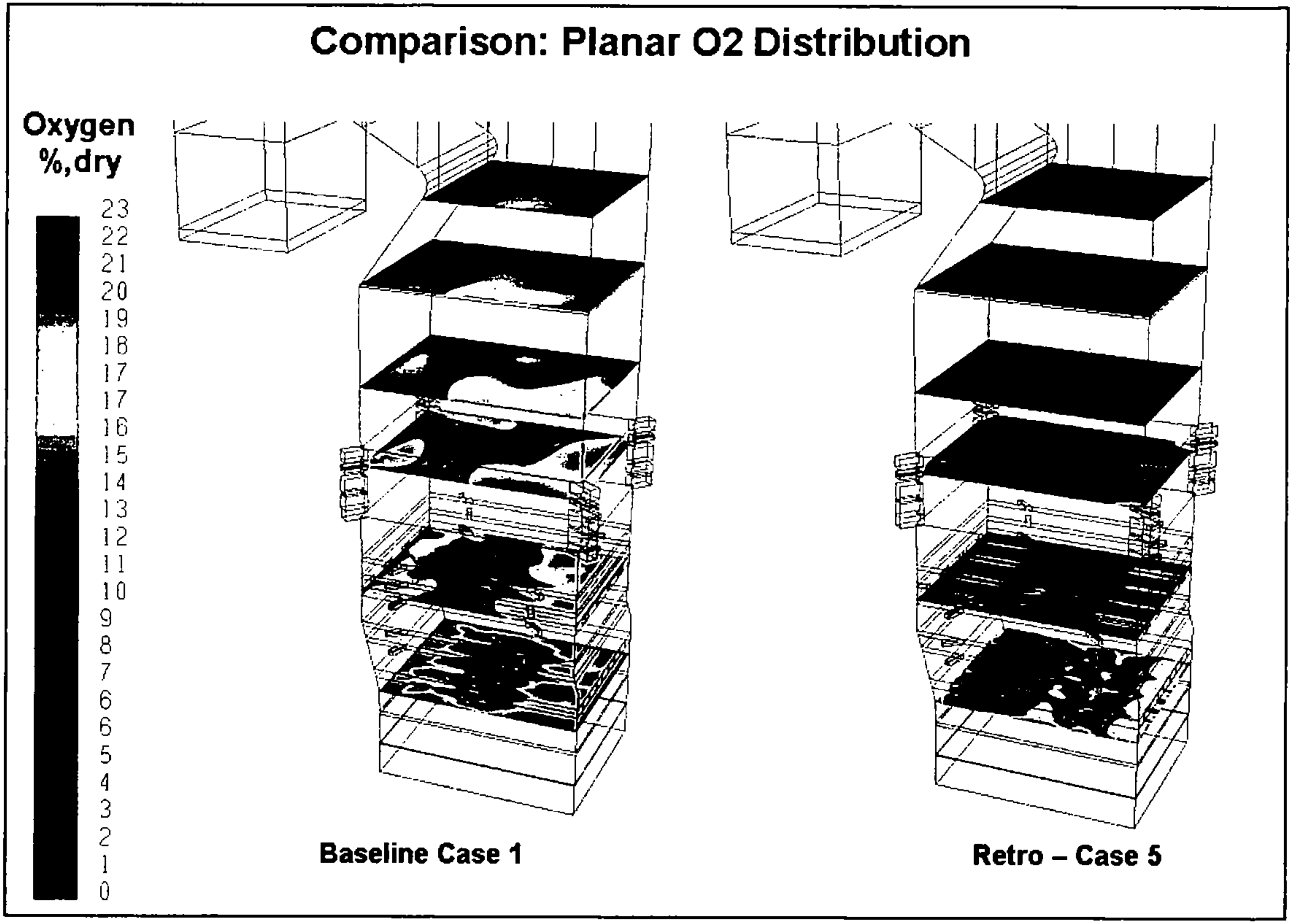


Fig. 7 O_2 **Distribution at Horizontal Planes**

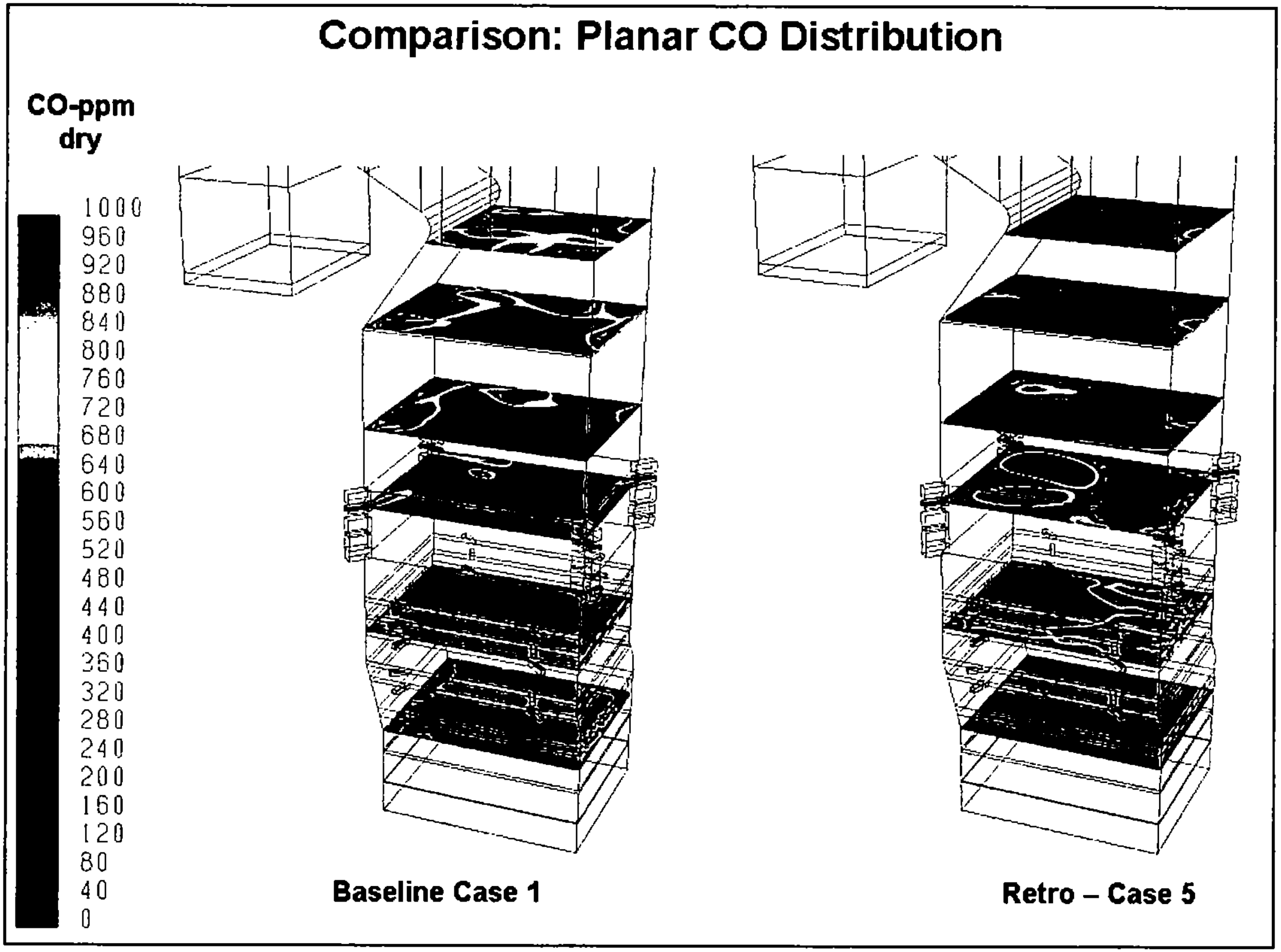


Fig. 8 CO Distribution at Horizontal Planes

5.0 MODELING APPROACH

The proposed retrofit air system will feature a front and rear wall Horizontal Mixing Zone (HMZ) design. The current 5 level sidewall air system nozzles will no longer be used. In addition, a fabric stoker seal will be installed to reduce the infiltration into the furnace and increase boiler efficiency. In conjunction with Performance Engineering calculations and design standards, some assumptions were required to estimate infiltration or tramp air quantities for the current and retrofit conditions. It is anticipated that the boiler will operate at lower excess air levels after the grate leakage air is reduced. The CFD modeling revealed some interesting effects of the current tangential burner air level, which will still be used to some degree, with or without coal firing.

The CFD modeling was performed using the commercially licensed CFD software FLUENT. The standard code was modified to represent the specific combustion characteristics of bark on moving grate stokers. The approach to the customization of FLUENT for this purpose has been previously described[2]. This report describes the modeling approach, model inputs, and predicted results for the modeled cases, with an emphasis on the bark firing mode before and after retrofit. Plots included in a companion PowerPoint presentation illustrate the flow distribution, species, and temperature profiles for each case. In addition, unburned carbon levels were predicted for the different cases.

Combustion of bark on a traveling grate is a dynamic process. Boiler operators constantly monitor the combustion characteristics while combustion controls tune air and fuel feeders to maintain steam flows as conditions change. Maintaining constant operation for stoker fired bark boilers is indeed challenging. From a boiler design perspective, simulation of this process using Computational Fluid Dynamics (CFD) presents challenges. The goal of simulating the boiler requires specification of all the air streams entering the furnace, along with the task of representing combustion on the stoker. A quasi steady-state approximation of the bark combustion process is used for the fuel, while a steady-state solution of the velocities and temperatures at each control volume in the modeled region is solved numerically. Bark particles of different diameters are injected with a random component to the trajectories. Next, the gas phase reactions and flow variables are recalculated for the updated fuel trajectories. The process alternates until a reasonably constant result is determined. For the gas-phase combustion, volatile species are allowed to burn using a global two-step reaction scheme. The gas phase reactions contribute to the overall heat release, along with the solid phase char burning that contributes to the CO pool for the gas phase combustion reactions. Gas radiation is modeled using the Discrete Ordinates method. The intensity function is solved over a finite number of directions at each cell in the domain. The radiation calculations include heat extraction to the waterwall and convective surfaces.

FLUENT includes the physical models that are defined to represent the described gas phase and particle combustion submodels. However, customization of the particle models for a moving grate process is used. Custom code was developed for this application and supplements the basic FLUENT framework to better handle the in-flight and grates burning process. Bark and coal particles are treated individually. Bark particles are injected from the distributors and can burn in suspension or on the grate surface. Particles pass through drying, devolatilization and char burning phases with rates depending on local temperatures and gas compositions. Larger particles tend to land close to the rear wall while smaller particles tend to land closer to the center of the grate. The CFD simulation takes this into account by spreading out bark particles according to their sizes. Depending on the local velocities on the grate, a particle may be retained on the surface or escape and continue burning in-flight. Particles escaping with residual carbon are tabulated. In addition, some particles may move all the way to the front ash hopper with remaining combustibles. The total mass for the entrained carryover particles is reported as combustion performance indicator.

The specific bark properties are used for each simulation. Bark samples taken during August testing by ALSTOM, were sent to ALSTOM's Power Plant Lab (PPL) and analyzed. The analysis included chemical analysis, proximate analysis and sieve screening for aerodynamic characteristics defined in the CFD model. In this manner the model is representative of the snapshot for the testing period. The bark analysis is tabulated in this report. In addition to the bark sample analyzed by PPL, a different bark sample analyzed by Columbia Analytical Lab was modeled in Case 8 for comparison purposes.

For the CFD modeling the bark was partitioned into a range of particle sizes. For this study, we used 8 particle size groups. Particles are retained in a burning layer just above the stoker surface, and migrate from back to front based on the stoker grate speed. An example of the particle trajectories for this study (Case 5) is shown in **Fig. 9**. The colors represent the burning state, with red particles still containing char. After the particles are completely combusted the track is not shown for clarity. From this plot it can be seen that the front wall OFA nozzles entrain some of the smaller particles. Three size groups are shown together in this plot, the small, medium and largest fractions. The larger particles land on the grate and may escape and burn in suspension, or be retained for their entire burn on the grate.

In calibrating the baseline bark case, the airflow distribution was defined using the PI-data, testing logs and some assumptions on the infiltration. The outlet gas O_2 and CO concentrations were measured. Tuning of the baseline case included refinement of the bark entrainment characteristics to match the measured CO levels. Once set for the baseline case, all combustion model settings related to bark and coal burning characteristics were retained for the remainder of the runs. Thus, the predictions were tuned to a baseline case for which data was available, and the other cases extrapolate from the baseline. Relative trends and patterns generated by the CFD model provide engineering with useful information on the relative performance of the baseline system to the retrofit performance.

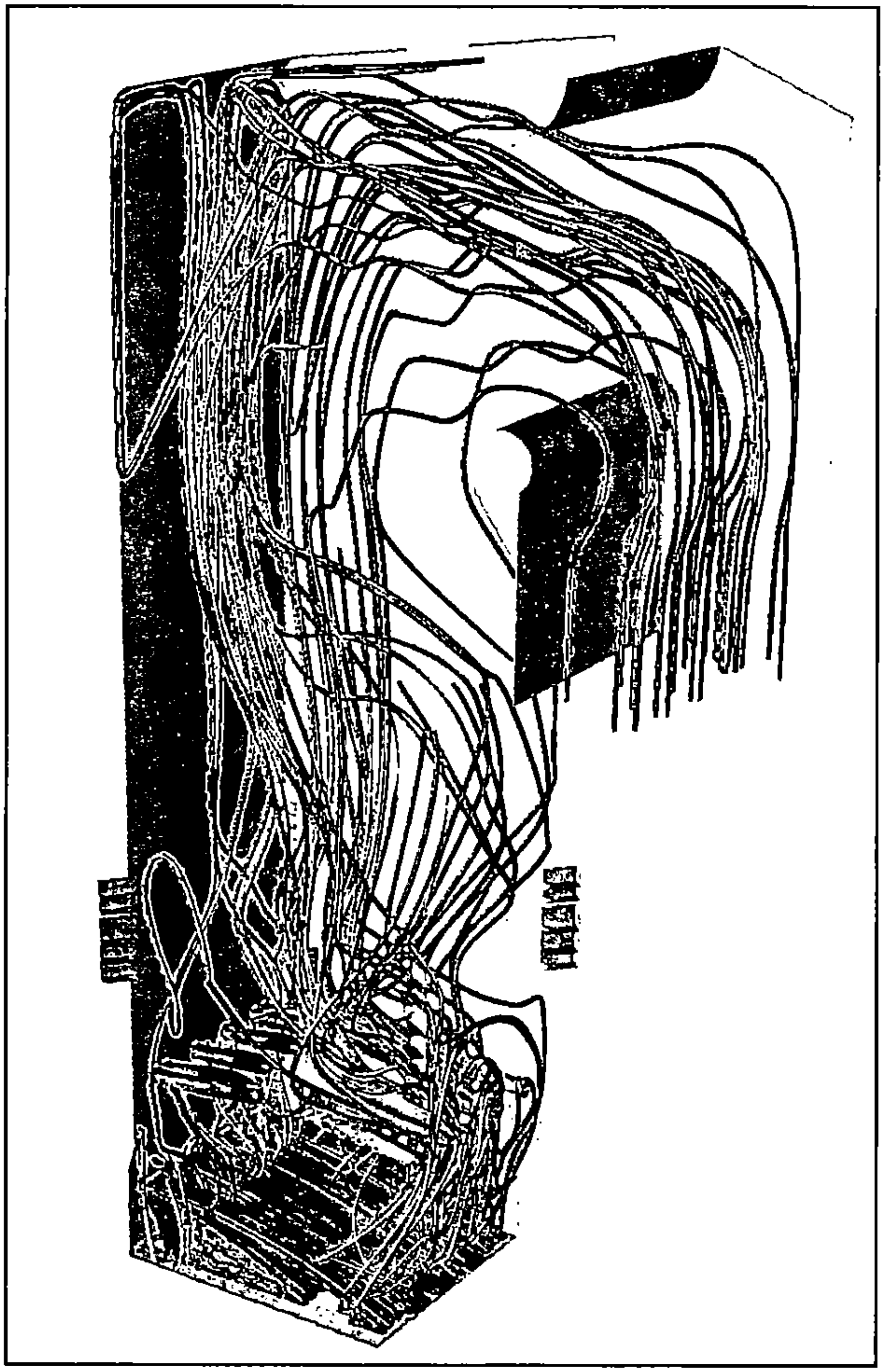


Fig. 9 Bark Particle burning trajectories colored by state

6.0 Case by Case Results

Section 4.2 provided a specific comparison of the baseline to the retrofit air system firing bark. Other operating conditions such as co-firing coal with bark, increased load, and lower excess air levels were also simulated. The results for these runs are included in this section on a case-by-case basis. A general description of each case and the key features of each are described. For each run velocity isosurface and pathlines are included along with the velocity, temperature, and species distributions. For reference, these figures and the associated case are:

Case 1.	Figures 7 - 10
Case 2.	Figures 11 – 14
Case 3.	Figures 15 – 18
Case 4.	Figures 19 – 22
Case 5.	Figures 23 – 26
Case 6.	Figures 27 – 30
Case 7.	Figures 31 – 34
Case 8.	Figures 35 – 38

Case 1. Baseline Bark Firing:

For the existing system burning bark only with 12% leakage, the current sidewall OFA system has high carbon loss and CO emissions. Near the grate, ambient air infiltration (tramp air) results in cooler temperatures around the edge of the stoker. This flow acts to sweep some of the bark away from the edges and delay drying and ignition, so that the cooling effect is mostly due to bark redistribution than temperature effects. This results in more concentrated bark combustion near the center, and stratification. This stratification initiated at the grate persists into the upper furnace. Entrainment of burning particles in this center zone increases the suspension burning level, and increases the carbon loss and CO at the outlet. The windbox air injection velocities are too low with our assumption of the dampers open. A slight bulk rotation of the gases due to the tangential level causes the high O_2 zone to shift from the front wall lower in the furnace to the left wall at the arch.

Case 2. Baseline Bark and Coal:

The run was based on field tests that had lower excess air levels. To represent this case, the bark flow was reduced from 45,150 to 26,600 lb/hr and the coal firing rate was 22,000 lb/hr. With coal firing, the center zone of the furnace was much hotter, with the support fuel contributing to higher bark combustion rates. As a result, the outlet CO levels were much lower. The CFD model was able to reproduce the field data reasonably well. It is assumed that the mill would prefer to attain higher bark firing rates without relying on coal, however it was clear that firing coal was beneficial to increasing bark combustion rates even at the grate level. The temperature plots show the impact of coal firing. The O_2 distribution plots illustrate the impact of co-firing on the O_2 distribution, which is low in the center of the furnace.

Case 3. Retrofit HMZ Bark:

This case is a comparison of the baseline bark to the retrofit design at high excess air levels. The impact of the air system change with reduced leakage is highlighted. With the stoker leakage and undergrate air reduced, temperatures in the lower furnace are significantly higher than the baseline. The mixing of the HMZ nozzles accelerates the combustion and burnout. With high excess air levels, the CO emissions were reduced from 1,430 to 575 PPM. Carbon loss levels were also reduced.

Case 4. Retrofit HMZ Bark and Coal:

This case represents the HMZ system running at 3.3% outlet O_2. Operation data for this condition was not available, but is believed to be a reasonable coal and bark comparison from the baseline to the new system. With lower excess air and coal firing, the upper furnace temperatures are higher than the bark case, increasing the carbon burning rates. The hot zone in the center contrasts with cases firing bark alone. The overall change in bark combustion performance for this case relative to the baseline case 2 was muted because coal was the predominant fuel fired. Bark impacts were relatively minor to the overall emissions. With coal firing the windbox velocities are increased, providing additional mixing benefit. This can be seen in the OFA tracer pathline plot and velocity isosurfaces.

Case 5. Retrofit HMZ Bark with Low Excess Air:

The case highlights the impact of running the HMZ design with lower excess air. The low excess air condition is likely to be the preferred operating mode with the revised air system and stoker seal. Note that the figures for this run are included and described relative to the baseline case in the earlier summary comparison.

Case 6. Retrofit HMZ Maximum Bark with Low Excess Air:

This case is similar to case 3 with bark feed rate increased and lower excess air. The nozzles were set with all of the nozzles associated with the "doubles" set fully-open, while the small nozzles were

75% open. This combination allowed the HMZ velocities to be nearly uniform, at the design velocity. The performance of the unit with maximum bark may require careful attention to the bark distribution on the grate by tuning the feeder speed and undergrate air distribution to attain best performance. With tuning of the bark injection to spread the fuel uniformly, the predicted O2 distribution in the upper furnace was quite good. The CO emissions were slightly lower than case 1 at lower load and higher O2. It was noted that the exit CO levels were higher than at the arch due to entrained particulates giving off CO in the convective section that was not fully oxidized. The predictions by the CFD model are again relative to the baseline calibration.

Case 7 Retrofit HMZ Bark and Coal with Low Excess Air:

This case represents an increased load relative to the tested conditions and yielded reasonable results at increased firing rates. As seen by the earlier runs, the benefits of firing coal with bark contribute to a performance improvement at the same load. With coal firing, the furnace zone is significantly hotter than with bark alone. These hotter temperatures are projected to the grate, for increased combustion rates. Elimination of the stoker leakage around the perimeter was also beneficial. However, as the firing rate increases linearly, the carryover rates ~~increase~~ would be expected to increase on a second order progression.

Case 8 Retrofit HMZ Bark and Coal with Low Excess Air:

This case is similar to case 7 except higher moisture bark, Columbia Analytical Analysis, was fired with slightly less coal. With this combination, the outlet O2 levels were higher, resulting in lower CO levels and improved carbon burnout. This higher moisture bark case was run to compare the results with Case 7 that was run with the sample taken during the August testing.

7.0 CONCLUSIONS

A CFD evaluation of the current operation and retrofit HMZ air system for Smurfit Stone Container - Panama City unit #4 was conducted. Using the baseline testing as a guide to setting up the current operation, a range of future operating conditions was simulated. Based on this study, several benefits were observed. In addition to the HMZ air system itself, several air system operation characteristics were found to be important. From this study we conclude:

1. Replacing the existing sidewall OFA system with a front and rear HMZ OFA system, as modeled provides significantly improved lower furnace mixing, lower carbon loss, and higher gas temperatures near the grate for the same firing rate. Compared to the baseline case, the flow patterns generated with HMZ system is expected to provide a significant improvement in bark burning.

2. Tuning of the HMZ nozzle dampers to provide an OFA/UGA split of 55/45 improved the performance of the system at peak loads. Increased bark firing at lower excess air levels compared to the current operation yielded lower CO levels with only slightly higher carbon loss.

3. The impact of stoker infiltration associated with the installation of a fabric~~-filter-~~seal provided an improvement to the grate combustion, and improved the burning performance. The stoker leakage reduction could not be accurately measured for modeling purposes. With the combination of reduced level of furnace air infiltration and the HMZ air system, a significant combustion performance improvement was predicted for the tested load conditions.

4. At increased bark firing rates, carryover rates, as expected, increase. However with careful tuning of the grate combustion the increase may be more modest than the relative model trends due to the assumptions made for the baseline grate combustion distribution. A comparison of carbon loss results as shown in the baseline Case 1, prorated to the higher design bark firing rates at increased boiler load, to the Max. Bark Case 6, predicts a drop in carbon loss and associated carryover on an equivalent throughput basis.

5. With coal firing added to the bark combustion, increased upper furnace gas temperatures and higher temperature near the grate were predicted. For wet bark conditions, the use of coal firing to improve grate combustion may still be important. With coal firing, the boiler can operate at significantly lower excess air levels with lower CO emissions due to the increased combustion rates.

8.0 References

[1] Steven Gibowski "Smurfit Stone Container Corp. Panama City, FL #4 Bark Boiler Testing, August 11th, 2005", ALSTOM Internal Report, August 19, 2005.

[2] P.J. Chapman, S. Morrison, "Biomass Boiler CFD Modeling and Design Validation", TAPPI Engineering and Finishing Conf, San Antonio, TX, Dec 2001.

Figure 1

CFD Model

Single Model for Simulating Both Existing and HMZ OFA Systems

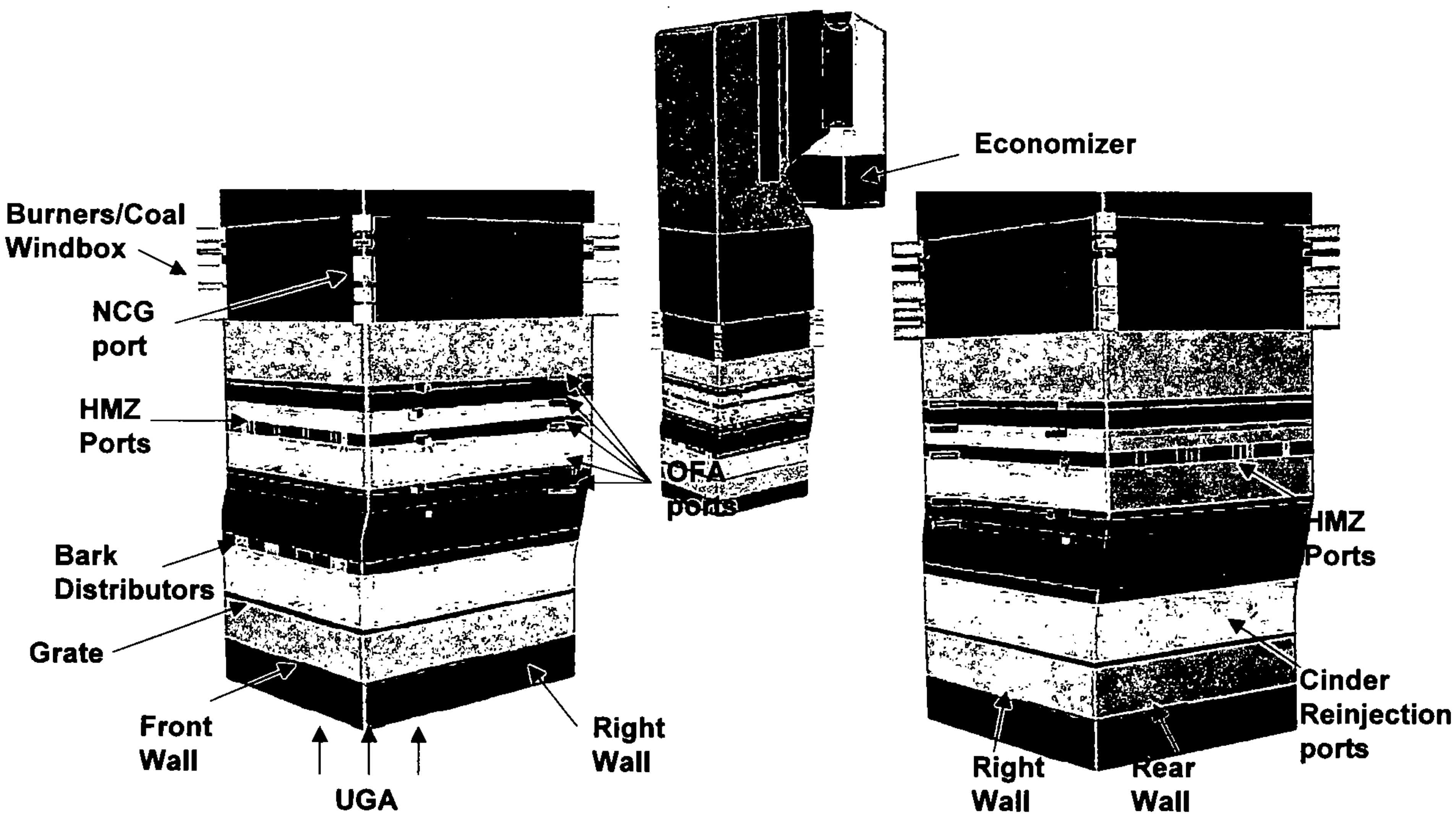
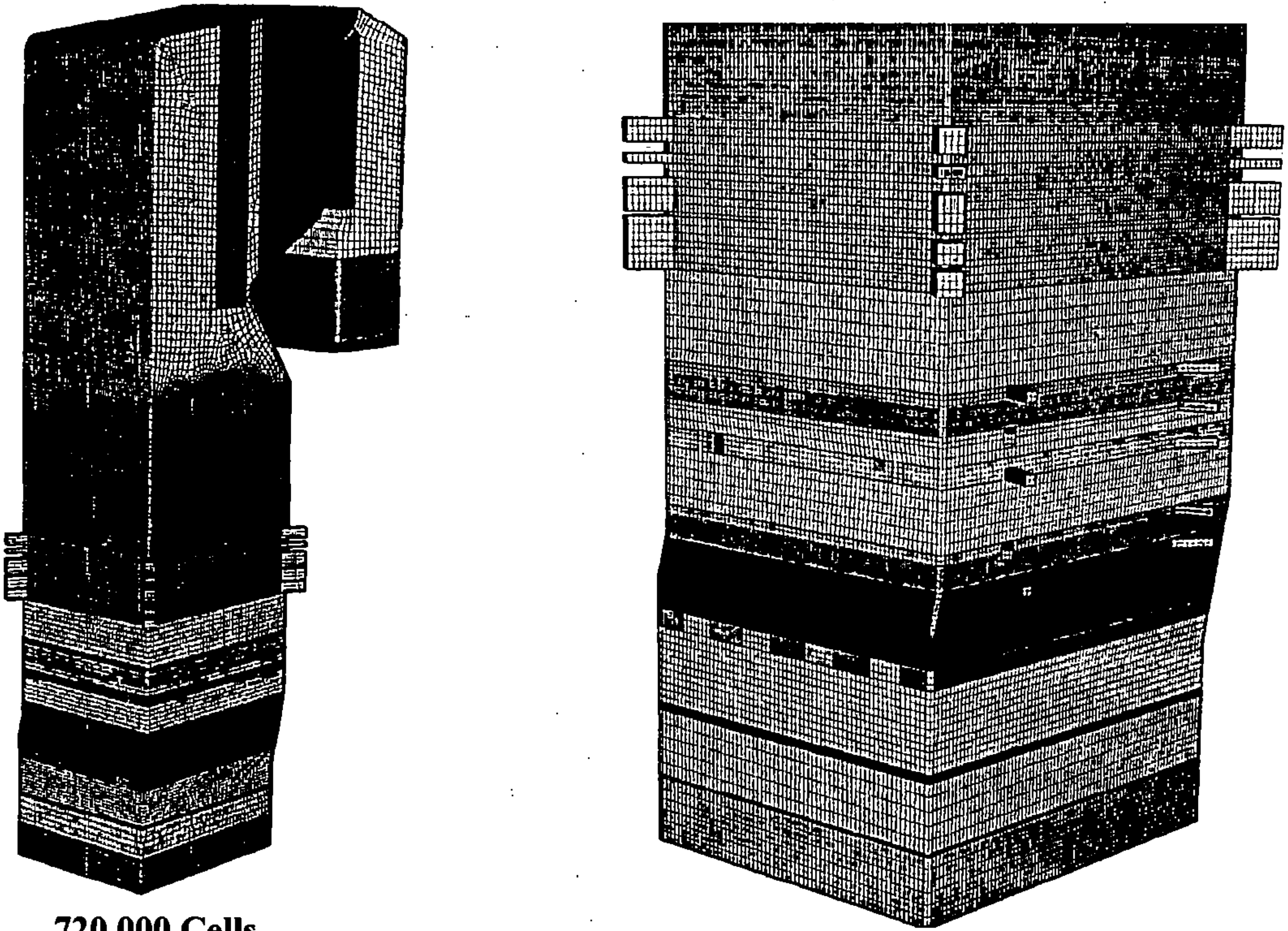


Figure 2

CFD Mesh



720,000 Cells

Figure 3

Cases Simulated

Case 1: Existing OFA, Bark Only

Case 2: Existing OFA, Bark & Coal

Case 3: HMZ OFA, Bark Only

Case 4: HMZ OFA, Bark & Coal

Case 5: HMZ OFA, Bark Only, Low Excess Air

Case 6: HMZ OFA, Max. Bark, Low Excess Air

Case 7: HMZ OFA, Max. Bark & Coal, Low Excess Air

Case 8: Same as Case 7 Except with 50% Moisture Bark

Note: All cases are with 39.5% moisture bark except Case 8

Figure 4

Flow Conditions

ALSTOM

		Baseline		*Retrofit*		*Retrofit, low excess air*			
		bark	bark & coal	bark	bark & coal	bark	max. bark	bark & coal	50% moisture bark & coal
INPUTS:	Case #	1	2	3	4	5	6	7	8
Steam Flow	Lbs/hr	138,000	267,000	138,000	267,000	138,000	221,000	300,000	300,000
Wood Steam Flow	Lbs/hr	138,000	85,000	138,000	84,500	138,000	221,000	180,000	180,000
Coal Steam Flow	Lbs/hr	0	182,000	0	182,500	0	0	120,000	120,000
Bark Fuel Flow	Lbs/hr	45,150	26,600	45,150	26,380	45,150	69,720	56,770	65,200
Bark Moist. Content	% m.c.	39.5	39.5	39.5	39.5	39.5	39.5	39.5	50.0
Coal Fuel Flow	Lbs/hr	0	22,000	0	22,000	0	0	14,625	13,720
Total Combustion Air	Lbs/hr	354,150	388,650	354,150	379,500	252,100	382,420	442,400	439,000
Total Burner Air	Lbs/hr	109,000	168,000	24,000	239,100	24,000	24,000	158,900	171,000
UGA + OFA	Lbs/hr	203,000	179,000	330,150	121,400	228,100	358,420	261,400	246,050
UGA	Lbs/hr	174,670	150,670	144,375	46,530	107,400	138,530	109,530	114,925
OFA	Lbs/hr	20,230	20,230	165,075	66,770	100,000	192,670	143,770	123,025
OFA / UGA split	% / %	10 / 90	10 / 90	50 / 50	55 / 45	44 / 56	55 / 45	55 / 45	50 / 50
Cinder Reinjection Air	Lbs/hr	8,100	8,100	8,100	8,100	8,100	8,100	8,100	8,100
Coal Transport Air	Lbs/hr	0	41,000	0	36,000	0	0	36,000	36,000
Leakage Air	Lbs/hr	42,150	41,650	12,600	19,000	12,600	19,120	22,100	21,950
Gross Heat Input	MBtu/hr	235.9	401.1	235.9	401.1	235.9	369.2	474.7	488.1
Grate Heat Rate	Btu/hr-ft^2	776,650	452,400	776,650	454,100	776,650	1,200,000	976,900	1,012,000

Figure 5

Fuel Compositions

ALSTOM

Fuel for Cases 1 - 7				Fuel for Case 8		
	Bark	Coal			Bark	Coal
%H2O	39.5	9.2		%H2O	50	5
%C	31.07	66.18		%C	25.98	72.33
%H	3.42	4.39		%H	2.92	6.17
%S	0.01	1.11		%S	0.01	0.67
%N	0.15	1.34		%N	0.02	1.55
%O	22.79	6.85		%O	20.78	6.89
%Ash	3.06	10.93		%Ash	0.29	7.39
HHV (BTU/lb)	5296	11906		HHV (BTU/lb)	4774	12888

Figure 6

CFD Results Summary

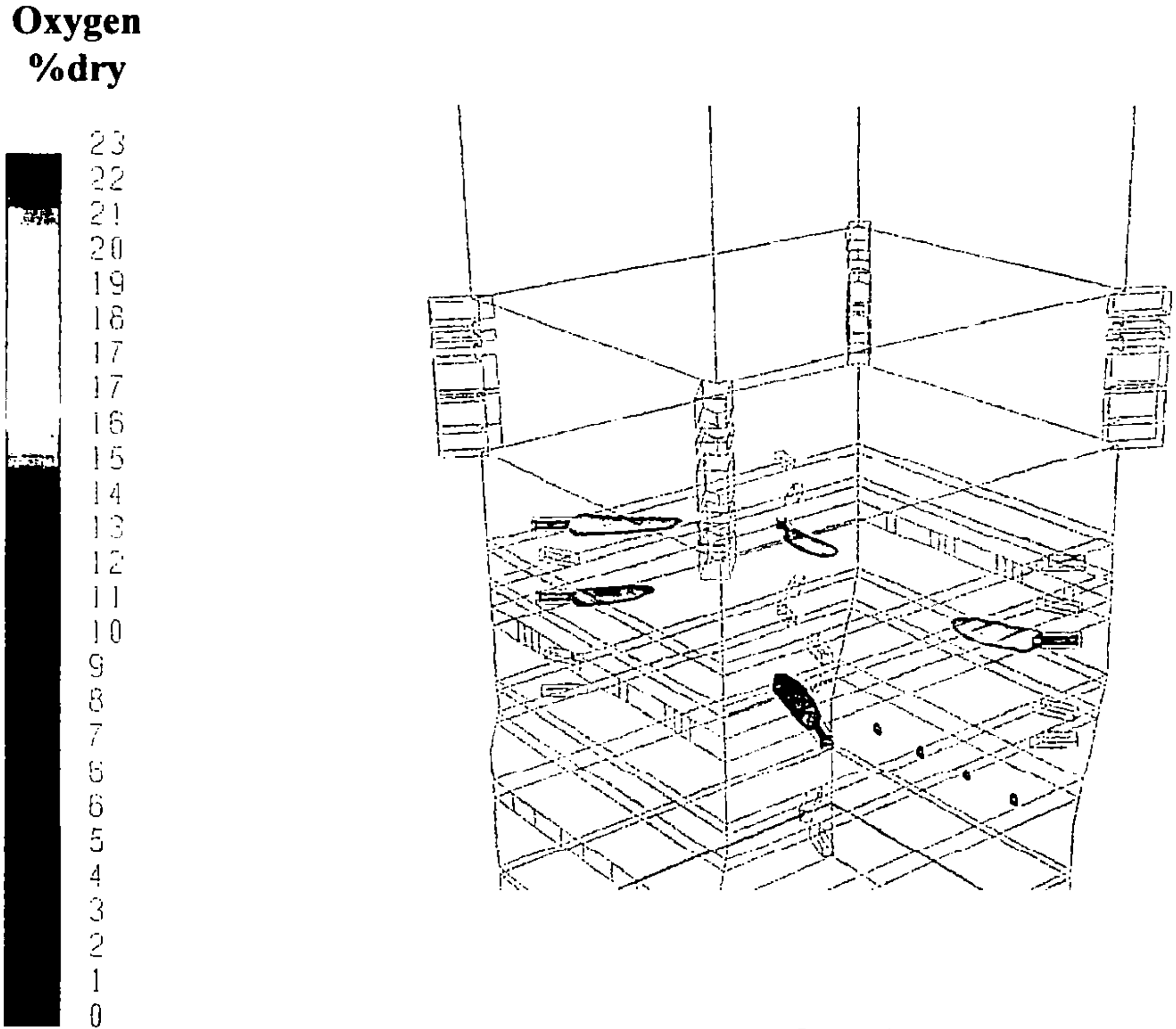
ALSTOM

		existing		retrofit		retrofit, low excess air			
		bark	bark & coal	bark	bark & coal	bark	max. bark	bark & coal	50% moisture bark & coal
	Case #	1	2	3	4	5	6	7	8
CO at exit of ECON	ppm, dry	1,430	270	575	314	986	1,234	500	302
CO at exit of ECON	Lbs/Mbtu	2.05	0.25	0.83	0.28	1.01	1.23	0.44	0.25
O2 at exit of ECON	%, dry	10.4	3.9	10.3	3.3	5.8	5.9	3.9	6.2
O2 at nose of arch	%, dry	10.8	4.6	10.4	3.9	6.0	6.3	4.4	6.8
Average Temperature at nose of arch	F	1,670	2,268	1,541	2,219	1,590	1,825	2,134	2,023
Carbon Loss	%	3.4	1.0	1.7	0.3	1.6	4.2	3.3	2.6
% Carbon Loss on Heat Input Basis	%	1.7	0.6	0.9	0.2	0.8	2.1	1.9	1.3

Figure 7

Iso-Surface of Velocity = 50 fps

ALSTOM

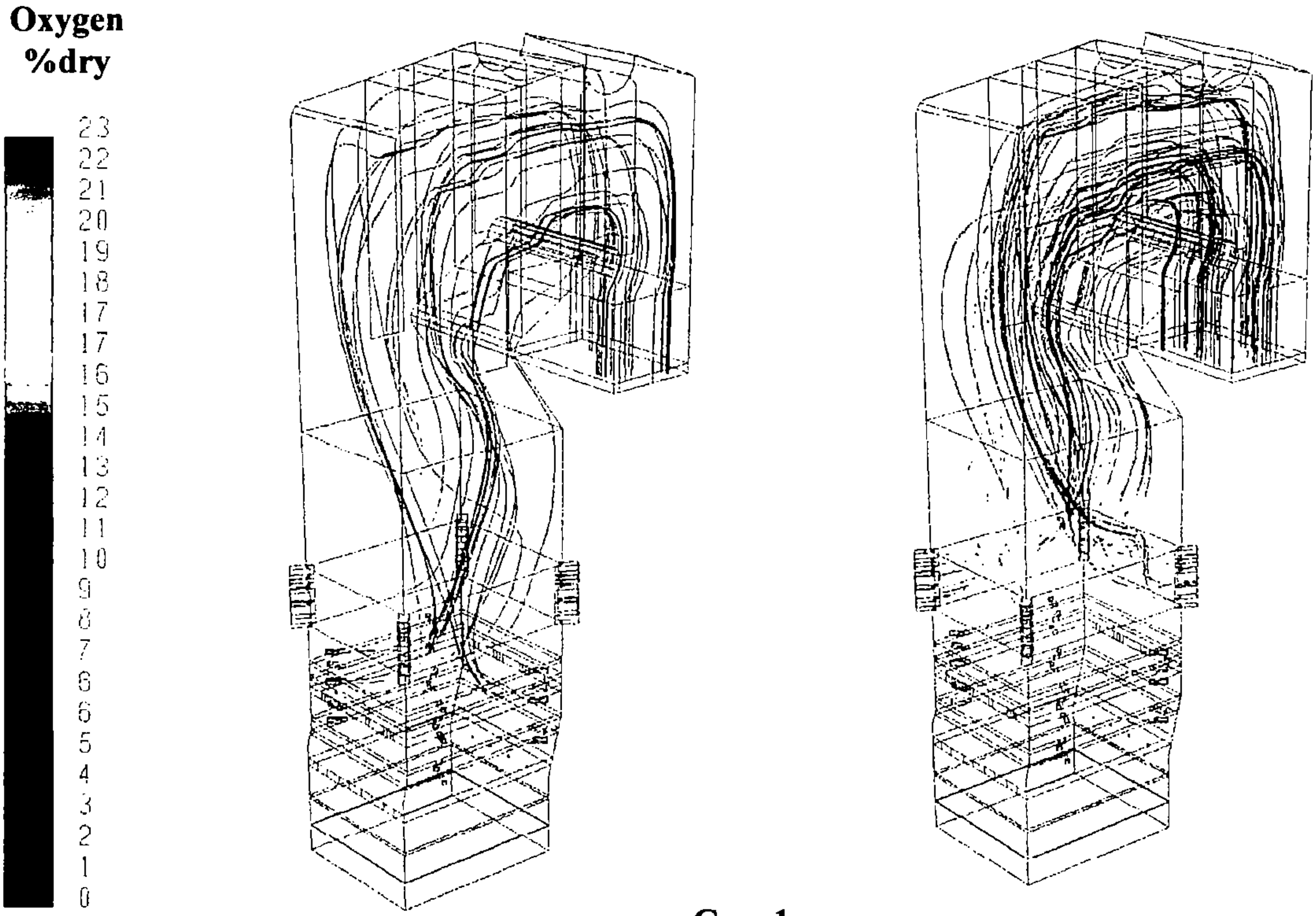


Case 1

Figure 8

Gas Path Lines

ALSTOM

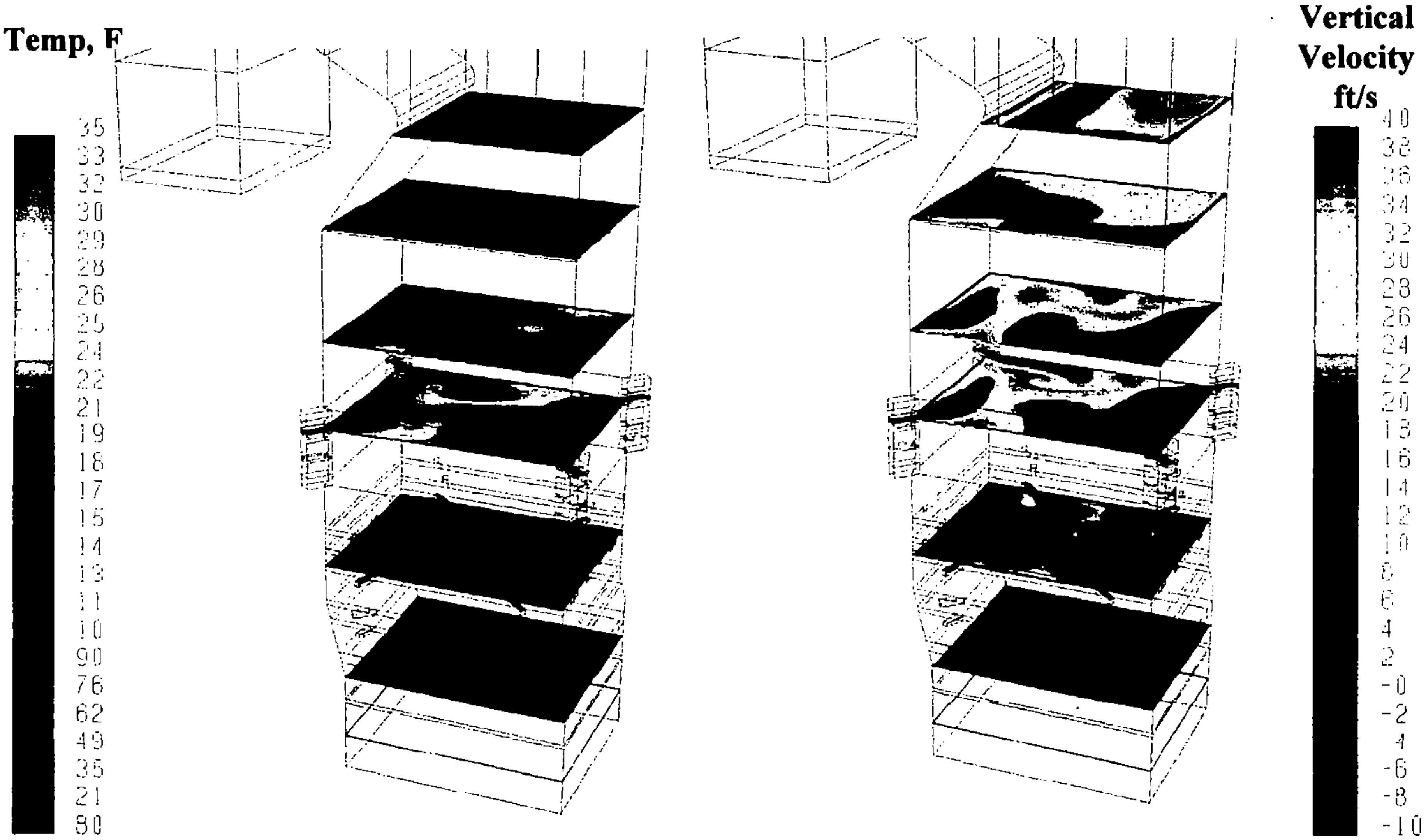


Case 1

Figure 9

Temperature & Velocity Contours

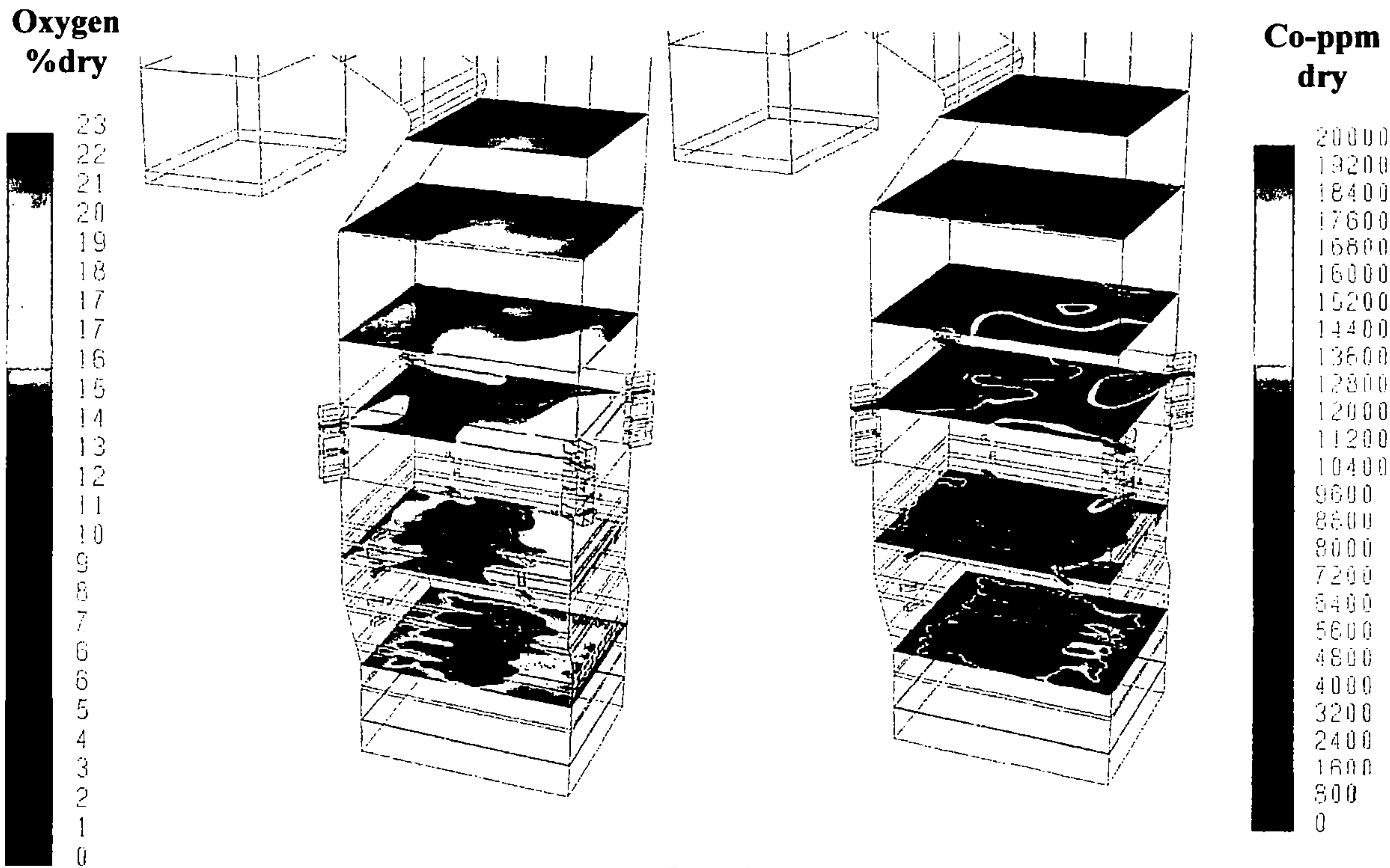
ALSTOM



Case 1

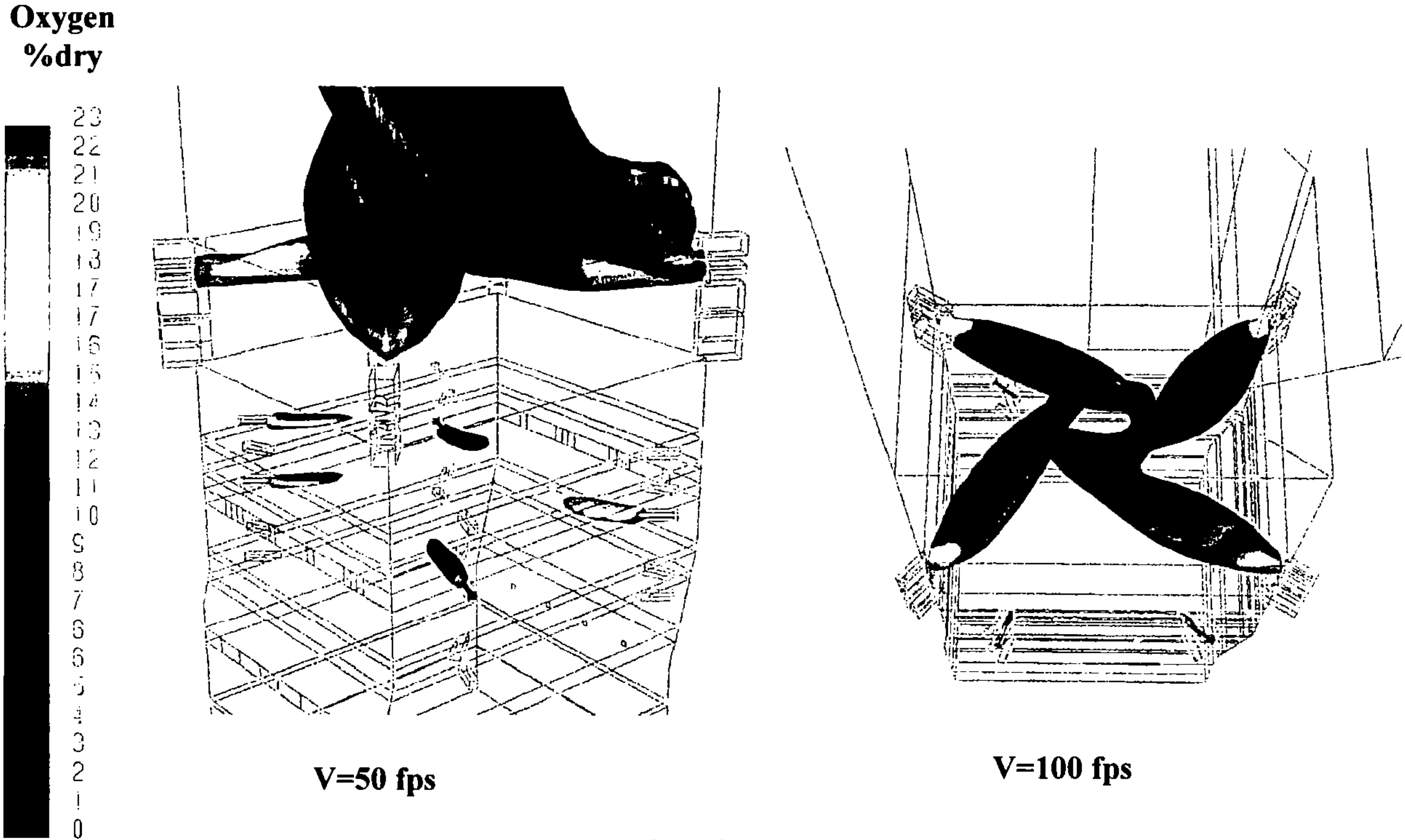
Figure 10

O2 & CO Concentrations



Case 1

Iso-Surface of Velocity



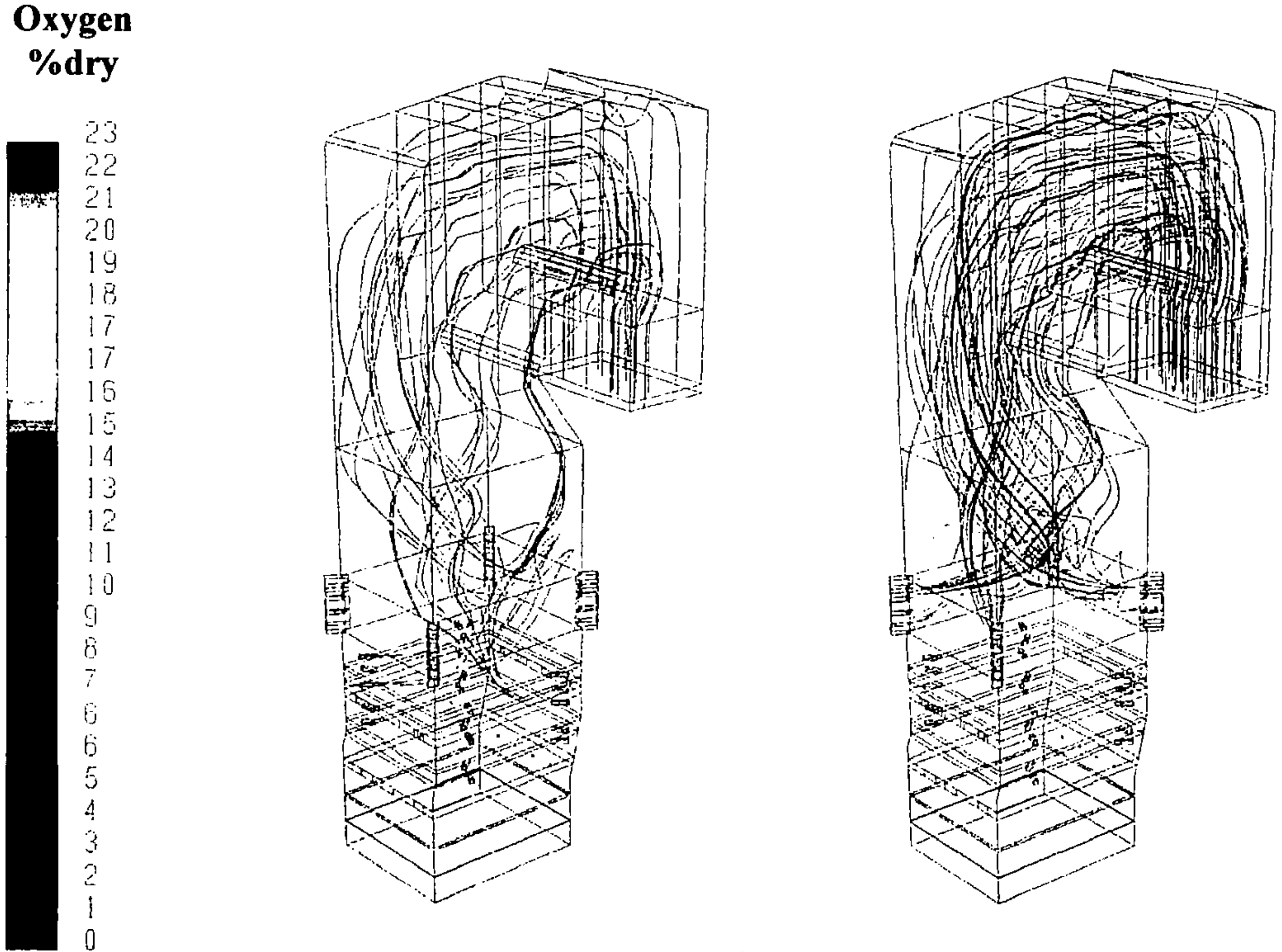
V=50 fps

V=100 fps

Case 2

Figure 12

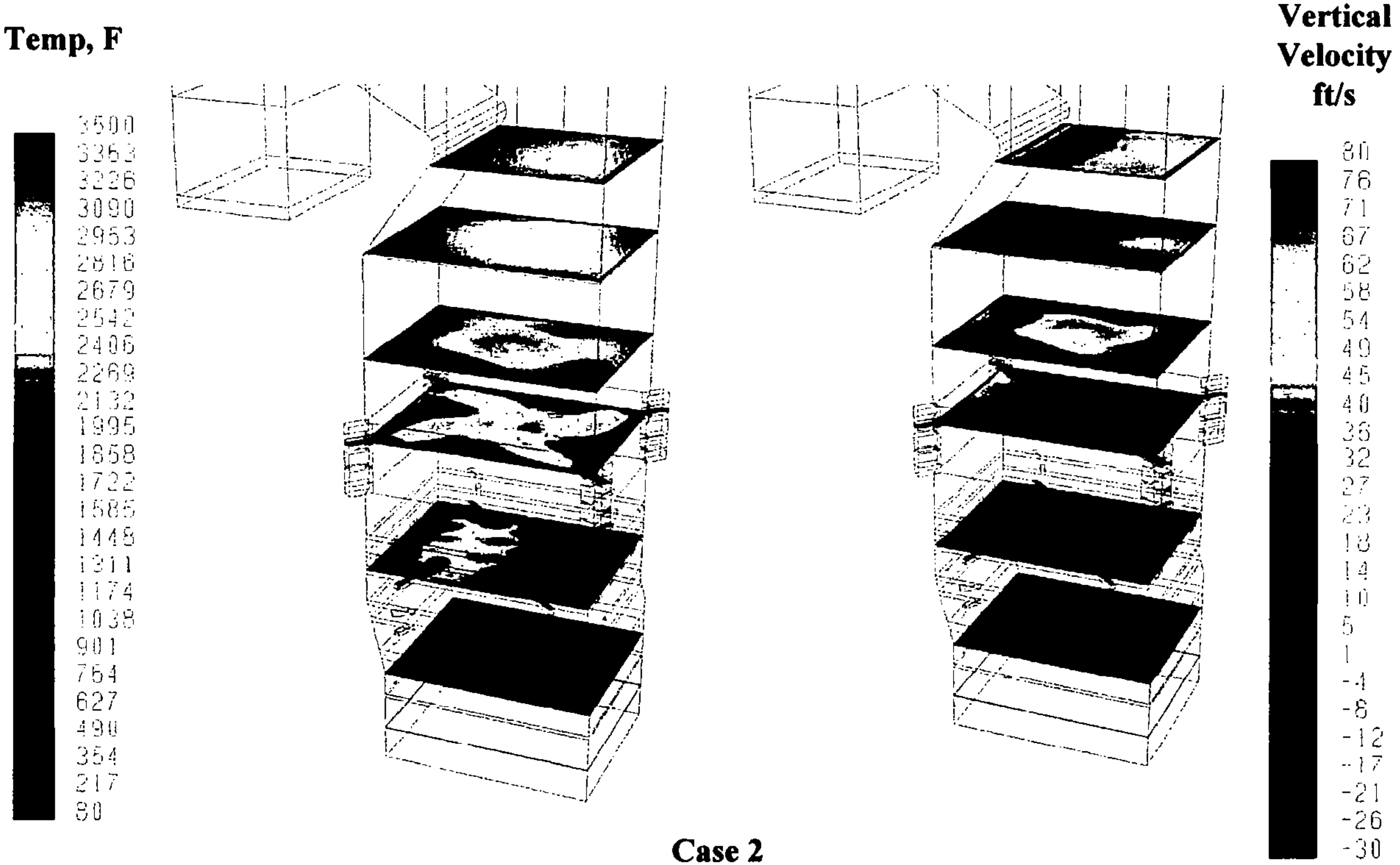
Gas Path Lines



Case 2

Figure 13

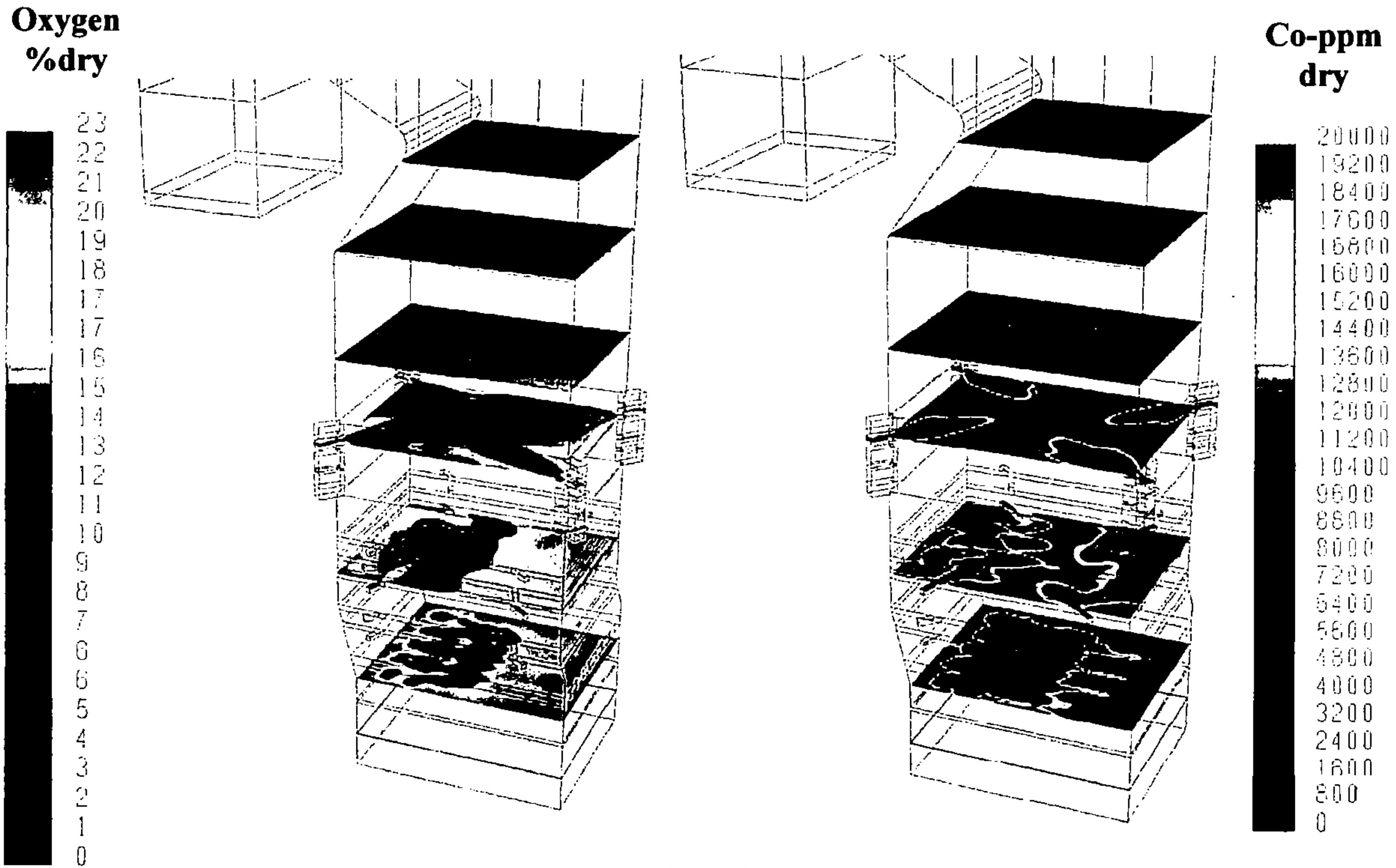
Temperature & Velocity Contours



Case 2

Figure 14

O2 & CO Concentrations

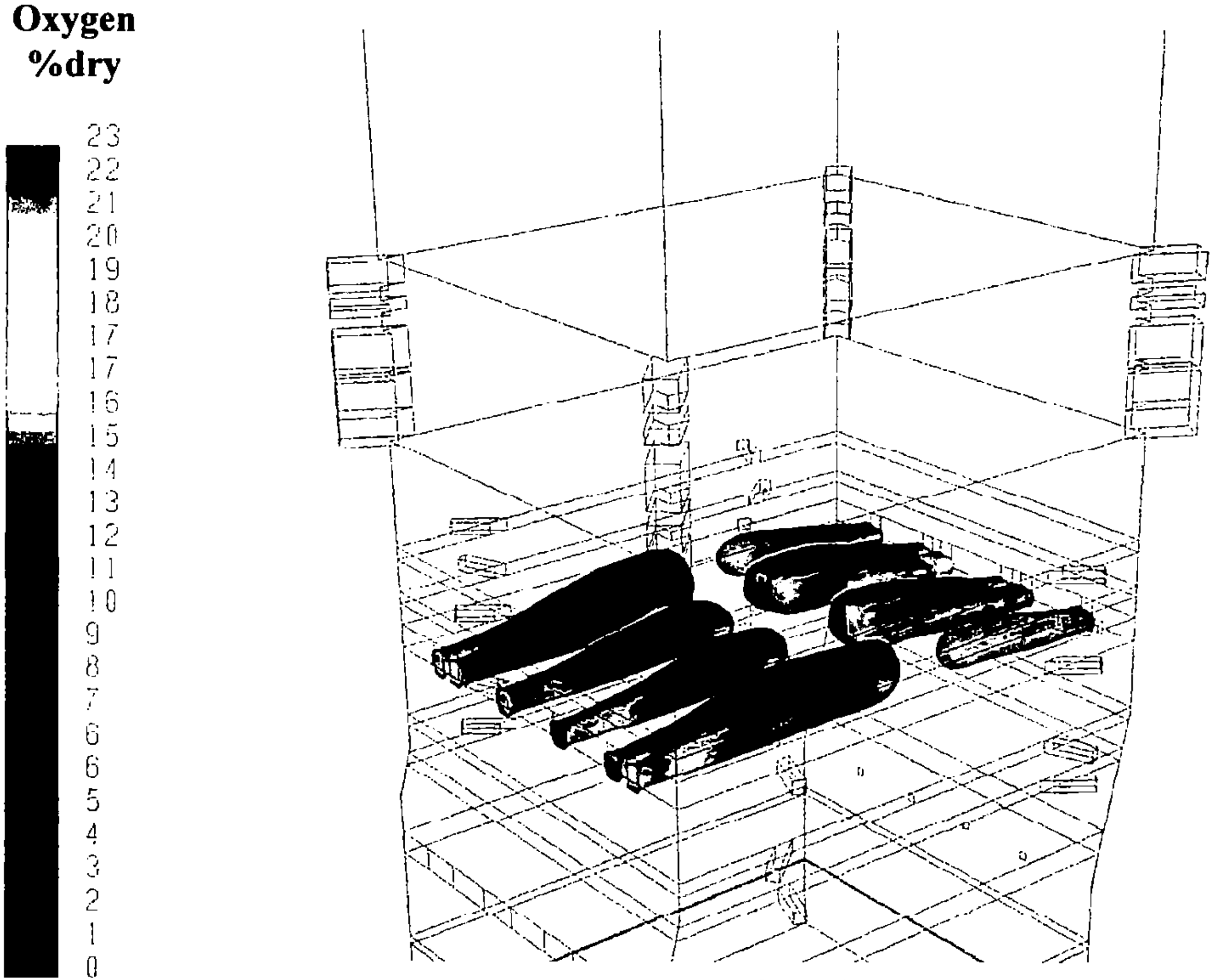


Case 2

Figure 15

Iso-Surface of Velocity = 100 fps

ALSTOM

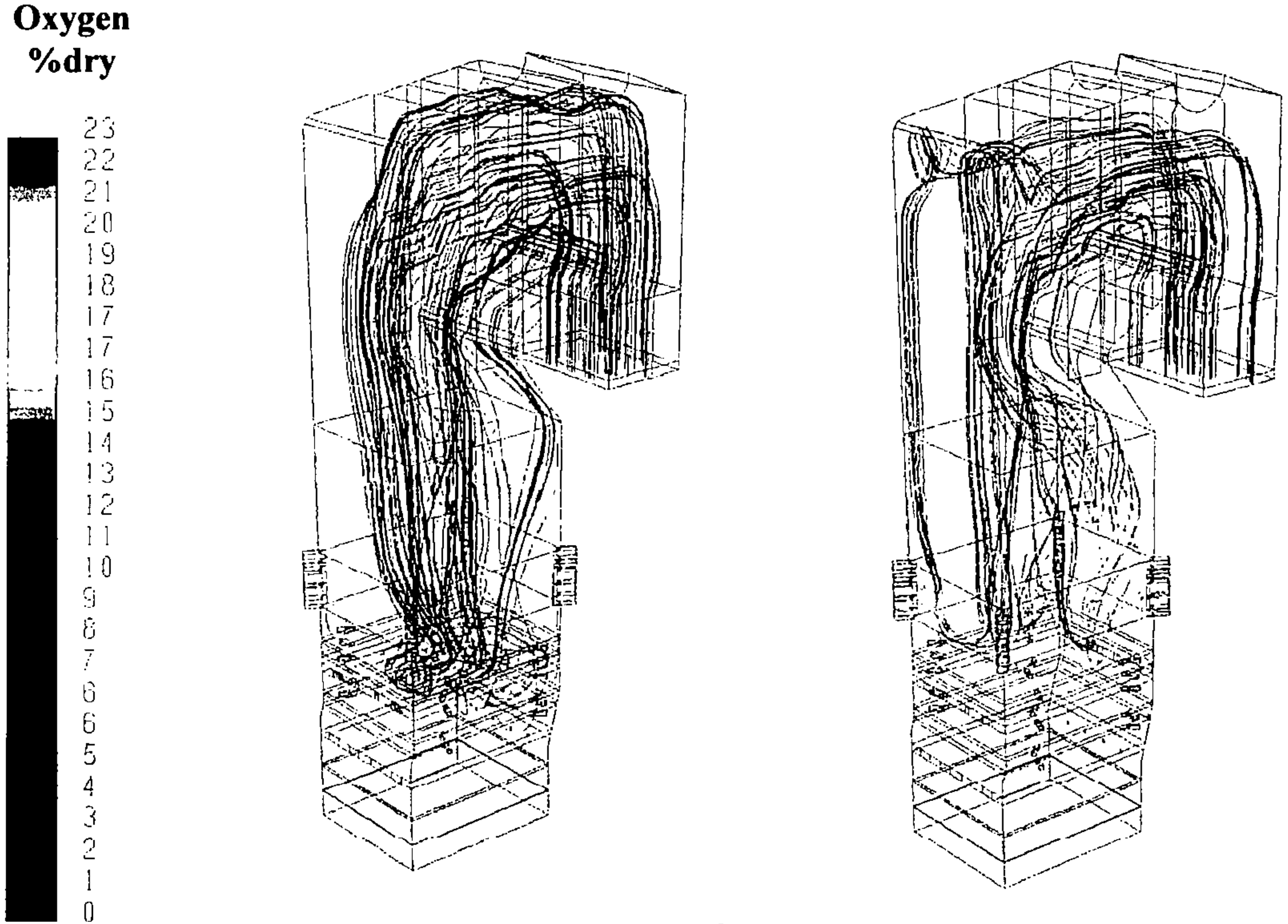


Case 3

Figure 16

Gas Path Lines

ALSTOM

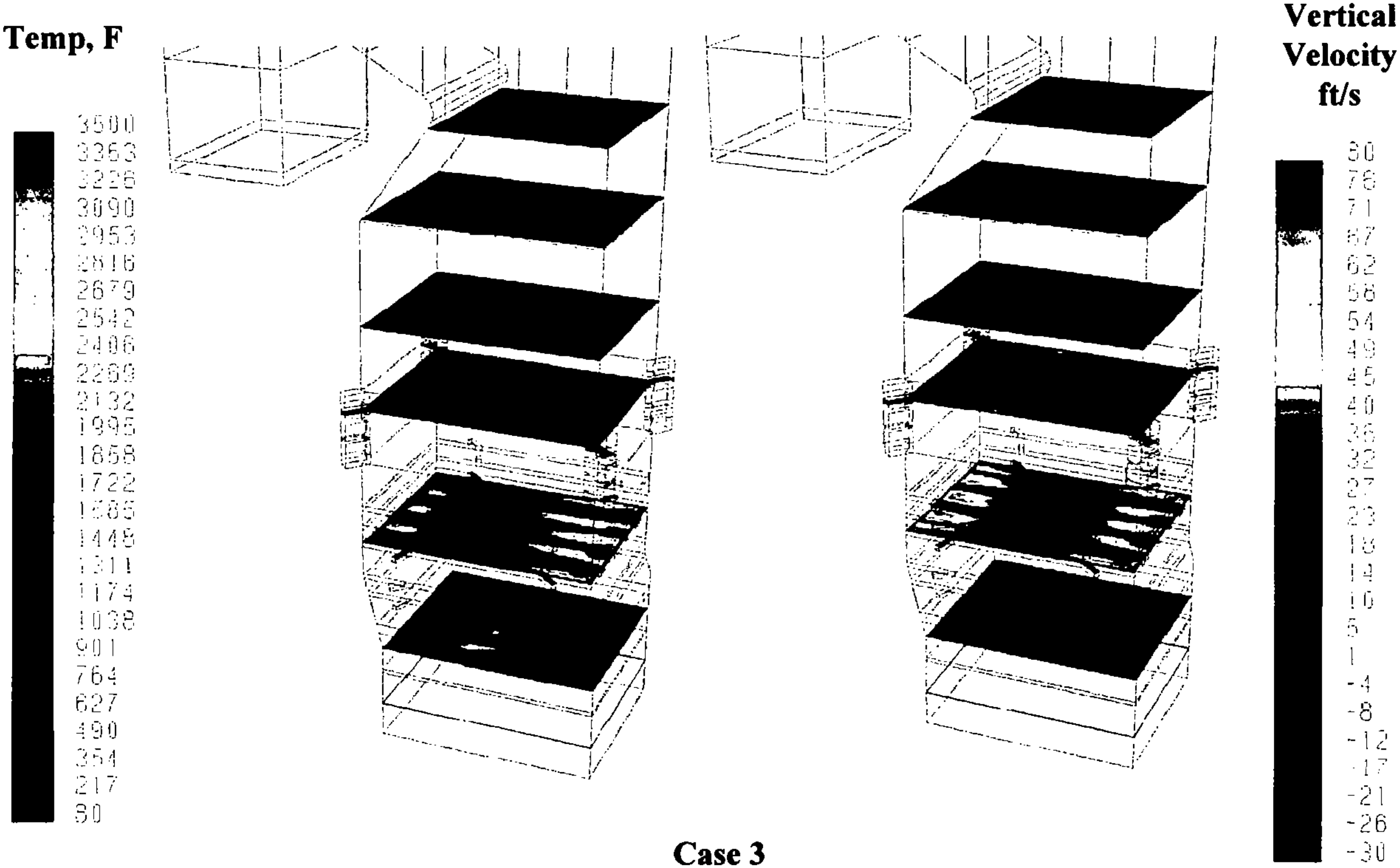


Case 3

Figure 17

Temperature & Velocity Contours

ALSTOM

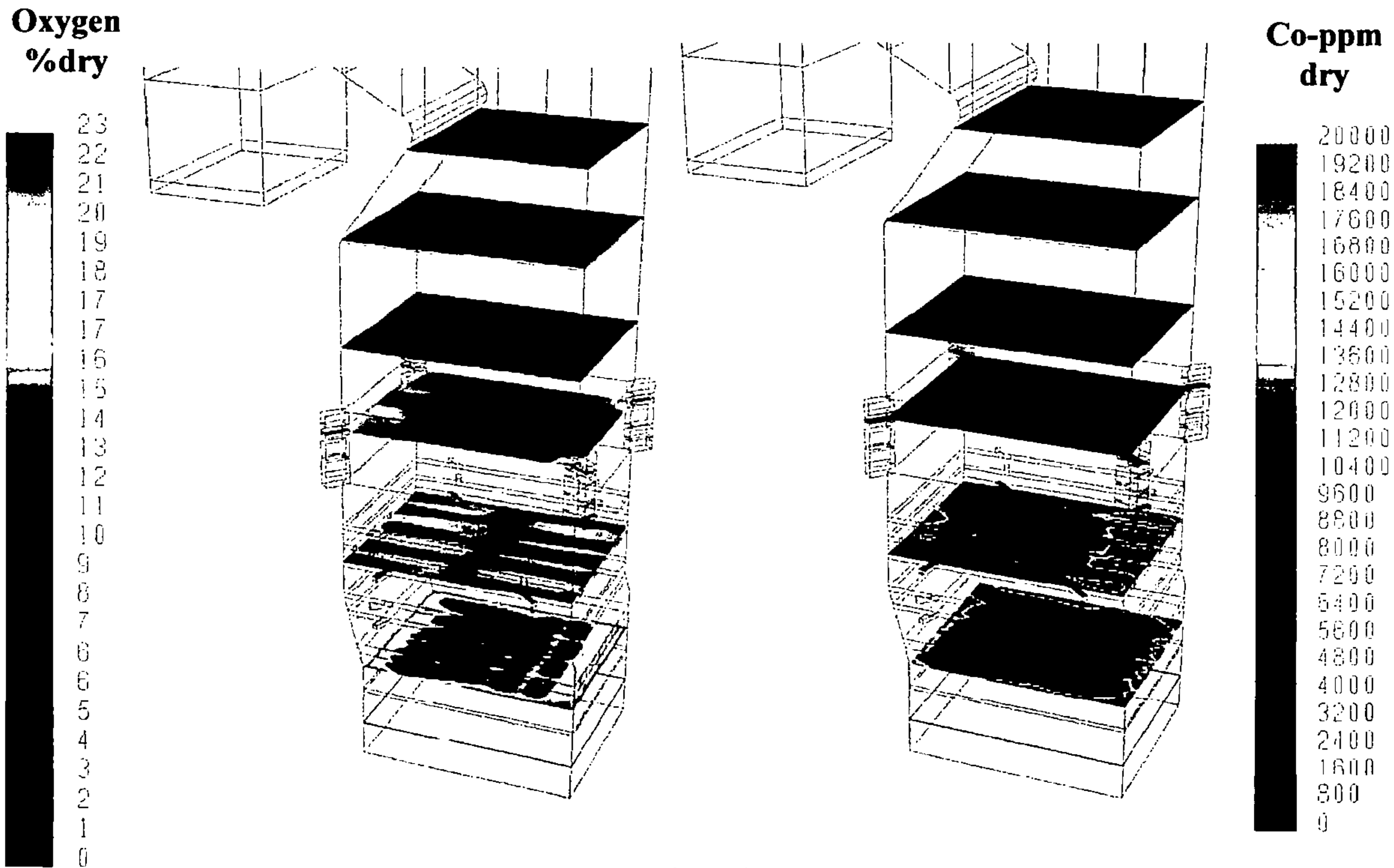


Case 3

Figure 18

O2 & CO Concentrations

ALSTOM

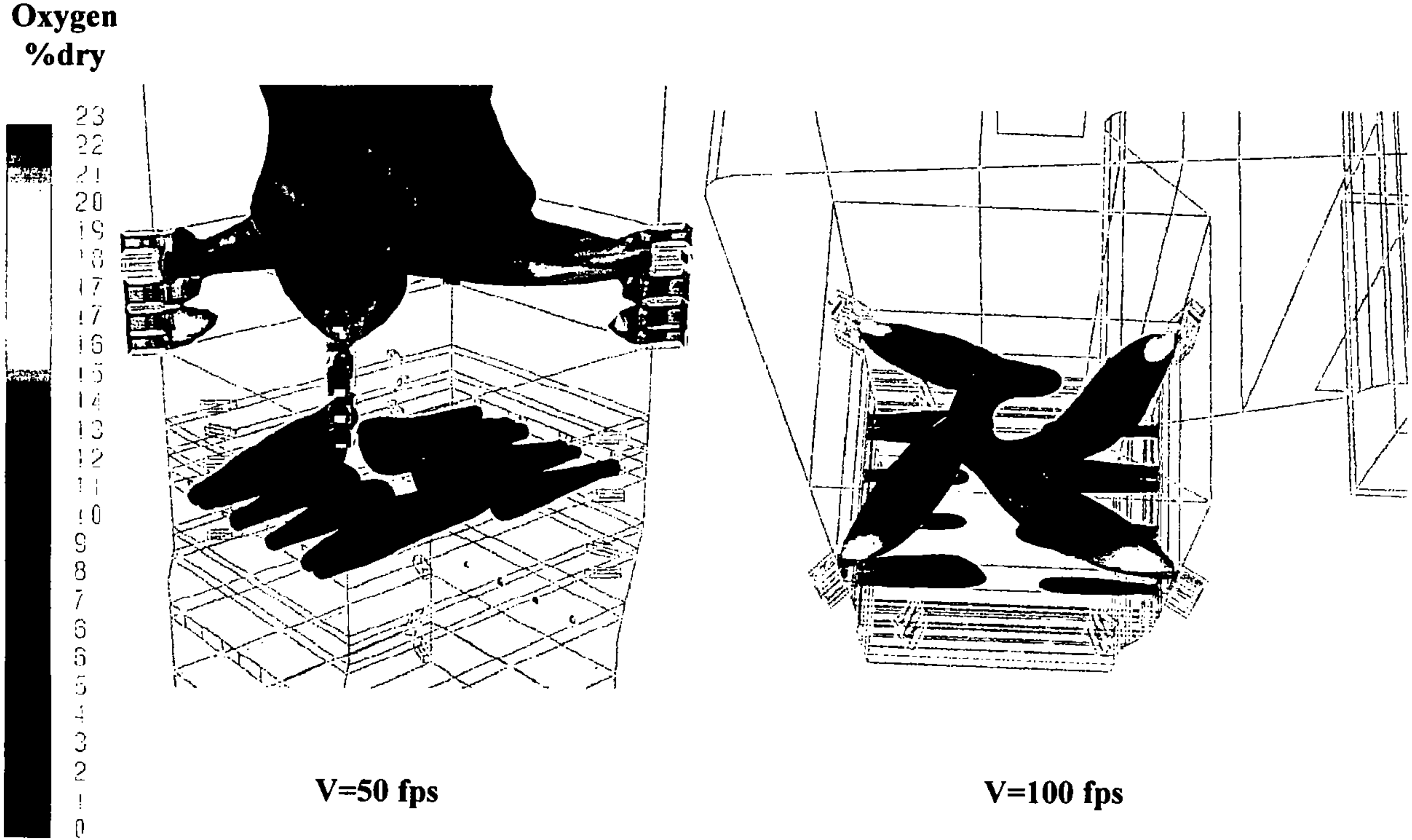


Case 3

Figure 19

Iso-Surface of Velocity

ALSTOM



V=50 fps

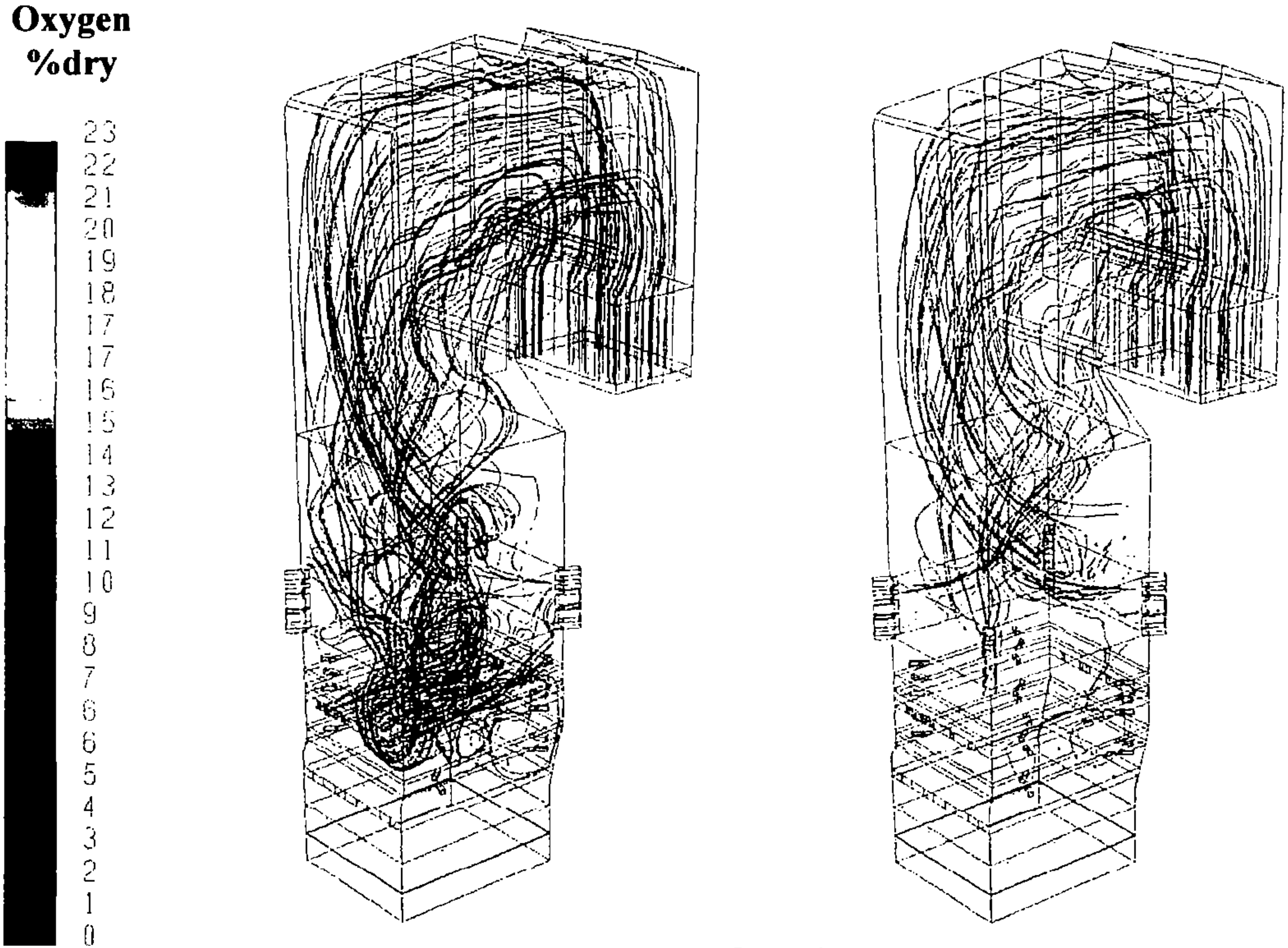
V=100 fps

Case 4

Figure 20

Gas Path Lines

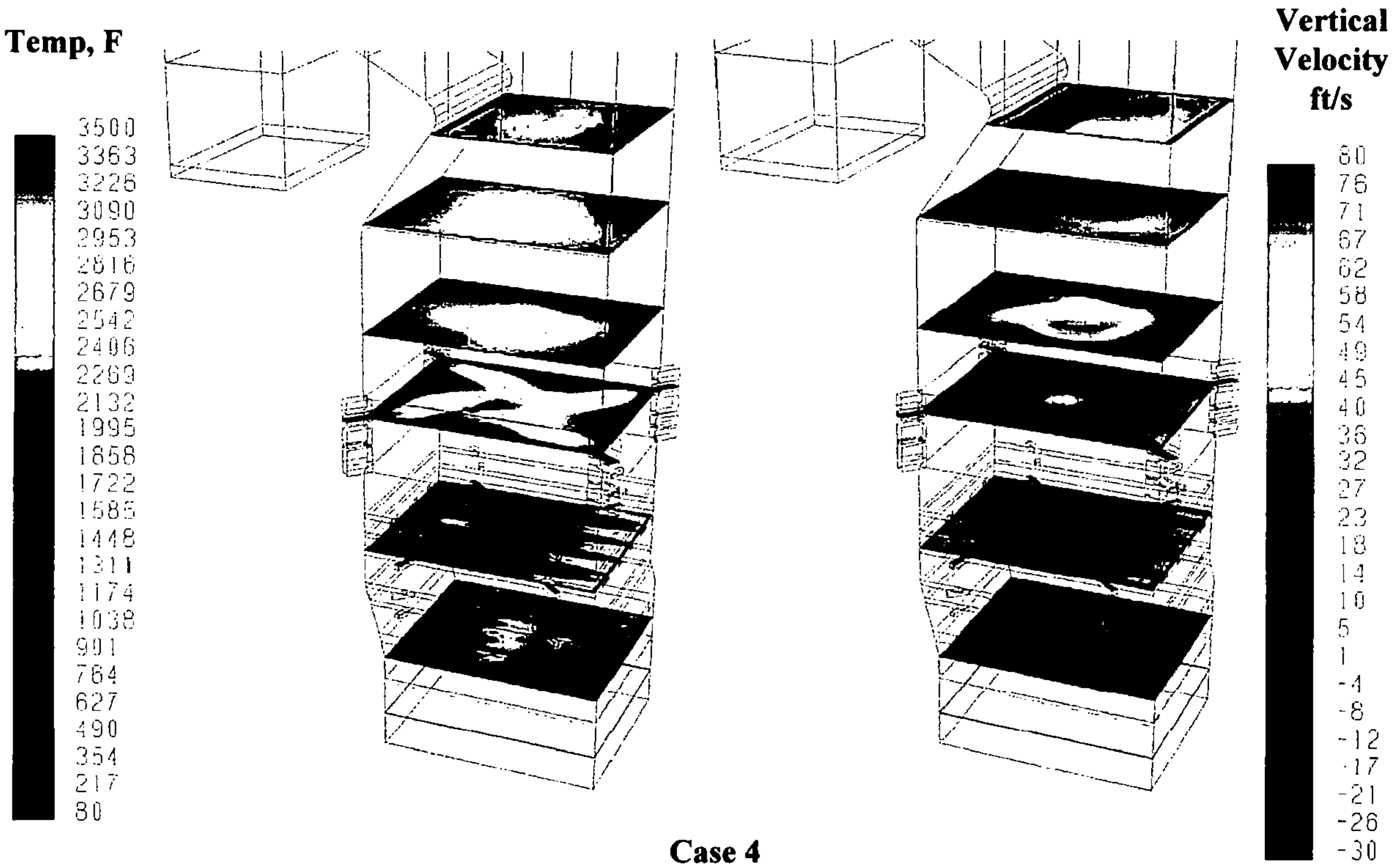
ALSTOM



Case 4

Figure 21

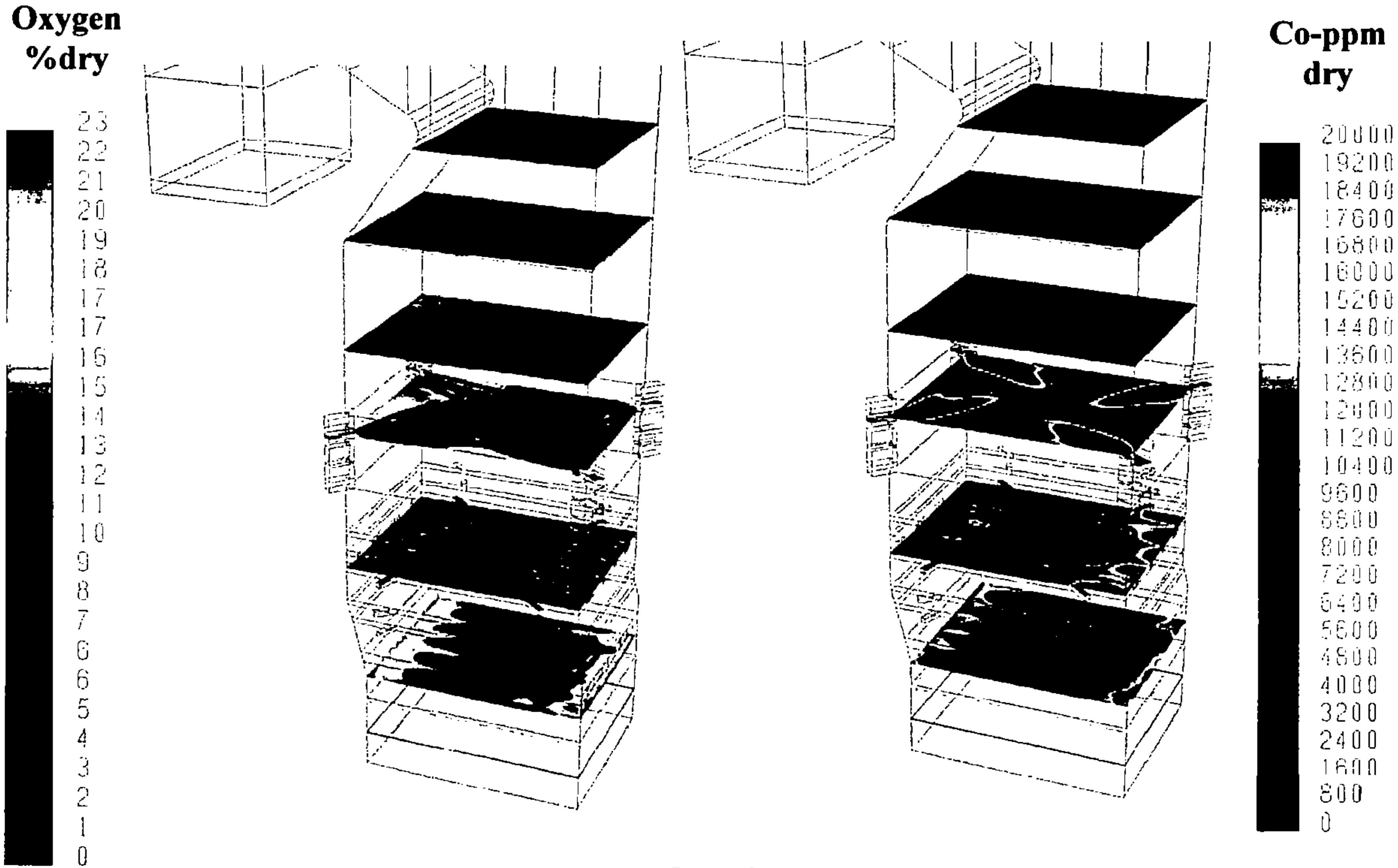
Temperature & Velocity Contours



Case 4

Figure 22

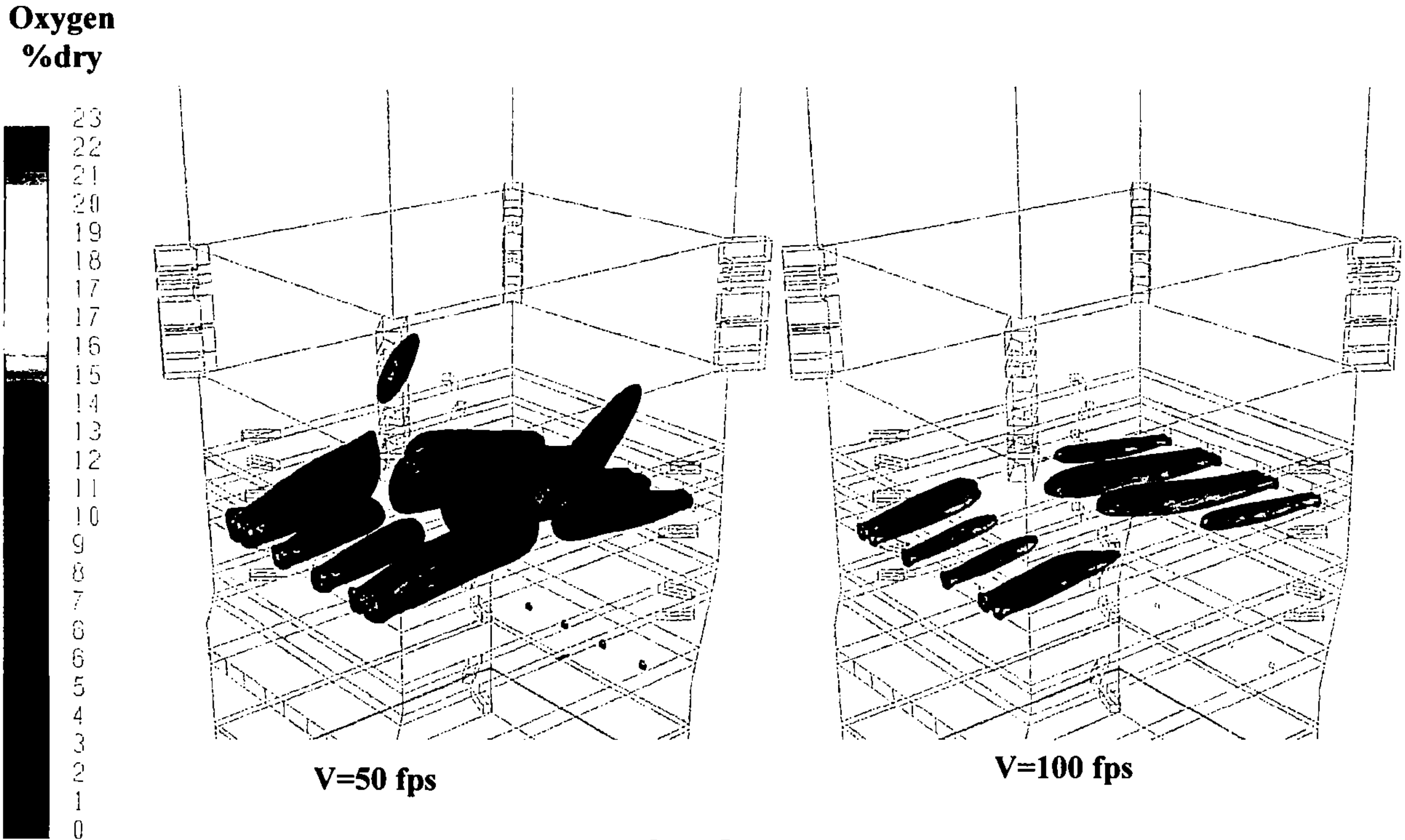
O2 & CO Concentrations



Case 4

Figure 23

Iso-Surface of Velocity



V=50 fps

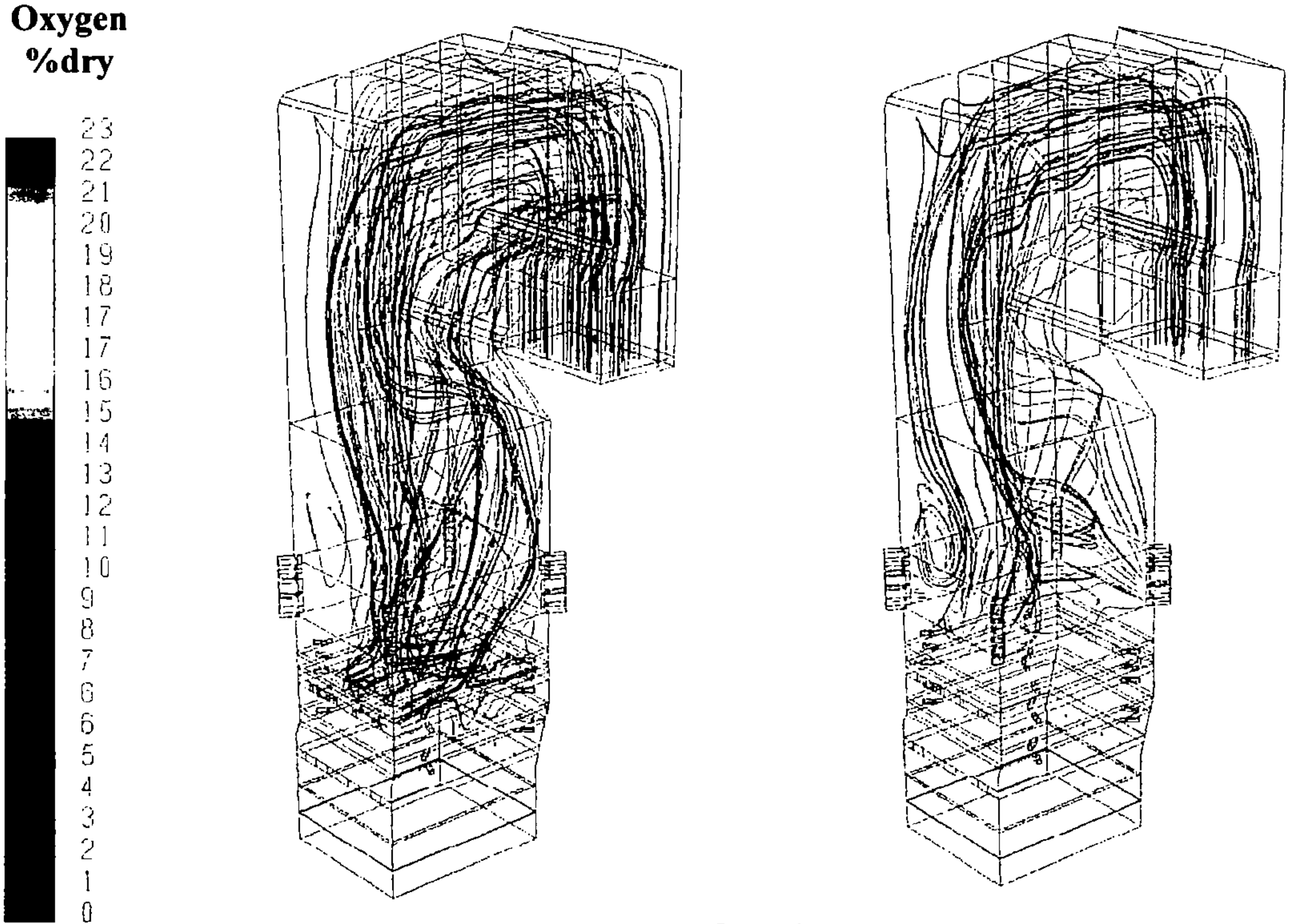
V=100 fps

Case 5

Figure 24

Gas Path Lines

ALSTOM

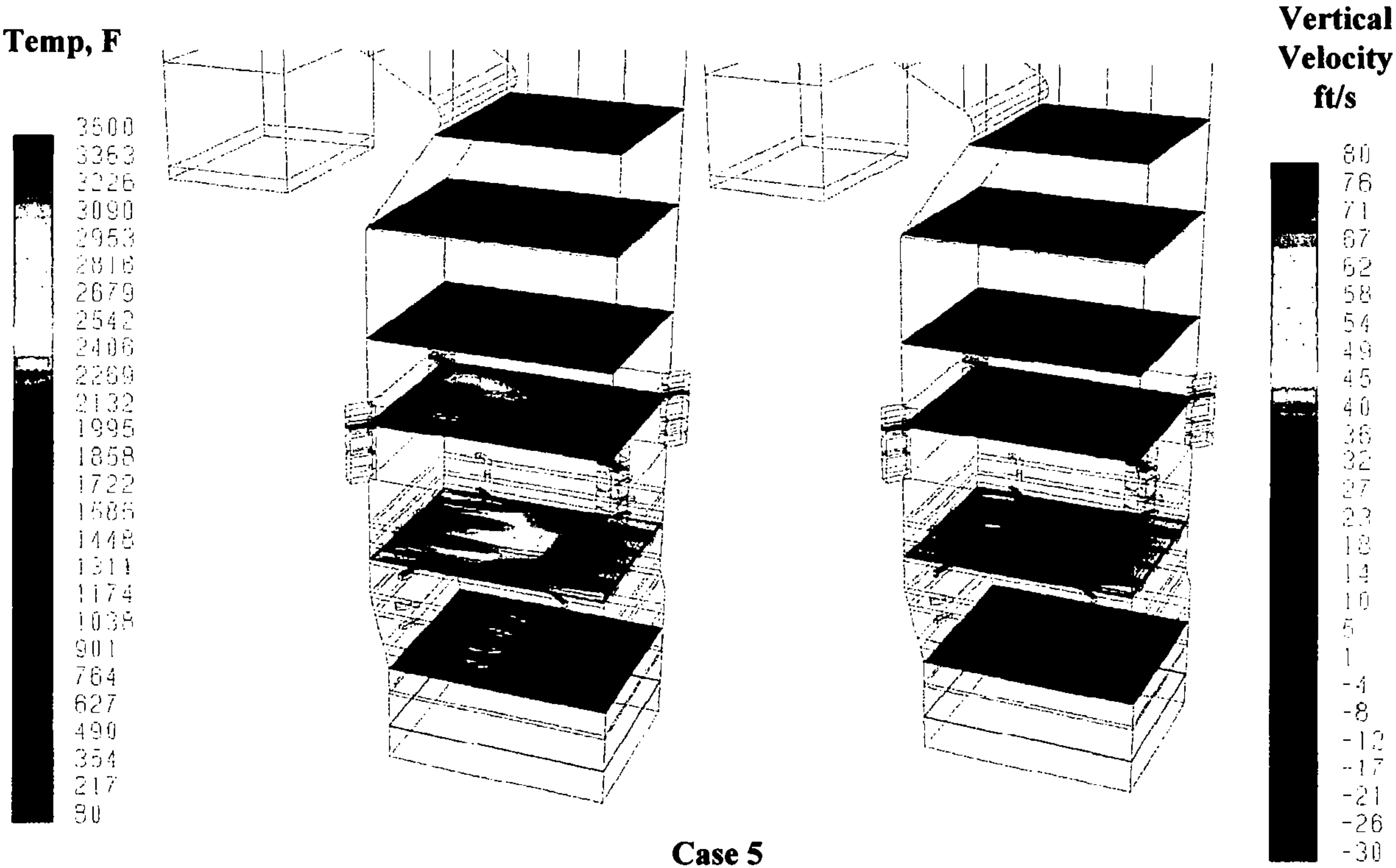


Case 5

Figure 25

Temperature & Velocity Contours

ALSTOM

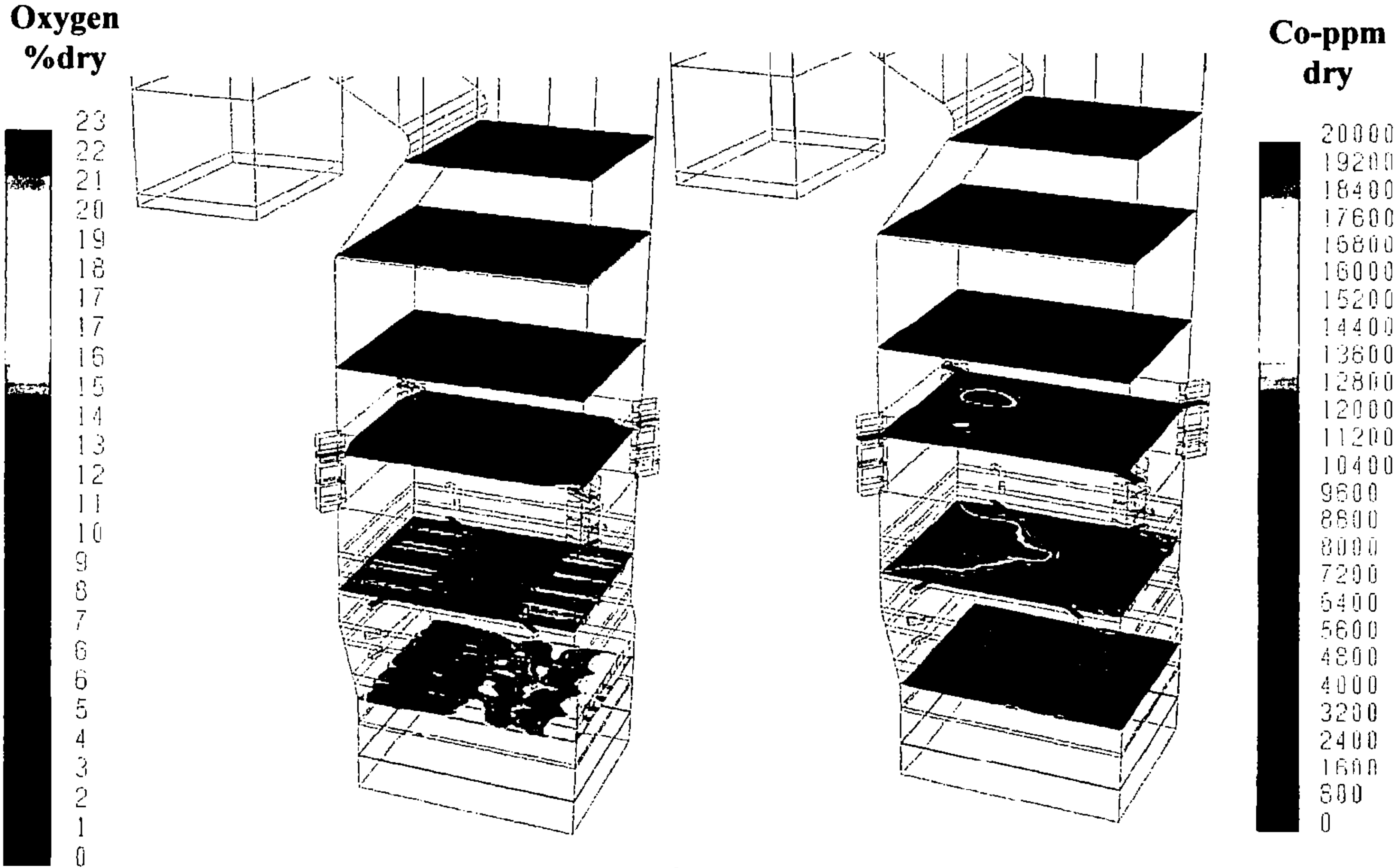


Case 5

Figure 26

O2 & CO Concentrations

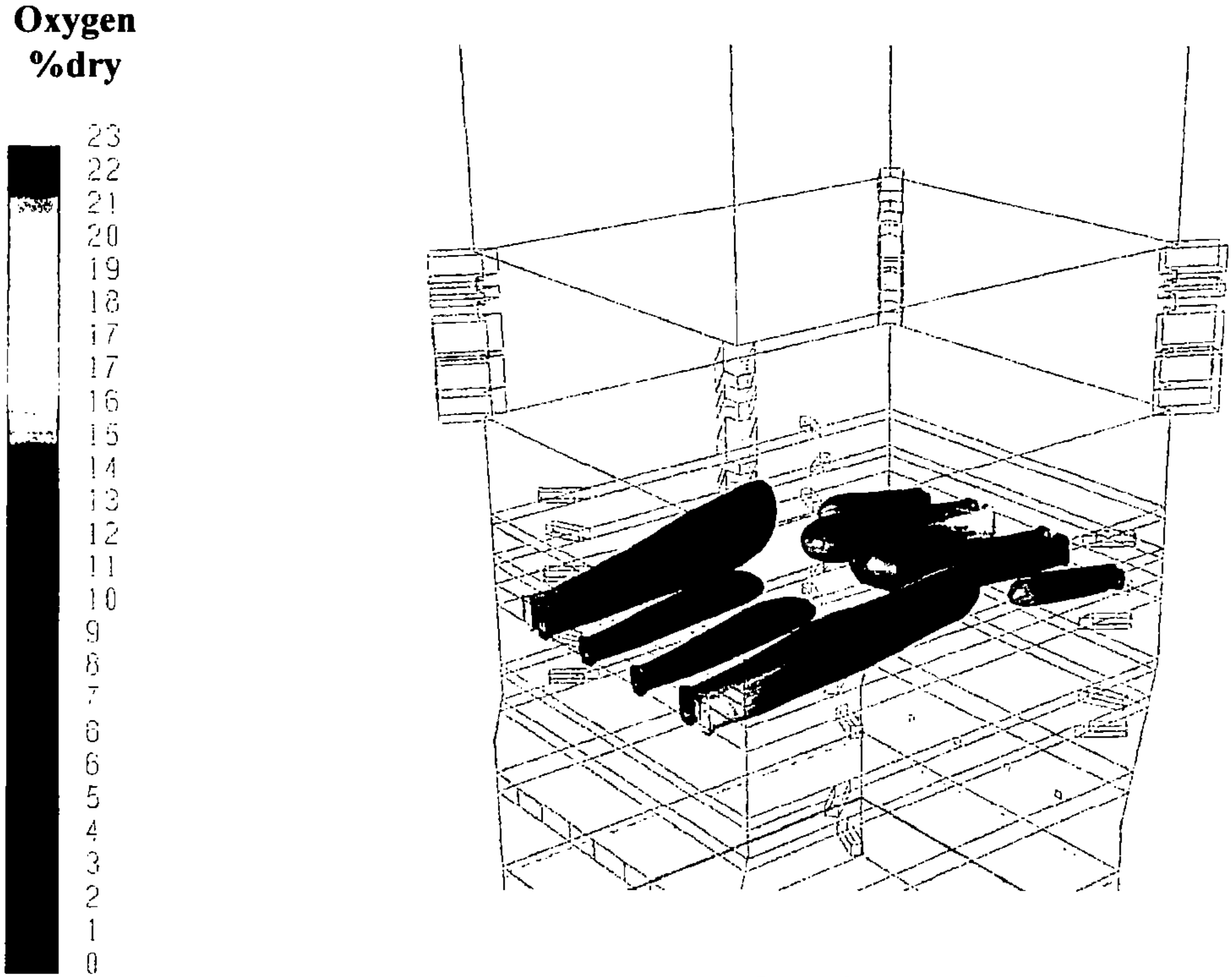
ALSTOM



Case 5

Figure 27

Iso-Surface of Velocity = 100 fps

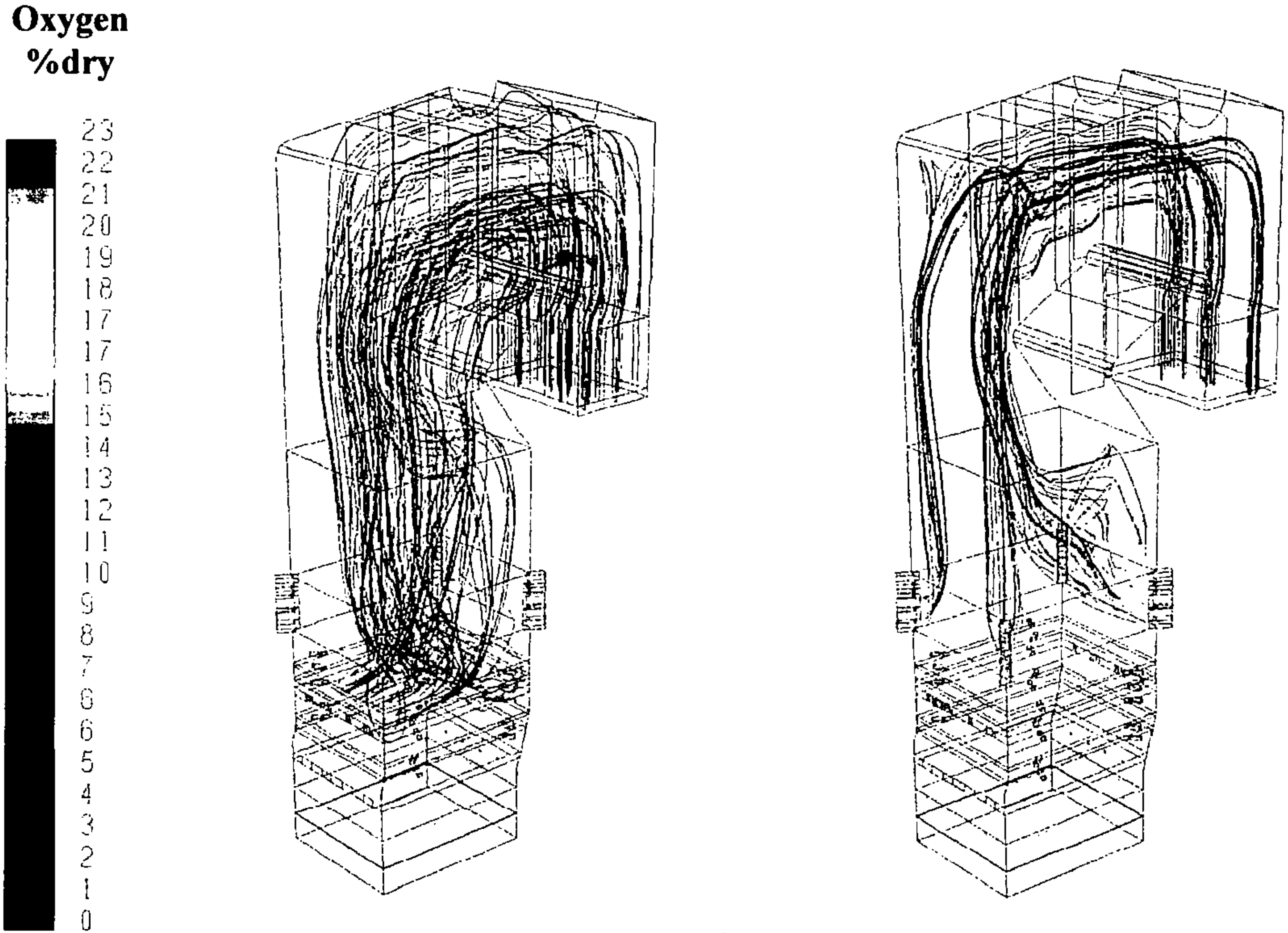


Case 6

Figure 28

Gas Path Lines

ALSTOM

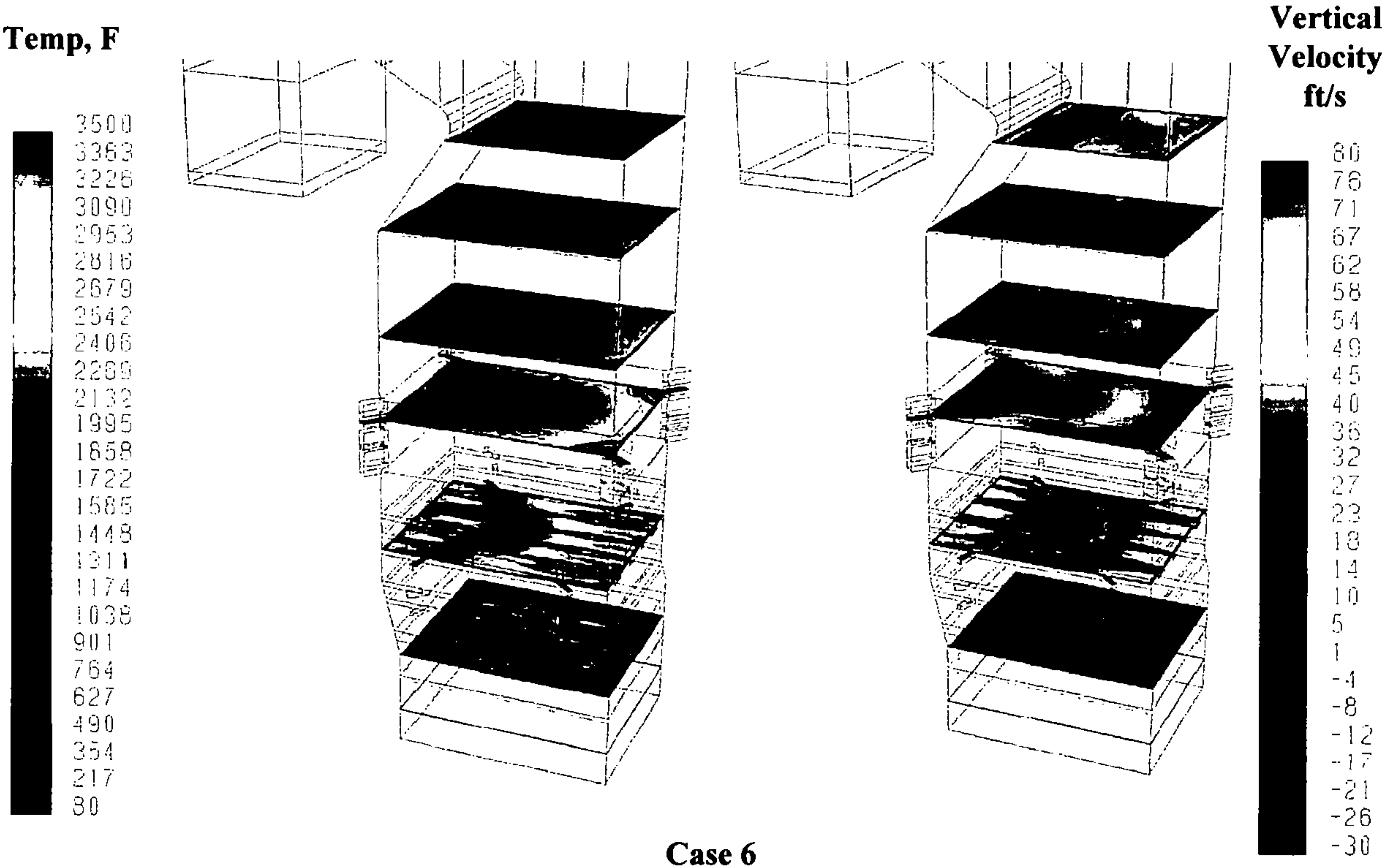


Case 6

Figure 29

Temperature & Velocity Contours

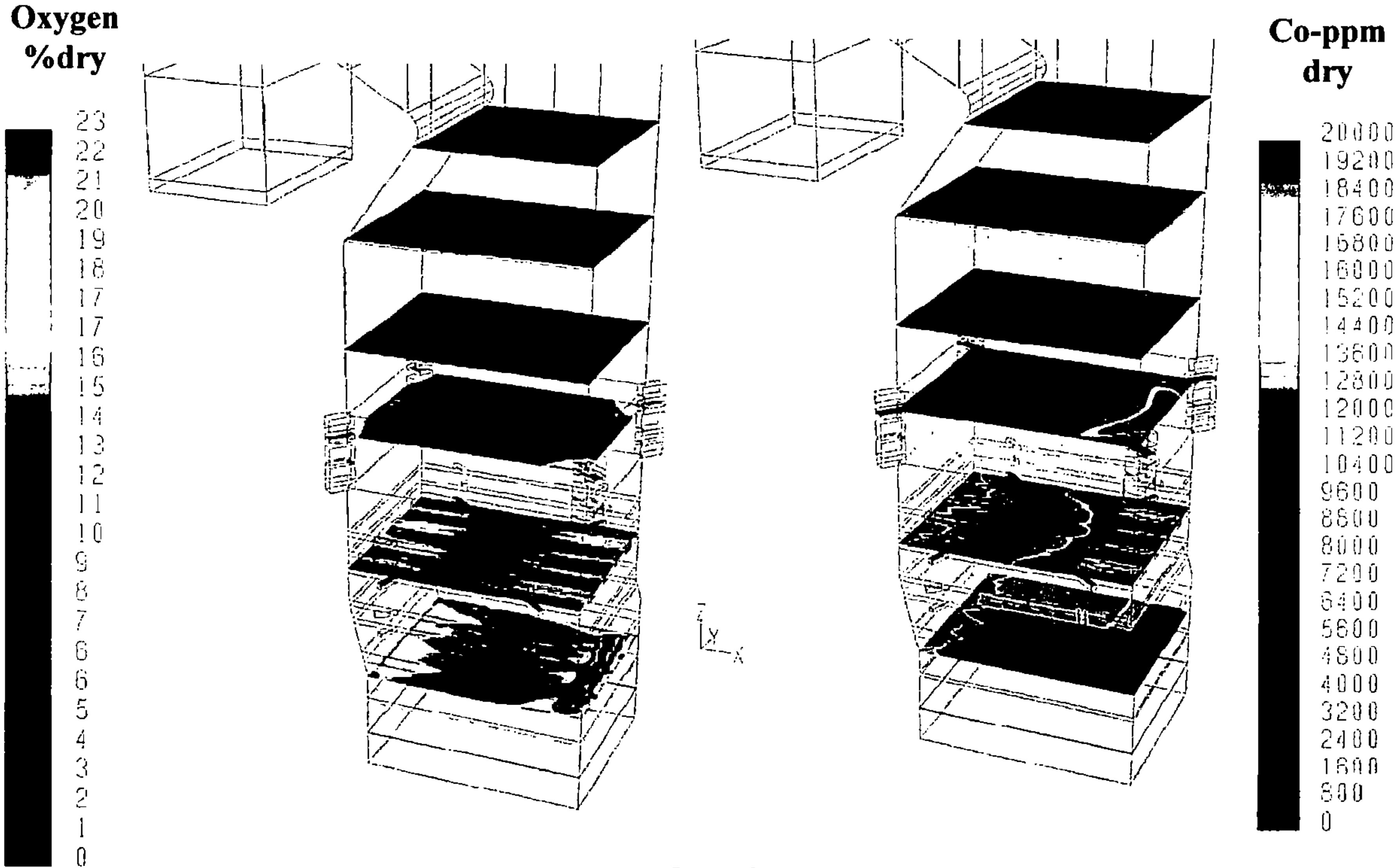
ALSTOM



Case 6

Figure 30

O2 & CO Concentrations

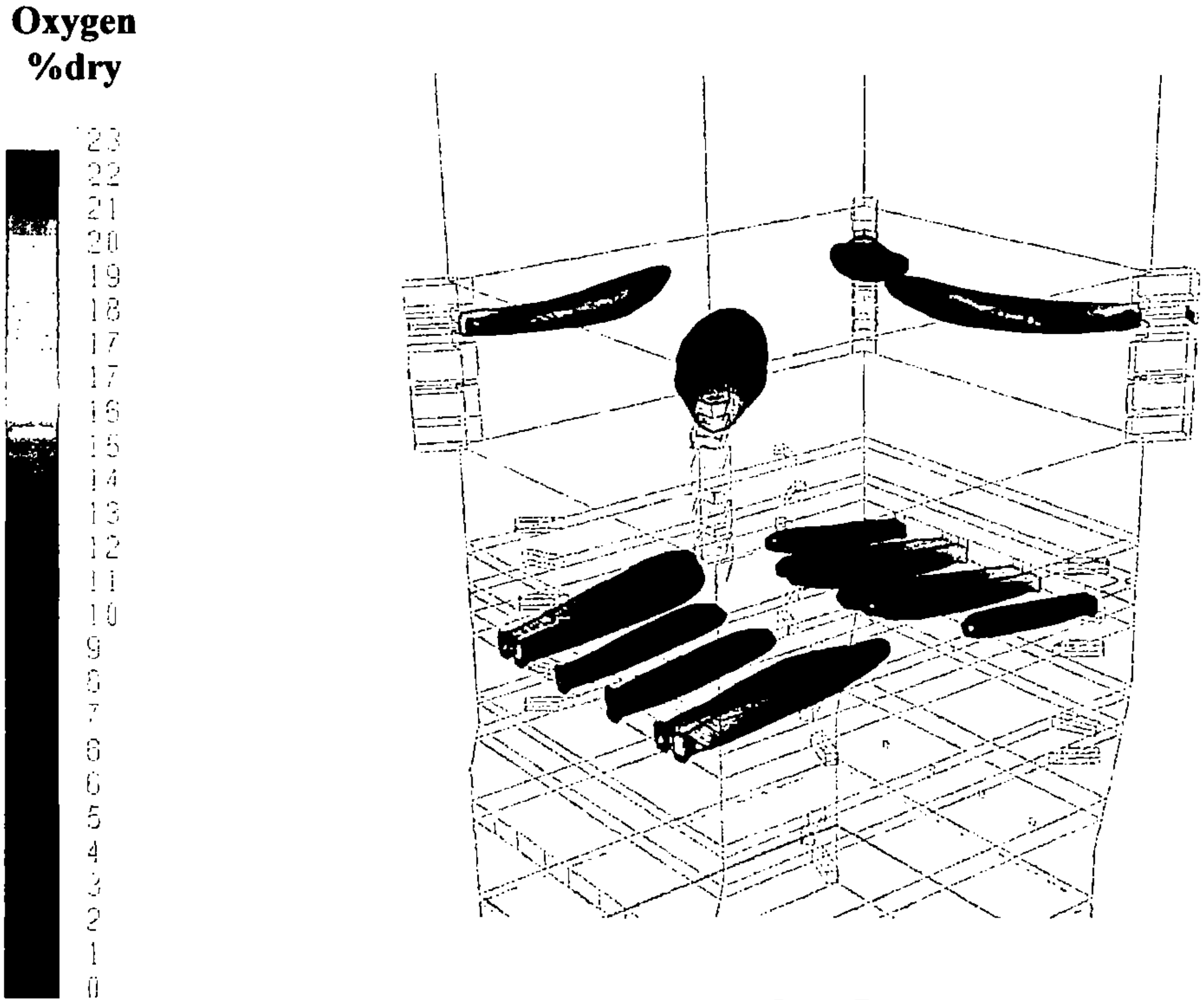


Case 6

Figure 31

Iso-Surface of Velocity = 100 fps

ALSTOM

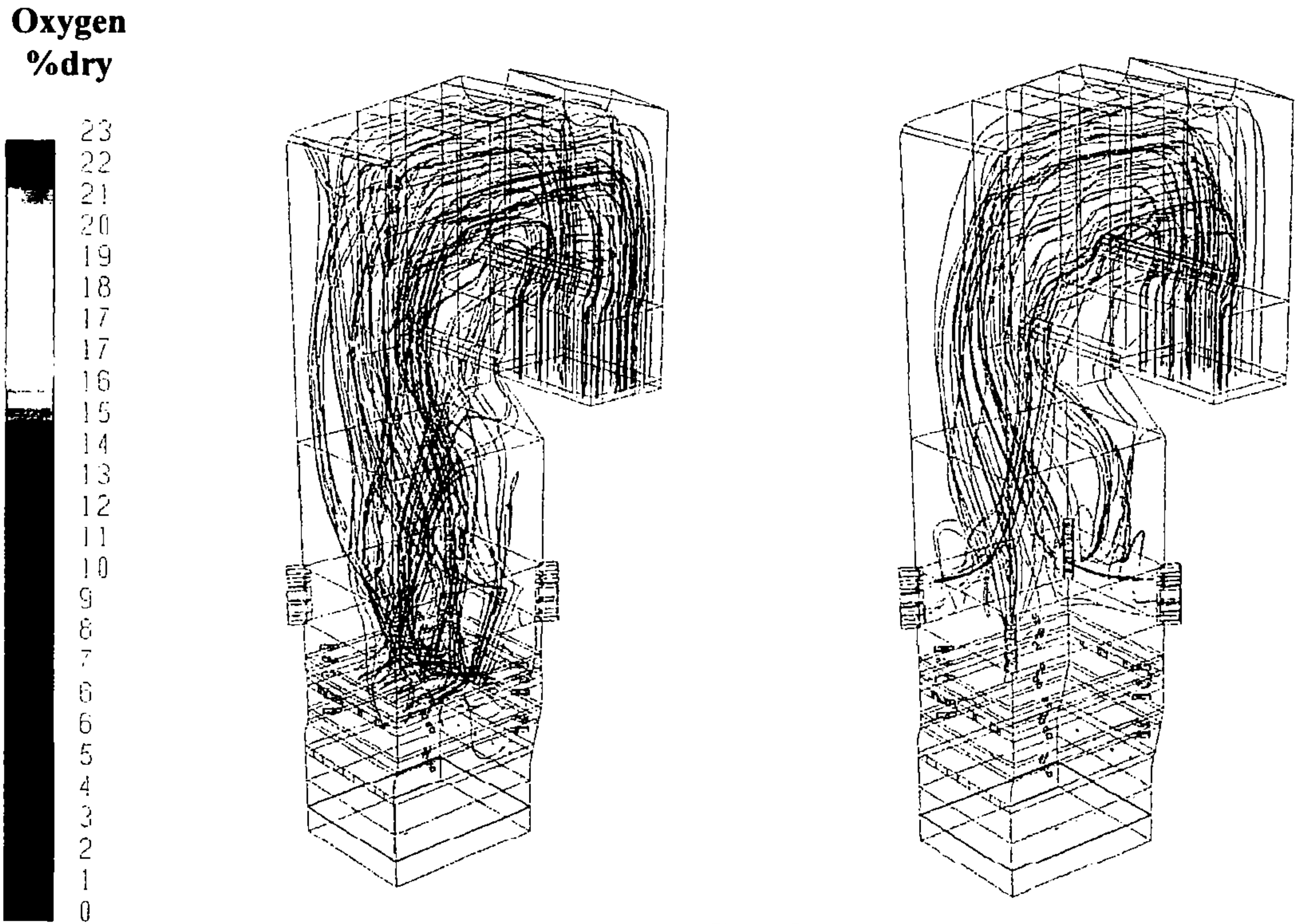


Case 7

Figure 32

Gas Path Lines

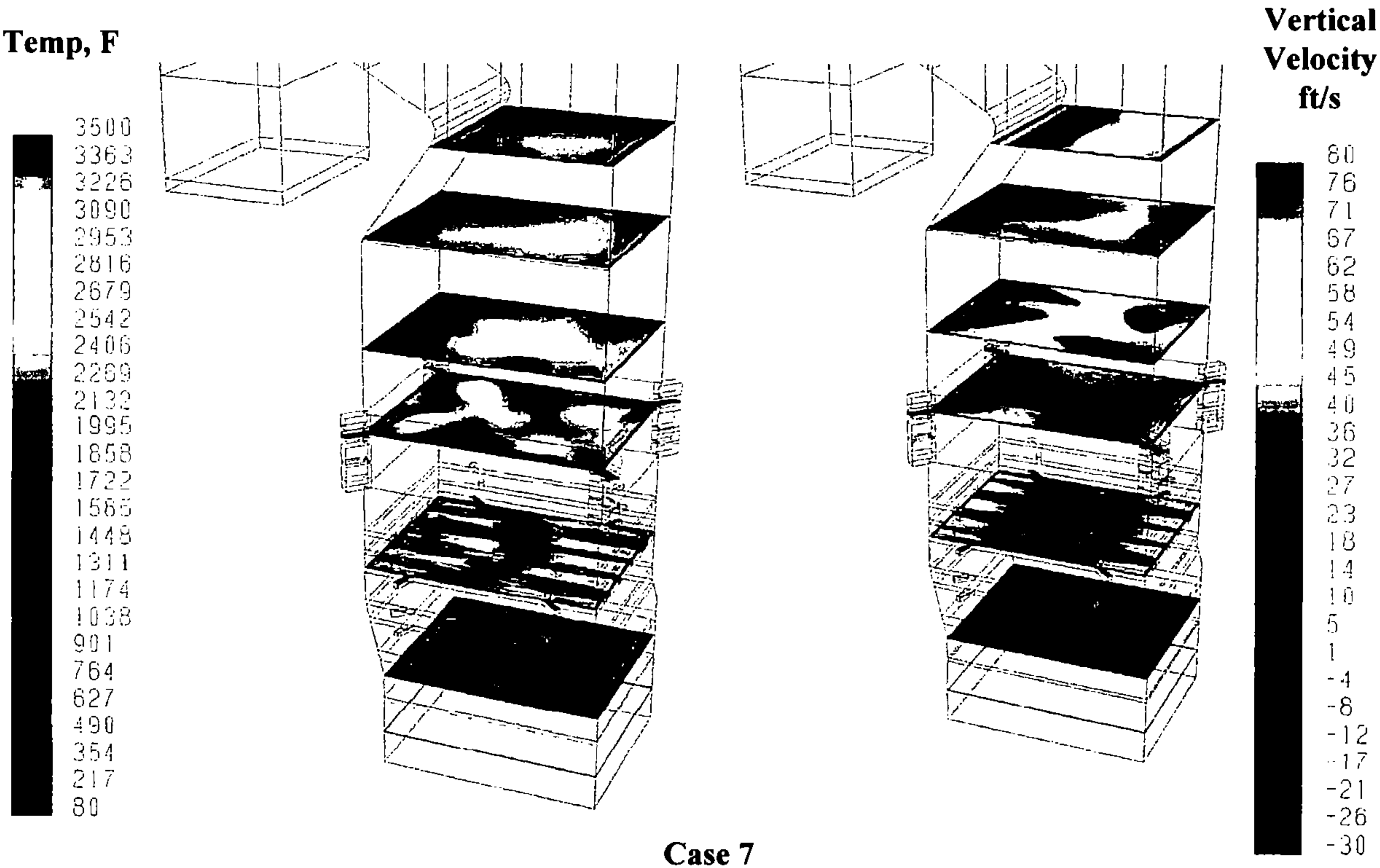
ALSTOM



Case 7

Figure 33

Temperature & Velocity Contours

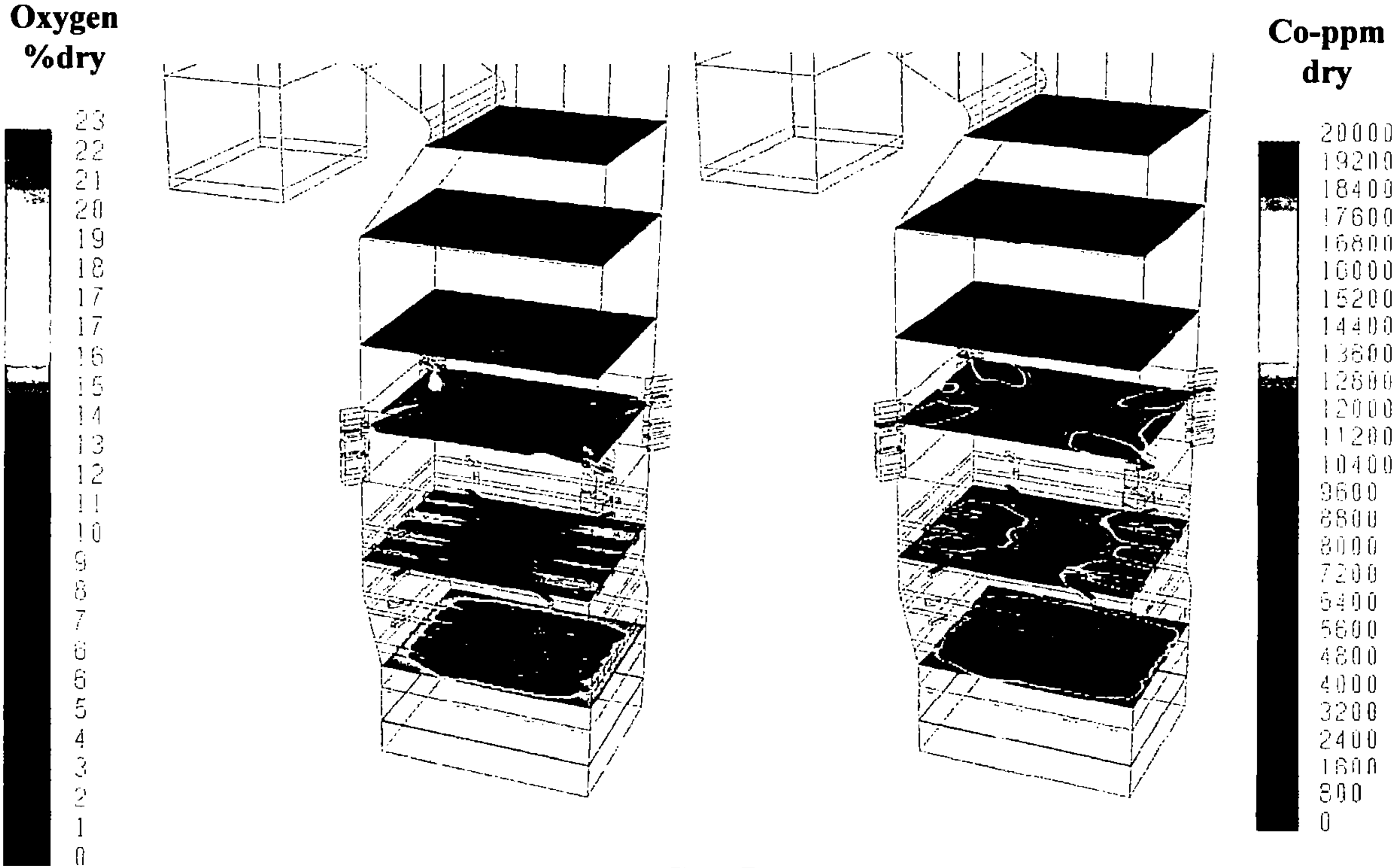


Case 7

Figure 34

O2 & CO Concentrations

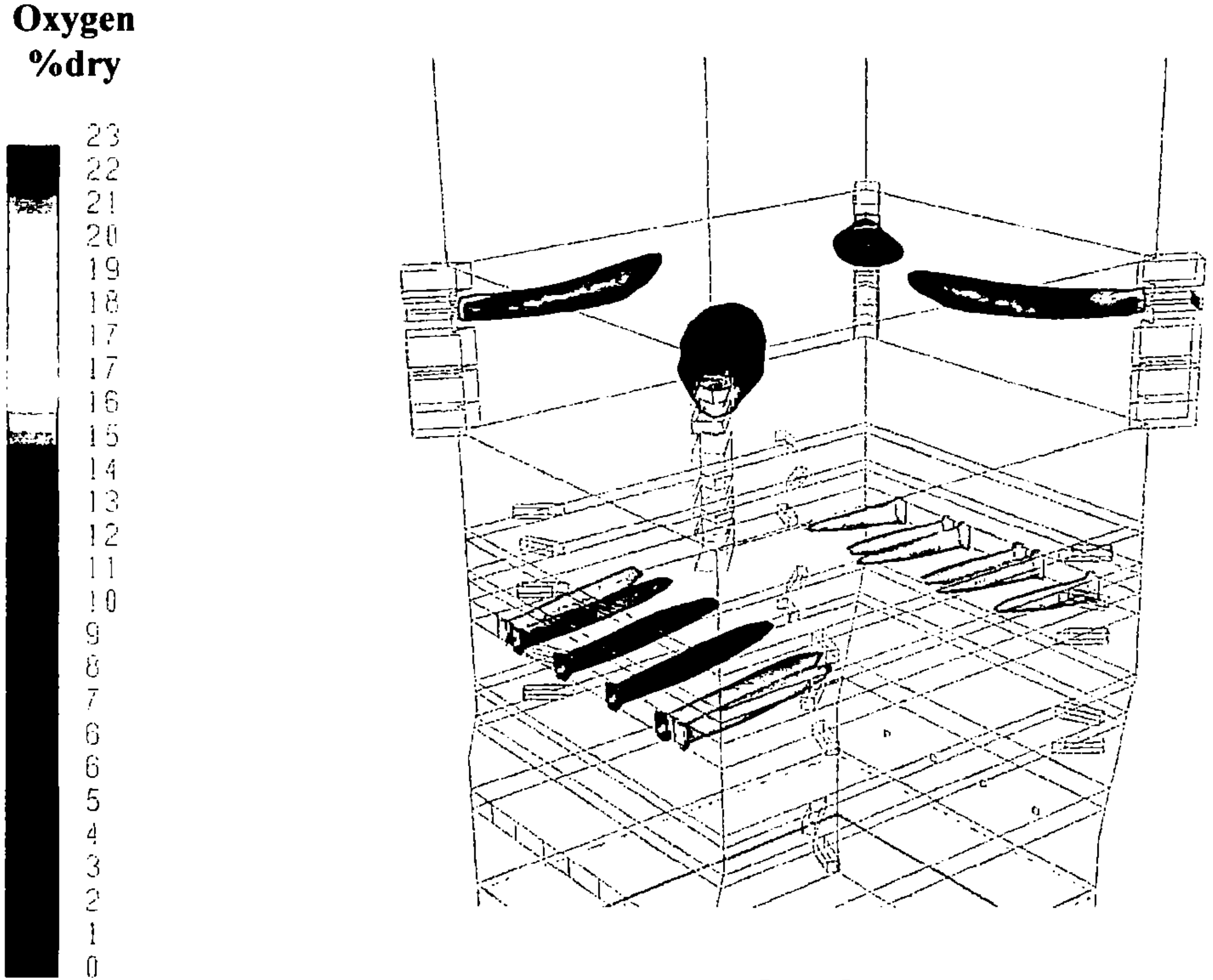
ALSTOM



Case 7

Figure 35

Iso-Surface of Velocity = 100 fps

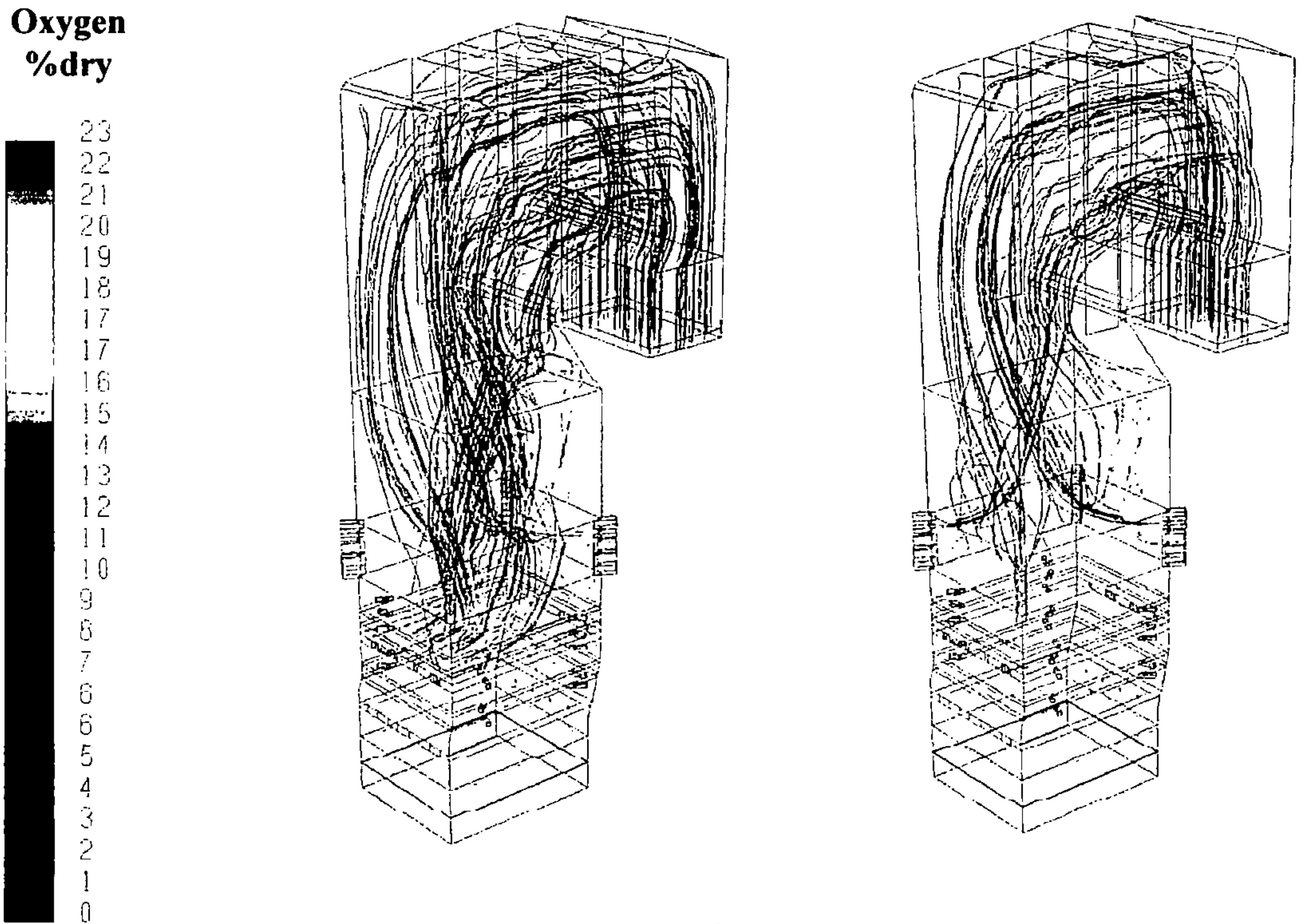


Case 8

Figure 36

Gas Path Lines

ALSTOM

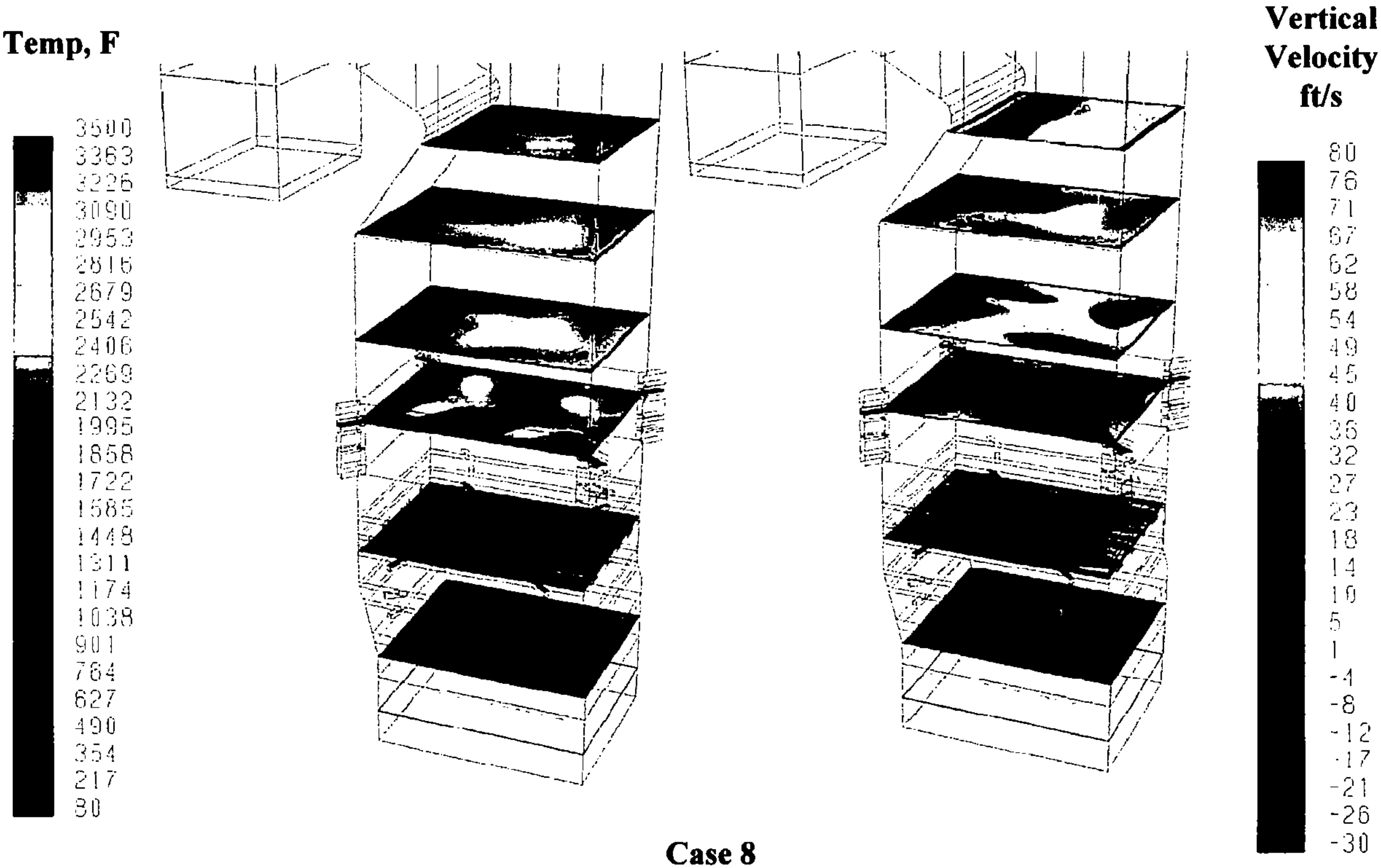


Case 8

Figure 37

Temperature & Velocity Contours

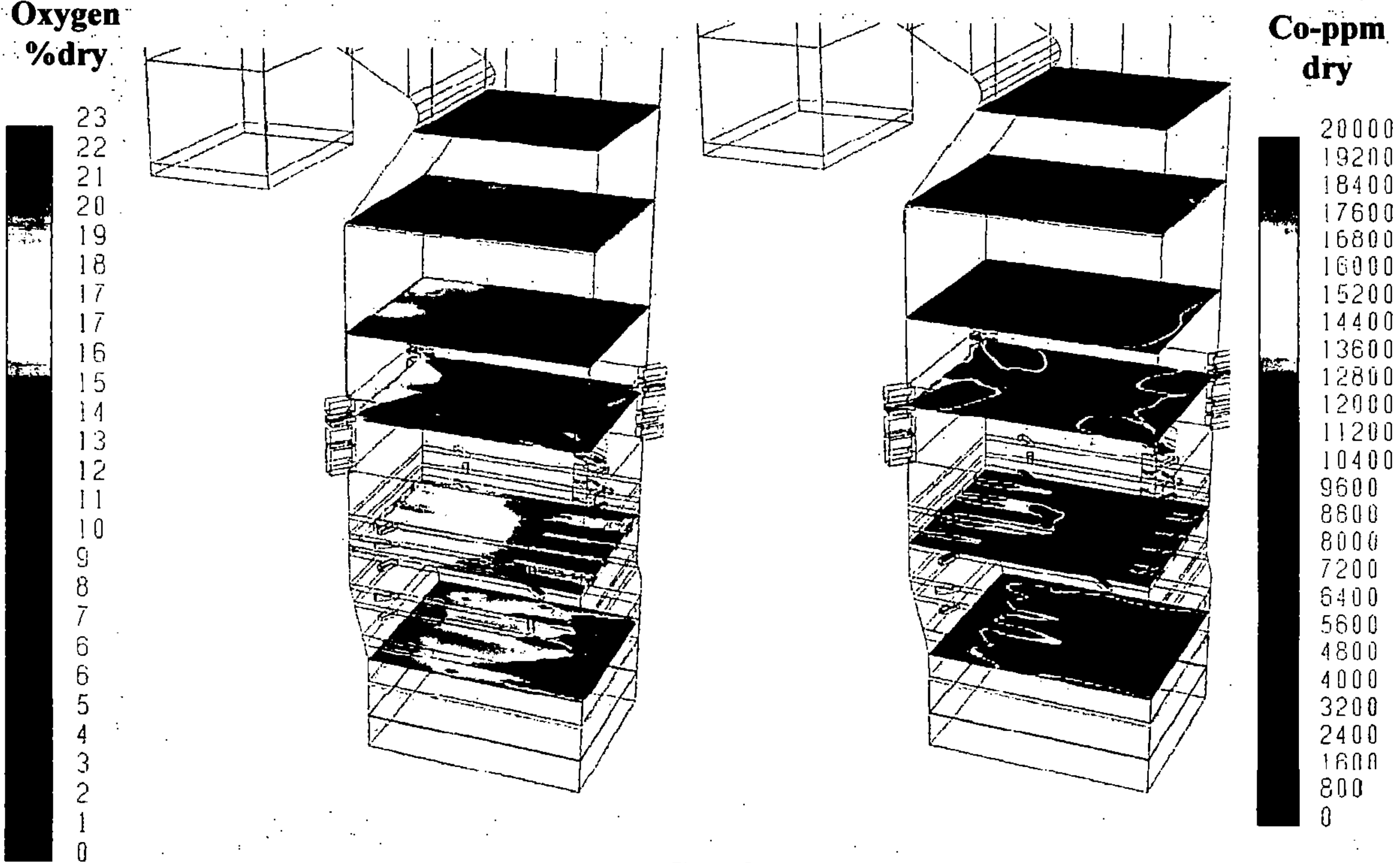
ALSTOM



Case 8

Figure 38

O2 & CO Concentrations



Case 8