PB 198 350

SYSTEMS ANALYSIS OF EMISSIONS AND EMISSIONS CONTROL IN THE IRON FOUNDRY INDUSTRY. VOLUME III. APPENDIX

A. T. Kearney and Company
Chicago, Illinois

February 1971

APCO-DPCE

CONTRACT NO. CPA 22-69-106

SYSTEMS ANALYSIS OF EMISSIONS AND EMISSIONS CONTROL IN THE IRON FOUNDRY INDUSTRY

VOLUME II - APPENDIX

FEBRUARY 1971

A. T. KEARNEY & COMPANY, INC.

BIBLIOGRAPHIC DATA SHEET	1. Report No. APTD-0646	2.	3. Recipient's Accession No.

4. Title and Subtitle

Systems Analysis of Emissions and Emissions Control in the Iron Foundry Industry Volume III - Appendix

5. Report Date February 1971

6.

7. Author(s)

8. Performing Organization Rept. No.

9. Performing Organization Name and Address

A. T. Kearney & Company, Inc.
100 South Wacker Drive
Chicago, Illinois 60606

10. Project/Task/Work Unit No.

11. Contract/Grant No. CPA 22-69-106

12. Sponsoring Organization Name and Address

EPA, Air Pollution Control Office
Technical Center, Box 12055
Research Triangle Park, N. C. 27709

13. Type of Report & Period Covered

14.

15. Supplementary Notes

16. Abstracts

~~One of the volumes of~~ a study which was conducted for the purpose of defining the air pollution problems of the iron foundry industry and of setting priorities for research and development activities that will lead to improved emission control capabilities at reduced cost. ~~This volume~~ consists of the following appendices: Bibliography, Data bank, material and heat balance of foundry melting furnances, Detail Economic Cost Curves, Emission Test Procedure, and Glossary of terms. Volume I contains the text, and Volume II contains exhibits.

17. Key Words and Document Analysis. 17a. Descriptors

Foundries
Foundry Core making
Foundry sands
Airborne wastes
Air pollution control equipment
Cost analysis

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group 13/B

18. Availability Statement

Unlimited

19. Security Class (This Report) UNCLASSIFIED	21. No. of Pages 346
20. Security Class (This Page) UNCLASSIFIED	22. Price $6.00

This report was furnished to the
Air Pollution Control Office by
the A. T. Kearney Company in fulfillment of Contract No. CPA 22-69-106.

SYSTEMS ANALYSIS OF EMISSIONS AND EMISSIONS CONTROL IN THE IRON FOUNDRY INDUSTRY

VOLUME III - APPENDIX
FEBRUARY, 1971

For

Division of Process Control Engineering
Air Pollution Control Office
Environmental Protection Agency

Contract No. CPA 22-69-106

Prepared by
A. T. Kearney & Company, Inc.
Chicago, Illinois

346

AIR POLLUTION CONTROL OFFICE

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Metallurgia
Metals (London)
Metalworking News
Mill and Factory
Mining Congress Journal
Mitteilungen der Vereinigung der Grosskesselbesitzer (German)
Modern Casting
Modern Materials Handling
Modern Plant Operation and Maintenance
NAPCA Abstract Bulletin
Neue Huette (German)
Pit and Quarry
Plant Engineering
Pollution Atmospherique (French)
Pollution Engineering
Pollution Equipment News
Power
Power Engineering
Przeglad Odlewnictwa (Polish)
Product Engineering

NAPCA-DPCE LITERATURE SEARCH

Sources of Information

LIST OF SERIALS (continued)

Production Engineer

Radex Rundschau (German)

Roads and Streets

Rock Products

Russian Castings Production (English Translation of Liteinoe Froizvodstvo)

Safety Maintenance

Sangyo Kogai (Japanese)

Science and Technology

Smoke Prevention Association of America Proceedings

Smokeless Air

Soviet Powder Metallurgy and Metal Ceramics

Stahl und Eisen (German)

Staub (German)

Steam Engineer (London)

Steel

TAPPI

Tetsu-to-Hagane/Iron and Steel Institute of Japan Journal

33/The Magazine of Metals Producing

U.S.S.R. Literature on Air Pollution and Related Occupational Diseases

Wasser Luft und Betrieb (German)

Welding Engineer

Western Metals

Zeitschrift des Nereins Deutscher Ingenieure (German)

Zentralblatt fur Arbeitsmedizin und Arbeitsschütz (Darmstadt) (German)

DATA BANK

All the data compiled on the foundries are contained in the data bank which is a part of this appendix. The actual listing of the data is given in Exhibit I of this appendix.

Exhibit I is divided into six sections with each section dealing with a different aspect of the foundry data. Each section begins with the foundry identification number and this number, therefore, provides the key between sections when obtaining additional data listed for that foundry number.

If a foundry number is omitted in a section it can be assumed that the data was not available or did not apply as the case may be.

The headings for each section which describe the data fields are, for the most part, abbreviations. A listing of the abbreviations and the appropriate descriptions are given in the Format for the Data Bank, Exhibit II of this appendix. The format for the data bank is arranged in sections which correspond to the sections of the data bank, Exhibit I.

In several cases the data is provided as coded input. The explanation of the code is given after the appropriate description of the abbreviated heading in Exhibit II.

GENERAL FOUNDRY DATA

FDRY NO.	CO TY	LOC	MET CST	PERCENT CAST GI	PERCENT CAST MI	PERCENT CAST DI	TON/MONTH MELT GI	TON/MONTH MELT MI	TON/MONTH MELT DI	SIZ CLA	IND CLA	WT RG	PRO CST	NOD	ALLOY ADDITIONS TO LADLE T	LB	T	LB	T	LB	1	LB	2	LB	CUP REP	TYP FCE	VENT TAP	EFF	VENT MOLD	EFF	VISITED BY EERP	ATK
0001	01	362	1	100	000	000		00000	00000	4	3		2	0																		
0002	01	902	1	100	000	000		00000	00000	3	3		2	0																	1	
0003	01	782	1	100	000	000		00000	00000	3				0																	1	
0004	01	492	2	000	100	000	00000	19000	00000	4	1	2	5	0	0	00	0	00	0	00	3	.1	0	00	1	1	1	3	2	2		1
0005	01	918	1	100	000	000	375	00000	00000	3	6	5		0																	1	
0006	01	212	1	100	000	000				3				0																		
0007	01	606	1	100	000	000	3200	00000	00000	3	7	2	4	0	0	00	0	00	0	00	0	00	0		0	0	1	2	1	2	1	1
0008	01	802	1	100	000	000	950	00000	00000	2	7	2	4	0	0	00	0	00	0	00	0	00	0		0	0	1	2	1	2	1	1
0009	01	074	1	100	000	000	3300	00000	00000	4				0																	1	
0010	01	641	1	100	000	000		00000	00000	3				0																		
0011	01	917	1	100	000	000	1500	00000	00000	3				0																	1	
0012	01	352	5	60	000	40	18000	00000	12000	4	3	6	2	1	3	90	4	54	5	90	1				0	0	1	3	1	3	1	1
0013	01	482	1	100	000	000		00000	00000	3				0																	1	
0014	01	070	1	100	000	000		00000	00000					0																		
0015	01	441	1	100	000	000	210	00000	00000	3		5		0																	1	1
0016	01	130	1	100	000	000	3000	00000	00000	3				0																	1	
0017	01	948	5		000			00000			4	3	3	1																		
0018	01	631	5		000			00000		3	4	5	3																		1	
0019	01	534	2	000	100	000	00000		00000	4				0																		
0020	01	138	1	100	000	000		00000	00000	2				0																	1	
0021	01	532	5	20	000	80	1500	00000	5000	3	3	2	8	1	4	3	6	48			1				1	1	1	3	2	1		1
0022	01	541	1	100	000	000		00000	00000	4	5	4	6	0																	1	
0023	01	029	1	100	000	000		00000	00000	3				0																		
0024	01	482	1	100	000	000		00000	00000	4				0																		
0025	01	492	1	100	000	000		00000	00000	3	4	5		0																		

FDRY	CO	LOC	MET	PERCENT CAST			TON/MONTH MELT			SIZ	IND	WT	PRO	NOD	ALLOY ADDITIONS TO LADLE										CUP	TYP	VENT	EFF	VENT	EFF	VISITED BY	
NO.	TY		CST	GI	MI	DI	GI	MI	DI	CLA	CLA	RG	CST		T	LB	T	LB	T	LB	1	LB	2	LB	REP	FCE	TAP		MOLD		EERP	ATK
0026	01	070	1	100	000	000	1500	00000	00000	3	6	6	9	0	7	3	0	00	0	00	0	00	0	00	0	0	1		1			1
0027	01	494	1	100	000	000	2000	00000	00000	3	1	3		0	0	00	0	00	0	00	0	00	0	00	0	0	1	3	2	3		1
0028	01	802	1	100	000	000		00000	00000	2																					1	
0029	01	489	1	100	000	000	4000	00000	00000	4	1	6	1	0	4	30	0	00	0	00	0	00	0	00	0	0	1	2	1	2		1
0030	01	631	1	100	000	000		00000	00000					0																	1	
0031	01	282	1	100	000	000		00000	00000	4	3			0	0	00	0	00	0	00	0	00	0									
0032	01	606	2	000	100	000	00000	2500	00000	4	6	6	4	0	0	00	0	00	0	00	2	3	9	00	0	0	1	2	1	3		1
0033	01	482	5	90	000	10		00000		4	1		5	1																	'	
0034	01	462	1	100	000	000		00000	00000	4	1		5	0																	1	
0035	01	452	5	92	000	8	1900	00000	160	4	4	6	5	1	1	12	2	45			0	00	0		0	0	1	2	1	2	1	1
0036	01	900	1	100	000	000	120	00000	00000	2				0																	1	
0037	01	902	1	100	000	000	160	00000	00000	2				0											0	0					1	
0038	01	606	1	100	000	000		00000	00000	4	5		6	0																	1	
0039	01	374	1	100	000	000		00000	00000	4	5		6	0																		
0040	01	016	1	100	000	000		00000	00000	3				0																	1	
0041	01	902	5		000			00000		3		5		1																		
0042	01	465	7	76	21	3	4400	1200	200	4	6	6		1	4	2	7	2							1	1	1	3	1	3		1
0043	01	467	1	100	000	000	500	00000	00000	3	4	2	3	0											0	0	1	2	1	2		1
0044	01	520	1	100	000	000		00000	00000	4	2		7	0																		
0045	01	507	5		000			00000		4	2		7	1																	1	
0046	01	612	5	21	000	79	1600	00000	6000	4	2	6	7	1	3	8	4	6							1	4	1	2	2	1		1
0047	01	465	5		000			00000		3		5		1																	1	
0048	01	017	1	100	000	000	900	00000	00000	2	6	6	3	0	0	00	0	00	0	00	2	3	2	6	0	0	2	2	1	2	1	1
0049	01	503	1	100	000	000		00000	00000	2				0																		
0050	01	195	1	100	000	000		00000	00000	3				0																		

FDRY NO.	CO TY	LOC	MET CST	PERCENT CAST GI	PERCENT CAST MI	PERCENT CAST DI	TON/MONTH MELT GI	TON/MONTH MELT MI	TON/MONTH MELT DI	SIZ CLA	IND CLA	WT RG	PRO CST	NOD	ALLOY ADDITIONS TO LADLE T	LB	T	LB	T	LB	1	LB	2	LB	CUP REP	TYP FCE	VENT TAP	EFF	VENT MOLD	EFF	VISITED BY EERP	ATK
0051	01	622	1	100	000	000	5500	00000	00000	4	1	4	5	0																		
0052	01	487	1	100	000	000	6300	00000	00000	4		2		0	0	00	0	00	0	00	0	00	0		1	1	2	1	1	2		1
0053	01	801	1	100	000	000		00000	00000					0																	1	
0054	01	624	1	100	000	000		00000	00000	3				0																		
0055	01	150	1	100	000	000		00000	00000					0																		
0056	01	071	1	100	000	000		00000	00000	3				0																		
0057	01	212	5		000			00000		3	5	5	6	1																		
0058	01	440	1	100	000	000		00000	00000	4	1	5	5	0																		1
0059	01	481	5		000			00000		4	1	3	5	1																		1
0060	01	481	5		000			00000		4	1	4	5	1																		1
0061	01	441	5	89	000	11	3200	00000	40	4	5	2	5	1					8		0	00	9	00	0	0	1	2	1	2	1	1
0062	01	441	5		000			00000		4	5	4	3	1																	1	
0063	01	165	2	000	100	000	00000		00000		4			0																		
0064	01	801	1	100	000	000		00000	00000	3				0																	1	
0065	01	485	1	100	000	000		00000	00000	4	1		5	0	0	00	0	00	0	00	0	00	0									
0066	01	618	4			000			00000	4	1		5	0																		
0067	01	435	7	65	5	30	47000	4000	21000	4	1	6	5	1											0	0	1	2	2	2		1
0068	01	486	2	000	100	000	00000	43000	00000	4	1	6	5	0											1	3	1	2	2	2		1
0069	01	486	1	100	000	000	60000	00000	00000	4	1	4	5	0											1	1	2	2	2	2		1
0070	01	486	5		000			00000		4	1		5	1																		1
0071	01	142	1	100	000	000		00000	00000	4	1	4	5	0											1	1	2	2	2	2		1
0072	01	480	1	100	000	000	30000	00000	00000	4	1	6	5	0											1	1	1	3	1	2		1
0073	01	454	1	100	000	000	8000	00000	00000	4	1	3	5	0																		
0074	01	150	1	100	000	000		00000	00000	3				0																		
0075	01	146	1	100	000	000		00000	00000					0																		

FDRY NO.	CO TY	LOC	MET CST	PERCENT GI	PERCENT MI	PERCENT DI	CAST TON/MONTH MELT GI	CAST TON/MONTH MELT MI	CAST TON/MONTH MELT DI	SIZ CLA	IND CLA	WT RG	PRO CST	NOD	ALLOY ADDITIONS TO LADLE T	LB	T	LB	T	LB	1	LB	2	LB	CUP REP	TYP FCE	VENT TAP	EFF	VENT MOLD	EFF	VISITED BY EERP	ATK
0076	01	191	1	100	000	000		00000	00000	2				0																	1	
0077	01	472	1	100	000	000	3300	00000	00000		6	5	3	0																		
0078	01	131	1	100	000	000		00000	00000	3				0																	1	
0080	01	917	1	100	000	000		00000	00000					0																	1	
0081	01	917	1	100	000	000	400	00000	00000	3	4	4	3	0																	1	
0082	01	631	1	100	000	000		00000	00000					0																		
0083	01	303	1	100	000	000	2350	00000	00000	3				0																	1	
0084	01	515																														
0085	01	175																														
0086	01	917	1	100	000	000		00000	00000					0																	1	
0087	01	619	1	100	000	000	500	00000	00000	3	6	6		0	0	00	0	00	0	00	0	00	0		0	0	1	3	1	3		1
0088	01	088	1	100	000	000		00000	00000	4	4	5	3	0																	1	
0089	01	606	1	100	000	000		00000	00000	2	2		7	0																		
0090	01	462	1	100	000	000	11200	00000	00000	4	1	6	5	0							1	6	1	9	0	0	2	1	2	1		1
0091	01	402	1	100	000	000	10500	00000	00000	4	2	6	7	0	4	2	5	10			1	10	2	12	0	0	1	2	2	2		1
0092	01	531	2	000	100	000	00000		00000	4	2		7	0																		
0093	01	601	5	50	000	50	1850	00000	1850	3	3	5	2	1	6	99	4	13	8	30	1	13			0	0	2	2	1	3		1
0094	01	352	5	85	000	15	6800	00000	1200	4	5	4	6	1	4	50	6				1				0	0	2	3	1	3		1
0095	01	534	1	100	000	000		00000	00000	4				0																	1	
0096	01	488	1	100	000	000	125	00000	00000	2				0																	1	
0097	01	083	1	100	000	000		00000	00000	2				0																		
0098	01	482	1	100	000	000		00000	00000	4			1	0																	1	
0099	01	611	1	100	000	000	5000	00000	00000	4	1	4	1	0	0	00	0	00	0	00	0	00	0	00	1	1	1	2	1			1
0100	01	176	2	000	100	000	00000		00000					0																		
0101	01	075	1	100	000	000		00000	00000	4				0																	1	

FDRY NO.	CO TY	LOC	MET CST	PERCENT CAST GI	PERCENT CAST MI	PERCENT CAST DI	TON/MONTH MELT GI	TON/MONTH MELT MI	TON/MONTH MELT DI	SIZ CLA	IND CLA	WT RG	PRO CST	NOD	ALLOY ADDITIONS TO LADLE T	LB	T	LB	T	LB	1	LB	2	LB	CUP REP	TYP FCE	VENT TAP	EFF	VENT MOLD	EFF	VISITED BY EERP	ATK
0102	01	024	1	100	000	000	500	00000	00000	3		5	2	0																		
0103	01	631	1	100	000	000		00000	00000	3				0																		
0104	01	900	5		000			00000		3	6	4	3	1	5						0	00	9	00	1	1	1	1	1	2		
0105	01	191	1	100	000	000		00000	00000	3				0																		
0106	01	331	1	100	000	000		00000	00000	2				0																	1	
0107	01	496	5	95	000	5	570	00000	30	3				1	9	40									1	1	1	2	1	3		
0108	01	947	5		000			00000		3	6	5	3	1																	1	
0109	01	850	1		000	000		00000	00000	3				0																	1	
0110	01	469	2	000	100	000	00000		00000					0																		
0111	01	761	1	100	000	000		00000	00000	3				0																		
0112	01	458	1	100	000	000	630	00000	00000	3	6	5		0																	1	
0113	01	601	2	000	100	000	00000	2015	00000	4	6	1		0	0	00	0	00	0	00	3		0	00	0	0	1	2	1	1		1
0114	01	481	1	100	000	000		00000	00000	3				0																		1
0115	01	374	1	100	000	000		00000	00000	4				0																	1	
0116	01	532																														
0117	01	606	2	000	100	000	00000		00000					0																		
0118	01	549	5		000			00000		4		5		1																	1	
0119	01	351	1	100	000	000		00000	00000					0																		
0120	01	028	2	000	100	000	00000		00000	3				0																		1
0121	01	532	5		000			00000		4				1																	1	
0122	01	074	1	100	000	000		00000	00000	3	6			0																		
0123	01	900	1	100	000	000		00000	00000	2				0																	1	
0124	01									2																					1	
0125	01	846	5		000			00000		4				1																		
0126	01	085	5	75	000	25	7500	00000	2500	3	3	5	2	1	6		0	00	0	00	0	00	0	00	0	0	1	2	1	2		1

FDRY NO.	CO TY	LOC	MET CST	PERCENT GI	MI	CAST DI	TON/MONTH MELT GI	MI	DI	SIZ CLA	IND CLA	WT RG	PRO CST	NOD	ALLOY ADDITIONS TO LADLE T	LB	T	LB	T	LB	1	LB	2	LB	CUP REP	TYP FCE	VENT TAP	EFF	VENT MOLD	EFF	VISITED BY EERP	ATK
0127	01	900	1	100	000	000		00000	00000	2				0																	1	
0128	01	452	1	100	000	000	260	00000	00000	3				0																	1	
0129	01	917	1	100	000	000	350	00000	00000	3	5	5	6	0																	1	
0130	01	900	1	100	000	000		00000	00000	3				0																	1	
0131	01	945	1	100	000	000		00000	00000		6	5	3	0																	1	
0132	01	083	1	100	000	000		00000	00000	2	3		2	0																	1	
0133	01	631	1	100	000	000	600	00000	00000	3	6	5	6	0																		
0134	01	088	1	100	000	000		00000	00000	4				0																		
0135	01	535								2																						
0136	01	194	4	11	89	000	500	4000	00000	4	5	1	6	0	0	00	0	00	0	00	0	00	0		0	0	1	3	1	3		1
0137	01	352	4			000			00000	4	5		6	0																	1	
0138	01	473	1	100	000	000	700	00000	00000	3	4	5	8	0																		
0139	01	441	5		000			00000		3	6	5	3	1																	1	
0140	01	112	1	100	000	000	525	00000	00000	3		5		0																		
0141	01	196	1	100	000	000		00000	00000	4				0																	1	
0142	01	631	1	100	000	000	350	00000	00000		6	5	3	0																		
0143	01	761	1	100	000	000		00000	00000	3				0																		
0144	01	195	1	100	000	000	400	00000	00000	3	6	4	8	0																		
0145	01	331	1	100	000	000		00000	00000	2				0																	1	
0146	01	080	5	60	000	40	16000	00000	12800	4	3	5	2	1	6		4								1	1	1	3	1	3		1
0147	01	352	5		000			00000		4	4	5	3	1																		
0148	01	374	1	100	000	000		00000	00000	4				0																		
0149	01	374	1	100	000	000		00000	00000	4				0																		
0150	01	945	5	78	000	22	4500	00000	1250	3	3	5	2	1	6	45	4	40			1	4	1	3	1	1	2	1	1	2		1
0151	01	604	1	100	000	000		00000	00000	3				0																		

GENERAL FOUNDRY DATA

FDRY NO.	CD TY	LOC	MET CST	PERCENT GI	PERCENT MI	CAST DI	TON/MONTH MELT GI	TON/MONTH MELT MI	TON/MONTH MELT DI	SIZ CLA	IND CLA	WT RG	PRO CST	NOD	ALLOY ADDITIONS TO LADLE T	LB	T	LB	T	LB	1	LB	2	LB	CUP REP	TYP FCE	VENT TAP	EFF	VENT MOLD	EFF	VISITED BY EERP	ATK
0152	01	156	1	100	000	000		00000	00000	4				0																		
0153	01	625	4			000			00000	4				0																		
0154	01	614	1	100	000	000		00000	00000	3				0																		
0155	01	982	1	100	000	000		00000	00000	2				0																	1	
0156	01	463	1	100	000	000		00000	00000	3				0																		
0157	01	950	1	100	000	000	200	00000	00000	3				0																	1	
0158	01	757	1	100	000	000	7300	00000	00000	4				0																	1	
0159	01	494	1	100	000	000	375	00000	00000	3	4	3		0																		
0160	01	374	1	100	000	000	24000	00000	00000	4	1	6	1	0	0	00	0	00	0	00	0	00	0		0	0	2	3	1	3		1
0161	01	191	1	100	000	000		00000	00000					0																		
0162	01	070	1	100	000	000		00000	00000	3				0																		
0163	01	070	1	100	000	000		00000	00000	4				0																		
0165	01	523	5	85	00.0	15	850	00000	150	3	5	6	6	1	4	9							9	00	0	0	2	1	2	1		1
0166	01	071																														
0167	01	081	1	100	000	000	3000	00000	00000					0	0	00	0	00	0	00	0	00	0	00								
0168	01	625	1	100	000	000	435	00000	00000	2	6	5		0											1		1		1	3		[illegible]

FURNACE DATA

FDRY NO.	CD TY	FCE NO	FCE TYP	LIN TYP	BLT DES	BLT HTG	TOP C/O	CHG	GAS T-O	AFT	CHG DR	FL IN	OX EN	FCE USE	FCE DIA	HLD CAP	MLT RAT	HT UT	PR UT	OT UT	BLAST VOLUM	BLAST PRES	BLAST TEMP	SIZE CH DR	HT DR	CHG PRE	AFT SIZE	AFT LOC	DIS AFT	POWR SPLY	CTL SYS
		**********FURNACE CLASSIFICATION**********																			******BLAST****										
0001	10	1	1	1	3	1	1	2	2		1	0	0	1	66	000	15				8600			52						0000	1
0001	10	2	1	1	3	1	1	2	2		1	0	0	1	78	000	15				8600			52						0000	1
0001	10	3	1	1	3	1	1	2			1	0	0	1	48	000	8				4500			43						0000	1
0001	10	4	1	1	3	1		2			1	0	0	1	48	000	8				4500			43						0000	
0002	10	1	1	1	3	1	1	2	1		2	0	0	1	54	000	9				6000			45						0000	1
0002	10	2	1	1	3	1	1	2	1		2	0	0	1	54	000	9				6000			45						0000	1
0003	10	1	1	1										1		000	7													0000	1
0004	10	1	2		0	0	0	1	0	0	0	0	0	2	000	100	00	00	24	00	00000	00	0000	00	00	0	0000	0	000	1400	0
0004	10	2	3	1	0	0	0	1	0	0	0	0	0	1	000	18	6	24	24	00	00000	00	0000	00	00	0	0000	0	000	3600	0
0004	10	3	4	1	0	0	0	1	3	0	0	0	0	1	120	20	13	24	24	00	00000	00	0000	00	00	0	0000	0	000	1400	1
0004	10	4	4	1	0	0	0	1	3	0	0	0	0	1	120	100	13	24	24	00	00000	00	0000	00	00	0	0000	0	000	1400	1
0004	10	5	4	1	0	0	0	1	3	0	0	0	0	1	120	100	13	24	24	00	00000	00	0000	00	00	0	0000	0	000	1400	1
0005	10	1	1	1	3	1	1	2	1	2	1	0	0	1	42	000	7				3500			76						0000	1
0006	10	1	1	1										1		000	9													0000	1
0007	10	1	1	1	3	1	1	2	2	2	1	0	0	1	72	000	20	8		00	5500	20		51	35	0	3700	3	40	0000	1
0008	10	1	1	2	3	1	1	2	1	1	1	0	0	1	60	000	11	8	8	00	5000	14		23	19	0	3300	1	252	0000	1
0009	10	1	1	1	2	3	1	2	1	2	1	0	0	1	66	000	18				10500		750	52			4000			0000	1
0009	10	2	1	1	2	3	1	2	1	2	1	0	0	1	66	000	18				10500		750	52			4000			0000	1
0009	10	3	1	1	3	1	1	2	1	2	1	0	0	1	56	000	11	14		00	4550			52			4000			0000	2
0010	10	1	1	1										1		000	9													0000	1
0011	10	1	1	1	3	1	1	2	1	2	1	0	0	1	84	000	10				5200			54						0000	1
0012	10	1	1	1	1	3	2	2	8	0	1	0	0	1	114	000	45	18	00	00	19000		1100	84	27	0	0000	0	000	0000	1
0012	10	2	1	2	1	3	2	2	8	0	1	0	0	1	114	000	35	24	00	00	26000		800	84	27	0	0000	0	000	0000	1
0012	10	3	1	1	2	3	2	2	8	0	1	0	1	1	48	000	14	18	00	00	8500		450	54	26	0	0000	0	000	0000	0
0012	10	4	1	2	3	1	2	2	8	0	1	0	0	1	48	000	6	6	00	00	6000			54	26	0	0000	0	000	0000	0

			**********FURNACE CLASSIFICATION**********																		******BLAST****										
FDRY NO.	CD TY	FCE NO	FCE TYP	LIN TYP	BLT DES	BLT HTG	TOP C/O	CHG	GAS T-O	AFT	CHG DR	FL IN	OX EN	FCE USE	FCE DIA	HLD CAP	MLT RAT	MT UT	PR UT	OT UT	VOLUM	PRES	TEMP	SIZE CH. DR	HT DR	CHG PRE	AFT SIZE	AFT LOC	DIS AFT	POWR SPLY	CTL SYS
0012	10	5	1	1	2	3	2	2	8	0	1	0	0	1	30	000	3	8	00	00	3500		400	18	18	0	0000	0	000	0000	0
0013	10	1	1	1	3	1	1	2	1	0	1	0	0	1	72	000	18	2			5000			30			0000	0	000	0000	1
0013	10	2	1	1							1	0	0	1		000	10	2												0000	
0014	10	1	1	1	3	1	1	2						1	54	000	10													0000	1
0014	10	2	1	1	3	1	1	2						1	54	000	10													0000	1
0015	10	1	1	1	3	1	1	2	1	1	2	0	0	1	42	000	6				3600			10						0000	1
0016	10	1	1	1			2		8		1	0	0	1	52	000	11				5000			44						0000	1
0016	10	2	1	1			2		8		1	0	0	1	52	000	11				5000			44						0000	2
0017	10	1	1	1			1	2						1	37	000					2400									0000	1
0017	10	2	1	1			1	2						1		000														0000	1
0018	10	1	1	2	3	1	2	2	8		1	0	0	1	48	000	8				4500		0000	11						0000	1
0018	10	2	1	2	3	1	2	2	8		1	0	0	1	48	000	8				4500		0000	11						0000	2
0019	10	1	1	1	3	1	2	2	8	0	1	0	0	1	48	000	18							28			0000	0	000	0000	1
0019	10	2	1	1	3	1	2	2	8	0	1	0	0	1	48	000	18							28			0000	0	000	0000	2
0019	10	3	6	0	0	0	0	0	0	0	0	0	0	3	000	30	00	00			00000	00	0000	00	00	0	0000	0	000	0000	
0019	10	4	6	0	0	0	0	0	0	0	0	0	0	3	000	30	00	00			00000	00	0000	00	00	0	0000	0	000	0000	
0020	10	1	2	6	0	0	0	0	0	0	0	0	0	1	000	13	.5				00000	00	0000	00	00	0	0000	0	000		
0020	10	2	2	6	0	0	0	0	0	0	0	0	0	1	000	13	.5				00000	00	0000	00	00	0	0000	0	000	0000	
0021	10	1	1	4	2	3	1	2	1	0	1	0	1	1	68	000	18	22	22	00	9000	36	1000	80	38	0	0000	0	000	0000	1
0021	10	2	1	4	1	3	1	2	1	0	1	0	1	1	68	000	18	22	22	00	9000	36	1000	80	38	0	0000	0	000	0000	1
0022	10	1	3	1	0	5	0	0	0	0	0	0	0	1	000	9	5				00000	00	0000	00	00	3	0000	0	000	1750	
0022	10	2	3	1	0	5	0	0	0	0	0	0	0	1	000	9	5				00000	00	0000	00	00	3	0000	0	000	1750	
0022	10	3	3	1	0	5	0	0	0	0	0	0	0	1	000	9	5				00000	00	0000	00	00	3	0000	0	000	1750	
0022	10	4	3	1	0	5	0	0	0	0	0	0	0	1	000	9	5				00000	00	0000	00	00	3	0000	0	000	1750	
0023	10	1	1	1	3	1	1	2	1					1	76	000					6000									0000	1

FDRY NO.	CD TY	FCE NO	FCE TYP	LIN TYP	BLT DES	BLT HTG	TOP C/O	CHG	GAS T-O	AFT	CHG DR	FL IN	OX EN	FCE USE	FCE DIA	HLD CAP	MLT RAT	MT UT	PR UT	OT UT	VOLUM	PRES	TEMP	SIZE CH DR	HT DR	CHG PRE	AFT SIZE	AFT LOC	DIS AFT	POWR SPLY	CTL SYS
			**********FURNACE CLASSIFICATION*********																		******BLAST****										
0024	10	1	1	4	2	3	1	2	1		1	0	0	1	86	000	32				22000		750							0000	1
0024	10	2	1	4	2	3	1	2	1		1	0	0	1	86	000	32				22000		750							0000	1
0025	10	1	1	4	3	1	2	2	8	2	1	0	1	1	84	000	20	13			11000			70		1		4		0000	1
0026	10	1	1	1	3	1	1	2	1	2	1	0	0	1	54	000	10	10		00	5400	19		58		0	8000	2	720	0000	1
0026	10	2	1	1	3	1	1	2	1	2	1	0	0	1	54	000	10	10		00	5400	19		58		0	8000	2	720	0000	1
0027	10	1	1	1	3	1	2	2	8	0	1	1	0	1	72	000	14	8			8000	14		68	33	0	0000	0	000	0000	1
0028	10	1	1	1										1		000	4													0000	
0028	10	2	3	1	0	5	0	0	0	0	0	0	0	1	000		.8				00000	00	0000	00	00		0000	0	000		
0029	10	1	1	4	2	3	1	2	1	6	1	0	0	1	78	000	15	14			12000	20	750	50		0	1780	1	276	0000	1
0029	10	2	4	1	0	0	0	2	8	0	0	0	0	3	72	6	00		16		00000	00	0000	00	00	0	0000	0	000	1000	0
0029	10	3	4	1	0	0	0	2	8	0	0	0	0	3	72	6	00		16		00000	00	0000	00	00	0	0000	0	000	1000	0
0029	10	4	4	1	0	0	0	2	8	0	0	0	0	3	60	6	00		16		00000	00	0000	00	00	0	0000	0	000	1000	0
0030	10	1	4	1	0	0	0			0	0	0	0	1		.5					00000	00	0000	00	00		0000	0	000		
0030	10	2	4	1	0	0	0			0	0	0	0	1		2					00000	00	0000	00	00		0000	0	000		
0030	10	3	4	1	0	0	0			0	0	0	0	1		4					00000	00	0000	00	00		0000	0	000		
0031	10	1	1	4	2	3	1	2	1	0	1	0	0	1	96	000	35				15000		750	60		0	0000	0	000	0000	1
0031	10	2	1	4	2	3	1	2	1	0	1	0	0	1	96	000	35				15000		750	60		0	0000	0	000	0000	1
0032	10	1	1	1	3	1	2	2	8	2	1	1	0	1	56	000	16	7			5400	15		60	26	0	1000	2	31	0000	1
0032	10	2	6	0	0	0	0	0	0	0	0	0	0	3		20	00	00	10	5	00000	00	0000	00	00	0	0000	0	000	0000	0
0033	10	1	1	4	1	3	1	2	1	2	1	0	0	1	108	000	50				25000		1400	99						0000	1
0033	10	2	1	4	1	3	1	2	1	2	1	0	0	1	108	000	50				25000		1400	99						0000	2
0033	10	3	2	7	0	0	0	0	0	0	0	0	0	1	000	137	10				00000	00	0000	00	00	0	0000	0	000	4400	
0033	10	4	2	7	0	0	0	0	0	0	0	0	0	1	000	137	10				00000	00	0000	00	00	0	0000	0	000	4400	
0033	10	5	2	7	0	0	0	0	0	0	0	0	0	1	000	137	10				00000	00	0000	00	00	0	0000	0	000	4400	
0033	10	6	2	7	0	0	0	0	0	0	0	0	0	2	000	137	00	00			00000	00	0000	00	00	0	0000	0	000	2200	

FURNACE DATA

FDRY NO.	CO TY	FCE NO	FCE TYP	LIN TYP	BLT DES	BLT HTG	TOP C/O	CHG	GAS T-D	AFT	CHG DR	FL IN	OX EN	FCE USE	FCE DIA	HLD CAP	MLT RAT	MT UT	PR UT	OT UT	VOLUM	PRES	TEMP	SIZE CH DR	HT DR	CHG PRE	AFT SIZE	AFT LOC	DIS AFT	POWR SPLY	CTL SYS
			**********FURNACE CLASSIFICATION**********																		******BLAST****										
0033	10	7	2	7	0	0	0	0	0	0	0	0	0	2	000	137	00	00			00000	00	0000	00	00	0	0000	0	000	2200	
0034	10	1	1	4	1	3	1	2	2	0	1	0	0	1	108	000	50				25000		1000	99			0000	0	000	0000	1
0034	10	2	2	6	0	5	0	0	0	0	0	0	0	5	000	100	10	00			00000	00	0000	00	00		0000	0	000	4000	
0035	10	1	1	4	2	3	1	2	1	2	1	0	0	1	54	000	13	9	9	00	5500	25	600	55		0				0000	1
0035	10	2	1	2	3	1	2	2	8	0	1	0	0	1	48	000	8	9	9	00	4500			55		0	0000	0	000	0000	2
0035	10	3	1	2	3	1	2	2	8	0	1	0	0	1	48	000	8	9	9	00	4500			55		0	0000	0	000	0000	3
0035	10	4	2	7	0	0	0	0	0	0	0	0	0	3	000	14	00	00	9	00	00000	00	0000	00	00	0	0000	0	000	420	
0036	10	1	1	1	3	1	1	2	1	2	1	0	0	1	42	000	4				2500			5						0000	1
0037	10	1	1	1	3	1	1	2	1	2	1	0	0	1	34	000	4	2			2000			4						0000	1
0038	10	1	1	4	1	3	1	2	1	0	1	0	0	1	78	000	23						1000	95			0000	0	000	0000	1
0040	10	1	1											1		000	6													0000	
0040	10	2	1											1		000	6													0000	
0040	10	3	1											1		000	6													0000	
0040	10	4	4		0		0			0	0	0	0								00000	00	0000	00	00		0000	0	000		
0041	10	1	1				1	2						1		000	4													0000	1
0041	10	2	2		0		0	0	0	0	0	0	0		000	.75					00000	00	0000	00	00		0000	0	000		
0041	10	3	2		0		0	0	0	0	0	0	0		000	.25					00000	00	0000	00	00		0000	0	000		
0041	10	4	2		0		0	0	0	0	0	0	0		000	.20					00000	00	0000	00	00		0000	0	000		
0042	10	1	1	4	1	3	2	2	8	2	1	0	0	1	72	000	25	16			12000	64	1000	16	46	0	2100	1	480	0000	1
0042	10	2	2	5	0	0	0	0	0	0	0	0	0	2	000	9	00	00		24	00000	00	0000	00	00	0	0000	0	000	600	0
0042	10	3	2	5	0	0	0	0	0	0	0	0	0	2	000	9	00	00		24	00000	00	0000	00	00	0	0000	0	000	600	0
0043	10	1	1	1	3	1	2	2	1	2	1	0	1	1	54	000	11	5			5300			50		0	4500	2		0000	1
0044	10	1	1	4	1	3	2	2	8		1	0	0	1	72	000	20						1400							0000	
0044	10	2	1	4	1	3	2	2	8		1	0	0	1	72	000	20						1400							0000	
0044	10	3	2	6	0		0	0	0	0	0	0	0	3	000	30	00	00			00000	00	0000	00	00	0	0000	0	000	750	

FDRY NO.	CO TY	FCE NO	FCE TYP	LIN TYP	BLT DES	BLT HTG	TOP C/O	CHG	GAS T-O	AFT	CHG DR	FL IN	OX EN	FCE USE	FCE DIA	HLD CAP	MLT RAT	MT UT	PR UT	OT UT	BLAST VOLUM	BLAST PRES	BLAST TEMP	SIZE CH	SIZE DR	HT DR	CHG PRE	AFT SIZE	AFT LOC	DIS AFT	POWR SPLY	CTL SYS
		********** FURNACE CLASSIFICATION **********																			****** BLAST ****											
0044	10	4	2	6	0		0	0	0	0	0	0	0	3	000	30	00	00			00000	00	0000	00		00	0	0000	0	000	750	
0045	10	1	1	4	1	3	2	2	8	0	1	0	0	1	84	000	18				10000		1400	88				0000	0	000	0000	
0045	10	2	1	4	1	3	2	2	8	0	1	0	0	1	84	000	18				10000		1400	88				0000	0	000	0000	
0045	10	3	1	4	1	3	2	2	8	0	1	0	0	1	84	000	18				9500		1400	72				0000	0	000	0000	
0045	10	4	1	4	1	3	2	2	8	0	1	0	0	1	84	000	18				9500		1400	72				0000	0	000	0000	
0045	10	5	1	4	1	3	2	2	8	0	1	0	0	1	84	000	18				9500		1400	84				0000	0	000	0000	
0045	10	6	1	4	1	3	2	2	8	0	1	0	0	1	84	000	18				9500		1400	84				0000	0	000	0000	
0045	10	7	1	4	1	3	1	2	1	0	1	0	0	1	96	000	26				12000		1400	70				0000	0	000	0000	1
0045	10	8	1	4	1	3	1	2	1	0	1	0	0	1	96	000	26				12000		1400	70				0000	0	000	0000	1
0046	10	1	4	1	0	0	0	1	3	0	0	0	0	1	103	15	13	16			00000	00	0000	00		00	0	0000	0	000	9100	1
0046	10	2	4	1	0	0	0	1	3	0	0	0	0	1	103	15	13	16			00000	00	0000	00		00	0	0000	0	000	9100	1
0046	10	3	4	1	0	0	0	1	3	0	0	0	0	1	103	15	13	16			00000	00	0000	00		00	0	0000	0	000	9100	2
0046	10	4	4	1	0	0	0	1	3	0	0	0	0	1	103	15	13	16			00000	00	0000	00		00	0	0000	0	000	9100	2
0046	10	5	2	6	0	0	0	0	0	0	0	0	0	2	000	83	00	00	15		00000	00	0000	00		00	0	0000	0	000	1400	0
0046	10	6	2	6	0	0	0	0	0	0	0	0	0	2	000	83	00	00	15		00000	00	0000	00		00	0	0000	0	000	1400	0
0046	10	7	2	6	0	0	0	0	0	0	0	0	0	2	000	83	00	00			00000	00	0000	00		00	0	0000	0	000		0
0047	10	1	1	1	2	3	1	2	1	2	1	0	0	1	54	000	10				7000		500	35							0000	1
0047	10	2	1	1	2	3	1	2	1	2	1	0	0	1	54	000	10				7000		500	35							0000	1
0048	10	1	4	1	0	0	0	1	4	0	0	0	0	1	103	20	8	8		00	00000	00	0000	00		00	0	0000	0	000	6000	1
0048	10	2	2	7	0	0	0	0	0	0	0	0	0	2	000	22	00	00	2	22	00000	00	0000	00		00	0	0000	0	000	800	
0048	10	3	2	7	0	0	0	0	0	0	0	0	0	2	000	22	00	00	2	22	00000	00	0000	00		00	0	0000	0	000	800	
0048	10	4	2	7	0	0	0	0	0	0	0	0	0	2	000	22	00	00	2	22	00000	00	0000	00		00	0	0000	0	000	800	
0049	10	1	1				1	2	1		2			1	72	000	5				3500										0000	1
0050	10	1	1	1	3	1	1	2	1		1	0	0	1	66	000	17				6000										0000	1
0051	10	1	1	1	3	1	1	2	1	0	1	0	0	1	48	000	10				6000			55				0000	0	000	0000	1

			**********FURNACE CLASSIFICATION**********																		******BLAST****			SIZE								
FDRY NO.	CD TY	FCE NO	FCE TYP	LIN TYP	BLT DES	BLT HTG	TOP C/O	CHG	GAS T-O	AFT	CHG DR	FL IN	OX EN	FCE USE	FCE DIA	HLD CAP	MLT RAT	HT UT	PR UT	OT UT	VOLUM	PRES	TEMP	CH	DR	HT DR	CHG PRE	AFT SIZE	AFT LOC	DIS AFT	POWR SPLY	CTL SYS
0051	10	2	1	1	3	1	1	2	1	0	1	0	0	1	48	000	10				6000			55				0000	0	000	0000	1
0052	0	1	1	1	2	3	2	2	8	0	1	0	1	1	60	000	16	16			5900	18	450	60			0	0000	0	000	0000	0
0052	10	2	1	1	2	3	2	2	8	0	1	0	1	1	60	000	16	16			5900	18	450	60			0	0000	0	000	0000	1
0052	10	3	1	1	2	3	2	2	8	0	1	0	1	1	60	000	16	16			5900	18	450	60			0	0000	0	000	0000	0
0052	10	4	1	1	3	1	2	2	8	4	1	0	0	1	48	000	8	8			3500	16		60			0	1000	4	480	0000	2
0053	10	1	4		0	0	0			0	0	0	0								00000	00	0000	00		00		0000	0	000		
0054	10	1	1	1	3	1	1	2	1	0	1	0	0	1	60	000	15				8800							0000	0	000	0000	1
0055	10	1	1											1		000	2														0000	
0055	10	2	1											1		000	5														0000	
0056	10	1	1				1	2						1	54	000	9														0000	1
0057	10	1	1	1	3	1								1		000	8														0000	1
0058	10	1	1	4	1	3	1	2	1	2	1	0	0	1	96	000	30						1000								0000	1
0058	10	2	1	4	1	3	1	2	1	2	1	0	0	1	96	000	30						1000								0000	2
0058	10	3	1	4	1	3	1	2	1	2	1	0	0	1	96	000	35						1000								0000	3
0058	10	4	1	4	1	3	1	2	1	2	1	0	0	1	96	000	35						1000								0000	4
0058	10	5	1	4	1	3	1	2	1	2	1	0	0	1	96	000	35						1000								0000	5
0058	10	6	1	4	1	3	1	2	1	2	1	0	0	1	96	000	35						1000								0000	6
0058	10	7	1											1	96	000	35														0000	
0058	10	8	4	1	0	0	0			0	0	0	0			12					00000	00	0000	00		00		0000	0	000		
0059	10	1	1	4	1	3	1	2	1		1			1	96	000	25						1000								0000	1
0059	10	2	1	4	1	3	1	2	1		1			1	96	000	25						1000								0000	2
0059	10	3	1	4	1	3	1	2	1		1			1	96	000	25						1000								0000	3
0059	10	4	1	4	1	3	1	2	1		1			1	96	000	25						1000								0000	4
0059	10	5	1	4	1	3	1	2	1		1			1	96	000	35						1000								0000	5
0059	10	6	1	4	1	3	1	2	1		1			1	96	000	35						1000								0000	6

			FURNACE CLASSIFICATION																		***BLAST***			SIZE								
FDRY NO.	CO TY	FCE NO	FCE TYP	LIN TYP	BLT DES	BLT HTG	TOP C/O	CHG	GAS T-O	AFT	CHG DR	FL IN	OX EN	FCE USE	FCE DIA	HLD CAP	MLT RAT	MT UT	PR UT	OT UT	VOLUM	PRES	TEMP	CH	DR	HT DR	CHG PRE	AFT SIZE	AFT LOC	DIS AFT	POWR SPLY	CTL SYS
0059	10	7	1	4	1	3	1	2	1		1			1	96	000	35						1000								0000	7
0059	10	8	1	4	1	3	1	2	1		1			1	96	000	35						1000								0000	8
0059	10	9	1	4	1	3	1	2	1		1			1	96	000	35						1000								0000	9
0059	10	10	4	1	0	0	0		3	0	0	0	0	2	120	20	00	00			00000	00	0000	00		00	0	0000	0	000		
0059	10	11	2	6	0	0	0	0	0	0	0	0	0	2	000	14	00	00			00000	00	0000	00		00	0	0000	0	000		
0059	10	12	2	6	0	0	0	0	0	0	0	0	0	2	000	14	00	00			00000	00	0000	00		00	0	0000	0	000		
0060	10	1	1	4	1	3	1	2	1		1			1	84	000	15						1000	99							0000	
0060	10	2	1	4	1	3	1	2	1		1			1	84	000	15						1000	99							0000	
0060	10	3	1	4	1	3	1	2	1		1			1	90	000	22						1000	99							0000	
0060	10	4	1	4	1	3	1	2	1		1			1	90	000	22						1000	99							0000	
0060	10	5	1	4	1				1		1			1	90	000	22						1000								0000	
0060	10	6	1	4	1				1		1			1	90	000	22						1000								0000	
0060	10	7	4	2	0	0	0			0	0	0	0	2		1	00	00			00000	00	0000	00		00	0	0000	0	000		
0060	10	8	4	2	0	0	0			0	0	0	0	2		1	00	00			00000	00	0000	00		00	0	0000	0	000		
0060	10	9	4	2	0	0	0			0	0	0	0	2		1	00	00			00000	00	0000	00		00	0	0000	0	000		
0060	10	10	4	2	0	0	0			0	0	0	0	2		4	00	00			00000	00	0000	00		00	0	0000	0	000		
0060	10	11	4	2	0	0	0			0	0	0	0	2		4	00	00			00000	00	0000	00		00	0	0000	0	000		
0060	10	12			0		0	0	0	0	0	0	0		000	4					00000	00	0000	00		00		0000	0	000		
0061	10	1	1	1	1	3	1	2	1	2	1	0	0	1	65	000	20	8	8	00	10000	24	1000	61			0	1500	1	480	0000	1
0061	10	2	2		0	0	0	0	0	0	0	0	0	1	000	1.5	1	8	8	00	00000	00	0000	00		00	0	0000	0	000		0
0062	10	1	1	1	1	3	1	2	1	2	1	0	0	1	66	000	14				8000		1000	48							0000	1
0062	10	2	1	1	1	3	1	2	1	2	1	0	0	1	66	000	14				8000		1000	48							0000	1
0063	10	1	4	1	0	0	0	1	3	0	0	0	0	1	132		12				00000	00	0000	00		00		0000	0	000	5000	1
0063	10	2	4	1	0	0	0	1	3	0	0	0	0	1	108		4				00000	00	0000	00		00		0000	0	000	3500	1
0064	10	1	1	1										1		000	8														0000	

FDRY NO.	CD TY	FCE NO	FCE TYP	LIN TYP	BLT DES	BLT HTG	TOP C/O	CHG	GAS T-O	AFT	CHG DR	FL IN	OX EN	FCE USE	FCE DIA	HLD CAP	MLT RAT	MT UT	PR UT	OT UT	******BLAST**** VOLUM	PRES	TEMP	SIZE CH	DR	HT DR	CHG PRE	AFT SIZE	AFT LOC	DIS AFT	POWR SPLY	CTL SYS
			**********FURNACE CLASSIFICATION*********																													
0064	10	2	1	1										1		000	21														0000	
0065	10	1	1	4	1	3	1	2	1	2	1	0	0	1	84	000	35				16000		1600	96			0	1500	1	600	0000	1
0065	10	2	1	4	1	3	1	2	1	2	1	0	0	1	84	000	35				16000		1600	96			0	1500	1	600	0000	2
0065	10	3	1	4	1	3	1	2	1	2	1	0	0	1	102	000	40				16000		1000								0000	3
0065	10	4	1	1	2	3	2	2	8		1	0	0	1	108	000	25				16000		750								0000	4
0065	10	5	1	1	2	3	2	2	8		1	0	0	1	108	000	25				16000		750								0000	5
0065	10	6	1	1	2	3	2	2	8		1	0	0	1	108	000	25				16000		750								0000	6
0065	10	7	4		0	0	0			0	0	0	0			10					00000	00	0000	00		00		0000	0	000		
0066	10	1	1	1										1		000	35														0000	
0066	10	2	1	1										1		000	35														0000	
0066	10	3	1	1										1		000	35														0000	
0066	10	4	1	4	1	3	2	2	8	0	1	0	0	1	108	000	35				25000		1000					0000	0	000	0000	
0066	10	5	1	4	1	3	1	2	2	0	1	0	0	1	108	000	40				25000	30	1000	97				0000	0	000	0000	1
0066	10	7	4	1	0	0	0	1		0	0	0	0	2	96	15	00	00			00000	00	0000	00		00	0	0000	0	000		
0066	10	8	2	6	0	0	0	0	0	0	0	0	0	2	000		00	00			00000	00	0000	00		00	0	0000	0	000		
0067	10	1	1	4	1	3	1	2	1	1	1	0	0	1	114	000	45	16		00	25000	72	1200	99		46	0	6000	2		0000	1
0067	10	2	1	4	1	3	1	2	1	1	1	0	0	1	114	000	50	16		00	25000	72	1400	51		35	0	9999	1		0000	2
0067	10	3	1	4	1	3	2	2	8	0	1	0	0	1	102	000	45	8		00	25000	72	1200	57		37	0	0000	0	000	0000	3
0067	10	4	3	3	0	5	0	1	0	0	0	0	0	1		33	10	10	2	4	00000	00	0000	00		00	2	0000	0	000	1300	0
0067	10	5	2	7	0	5	0	1	0	0	0	0	0	2		60	00	00	16	00	00000	00	0000	00		00	0	0000	0	000	1100	0
0067	10	6	2	7	0	5	0	1	0	0	0	0	0	2		60	00	00	16	00	00000	00	0000	00		00	0	0000	0	000	1100	0
0067	10	7	4	3	0	0	0	1	0	0	0	0	0	2		30	00	00	8	00	00000	00	0000	00		00	0	0000	0	000	3500	0
0067	10	8	4	3	0	0	0	1	0	0	0	0	0	2		4	00	00	8	00	00000	00	0000	00		00	0	0000	0	000	3500	0
0068	10	1	1	1	2	3	2	2	8	0	1	0	0	1	102	000	45	16	00	00	20000	35	350	85		30	0	0000	0	000	0000	1
0068	10	2	1	1	2	3	2	2	8	0	1	0	0	1	102	000	45	16	00	00	20000	35	350	85		30	0	100	1		0000	2

FDRY NO.	CD TY	FCE NO	FCE TYP	LIN TYP	BLT DES	BLT HTG	TOP C/O	CHG	GAS T-O	AFT	CHG DR	FL IN	OX EN	FCE USE	FCE DIA	HLD CAP	MLT RAT	MT UT	PR UT	OT UT	******BLAST**** VOLUM	PRES	TEMP	SIZE CH DR	HT DR	CHG PRE	AFT SIZE	AFT LOC	DIS AFT	POWR SPLY	CTL SYS
			**********FURNACE CLASSIFICATION*********																												
0068	10	3	1	1	2	3	2	2	8	0	1	0	0	1	102	000	45	16	00	00	20000	35	350	85	30	0	100	1		0000	3
0068	10	4	1	1	2	3	2	2	8	0	1	0	0	1	102	000	45		00	00	20000	35	350	85	30	0	100	1		0000	4
0068	10	5	3		0	0	0	0	0	1	0	0	0	1	72	65	40	16	16	00	00000	00	0000	00	00	1	5000				5
0068	10	6	3		0	0	0	0	0	1	0	0	0	3	60	33	10		16		00000	00	C000	00	00	0	0000			1700	
0068	10	7	4	1	0	0	0	0	0	1	0	0	0	3	108	18	3		16		00000	00	0000	00	00	0	0000			470	
0068	10	8	4	1	0	0	0	0	0	1	0	0	0	3	108	18	3		16		00000	00	0000	00	00	0	0000			350	
0068	10	9	4	1	0	0	0	0	0	1	0	0	0	3	108	18	3		16		00000	00	0000	00	00	0	0000			350	
0069	10	1	1	1	1	3	1	2	2	0	1	0	1	1	114	000	55	16			28000	80	1000		51	0	0000	0	000	0000	5
0069	10	2	1	1	1	3	1	2	2	0	1	0	1	1	114	000	55	16			28000	80	1000		51	0	0000	0	000	0000	6
0069	10	3	1	1	1	3	1	2	2	0	1	0	1	1	108	000	45	16			20000	56	1000		58	0	0000	0	000	0000	3
0069	10	4	1	1	1	2	1	2	2	0	1	0	1	1	108	000	45	16			22000	72	1000		58	0	0000	0	000	0000	4
0069	10	5	1	1	1	2	1	2	2	0	1	0	1	1	102	000	35	16			20000	56	1000		46	0	0000	0	000	0000	1
0069	10	6	1	1	1	2	2	2	2	0	1	0	1	1	102	000	35	16			20000	56	1000		46	0	0000	0	000	0000	2
0069	10	7	1	1	3	1	2	2	8	0	1	0	0	1	72	000	20	16			15000	40			25	0	0000	0	000	0000	
0069	10	8	1	1	3	1	2	2	8	0	1	0	0	1	72	000	20	16			15000	40			25	0	0000	0	000	0000	
0069	10	9	1	1	3	1	2	2	8	0	1	0	0	1	72	000	20	16			15000	40			25	0	0000	0	000	0000	
0069	10	10	1	1	3	1	2	2	8	0	1	0	0	1	72	000	20	16			15000	40			25	0	0000	0	000	0000	
0069	10	11	1	1	3	1	2	2	8	0	1	0	0	1	72	000	20	16			15000	40			25	0	0000	0	000	0000	
0069	10	12	1	1	3	1	2	2	8	0	1	0	0	1	72	000	20	16			15000	40			25	0	0000	0	000	0000	
0069	10	13	1	1	3	1	2	2	8	0	1	0	0	1	72	000	20	16			15000	40			25	0	0000	0	000	0000	
0069	10	14	1	1	3	1	2	2	8	0	1	0	0	1	72	000	20	16			15000	40			25	0	0000	0	000	0000	
0069	10	15	1	1	3	1	2	2	8	0	1	0	0	1	72	000	20	16			15000	40			25	0	0000	0	000	0000	
0069	10	16	1	1	3	1	2	2	8	0	1	0	0	1	72	000	20	16			15000	40			25	0	0000	0	000	0000	
0069	10	17	4	1	0	0	0	0	0	0	0	0	0	3	96	17	00	00	15		00000	00	0000	00	00	0	0000	0	000	3500	
0069	10	18	4	1	0	0	0	0	0	0	0	0	0	1	108	18	3	8	16	00	00000	00	0000	00	00	0	0000	0	000	6250	

FORM NO.	CY	FCE NO	FCE TYP	LIN TYP	BLT DES	BLT HTG	TOP C/O	CHG	GAS T-O	AFT	CHG DR	FL IN	OX EN	FCE USE	FCE DIA	HLD CAP	MLT RAT	MT UT	PR UT	UT UT	******BLAST**** VOLUM	PRES	TEMP	SIZE CH DR	HT DR	CHT PRF	AFT SIZE	AFT LOC	DIS AFT	POWR SPLY	CTL SYS
		*****FURNACE CLASSIFICATION********																													
0069	10	19	4	1	0	0	0	0	0	0	0	0	0	1	60	3	1	8	00	00	00000	00	0000	00	00	0	0000	0	000	1100	
0069	10	20	2	7	0	0	0	0	0	0	0	0	0	3	72	33	00	00	16	00	00000	00	0000	00	00	0	0000	0	000	1100	
0069	10	21	2	7	0	0	0	0	0	0	0	0	0	3	72	33	00	01	60	00	00000	00	0000	00	00	0	0000	0	000	1100	
0069	10	22	4	1	0	0	0	0	0	0	0	0	0	3	67	6	00	00	16	00	00000	00	0000	00	00	0	0000	0	000	1600	
0070	10	1	1	4	1	3	1	2	2	0	1	0	0	1	102	000	50				22500		1000				0000	0	000	0000	1
0070	10	2	1	4	1	3	1	2	2	0	1	0	0	1	102	000	50				22500		1000				0000	0	000	0000	2
0070	10	3	1	4	1	3	1	2	2	0	1	0	0	1	102	000	50				22500		1000				0000	0	000	0000	3
0070	10	4	1	4	1	3	1	2	2	0	1	0	0	1	102	000	50				22500		1000				0000	0	000	0000	4
0070	10	5	1	4	1	2	1	2	2	0	1	0	0	1	102	000	50				22500		1000				0000	0	000	0000	
0070	10	6	4	2	0	0	0			0	0	0	0	3		40					00000	00	0000	00	00		0000	0	000		
0070	10	7	4	2	0	0	0			0	0	0	0	3		40					00000	00	0000	00	00		0000	0	000		
0070	10	8	2	6	0	0	0	0	0	0	0	0	0	3	000	40					00000	00	0000	00	00		0000	0	000		
0071	10	1	1	4	1	3	1	2	2	0	1	0	1	1	96	000	40	16	16		17500	80	1100		51	0	0000	0	000	0000	1
0071	10	2	1	4	1	3	1	2	2	0	1	0	1	1	96	000	40	16	16		17500	80	1100		51	0	0000	0	000	0000	2
0071	10	3	1	4	1	3	1	2	2	0	1	0	1	1	96	000	40	16	16		17500	80	1100		51	0	0000	0	000	0000	3
0071	10	4	1	4	1	3	1	2	2	0	1	0	1	1	108	000	50	16	16		17500	96	1100		57	0	0000	0	000	0000	
0071	10	5	2	7	0	0	0	0	0	0	0	0	0	2	000	26	00	00	16	24	00000	00	0000	00	00	0	0000	0	000		0
0071	10	6	2	7	0	0	0	0	0	0	0	0	0	2	000	26	00	00	16	24	00000	00	0000	00	00	0	0000	0	000		0
0071	10	7	2	7	0	0	0	0	0	0	0	0	0	2	000	26	00	00	16	24	00000	00	0000	00	00	0	0000	0	000		0
0071	10	8	2	7	0	0	0	0	0	0	0	0	0	2	000	26	00	00	16	24	00000	00	0000	00	00	0	0000	0	000		0
0071	10	9	2	7	0	0	0	0	0	0	0	0	0	2	000	26	00	00	16	24	00000	00	0000	00	00	0	0000	0	000		0
0071	10	10	2	7	0	0	0	0	0	0	0	0	0	2	000	54	00	00	16	24	00000	00	0000	00	00	0	0000	0	000		0
0072	10	1	1	4	2	3	2	2	8	0	1	0	0	1	96	000	30	16	16	00	15000	30	700	88	30	4	0000	0	000	0000	1
0072	10	2	1	4	2	3	2	2	8	0	1	0	0	1	96	000	30	16	16	00	15000	30	700	88	30	4	0000	0	000	0000	2
0072	10	3	1	4	1	3	2	2	8	0	1	0	0	1	96	000	30	16	16	00	15000	30	900	88	39	4	0000	0	000	0000	3

FDRY NO.	CO TY	FCE NO	FCE TYP	LIN TYP	BLT DES	BLT HTG	TOP C/O	CHG	GAS T-O	AFT	CHG DR	FL IN	OX EN	FCE USE	FCE DIA	HLD CAP	MLT RAT	MT UT	PR UT	OT UT	******BLAST**** VOLUM	PRES	TEMP	SIZE CH	DR	HT DR	CHG PRE	AFT SIZE	AFT LOC	DIS AFT	POWR SPLY	CTL SYS
			**********FURNACE CLASSIFICATION**********																													
0072	10	4	1	4	1	3	2	2	8	0	1	0	0	1	96	000	30	16	16	00	15000	30	900	88		39	4	0000	0	000	0000	4
0072	10	5	1	4	3	1	2	2	8	0	1	0	0	1	92	000	24	16	16	00	12000	30		88		30	4	0000	0	000	0000	5
0072	10	6	1	4	3	1	2	2	8	0	1	0	0		84	000	21	16	16	00	12000	30		88		30	4	0000	0	000	0000	6
0072	10	7	4	1	0	0	0	0	0	0	0	0	0	3	105	15	00	00	16		00000	00	0000	00		00	0	0000	0	000	3500	
0072	10	8	4	1	0	0	0	0	0	0	0	0	0	3	105	15	00	00	16		00000	00	0000	00		00	0	0000	0	000	3500	
0072	10	9	4	1	0	0	0	0	0	0	0	0	0	3	105	15	00	00	16		00000	00	0000	00		00	0	0000	0	000	6500	
0072	10	10	4	1	0	0	0	1	3	0	0	0	0	1	178	65	00	18	16		00000	00	0000	00		00	4	0000	0	000	2000	7
0073	10	1	1	4	1	3	1	2	1	2	1	0	0	1	102	000	45				18000		1200					3000			0000	1
0073	10	2	1	4	1	3	1	2	1	2	1	0	0	1	102	000	45				18000		1200					3000			0000	1
0074	10	1	1	1			2	2	8		1			1	48	000	10				4000			15							0000	1
0075	10	1	4	1	0	0	0	1	3	0	0	0	0	1	108	8	4				00000	00	0000	00		00		0000	0	000	5000	1
0076	10	1	1								2			1	36	000	3				5600			33							0000	1
0076	10	2			0		0	0	0	0	0	0	0		000		1				00000	00	0000	00		00		0000	0	000		
0076	10	3			0		0	0	0	0	0	0	0		000		1				00000	00	0000	00		00		0000	0	000		
0076	10	4			0		0	0	0	0	0	0	0		000		1				00000	00	0000	00		00		0000	0	000		
0077	10	1	1	1	1	3	1	2	1	2	1	0	0	1	48	000	10						1000								0000	1
0077	10	2	1	1	1	3	1	2	1	2	1	0	0	1	48	000	10						1000								0000	1
0077	10	3	1	1	1	3	1	2	1	2	1	0	0	1	78	000	20				17500		1000								0000	2
0077	10	4	1	1	1	3	1	2	1	2	1	0	0	1	78	000	20				17500		1000								0000	2
0078	10	1	1											1		000	22														0000	
0080	10	1	4	1	0	0	0	1	4	0	0	0	0	1		4					00000	00	0000	00		00		0000	0	000		1
0081	10	1	1	2	3	1	1	2	1	0	1	0	0	1	36	000	4				2200			12				0000	0	000	0000	1
0082	10	1	1	1	3	1	2	2	8	0	1	0	0	1	68	000	20											0000	0	000	0000	
0082	10	2	1	1	3	1	2	2	8	0	1	0	0	1	68	000	20											0000	0	000	0000	
0083	10	1	1	1			2	2	8		1			1	42	000	8				5000			22							0000	1

FDRY NO.	CD IY	FCE NO	FCE TYP	LIN TYP	BLT DES	BLT HTG	TOP C/O	CHG	GAS T-O	AFT	CHG DR	FL IN	OX EN	FCE USE	FCE DIA	HLD CAP	MLT RAT	MT UT	PR UT	OT UT	******BLAST**** VOLUM	PRES	TEMP	SIZE CH DR	HT DR	CHG PRE	AFT SIZE	AFT LOC	DIS AFT	POWR SPLY	CTL SYS
0083	10	2	1	1			1	2			1			1	42	000	8				5000			22						0000	2
0084	10	1	1	4	1	3	1	2	1	2	1	0	0	1	96	000	35	16			12000		1000	83		0	3500			0000	1
0085	10	1	1		2	3	2	2	8	0	1	0	0	1	84	000	24				8000		500	52			0000	0	000	0000	
0086	10	1			0		0	0	0	0	0	0	0	1	000	3					00000	00	0000	00	00		0000	0	000		
0087	10	1	1	1	3	1	1	2	1	0	1	0	0	1	48	000	8	3	2	00	4250	32		31		0	0000	0	000	0000	1
0088	10	1	1	1	3	1	2	2	8		1	0	0	1	64	000	17				7500			72						0000	1
0088	10	2	1	1	3	1	2	2	8		1	0	0	1	64	000	17				7500			72						0000	2
0089	10	1	1	1	1	2	2	2	8		1	0	0	1		000	3													0000	1
0090	10	1	1	1	2	3	1	2	1	3	1	0	0	1	72	000	25	16			13600	22	400	72	35	0	80	2	660	0000	1
0090	10	2	1	1	2	3	1	2	1	3	1	0	0	1	72	000	25	16			13600	22	400	72	35	0	80	0	660	0000	1
0090	10	3	1	1	2	3	1	2	1	3	1	0	0	1	72	000	25	16			13600	22	400	72	35	0	80	0	660	0000	2
0090	10	4	1	1	2	3	1	2	1	3	1	0	0	1	72	000	25	16			13600	22	400	72	35	0	80	0	660	0000	2
0090	10	5	2	7	0	0	0	0	0	0	0	0	0	2			00	00	00	24	00000	00	0000	00	00	0	0000	0	000	600	
0090	10	6	2	7	0	0	0	0	0	0	0	0	0	2			00	00	00	24	00000	00	0000	00	00	0	0000	0	000	720	
0091	10	1	1	1	2	2	1	2	1	1	2	0	0	1	54	000	22	16	16		10800	32	350	57	37	0	1000	2	648	0000	1
0091	10	2	1	1	2	2	1	2	1	1	2	0	0	1	54	000	22	16	16		10800	32	350	57	37	0	1000	2	648	0000	1
0091	10	3	1	1	2	2	1	2	1	1	2	0	0	1	54	000	22	16	16		10800	32	350	57	37	0	1000	2	648	0000	2
0091	10	4	1	1	2	2	1	2	1	1	2	0	0	1	54	000	22	16	16		10800	32	350	57	37	0	1000	2	648	0000	2
0091	10	5	1	1	2	2	1	2	1	1	2	0	0	1	54	000	22	16	16		10800	32	350	57	37	0	1000	2	648	0000	3
0091	10	6	1	1	2	2	1	2	1	1	2	0	0	1	54	000	22	16	16		10800	32	350	57	37	0	1000	2	648	0000	3
0092	10	1	1				1	2						1	66	000	15				7500			50						0000	1
0092	10	2	1											1		000	15													0000	
0092	10	4	3	1	0	5	0	0	0	0	0	0	0	1	000	22					00000	00	0000	00	00		0000	0	000		
0092	10	5	3	1	0	5	0	0	0	0	0	0	0	1	000	22					00000	00	0000	00	00		0000	0	000	3850	
0093	10	1	1	1	2	3	2	2	8	2	1	0	1	1	72	000	22	8	00	00	12000	16	730	93	32	0	6000	1		0000	1

			**********FURNACE	CLASSIFICATION*********																	******BLAST****										
FDRY NO.	CD TY	FCE NO	FCE TYP	LIN TYP	BLT DES	BLT HTG	TOP C/O	CHG	GAS T-O	AFT	CHG DR	FL IN	OX EN	FCE USE	FCE DIA	HLD CAP	MLT RAT	MT UT	PR UT	OT UT	VOLUM	PRES	TEMP	SIZE CH DR	HT DR	CHG PRE	AFT SIZE	AFT LOC	DIS AFT	POWR SPLY	CTL SYS
0093	10	2	1	1	2	3	2	2	8	2	1	0	1	1	72	000	22	8	00	00	12000	16	730	93	32	0	6000	1		0000	2
0093	10	3	3		0	0	0	0	0	0	0	0	0	3	000	14	00	00	00	8	00000	00	0000	00	00	0	0000	0	000	1825	0
0093	10	4	3		0	0	0	0	0	0	0	0	0	3	000	14	00	00	00	8	00000	00	0000	00	00	0	0000	0	000	1825	0
0094	10	1	1	4	1	3	1	2	2	0	1	0	0	1	112	000	30	17	17		12000	30	900	99	43		0000	0	000	0000	1
0094	10	2	1	4	1	3	1	2	2	0	1	0	0	1	112	000	30	17	17		12000	30	900	99	43		0000	0	000	0000	1
0094	10	3	4	1	0	0	0	1	4	0	0	0	0	1	96	8	4	9	8		00000	00	0000	00	00	0	0000	0	000	3000	2
0095	10	1	1	1	3	1	1	2	1	0	1	0	0	1	102	000	25				13000			55		0	0000	0	000	0000	1
0095	10	2	1	1	3	1	1	2	1	0	1	0	0	1	102	000	25				13000			55		0	0000	0	000	0000	1
0095	10	3	1	1	3	1		2						1	102	000	25													0000	
0095	10	4	1	1	3	1		2						1	102	000	25													0000	
0096	10	1	1	1			1	2	1		2			1	102	000	15				2700			8						0000	1
0097	10	1	1	1	3	1	1	2	1	0	1			1	28	000	.4				1725			3			0000	0	000	0000	1
0098	10	1	1	4	1	3	1	2	1		1	0	0	1	102	000	40				20000		800	90						0000	1
0098	10	2	1	4	1	3	1	2	1		1	0	0	1	102	000	40				20000		800	90						0000	1
0098	10	3	4	1	0	0	0	0		0	0	0	0	2	240	60					00000	00	0000	00	00	0	0000	0	000	8000	
0098	10	4	3	1	0	5	0	0	0	0	0	0	0	1	000	23					00000	00	0000	00	00		0000	0	000	3200	
0098	10	5	3	1	0	5	0	0	0	0	0	0	0	1	000	23					00000	00	0000	00	00		0000	0	000	3200	
0099	10	1	1	4	1	3	1	2	2	0	1	0	0	1	54	000	12	20			6200	64	1000	69		0	0000	0	000	0000	1
0099	10	2	1	4	1	3	1	2	2	0	1	0	0	1	54	000	12	20			6200	64	1000	69		0	0000	0	000	0000	1
0099	10	3	2		0	0	0	0	0	0	0	0	0	3	000	20					00000	00	0000	00	00	0	0000	0	000		
0100	10	1	6	0	0	0	0	0	0	0	0	0	0	1	000	80					00000	00	0000	00	00		0000	0	000		
0101	10	1	1	2			1	2						1	60	000	14				8700			14						0000	1
0101	10	2	1	2			1	2						1	60	000	14				8700			14						0000	1
0102	10	1	1						1					1	72	000	10				4000									0000	1
0103	10	1	1											1		000	10													0000	

		**********FURNACE CLASSIFICATION**********																			******BLAST****										
FDRY NO.	CO TY	FCE NO	FCE TYP	LIN TYP	BLT DES	BLT HTG	TOP C/O	CHG	GAS T-O	AFT	CHG DR	FL IN	OX EN	FCE USE	FCE DIA	HLD CAP	MLT RAT	MT UT	PR UT	OT UT	VOLUM	PRES	TEMP	SIZE CH DR	HT DR	CHG PRE	AFT SIZE	AFT LOC	DIS AFT	POWR SPLY	CTL SYS
0103	10	2	1											1		000	12													0000	
0103	10	3	4	1	0	0	0			0	0	0	0			3					00000	00	0000	00	00		0000	0	000		
0103	10	4	4	1	0	0	0			0	0	0	0			.6					00000	00	0000	00	00		0000	0	000		
0104	10	1	1	1	3	1	1	2	1	2	2	0	0	1	54	000	9	3			4700	20			35			2	360	0000	1
0105	10	1	1				1	2						1	54	000	8				6000									0000	1
0105	10	2	1				1	2						1	54	000	8													0000	
0105	10	3	3		0		0	0	0	0	0	0	0		000	.5					00000	00	0000	00	00		0000	0	000		
0105	10	4	3		0		0	0	0	0	0	0	0		000	.5					00000	00	0000	00	00		0000	0	000		
0106	10	1	1	1			2	2	8		1			1	42	000	8							5						0000	1
0107	10	1	1	1	3	1	2	2	8	0	1	0	0	1	48	4	8	4	4	00	7000	21		27	8	0	0000	0	000	0000	
0108	10	1	1	2			1	2			1			1		000	8				3800			10						0000	1
0108	10	2	1	1			1	2						1		000	7				3700			10						0000	1
0108	10	3	3		0		0	0	0	0	0	0	0		000		5				00000	00	0000	00	00		0000	0	000		
0109	10	1	1				1	2			1			1	36	000	5				4000			12						0000	1
0109	10	2	1				1	2			1			1	36	000	5				4000			12						0000	2
0109	10	3	1				1	2			1			1	36	000	5				4000			12						0000	2
0109	10	4	4	1	0	0	0			0	0	0	0		36		5				00000	00	0000	00	00		0000	0	000		3
0110	10	1	1	1	3	1	1	2	1	0	1	0	0	1	84	000	18				9500						0000	0	000	0000	1
0110	10	2	1	1	3	1	1	2	1	0	1	0	0	1	84	000	18				9500						0000	0	000	0000	1
0110	10	3	6	0	0	0	0	0	0	0	0	0	0	3	000	50	00	00			00000	00	0000	00	00	0	0000	0	000		
0110	10	4	6	0	0	0	0	0	0	0	0	0	0	1	000	50	00	00			00000	00	0000	00	00	0	0000	0	000		
0111	10	1	1											1		000	12													0000	1
0112	10	1	1	1			2	2	8		1			1	54	000	10				4600			55						0000	1
0113	10	1	1	1	2	3	2	2	8	0	1	0	1	1	36	000	10	10	9		3950	16	600	18	27	0	0000	0	000	0000	1
0113	10	2	1	1	2	3	2	2	8	0	1	0	1	1	36	000	10	10	9		3950	16	600	18	27	0	0000	0	000	0000	2

FDRY NO.	CD TY	FCE NO	FCE TYP	LIN TYP	BLT DES	BLT HTG	TOP C/O	CHG	GAS T-O	AFT	CHG DR	FL IN	OX EN	FCE USE	FCE DIA	HLD CAP	MLT RAT	MT UT	PR UT	OT UT	******BLAST**** VOLUM	PRES	TEMP	SIZE CH DR	HT DR	CHG PRE	AFT SIZE	AFT LOC	DIS AFT	POWR SPLY	CTL SYS
			**********FURNACE CLASSIFICATION*********																												
0113	10	3	6	0	0	0	0	0	0	0	0	0	0	3	000	12	00				00000	00	0000	00	00	0	0000	0	000	0000	0
0113	10	4	2	6	0	0	0	0	0	0	0	0	0	2	000	25	00	10	18		00000	00	0000	00	00	0	0000	0	000	600	0
0114	10	1	1	1	2	3	1	2	1	0	1	0	0	1	60	000	18				18500		750	80		0	0000	0	000	0000	1
0114	10	2	1	1	2	3	1	2	1	0	1	0	0	1	60	000	18				18500		750	80		0	0000	0	000	0000	1
0115	10	1	1	2							1			1	36	000	5				2800			31						0000	1
0115	10	2	2	2							1			1	36	000	5				2800			31						0000	2
0115	10	3	2	2										1		000														0000	
0115	10	4	1	2										1		000														0000	
0116	10	1	1	4			2	2	8	3	1	0	0	1	50	000	9	9			4400			54	30	0	1050	1		0000	1
0116	10	2	1	4			2	2	8	3	1	0	0	1	50	000	9	9			4400			54	30	0	1050	1		0000	2
0117	10	1	1	1	2	3	1	2	1	2	1	0	0	1		000	32						750							0000	
0117	10	2	1	1	2	3	1	2	1	2	1	0	0	1		000	32						750							0000	
0117	10	3	6	0	0	0	0	0	0	0	0	0	0	3	000	34	00	00			00000	00	0000	00	00	0	0000	0	000		
0117	10	4	6	0	0	0	0	0	0	0	0	0	0	3	000	34	00	00			00000	00	0000	00	00	0	0000	0	000		
0118	10	1	1	4	2	3	2	2	8	0	1	0	0	1	54	000	12				6000			48			0000	0	000	0000	1
0118	10	2	1	4	2	3	2	2	8	0	1	0	0	1	61	000	14				6500			46			0000	0	000	0000	1
0118	10	3	1	1	2	3	2	2	8		1	0	0	1	66	000	16				8000			61						0000	2
0118	10	4	1	1	2	3	2	2	8		1	0		1	66	000	16				8000			61						0000	2
0118	10	5	1	4	2	3	2	2	8	0	1	0	0	1	60	000	14				6500			55			0000	0	000	0000	3
0119	10	1	1											1		000	7													0000	
0119	10	2	1				1	2						1	78	000	10													0000	1
0120	10	1	1	1	3	1	1	2	1		1	0	0	1	32	000	6													0000	1
0120	10	2	1	1	3	1	1	2	1		1	0	0	1	32	000	6													0000	1
0120	10	3	6	0	0	0	0	0	0	0	0	0	.	3	000	6	00	00			00000	00	0000	00	00	0	0000	0	000		
0120	10	4	7		0		0	0		0	0	[illegible]				.5					00000	00	0000	00	00		0000	0	000		

FDRY NO.	CD TY	FCE NO	FCE TYP	LIN TYP	DLT DES	BLT HTG	TOP C/O	CHG	GAS T-O	AFT	CHG DR	FL IN	OX EN	FCE USE	FCE DIA	HLD CAP	MLT RAT	MT UT	PR UT	OT UT	BLAST VOLUM	BLAST PRES	BLAST TEMP	SIZE CH DR	HT DR	CHG PRE	AFT SIZE	AFT LOC	DIS AFT	POWR SPLY	CTL SYS
0121	10	1	1	1	3	1	2	2	8		1	0	0	1	72	000	12				7500			53						0000	1
0121	10	2	1	1	3	1	2	2	8		1	0	0	1	60	000	12				7500			45						0000	2
0121	10	3	1	1	3	1	2	2	8		1	0	0	1		000	6													0000	
0121	10	4	4	1	0	0	0			0	0	0	0				3				00000	00	0000	00	00		0000	0	000		
0122	10	1	1	1	3	1	1	2	1	1	1	0	0	1	48	000	8				3800			22				1		0000	1
0123	10	1	1	1			1	2			1			1	36	000	6							7						0000	1
0124	10	1	1	2			1	2			1			1	36	000	4							8						0000	1
0125	10	1	1	4	1	3	1	2	1	2	1	0	0	1	108	000	35	9			15500		1000	92		4	5250	1	484	0000	1
0125	10	2	1	4	1	3	1	2	1	2	1	0	0	1	108	000	35	9			15500		1000	92		4	5250	1	484	0000	1
0125	10	3	1											1		000														0000	
0125	10	4	1											1		000	20													0000	
0125	10	5	1											1		000	20													0000	
0125	10	6	1											1		000	12													0000	
0126	10	1	1	4	1	3	1	2	1	0	1	0	0	1	102	000	40	17		00	20000	42	1200	99		0	0000	0	000	0000	1
0126	10	2	3		0	0	0	0	0	0	0	0	0	2	000	23		00	00	17	00000	00	0000	00	00	0	0000	0	000	1500	0
0126	10	3	3		0	0	0	0	0	0	0	0	0	2	000	23		00	00	17	00000	00	0000	00	00	0	0000	0	000	1500	0
0126	10	4	3		0	0	0	0	0	0	0	0	0	2	000	23		00	00	17	00000	00	0000	00	00	0	0000	0	000	1500	0
0126	10	5	3		0	0	0	0	0	0	0	0	0	2	000	23		00	00	17	00000	00	0000	00	00	0	0000	0	000	1500	0
0127	10	1	1	1			1	2			1			1	40	000	6							8						0000	1
0128	10	1	1	1			1	2			1			1	36	000	5				1600			5						0000	1
0129	10	1	1				1	2						1		000	9							30						0000	1
0130	10	1	1	2			1	2	1		2			1	45	000	9				4000			30						0000	1
0132	10	1	1	1			1	2	1		1			1	78	000	12	8			7500			35						0000	1
0132	10	2	1	1			1	2	1		1			1	60	000	12	8			7500			35						0000	1
0133	10	1	1	1	3	1	2	2	8	0	1	0	0	1	42	000	7										0000	0	000	0000	

FDRY NO.	CD TY	FCE NO	FCE TYP	LIN TYP	BLT DES	BLT HTG	TOP C/O	CHG	GAS T-O	AFT	CHG DR	FL IN	OX EN	FCE USE	FCE DIA	HLD CAP	MLT RAT	MT UT	PR UT	OT UT	******BLAST**** VOLUM	PRES	TEMP	SIZE CH	SIZE DR	HT DR	CHG PRE	AFT SIZE	AFT LOC	DIS AFT	POWR SPLY	CTL SYS
			***********FURNACE CLASSIFICATION*******.**																													
0133	10	2	1	1	3	1	2	2	8	0	1	0	0	1	42	000	7											0000	0	000	0000	
0133	10	3	7	0	0	0	0	0	0	0	0	0	0			.5					00000	00	0000	00		00		0000	0	000		
0134	10	1	1	4	1	3	1	2	1		1	0	0	1	84	000	60	16			15000		1000								0000	1
0134	10	2	1	4	1	3	1	2	1		1	0	0	1	84	000	60	16			15000		1000								0000	1
0135	10	1	1	2			1	2						1	52	000	4				3000										0000	1
0136	10	1	1	1	2	3	1	2	1	0	1	0	0	1	63	000	16	18		00	5500	14	700	45			0	0000	0	000	0000	1
0136	10	2	1	1	2	3	1	2	1	0	1	0	0	1	63	000	16	18		00	5500	14	700	45			0	0000	0	000	0000	1
0136	10	3	6	0	0	0	0	0		0	0	0	0	3	000	30	14	00	16	00	00000	00	0000	00		00	0	0000	0	000	0000	0
0137	10	1	1	1	1	3	2	2	8		1	0	0	1	72	000	18				10700		1000	69							0000	1
0137	10	2	1	1	1	3	2	2	8		1	0	0	1	72	000	18				10700		1000	69							0000	2
0137	10	3	1	1	1	3								1		000	25						1000								0000	
0137	10	4	1	1	1	3								1		000	25						1000								0000	
0138	10	1	1		3	1	1	2						1	60	000	10				3600			17							0000	1
0138	10	2	1											1		000	6														0000	
0139	10	1	1	1	3	1	1	2						1	60	000	16				6400			50							0000	1
0140	10	1	1	1	3	1	1	2	1		1	0	0	1	54	000	7				5300			37							0000	1
0140	10	2	1	1	3	1	1	2	1		1		0	1	54	000	7				5300			37							0000	1
0141	10	1	1	1	1		1	2			1			1	54	000	12				6000			40							0000	1
0141	10	2	1	1	1		1	2			1			1	54	000	12				6000			40							0000	1
0141	10	3	4	1	0	0	0			0	0	0	0								00000	00	0000	00		00		0000	0	000		
0141	10	4	3		0		0	0	0	0	0		0		000						00000	00	0000	00		00		0000	0	000		
0141	10	5	3		0		0	0	0	0	0		0		000						00000	00	0000	00		00		0000	0	000		
0141	10	6	3		0		0	0	0	0	0		0		000						00000	00	0000	00		00		0000	0	000		
0141	10	7	3		0		0	0	0	0	0		0		000						00000	00	0000	00		00		0000	0	000		
0142	10	1	1											1		000	5														0000	1

				**********FURNACE CLASSIFICATION*********																	******BLAST****										
FDRY NO.	CO TY	FCE NO	FCE TYP	LIN TYP	BLT DES	BLT HTG	TOP C/O	CHG	GAS T-O	AFT	CHG DR	FL IN	OX EN	FCE USE	FCE DIA	HLD CAP	MLT RAT	MT UT	PR UT	OT UT	VOLUM	PRES	TEMP	SIZE CH DR	HT DR	CHG PRE	AFT SIZE	AFT LOC	DIS AFT	POWR SPLY	CTL SYS
0143	10	1	1				1	2						1		000	8													0000	1
0144	10	1	1		3	1	1	2						1	43	000	9				4800			8						0000	1
0145	10	1	1	1			1	2	1		1			1	48	000	5				4200			21						0000	1
0146	10	1	1	1	3	1	1	2	1	0	2	0	1	1	108	000	55	16	00	00	16500	40		91	38	0	0000	0	000	0000	1
0146	10	2	1	1	3	1	1	2	1	0	2	0	1	1	108	000	55	16	00	00	16500	40		91	38	0	0000	0	000	0000	1
0147	10	1	1	1			2	1	8	0	0	0	0	1	70	000	20										0000	0	000	0000	
0147	10	2	1	1			2	1	8	0	0	0	0	1	70	000	20										0000	0	000	0000	
0147	10	3	1	1			2	1	8	0	0	0	0	1	70	000	55										0000	0	000	0000	
0147	10	4	1	1			2	1	8	0	0	0	0	1	70	000	55										0000	0	000	0000	
0147	10	5	1	1			2	1	8	0	0	0	0	1	70	000	55										0000	0	000	0000	
0148	10	1	1											1		000	35													0000	
0148	10	2	1											1		000	35													0000	
0149	10	1	1	1										1		000	13													0000	
0149	10	2	1	1										1		000	13													0000	
0150	10	1	1	1	2	2	1	1	2	3	2	0	1	1	78	000	38	9			11000	40	700		21	0	4250	1	150	0000	1
0150	10	2	1	1	2	2	2	1	2	3	2	0	1	1	78	000	38	9			11000	40	700		21	0	4250	1	150	0000	1
0151	10	1	1	4	1	3	1	2	1	0	1	0	0	1	96	000	25				12500	24	1000	60			0000	0	000	0000	1
0152	10	1	1	1	3	1	1	2	1		1	0	0	1	60	000	22				10500									0000	1
0152	10	2	1	1	3	1	1	2	1		1	0	0	1	60	000	22				10500									0000	1
0153	10	1	1	1	2	3	2	2	8	0	1	0	0	1	50	000	22						700				0000	0	000	0000	
0153	10	2	1	1	2	3	2	2	8	0	1	0	0	1	50	000	22						700				0000	0	000	0000	
0153	10	3	6	0	0	0	0	0	0	0	0	0	0	3	000	35					00000	00	0000	00	00		0000	0	000		
0153	10	4	6	0	0	0	0	0	0	0	0	0	0	3	000	35					00000	00	0000	00	00		0000	0	000		
0153	10	5	3		0		0	0	0	0	0	0	0		000	9	3				00000	00	0000	00	00		0000	0	000	1600	
0153	10	6	3		0		0	0	0	0	0	0	0		000	9	3				00000	00	0000	00	00		0000	0	000	1600	

		**********FURNACE CLASSIFICATION*********																			******BLAST****			SIZE								
FDRY NO.	CO TY	FCE NO	FCE TYP	LIN TYP	BLT DES	BLT HTG	TOP C/O	CHG	GAS T-O	AFT	CHG DR	FL IN	OX EN	FCE USE	FCE DIA	HLD CAP	MLT RAT	MT UT	PR UT	OT UT	VOLUM	PRES	TEMP	CH	DR	HT DR	CHG PRE	AFT SIZE	AFT LOC	DIS AFT	POWR SPLY	CTL SYS
0154	10	1	1	1	3	1	2	2	8	0	1	0	0	1	48	000	6											0000	0	000	0000	
0154	10	2	1	1	3	1	2	2	8	0	1	0	0	1	60	000	15											0000	0	000	0000	
0154	10	3	1	1	3	1	2	2	8	0	1	0	0	1	60	000												0000	0	000	0000	
0155	10	1	1	1										1		000	5														0000	
0156	10	1	1	1	2	3	2	2	8	2	1	0	0	1	66	000	23						750								0000	1
0157	10	1	1				1	2			2			1	37	000	4				2700			20							0000	1
0158	10	1	1	1	3	1	2	2	8		1	0	0	1	88	000	21				15000			60							0000	1
0159	10	1	1		3	1	1	2						1	42	000	6				3400			14							0000	1
0160	10	1	1	4	3	1	1	2	1	0	1	0	0	1	90	000	34	16	16	00	14000	54		99			0	0000	0	000	0000	1
0160	10	2	1	4	3	1	1	2	1	0	1	0	0	1	90	000	34	16	16	00	14000	54		99			0	0000	0	000	0000	1
0160	10	3	1	1	1		2	2	8	0	1	0	0	1	68	000	23	16	16	00		35		60			0	0000	0	000	0000	0
0160	10	4	1	1			2	2	8	0	1	0	0	1	68	000	23	16	16	00		35		60			0	0000	0	000	0000	0
0160	10	5	1	1	0		2	2	8	0	1	0	0	1	68	000	23	16	16	00	00000	35	0000	60			0	0000	0	000	0000	0
0160	10	6	1	1	0		2	2	8	0	1	0	0	1	68	000	23	16	16	00	00000	35	0000	60			0	0000	0	000	0000	0
0160	10	7	2	5	0	0	0	0	0	0	0	0	0	2	000	35	00	00	16	24	00000	00	0000	00		00	0	0000	0	000	600	0
0160	10	8	2	5	0	0	0	0	0	0	0	0	0	2	000	30	00	00	16	24	00000	00	0000	00		00	0	0000	0	000	600	0
0160	10	9	2	5	0	0	0	0	0	0	0	0	0	2	000	25	00	00	16	24	00000	00	0000	00		00	0	0000	0	000	600	0
0161	10	1	1				1	2						1	54	000	4				6000										0000	1
0161	10	2	1											1	54	000	4														0000	
0161	10	3	7				0	0		0	0	0	0			.5					00000	00	0000	00		00		0000	0	000		
0162	10	1	1	1			1	2		0				1		000					3500							0000	0	000	0000	1
0163	10	1	1	1	3	1	1	2	1		1	0	0	1	54	000	15				9000										0000	1
0163	10	2	1	1	3	1	1	2	1		1	0	0	1	54	000	15				9000										0000	1
0165	10	1	4	1	0	0	0	1	3	0	0	0	0	1	96		5	8			00000	00	0000	00		00	0	0000	0	000	4500	1
0165	10	2	4	1	0	0	0	1	3	0	0	0	0	1	96		5	8			00000	00	0000	00		00	0	0000	0	000	4500	1

			**********FURNACE CLASSIFICATION**********																		******BLAST****										
FDRY NO.	CO TY	FCE NO	FCE TYP	LIN TYP	BLT DES	BLT HTG	TOP C/O	CHG	GAS T-O	AFT	CHG DR	FL IN	OX EN	FCE USE	FCE DIA	HLD CAP	MLT RAT	MT UT	PR UT	OT UT	VOLUM	PRES	TEMP	SIZE CH DR	HT DR	CHG PRE	AFT SIZE	AFT LOC	DIS AFT	POWR SPLY	CTL SYS
0165	10	3	2	6	0	0	0	0	0	0	0	0	0	2	000	20	00		8	16	00000	00	0000	00	00	0	0000	0	000	500	0
0165	10	4	2	6	0	0	0	0	0	0	0	0	0	2	000	20	00		8	16	00000	00	0000	00	00	0	0000	0	000	500	0
0166	10	1	6	0	0	0	0	0	0		0	0	0	1	48		10				00000	00	0000	00	00					0000	1
0167	10	1	1	1	2	3	2	2	8	1	1	0	0	1	70	000	22				10000		550	40				1		0000	1
0167	10	2	1	1	2	3	2	2	8	1	1	0	0	1	70	000	22				10000		550	40				1		0000	2
0168	10	1	1	1	3	1	1	2	1	0	1	0	0	1	40	000	7	6	00	00	3500	35		9		0	0000	0	000	0000	1

ING OPERATION

FDRY NO.	CO TY	FCE NO	TOTAL MTL CH	REMELT	PIG IRON	PURCH CST I	PURCH STEEL	BRIQ	RUN/ TURN		DOLO MITE	SODA ASH	FLOU SPAR	OTH ER	CARB COKE	FE- SIL	MN	ADDIT T	LBS	ME/CO RATIO	SUL CON	O A	Q S	C M	S P	LITE-UP TIME	METH	CO	CO2	N2
0001	20	1													000					8										
0001	20	2													000					8										
0001	20	3													000					7										
0001	20	4													000					7										
0002	20	1													000					9										
0002	20	2													000					9										
0004	21	2	6000	6300	0000	0000	00000	000	0000	)	000	00	00	00	000	000	00	0	000	00	00	0	4	0	0	000	0	00	00	00
0004	21	3	39600	21500	0000	0000	16000	000	2000		200	00	00	00	450	500	00	0	000	00	00	0	2	6	0	000	0	00	00	00
0004	21	4	39600	21600	0000	0000	16000		2000						450	500	00	0	000	00	00	0	2	6	0	000	0	00	00	00
0004	21	5	39600	21500	0000	0000	16000		2000		200				450	500	00	0	000	00	00	0	2	6	0	000	0	00	00	00
0005	20	1													000					8										
0007	20	1	2500	500	0000	1500	500	000	0000	0	000	00	00	00	000	000	00	0	000	9	.6	0	3	2	0	30	2			
0008	20	1	4000	1500	0000	2200	300	000	0000	5	000	00	00	00	000	000	00	0	000	7	.6	0	3	2	0	100	2			
0009	20	1	22000	8360											000	150				10			3	2			1			
0009	20	2	22000	8360											000	150				10			3	2			1			
0011	20	1													000					8										
0012	20	1	7000	1000	1000	4500	500	000	0000	0	000	00	00	00	000	000	20	0	000	12	.6	2	2	3	3	120	5	10	14	65
0012	22	2	5400	700	700	0000	4000	000	000(	0	000	00	00	00	000	000	00	0	000	9	.6	2	1	3	3	120	6	16	12	68
0012	20	3	2500	00000	900	0000	800	800	000(	0	000	00	00	00	000	35	15	0	000	8	.6	0	1	3	3	120	6	18	14	63
0012	22	4	1500	00000	600	0000	900	000	000(	5	000	00	30	00	000	45	00	2	550	5	.6	0	1	3	3	120	6			
0012	20	5	200	60	0000	0000	140	000	000	:	000	00	00	00	000	12	00	1	1	6	.6	0	1	3	3	120	6			
0013	20	1													000					18										
0014	20	1	2000	00000	687	1250	00000	*63	000	)					000					7	.7									
0014	20	2	2000	00000	687	1250	00000	*63	000	)					000					7	.7									
0015	20	1													000					12										

FURY NO.	CD TY	FCE NO	TOTAL MTL CH	REMELT	PIG IRON	PURCH CST I	PURCH STEEL	BRIQ	PUN/ TURN	LIM STN	DOLO MITE	SODA ASH	FLOU SPAR	OTH ER	CARB COKE	FF- SIL	MN	ADDIT T	LBS	ME/CO RATIO	SUL CON	D A	Q S	C M	S P	LITE-UP TIME	METH	CO	CO2	N2
0016	20	1													000					10										
0016	20	2													000					10										
0018	20	1	1000	500	0000	0000	400	000	0000	40	000	00	00	00	000	000	00	3	2	6										
0018	20	2	1000	500	0000	0000	400	000	0000	40	000	00	00	00	000	000	00	3	2	6										
0021	20	1						000	0000						000	000	00	0	000	10	.6	0	4	2	0	20	6			
0021	22	1	2275	1000	75	0000	1200	000	0000	120	000	00	30	00	000	000	3		5	7	.6	0	4	2	0	20	6			
0021	20	2													000	000	00	0	000	10	.6	0	4	2	0	20	6			
0021	22	2	2275	1000	75	0000	1200	000	0000	120	000	00	30	00	000	000	3		5	7	.6	0	4	2	0	20	6			
0022	20	1	2500	1000	100	0000	1400	000	0000											00	00			0	1			00	00	00
0022	20	2	2500	1000	100	0000	1400	000	0000											00	00			0	1			00	00	00
0022	20	3	2500	1000	100	0000	1400	000	0000											00	00			0	1			00	00	00
0022	20	4	2500	1000	100	0000	1400	000	0000											00	00			0	1			00	00	00
0025	20	1	4000	400	0000	0000	2000		0000	125	000	00	00	00	000	000	00	0	000	6			3					16	3	78
0026	20	1	2000	200	0000	1500	300	000	0000	75	000	00	2	00	000		12	0	000	8	1.	0	3	3	0	120	1			
0026	20	2	2000	200	0000	1500	300	000	0000	75	000	00	2	00	000		12	0	000	8	1.	0	3	3	0	120	1			
0027	20	1	4000	1600	800	0000	1500	100	0000	130	000	00	00	00	000			0	000	7	.6	2	2		0	30	2		8	
0029	20	1	3000	750	*62	1050	450	750	0000		125			25						6		0	3	3	0	60	6			
0031	20	1	4000	1000	1000	2000				80	000	00	00	00	000	000	00	0	000	10		0								
0031	20	2	4000	1000	1000	2000				80	000	00	00	00	000	000	00	0	000	10		0								
0032	21	1	1935	800	0000	0000	1135	000	0000	60	000	5	00	00	000		65			12	.6	0	1	2	0	60	1			
0033	20	1													000					7										
0033	20	2													000					7										
0034	20	1			900	3600	4500			200					000					8										
0035	20	1	1800	400	230	200	00000	750	200	120	000	00	5	00	000	40	4	0	000	8	.6	0	3	3	3		5			
0035	20	2	1800	550	230	200	00000	600	200	90	000	00	3	00	000	40	2	0	000	8	.6	0	3	3	3		5			

MELTING OPERATION

FDRY NO.	CO TY	FCE NO	TOTAL MTL CH	REMELT	PIG IRON	PURCH CST I	PURCH STEEL	BRIQ	PUN/ TURN	LIM STN	DOLO MITE	SODA ASH	FLOU SPAR	OTH ER	CARB COKE	FE- SIL	MN	ADDIT T LBS	ME/CO RATIO	SUL CON	D A	Q S	C M	S P	LITE-UP TIME	METH	CO	CO2	N2
0035	20	3	1800	550	230	200	00000	600	200	90	000	00	3	00	000	40	2	0 000	8	.6	0	3	3	3		5			
0036	20	1													000				6										
0037	20	1													000				6						90	1			
0042	20	1	4000	1200	0000	0000	800		0000	000	12	00	00	00	000	136	4	0 000	8		0	3	5	0	90	2			
0043	20	1	1500	400	475	500	00000	125	0000	80	000	00	00	00	000	6	00	0 000	6		0	3	2	0	60	1			
0045	20	1													000				9										
0045	20	2													000				9										
0045	20	3													000				9										
0045	20	4													000				9										
0045	20	5													000				9										
0045	20	6													000				9										
0045	20	7													000				9										
0045	20	8													000				9										
0046	22	1	30000	15000	0000	0000	15000	000	0000	000	000	00	00	00	600	000	00	0 000	00	00		4	3	0	000	0	00	00	00
0046	22	2	30000	15000	0000	0000	15000	000	0000	000	000	00	00	00	600	000	00	0 000	00	00		4	3	0	000	0	00	00	00
0046	22	3	30000	15000	0000	0000	15000	000	0000	000	000	00	00	00	600	000	00	0 000	00	00		4	3	0	000	0	00	00	00
0046	22	4	30000	15000	0000	0000	15000	000	0000	000	000	00	00	00	600	000	00	0 000	00	00		4	3	0	000	0	00	00	00
0047	20	1													000				10										
0047	20	2													000				10										
0048	20	1	32000	15000	0000	5000	10000	000	1000	000	000	00	00	00	550	250	25		00	00		3	3	0	000	0	00	00	00
0049	20	1													000							3							
0052	20	1	4000	1500	1600	800	00000	*75	0000	60	000	00	00	00	000	000	00	0 000	10	.6	2	2		0	90	2	12	14	74
0052	20	2	4000	1500	1600	800	00000	*75	0000	60	000	00	00	00	000	000	00	0 000	10	.6	2	2		0	90	2	12	14	74
0052	20	3	4000	1500	1600	800	00000	*75	0000	60	000	00	00	00	000	000	00	0 000	10	.6	2	2		0	90	2	12	14	74
0052	20	4	4000	1500	1600	800	00000	*75	0000	60	000	00	00	00	000	000	00	0 000	10	.6	2	2		0	90	2			

FDRY NO.	CO TY	FCE NO	TOTAL MTL CH	REMELT	PIG IRON	PURCH CST I	PURCH STEEL	BRIQ	PUN/ TURN	LIM STN	DOLO MITE	SODA ASH	FLOU SPAR	OTH ER	CARB COKE	FE- SIL	MN	ADDIT T	ADDIT LBS	ME/CO RATIO	SUL CON	O A	Q S	C M	S P	LITE-UP TIME	METH	CO	CO2	N2
0061	20	1	3000	1300	600	300	800	000	0000	000	60	00	00	00	000	000	6	0	000	9	.6	0	1		0	90	2			
0062	20	1													000					10										
0062	20	2													000					10										
0065	20	1	5870	00000	0000	3170	2700	000	0000	170	000	00	00	00	000	170	00	0	000	8				2	0					
0065	20	2	5870	00000	0000	3170	2700	000	0000	170	000	00	00	00	000	170	00	0	000	8				2	0					
0066	20	5	10000	4000	1450		2000		0000						000															
0067	20	1													000						.6						1			
0067	20	2													000						.6						1			
0067	20	3													000						.6						1			
0070	20	1													000					5										
0070	20	2													000					5										
0070	20	3													000					5										
0070	20	4													000					5										
0070	20	5													000					5										
0072	20	1													000											120	2	00	00	00
0072	20	2													000											120	2	00	00	00
0072	20	3													000											120	2	00	00	00
0072	20	4													000											120	2	00	00	00
0072	20	5													000											120	2	00	00	00
0072	20	6													000											120	2	00	00	00
0074	20	1													000					8										
0076	20	1													000					7										
0081	20	1													000					5										
0083	20	1													000					9										
0083	20	2													000					9										

MELTING OPERATION

FDRY NO.	CO TY	FCE NO	TOTAL MTL CH	REMELT	PIG IRON	PURCH CST I	PURCH STEEL	BRIQ	PUN/ TURN	LIM STN	DOLO MITE	SODA ASH	FLOU SPAR	OTH ER	CARB COKE	FE- SIL	MN	ADDIT T	LBS	ME/CO RATIO	SUL CON	D A	Q S	C M	S P	LITE-UP TIME	METH	CO	CO2	N2
0084	20	1	4000	00000	0000	400	3600	000	0000	300	000	00	30		000	150	00	4	10	7	.6							11	13	76
0085	20	1	2950	1030	900	0000	1050	000	0000	120	000	00	00	00	000	50	00	0	000	11								3	13	82
0087	20	1	1000	450	275	0000	275	000	0000	26	000	00	00	00	000	5	3	0	000	8	.5	0	4	1	1	90	6			
0088	20	1	2000	00000	*250	150	1600	000	0000	70	000	00	4	00	000	8	12	0	000	8						45				
0088	20	2													000					8										
0090	20	1	4200	1435	1200	260	600	500	*125	125	000	00	00	00	000	000	00	0	000	11	.6	0	3	3	0	45	1			
0090	20	2	4200	1495	1200	260	600	500	*125	125	000	00	00	00	000	000	00	0	000	11	.6	0	3	3	0	45	1			
0090	20	3	4200	1495	1200	260	600	500	*125	125	000	00	00	00	000	000	00	0	000	11	.6	0	3	3	0	45	1			
0090	20	4	4200	1495	1200	260	600	500	*125	125	000	00	00	00	000	000	00	0	000	11	.6	0	3	3	0	45	1			
0091	20	1	4000	1400	900	500	1000	200	0000	110	000	00	00	00	000	26	20	5	30	11	.6	0	3	3	0	90	1			
0091	20	2	4000	1400	900	500	1000	200	0000	110	000	00	00	00	000	26	20	5	30	11	.6	0	3	3	0	90	1			
0091	20	3	4000	1400	900	500	1000	200	0000	110	000	00	00	00	000	26	20	5	30	11	.6	0	3	3	0	90	1			
0091	20	4	4000	1400	900	500	1000	200	0000	110	000	00	00	00	000	26	20	5	30	11	.6	0	3	3	0	90	1			
0091	20	5	4000	1400	900	500	1000	200	0000	110	000	00	00	00	000	26	20	5	30	11	.6	0	3	3	0	90	1			
0091	20	6	4000	1400	900	500	1000	200	0000	110	000	00	00	00	000	26	20	5	30	11	.6	0	3	3	0	90	1			
0092	21	1													000					9										
0093	20	1	5500	1100	0000	1650	2750	000	0000	70	000	00	00	00	000	75	00	0	000	8	.6	2	1	3	0	120	2		13	
0093	22	1	6000	1200	0000	0000	4800	000	0000	90	000	00	00	5	000	100	00	0	000	18	.6	2	4	3	0	120	2			
0093	20	2	5500	1100	0000	1650	2750	000	0000	70	000	00	00	00	000	75	00	0	000	8	.6	2	1	3	0		2		13	
0093	22	2	6000	1200	0000	0000	4800	000	0000	90	000	00	00	5	000	100	00	0	000	8	.6	2	4	3	0	120	2			
0093	20	3	00000	00000	0000	0000	00000	000	0000	000	000	00	00	13	000	000	00	3	11	00	00	0	0	0	0	000	0	00	00	00
0093	22	3	00000	00300	0000	0000	00000	000	0000	000	000	00	00	8	000	000	00	3	13	00	00	0	0	0	0	000	0	00	00	00
0093	20	4	00000	00000	0000	0000	00000	000	0000	000	000	00	00	13	000	000	00	3	11	00	00	0	0	0	0	000	0	00	00	00
0093	22	4	00000	00300	0000	0000	00000	000	0000	000	000	00	30	8	300	000	00	3	13	00	00	0	0	0	0	000	0	00	00	00
0094	20	1	6500	1400	0000	2500	2600	000	0000	000	100	00	00	00	000	35	00	0	000	9	.6	2	3	3	0	240	2	16	13	71

FDRY NO.	CD TY	FCE NO	TOTAL MTL CH	REMELT	PIG IRON	PURCH CST I	PURCH STEEL	BRIQ	PUN/ TURN	LIM STN	DOLO MITE	SODA ASH	FLOU SPAR	OTH ER	CARB COKE	FE- SIL	MN	ADDIT T	LBS	ME/CO RATIO	SUL CON	D A	Q S	C M	S P	LITE-UP TIME	METH	CO	CO2	N2
0094	22	1	5000	750	0000	0000	4250	000	0000	000	80	00	00	00	000	40	00	0	000	6	.6	2	2	3	0	240	2	16	13	71
0094	20	2	6500	1400	0000	2500	2600	000	0000	000	100	00	00	00	000	35	00	0	000	9	.6	2	3	3	0	240	2	16	13	71
0094	22	2	5000	750	0000	0000	4250	000	0000	000	80	00	00	00	000	40	00	0	000	6	.6	2	2	3	0	240	2	16	13	71
0094	20	3	7200	1550	1550	0000	4100	000	0000	000	000	00	00	00		000	00	0	000	00	00	0	0	3	0	000	0	00	00	00
0095	20	1													000								3							
0095	20	2													000								3							
0096	20	1													000					8										
0097	20	1	800	00300	400	0000	400	000	0000						000															
0098	20	1													000					7										
0098	20	2													000					7										
0099	20	1	1100	200	0000	700	00000	200	0000	60	000	00	00	00	000	000	00	0	000	6		0	3	3	0		2	3	2	80
0099	20	2	1100	200	0000	700	00000	200	0000	60	000	00	00	00	000	000	00	0	000	6		0	3	3	0		2	3	2	80
0102	20	1													000								3							
0104	20	1	2000	800	400	200	600			60	000	00	00	00	000					6	.6	3	4	2	0		2			
0106	20	1													000					8										
0107	20	1	1200	600	0000	0000	600	000	0000	12	.5	4			000	8	4	0	000	8	55	3	4			20	1			
0108	20	1													000					9										
0108	20	2													000					9										
0109	20	1													000					10										
0109	20	2													000					10										
0109	20	3													000					10										
0110	21	1	2945	1800	0000	0000	1145	000	0000	60	000	00	00	00	000	55	00	6	4	10			3							
0110	21	2	2945	1800	0000	0000	1145	000	0000	60	000	00	00	00	000	55	00	5	4	10			3							
0113	21	1	1000	580	*80	0000	340	000	0000	20	000	.5	00	00	000	.75	.3	7	.5	11	.7	0	4	1	0	60	2			
0113	21	2	1000	580	*80	0000	340	000	0000	20	000	.5	00	00	000	.75	.3	7	.5	11	.7	0	4	1	0	60	2			

MELTING OPERATION

FDRY NO.	CO TY	FCE NO	TOTAL MTL CH	REMELT	PIG IRON	PURCH CST I	PURCH STEEL	BRIQ	PUN/ TURN	LIM STN	DOLO MITE	SODA ASH	FLOU SPAR	OTH ER	CARB COKE	FE-SIL	MN	ADDIT T	LBS	ME/CO RATIO	SUL CON	D A	Q S	C M	S P	LITE-UP TIME	METH	CO	CO2	N2
0114	20	1	2000	1200	200	0000	600	000	0000	75	000	00	00	00	000	000	00	5	23	9			4							
0114	20	2	2000	1200	200	0000	600	000	0000	75	000	00	00	00	000	000	00	5	23	9			4							
0115	20	1													000					6										
0115	20	2													000					6										
0116	20	1	1430	730	400	0000	300	000	0000	60	000	00	00	00	000					6								.2	8	71
0116	20	2	1430	730	400	0000	300	000	0000	60	000	00	00	00	000					6								.2	8	71
0122	20	1	1280	450	320	125	385	000	0000	60	000	00	00	10	000					8			4	2			2			
0123	20	1													000					10										
0124	20	1													000					10										
0125	20	1													000					10			3					16	11	72
0125	20	2													000					10			3					16	11	72
0126	20	1	10000	500	0000	3500	5000	000	900	400	000	00	18	00	000	260	00	0	000	9	.6	3	2	2	0		5			
0126	22	1	10000	1000	0000	0000	9000	000	000	400	000	00	18	00	000	210	00	0	000	9	.6	3	2	2	0		5			
0127	20	1													000					5										
0128	20	1													000					4										
0130	20	1													000					9										
0132	20	1	1933	735	0000	1265	00000	33	0000	66	000	00	00	00	000					10										
0132	20	2	1933	735	0000	1265	00000	33	0000	66	000	00	00	00	000					10										
0136	20	1	2500	1250	400	750	00000	100	0000	80	000	00	4	00	000	000	00	5	25	12										
0136	21	1	2500	1650	0000	0000	750	100	0000	30	000	00	1	00	000	000	5	5	8	8	.5	2	2	3	0	60	2			
0136	20	2	2500	1250	400	750	00000	100	0000	80	000	00	4	00	000	000	00	5	25	12										
0136	21	2	2500	1550	0000	0000	750	100	0000	30	000	00	1	00	000	000	5	5	8	8	.5	2	2	3	0	60	2			
0137	20	1													000					10										
0137	20	2													000					10										
0141	20	1													000					7										

FDRY NO.	CD TY	FCE NO	TOTAL MTL CH	REMELT	PIG IRON	PURCH CST I	PURCH STEEL	BRIQ	PUN/ TURN	LIM STN	DOLO MITE	SODA ASH	FLOU SPAR	OTH ER	CARB COKE	FE- SIL	MN	ADDIT T	LBS	ME/CO RATIO	SUL CON	D A	Q S	C M	S P	LITE-UP TIME	METH	CO	CO2	N2
0141	20	2													000					7										
0145	20	1													000					10			4							
0146	20	1	8000	560	1760	3680	2000	000	0000	160	000	00	00	00	000	25	00	0	000	9	.6	3	4	2	3	120	2			
0146	22	1	8000	800	3200	0000	4000	000	0000	160	000	00	00	00	000	25	00	0	000	8	.6	3	4	2	3	120	2			
0146	20	2	8000	560	1760	3680	2000	000	0000	160	000	00	00	00	000	25	00	0	000	9	.6	3	4	2	3	120	2			
0146	22	2	8000	800	3200	0000	4000	000	0000	160	000	00	00	00	000	25	00	0	000	8	.6	3	4	2	3	120	2			
0150	20	1	6000	900	1500	2700	900	000	0000	130	000	00	00	00	000	000	00	7	20	11	.6	2	1	1	0		6	8	17	76
0150	22	1	5000	500	2250	0000	2250	000	0000	130	000	00	00	00	000	20	00	7	000	10	.6	2	4	1	0		6			
0150	20	2	6000	900	1500	2700	900	000	0000	130	000	00	00	00	000	000	00	7	20	11	.6	2	1	1	0		6	8	17	76
0150	22	2	5000	500	2250	0000	2250	000	0000	130	000	00	00	00	000	20	00	7	000	10	.6	2	4	1	0		6			
0151	20	1	7060	5250	1050	700	00000	000	0000	200	000	00	00	00	000	60	00	0	000	9	.6			2						
0157	20	1													000					E										
0158	20	1													000					9										
0160	20	1	5000	2300	600	0000	1900	500	0000	150	000	00	00	00	000		99			8		0	1	3	0		2			
0160	20	2	5000	2000	600	0000	1900	500	0000	150	000	00	00	00	000		99			8		0	1	3	0		2			
0160	20	3	3764	1700	500	0000	1500	64	0000	90	000	00	00	00	000		30	0	000	9		0	1	3	0		2			
0160	20	4	3764	1700	500	0000	1500	64	0000	90	000	00	00	00	000		30	0	000	9		0	1	3	0		2			
0160	20	5	3764	1700	500	0000	1500	64	0000	90	000	00	00	00	000		30	0	000	9		0	1	3	0		2			
0160	20	6	3764	1700	500	0000	1500	64	0000	90	000	00	00	00	000		30	0	000	9		0	1	3	0		2			
0162	20	1	1000	200	300	200	300	000	0000	000	000	00	00	00	000	000	00													
0163	20	1	2025							70					000					8										
0163	20	2	2025							70					000					8										
0165	20	1	10000	3500	1000	1700	3000	000	700	000	000	00	00	00	100	120	00	8	30	00	00	3	4	3	0	000	0			
0165	22	1	10000	4300	2000	0000	3000	000	700	000	000	00	00	00	100	120	00	8	20	00	00	3	4	3	0	000	0			
0165	20	2	10000	3600	1000	1700	3000	000	700	000	000	00	00	00	100	120	00	8	30	00	00	3	4	3	0	000	0			

FDRY NO.	CO TY	FCE NO	TOTAL MTL CH	REMELT	PIG IRON	PURCH CST I	PURCH STEEL	BRIQ	PUN/ TURN	LIM STN	DOLO MITE	SODA ASH	FLOU SPAR	OTH ER	CARB COKE	FE- SIL	MN	ADDIT	T LBS	ME/CO RATIO	SUL CON	D A	Q S	C M	S P	LITE-UP TIME	METH	CO	CO2	N2
0165	72	2	10000	4300	2000	0000	3000	000	700	000	000	00	00	00	100	120	00	8	20	00	00	3	4	3	0	000	0			
0166	20	1	14000	6800	5600	0000	1600	LBP	ERHR				CO	AL	100	OLB	PE	R	TON				4				3			
0167	20	1	2400	2250	0000	0000	150	000	0000	120	000	00	00	00	000	17	00	0	000	8			4	3			3			
0167	20	2	2400	2250	0000	0000	150	000	0000	120	000	00	00	00	000	17	00	0	000	8			4	3			3			
0168	20	1	660	00300	0000	255	405	000	0000	6	000	00	00	00	000	000	00	0	000	8			3	2	0	120	1			

CONTROL SYSTEM

FORY NO.	CO TY	CTL SYS	SYS TYP	FCES CONT	YEAR INST	GAS VOLUME	GAS TEMP	PRES DROP	HEIGHT EXH STK	AFTBURN SIZE	WATER DUST	CONSUMPTION GAS	RECIRC	NOISE CONTR	FIL MED	AIR/CLOTH RATIO	INLET CONC	OUT CONC	CATCH	COLL EFF	MLT RTE
0001	30	1	4	123	58	104000	400	8	87	0000			72	2	0	0		.28		80	15
0002	30	1	27	12	54	45300	550	4	46	9999			25	2	0	0		.039		90	12
0004	30	1	5	345		200000	120	9	13	0000	0000	000	0000	2	3	3			6	99	
0005	30	1	26	1	51	11500	200	4		250				2	3	2		.008		99	7
0006	30	1	6	1	68					0000					3						
0007	30	1	26	1	67	54000	500	6	83	7400	0000	30	30	2	3	2	.86		26	99	20
0008	30	1	26	1	67	38000	500	7	46	3300	0000	20	20	2	3	2		.69	11	99	12
0009	30	1	24	12	67	84000	450		125	8000	0000	000	0000	2	0	0	.65	.13	11	80	
0009	30	2	24	3	67	84000	450		125	8000	0000	000	0000	2	0	0	.678	.163	13	75	13
0010	30	1	6	1	69					0000					3						
0011	30	1	26	1	65	46000	450	6		7800			20	2	3	2					
0012	30	1	4	12	55	101000	500	6	82	0000			200	2	0	0	.5	.075		85	40
0013	30	1	25	1	63	34000	163	12	60	500			140	2	0	0					18
0014	30	1	4	12	68	48000	400		125		0000	000	0000	2	0	0	.311	.153		51	6
0015	30	1	5	1	67	11000	1500	15		0000			2200		0	0		.25		80	6
0016	30	1	23	1	58			00	61	3300			175	2	0	0					
0016	30	2	23	2	58			00	61	3300			175	2	0	0					
0017	30	1	6	12		16500	500								3	2					
0018	30	1	3	1	56	32050	1435	00	45	0000			20		0	0	1.06	.159		85	6
0018	30	2	3	2	56	32050	1435	00	45	0000			20		0	0					
0019	30	1	3	1																	
0019	30	2	3	2																	
0021	30	1	35	12	66	24000			76	0000	175	250	0000	2	0	0		.269	6		18
0023	30	1	4	1	59	36000	500			0000					0	0					
0024	30	1	5	12	67					0000					0	0					

FDRY NO.	CO TY	CTL SYS	SYS TYP	FCES CONT	YEAR INST	GAS VOLUME	GAS TEMP	PRES DROP	HEIGHT EXH STK	AFTBURN SIZE	WATER DUST	CONSUMPTION GAS	RECIRC	NOISE CONTR	FIL MED	AIR/CLOTH RATIO	INLET CONC	OUT CONC	CATCH	COLL EFF	MLT RTE
0025	30	1	3	1	67													.314			20
0026	30	1	24	12	68	46500	389	8	125	8000	0000			2	0	0	.46	.174	19	65	10
0027	30	1	3	1	68			00	76	0000	200	000	180	2	0	0					
0029	30	1	235	1	69	82000	300	40	125		150	000	0000		0	0	1.06	.12	17	93	16
0031	30	1	35	12	69	19500	150	45	100	0000	1100	200	1150		0	0		.177			30
0032	30	1	23	1	58		1000	00	70	2000	350	000	320	2	0	0		.37	20	80	16
0033	30	1	25	1	66	96000	180	58	107	4240			3000	1	0	0		.016			
0033	30	2	25	2	66	96000	120	3	107				3000	2	0	0					
0034	30	1	5	1	65	34500	122	70	124				300	2	0	0		.05		95	50
0035	30	1	25	1	64	25000	140	35	175		450		400	2	0	0	2.26	.13		95	12
0035	30	2	3	2	47	20000		00		0000	70	000	0000	2	0	0					
0035	30	3	3	3	47	20000		00		0000	70	000	0000	2	0	0					
0036	30	1	6	1	51	13200	450	6		60			12		3	2					
0037	30	1	6	1	50	13500	425	6						2	3		.6			99	4
0038	30	1	4	1	58	84000	500	9	71					2	0	0					
0039	30	1	5	1	70										0	0					
0041	30	1	6	1	57										3						
0042	30	1	23	1	69	50000	2000		99	4200	360	20		2	0	0					
0043	30	1	7	1	70	20000	410	4	50	9000	0000	42	20	2	0	0	2.0	.029	38.	98	9
0045	30	1	5	78	63	50000	155	14	70	418			150	2	0	0	1.24			50	26
0046	30	1	6	12	68	100000	250	13	35	0000	0000	000	0000	2	2	3	.85			99	
0046	30	2	6	34	68	100000	250	13	35	0000	0000	000	0000	2	2	3	.85			99	
0047	30	1	24	12	58	60000	500	6	90	100					0	0					
0048	30	1	6	1	65	32000	250	4	27	0000	0000	000	0000	2	2	2			18		7
0049	30	1	5	1	67			6							0	0					

CONTROL SYSTEM

FURY NO.	CO TY	CTL SYS	SYS TYP	FCES CONT	YEAR INST	GAS VOLUME	GAS TEMP	PRES DROP	HEIGHT EXH STK	AFTBURN SIZE	WATER DUST	CONSUMPTION GAS	RECIRC	NOISE CONTR	FIL MED	AIR/CLOTH RATIO	INLET CONC	OUT CONC	CATCH	COLL EFF	MLT RTE
0050	30	1	5	1	68	27500		50							0	0	1.09	.034		97	
0051	30	1	6	12																	
0052	30	1	3	2	69	26000	450	00	86	0000	150	000	0000	2	0	0		.165			8
0052	30	2	23	4	69	24000	2200	00	98	0000	520	000	0000	2	0	0					
0054	30	1	5	1	69										0	0					
0056	30	1	4	1	69										0	0					
0058	30	1	4	1	57										0	0		.15			
0058	30	2	4	2	57										0	0		.15			
0061	30	1	4	12	69	85000	500		80	750	0000	70		2	0	0			22	81	20
0062	30	1	4	12	66	72000	500	4	85	750			40	2	0	0		.227		80	17
0063	30	1	6	12	67	52000															
0065	30	1	25	1	69	80000	185	80		3000	1600	400	1800		0	0		.047			30
0065	30	2	25	2	69	80000	185	80		3000	1600	400	1800		0	0		.035			30
0065	30	3	3	3											0	0					
0065	30	4	3	4											0	0					
0065	30	5	3	6											0	0					
0066	30	1	5	5											0	0					
0067	30	1	125	1	66	27000	600	53	120	6000		999	785	1	0	0	12.9	.079		99	45
0067	30	2	125	2	69	50000	1900	53	98	9999			2200	1	0	0	5.83				50
0067	30	3	3	3	55				98		600				0	0					
0068	30	1	3	1	64	30000	800		100	0000	600			2	0	0					
0068	30	2	23	2	64	30000	800		100		600			2	0	0					
0068	30	3	23	3	64	30000	800		95					2	0	0					
0068	30	4	23	4	64	30000	800							2	0	0					
0068	30	5	2	5	69	35000	1200							2	0	0					

FORY NO.	CO TY	CTL SYS	SYS TYP	PIES CONT	YEAR INST	GAS VOLUME	GAS TEMP	PRES DROP	HEIGHT EXH STK	AFTBURN SIZE	WATER DUST	CONSUMPTION GAS	RECIRC	NOISE CONTR	FIL MED	AIR/CLOTH RATIO	INLET CONC	OUT CONC	CATCH	COLL EFF	MLT RTE
0069	30	1	236	5	70	35500	500	18	85		40			2	3	2	4.0	.02	15.	99	
0069	30	2	236	6	70	35600	500	18	85		60			2	3	2	4.0	.02	15.	99	
0069	30	3	35	3	69	22400	170	72	120	0000	300	23	850	2	0	0	4.0	.05	15.	99	
0069	30	4	35	4	68	26600	170	72	120	0000	300	23	850	2	0	0	4.0	.05	15.	99	
0069	30	5	35	1	68	29000	170	72	120	0000	450	30	800	2	0	0	4.0	.05	15.	99	
0069	30	6	35	2	70	29000	170	72	120	0000	350	30	1000	2	0	0	4.0	.05	15.	99	40
0070	30	1	5	1	66										0	0		.05		99	
0070	30	2	5	2	67										0	0		.05		99	
0070	30	3	5	3	67										0	0		.05		99	
0070	30	4	5	4	68										0	0		.05		99	
0071	30	1	5	1	65	027000	110	80	129	0000	1000		2700	2	0	0	6.67	.075		99	35
0071	30	2	5	2	65	027000	110	80	129	0000	1000		2700	2	0	0	8.8	.051		99	45
0071	30	3	5	3	65	027000	110	80	129	0000	1000		2700	2	0	0		.05			
0071	30	4	5	4	70	27000	110	80	150	0000	800		2500	2	0	0					
0072	30	1	3	1					81	0000	750			2	0	0					
0072	30	2	3	2					81	0000	750			2	0	0					
0072	30	3	3	3					81	0000	750			2	0	0					
0072	30	4	3	4					81	0000	750			2	0	0					
0072	30	5	3	5					81	0000	750			2	0	0					
0072	30	6	3	6					81	0000	750			2	0	0					
0072	30	7	6	10	68	110000	265	12	107	0000	0000			2	2	3					
0073	30	1	4	12	64	126000	500								0	0					
0074	30	1	3	1	57			00	50	50			200	2	0	0					
0075	30	1	6	1																	
0076	30	1	26	1	52	12500	450	6		500			3	2	3	2	.6				

FDRY NO.	CD TY	CTL SYS	SYS TYP	FCES CONT	YEAR INST	GAS VOLUME	GAS TEMP	PRES DROP	HEIGHT EXH STK	AFTBURN SIZE	WATER CONSUMPTION DUST	GAS	RECIRC	NOISE CONTR	FIL MED	AIR/CLOTH RATIO	INLET CONC	OUT CONC	CATCH	COLL EFF	MLT RTE
0077	30	1	4	12	57	84000	500								0	0					
0077	30	2	4	34	57										0	0					
0080	30	1	6	1																	
0081	30	1	6	1	52	32000	500	6		2000			35	2	3	2					
0083	30	1	23	1	57			00	60	2300			400	2	0	0					
0083	30	2	4	2	57				60	2300			400	2	0	0					
0084	30	1	6	1		40000	175			7000	0000	000	0000		2	2	4.0	.8	35	80	30
0085	30																8.35	.154	23		24
0087	30	1	5	1	69	21100	1500	25	52	0000	420		395	2	0	0					
0088	30	1	3	1	57	69000	300	25	93						0	0		.144			17
0088	30	2	3	2	57	69000	300	00	93						0	0		.144			17
0089	30	1	3	1																	
0090	30	1	24	12	61	96000	500	5	100	2400	0000	000	0000	2	0	0	1.98	.83	6.8	51	17
0090	30	2	24	34	61	96000	500	5	100	2400	0000	000	0000	2	0	0	1.98	.83	6.8	61	17
0091	30	1	24	12	59	84000	400	6	94	1000	0000	220	0000	2	0	0		.27		86	21
0091	30	2	24	34	60	84000	400	6	94	1000	0000	220	0000	2	0	0		.30		84	21
0091	30	3	24	56	61	84000	400	6	94	1000	0000	220	0000	2	0	0		.17		88	21
0092	30	1	4	1		60000	500								0	0	.97	.16		84	
0093	30	1	23	1	58				96		200		0000	2	0	0					
0093	30	2	23	2	60				96		200		0000	2	0	0					
0094	30	1	5	12	67	33000	300	11	84					2				.7			
0094	30	2	5	3	55	16600	900	6			68	000	68	2							
0095	30	1	25	12	66	36000	130	26			500		450	2	0	0		.16			20
0096	30	1	26	1	64	16000	540	7	70	3000				2	3			.148			20
0097	30	1	5	1	68	7200	110	20	40	0000				2	0	0		.110			

FCRY NO.	CD TY	CTL SYS	SYS TYP	FCES CONT	YEAR INST	GAS VOLUME	GAS TEMP	PRES DROP	HEIGHT EXH STK	AFTBURN SIZE	WATER DUST	CONSUMPTION GAS	RECIRC	NOISE CONTR	FIL MED	AIR/CLOTH RATIO	INLET CONC	OUT CONC	CATCH	COLL EFF	MLT RTE
0098	30	1	26	12	61	100000	550	7	70						3	2				99	40
0099	30	1	35	12	69	19380	80	25	104	0000	190	60	250	2	0	0		.27			11
0101	30	1	25	12	67	30000	170	40							0	0	1.48	.04		98	
0102	30	1	5	1	67										0	0					
0104	30	1	26	1	60		420	4	60		0000		0000	2	3						
0105	30	1	4	12	57	33000	500								0	0					
0106	30	1	3	1	66		1800	00	65				300	2	0	0					9
0108	30	1	6	12	63	24000	530	6	61				25		3	2		.243			9
0109	30	1	45	12	66	4500	1500	21	42				75		0	0				80	5
0109	30	2	45	23	66	4500	1500	21	42				75		0	0				80	5
0109	30	3	45	4	66	4500	1500	28	42				75		0	0				80	5
0110	30	1	5	12	66	25000	70	25			700		650		0	0		.153			20
0112	30	1	3	1	52			00	68				175		0	0					
0113	30	1	1	1				00	52	0000	0000	000	0000	2	0	0	.95				
0113	30	2	1	2				00	52	0000	0000	000	0000	2	0	0	.95				
0114	30	1	3	12	69			40	125						0	0					
0115	30	1						00	56				200	2	0	0					
0115	30	2						00	56				200	2	0	0					
0116	30	1	23	1		23000	800		45	3150					0	0		.88			
0116	30	2	23	2		23000	800		45	3150					0	0		.88			
0118	30	1	3	12	55		2000	00					250		0	0					
0118	30	2	3	34	63		2000	00					250		0	0					
0118	30	3	3	5	68			00							0	0					
0119	30	1	5	2											0	0					
0120	30	1	6	12											3						

FDRY NO.	CD TY	CTL SYS	SYS TYP	FCES CONT	YEAR INST	GAS VOLUME	GAS TEMP	PRES DROP	HEIGHT EXH STK	AFTBURN SIZE	WATER CONSUMPTION DUST	GAS	RECIRC	NOISE CONTR	FIL MED	AIR/CLOTH RATIO	INLET CONC	OUT CONC	CATCH	COLL EFF	MLT RTE
0121	30	1	3	1	64			00					250		0	0					
0121	30	2	3	2	64			00					250		0	0					
0122	30	1	5	1	70	16600	158	25	81		330	000	300	2	0	0		.024			8
0123	30	1	6	1	51	13000	500		20					2	3						6
0124	30	1	26	1	66		500	3						2	3						4
0125	30	1	5	12	67	33000	80	88	78	9999	750		750		0	0		.05	24	99	35
0126	30	1	5	1	70	43800	150	26	114	0000	450	350	550	2	0	0					
0127	30	1	26	1	51	10800	440	4		80				2	3	2					
0128	30	1	26	1	50	12550	450	3		2000			15	2	3						
0129	30	1	6	1	60										3						
0130	30	1	26	1	60	28000	500	6	49	3000			20	2	3					90	9
0132	30	1	25	12	68	30000	165	45	62	1200			60	2	0	0	5.0	.038		99	10
0134	30	1	5	12	67	60000		50							0	0	2.43	.068		97	
0135	30	1	5	1	69										0	0					
0136	30	1	5	12	69	30000	250	7	150	0000	150	75	0000	2	0	0					
0137	30	1	23	1	53			00	77	640			450	2	0	0					
0137	30	2	23	2	53			00	77	640			450	2	0	0					
0138	30	1	5	1	68	18600									0	0		.114			
0139	30	1	24	1	67	72000	1400	7	85						0	0		.183		83	16
0140	30	1	5	12	69	26000		35							0	0					
0141	30	1	24	12	67	60000	350	8	125	1500			30	2	0	0					
0143	30	1	7	1											0	0					
0144	30	1	5	1	69	20000		25							0	0					
0145	30	1	5	1	67	27000	867	6	50				115	2	0	0					
0146	30	1	5	12	69	40000	155	20		0000	1300	400		2	0	0	1.84	.83	20		52

FDRY NO.	CD TY	CTL SYS	SYS TYP	FCES CONT	YEAR INST	GAS VOLUME	GAS TEMP	PRES DROP	HEIGHT EXH STK	AFTBURN SIZE	WATER DUST	CONSUMPTION GAS	RECIRC	NOISE CONTR	FIL MED	AIR/CLOTH RATIO	INLET CONC	OUT CONC	CATCH	COLL EFF	MLT RTE
0150	30	1	26	12	61	48500	500	9	32		0000	10	0000	2	3	2	2.04		18	99	37
0151	30	1	5	1	70	20000	1200	50		0000					0	0	1.09	.054		97	23
0152	30	1	5	12	70	42000		50							0	0	1.19	.033		97	
0156	30	1	3	1																	
0157	30	1	26	1	62	15000	480	15		3000			20	2	3	3					
0158	30	1	3	1	65	35000	800	00	80				600	2	0	0					
0159	30	1	5	1	70	11800		25							0	0					
0160	30	1	5	12	68	35000	150	5	120	0000			300	2	0	0	2.16	.257	34	88	16
0161	30	1	4	1	57	18000	500								0	0					
0162	30	1	5	1		20000	160	16	50	0000	70	30		2	0	0	1.14	.25		78	
0163	30	1	5	12	68	50700	171	30	82					2	0	0		.074			
0165	30	1	6	12	69	34700	120		50	0000	0000	000	0000	2	2	3			20		
0166	30	1	2	1					97					2	0	0		15.2	LBP	ER	HR
0167	30	1	3	1					79				300	2	0	0		1.43			22
0167	30	2	3	2					79				300	2	0	0		1.43			22
0168	30	1	5	1	69				45	0000			25	2	0	0					

ANALYSIS

FDRY NO.	CD TY	CTL SYS	GAS ANALYSIS PERCENT CO	CO2	O2	N2	H2	SO2	H2O	PARTICLE PROP. PERCENT :LESS THAN 2	5	10	20	50	100	200	500	1000	CATCH PROP. PERCENT :LESS THAN 2	5	10	20	50	100	200	500
0009	40	1								65	92	98	99													
0009	40	2								30	50	65	82	90	99											
0014	40	1								64	82	98	99													
0018	40	1	.2	9	10	77			4		2	12	34	92	99	99										
0021	40	1	2	7	12	75		4																		
0025	40	1	00	12	12	76																				
0026	40	1								13	28	45	55	60					74	90	95	98	99	99		
0032	40	1	2	4	7	86					54	86	98	99	99	99										
0035	40	1								99																
0046	40	1								99	99															
0046	40	2								99	99															
0061	40	1																	8	16	23	31	99	99		
0067	40	1	12	10	3						14	15	15	21	99								16	99		
0067	40	2	3	16	1								19	25	99											
0084	40	1	.2	10	11																					
0099	40	1	1	3	17	75	3																			
0113	40	1								64	90	97	99	99												
0113	40	2								64	90	97	99	99												
0116	40	1									5	25		53												
0116	40	2									5	25		53												
0122	40	1												82												
0125	40	1	00	14	7																					
0146	40	1	00	13	7	80	00							99	99											
0151	40	1								.6	2	3	8	99	99											
0162	40	1																								

FDRY NO.	CD TY	CTL SYS	GAS ANALYSIS PERCENT CO	CO2	O2	N2	H2	SO2	H2O	PARTICLE PROP. PERCENT :LESS THAN 2	5	10	20	50	100	200	500	1000	CATCH PROP. PERCENT :LESS THAN 2	5	10	20	50	100	200	500
0163	40	1	00	5	14	81																				
0166	40	1												86												
0167	40	1	00	9	12	79																				
0167	40	2	00	9	12	79																				

ANALYSIS AND COSTS

FDRY NO.	CO TY	CTL SYS	SIO2	CAO	AL2O3	MGO	FEO,FE	MNO	PBO	ZNO	SNO	SOX	COM BUS	BASIC EQUIP	AUX EQUIP	ENG COST	INST COST	TOT COST	OPER COST	MAINT COST	DEPR	OVE HEA
0001	50	1																150				
0002	50	1																375				
0003	50	1																8				
0004	50	1												153	21	000	7	181			14	
0005	50	1																60				
0007	50	1																420				
0008	50	1												33	000	8	8	49	10	1		
0009	50	1																384				
0009	50	2																384				
0011	50	1																358				
0012	50	1																999				
0013	50	1																44				
0015	50	1																70				
0016	50	1																45				
0016	50	2																45				
0020	50																	200				
0021	50	1												302	108			410				
0026	50	1												150	50	25	50	275	2	1	28	2
0027	50	1												60	20	5	15	100				
0028	50	1																100				
0029	50	1												284	31	85		610	63	5	50	53
0030	50																	35				
0031	50	1												80	160							
0032	50	1												26	6	2	5	39	1	3	2	1
0034	50	1																500				

ANALYSIS AND COSTS

FDRY NO.	CD TY	CTL SYS	SIO2	CAO	AL2O3	MGO	FEO,FE	MNO	PBO	ZNO	SNO	SOX	COMBUS	BASIC EQUIP	AUX EQUIP	ENG COST	INST COST	TOT COST	OPER COST	MAINT COST	DEPR	OVERHEAD	EQUIP CHANG	TOT ANN
0001	50	1																150						
0002	50	1																375						
0003	50	1																8						
0004	50	1												153	21	000	7	181			14			
0005	50	1																60						
0007	50	1																420						
0008	50	1												33	000	8	8	49	10	1			00	
0009	50	1																384						50
0009	50	2																384						50
0011	50	1																358						
0012	50	1																999						
0013	50	1																44						
0015	50	1																70						
0016	50	1																45						
0016	50	2																45						
0020	50																	200						
0021	50	1												302	108			410						
0026	50	1												150	50	25	50	275	2	1	28	2	1	34
0027	50	1												60	20	5	15	100						
0028	50	1																100						
0029	50	1												284	31	85		610	63	5	50	58	00	176
0030	50																	35						
0031	50	1												80	160									
0032	50	1												26	6	2	5	39	1	3	2	1	00	7
0034	50	1																500						

FDRY NO.	CO TY	CTL SYS	SIO2	CAO	AL2O3	MGO	FEO,FE	MNO	PBO	ZNO	SNO	SOX	COM BUS	BASIC EQUIP	AUX EQUIP	ENG COST	INST COST	TOT COST	OPER COST	MAINT COST	DEPR	OVER HEAD	EQUIP CHANG	TOT ANN
			CHEMICAL ANALYSIS																					
0035	50	1					95.							45	56	10	10	121	12	10				
0035	50	2												4	1	1	2	8	5	4				
0035	50	3												4	1	000	2	7	5	4				
0036	50	1																70						
0037	50	1												16	5		3	24	1	4	1	2		8
0038	50	1																120						
0040	50																	31						
0042	50	1												18	10	1	8	37						25
0043	50	1																150						46
0045	50	1																125						
0046	50	1																250						
0046	50	2																250						
0047	50	1																150						
0048	50	1															9	45		1				
0050	50	1																						30
0052	50	1												28	40	5	32	105	4	5	5	15	00	29
0052	50	2												26	9	000	23	58	3	2	3	8	00	15
0053	50																	125						
0061	50	1												80	30	4	40	154	7	5	6		00	
0062	50	1																132						
0064	50																	250						
0065	50	1												350										
0065	50	2												350										
0066	50	1	12.3				11.1																	
0074	50	1																40						

FDRY NO.	CO TY	CTL SYS	SIO2	CAO	AL2O3	MGO	FEO,FE	MNO	PBO	ZNO	SNO	SOX	COM BUS	BASIC EQUIP	AUX EQUIP	ENG COST	INST COST	TOT COST	OPER COST	MAINT COST	DEPR	OVER HEAD	EQUIP CHANG	TOT ANN
0076	50	1																12						
0078	50																	45						
0080	50	1																75						
0081	50	1																81						
0083	50	1																100						
0085	50		28.7			1.3	14.7		1.4				24											
0086	50																	5						
0087	50	1												45	7		53	105	5	5				
0088	50	1																75						
0090	50	1	56.3	42.									.9					325	12	15	22	7		56
0090	50	2	56.3	42.									.9					325	12	15	22	7		56
0091	50	1												45	14	000		277	16	20	14	20		70
0091	50	2												45	14	000		277	16	20	14	20		70
0091	50	3												45	14	000		277	16	20	14	20		70
0094	50	1												100			90	300	6	8				14
0094	50	2												6	3	2	5	16	3	1				4
0095	50	1																219						
0096	50	1																40						
0097	50	1												30										2
0098	50	1																450						
0101	50	1																226						
0106	50	1																21						
0108	50	1																100						
0109	50	1																60						
0110	50	1												51	58	6								

FDRY NO.	CO TY	CTL SYS	SIO2	CAO	AL2O3	MGO	FEO,FE	MNO	PBO	ZNO	SNO	SOX	COM BUS	BASIC EQUIP	AUX EQUIP	ENG COST	INST COST	TOT COST	OPER COST	MAINT COST	DEPR	OVER HEAD	EQUIP CHANG	TOT ANN
0112	50	1																38						
0113	50	1	31.8	3.1	.05		8.6	3.7				13.9	27											
0113	50	2	31.8	3.1	.05		8.6	3.7				13.9	27											
0115	50	1																25						
0115	50	2																25						
0116	50	1	10.	3.	5.	5.	10.	10.		1.			5											
0116	50	2	10.	3.	5.	5.	10.	10.		1.			5											
0118	50	1																997						
0118	50	2																997						
0118	50	3																997						
0121	50	1																175						
0121	50	2																175						
0122	50	1												45										3
0123	50	1																35						
0124	50	1																30						
0125	50	1												72	136	27		430						
0126	50	1												120	113		23	256						
0127	50	1																40						
0128	50	1																30						
0129	50	1																23						
0130	50	1																100						
0131	50																	90						
0132	50	1												110				170						6
0136	50	1												110	45	20	35	210	6	10	6	14	00	36
0137	50	1																85						

FDRY NO.	CD TY	CTL SYS	SIO2	CAO	AL2O3	MGO	FEO,FE	MNO	PBO	ZNO	SNO	SOX	COM BUS	BASIC EQUIP	AUX EQUIP	ENG COST	INST COST	TOT COST	OPER COST	MAINT COST	DEPR	OVER HEAD	EQUIP CHANG	TOT ANN
			CHEMICAL ANALYSIS																					
0137	50	2																85						
0139	50	1																94						
0141	50	1																220						
0144	50	1																90						10
0145	50	1																52						
0146	50	1	20.0	1.0			33.0	1.0	5.0	38.0	2.0			80	490	100		999	30	20	99	99		380
0150	50	1	30.1	1.1	1.4	.99	11.6	5.5	20.	14.7				300	25	25		500	25	10				
0151	50	1												250				389						
0155	50																	140						
0157	50	1																40						
0158	50	1																71						
0160	50	1												45	105		50	200	24	10			00	34
0162	50	1																150						15
0163	50	1																367						20
0165	50	1												60	5	5	30	100	5	1	5	5	.5	16
0166	50	1											3.	8			5	13						14

FORMAT FOR DATA BANK

SECTION I GENERAL FOUNDRY DATA

CONTENT

Abbreviation	Description
FDRY NO.	Foundry No.
CD TY	Card Type
LOC	Location (1st 3 Digits of Zip Code)
MET CST	Type Metal Cast (Code) 1 Gray Iron 2 Malleable Iron 3 Ductile Iron 4 Gray and Malleable 5 Gray and Ductile 6 Malleable and Ductile 7 All Three
	Percent Cast
GI	Grey Iron
MI	Malleable Iron
DI	Ductile Iron
	Ton/Mo. Melt
GI	Grey Iron
MI	Malleable Iron
DI	Ductile Iron
SIZ CLA	Size Classification (Code) 1 Under 10 2 10 - 49 3 50 - 249 4 Over 250

Abbreviation	Description
IND CLA	Industry Classification (Code) 1 Automotive 2 Agricultural 3 Cast Iron Pipe 4 Industrial and Electrical Equipment 5 Valves and Fittings, Refrigeration 6 Jobbing 7 Railroad
WT RG	Weight Range of Castings (Code) 1 Under 10 lbs 2 10 - 49 3 50 - 99 4 100 - 500 5 Over 500 6 Several of above
PRO CST	Basic Product Cast (Code) 1 Brake Drums 2 Pipe 3 Machinery and Machine Tools 4 Railroad Products 5 Automotive 6 Valves and Fittings 7 Agricultural Parts 8 Motors, Hardware, Appliances, Tools 9 Municipal items (sewer covers, grates, etc.)
NOD	Nodularization (Code) 0 None or does not apply 1 Yes

Abbreviation	Description
	Alloy Additions to the Ladle
T	Alloys Type (Code) 0 None or does not apply 1 Caloy 2 Calcium Carbide 3 Mag-Coke 4 FeSi 5 FeCr 6 Mg Fe Si 7 Inoculoy 63 8 Ce 9 Noduloy 5C
LB T	Addition, lbs. Alloys Type (Code) (See Above)
LB T	Additions, lbs. Alloys Type (Code) (See Above)
LB 1	Additions, lbs. #1 Other Additions (Code) 0 None 1 Graphite 2 SmZ 3 Bi
LB 2	Additions, lbs. #2 Other Additions (Code) 0 None 1 Fe Si 2 Fe Mo 3 Al 9 See Questionnaire
LB	Additions, lbs.

Abbreviation	Description
CUP REP	Cupola Replaced last 10 yrs? (Code) 0 No 1 Yes
TYP FCE	If Yes, Type of Furnace (Code) 0 Does not apply 1 Cupola 2 Channel induction 3 Coreless induction 4 Direct Arc 5 Indirect Arc 6 Air Furnace 7 Other, see Questionnaire
VENT TAP	Ventilation During Fce. Tapping (Code) 1 General 2 Local
EFF	Effectiveness (Code) 1 Excellent 2 Good 3 Fair
VENT MOLD	Ventilation During Mold Pouring (Code) 1 General 2 Local
EFF	Effectiveness (Code) 1 Excellent 2 Good 3 Fair
EERP	Foundries Visited by EERP/OLPA
ATK	Foundries Visited by A. T. Kearney & Company, Inc.

SECTION 2 FURNACE DATA

CONTENT

Abbreviation	Description
FDRY NO.	Foundry No.
CD TY	Card Type
FCE NO.	Furnace No.
FCE TYP	Furnace Type (Code) 1 Cupola 2 Channel Induction 3 Coreless Induction 4 Direct Arc 5 Indirect Arc 6 Air Furnace 7 Other
LIN TYP	Lining Type or Coil Type (Code) 0 Does Not Apply 1 Acid 2 Basic 3 Neutral 4 Unlined 5 Single Channel Open 6 Single Channel Closed 7 Double Channel
BLT DES	Blast Description (Code) 0 Does Not Apply 1 Hot Blast $>800^{\circ}F$ 2 Warm Blast 3 Cold Blast

Abbreviation	Description
BLT HTG	Blast Heating or Frequency (Code) 0 Does Not Apply 1 No Blast Heating 2 Recuperative Heating 3 Externally Fired 4 Recup. and Ext. Fired 5 Line Frequency 6 Medium Frequency 7 High Frequency
TOP C/O	Cupola Top - Closed or Open (Code) 0 Does not Apply 1 Closed Top 2 Open Top
CHG	Top or Side Charged (Code) 0 Does Not Apply 1 Top 2 Side
GAS T-O	Gas Take-Off (Code) 0 Does Not Apply 1 Above Charging Door 2 Below Charging Door 3 Gas Take-Off into Side Draft Hood 4 Gas Take-Off into Full Roof Hood 5 Gas Take-Off into Canopy Hood 6 Gas Take-Off into Snorkel 7 Direct Shell Evacuation 8 No Gas Take-Off
AFT	Afterburners (Code) 0 Does Not Apply or None No. Indicates Use and Quantity of Burners
CHG DR	Charging Door - Open or Closed (Code) 0 Does Not Apply 1 Door Open 2 Door Closed

Abbreviation	Description
FL IN	Fuel Injection (Code) 0 Does Not Apply or Without Fuel Injection 1 With Fuel Injection
OX EN	Oxygen Enrichment (Code) 0 Does Not Apply or Without Oxygen Enrichment 1 With Oxygen
FCE USE	Furnace Use (Code) 1 Melting 2 Holding 3 Duplexing
FCE DIA	Furnace Dia., Inches
HLD CAP	Holding Cap., Tons
MLT RAT	Melt Rate, Tons/Hours
MT UT	Melting Utilization, Hour/Day
PR UT	Pouring Utilization, Hour/Day
OT UT	Other Utilization, Hour/Day
VOLUME	Blast Volume, SCFM
PRES	Blast Pressure, Oz H_2O
TEMP	Blast Temperature, ^oF
SIZE CH DR	Size of Charge Door, Sq. Ft.
HT DR	Height Charge Door Sill Above Floor, Ft.
CHG PRE	Charge Preheated and/or Dried (Code) 0 No or Does Not Apply 1 Preheated 2 Dried 3 Both
SIZE AFT	Afterburner Size, BUT/Hr x 10^3
AFT LOC	Afterburner Location (Code) 0 Does Not Apply 1 Above Charge Door 2 Below Charge Door 3 In Gas Take-Off 4 Above and Below Door
DIS AFT	Distance Afterburner to Gas Take-Off, Inch.
POWR SPLY	Power Supply, KW or KVA
CTL SYS	Control System No.

SECTION 3 MELTING OPERATION

CONTENT

Abbreviation	Description
FDRY NO.	Fourdry No.
CD TY	Card Type (Code) 20 Grey Iron 21 Malleable Iron 22 Ductile Iron
FCE NO	Furnace No.
TOTAL MTL CH	Total Metallic Charge, lbs.
	Remelt, lbs.
	Pig Iron, lbs. (With *, Silvery Pig)
PURCH CST I	Purchased Cast Iron, lbs
PURCH STEEL	Purchased Steel, lbs.
BRIQ	Briquettes, lbs.
PUN/TURN	Punchings and/or Turnings, lbs.
LIM STN	Limestone, lbs.
	Dolomite, lbs.
	Soda Ash, lbs.
FLOU SPAR	Flourspar, lbs.
	Other, lbs.
	Carbo-Coke, Lbs.
FE-SIL	Ferrosilican, lbs.
MN	Manganese, FeMn, SiMn. lbs.
T	Additive, Type (Code) 0 None 1 Copper 2 Silvery Iron 3 Silicon 4 Calcium Carbide 5 Silicon Carbide 6 Carnell (C_aF_2) 7 Ferrophosphorous 8 Graphite
LB	Additive, lbs.
ME/CO RATIO	Metal to Coke Ratio
SUL CON	Sulphur Content of Coke, %
D A	Desulphurizing Agents (Code) 0 Does Not Apply or None 1 Caustic Soda NaOH 2 Soda Ash Na_2CO_3 3 Calcium Carbide

Abbreviation	Description
Q S	Quality of Scrap (Code) 0 Does Not Apply 1 Rusty 2 Dirty 3 Oily 4 Clean
C M	Charging Method (Code) 0 Does Not Apply 1 Skip Hoist Side Discharge Bucket 2 Skip Hoist Bottom Discharge Bucket 3 Crane Type Charger 4 Belt Conveyor 5 Vibrating Feeder 6 Magnet 7 Manual
S P	Scrap Preparation (Code) 0 Does Not Apply or None 1 Shot Blast 2 Degreasing 3 Cut to Size
TIME	Average Length of "Light-Up", Min. Per Day
METH	Method of light-up (Code) 0 Does Not Apply 1 Wood 2 Gas 3 Oil 4 Electric 5 Other 6 More than one of above
CO	Carbon Monoxide, %
CO_2	Carbon Dioxide, %
N_2	Nitrogen, %

SECTION 4 CONTROL SYSTEM

CONTENT

Abbreviation	Description
FDRY NO.	Foundry No.
CD TY	Card Type
CTL SYS	Control System No.
SYS TYP	Control System Type (Code) 0 No Control System 1 Fly Ash and Spark Arrester 2 Afterburner 3 Wet Cap 4 Mechanical Collector 5 Wet Scrubber 6 Fabric Filter 7 Electrostatic Precipitator
FCES CONT	Furnaces Controlled
YEAR INST	Year Installed
GAS VOLUME	Rated Gas Volume at Exh. Inlet, CFM
GAS TEMP	Gas Temperature at Exh. Inlet, ^oF
PRES DROP	Pressure Drop, in H_2O
HEIGHT EXH STK	Height Exhaust Stack, Ft.
AFTBURN SIZE	Afterburner Size, BTU.Hr. x 10^3
DUST	Water Consumption, Dust Collector, GPM
GAS	Water Consumption, Gas Cooling, GPM
RECIRC	Water Consumption, Recirculated, GPM
NOISE CONTR	Noise Control (Code) 1 Yes 2 No
FIL MED	Filter Media (Code) 0 Does Not Apply 1 Natural Fibre 2 Synthetic Fibre 3 Glass Fibre
	Air to Cloth Ratio
INLET CONC	Inlet Concentration, GR/SCF
OUT CONC	Outlet Concentration, GR/SCF
	Catch, lb. Dust/Ton Melt
COLL EFF	Collection Efficiency, %
MLT RTE	Melt Rate at Which Test was Made, TPH

SECTION 5 ANALYSIS

CONTENT

Abbreviation	Description
FDRY NO.	Foundry No.
CD TY	Card Type
CTL SYS	Control System No.
	Gas Analysis % CO
	Cas Analysis % CO_2
	Gas Analysis % O_2
	Gas Analysis % N_2
	Gas Analysis % H_2
	Gas Analysis % SO_2
	Gas Analysis % H_2O
	Particle Prop. %
	Less Than 2 Microns
	Less Than 5 Microns
	Less Than 10 Microns
	Less Than 20 Microns
	Less Than 50 Microns
	Less Than 100 Microns
	Less Than 200 Microns
	Less Than 500 Microns
	Less Than 1,000 Microns
	Catch Prop., %
	Less Than 2 Microns
	Less Than 5 Microns
	Less Than 10 Microns
	Less Than 20 Microns
	Less Than 50 Microns
	Less Than 100 Microns
	Less Than 200 Microns
	Less Than 500 Microns

SECTION 6 ANALYSIS AND COSTS

CONTENT

Abbreviation	Description	
FDRY NO.	Foundry No.	
CD TY	Card Type	
CTL SYS	Control System No.	
	Chemical Analysis	
	SiO_2	
	CaO	
	Al_2O_3	
	MgO	
	FeO, Fe_2O_3, Fe	
	MnO, Mn_3O_4	
	PbO	
	ZnO	
	SnO	
	SO_x	
COMBUS	Combustibles	
BASIC EQUIP	Basic Equipment Costs	$ x 10^3
AUX EQUIP	Aux. Equipment Costs	$ x 10^3
ENG COST	Engineering Costs	$ x 10^3
INST COST	Installation Costs	$ x 10^3
TOT COST	Total Cost	$ x 10^3
OPER COST	Operating Cost	$ x 10^3
MAINT COST	Maintenance Cost	$ x 10^3
DEPR	Depreciation	$ x 10^3
	Overhead	$ x 10^3
EQUIP CHANG	Process and Equipment Changes	$ x 10^3
TOT ANN	Total Annual Costs	$ x 10^3

MATERIAL AND HEAT BALANCE

Appendix C consists of three exhibits, each of which deals with material and heat balances of foundry melting furnaces. The first exhibit of this appendix is the Cupola Material and Heat Balance Model. This exhibit discusses the development of the mathematical model and the nature of input required. A sample of the material balance and heat balance outputs and the chemical reactions considered in the model are given.

Exhibit 2 of this appendix is a listing of the FORTRAN IV computer program version of the material and heat balance.

The final exhibit of Appendix C is a series of material and heat balances for cupolas and electric furnaces. A material and heat balance is given for different furnace classifications. Each classification, as discussed earlier in this report, represents a unique furnace type and operating characteristics found in practice.

CUPOLA MATERIAL AND HEAT BALANCE MODEL

Because the major single source of air emissions from the foundry is the cupola, a material and heat balance model has been developed to compute (for given operating conditions) the estimated emissions generated by the cupola.

The model requires the following general inputs:

1. Size and certain design characteristics of the cupola.
2. The type and hourly melting rate of iron being produced.
3. The makeup of the charge, including metallics, fuel, flux and additives.
4. The rate and temperature of the blast air including any oxygen enrichment.
5. The temperature of the top gases immediately above the burden.

Using these inputs, the computerized version of the model will calculate a material and heat balance for the cupola and print out a summary report showing these results. An example of the output report is shown in a later section of this appendix.

The approach taken in constructing the model has been to concentrate on those aspects of cupola design and operation which will influence the emissions characteristics of the top gases. Those aspects which relate to such matters as detailed metallurgical characteristics of the tapped iron but do not influence emissions have not been included in the model.

A search of the literature and previous research was undertaken to collect the known physical and chemical relationships in the cupola that influence emissions characteristics in terms of composition and quantity.

Most of the relationships included in the model are based on known chemical and physical laws and their accuracy with regard to the computed results is limited only by the accuracy of the input data. It has been necessary, however, to include in the model several empirical relationships cited in the literature to permit the calculation of estimated quantities in the top gases of particulate matter and sulfur dioxide. Furthermore, in order to simplify the task of specifying the input values and to limit the required data to figures commonly available in foundry operation, the average or typical composition of charge materials has been incorporated into the model. For example, when specifying for the model that the tapped iron is gray iron, the model uses an average composition for gray iron in its calculations. This has been done to avoid having to specify the actual chemical composition of charging materials and tapped iron in order to use the model. In practice, the slight variations in the actual composition of materials from the averages used in the model will have very little effect on the results calculated by the model as far as emissions are concerned.

The average compositions for materials used in the model have been taken from the literature and are shown in the following table. It will be noted that the chemical compositions used are not rigorously complete and only those components which can significantly affect the calculated emissions are included.

The balance of the documentation of the model included in the report consists of a description of the chemical and physical relationships incorporated in the model. A listing of the FORTRAN IV computer program version of the model is given in Exhibit 2 of this appendix.

Average Composition of Materials
Used in the Cupola Model
(Figures Given Are Weight Percentages)

A. Metallics

	C	Si	Mn	S
Gray Iron	3.2%	2.0%	0.6%	0.12%
Malleable Iron	2.5	1.2	0.6	0.12
Ductile Iron	3.8	2.4	0.6	.03
Pig Iron	3.5	0.6	1.5	.05
Silvery Pig	2.5	10.0	0.7	.05
Iron Scrap	3.3	2.1	0.6	.12
Steel Scrap	0.4	0.2	0.6	.05
Ferrosilicon	0.05	50.0	0.0	0.00

B. Fluxes

	SiO_2	(Ca, Mg)O	CaF_2	CaC_2	Na_2O	CO_2 (asCO_3)	Al_2O_3
Limestone & Dolomite	1.0%	54.0%	-	-	-	45.0%	-
Fluorspar	2.0	8.0	84.0	-	-	6.0	-
Fdry Carbide	3.0	14.0	-	70.0	-	11.0	2.0
Soda Ash	-	-	-	-	57.0	43.0	-

C. Foundry Coke Ash

SiO_2	Al_2O_3	Fe_2O_3	(Ca, Mg)O	Misc.(1)
50.0%	35.0%	8.0%	3.0%	4.0%

D. Cupola Refractory Linings

	SiO_2	Al_2O_3	MgO	Misc(1)
Acid	60.0%	30.0%	-	10.0%
Basic	20.0	20.0	60.0	-

Note: (1) Miscellaneous category includes various other metallic oxides and trace elements not listed.

SPECIFIC INPUTS REQUIRED FOR THE MODEL

Nature of Cupola and Metal Produced

1. Diameter of the cupola in inches
2. Type of lining
   - a. Acid
   - b. Basic
   - c. None (water cooled)
3. Type of iron being produced
   - a. Gray
   - b. Malleable
   - c. Ductile
4. Rate of molten iron produced in tons per hour
5. Temperature of the tapped iron in degrees Fahrenheit

Characteristics of Charge

1. Metallics (fraction or relative weight of each)
   - a. Pig iron
   - b. Silvery pig
   - c. Scrap
     - 1) Steel
     - 2) Iron
   - d. Foundry returns
     - 1) Gray
     - 2) Malleable
     - 3) Ductile
   - e. Ferrosilicon (50%)

2. Fuel

   a. Metal to coke ratio

   b. Coke analysis

      1) Fixed carbon (fraction)

      2) Ash content (percent)

      3) Sulfur content (percent)

   c. Other fuels (if any)

      1) Natural gas (SCFM)

      2) Fuel oil (gallons/min.)

3. Flux (percent to metal of each)

   a. Limestone and/or dolomite

   b. Flourspar

   c. Foundry carbide

   d. Soda ash

Characteristics of the Blast

1. Air

   a. Quantity of air (SCFM)

   b. Inlet air temperature (^{o}F)

   c. Relative humidity of air (fraction)

2. Oxygen enrichment (SCFM)

3. Blast temperature (^{o}F)

Characteristics of Exhaust Gases

1. Top gas temperature (top of burden-^{o}F)

2. Stack gas above charge door

   a. Volume of stack gas (CFM)

   b. Temperature of stackgas for volume given (^{o}F)

   c. Carbon monoxide in stack gas (%/vol.)

CHEMICAL REACTIONS CONSIDERED IN THE MODEL

Oxidation Zone

1. C (coke) + O_2 -> CO_2
2. CH_4 (natural gas) + $2 \cdot O_2$ -> CO_2 + $2 \cdot H_2O$
3. $4 \cdot C_5H_{11}$ (fuel oil*) + $31 \cdot O_2$ -> $20 \cdot CO_2$ + $22 \cdot H_2O$

   *The composition shown for fuel oil represents the average total ratio of carbon to hydrogen for the sum of the many hydrocarbon compounds which comprise a typical fuel oil used in cupola operations.

4. Si + O_2 -> SiO_2
5. $2 \cdot$(Fe, Mn) + O_2 -> $2 \cdot$(Fe, Mn)O
6. $2 \cdot CaC_2$ (foundry carbide) + $5 \cdot O_2$ -> $2 \cdot CaO$ + $4 \cdot CO_2$

Reduction Zone

7. C (coke) + CO_2 -> $2 \cdot CO$
8. C (coke) + H_2O -> CO + H_2

Preheating Zone

9. (Ca, Mg)CO_3 -> (Ca, Mg)O + CO_2
10. Na_2CO_3 -> Na_2O + CO_2
11. S + Fe -> FeS

Slagging Reactions

12. (Ca, Mg, Fe, Mn)O + SiO_2 -> (Ca, Mg, Fe, Mn)SiO_3
13. CaO + FeS -> CaS + FeO
14. CaS + $FeSiO_3$ + $2 \cdot MnO$ -> $CaSiO_3$ + Fe + $2 \cdot Mn$ + SO_2

MATERIAL BALANCE RELATIONSHIPS CONSIDERED IN THE MODEL

The material balance relationships employed in the model use the input quantities (specified on the preceding pages) of materials and the average compositions of materials shown earlier in this exhibit. The source of empirical relationships used are shown for reference. The quantities are all computed to a base of 2,000 pounds of tapped iron.

1. Silicon Oxidized = Net Silicon Loss from Metalics

   Net Silicon Loss From Metalics = Weight of Silicon in Metalic Charge - Weight of Silicon in Tapped Iron

2. Manganese Oxidized (same approach as for silicon above)

3. Carbon From Coke Into Iron = Net Carbon Gain of Tapped Iron

   Net Carbon Gain = Weight of Carbon in Tapped Iron - Weight of Carbon in Charged Metalics

4. Oxygen Input = Weight of Oxygen in Blast Air + Oxygen Enrichment

5. Water Input = Water Content of Blast Air as a Function of Temperature and Relative Humidity

6. Oxygen Available For Fuel Combustion = Oxygen Input - Oxygen Used to Oxidize Silicon, Manganese and Foundry Carbide

7. Oxygen Available to Burn Coke = Oxygen Available For Fuel Combustion - Oxygen Consumed to Burn Natural Gas and/or Fuel Oil

8. Coke Consumed in Complete Burning

= Carbon Required to Combine with Available Oxygen /Carbon Content of Coke

9. Total Water to React With Coke

= Water Input in Air + Water Generated in Combustion of Natural Gas and Fuel Oil

10. Coke Available to Reduce Carbon Dioxide

= Total Coke Input - Coke Consumed in Complete Burning - Coke Required to Reduce Total Water

11. Resulting Carbon Dioxide

= CO_2 from Complete Combustion of Coke

- CO_2 Reduced by Remaining Coke

+ CO_2 from Calcining of Carbonates

12. Resulting Carbon Monoxide

= CO from Water Reduction + CO from CO_2 Reduction

13. Resulting Hydrogen = Weight of Hydrogen in Total Water

14. Silica From Cupola Lining = Weight of Lining Melted as a function of Cupola Diameter* x Silica Content of Lining

15. Magnesium Oxide From Cupola Lining (same approach as for silica)

16. Total Silica For Slag = Silica From Coke Ash + Silica Fluxes + Silica From Cupola Lining

17. Total Calcium and Magnesium Oxide for Slag

= (Ca, Mg)O from Fluxes, Cupola Lining, and Coke Ash

18. Slag Basicity Ratio = Total (Ca, Mg)O/SiO_2

*The Cupola and Its Operation (third edition; Des Plaines, Illinois: American Foundrymen's Society, 1965), p. 233.

19. Sulfur in Slag = Function of the Basicity Ratio* of the Slag

20. Sulfur To Top Gas (SO_2) = Total Sulfur Input in Coke and Metalics - Sulfur Output in Tapped Iron - Sulfur Output in the Slag

21. Oxidation of Iron To Slag = Assumption that Slag Contains Two Percent FeO Derived from Oxidation of Iron*

*Note: No method could be found in the literature to predict the amount of iron oxidized and going into the slag. Typical compositions suggest that two percent is a good average value.

22. Particulate Matter in Top Gases = Empirical Function**of:
   a) Blast Volume
   b) Coke Ratio
   c) Melting Rate

23. Total Slag Output = Weight of Slag Forming Constituents in Coke Ash and Fluxes
   + SiO_2, MnO, and FeO from Metalics
   + Cupola Lining Melted
   - Emissions Dust

24. Total Metallic Inputs = Tapped Iron Weight
   + Si, Mn, Fe Loss From Metallic Charge
   - C and S Gain in Tapped Iron

*The Cupola and Its Operation, p. 236
**Engels and Weber, Cupola Emission Control, trans. (Cleveland, Ohio: Gray and Durtile Iron Founders' Society, 1969, Original, 1967), pp. 52-54.

HEAT BALANCE RELATIONSHIPS CONSIDERED IN THE MODEL

The heat balance relationships are calculated in B.T.U.'s per hour of cupola operation.

Heat Inputs

1. Potential Heat of Fuels = Heat of Total Combustion for Weight of Carbon in Coke plus Natural Gas and Fuel Oil Combustion.
2. Heat of Oxidation of Metallics = Heats of Oxidation for Weight of Iron, Silicon, Manganese, and Carbide Oxidized per Hour
3. Sensible Heat of Air Blast = Temperature x Specific Heat x Weight of Air Blast Per Hour

Heat Outputs

1. Heat Content of Tapped Iron = Temperature x Specific Heat x Weight of Molten Iron Tapped Per Hour
2. Heat for Calcining Carbonates = Heat of Reaction for Calcining x Weight of Carbonate Fluxes Per Hour
3. Heat of Slagging = Heat of Reaction of Calcium and Magnesium Oxides with Silica To Form Silicates in the Slag

4. Heat Content of Slag = Temperature x Specific Heat x Weight of Slag - Heat of Slagging Reactions

5. Heat of Water Decomposition = Heat of Reaction with Carbon to Reduce Water to Hydrogen and Carbon Monoxide

6. Sensible Heat of Top Gas = Temperature x Specific Heat x Weight of Top Gases

7. Latent Heat of Top Gas = Potential Heat of Combustion of Carbon Monixide x Weight of Carbon Monoxide in the Top Gas Per Hour

8. Heat Radiation From the Cupola = Sum of Heat Inputs - Sum of Heat Outputs (above)

SAMPLE OUTPUT
MATERIAL BALANCE

INPUTS

	POUNDS	PERCENT
METAL CHARGE	2015	51.50
PIG IRON	288.	7.36
RETURNS	959.	24.52
STEEL SCRAP	672.	17.17
IRON SCRAP	0.	0.00
FERROALLOYS	96.	2.45
COKE	208.	5.33
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	27.	0.68
AIR	1641.	41.95
OXYGEN	0.	0.01
CUPOLA LINING	20.	0.52
TOTAL INPUT MTLS	3912.	100.00

OUTPUTS

MOLTEN IRON	2000.	51.13
SLAG	64.	1.62
EMISSIONS DUST	16.	0.40
TOP GASES	1833.	46.85
NITROGEN	1254.	68.41
CARBON DIOXIDE	375.	20.44
CARBON MONOXIDE	201.	10.99
HYDROGEN	1.	0.07
SULFUR DIOXIDE	2.	0.09

SAMPLE OUTPUT
HEAT BALANCE

INPUT HEAT	B.T.U.'s (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	56208.	91.51
SENSIBLE HEAT OF THE BLAST	2554.	4.16
HEAT FROM OXIDATION OF MN, FE, SI	2664.	4.34
TOTAL INPUT HEAT	61426.	100.00
OUTPUT HEAT		
HEATING AND MELTING OF IRON	24212.	39.42
HEAT CONTENT OF THE SLAG	1085.	1.77
CALCINING OF LIMESTONE	419.	0.68
DECOMPOSITION OF WATER	713.	1.16
TOP GASES		
-SENSIBLE HEAT	8112.	13.21
-LATENT HEAT	19168.	31.20
HEAT RADIATION FROM THE CUPOLA	7717.	12.56

VOLUME OF TOP GAS (MCF)
ACTUAL 1280.
STANDARD 508.
STOP

MATERIAL AND HEAT BALANCE

```
5 REAL I,I1,I2,I3,I4,I5,I6,I7,I8,I9,J,M1,M2,M3,M4,M5,M8
6 REAL K,K1,K2,K3,K4,K5,K6,K7,K8,K9,L1,L2,L3,L4,L5,N2,N3
   15 READ (1,16)D,L1,L2,I7,I8,I9
   16 16 FORMAT (10F10.0)
   20 READ (1,16)M1,T4,I1,I2,R3,I3,I
   25 READ (1,16)I4,I5,I6,K1,K2,K7,K8,G1,G2
   30 READ (1,16)F1,F2,F3,F4,A1,T1,H3,O2,T2,T3
32 READ (1,16) V3,T5,COP
   35 J=I1+I2+I3+I4+I5+I6+I+R3
   40 I1=I1/J
   45 I2=I2/J
   50 I3=I3/J
   55 I4=I4/J
   60 I5=I5/J
   65 I6=I6/J
   70 I=I/J
   75 R3=R3/J
   80 S9=(.006*I1+.1*I2+.002*I3+.49*R3+.021*I+.02*I4+.012*I5+.024*I6)
   85 S9=M1*2000.0*S9
   90 S9=S9-2000.0*M1*(.02*I7+.012*I8+.024*I9)
   92 IF (S9.LT.2.*M1) S9=2.0*M1
   95 C8=.032*I7+.025*I8+.038*I9
  100 C8=(C8-.035*I1-.025*I2-.004*I3-.033*I-.032*I4-.025*I5-.038*I6)
  105 C8=2000.0*M1*C8
  110 M8=2000.0*M1*(.009*I1+.002*(1.0-I1))
  115 O1=(.209*A1+O2)*.0847*60.0
  120 O3=O1-20.0*M1*.86*F3-1.14S9-.41*M8
  125 H4=8.631*EXP(.03598*T1)*H3*.0763*A1*60.0/7000.0
  130 K3=(O3-(10.03*G1)-1450.0*G2)/(2.66*K2)
  135 C2=1.38*O3
  140 H1=5.72*G1+519.0*G2+H4
  145 K4=.667*H1/K2
  150 H=.111*H1
  155 K5=2000.0*M1/K1
  160 K6=K5-K3-K4-C8/K2
  165 C3=4.66*K6*K2
  170 C2=C2-3.66*K6*K2
  175 C1=1.55*H1
  180 C4=100.0*C2/(C3+C2)
  185 C5=20.0*M1*(.45*F1+.06*F2+1.06*F3+.43*F4)
  190 C2=C2+C5
  195 C1=C1+C3
  200 N2=3.52*A1
  205 L4=(M1*20.0*465.0/(D/2.0)**1.75)*(L1+L2)
  210 S5=.5*K5*K7/100.+L4*(.6*L1+.2*L2)+20.0*M1*(.01*F1+.02*F2+.03*F3)
  211 S5=S5+2.14*S9
  215 M5=.0003*K7*K5+L4*(.6*L2)+20.0*M1*(.54*F1+.08*F2+.75*F3)
  220 B1=M5/S5
  225 S1=K8*K5/100.0+.0076*G1+1.34*G2
  230 S2=2000.0*M1*(.0005*(I1+I2+I3+I6)+.0012*(I4+I5+I))
  235 S2=S2-2000.0*M1*(.0012*(I7+I8)+.0003*I9)
  240 S8=L4+K7*K5/100.0
  245 S8=S8+20.0*M1*(.55*F1+.94*F2+.8*F3+.57*F4)+2.14*S9+1.29*M8
  250 S8=1.02*S8
  255 S3=(.0000659*(B1*100.0)**2.65)*S8/10000.0
  260 S8=S8+S3
```

MATERIAL AND HEAT BALANCE

```
265 S4=2.0*(S1+S2-S3)
270 R1=.02*S8*.78
275 M2=M1*2005.0-C8+S9+M8+R1+S2
280 B3=(A1+O2+G1)/((D/24.0)**2*3.1416)
285 D3=.0625*(4.0+(B3/32.8-7.0))
290 D4=280.0/K1-16.0
295 D5=56.0-29.2*M1/((D/24.0)**2*3.14)
300 V1=(N2/28.0+C2/44.0+C1/28.0+H/2.0+S4/64.0)*.01073*(T3+460.0)/14.7
305 V2=520.0*V1/(T3+460.0)
310 D6=D3*V2/M1
315 D7=.5*D6+.25*D4+.25*D5
320 S8=S8-D7*M1
325 Q1=14.45*((K5-K4)*K2-C8)+60.0*G1+8470.0*G2
330 Q2=127.4*F3*M1+2.05*R1+13.1*S9+3.02*M8
335 Q3=(T2-60.0)*(.249*N2+.224*O1+.453*H4)/1000.0
340 M3=M2/M1
345 F5=(F1+F2+F3+F4)*M2/M1/100.0
350 A5=(N2*1.3+H4)/M1
355 O6=O2*5.08/M1
360 K=K5/M1
365 G4=2.54*G1/M1
370 G5=446.0*G2/M1
375 L5=L4/M1
380 W1=M3+F5+A5+O6+K+G4+G5+L5
385 M4=2000
390 S6=S8/M1
395 N3=N2/M1
400 C6=C2/M1
405 C7=C1/M1
410 H7=H/M1
415 S7=S4/M1
420 W2=N3+C6+C7+H7+S7
425 W6=W2/100.0
430 W3=2000.0+S6+D7+W2
435 W4=W1-W3
440 S6=S6+W4
445 W1=W1/100.0
450 R5=(I4+I5+I6)*M3
455 R6=(I2+R3)*M3
460 Q4=(T4-60.0)*.2086*2.0*M1
465 Q5=2.16*.750*(C5-20.0*M1*F3*.95)
470 CS=S5*(1.-DIM(1.,(61.*M5/52./S5)))
472 Q6=.82*M5-.44*CS
475 Q7=(T4-60.0)*.321*S6*M1/1000.0
480 Q7=Q7-Q6
485 Q8=2.098*H1
490 Q9=(T3-60.0)*(.254*N2+.243*C2+.256*C1+3.466*H+.226*D7*M1)/1000.0
495 P1=4.346*C1
500 Q=Q1+Q2+Q3
505 P2=Q-Q4-Q5-Q7-Q8-Q9-P1
510 Z=Q/100.0
700 RM32=M3/W1
705 RI11=I1*M3
710 RI12=RI11/W1
715 R52=R5/W1
720 RI31=I3*M3
```

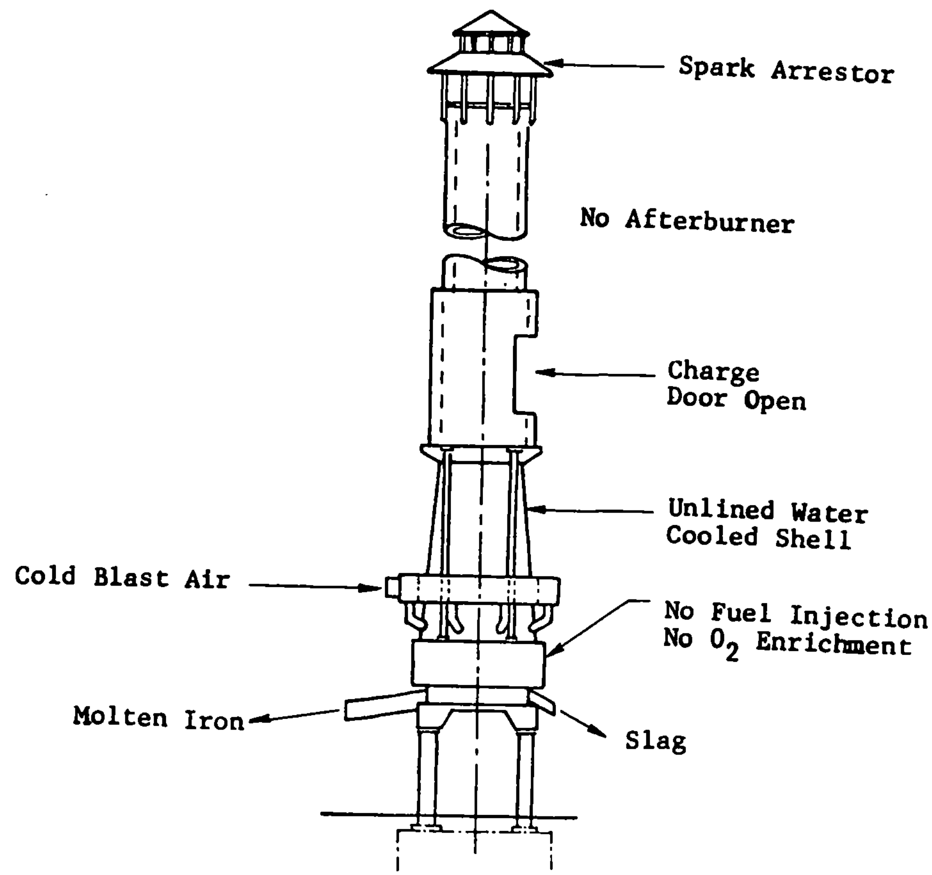
MATERIAL AND HEAT BALANCE

```
RI32=RI31/W1
RI01=I*M3
RI02=RI01/W1
R62=R6/W1
RK02=K/W1
G42=G4/W1
G52=G5/W1
F52=F5/W1
A52=A5/W1
O62=O6/W1
RL52=L5/W1
W11=100.*W1
W12=W11/W1
RM42=M4/W1
S62=S6/W1
D72=D7/W1
W22=W2/W1
RN32=N3/W6
C62=C6/W6
C72=C7/W6
H72=H7/W6
S72=S7/W6
Q12=Q1/Z
Q32=Q3/Z
Q22=Q2/Z
Q02=Q/Z
Q42=Q4/Z
Q72=Q7/Z
Q52=Q5/Z
Q82=Q8/Z
Q92=Q9/Z
P12=P1/Z
P22=P2/Z
WRITE (9,30)
30 FORMAT (5X16HMATERIAL BALANCE//6HINPUTS/20X17HPOUNDS     PERCENT
WRITE (9,40)M3,RM32
40 FORMAT (12HMETAL CHARGE8X,F7.0,F9.2)
WRITE (9,50)RI11,RI12
50 FORMAT (8HPIG IRON12X,F7.0,F9.2)
WRITE (9,60)R5,R52
60 FORMAT (7HRETURNS13X,F7.0,F9.2)
WRITE (9,70)RI31,RI32
70 FORMAT (11HSTEEL SCRAP9X,F7.0,F9.2)
WRITE (9,80)RI01,RI02
80 FORMAT (10HIRON SCRAP10X,F7.0,F9.2)
WRITE (9,90)R6,R62
90 FORMAT (11HFERROALLOYS9X,F7.0,F9.2)
WRITE (9,100)K,RK02
100 FORMAT (/4HCOKE16X,F7.0,F9.2)
WRITE (9,110)G4,G42
110 FORMAT (11HNATURAL GAS9X,F7.0,F9.2)
WRITE (9,120)G5,G52
120 FORMAT (8HFUEL OIL12X,F7.0,F9.2)
WRITE (9,130)F5,F52
130 FORMAT (/18HFLUX AND ADDITIVES2X,F7.0,F9.2)
WRITE (9,140)A5,A52
```

MATERIAL AND HEAT BALANCE

```
140 FORMAT (/3HAIR17X,F7.0,F9.2)
WRITE (9,150)O6,O62
150 FORMAT (6HOXYGEN14X,F7.0,F9.2)
WRITE (9,160)L5,RL52
160 FORMAT (/13HCUPOLA LINING7X,F7.0,F9.2)
WRITE (9,170)W11,W12
170 FORMAT (/16HTOTAL INPUT MTLS4X,F7.0,F9.2)
WRITE (9,180)M4,RM42
180 FORMAT (//7HOUTPUTS//11HMOLTEN IRON9X,F7.0,F9.2)
WRITE (9,190)S6,S62
190 FORMAT (/4HSLAG16X,F7.0,F9.2)
WRITE (9,200)D7,D72
200 FORMAT (/14HEMISSIONS DUST6X,F7.0,F9.2)
WRITE (9,210)W2,W22
210 FORMAT (/9HTOP GASES11X,F7.0,F9.2)
WRITE (9,220)N3,RN32
220 FORMAT (8HNITROGEN12X,F7.0,F9.2)
WRITE (9,230)C6,C62
230 FORMAT (14HCARBON DIOXIDE6X,F7.0,F9.2)
WRITE (9,240)C7,C72
240 FORMAT (15HCARBON MONOXIDE5X,F7.0,F9.2)
WRITE (9,250)H7,H72
250 FORMAT (8HHYDROGEN12X,F7.0,F9.2)
WRITE (9,260)S7,S72
260 FORMAT (14HSULFUR DIOXIDE6X,F7.0,F9.2)
WRITE (9,265)
265 FORMAT (///5X12HHEAT BALANCE//10HINPUT HEAT10X7HB.T.U.S)
WRITE (9,270)
270 FORMAT (20X20H(000/HR.)    PERCENT)
WRITE (9,280)Q1,Q12
280 FORMAT (/14HPOTENTIAL HEAT/10H   OF FUEL10X,F7.0,F9.2)
WRITE (9,290)Q3,Q32
290 FORMAT (/13HSENSIBLE HEAT/15H   OF THE BLAST5X,F7.0,F9.2)
WRITE (9,300)Q2,Q22
300 FORMAT (/19HHEAT FROM OXIDATION/16H   OF MN, FE, SI4X,F7.0,F9.
WRITE (9,310)Q,Q02
310 FORMAT (/19H   TOTAL INPUT HEATX,F7.0,F9.2)
WRITE (9,320)
320 FORMAT (//11HOUTPUT HEAT)
WRITE (9,330)Q4,Q42
330 FORMAT (/19HHEATING AND MELTING/10H   OF IRON10X,F7.0,F9.2)
WRITE (9,340)Q7,Q72
340 FORMAT (/12HHEAT CONTENT/14H   OF THE SLAG6X,F7.0,F9.2)
WRITE (9,350)Q5,Q52
360 FORMAT (/13HDECOMPOSITION/11H   OF WATER9X,F7.0,F9.2)
WRITE (9,360)Q8,Q82
350 FORMAT (/12HCALCINING OF/12H   LIMESTONE8X,F7.0,F9.2)
WRITE (9,370)Q9,Q92
370 FORMAT (/9HTOP GASES/16H  -SENSIBLE HEAT4X,F7.0,F9.2)
WRITE (9,380)P1,P12
380 FORMAT (14H  -LATENT HEAT6X,F7.0,F9.2)
WRITE (9,390)P2,P22
390 FORMAT (/19HHEAT RADIATION FROM/13H   THE CUPOLA7X,F7.0,F9.2)
WRITE (9,400)V1,V2
400 FORMAT (//23HVOLUME OF TOP GAS (MCF)/6HACTUAL4X,F7.0/
+ 8HSTANDARD2X,F7.0)
    Stop
    End
```

Insufficient Data for Heat and Material Balance Calculations



CUPOLA CLASSIFICATION - 1

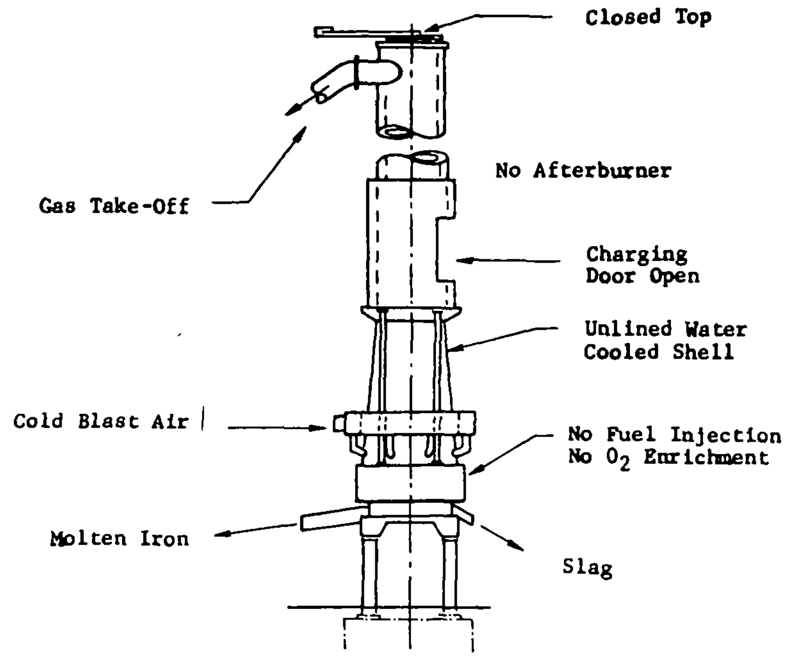
HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	100823.	98.35
SENSIBLE HEAT OF THE BLAST	158.	0.15
HEAT FROM OXIDATION OF MN, FE, SI	1537.	1.50
TOTAL INPUT HEAT	102518.	100.00
OUTPUT HEAT		
HEATING AND MELTING OF IRON	38157.	37.22
HEAT CONTENT OF THE SLAG	598.	0.58
CALCINING OF LIMESTONE	1438.	1.40
DECOMPOSITION OF WATER	1388.	1.35
TOP GASES		
-SENSIBLE HEAT	14714.	14.35
-LATENT HEAT	32509.	31.71
HEAT RADIATION FROM THE CUPOLA	13714.	13.38

VOLUME OF TOP GAS (MCF)
ACTUAL 2309.
STANDARD 917.

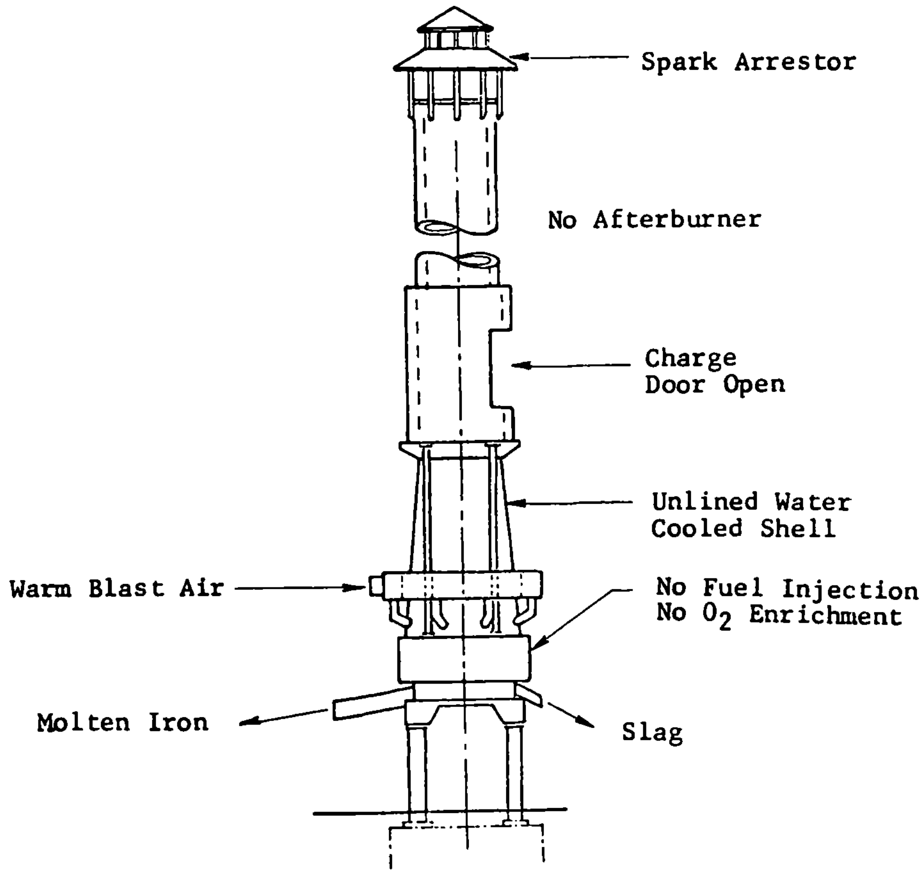
MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	1992.	47.42
PIG IRON	233.	5.56
RETURNS	996.	23.71
STEEL SCRAP	739.	17.60
IRON SCRAP	0.	0.00
FERROALLOYS	23.	0.56
COKE	253.	6.03
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	58.	1.38
AIR	1898.	45.18
OXYGEN	0.	0.00
CUPOLA LINING	0.	0.00
TOTAL INPUT MTLS	4201.	100.00
OUTPUTS		
MOLTEN IRON	2000.	47.60
SLAG	44.	1.04
EMISSIONS DUST	19.	0.45
TOP GASES	2139.	50.90
NITROGEN	1449.	67.77
CARBON DIOXIDE	468.	21.87
CARBON MONOXIDE	220.	10.29
HYDROGEN	2.	0.07
SULFUR DIOXIDE	-0.	-0.00



CUPOLA CLASSIFICATION - 2

Insufficient Data for
Heat and Material
Balance Calculations



CUPOLA CLASSIFICATION - 3

HEAT BALANCE

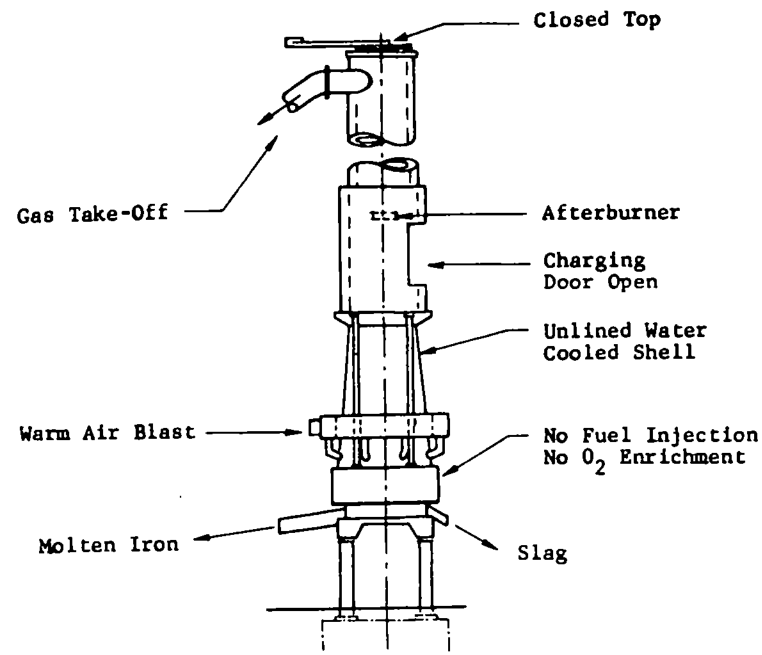
INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	56685.	85.19
SENSIBLE HEAT OF THE BLAST	9301.	13.98
HEAT FROM OXIDATION OF MN, FE, SI	556.	0.84
TOTAL INPUT HEAT	66541.	100.00
OUTPUT HEAT		
HEATING AND MELTING OF IRON	15432.	23.19
HEAT CONTENT OF THE SLAG	156.	0.23
CALCINING OF LIMESTONE	984.	1.48
DECOMPOSITION OF WATER	680.	1.02
TOP GASES		
-SENSIBLE HEAT	11973.	17.99
-LATENT HEAT	-15611.	-23.46
HEAT RADIATION FROM THE CUPOLA	52926.	79.54

VOLUME OF TOP GAS (MCF)

ACTUAL	1793.
STANDARD	712.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	2004.	30.73
PIG IRON	0.	0.00
RETURNS	982.	15.05
STEEL SCRAP	295.	4.52
IRON SCRAP	687.	10.54
FERROALLOYS	41.	0.62
COKE	333.	5.11
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	100.	1.54
AIR	4085.	62.63
OXYGEN	0.	0.00
CUPOLA LINING	0.	0.00
TOTAL INPUT MTLS	6523.	100.00
OUTPUTS		
MOLTEN IRON	2000.	30.66
SLAG	56.	0.86
EMISSIONS DUST	32.	0.49
TOP GASES	4435.	67.99
NITROGEN	3129.	70.55
CARBON DIOXIDE	1573.	35.46
CARBON MONOXIDE	-266.	-6.00
HYDROGEN	2.	0.04
SULFUR DIOXIDE	-3.	-0.06



CUPOLA CLASSIFICATION - 4

HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	40947.	86.57
SENSIBLE HEAT OF THE BLAST	3247.	6.86
HEAT FROM OXIDATION OF MN, FE, SI	3106.	6.57
TOTAL INPUT HEAT	47300.	100.00

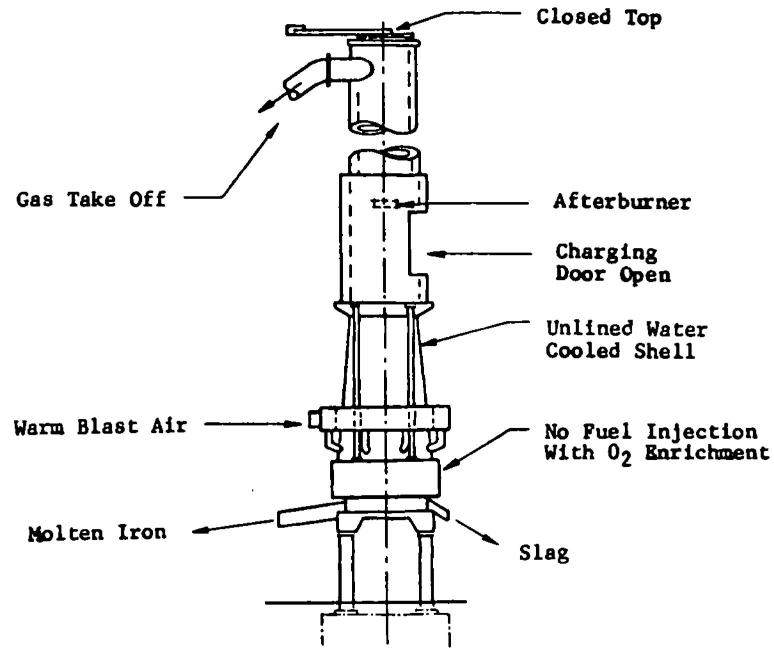
OUTPUT HEAT		
HEATING AND MELTING OF IRON	14028.	29.66
HEAT CONTENT OF THE SLAG	806.	1.70
CALCINING OF LIMESTONE	1221.	2.58
DECOMPOSITION OF WATER	292.	0.62
TOP GASES		
-SENSIBLE HEAT	5652.	11.95
-LATENT HEAT	10785.	22.80
HEAT RADIATION FROM THE CUPOLA	14515.	30.69

VOLUME OF TOP GAS (MCF)
ACTUAL 872.
STANDARD 346.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	2030.	46.23
PIG IRON	256.	5.83
RETURNS	1507.	34.32
STEEL SCRAP	0.	0.00
IRON SCRAP	223.	5.07
FERROALLOYS	45.	1.01
COKE	250.	5.69
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	136.	3.10
AIR	1893.	43.13
OXYGEN	81.	1.85
CUPOLA LINING	0.	0.00
TOTAL INPUT MTLS	4390.	100.00

OUTPUTS		
MOLTEN IRON	2000.	45.55
SLAG	120.	2.74
EMISSIONS DUST	19.	0.44
TOP GASES	2251.	51.27
NITROGEN	1450.	64.43
CARBON DIOXIDE	600.	26.65
CARBON MONOXIDE	199.	8.82
HYDROGEN	1.	0.04
SULFUR DIOXIDE	1.	0.06



CUPOLA CLASSIFICATION - 5

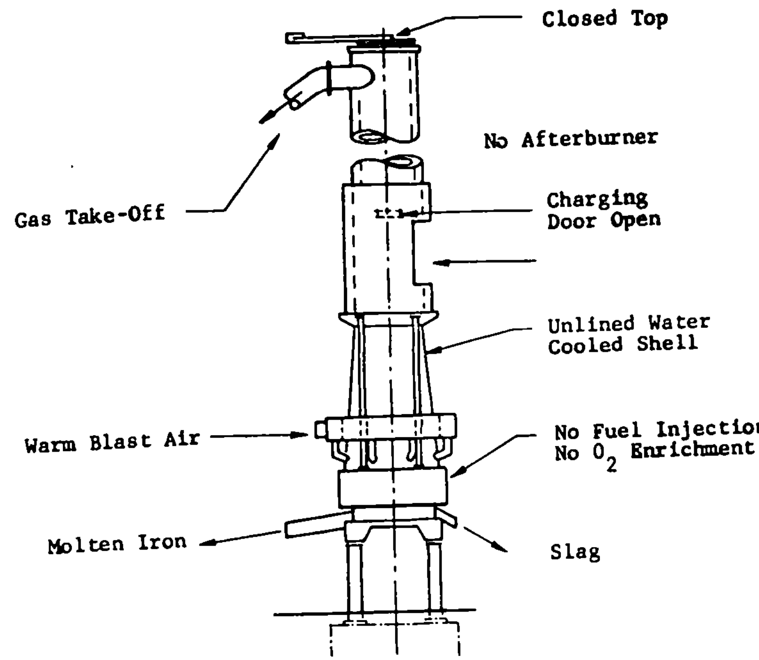
HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
PØTENTIAL HEAT ØF FUEL	44940.	89.05
SENSIBLE HEAT ØF THE BLAST	4694.	9.30
HEAT FRØM ØXIDATIØN ØF MN, FE, SI	834.	1.65
TØTAL INPUT HEAT	50468.	100.00
ØUTPUT HEAT		
HEATING AND MELTING ØF IRØN	23343.	46.25
HEAT CØNTENT ØF THE SLAG	706.	1.40
CALCINING ØF LIMESTØNE	326.	0.64
DECØMPØSITIØN ØF WATER	615.	1.22
TØP GASES -SENSIBLE HEAT	6892.	13.66
-LATENT HEAT	14898.	29.52
HEAT RADIATIØN FRØM THE CUPØLA	3688.	7.31

VØLUME ØF TØP GAS (MCF)
ACTUAL 1059.
STANDARD 405.

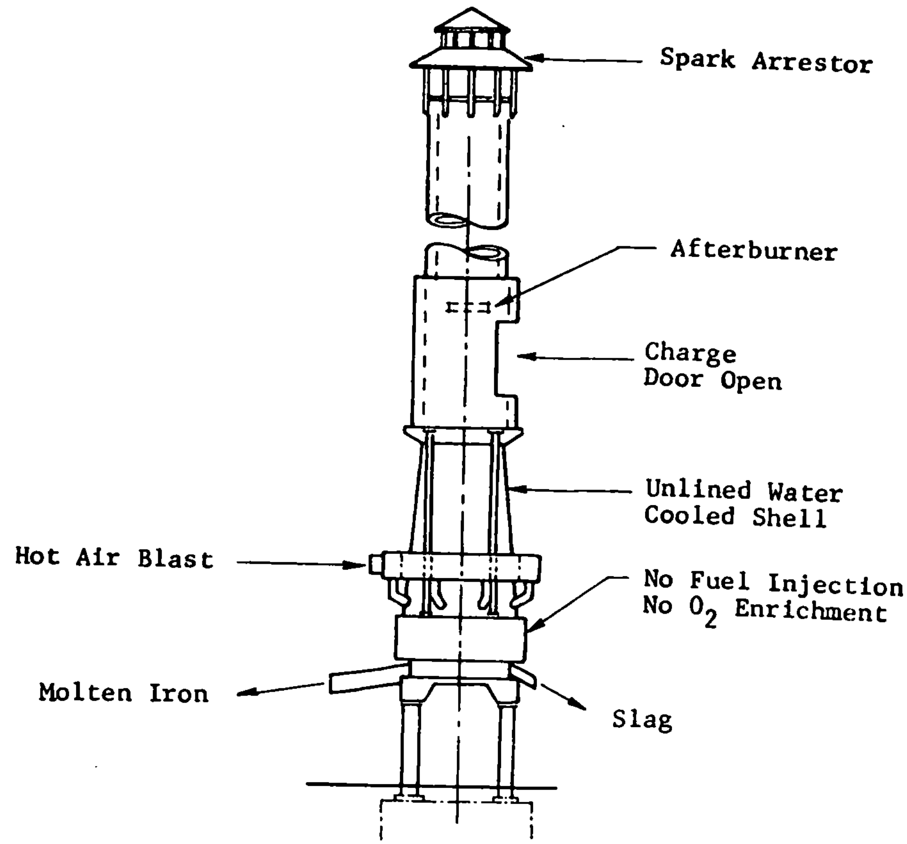
MATERIAL BALANCE

INPUTS	PØUNDS	PERCENT
METAL CHARGE	1981.	55.05
PIG IRØN	0.	0.00
RETURNS	869.	24.14
STEEL SCRAP	1043.	28.97
IRØN SCRAP	0.	0.00
FERRØALLØYS	70.	1.93
CØKE	200.	5.56
NATURAL GAS	0.	0.00
FUEL ØIL	0.	0.00
FLUX AND ADDITIVES	44.	1.21
AIR	1374.	38.18
ØXYGEN	0.	0.00
CUPØLA LINING	0.	0.00
TØTAL INPUT MTLS	3599.	100.00
ØUTPUTS		
MØLTEN IRØN	2000.	55.57
SLAG	45.	1.26
EMISSIØNS DUST	14.	0.38
TØP GASES	1540.	42.79
NITRØGEN	1049.	68.13
CARBØN DIØXIDE	324.	21.05
CARBØN MØNØXIDE	165.	10.70
HYDRØGEN	1.	0.07
SULFUR DIØXIDE	1.	0.04



CUPOLA CLASSIFICATION - 6

Insufficient Data for
Heat and Material
Balance Calculations



CUPOLA CLASSIFICATION - 7

HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
PØTENTIAL HEAT ØF FUEL	64255.	76.64
SENSIBLE HEAT ØF THE BLAST	12745.	15.20
HEAT FRØM ØXIDATIØN ØF MN, FE, SI	6840.	8.16
TØTAL INPUT HEAT	83840.	100.00

ØUTPUT HEAT		
HEATING AND MELTING ØF IRØN	22863.	27.27
HEAT CØNTENT ØF THE SLAG	1271.	1.52
CALCINING ØF LIMESTØNE	875.	1.04
DECØMPØSITIØN ØF WATER	1190.	1.42
TØP GASES		
-SENSIBLE HEAT	12113.	14.45
-LATENT HEAT	356.	0.42
HEAT RADIATIØN FRØM THE CUPØLA	45172.	53.88

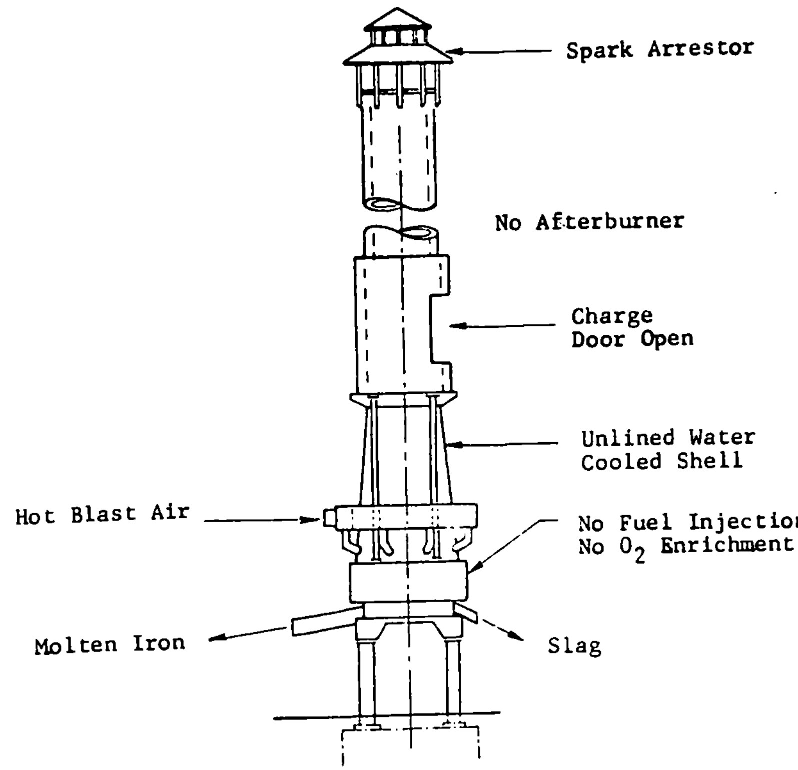
VØLUME ØF TØP GAS (MCF)

ACTUAL	1653.
STANDARD	736.

MATERIAL BALANCE

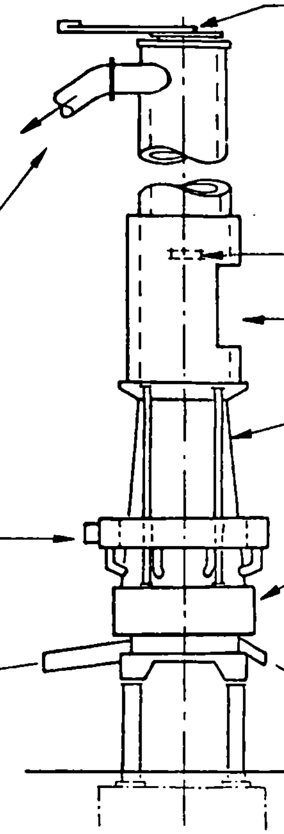
INPUTS	PØUNDS	PERCENT
METAL CHARGE	2023.	39.54
PIG IRØN	0.	0.00
RETURNS	587.	11.47
STEEL SCRAP	391.	7.65
IRØN SCRAP	978.	19.12
FERRØALLØYS	67.	1.30
CØKE	267.	5.21
NATURAL GAS	0.	0.00
FUEL ØIL	0.	0.00
FLUX AND ADDITIVES	61.	1.19
AIR	2766.	54.06
ØXYGEN	0.	0.00
CUPØLA LINING	0.	0.00
TØTAL INPUT MTLS	5117.	100.00

ØUTPUTS		
MØLTEN IRØN	2000.	39.09
SLAG	84.	1.63
EMISSIØNS DUST	26.	0.50
TØP GASES	3008.	58.78
NITRØGEN	2112.	70.22
CARBØN DIØXIDE	887.	29.46
CARBØN MØNØXIDE	4.	0.14
HYDRØGEN	2.	0.08
SULFUR DIØXIDE	2.	0.08



CUPOLA CLASSIFICATION - 8

Insufficient Data for
Heat and Material
Balance Calculations



CUPOLA CLASSIFICATION - 9

HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
PØTENTIAL HEAT ØF FUEL	39360.	56.01
SENSIBLE HEAT ØF THE BLAST	6373.	9.07
HEAT FRØM ØXIDATIØN ØF MN, FE, SI	24545.	34.93
TØTAL INPUT HEAT	70278.	100.00

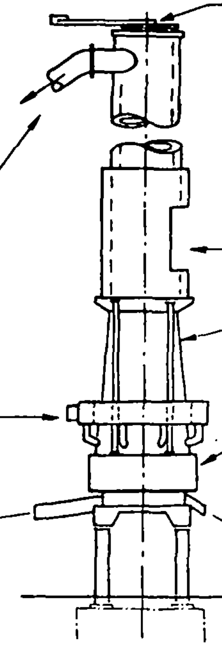
ØUTPUT HEAT		
HEATING AND MELTING ØF IRØN	11223.	15.97
HEAT CØNTENT ØF THE SLAG	4148.	5.90
CALCINING ØF LIMESTØNE	795.	1.13
DECØMPØSITIØN ØF WATER	595.	0.85
TØP GASES		
-SENSIBLE HEAT	5902.	8.40
-LATENT HEAT	24225.	34.47
HEAT RADIATIØN FRØM THE CUPØLA	23390.	33.28

VØLUME ØF TØP GAS (MCF)
ACTUAL 971.
STANDARD 386.

MATERIAL BALANCE

INPUTS	PØUNDS	PERCENT
METAL CHARGE	2190.	40.38
PIG IRØN	0.	0.00
RETURNS	640.	11.81
STEEL SCRAP	0.	0.00
IRØN SCRAP	1121.	20.66
FERRØALLØYS	429.	7.91
CØKE	320.	5.90
NATURAL GAS	0.	0.00
FUEL ØIL	0.	0.00
FLUX AND ADDITIVES	119.	2.20
AIR	2766.	50.99
ØXYGEN	0.	0.00
CUPØLA LINING	29.	0.54
TØTAL INPUT MTLS	5425.	100.00

OUTPUTS		
MØLTEN IRØN	2000.	36.87
SLAG	501.	9.24
EMISSIØNS DUST	27.	0.49
TØP GASES	2897.	53.40
NITRØGEN	2112.	72.91
CARBØN DIØXIDE	222.	7.67
CARBØN MØNØXIDE	557.	19.24
HYDRØGEN	2.	0.08
SULFUR DIØXIDE	3.	0.10



CUPOLA CLASSIFICATION - 10

HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	94371.	88.08
SENSIBLE HEAT OF THE BLAST	11389.	10.63
HEAT FROM OXIDATION OF MN, FE, SI	1386.	1.29
-TOTAL INPUT HEAT	107146.	100.00

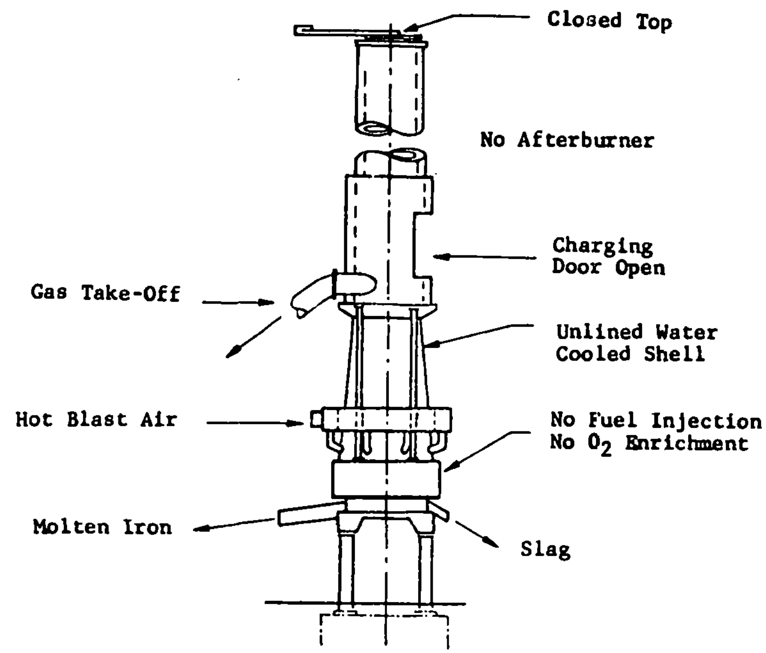
OUTPUT HEAT		
HEATING AND MELTING OF IRON	39279.	36.66
HEAT CONTENT OF THE SLAG	505.	0.47
CALCINING OF LIMESTONE	786.	0.73
DECOMPOSITION OF WATER	1190.	1.11
TOP GASES		
-SENSIBLE HEAT	12693.	11.85
-LATENT HEAT	39035.	36.43
HEAT RADIATION FROM THE CUPOLA	13658.	12.75

VOLUME OF TOP GAS (MCF)
ACTUAL 2018.
STANDARD 801.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	1989.	51.90
PIG IRON	0.	0.00
RETURNS	426.	11.12
STEEL SCRAP	791.	20.65
IRON SCRAP	761.	19.85
FERROALLOYS	11.	0.28
COKE	233.	6.07
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	31.	0.80
AIR	1581.	41.24
OXYGEN	0.	0.00
CUPOLA LINING	0.	0.00
TOTAL INPUT MTLS	3833.	100.00

OUTPUTS		
MOLTEN IRON	2000.	52.18
SLAG	27.	0.70
EMISSIONS DUST	16.	0.42
TOP GASES	1790.	46.70
NITROGEN	1207.	67.43
CARBON DIOXIDE	324.	18.09
CARBON MONOXIDE	257.	14.34
HYDROGEN	1.	0.07
SULFUR DIOXIDE	1.	0.08



CUPOLA CLASSIFICATION - 11

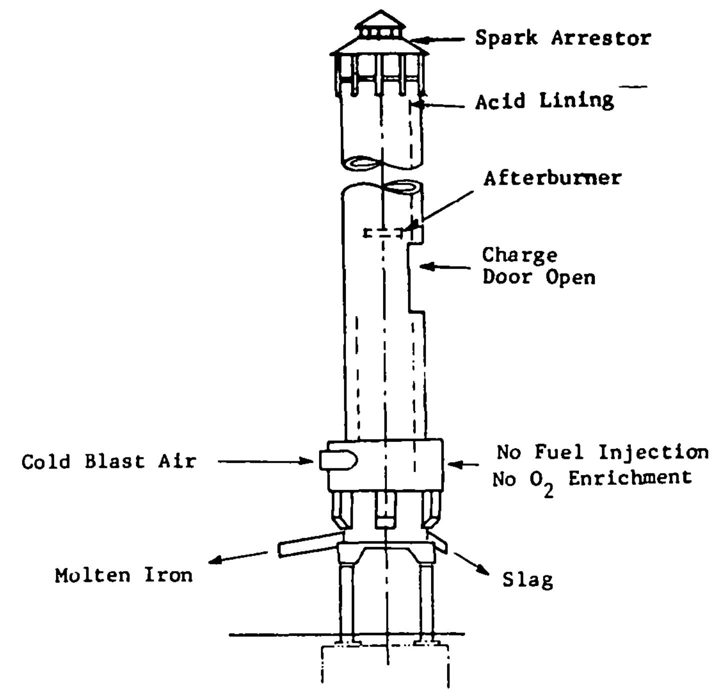
HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	29060.	86.72
SENSIBLE HEAT OF THE BLAST	61.	0.18
HEAT FROM OXIDATION OF MN, FE, SI	4390.	13.10
TOTAL INPUT HEAT	33511.	100.00
OUTPUT HEAT		
HEATING AND MELTING OF IRON	17623.	52.59
HEAT CONTENT OF THE SLAG	274.	0.82
CALCINING OF LIMESTONE	756.	2.25
DECOMPOSITION OF WATER	3569.	10.65
TOP GASES		
-SENSIBLE HEAT	6182.	18.45
-LATENT HEAT	6880.	20.53
HEAT RADIATION FROM THE CUPOLA	-1772.	-5.29

VOLUME OF TOP GAS (MCF)
ACTUAL 952.
STANDARD 375.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	2004.	52.08
PIG IRON	0.	0.00
RETURNS	802.	20.83
STEEL SCRAP	1137.	29.56
IRON SCRAP	0.	0.00
FERROALLOYS	65.	1.69
COKE	167.	4.33
NATURAL GAS	29.	0.75
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	65.	1.69
AIR	1556.	40.43
OXYGEN	0.	0.00
CUPOLA LINING	27.	0.71
TOTAL INPUT MTLS	3848.	100.00
OUTPUTS		
MOLTEN IRON	2000.	51.97
SLAG	32.	0.83
EMISSIONS DUST	14.	0.37
TOP GASES	1802.	46.84
NITROGEN	1188.	65.91
CARBON DIOXIDE	507.	28.10
CARBON MONOXIDE	99.	5.49
HYDROGEN	9.	0.47
SULFUR DIOXIDE	0.	0.02



CUPOLA CLASSIFICATION - 12

HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
PØTENTIAL HEAT ØF FUEL	51194.	98.50
SENSIBLE HEAT ØF THE BLAST	90.	0.17
HEAT FRØM ØXIDATIØN ØF MN, FE, SI	691.	1.33
TØTAL INPUT HEAT	51976.	100.00

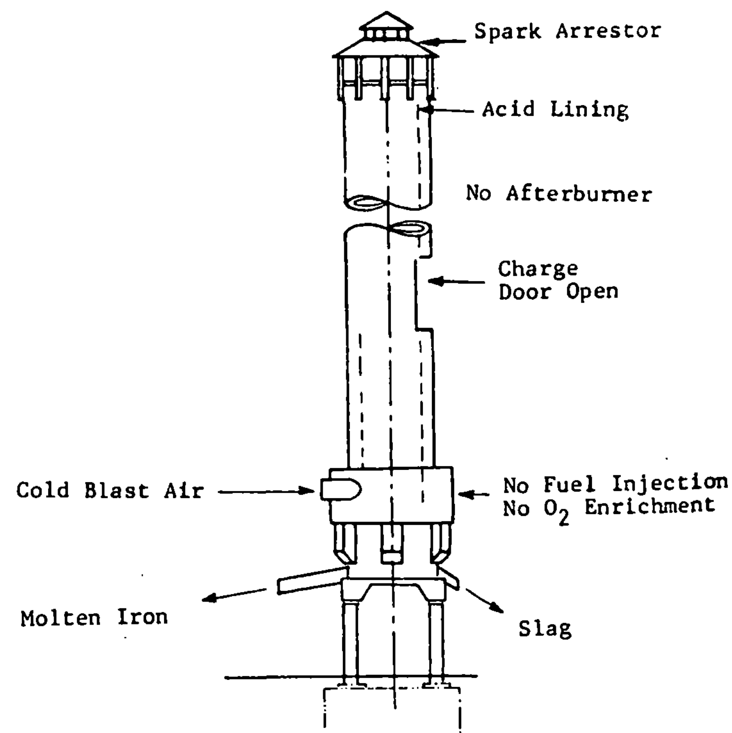
ØUTPUT HEAT		
HEATING AND MELTING ØF IRØN	15712.	30.23
HEAT CØNTENT ØF THE SLAG	511.	0.98
CALCINING ØF LIMESTØNE	674.	1.30
DECØMPØSITIØN ØF WATER	793.	1.53
TØP GASES		
-SENSIBLE HEAT	8281.	15.93
-LATENT HEAT	9439.	18.16
HEAT RADIATIØN FRØM THE CUPØLA	16567.	31.87

VØLUME ØF TØP GAS (MCF)
ACTUAL 1283.
STANDARD 509.

MATERIAL BALANCE

INPUTS	PØUNDS	PERCENT
METAL CHARGE	1994.	39.73
PIG IRØN	389.	7.75
RETURNS	803.	15.99
STEEL SCRAP	730.	14.53
IRØN SCRAP	49.	0.97
FERRØALLØYS	24.	0.46
CØKE	308.	6.13
NATURAL GAS	0.	0.00
FUEL ØIL	0.	0.00
FLUX AND ADDITIVES	66.	1.31
AIR	2634.	52.46
ØXYGEN	0.	0.00
CUPØLA LINING	18.	0.35
TØTAL INPUT MTLS	5020.	100.00

OUTPUTS		
MØLTEN IRØN	2000.	39.84
SLAG	64.	1.27
EMISSIØNS DUST	24.	0.47
TØP GASES	2932.	58.42
NITRØGEN	2011.	68.59
CARBØN DIØXIDE	762.	25.99
CARBØN MØNØXIDE	155.	5.29
HYDRØGEN	2.	0.07
SULFUR DIØXIDE	1.	0.05



CUPOLA CLASSIFICATION - 13

HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	31164.	98.54
SENSIBLE HEAT OF THE BLAST	49.	0.16
HEAT FROM OXIDATION OF MN, FE, SI	414.	1.31
TOTAL INPUT HEAT	31628.	100.00

OUTPUT HEAT		
HEATING AND MELTING OF IRON	11160.	35.29
HEAT CONTENT OF THE SLAG	459.	1.45
CALCINING OF LIMESTONE	547.	1.73
DECOMPOSITION OF WATER	431.	1.36
TOP GASES		
-SENSIBLE HEAT	4581.	14.48
-LATENT HEAT	9802.	30.99
HEAT RADIATION FROM THE CUPOLA	4647.	14.69

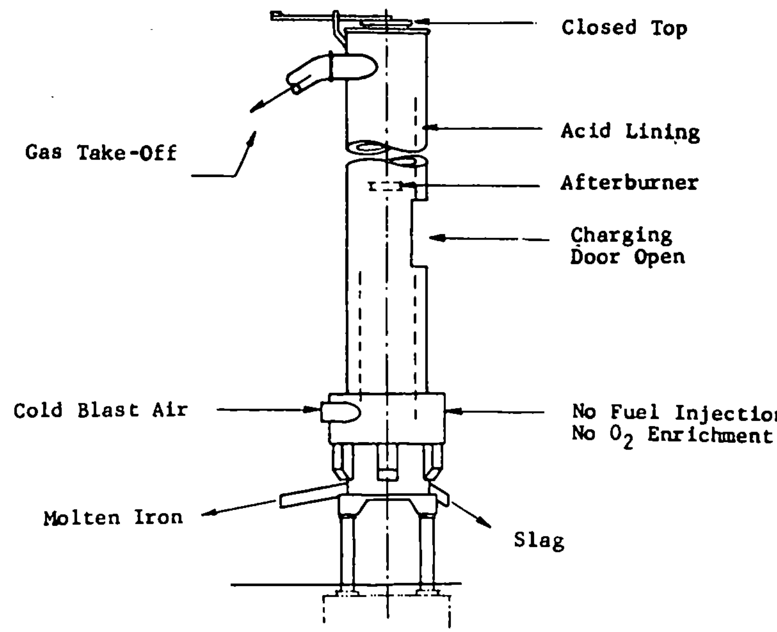
VOLUME OF TOP GAS (MCF)

ACTUAL	719.
STANDARD	285.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	2005.	45.94
PIG IRON	0.	0.00
RETURNS	201.	4.59
STEEL SCRAP	301.	6.89
IRON SCRAP	1504.	34.45
FERROALLOYS	0.	0.00
COKE	250.	5.73
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	75.	1.73
AIR	2005.	45.94
OXYGEN	0.	0.00
CUPOLA LINING	29.	0.67
TOTAL INPUT MTLS	4365.	100.00

OUTPUTS		
MOLTEN IRON	2000.	45.82
SLAG	77.	1.77
EMISSIONS DUST	19.	0.43
TOP GASES	2269.	51.99
NITROGEN	1531.	67.47
CARBON DIOXIDE	507.	22.34
CARBON MONOXIDE	226.	9.94
HYDROGEN	2.	0.07
SULFUR DIOXIDE	4.	0.18



CUPOLA CLASSIFICATION - 14

HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
PØTENTIAL HEAT ØF FUEL	35065.	98.73
SENSIBLE HEAT ØF THE BLAST	53.	0.15
HEAT FRØM ØXIDATIØN ØF MN, FE, SI	399.	1.12
TØTAL INPUT HEAT	35518.	100.00

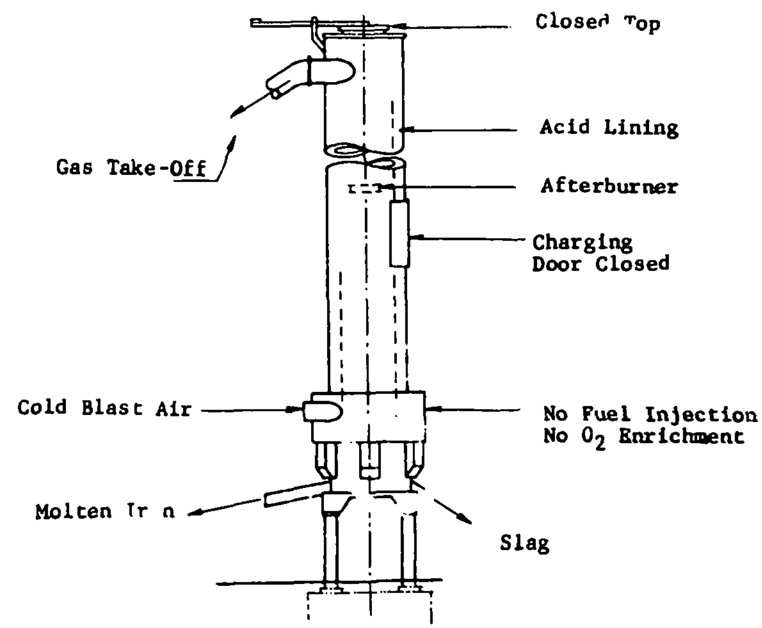
ØUTPUT HEAT		
HEATING AND MELTING ØF IRØN	9312.	26.22
HEAT CØNTENT ØF THE SLAG	420.	1.18
CALCINING ØF LIMESTØNE	350.	0.99
DECØMPØSITIØN ØF WATER	466.	1.31
TØP GASES		
-SENSIBLE HEAT	4945.	13.92
-LATENT HEAT	12530.	35.28
HEAT RADIATIØN FRØM THE CUPØLA	7495.	21.10

VØLUME ØF TØP GAS (MCF)
ACTUAL 780.
STANDARD 310.

MATERIAL BALANCE

INPUTS	PØUNDS	PERCENT
METAL CHARGE	1999.	38.79
PIG IRØN	400.	7.76
RETURNS	800.	15.52
STEEL SCRAP	600.	11.64
IRØN SCRAP	200.	3.88
FERRØALLØYS	0.	0.00
CØKE	357.	6.93
NATURAL GAS	0.	0.00
FUEL ØIL	0.	0.00
FLUX AND ADDITIVES	60.	1.16
AIR	2709.	52.55
ØXYGEN	0.	0.00
CUPØLA LINING	29.	0.56
TØTAL INPUT MTLS	5154.	100.00

ØUTPUTS		
MØLTEN IRØN	2000.	38.81
SLAG	72.	1.40
EMISSIONS DUST	26.	0.51
TØP GASES	3055.	59.28
NITRØGEN	2068.	67.68
CARBØN DIØXIDE	623.	20.38
CARBØN MØNØXIDE	360.	11.79
HYDRØGEN	2.	0.07
SULFUR DIØXIDE	2.	0.07



CUPOLA CLASSIFICATION - 15

HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	25435.	98.08
SENSIBLE HEAT OF THE BLAST	48.	0.19
HEAT FROM OXIDATION OF MN, FE, SI	450.	1.74
TOTAL INPUT HEAT	25934.	100.00

OUTPUT HEAT		
HEATING AND MELTING OF IRON	9539.	36.78
HEAT CONTENT OF THE SLAG	485.	1.87
CALCINING OF LIMESTONE	322.	1.24
DECOMPOSITION OF WATER	421.	1.63
TOP GASES		
-SENSIBLE HEAT	4365.	16.83
-LATENT HEAT	2615.	10.08
HEAT RADIATION FROM THE CUPOLA	8186.	31.57

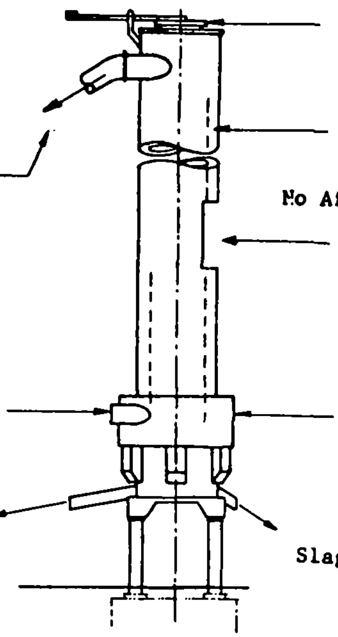
VOLUME OF TOP GAS (MCF)

ACTUAL	671.
STANDARD	266.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	2002.	43.10
PIG IRON	548.	11.79
RETURNS	896.	19.30
STEEL SCRAP	548.	11.79
IRON SCRAP	0.	0.00
FERROALLOYS	10.	0.21
COKE	250.	5.38
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	52.	1.12
AIR	2305.	49.63
OXYGEN	0.	0.00
CUPOLA LINING	36.	0.77
TOTAL INPUT MTLS	4644.	100.00

OUTPUTS		
MOLTEN IRON	2000.	43.06
SLAG	76.	1.64
EMISSIONS DUST	21.	0.45
TOP GASES	2547.	54.85
NITROGEN	1760.	69.09
CARBON DIOXIDE	714.	28.03
CARBON MONOXIDE	71.	2.78
HYDROGEN	2.	0.07
SULFUR DIOXIDE	1.	0.03



CUPOLA CLASSIFICATION - 16

HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	144207.	97.67
SENSIBLE HEAT OF THE BLAST	194.	0.13
HEAT FROM OXIDATION OF MN, FE, SI	3240.	2.19
TOTAL INPUT HEAT	147641.	100.00

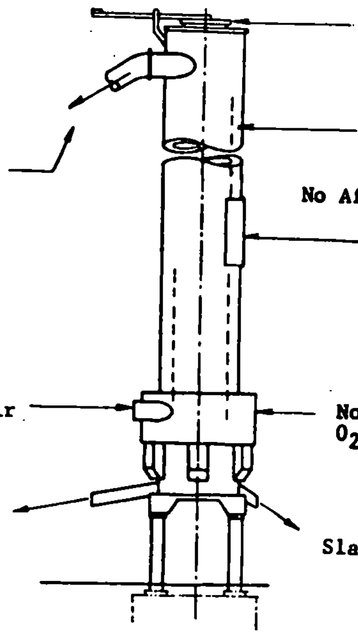
OUTPUT HEAT		
HEATING AND MELTING OF IRON	62872.	42.58
HEAT CONTENT OF THE SLAG	2249.	1.52
CALCINING OF LIMESTONE	1604.	1.09
DECOMPOSITION OF WATER	1636.	1.11
TOP GASES		
-SENSIBLE HEAT	18321.	12.41
-LATENT HEAT	49633.	33.62
HEAT RADIATION FROM THE CUPOLA	11326.	7.67

VOLUME OF TOP GAS (MCF)
ACTUAL 2863.
STANDARD 1137.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	1984.	53.30
PIG IRON	861.	23.13
RETURNS	186.	5.00
STEEL SCRAP	931.	25.01
IRON SCRAP	0.	0.00
FERROALLOYS	6.	0.16
COKE	242.	6.51
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	40.	1.07
AIR	1383.	37.16
OXYGEN	61.	1.64
CUPOLA LINING	12.	0.33
TOTAL INPUT MTLS	3722.	100.00

OUTPUTS		
MOLTEN IRON	2000.	53.73
SLAG	57.	1.52
EMISSIONS DUST	15.	0.40
TOP GASES	1651.	44.35
NITROGEN	1056.	63.97
CARBON DIOXIDE	382.	23.17
CARBON MONOXIDE	208.	12.58
HYDROGEN	1.	0.07
SULFUR DIOXIDE	4.	0.21



CUPOLA CLASSIFICATION - 17

HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
PØTENTIAL HEAT ØF FUEL	53096.	98.37
SENSIBLE HEAT ØF THE BLAST	62.	0.12
HEAT FRØM ØXIDATIØN ØF MN, FE, SI	816.	1.51
TØTAL INPUT HEAT	53975.	100.00

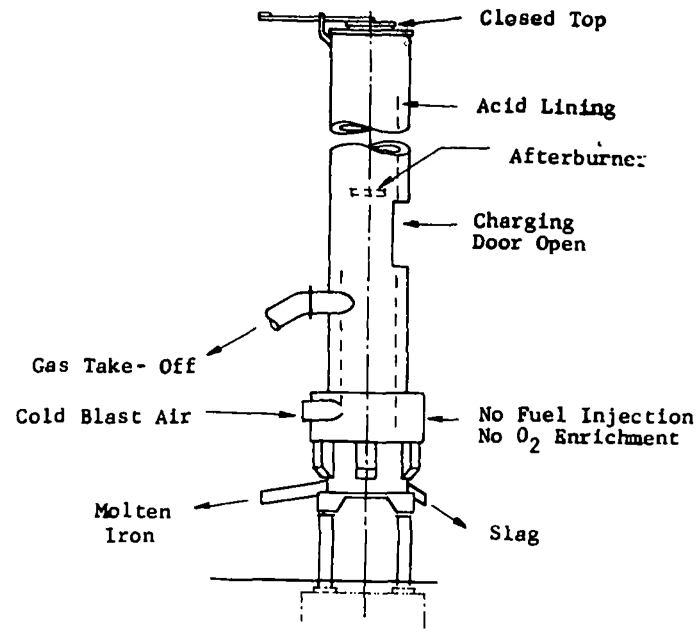
ØUTPUT HEAT	B.T.U.S (000/HR.)	PERCENT
HEATING AND MELTING ØF IRØN	22445.	41.59
HEAT CØNTENT ØF THE SLAG	885.	1.64
CALCINING ØF LIMESTØNE	816.	1.51
DECØMPØSITIØN ØF WATER	545.	1.01
TØP GASES -SENSIBLE HEAT	6038.	11.19
-LATENT HEAT	31804.	58.92
HEAT RADIATIØN FRØM THE CUPØLA	-8559.	-15.86

VØLUME ØF TØP GAS (MCF)
ACTUAL 985.
STANDARD 391.

MATERIAL BALANCE

INPUTS	PØUNDS	PERCENT
METAL CHARGE	2002.	56.15
PIG IRØN	0.	0.00
RETURNS	400.	11.23
STEEL SCRAP	400.	11.23
IRØN SCRAP	1201.	33.69
FERRØALLØYS	0.	0.00
CØKE	222.	6.23
NATURAL GAS	0.	0.00
FUEL ØIL	0.	0.00
FLUX AND ADDITIVES	56.	1.57
AIR	1268.	35.56
ØXYGEN	0.	0.00
CUPØLA LINING	18.	0.49
TØTAL INPUT MTLS	3566.	100.00

ØUTPUTS	PØUNDS	PERCENT
MØLTEN IRØN	2000.	56.09
SLAG	68.	1.90
EMISSIØNS DUST	14.	0.40
TØP GASES	1484.	41.61
NITRØGEN	968.	65.24
CARBØN DIØXIDE	147.	9.90
CARBØN MØNØXIDE	366.	24.66
HYDRØGEN	1.	0.07
SULFUR DIØXIDE	2.	0.12



CUPOLA CLASSIFICATION - 18

HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	68407.	90.79
SENSIBLE HEAT OF THE BLAST	5504.	7.31
HEAT FROM OXIDATION OF MN, FE, SI	1434.	1.90
TOTAL INPUT HEAT	75345.	100.00

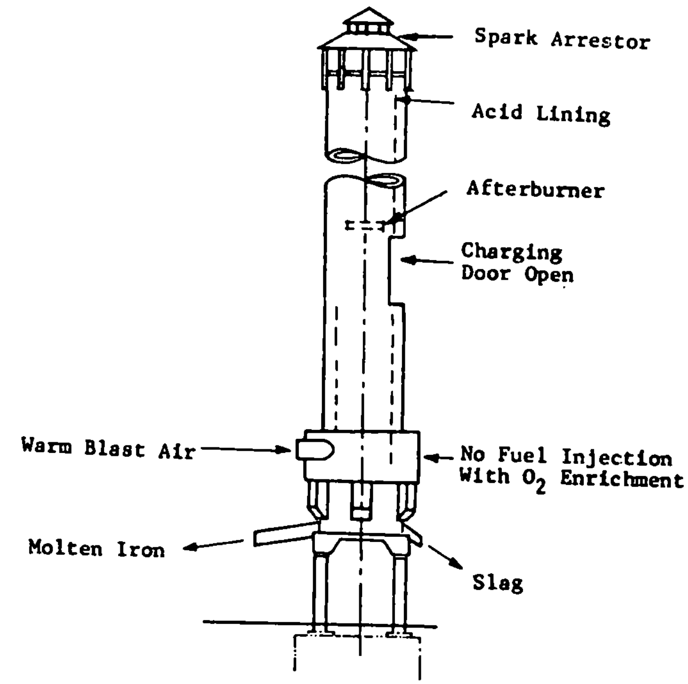
OUTPUT HEAT		
HEATING AND MELTING OF IRON	25332.	33.62
HEAT CONTENT OF THE SLAG	1103.	1.46
CALCINING OF LIMESTONE	1604.	2.13
DECOMPOSITION OF WATER	567.	0.75
TOP GASES		
-SENSIBLE HEAT	11610.	15.41
-LATENT HEAT	17324.	22.99
HEAT RADIATION FROM THE CUPOLA	17804.	23.63

VOLUME OF TOP GAS (MCF)
ACTUAL 1734.
STANDARD 644.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	2010.	44.99
PIG IRON	0.	0.00
RETURNS	1873.	41.91
STEEL SCRAP	125.	2.79
IRON SCRAP	0.	0.00
FERROALLOYS	13.	0.29
COKE	250.	5.59
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	101.	2.25
AIR	2089.	46.75
OXYGEN	0.	0.00
CUPOLA LINING	18.	0.41
TOTAL INPUT MTLS	4468.	100.00

OUTPUTS		
MOLTEN IRON	2000.	44.76
SLAG	93.	2.08
EMISSIONS DUST	20.	0.46
TOP GASES	2355.	52.70
NITROGEN	1600.	67.94
CARBON DIOXIDE	572.	24.27
CARBON MONOXIDE	181.	7.69
HYDROGEN	1.	0.04
SULFUR DIOXIDE	1.	0.05



CUPOLA CLASSIFICATION - 19

HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
RØTENTIAL HEAT ØF FUEL	69898.	87.22
SENSIBLE HEAT ØF THE BLAST	9237.	11.53
HEAT FRØM ØXIDATIØN ØF MN, FE, SI	1004.	1.25
TØTAL INPUT HEAT	80140.	100.00

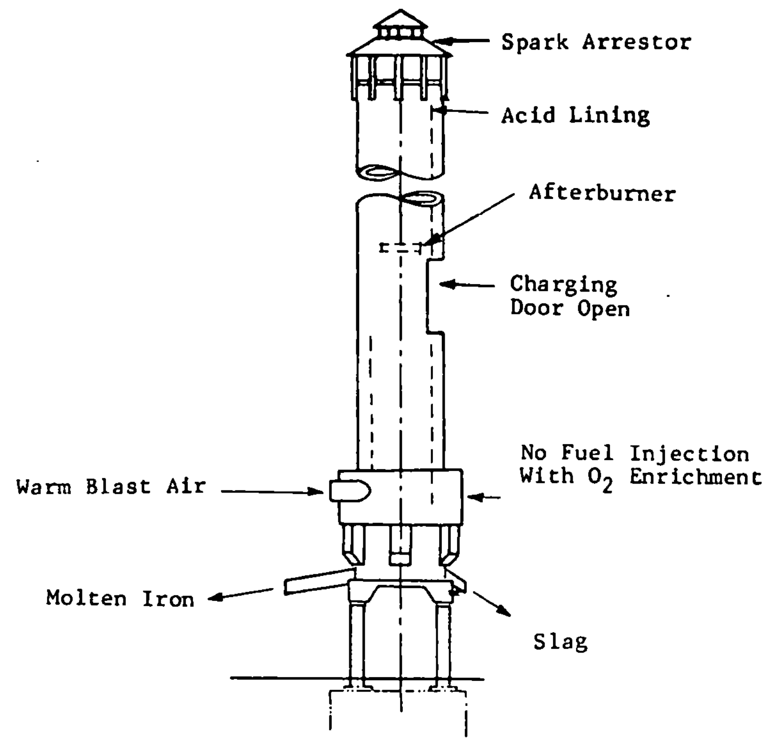
ØUTPUT HEAT		
HEATING AND MELTING ØF IRØN	29100.	36.31
HEAT CØNTENT ØF THE SLAG	695.	0.87
CALCINING ØF LIMESTØNE	474.	0.59
DECØMPØSITIØN ØF WATER	1190.	1.48
TØP GASES		
-SENSIBLE HEAT	12431.	15.51
-LATENT HEAT	-3301.	-4.12
HEAT RADIATIØN FRØM THE CUPØLA	39552.	49.35

VØLUME ØF TØP GAS (MCF)
ACTUAL 1879.
STANDARD 746.

MATERIAL BALANCE

INPUTS	PØUNDS	PERCENT
METAL CHARGE	1983.	43.78
PIG IRØN	0.	0.00
RETURNS	390.	8.60
STEEL SCRAP	974.	21.50
IRØN SCRAP	584.	12.90
FERRØALLØYS	35.	0.76
CØKE	250.	5.52
NATURAL GAS	0.	0.00
FUEL ØIL	0.	0.00
FLUX AND ADDITIVES	26.	0.57
AIR	2213.	48.85
ØXYGEN	41.	0.90
CUPØLA LINING	18.	0.39
TØTAL INPUT MTLS	4530.	100.00

ØUTPUTS		
MØLTEN IRØN	2000.	44.15
SLAG	36.	0.79
EMISSIØNS DUST	22.	0.48
TØP GASES	2472.	54.58
NITRØGEN	1690.	68.34
CARBØN DIØXIDE	810.	32.76
CARBØN MØNØXIDE	-30.	-1.23
HYDRØGEN	2.	0.07
SULFUR DIØXIDE	1.	0.06



CUPOLA CLASSIFICATION - 20

HEAT BALANCE

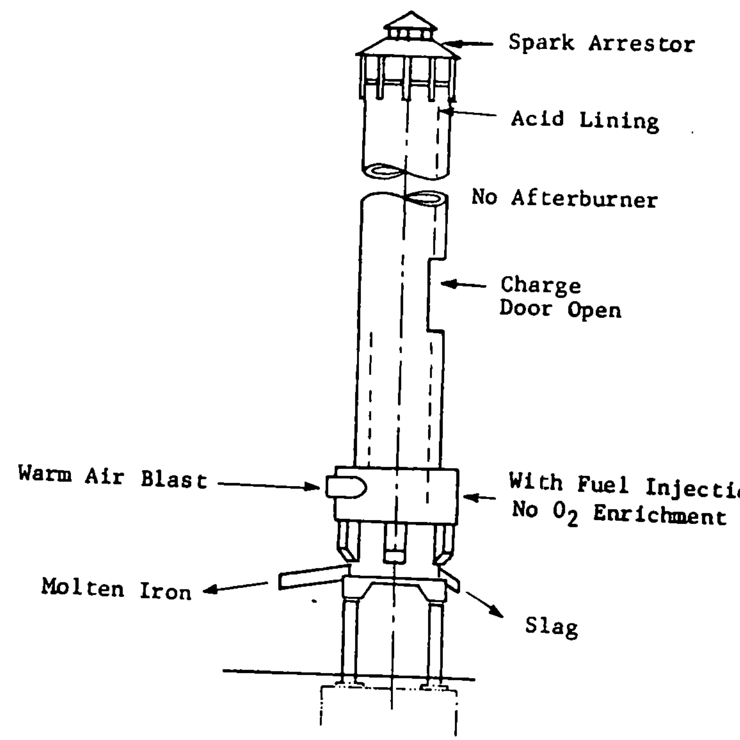
INPUT HEAT	B.T.U.S. (000/HR.)	PERCENT
PØTENTIAL HEAT ØF FUEL	9985.	79.64
SENSIBLE HEAT ØF THE BLAST	1337.	10.66
HEAT FRØM ØXIDATIØN ØF MN, FE, SI	1216.	9.70
TØTAL INPUT HEAT	12538.	100.00
ØUTPUT HEAT		
HEATING AND MELTING ØF IRØN	3367.	26.85
HEAT CØNTENT ØF THE SLAG	401.	3.20
CALCINING ØF LIMESTØNE	262.	2.09
DECØMPØSITIØN ØF WATER	198.	1.58
TØP GASES		
- SENSIBLE HEAT	3371.	26.89
- LATENT HEAT	13044.	-104.04
HEAT RADIATIØN FRØM THE CUPØLA	17982.	143.42

VØLUME ØF TØP GAS (MCF)

ACTUAL	487.
STANDARD	193.

MATERIAL BALANCE

INPUTS	PØUNDS	PERCENT
METAL CHARGE	2001.	25.42
PIG IRØN	0.	0.00
RETURNS	566.	7.19
STEEL SCRAP	1321.	16.78
IRØN SCRAP	0.	0.00
FERRØALLØYS	113.	1.44
CØKE	308.	3.91
NATURAL GAS	0.	0.00
FUEL ØIL	0.	0.00
FLUX AND ADDITIVES	120.	1.52
AIR	5361.	68.12
ØXYGEN	0.	0.00
CUPØLA LINING	81.	1.03
TØTAL INPUT MTLS.	7871.	100.00
ØUTPUTS		
MØLTEN IRØN	2000.	25.41
SLAG	178.	2.26
EMISSIØNS DUST	54.	0.69
TØP GASSES	5639.	71.64
NITRØGEN	4107.	72.82
CARBØN DIØXIDE	2529.	44.85
CARBØN MØNØXIDE	-1000.	-17.74
HYDRØGEN	3.	0.04
SULFUR DIØXIDE	1.	0.03



CUPOLA CLASSIFICATION - 21

HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	43896.	92.59
SENSIBLE HEAT OF THE BLAST	2600.	5.48
HEAT FROM OXIDATION OF MN, FE, SI	915.	1.93
TOTAL INPUT HEAT	47411.	100.00

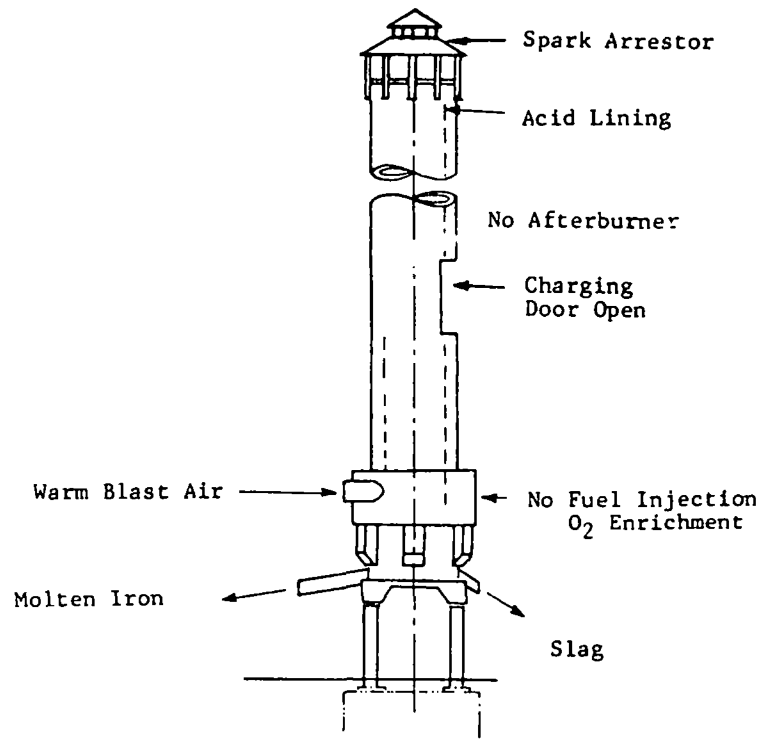
OUTPUT HEAT		
HEATING AND MELTING OF IRON	17956.	37.87
HEAT CONTENT OF THE SLAG	718.	1.51
CALCINING OF LIMESTONE	350.	0.74
DECOMPOSITION OF WATER	585.	1.23
TOP GASES		
-SENSIBLE HEAT	6186.	13.05
-LATENT HEAT	15923.	33.59
HEAT RADIATION FROM THE CUPOLA	5693.	12.01

VOLUME OF TOP GAS (MCF)
ACTUAL 978.
STANDARD 388.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	2020.	50.68
PIG IRON	793.	19.90
RETURNS	793.	19.90
STEEL SCRAP	0.	0.00
IRON SCRAP	396.	9.95
FERROALLOYS	37.	0.93
COKE	211.	5.28
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	30.	0.76
AIR	1700.	42.67
OXYGEN	0.	0.00
CUPOLA LINING	24.	0.61
TOTAL INPUT MTLS	3985.	100.00

OUTPUTS		
MOLTEN IRON	2000.	50.19
SLAG	58.	1.45
EMISSIONS DUST	16.	0.40
TOP GASES	1911.	47.95
NITROGEN	1298.	67.93
CARBON DIOXIDE	381.	19.94
CARBON MONOXIDE	229.	11.98
HYDROGEN	1.	0.07
SULFUR DIOXIDE	1.	0.07



CUPOLA CLASSIFICATION - 22

HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	33777.	83.55
SENSIBLE HEAT OF THE BLAST	3977.	9.84
HEAT FROM OXIDATION OF MN, FE, SI	2673.	6.61
TOTAL INPUT HEAT	40427.	100.00

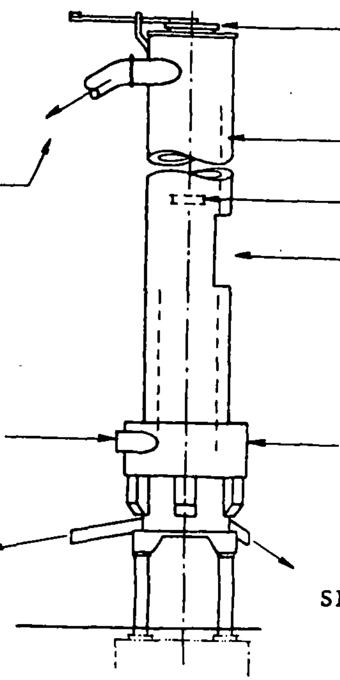
OUTPUT HEAT		
HEATING AND MELTING OF IRON	18123.	44.83
HEAT CONTENT OF THE SLAG	1157.	2.86
CALCINING OF LIMESTONE	751.	1.86
DECOMPOSITION OF WATER	545.	1.35
TOP GASES		
-SENSIBLE HEAT	5668.	14.02
-LATENT HEAT	5977.	14.78
HEAT RADIATION FROM THE CUPOLA	8205.	20.29

VOLUME OF TOP GAS (MCF)
ACTUAL 878.
STANDARD 348.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	2024.	52.36
PIG IRON	319.	8.25
RETURNS	996.	25.77
STEEL SCRAP	0.	0.00
IRON SCRAP	677.	17.52
FERROALLOYS	32.	0.82
COKE	167.	4.31
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	68.	1.76
AIR	1585.	40.99
OXYGEN	0.	0.00
CUPOLA LINING	22.	0.57
TOTAL INPUT MTLS	3866.	100.00

OUTPUTS		
MOLTEN IRON	2000.	51.73
SLAG	95.	2.46
EMISSIONS DUST	14.	0.35
TOP GASES	1757.	45.45
NITROGEN	1210.	68.87
CARBON DIOXIDE	459.	26.11
CARBON MONOXIDE	86.	4.89
HYDROGEN	1.	0.07
SULFUR DIOXIDE	1.	0.06



CUPOLA CLASSIFICATION - 23

HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	85775.	89.46
SENSIBLE HEAT OF THE BLAST	8173.	8.52
HEAT FROM OXIDATION OF MN, FE, SI	1937.	2.02
TOTAL INPUT HEAT	95886.	100.00

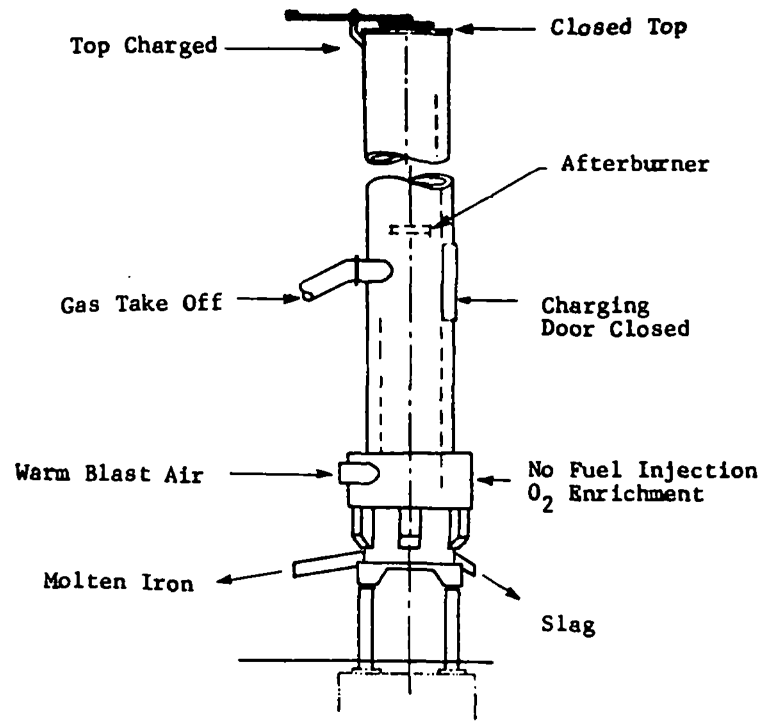
OUTPUT HEAT		
HEATING AND MELTING OF IRON	43043.	44.89
HEAT CONTENT OF THE SLAG	1450.	1.51
CALCINING OF LIMESTONE	1219.	1.27
DECOMPOSITION OF WATER	1091.	1.14
TOP GASES		
-SENSIBLE HEAT	11927.	12.44
-LATENT HEAT	23741.	24.76
HEAT RADIATION FROM THE CUPOLA	13415.	13.99

VOLUME OF TOP GAS (MCF)
ACTUAL 1852.
STANDARD 735.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	2009.	55.42
PIG IRON	502.	13.86
RETURNS	301.	8.31
STEEL SCRAP	301.	8.31
IRON SCRAP	904.	24.94
FERROALLOYS	0.	0.00
COKE	182.	5.02
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	44.	1.22
AIR	1335.	36.82
OXYGEN	40.	1.11
CUPOLA LINING	15.	0.42
TOTAL INPUT MTLS	3625.	100.00

OUTPUTS		
MOLTEN IRON	2000.	55.17
SLAG	56.	1.56
EMISSIONS DUST	12.	0.34
TOP GASES	1556.	42.92
NITROGEN	1019.	65.49
CARBON DIOXIDE	391.	25.14
CARBON MONOXIDE	144.	9.24
HYDROGEN	1.	0.07
SULFUR DIOXIDE	1.	0.06



CUPOLA CLASSIFICATION - 24

HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	54422.	89.26
SENSIBLE HEAT OF THE BLAST	5225.	8.57
HEAT FROM OXIDATION OF MN, FE, SI	1323.	2.17
TOTAL INPUT HEAT	60970.	100.00

OUTPUT HEAT		
HEATING AND MELTING OF IRON	28057.	46.02
HEAT CONTENT OF THE SLAG	797.	1.31
CALCINING OF LIMESTONE	1130.	1.85
DECOMPOSITION OF WATER	1349.	2.21
TOP GASES		
-SENSIBLE HEAT	13526.	22.19
-LATENT HEAT	-29511.	-48.40
HEAT RADIATION FROM THE CUPOLA	45622.	74.83

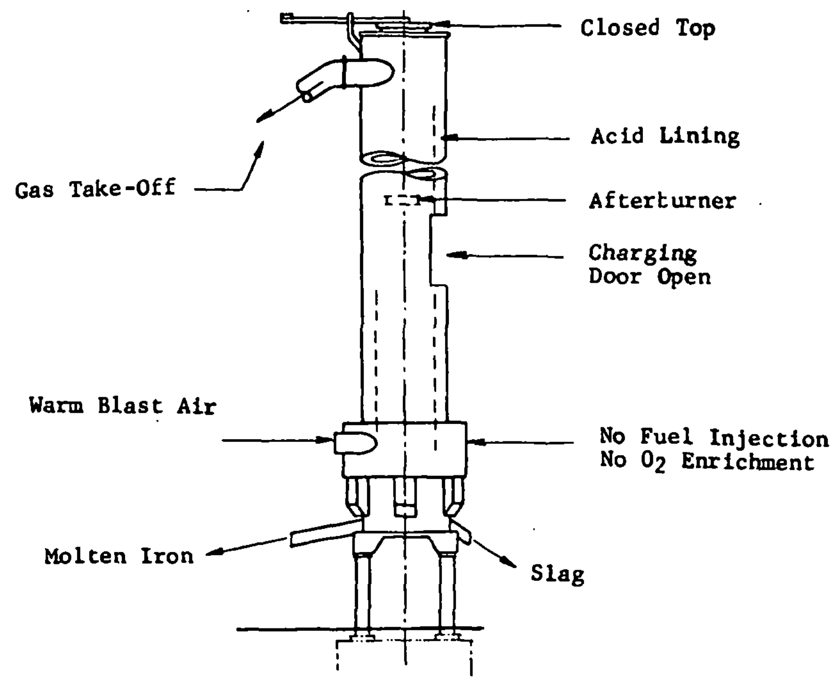
VOLUME OF TOP GAS (MCF)

ACTUAL	2000.
STANDARD	794.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	2009.	42.04
PIG IRON	574.	12.01
RETURNS	954.	19.97
STEEL SCRAP	287.	6.01
IRON SCRAP	134.	2.80
FERROALLOYS	60.	1.25
COKE	182.	3.80
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	62.	1.30
AIR	2506.	52.48
OXYGEN	0.	0.00
CUPOLA LINING	18.	0.37
TOTAL INPUT MTLS	4779.	100.00

OUTPUTS		
MOLTEN IRON	2000.	41.85
SLAG	58.	1.22
EMISSIONS DUST	21.	0.45
TOP GASES	2699.	56.48
NITROGEN	1915.	70.95
CARBON DIOXIDE	1054.	39.04
CARBON MONOXIDE	-272.	-10.06
HYDROGEN	2.	0.08
SULFUR DIOXIDE	0.	0.00



CUPOLA CLASSIFICATION - 25

HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	48492.	91.27
SENSIBLE HEAT OF THE BLAST	3539.	6.66
HEAT FROM OXIDATION OF MN, FE, SI	1102.	2.07
TOTAL INPUT HEAT	53133.	100.00

OUTPUT HEAT	B.T.U.S (000/HR.)	PERCENT
HEATING AND MELTING OF IRON	24690.	46.47
HEAT CONTENT OF THE SLAG	949.	1.79
CALCINING OF LIMESTONE	898.	1.69
DECOMPOSITION OF WATER	1071.	2.02
TOP GASES		
-SENSIBLE HEAT	10842.	20.41
-LATENT HEAT	-16022.	-30.15
HEAT RADIATION FROM THE CUPOLA	30705.	57.79

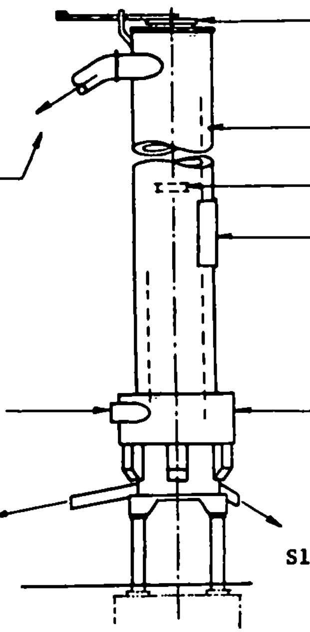
VOLUME OF TOP GAS (MCF)

ACTUAL	1618.
STANDARD	642.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	2001.	44.08
PIG IRON	429.	9.44
RETURNS	698.	15.37
STEEL SCRAP	498.	10.98
IRON SCRAP	343.	7.55
FERROALLOYS	34.	0.75
COKE	190.	4.20
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	56.	1.23
AIR	2263.	49.85
OXYGEN	0.	0.00
CUPOLA LINING	29.	0.64
TOTAL INPUT MTLS	4540.	100.00

OUTPUTS	POUNDS	PERCENT
MOLTEN IRON	2000.	44.05
SLAG	65.	1.43
EMISSIONS DUST	23.	0.50
TOP GASES	2453.	54.02
NITROGEN	1728.	70.46
CARBON DIOXIDE	890.	36.28
CARBON MONOXIDE	-168.	-6.83
HYDROGEN	2.	0.08
SULFUR DIOXIDE	1.	0.03



CUPOLA CLASSIFICATION - 26

HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	97700.	80.01
SENSIBLE HEAT OF THE BLAST	22327.	18.28
HEAT FROM OXIDATION OF MN, FE, SI	2085.	1.71
TOTAL INPUT HEAT	122112.	100.00

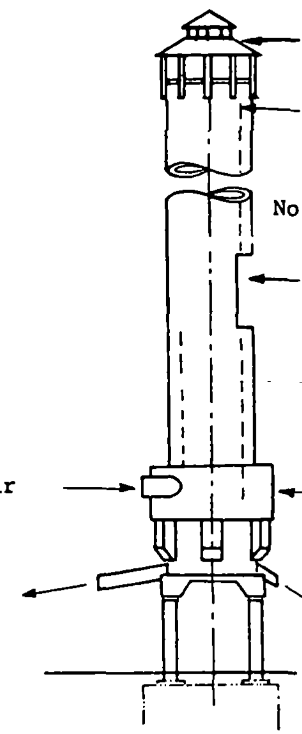
OUTPUT HEAT		
HEATING AND MELTING OF IRON	51441.	42.13
HEAT CONTENT OF THE SLAG	1122.	0.92
CALCINING OF LIMESTONE	1837.	1.50
DECOMPOSITION OF WATER	1884.	1.54
TOP GASES		
-SENSIBLE HEAT	19276.	15.79
-LATENT HEAT	-10714.	-8.77
HEAT RADIATION FROM THE CUPOLA	57267.	46.90

VOLUME OF TOP GAS (MCF)
ACTUAL 2917.
STANDARD 1158.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	2012.	47.94
PIG IRON	287.	6.83
RETURNS	292.	6.97
STEEL SCRAP	143.	3.41
IRON SCRAP	1290.	30.73
FERROALLOYS	0.	0.00
COKE	174.	4.14
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	56.	1.34
AIR	1947.	46.38
OXYGEN	0.	0.00
CUPOLA LINING	8.	0.19
TOTAL INPUT MTLS	4196.	100.00

OUTPUTS		
MOLTEN IRON	2000.	47.66
SLAG	49.	1.17
EMISSIONS DUST	16.	0.37
TOP GASES	2132.	50.80
NITROGEN	1486.	69.72
CARBON DIOXIDE	698.	32.75
CARBON MONOXIDE	-55.	-2.57
HYDROGEN	2.	0.08
SULFUR DIOXIDE	0.	0.02



CUPOLA CLASSIFICATION - 27

HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
PØTENTIAL HEAT ØF FUEL	52620.	82.89
SENSIBLE HEAT ØF THE BLAST	9878.	15.56
HEAT FRØM ØXIDATIØN ØF MN, FE, SI	961.	1.54
TØTAL INPUT HEAT	63478.	100.00

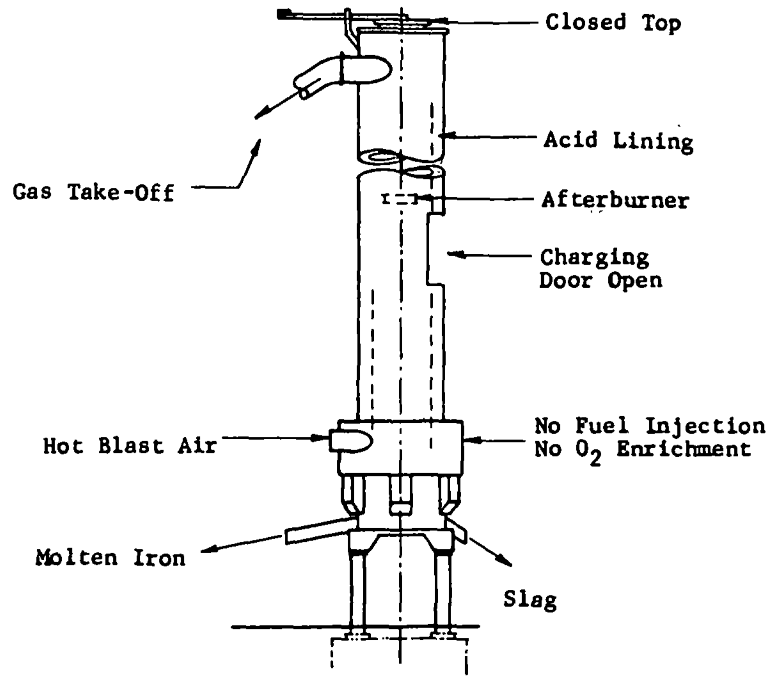
ØUTPUT HEAT	B.T.U.S (000/HR.)	PERCENT
HEATING AND MELTING ØF IRØN	23029.	36.28
HEAT CONTENT ØF THE SLAG	789.	1.24
CALCINING ØF LIMESTØNE	583.	0.92
DECØMPØSITIØN ØF WATER	922.	1.45
TØP GASES		
-SENSIBLE HEAT	9487.	14.95
-LATENT HEAT	1458.	2.30
HEAT RADIATIØN FRØM THE CUPØLA	27209.	42.86

VØLUME ØF TØP GAS (MCF)
ACTUAL 1450.
STANDARD 576.

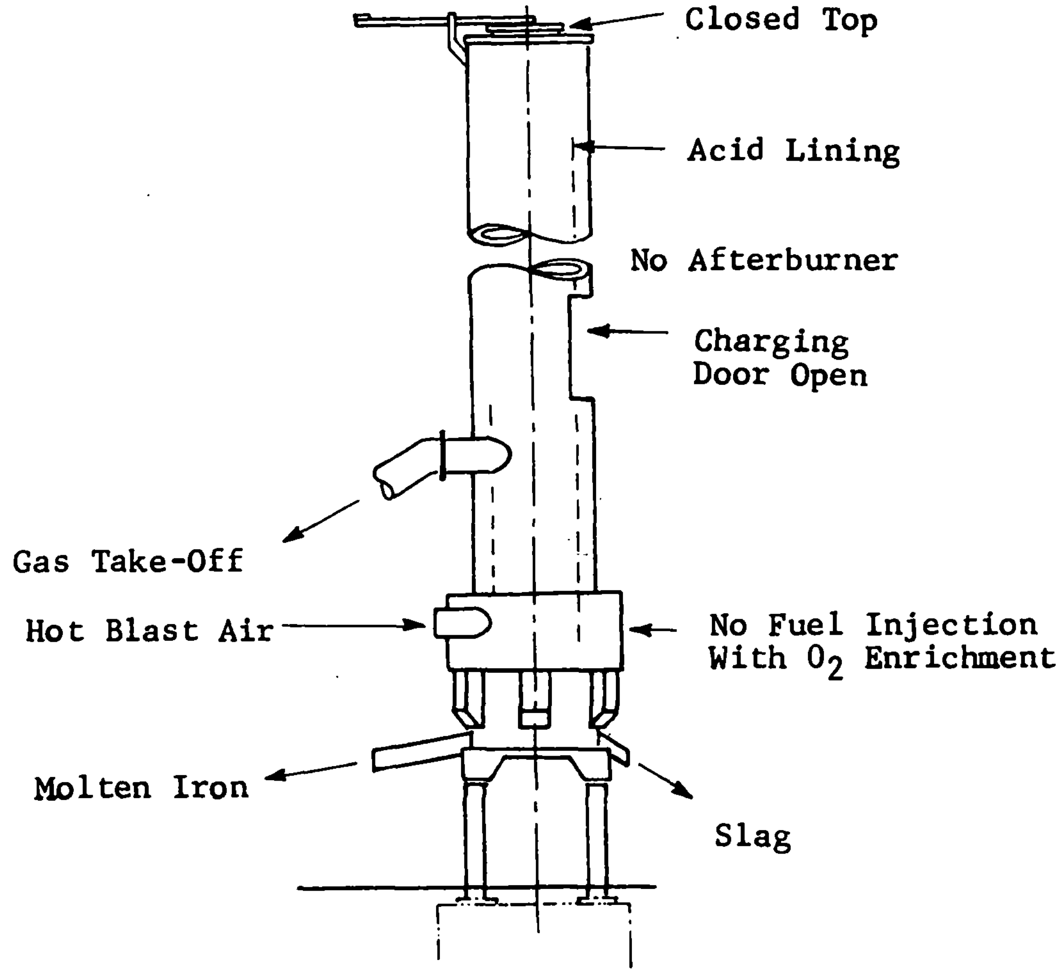
MATERIAL BALANCE

INPUTS	PØUNDS	PERCENT
METAL CHARGE	2001.	45.19
PIG IRØN	400.	9.04
RETURNS	867.	19.58
STEEL SCRAP	534.	12.05
IRØN SCRAP	200.	4.52
FERRØALLØYS	0.	0.00
CØKE	222.	5.02
NATURAL GAS	0.	0.00
FUEL ØIL	0.	0.00
FLUX AND ADDITIVES	40.	0.90
AIR	2144.	48.42
ØXYGEN	0.	0.00
CUPØLA LINING	21.	0.47
TØTAL INPUT MTLS	4428.	100.00

ØUTPUTS	PØUNDS	PERCENT
MØLTEN IRØN	2000.	45.17
SLAG	53.	1.19
EMISSIØNS DUST	20.	0.45
TØP GASES	2355.	53.19
NITRØGEN	1637.	69.50
CARBØN DIØXIDE	699.	29.67
CARBØN MØNØXIDE	17.	0.71
HYDRØGEN	2.	0.07
SULFUR DIØXIDE	1.	0.04



Insufficient Data for
Heat and Material
Balance Calculations



CUPOLA CLASSIFICATION - 29

HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	23751.	92.57
SENSIBLE HEAT OF THE BLAST	37.	0.15
HEAT FROM OXIDATION OF MN, FE, SI	1870.	7.29
TOTAL INPUT HEAT	25658.	100.00

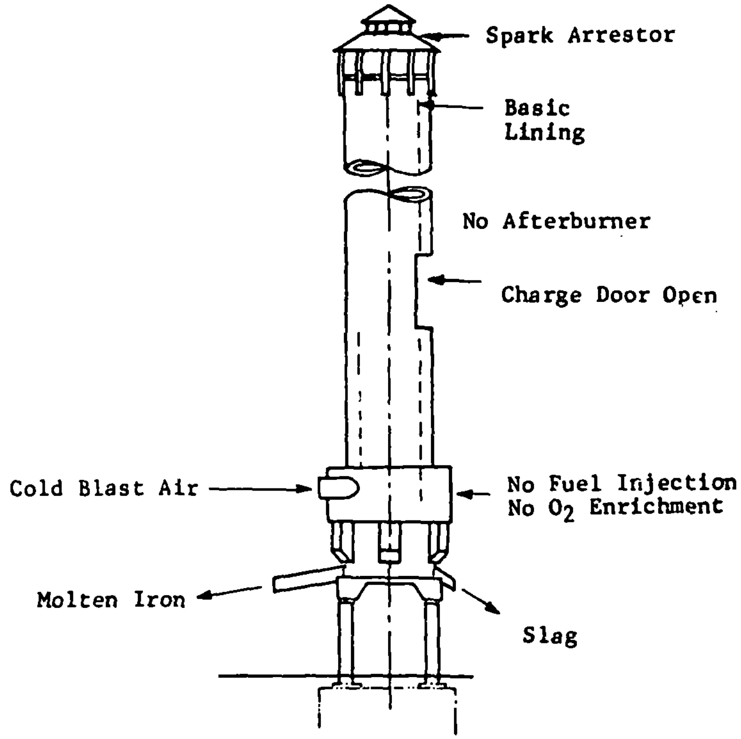
OUTPUT HEAT		
HEATING AND MELTING OF IRON	8323.	32.44
HEAT CONTENT OF THE SLAG	588.	2.29
CALCINING OF LIMESTONE	547.	2.13
DECOMPOSITION OF WATER	327.	1.28
TOP GASES		
-SENSIBLE HEAT	3468.	13.52
-LATENT HEAT	8626.	33.62
HEAT RADIATION FROM THE CUPOLA	3779.	14.73

VOLUME OF TOP GAS (MCF)
ACTUAL 547.
STANDARD 217.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	2030.	45.69
PIG IRON	256.	5.77
RETURNS	1506.	33.90
STEEL SCRAP	0.	0.00
IRON SCRAP	223.	5.02
FERROALLOYS	45.	1.00
COKE	247.	5.56
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	102.	2.29
AIR	2028.	45.66
OXYGEN	0.	0.00
CUPOLA LINING	36.	0.80
TOTAL INPUT MTLS	4443.	100.00

OUTPUTS		
MOLTEN IRON	2000.	45.02
SLAG	137.	3.09
EMISSIONS DUST	19.	0.42
TOP GASES	2286.	51.47
NITROGEN	1549.	67.74
CARBON DIOXIDE	470.	20.55
CARBON MONOXIDE	265.	11.57
HYDROGEN	2.	0.07
SULFUR DIOXIDE	1.	0.06



CUPOLA CLASSIFICATION - 30

HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	39465.	98.70
SENSIBLE HEAT OF THE BLAST	56.	0.14
HEAT FROM OXIDATION OF MN, FE, SI	462.	1.16
TOTAL INPUT HEAT	39984.	100.00

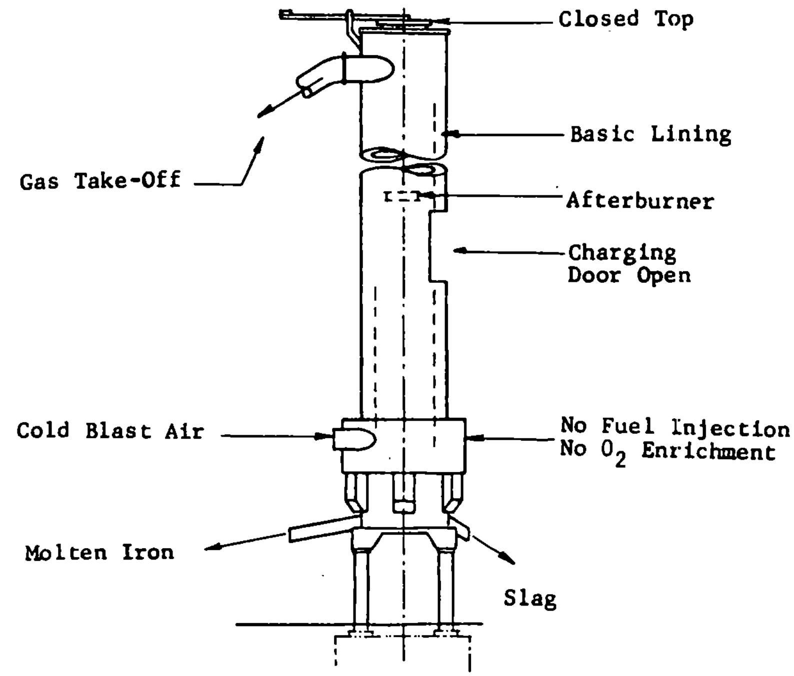
OUTPUT HEAT	B.T.U.S (000/HR.)	PERCENT
HEATING AND MELTING OF IRON	12686.	31.73
HEAT CONTENT OF THE SLAG	413.	1.03
CALCINING OF LIMESTONE	474.	1.18
DECOMPOSITION OF WATER	496.	1.24
TOP GASES		
-SENSIBLE HEAT	11694.	29.25
-LATENT HEAT	16365.	40.93
HEAT RADIATION FROM THE CUPOLA	-2144.	-5.36

VOLUME OF TOP GAS (MCF)
ACTUAL 1455.
STANDARD 335.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	2009.	45.30
PIG IRON	0.	0.00
RETURNS	753.	16.99
STEEL SCRAP	151.	3.40
IRON SCRAP	1105.	24.91
FERROALLOYS	0.	0.00
COKE	286.	6.44
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	58.	1.31
AIR	2058.	46.40
OXYGEN	0.	0.00
CUPOLA LINING	24.	0.55
TOTAL INPUT MTLS	4436.	100.00

OUTPUTS	POUNDS	PERCENT
MOLTEN IRON	2000.	45.09
SLAG	75.	1.69
EMISSIONS DUST	20.	0.46
TOP GASES	2340.	52.77
NITROGEN	1571.	67.14
CARBON DIOXIDE	430.	18.35
CARBON MONOXIDE	336.	14.37
HYDROGEN	2.	0.07
SULFUR DIOXIDE	2.	0.07



CUPOLA CLASSIFICATION - 31

HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
PØTENTIAL HEAT ØF FUEL	79902.	77.46
SENSIBLE HEAT ØF THE BLAST	21611.	20.95
HEAT FRØM ØXIDATIØN ØF MN, FE, SI	1634.	1.58
TØTAL INPUT HEAT	103147.	100.00

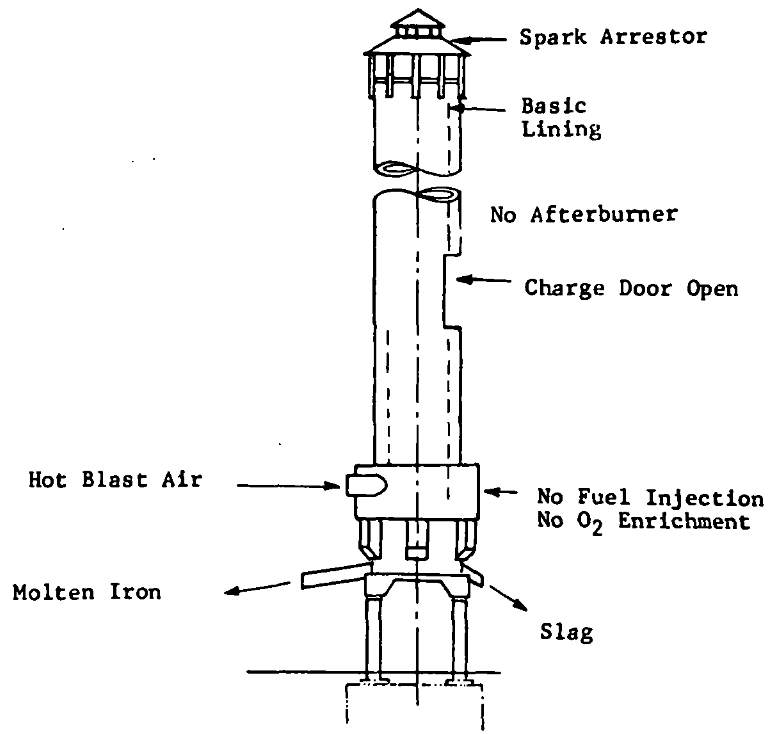
ØUTPUT HEAT	B.T.U.S (000/HR.)	PERCENT
HEATING AND MELTING ØF IRØN	40009.	38.79
HEAT CØNTENT ØF THE SLAG	617.	0.60
CALCINING ØF LIMESTØNE	2347.	2.28
DECØMPØSITIØN ØF WATER	1473.	1.43
TØP GASES		
-SENSIBLE HEAT	25238.	24.47
-LATENT HEAT	-93602.	-90.75
HEAT RADIATIØN FRØM THE CUPØLA	127064.	123.19

VØLUME ØF TØP GAS (MCF)
ACTUAL 3651.
STANDARD 1449.

MATERIAL BALANCE

INPUTS	PØUNDS	PERCENT
METAL CHARGE	1963.	34.38
PIG IRØN	255.	4.46
RETURNS	255.	4.46
STEEL SCRAP	1454.	25.47
IRØN SCRAP	0.	0.00
FERRØALLØYS	0.	0.00
CØKE	235.	4.12
NATURAL GAS	0.	0.00
FUEL ØIL	0.	0.00
FLUX AND ADDITIVES	90.	1.58
AIR	3414.	59.78
ØXYGEN	0.	0.00
CUPØLA LINING	8.	0.14
TØTAL INPUT MTLS	5711.	100.00

ØUTPUTS	PØUNDS	PERCENT
MØLTEN IRØN	2000.	35.02
SLAG	64.	1.12
EMISSIØNS DUST	25.	0.44
TØP GASES	3622.	63.42
NITRØGEN	2615.	72.20
CARBØN DIØXIDE	1625.	44.86
CARBØN MØNØXIDE	-615.	-16.99
HYDRØGEN	2.	0.04
SULFUR DIØXIDE	-4.	-0.12



CUPOLA CLASSIFICATION - 32

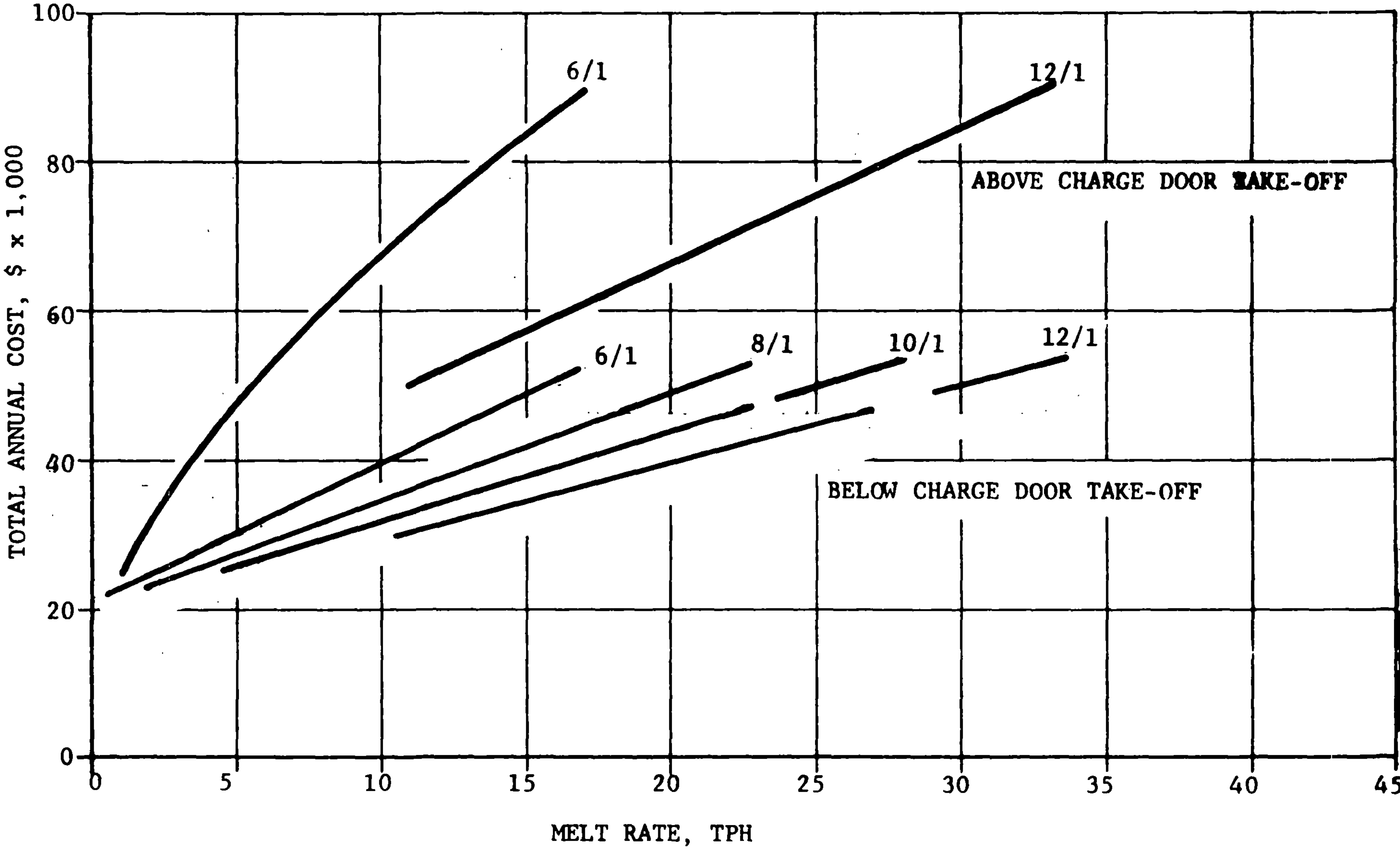
APPENDIX D

DETAIL ECONOMIC COST CURVES

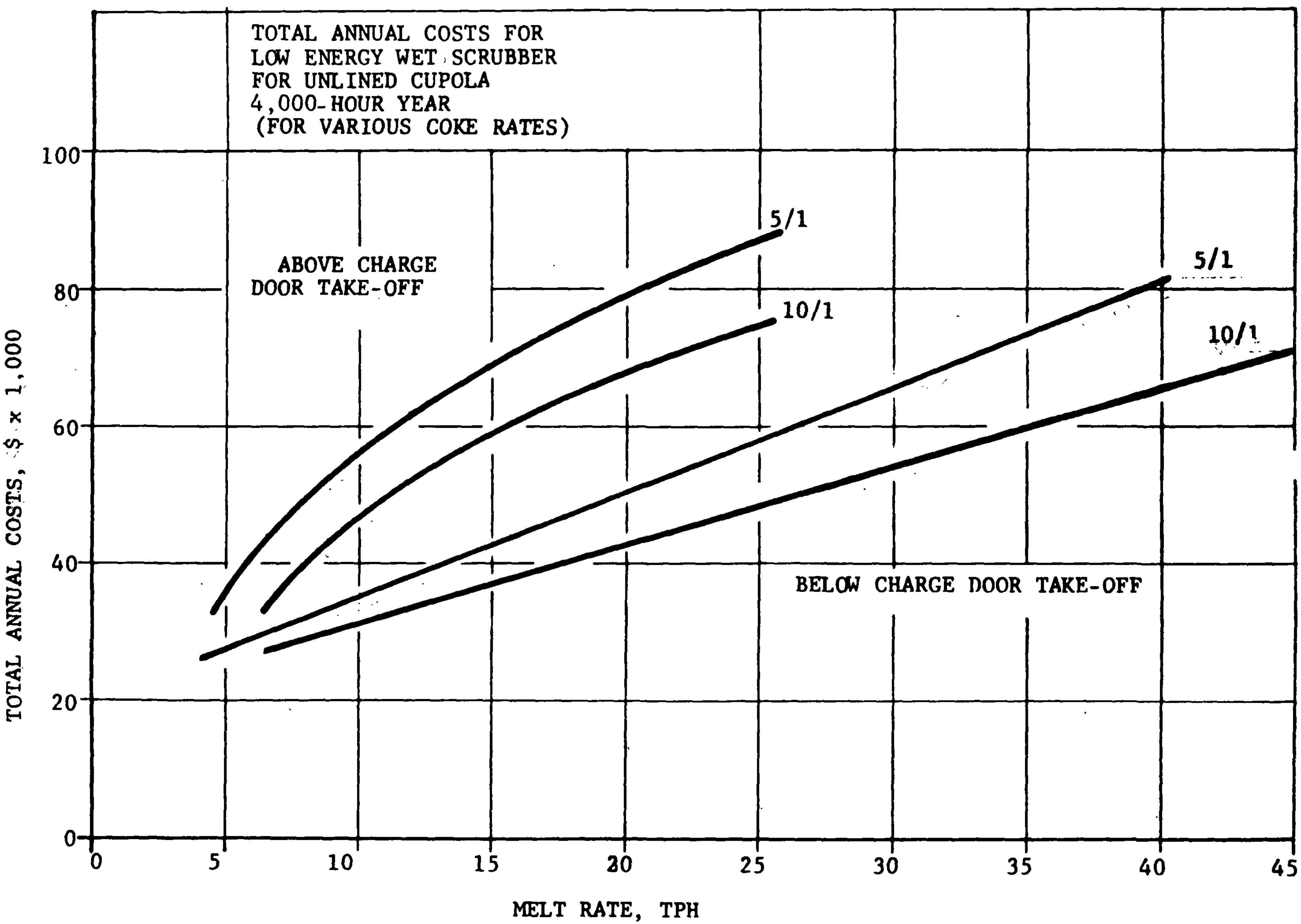
This appendix contains the detail curves used to determine the cost of pollution control equipment. Summaries of these curves appear as exhibits in Section VIII of the report.

Following the economic cost curves are the detail data for determining the melt shop costs for the model foundries.

TOTAL ANNUAL COSTS FOR
LOW ENERGY WET SCRUBBER
FOR LINED CUPOLA
4,000-HOUR YEAR
(FOR VARIOUS COKE RATES)

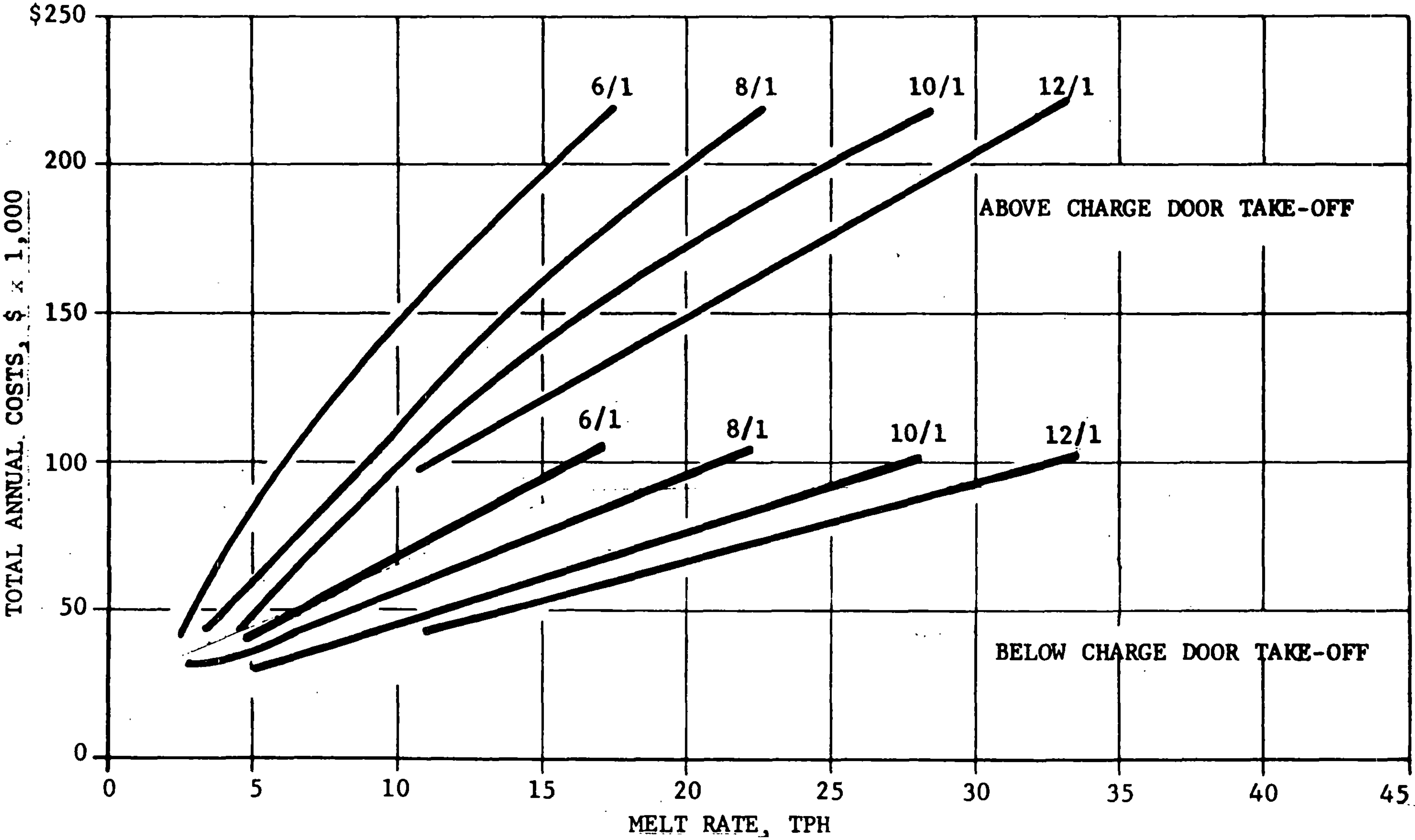


APPENDIX D
NUMBER 1

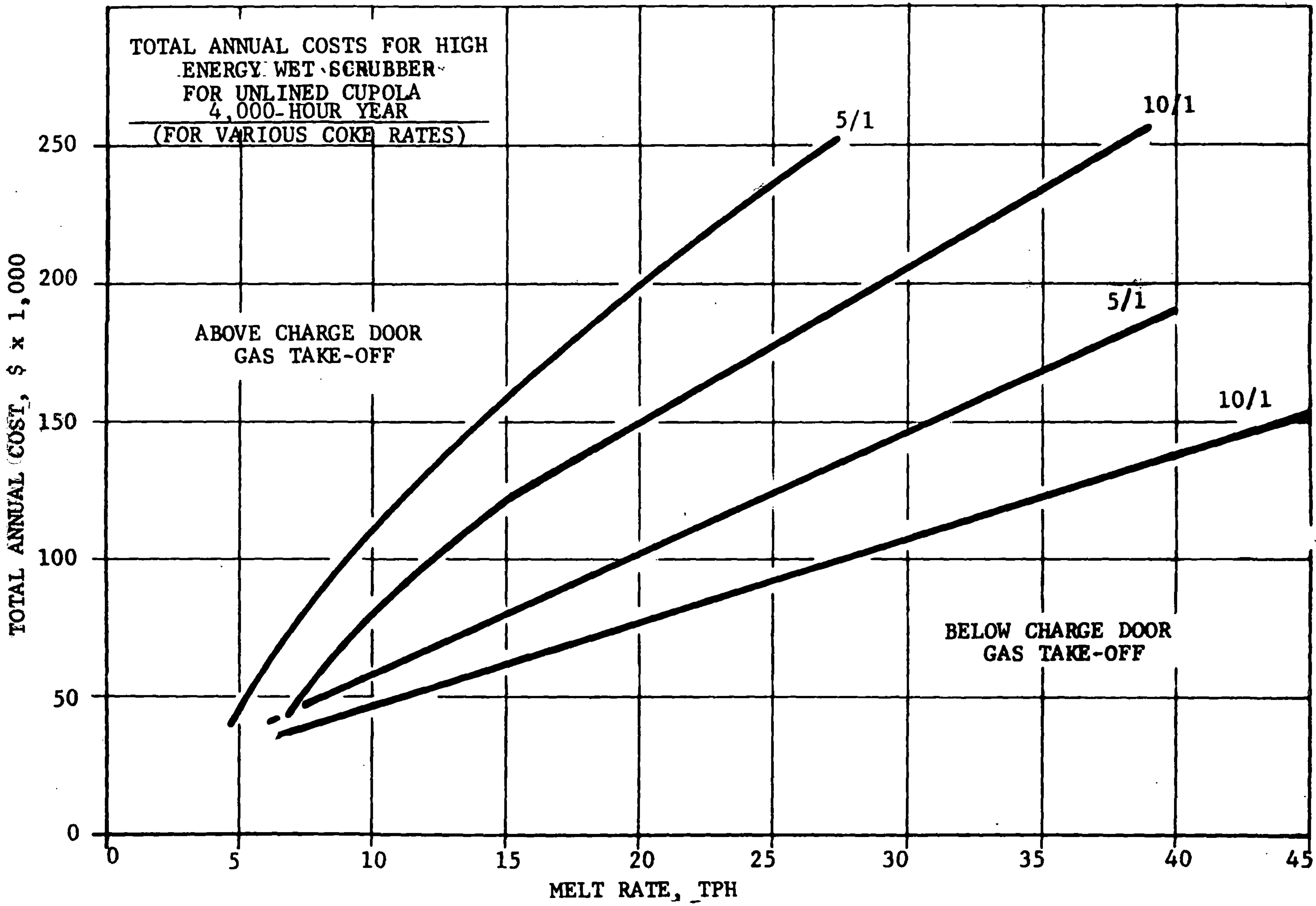


APPENDIX D
NUMBER 2

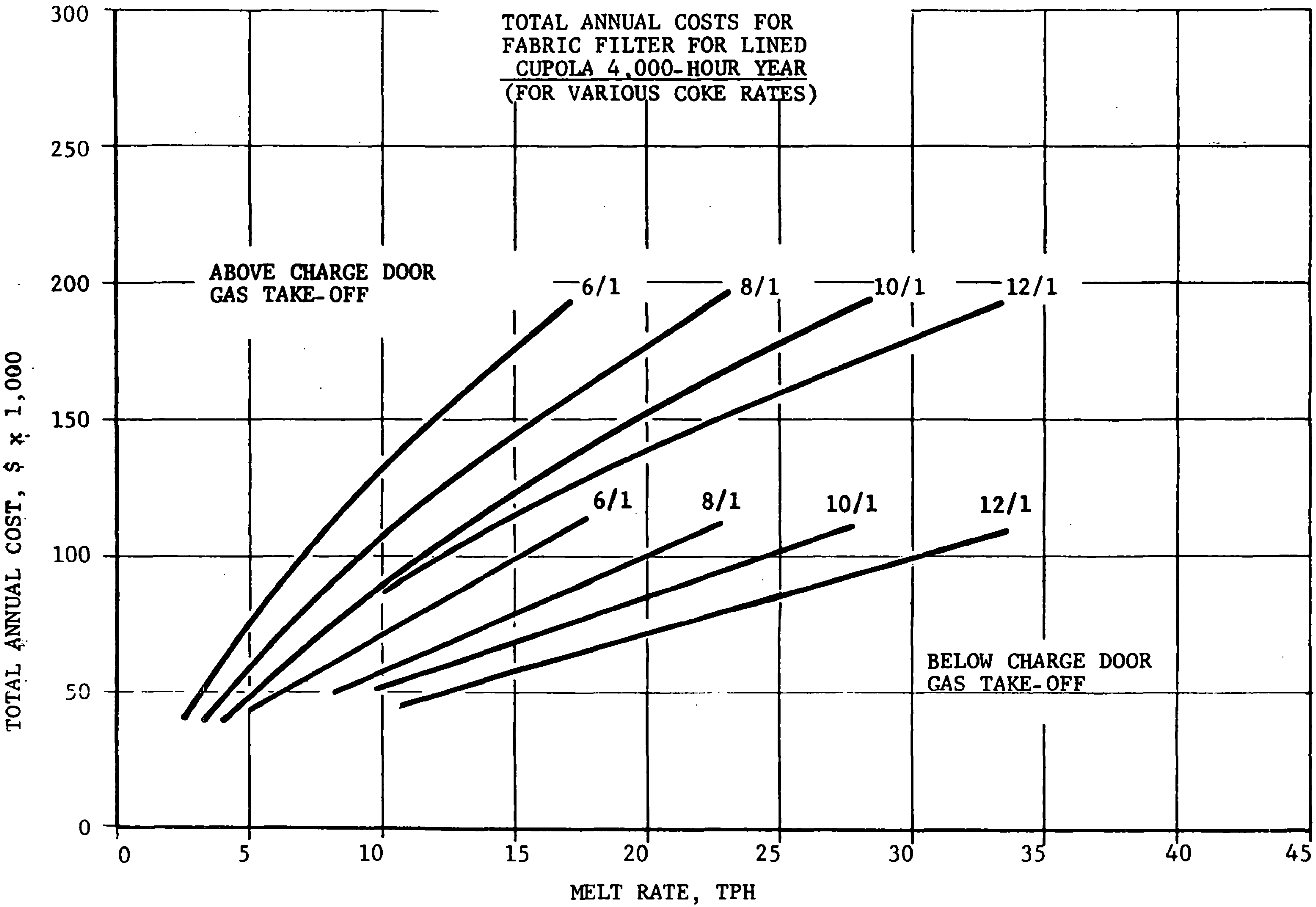
TOTAL ANNUAL COSTS FOR HIGH ENERGY
WET SCRUBBER FOR LINED CUPOLA
4,000-HOUR YEAR
(FOR VARIOUS COKE RATES)



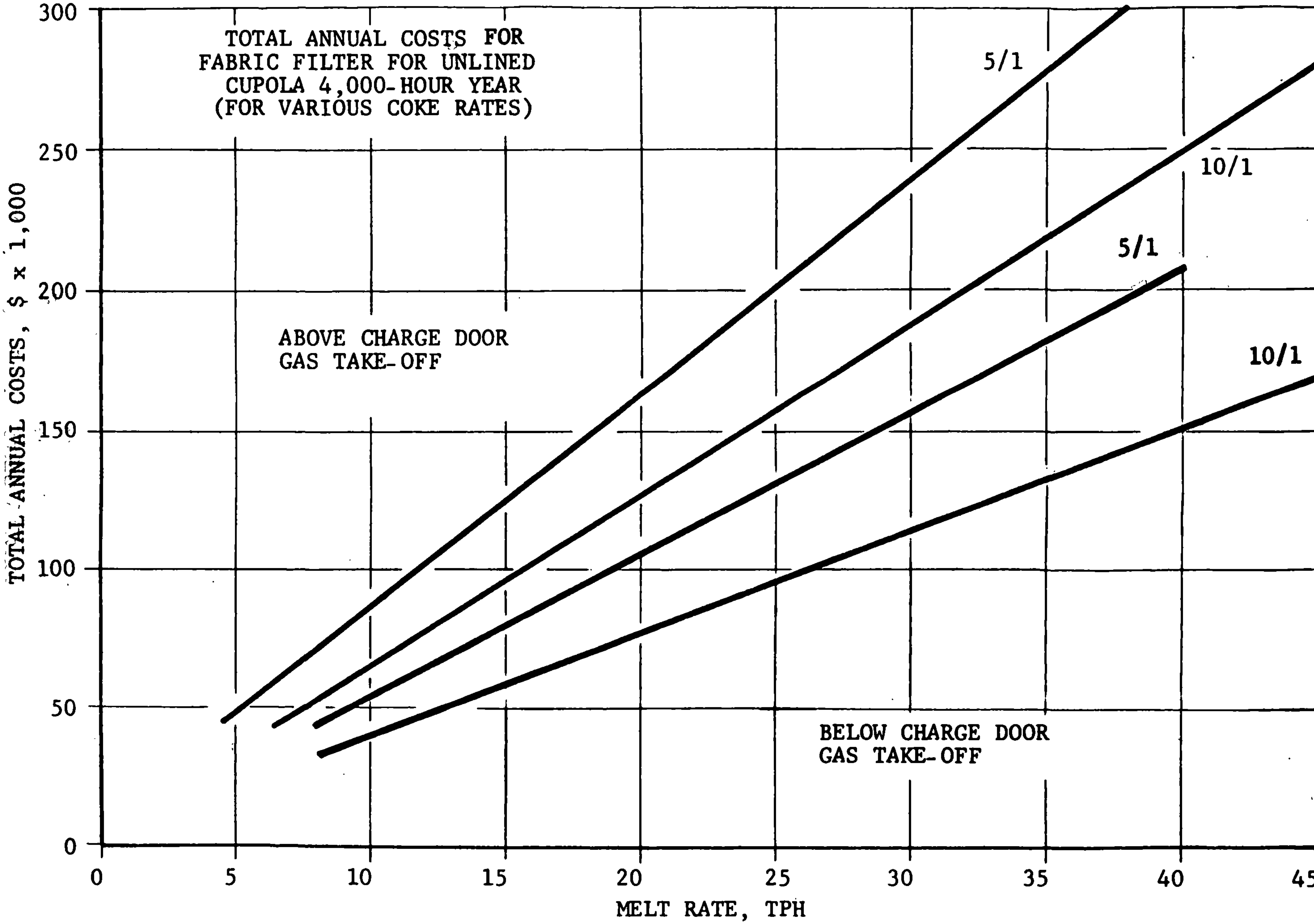
APPENDIX D
NUMBER 3



APPENDIX D
NUMBER 4

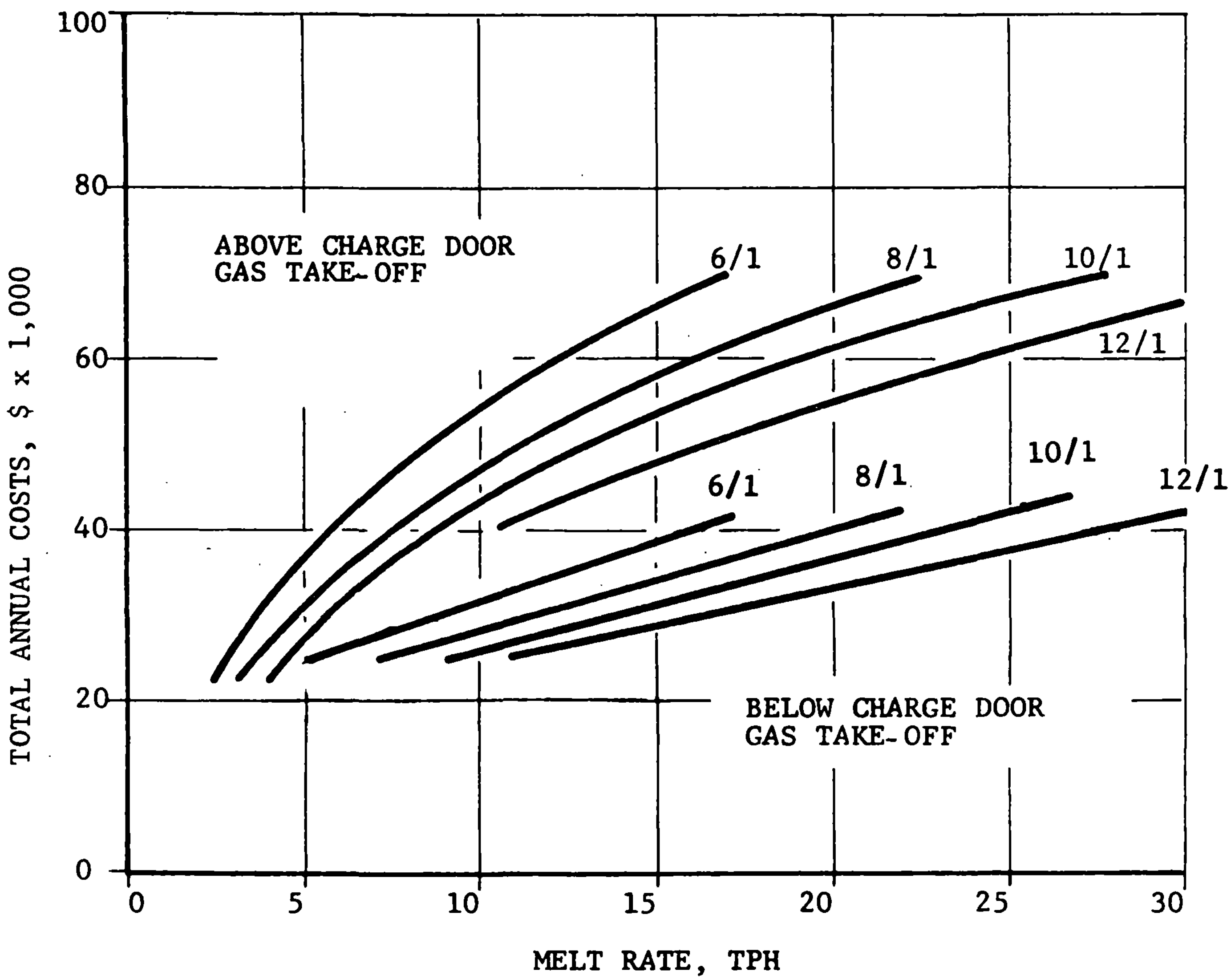


APPENDIX D
NUMBER 5

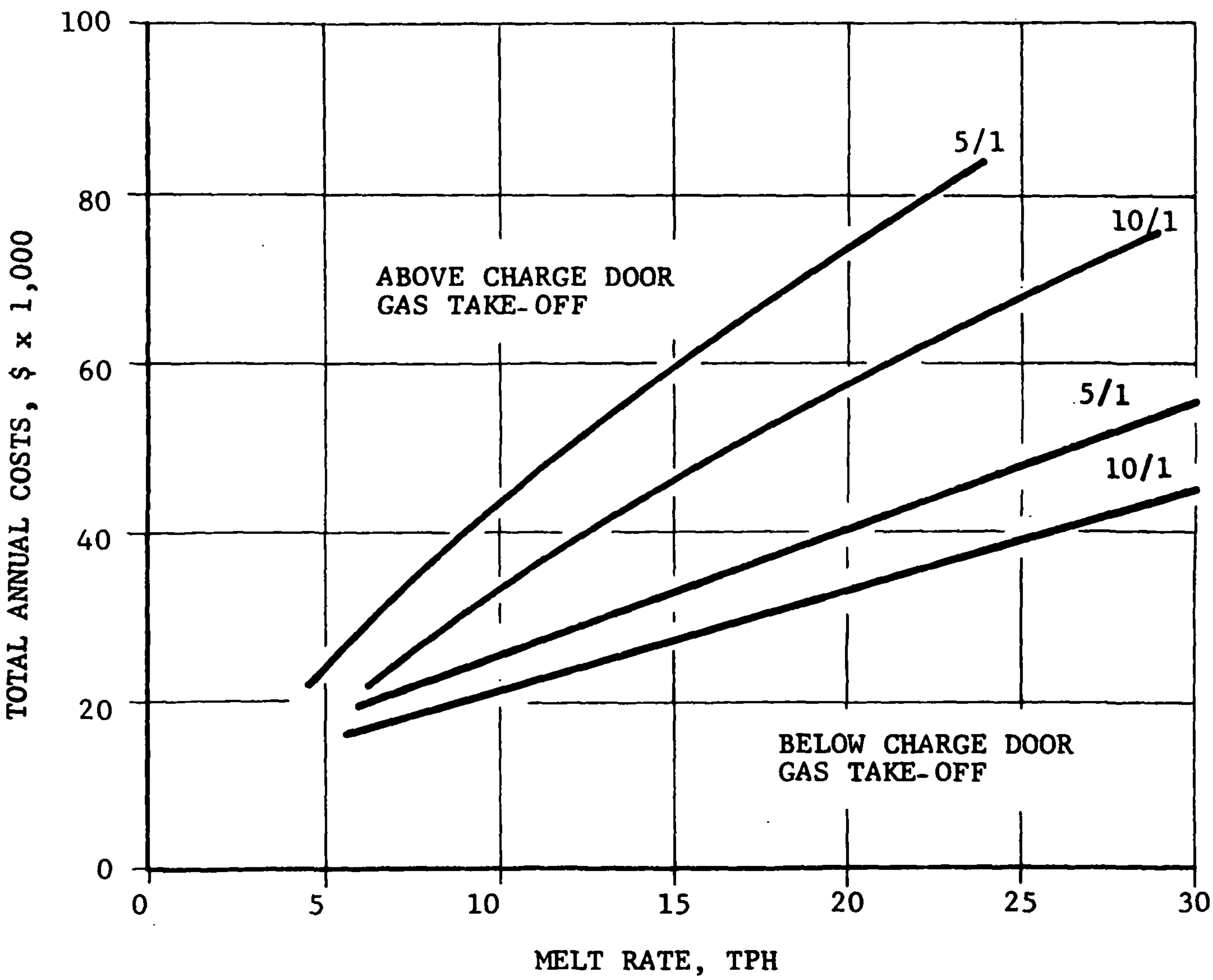


APPENDIX D
NUMBER 6

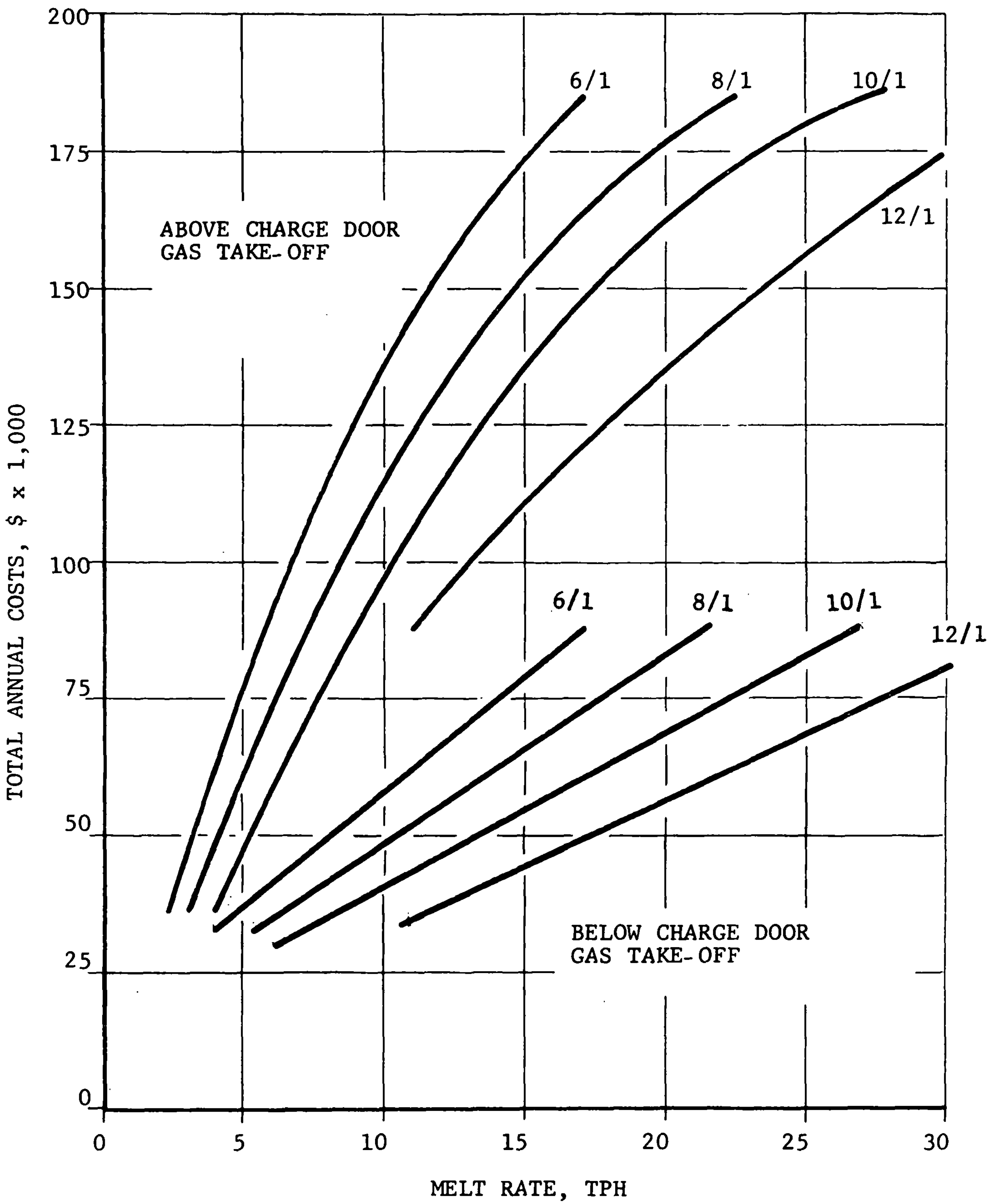
TOTAL ANNUAL COSTS FOR
LOW ENERGY WET SCRUBBER
ON LINED CUPOLA 2,000-HOUR YEAR
(FOR VARIOUS COKE RATES)



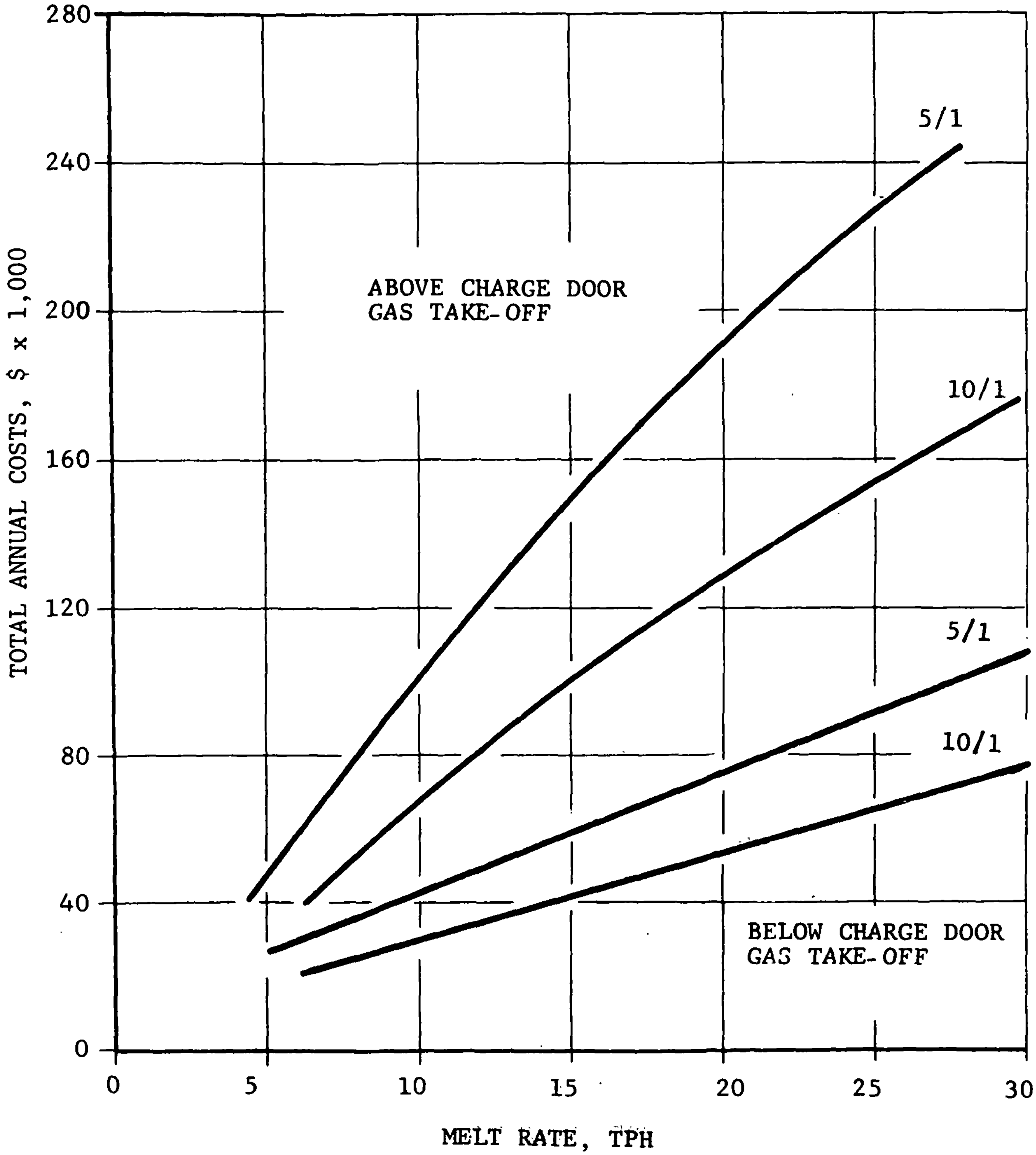
TOTAL ANNUAL COSTS FOR
LOW ENERGY WET SCRUBBER
ON UNLINED CUPOLA
2,000-HOUR YEAR
(FOR VARIOUS COKE RATES)

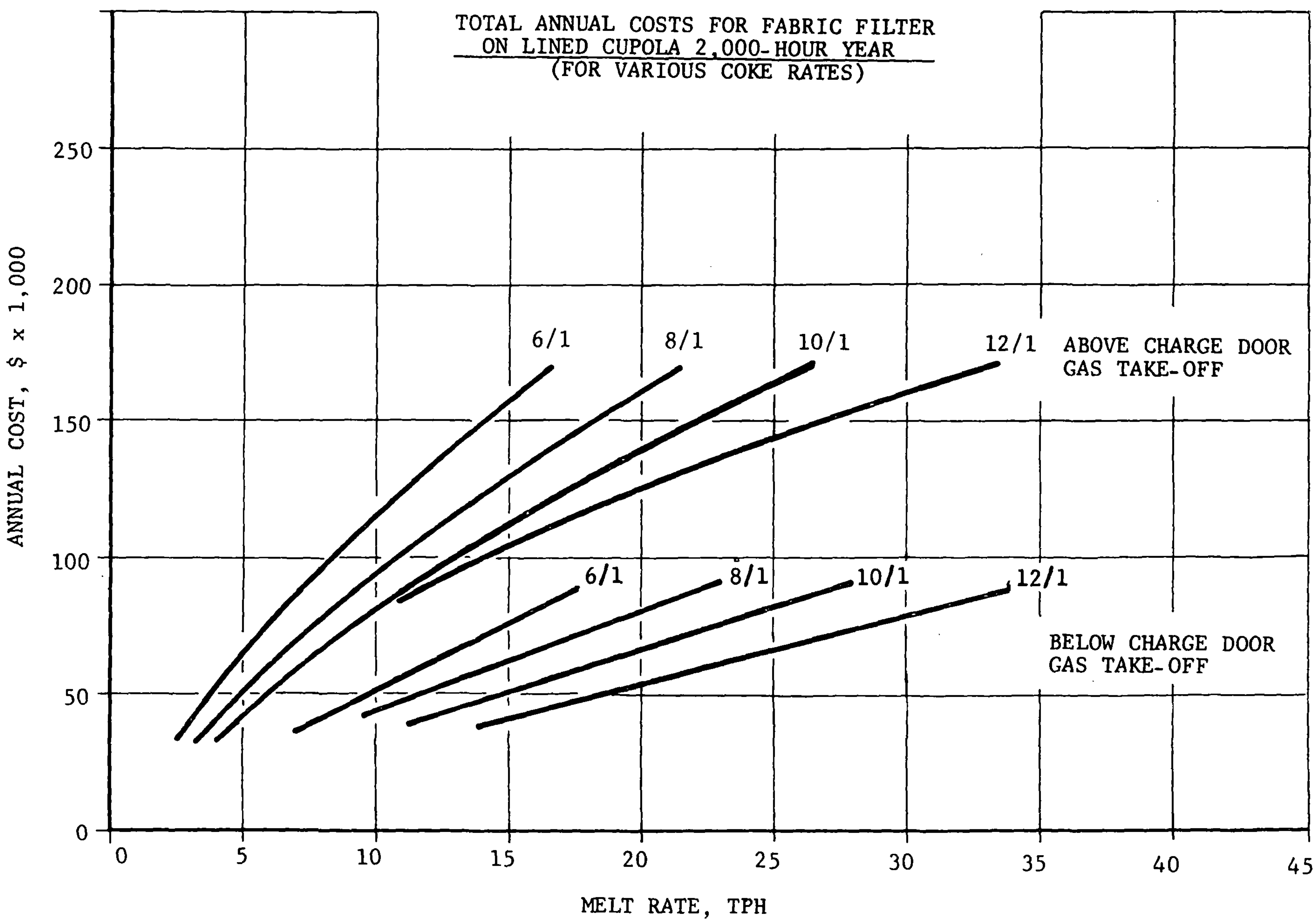


TOTAL ANNUAL COSTS FOR HIGH ENERGY WET SCRUBBER ON LINED CUPOLA 2,000-HOUR YEAR (FOR VARIOUS COKE RATES)

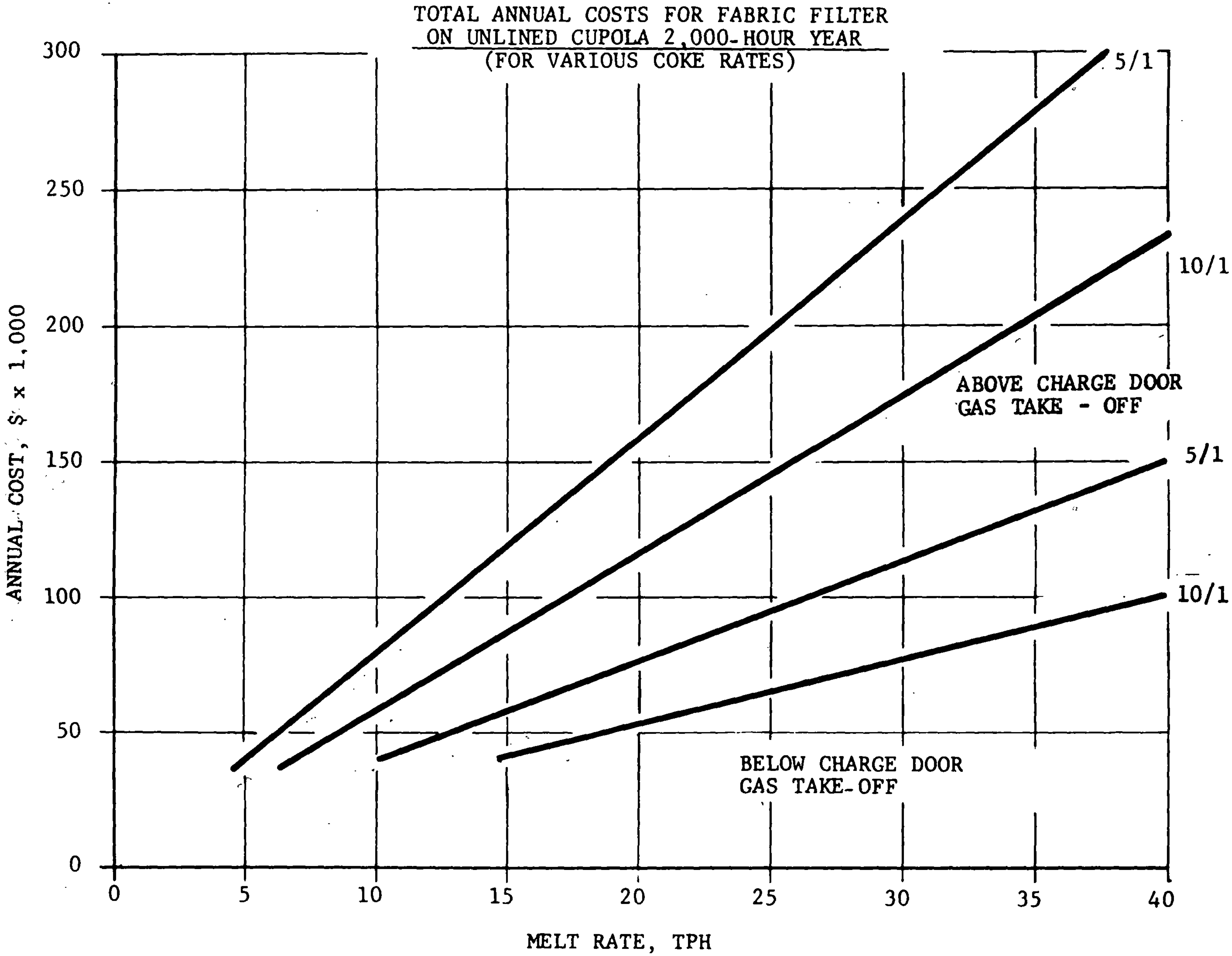


TOTAL ANNUAL COSTS FOR
HIGH ENERGY WET SCRUBBER
ON UNLINED CUPOLA
2,000-HOUR YEAR
(FOR VARIOUS COKE RATES)



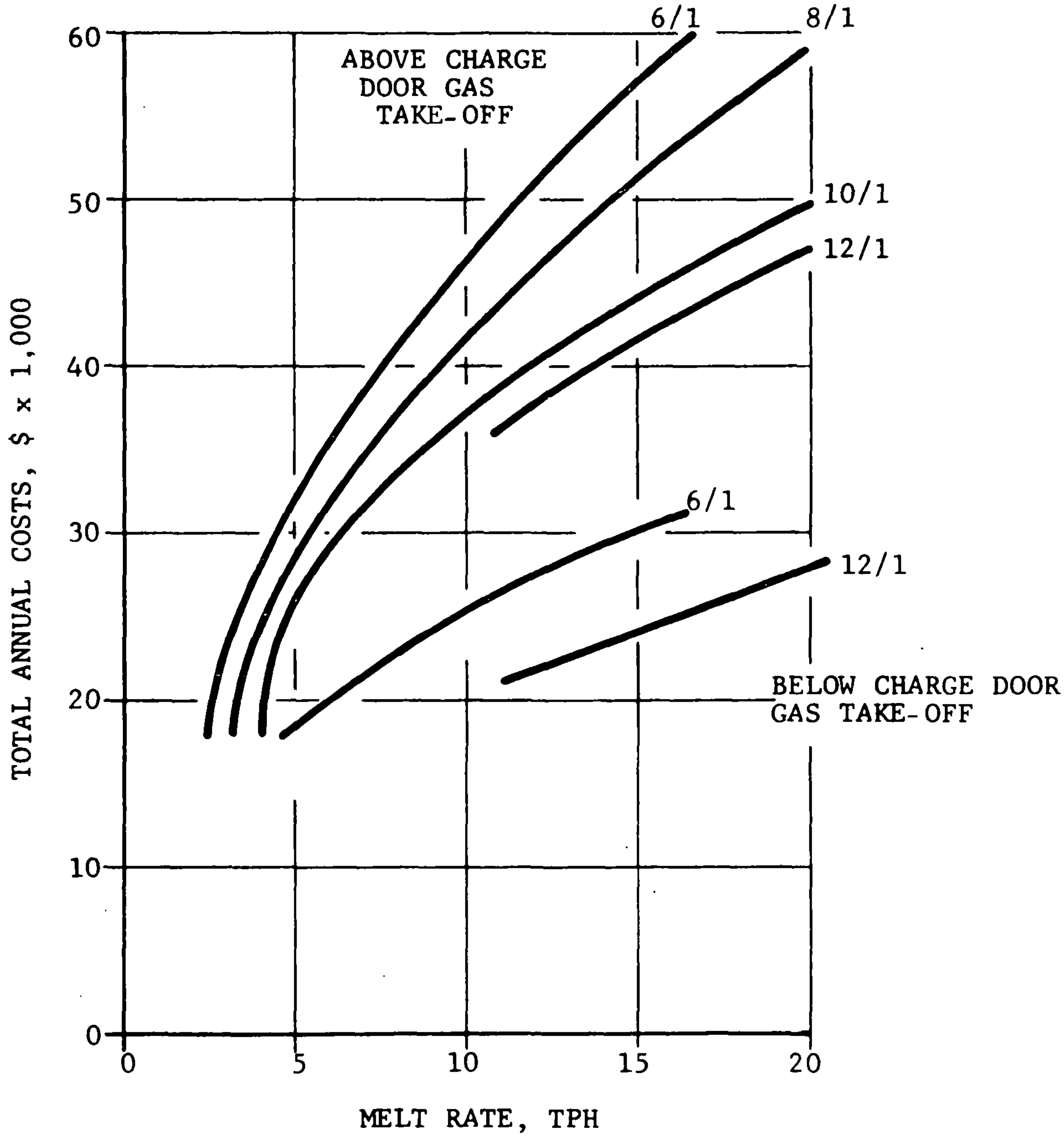


APPENDIX D
NUMBER 11

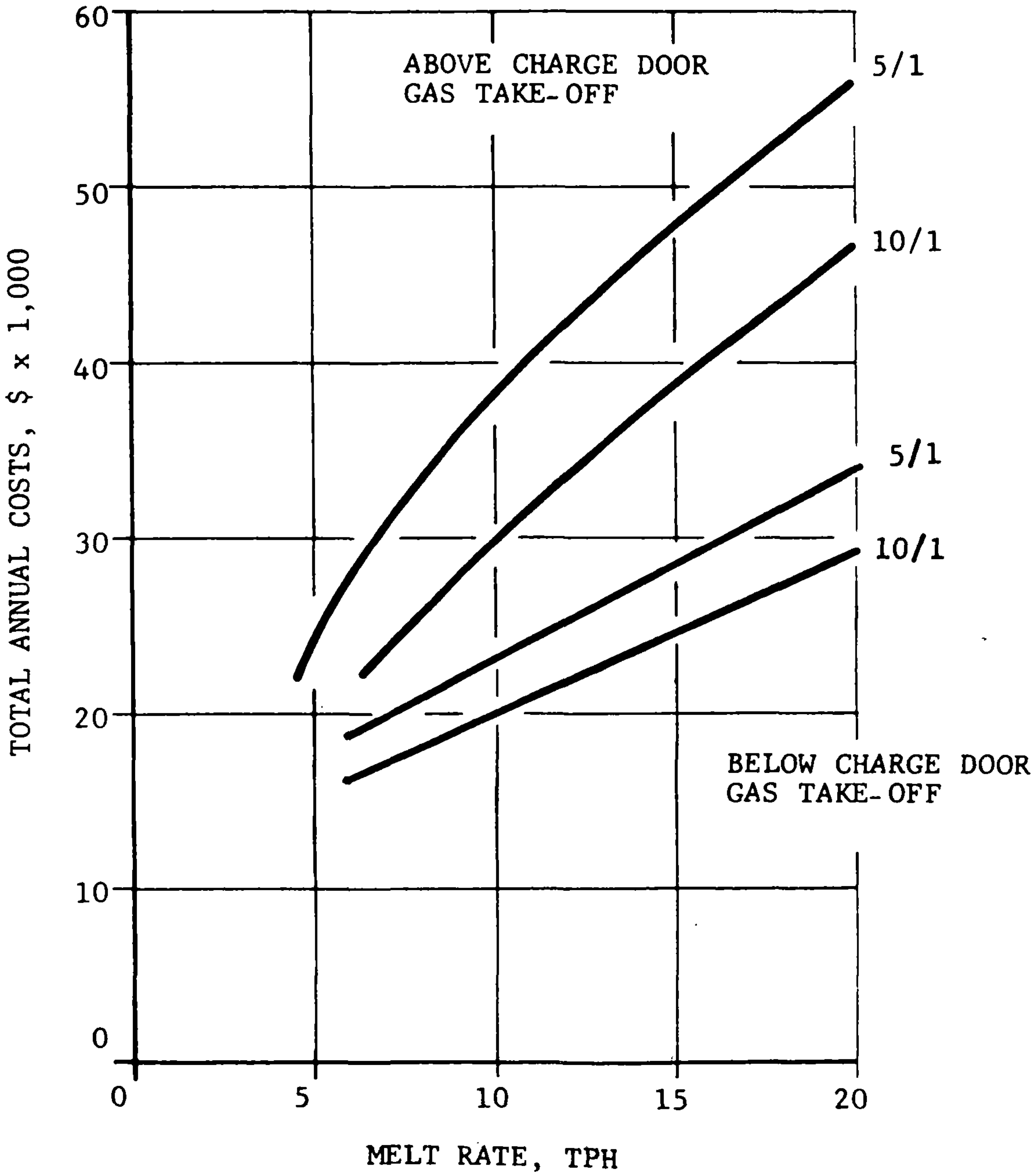


APPENDIX D
NUMBER 12

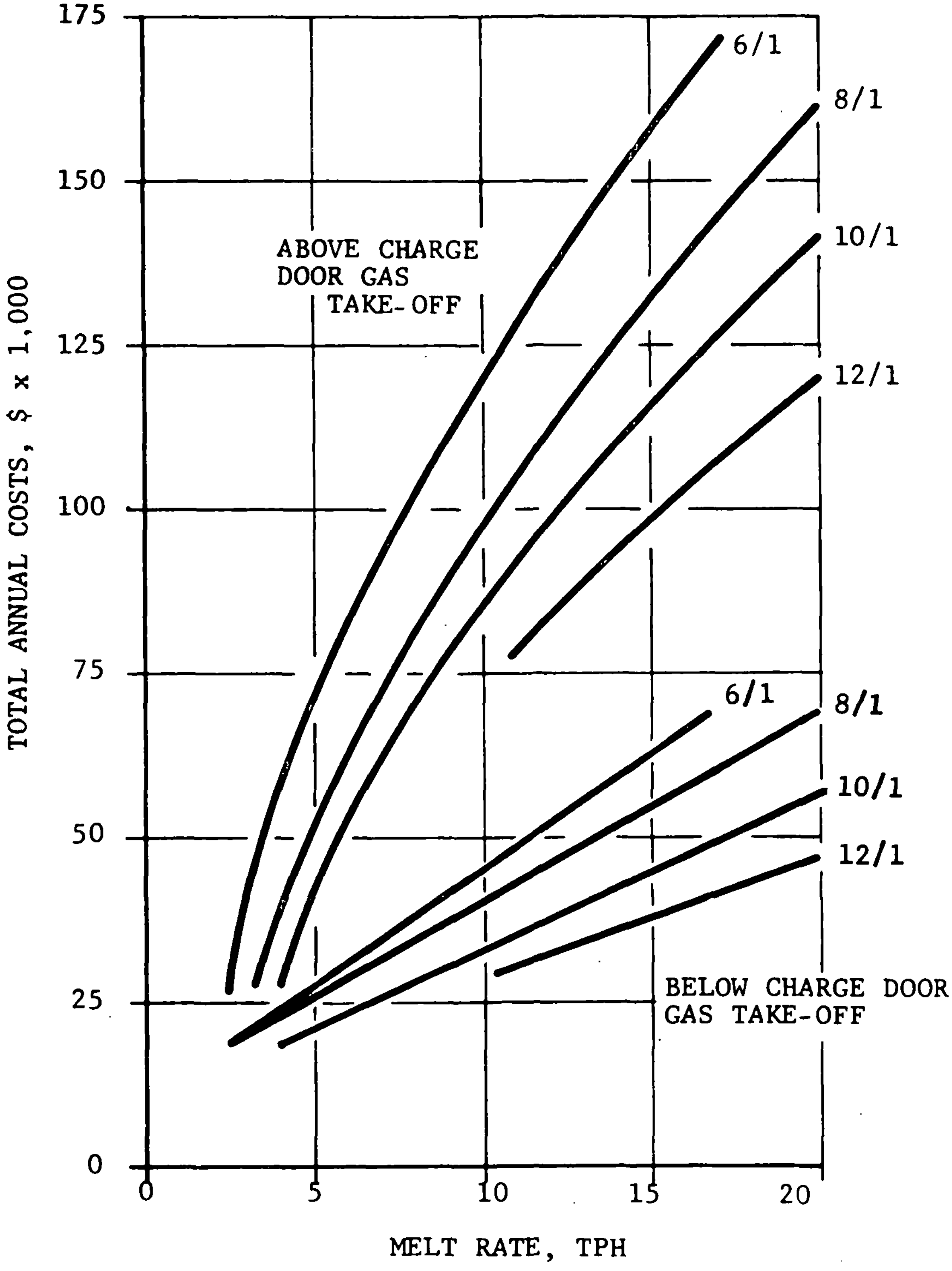
TOTAL ANNUAL COSTS FOR
LOW ENERGY WET SCRUBBER
ON LINED CUPOLA
1,000-HOUR YEAR
(FOR VARIOUS COKE RATES)



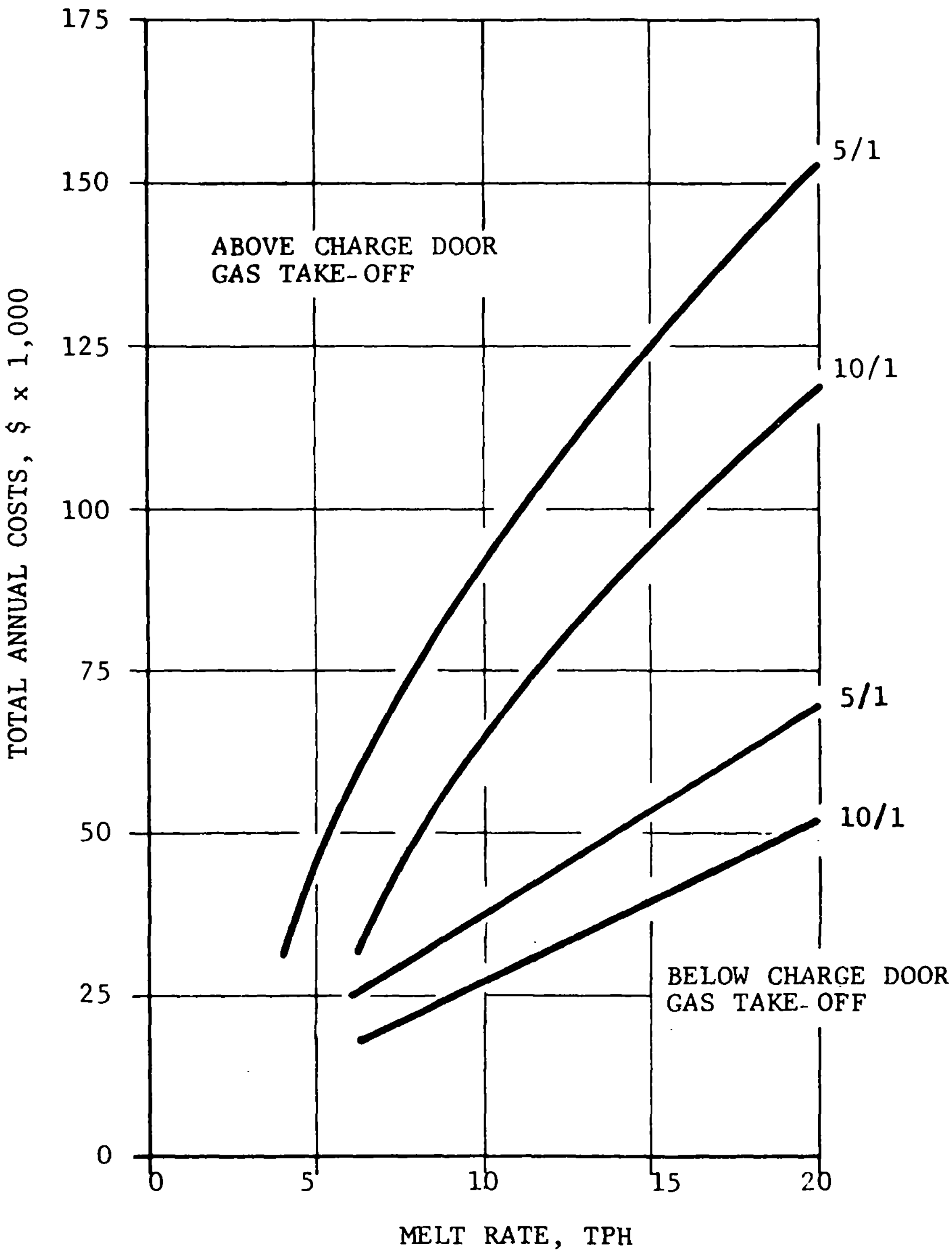
TOTAL ANNUAL COSTS FOR
LOW ENERGY WET SCRUBBER
ON UNLINED CUPOLA
1,000-HOUR YEAR
(FOR VARIOUS COKE RATES)



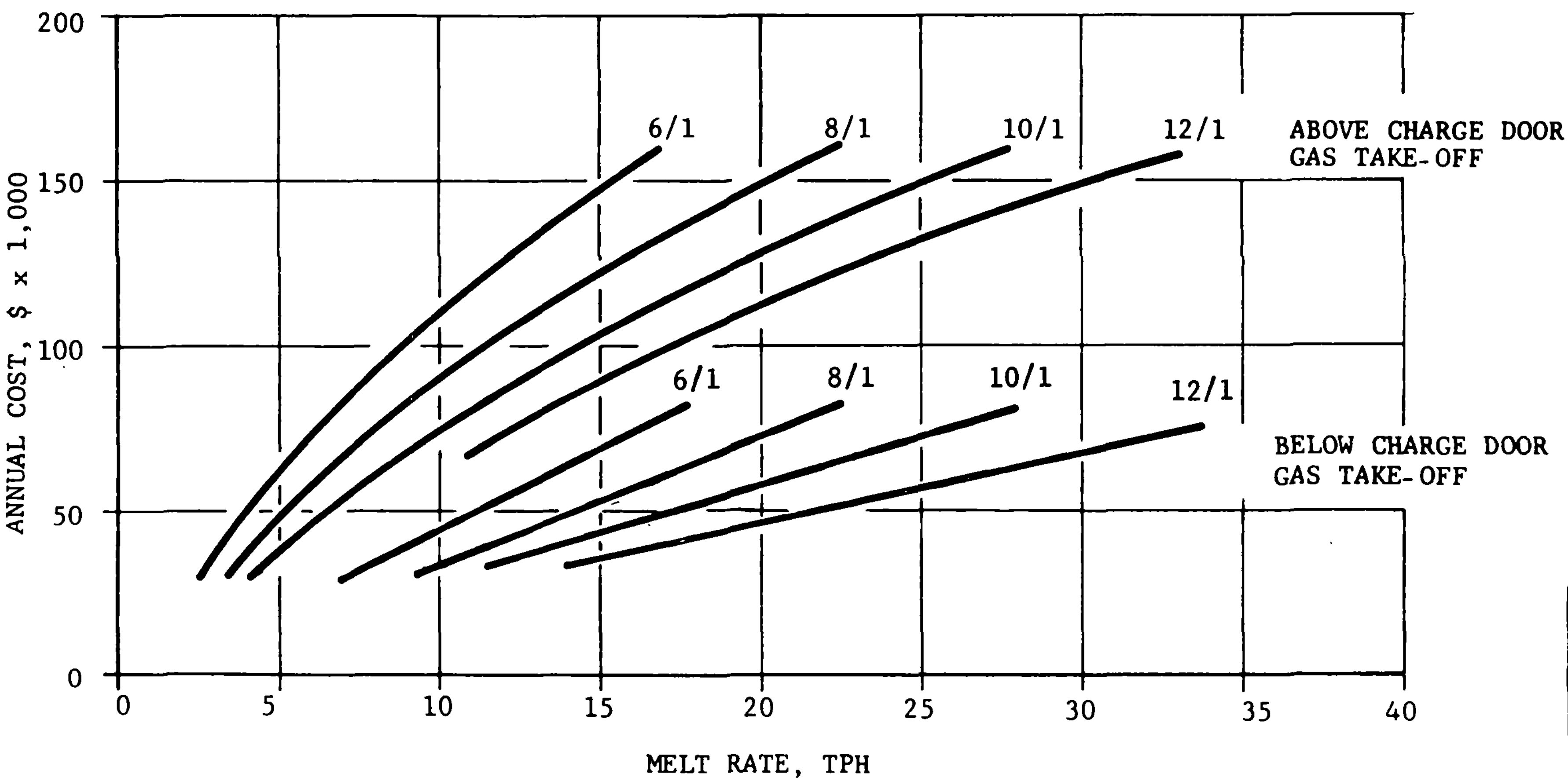
TOTAL ANNUAL COSTS FOR
HIGH ENERGY WET SCRUBBER
ON LINED CUPOLA
1,000-HOUR YEAR
(FOR VARIOUS COKE RATES)



TOTAL ANNUAL COSTS FOR
HIGH ENERGY WET SCRUBBER
ON UNLINED CUPOLA
1,000-HOUR YEAR
(FOR VARIOUS COKE RATES)

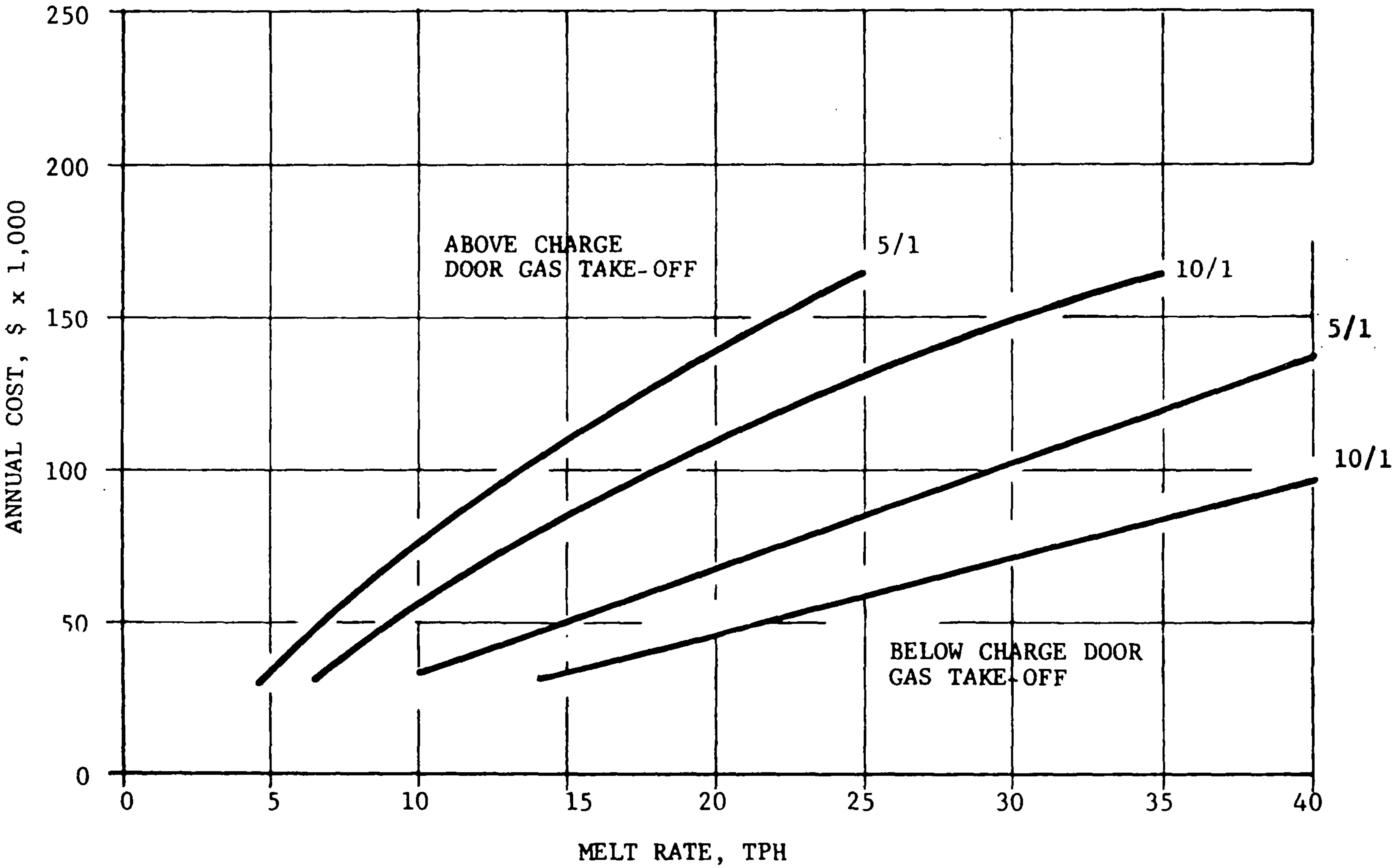


TOTAL ANNUAL COSTS FOR FABRIC FILTER
ON LINED CUPOLA 1,000-HOUR YEAR
(FOR VARIOUS COKE RATES)

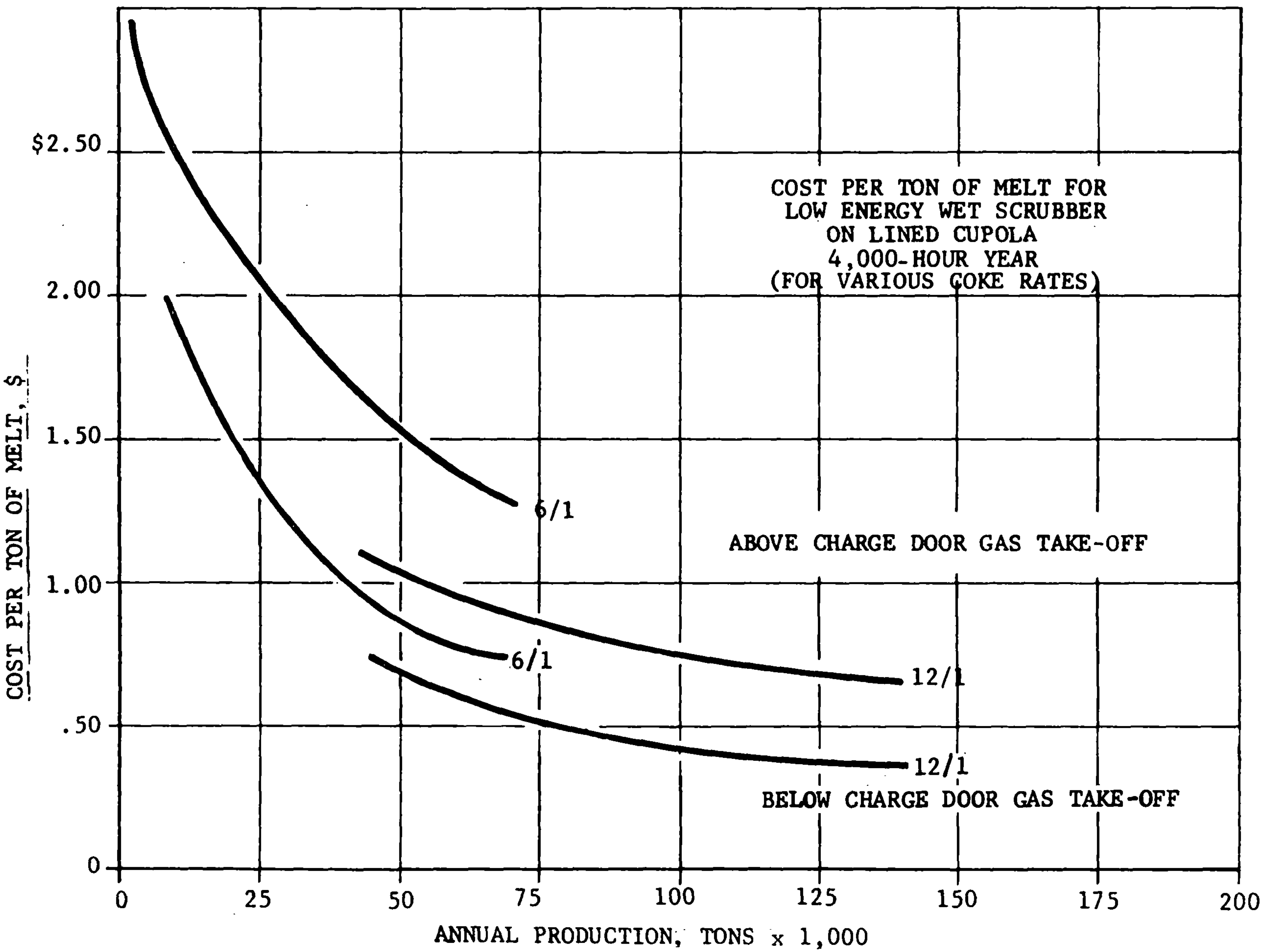


APPENDIX D
NUMBER 17

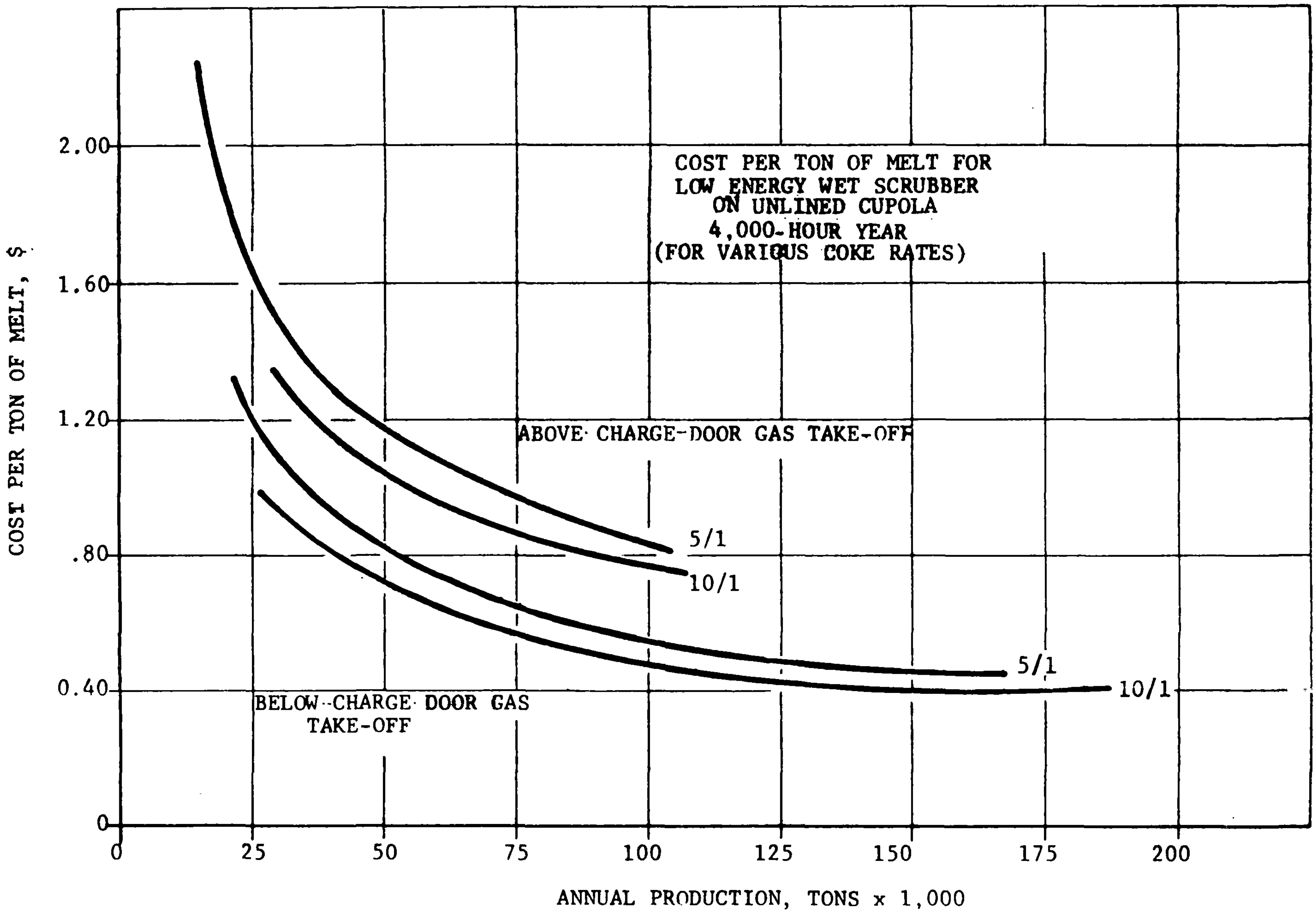
TOTAL ANNUAL COSTS FOR FABRIC FILTER
ON UNLINED CUPOLA 1,000-HOUR YEAR
(FOR VARIOUS COKE RATES)



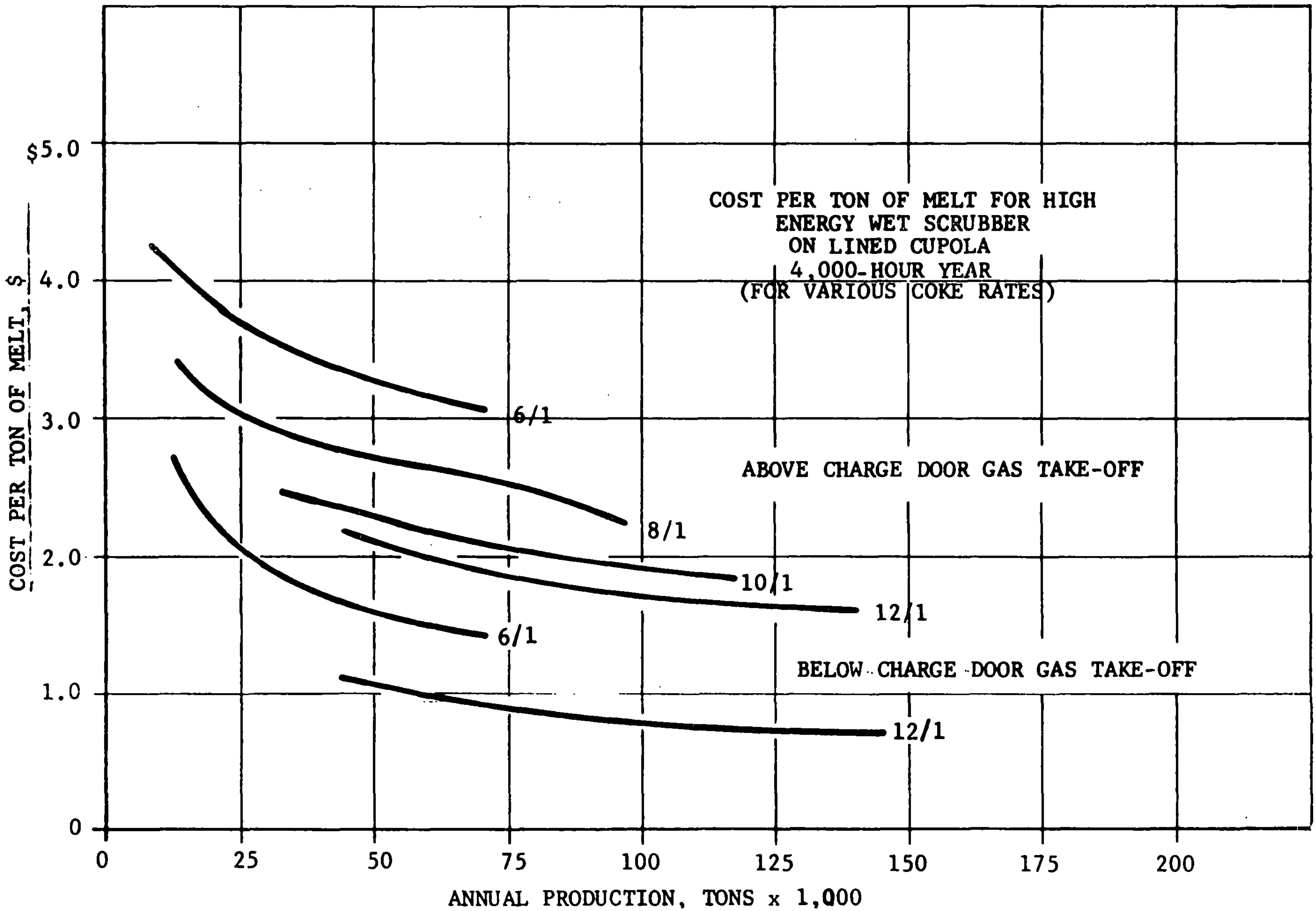
APPENDIX D
NUMBER 18



APPENDIX D
NUMBER 19

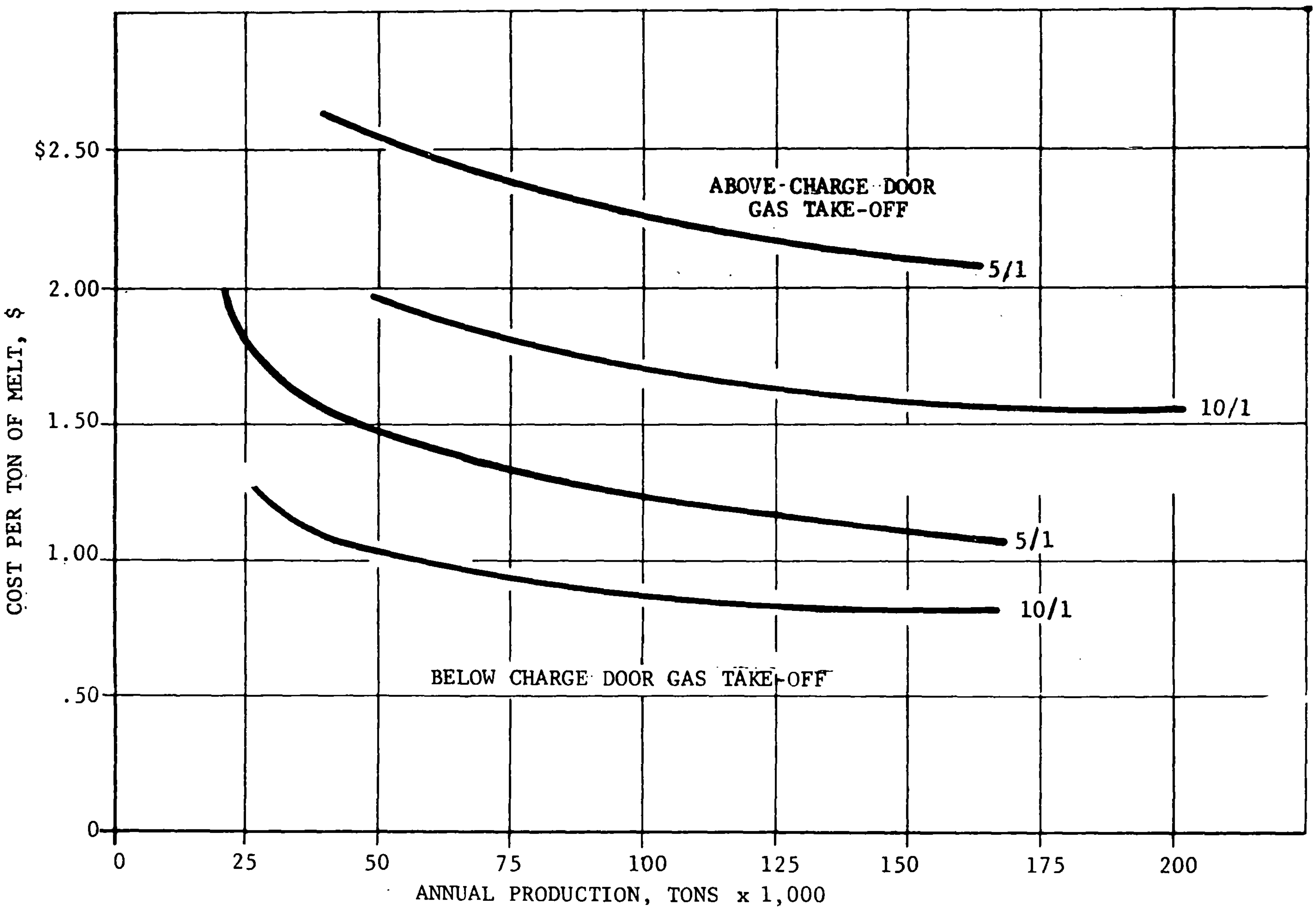


APPENDIX D
NUMBER 20



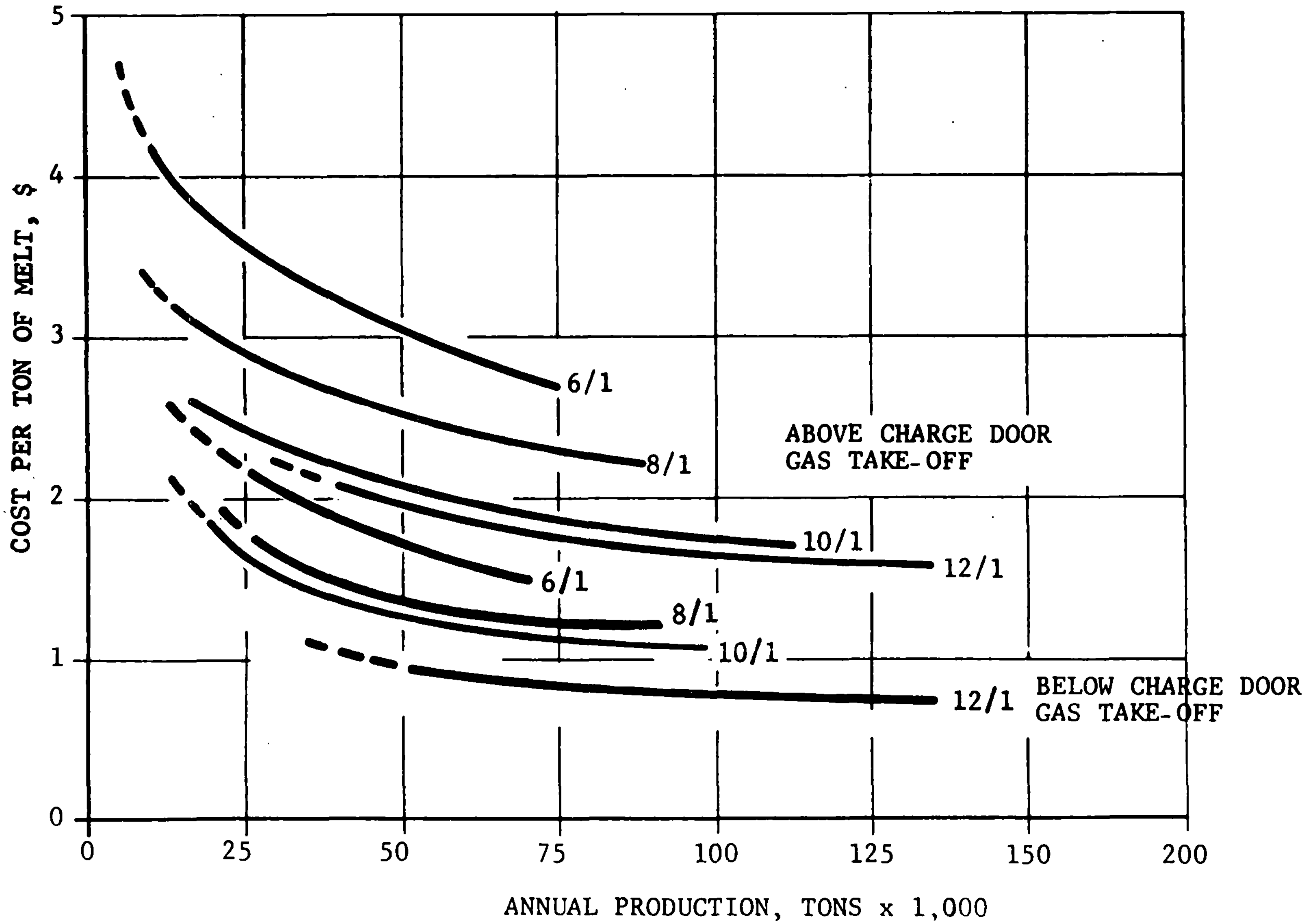
APPENDIX D
NUMBER 21

COST PER TON OF MELT FOR HIGH ENERGY
WET SCRUBBER ON UNLINED CUPOLA
4,000-HOUR YEAR
(FOR VARIOUS COKE RATES)

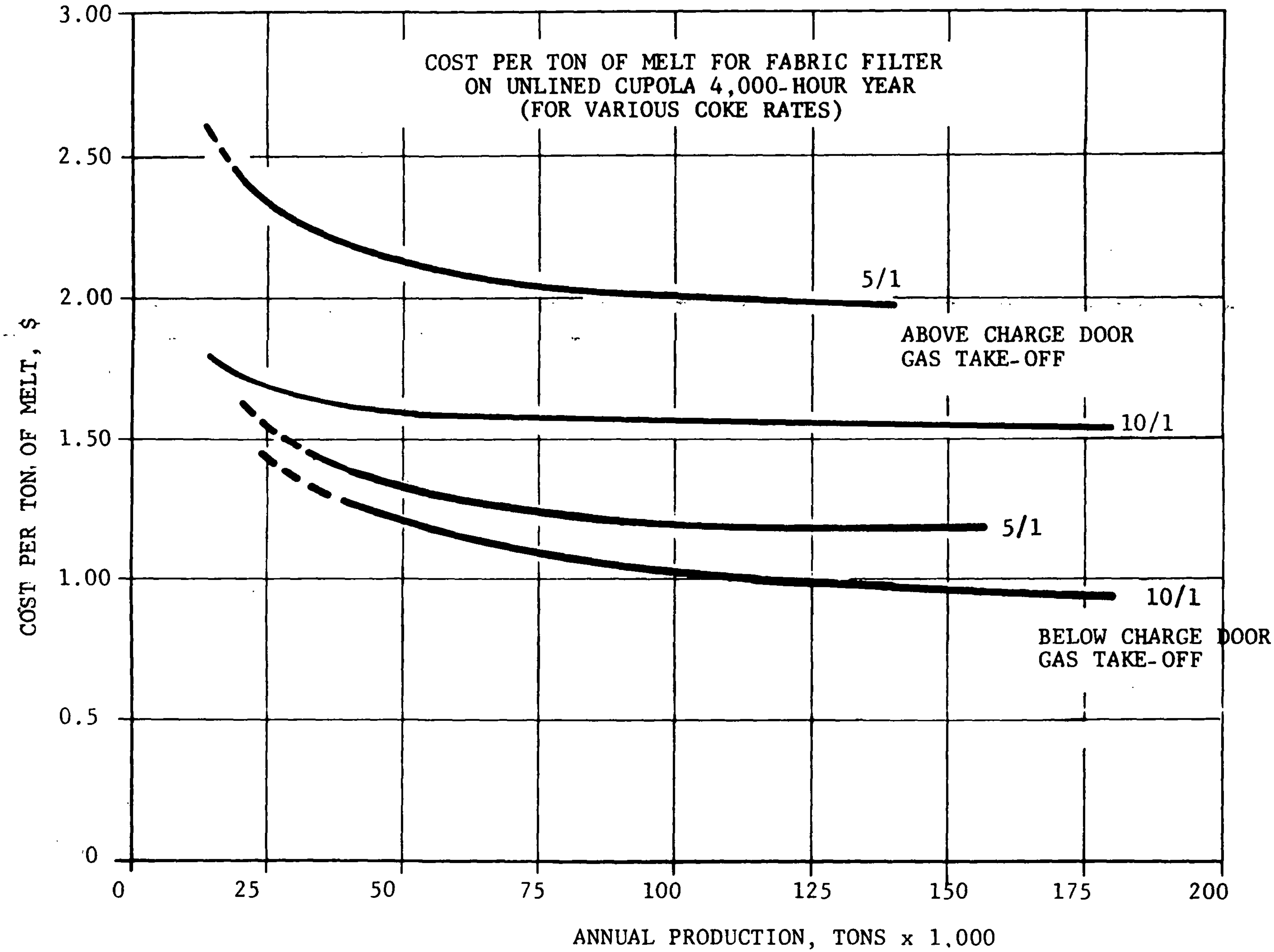


APPENDIX D
NUMBER 22

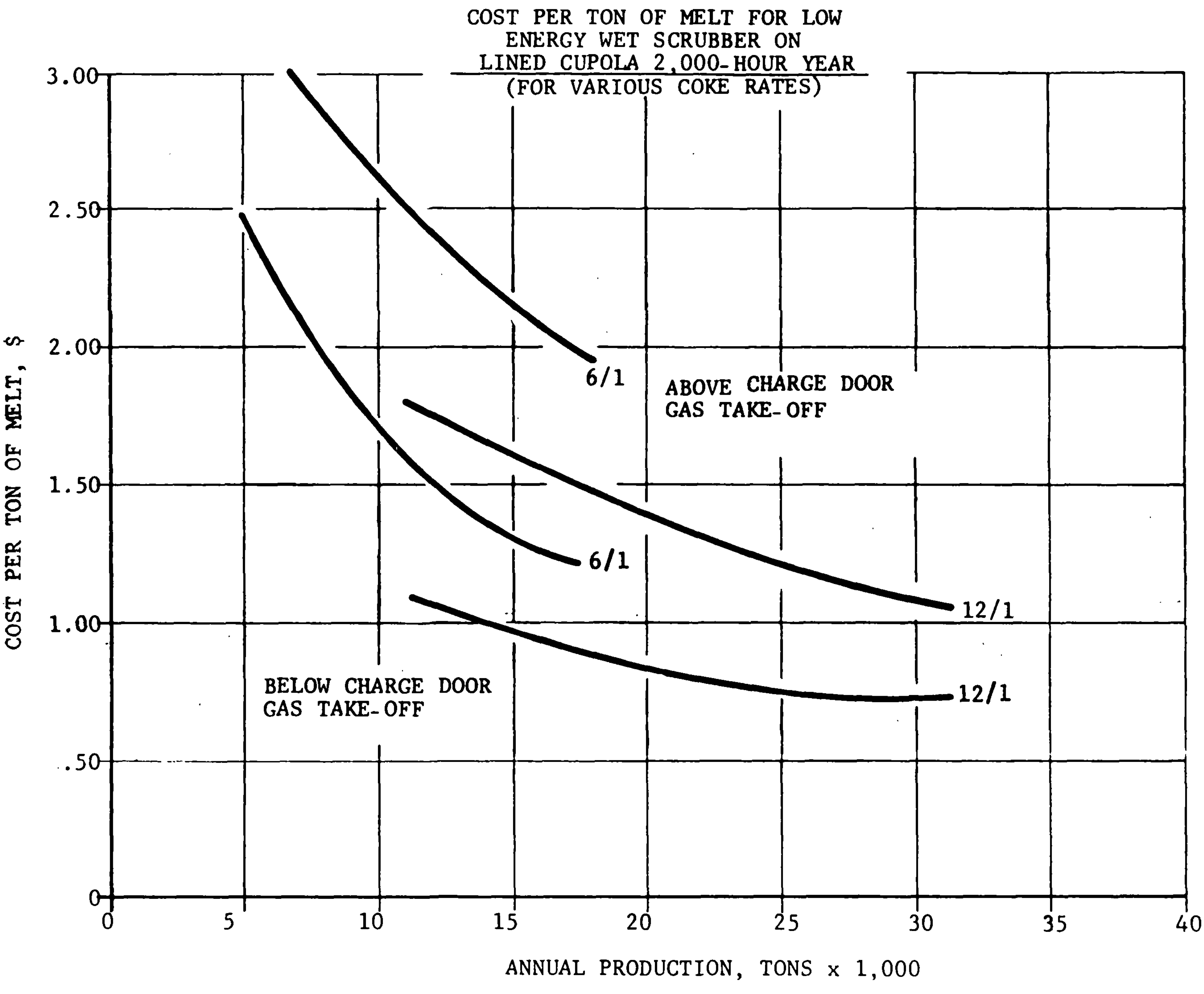
COST PER TON OF MELT FOR FABRIC FILTER
ON LINED CUPOLA 4,000-HOUR YEAR
(FOR VARIOUS COKE RATES)



APPENDIX D
NUMBER 23

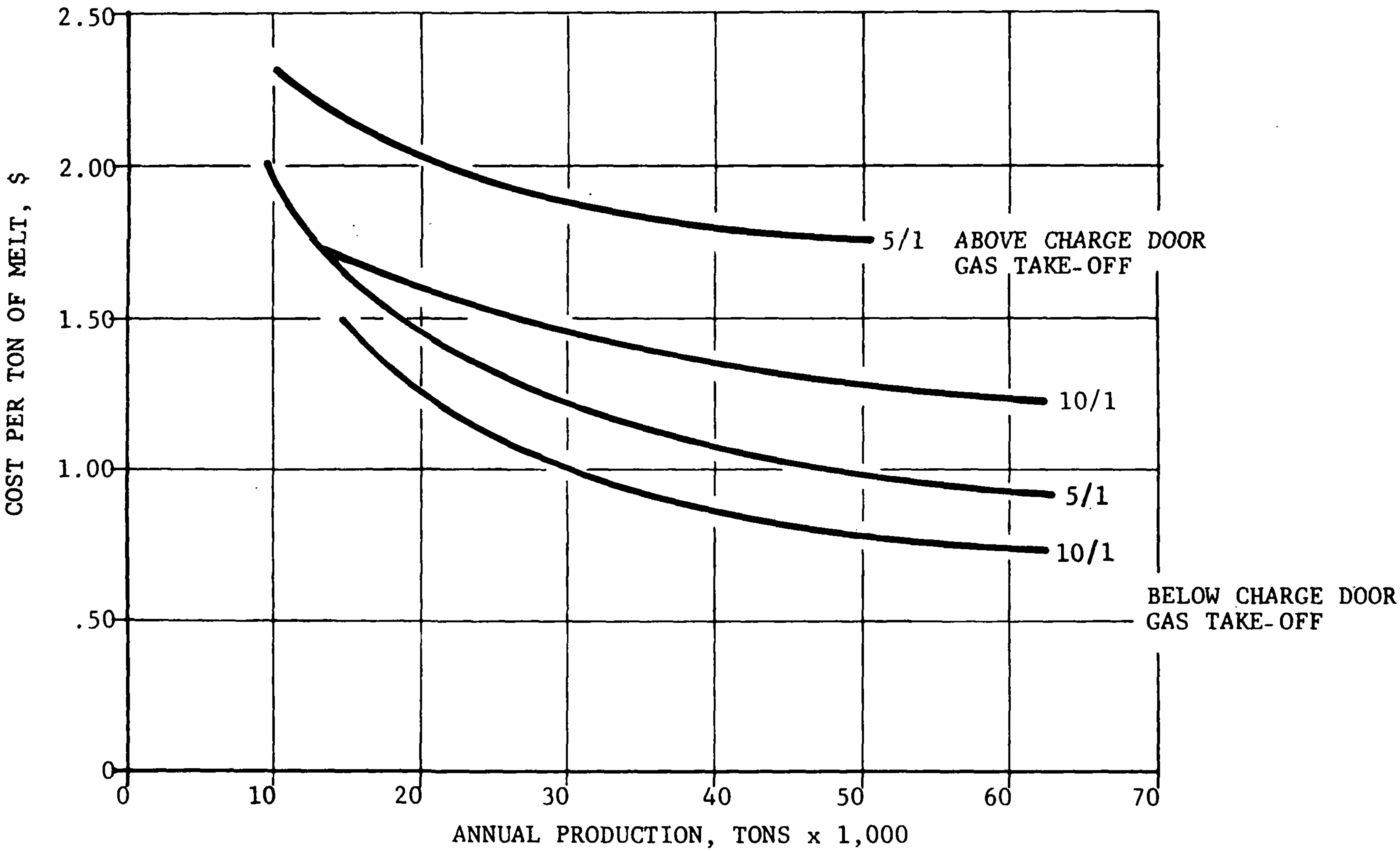


APPENDIX D
NUMBER 24



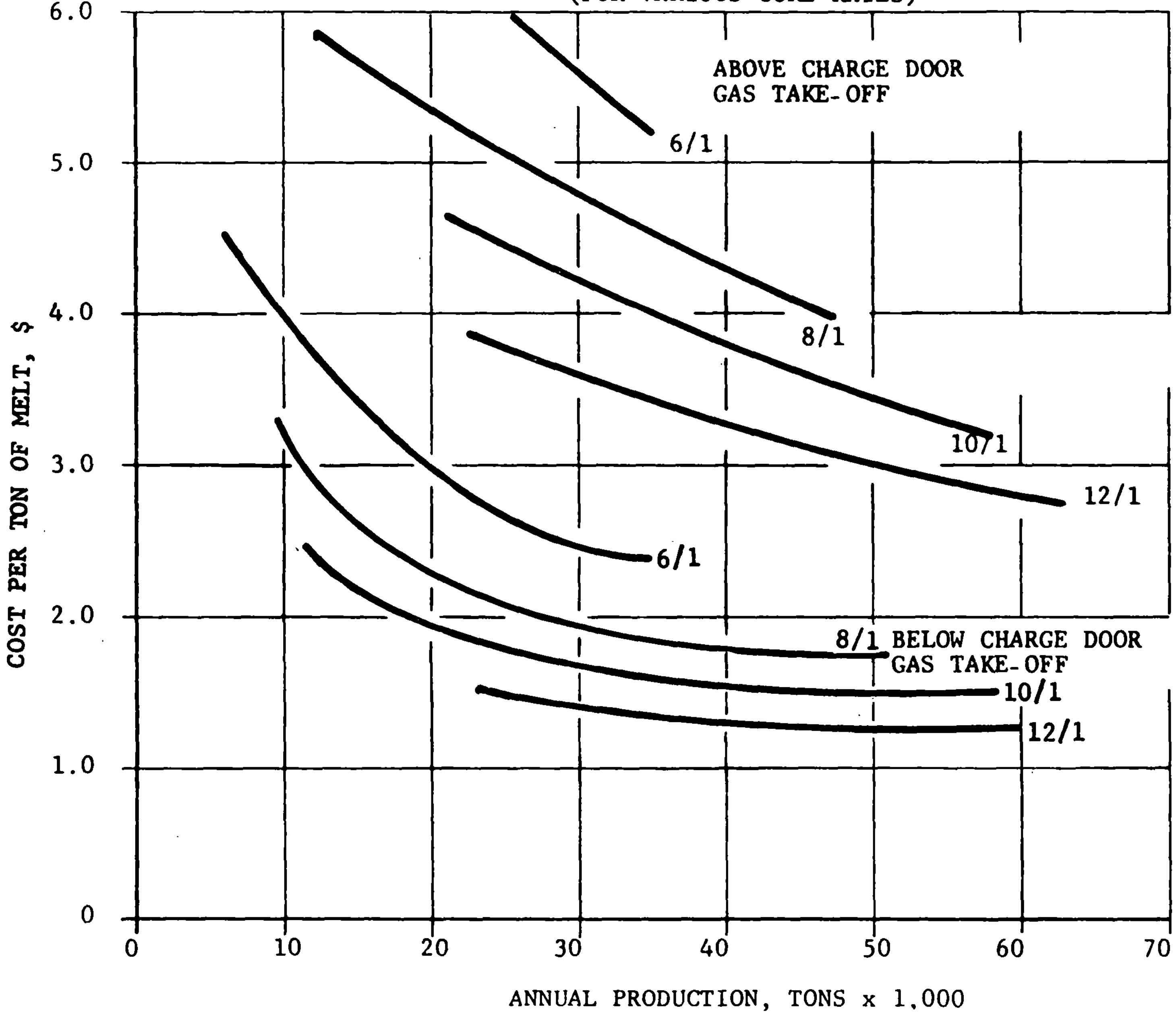
APPENDIX D
NUMBER 25

COST PER TON OF MELT FOR
LOW ENERGY WET SCRUBBER
ON UNLINED CUPOLA
2,000-HOUR YEAR
(FOR VARIOUS COKE RATES)



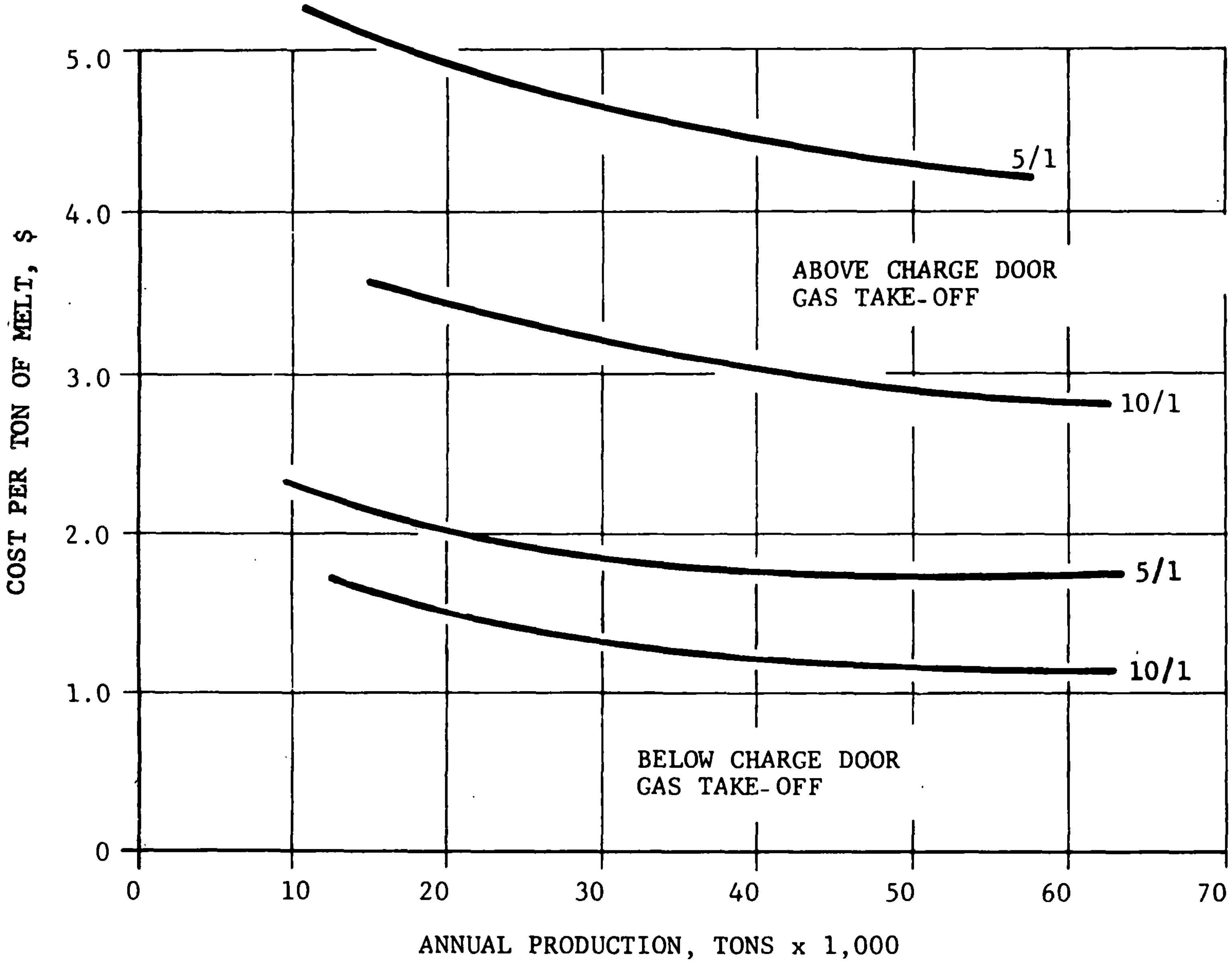
APPENDIX D
NUMBER 26

COST PER TON OF MELT FOR
HIGH ENERGY WET SCRUBBER
ON LINED CUPOLA 2,000-HOUR YEAR
(FOR VARIOUS COKE RATES)

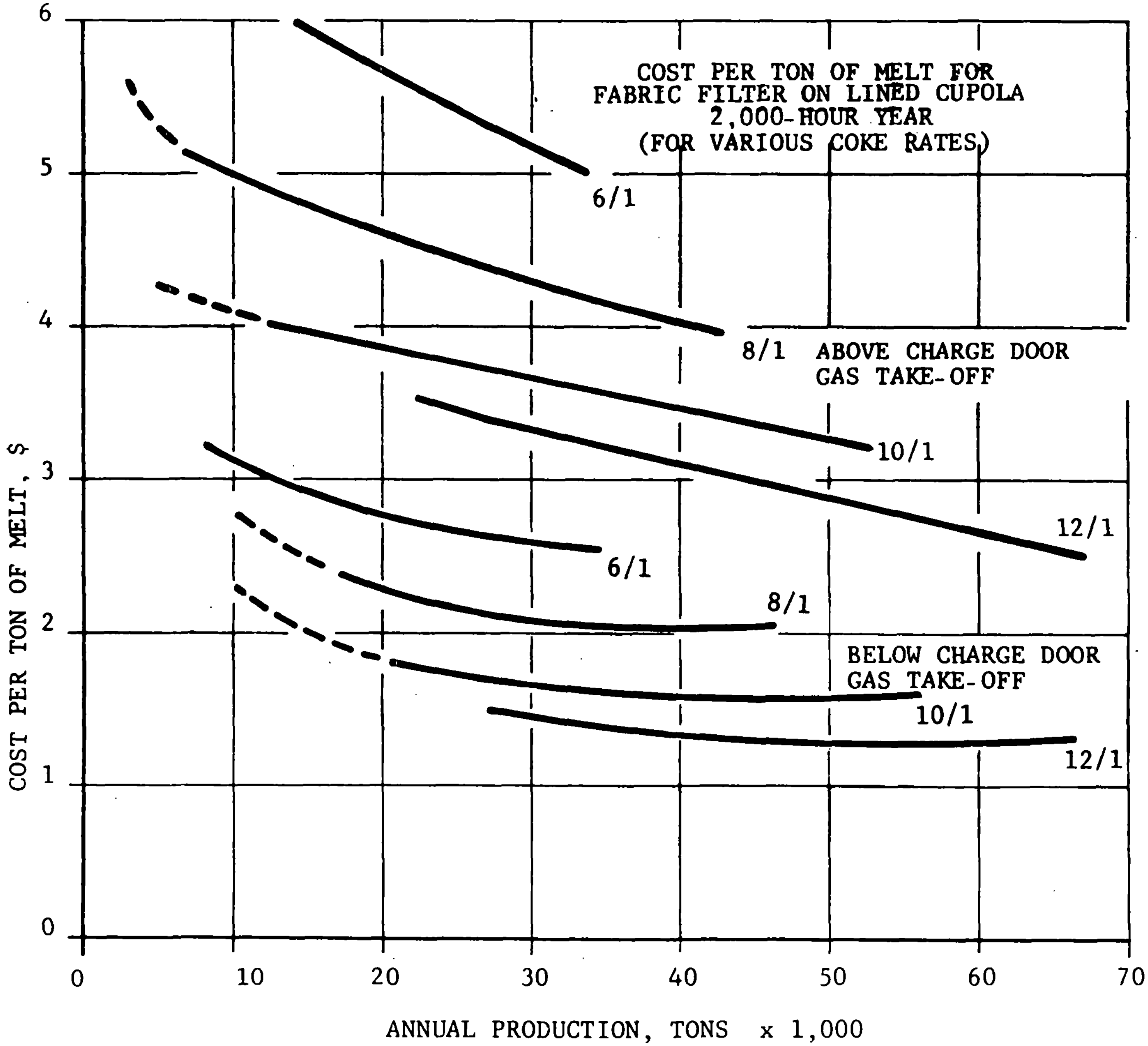


APPENDIX D
NUMBER 27

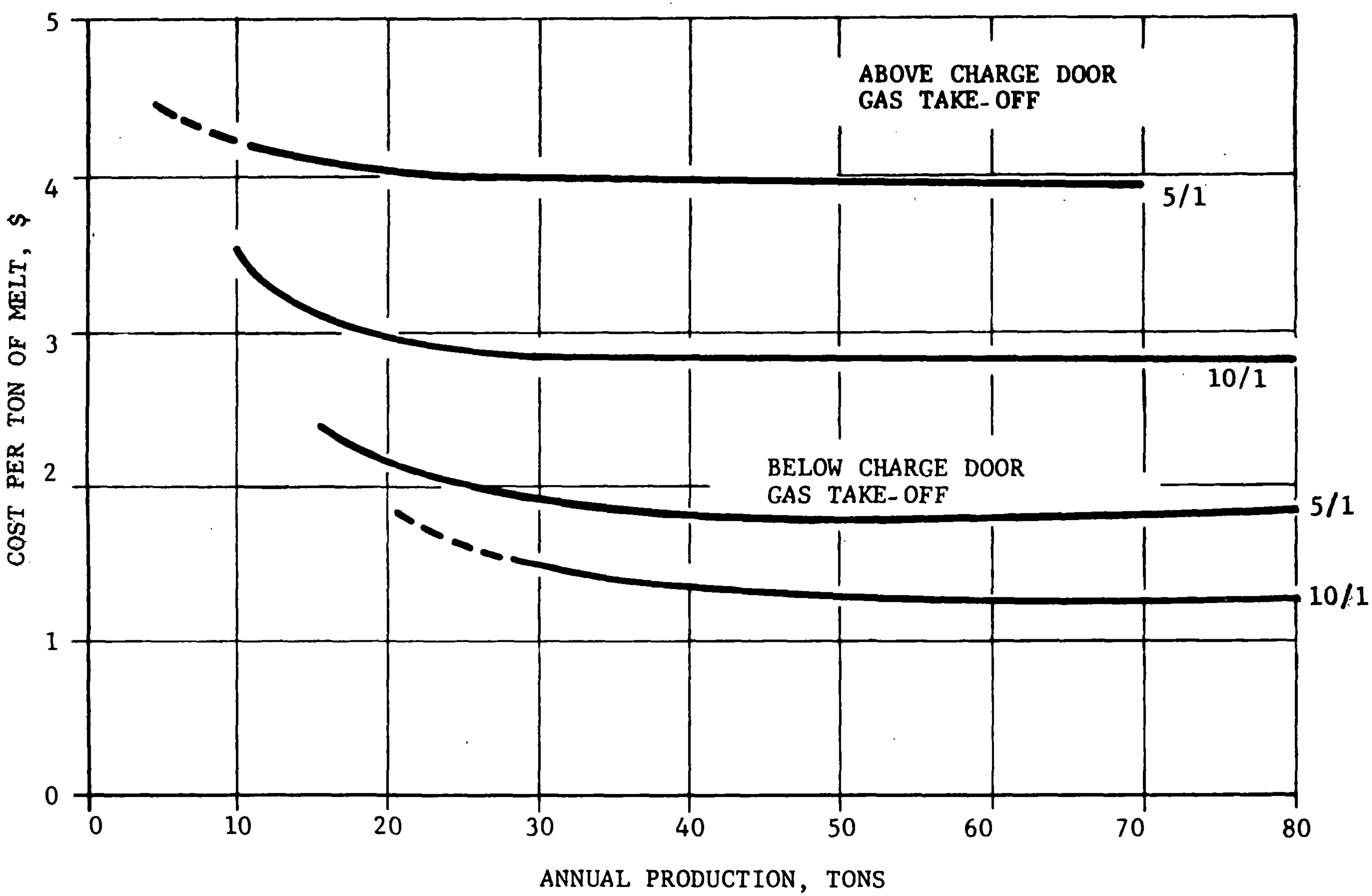
COST PER TON OF MELT FOR
HIGH ENERGY WET SCRUBBER
ON UNLINED CUPOLA
2,000-HOUR YEAR
(FOR VARIOUS COKE RATES)



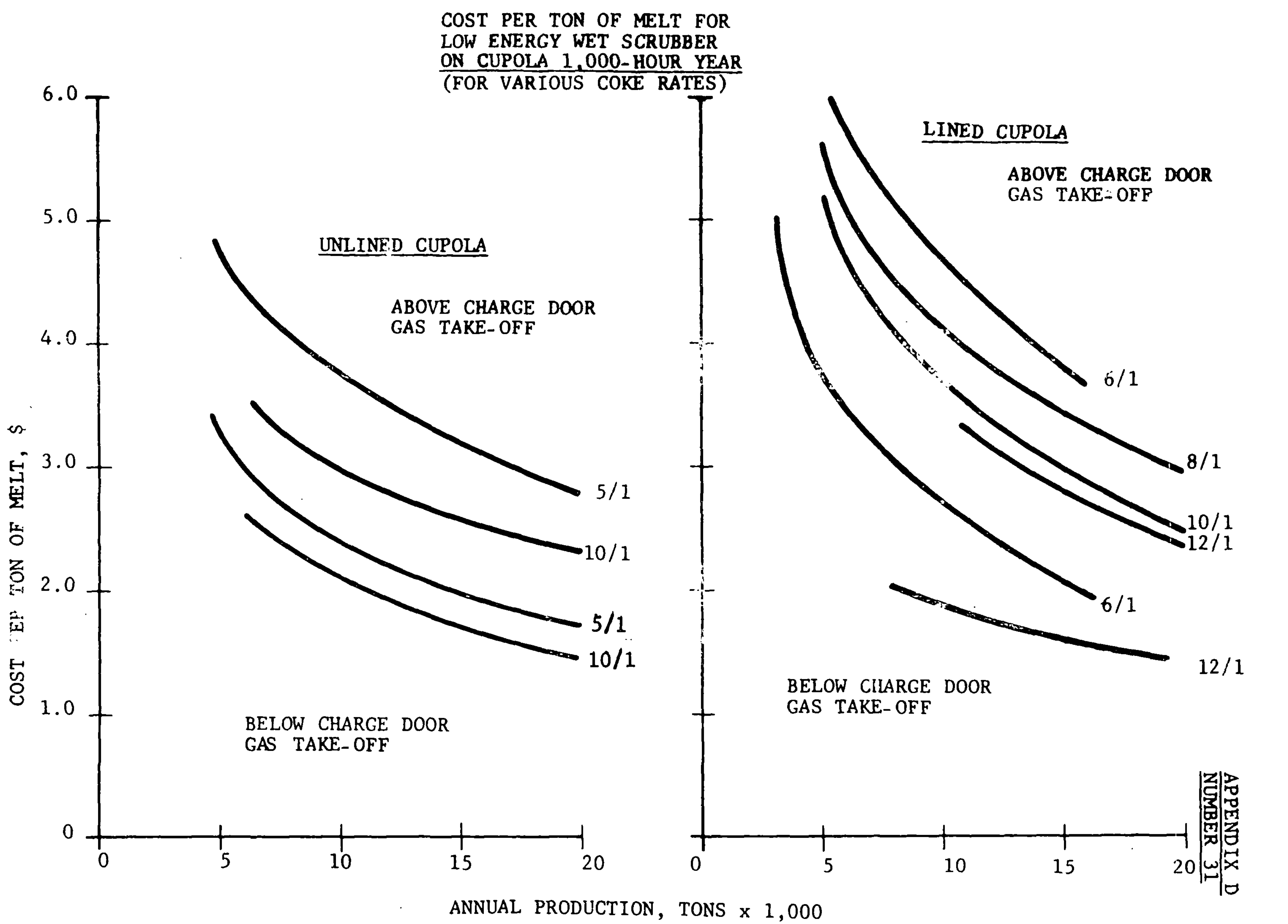
APPENDIX D
NUMBER 28


COST PER TON OF MELT FOR
FABRIC FILTER ON LINED CUPOLA
2,000-HOUR YEAR
(FOR VARIOUS COKE RATES)
6/1
8/1
ABOVE CHARGE DOOR
GAS TAKE-OFF
10/1
12/1
6/1
8/1
BELOW CHARGE DOOR
GAS TAKE-OFF
10/1
12/1
COST PER TON OF MELT, $
0
1
2
3
4
5
6
0
10
20
30
40
50
60
70
ANNUAL PRODUCTION, TONS x 1,000

COST PER TON OF MELT FOR FABRIC FILTER
ON UNLINED CUPOLA 2,000-HOUR YEAR
(FOR VARIOUS COKE RATES)

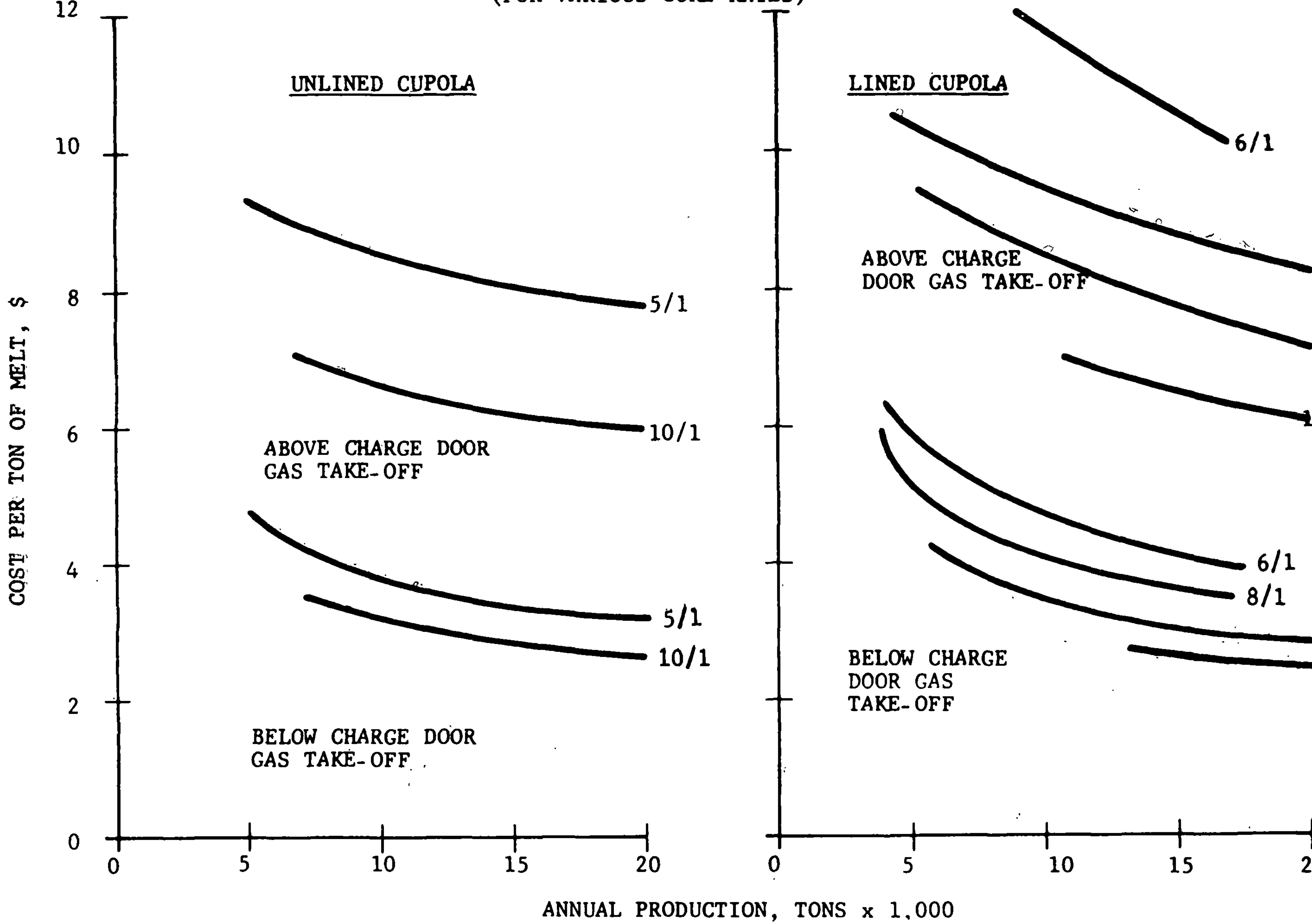


APPENDIX D
NUMBER 30

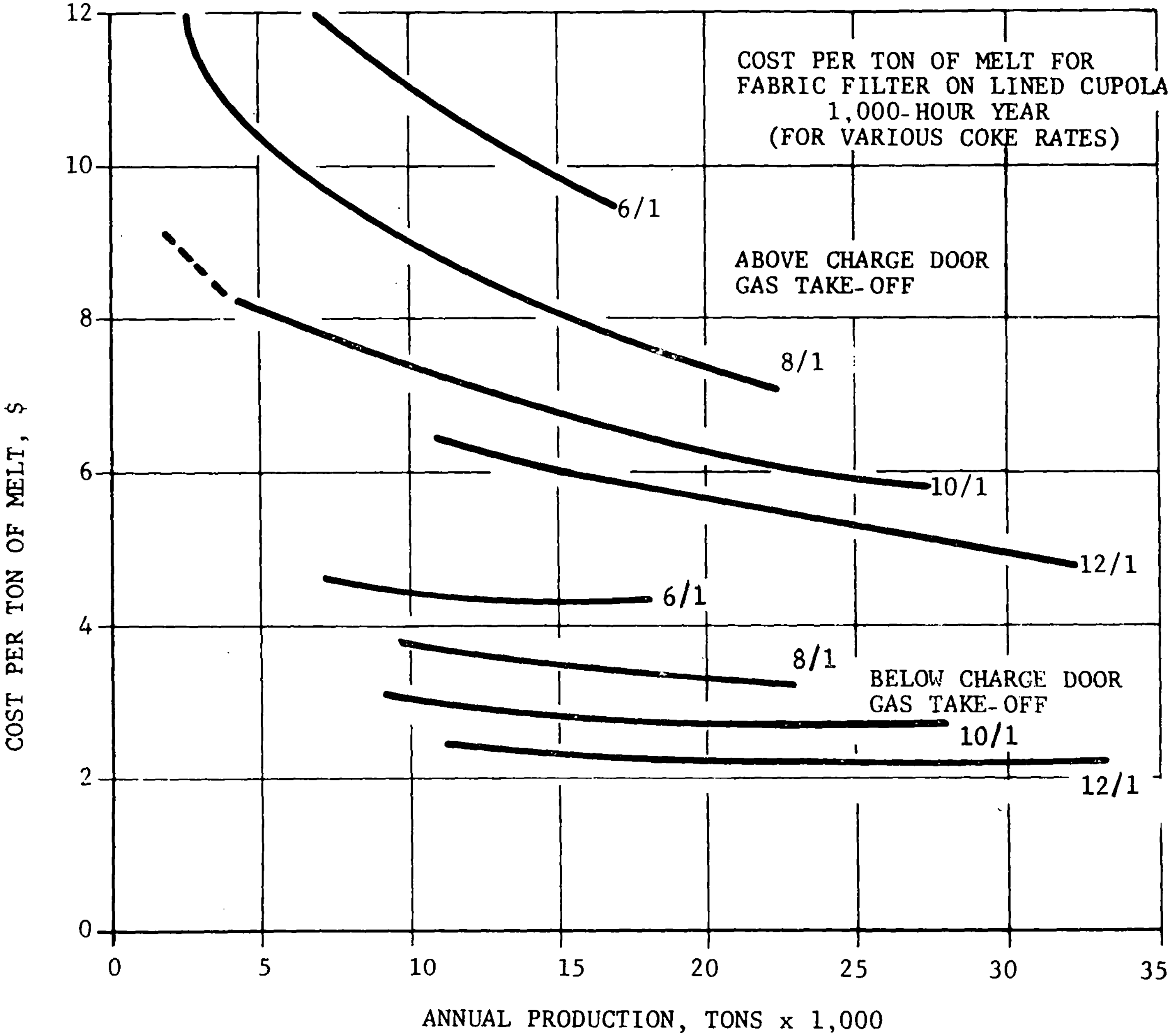


APPENDIX D
NUMBER 31

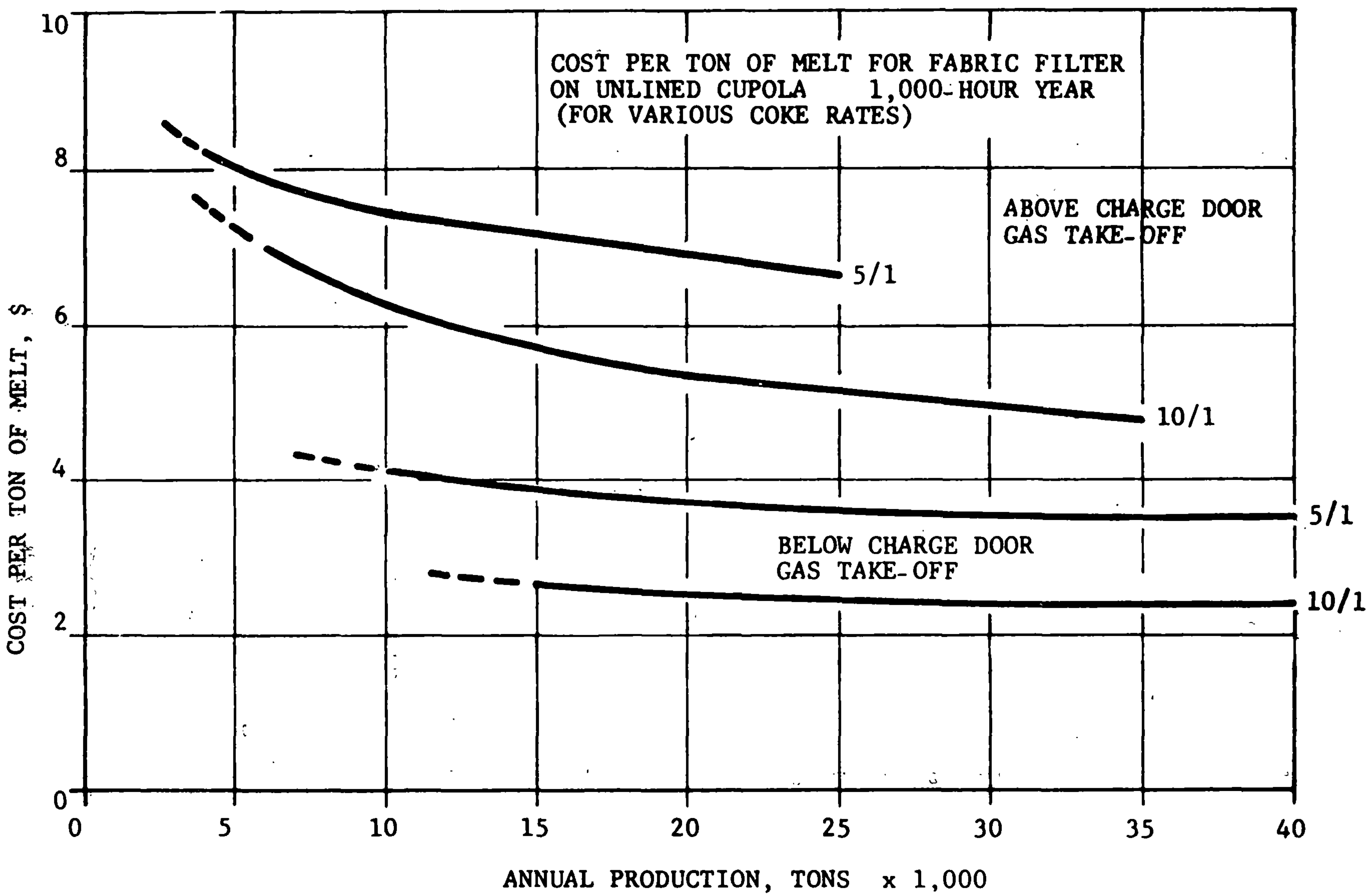
COST PER TON OF MELT FOR HIGH
ENERGY WET SCRUBBER ON CUPOLA
1,000-HOUR YEAR
(FOR VARIOUS COKE RATES)



APPENDIX D
NUMBER 32

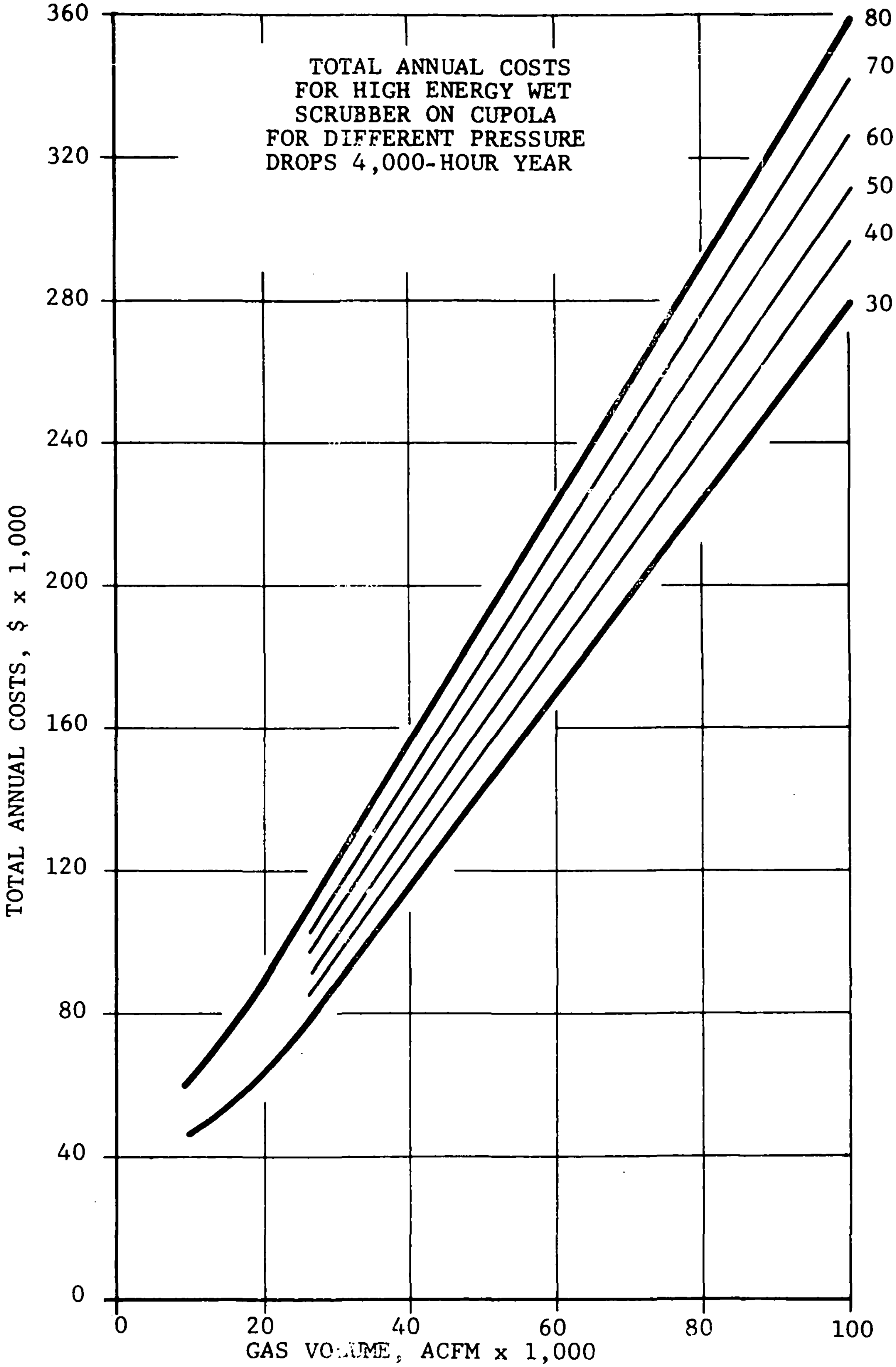


APPENDIX D
NUMBER 33

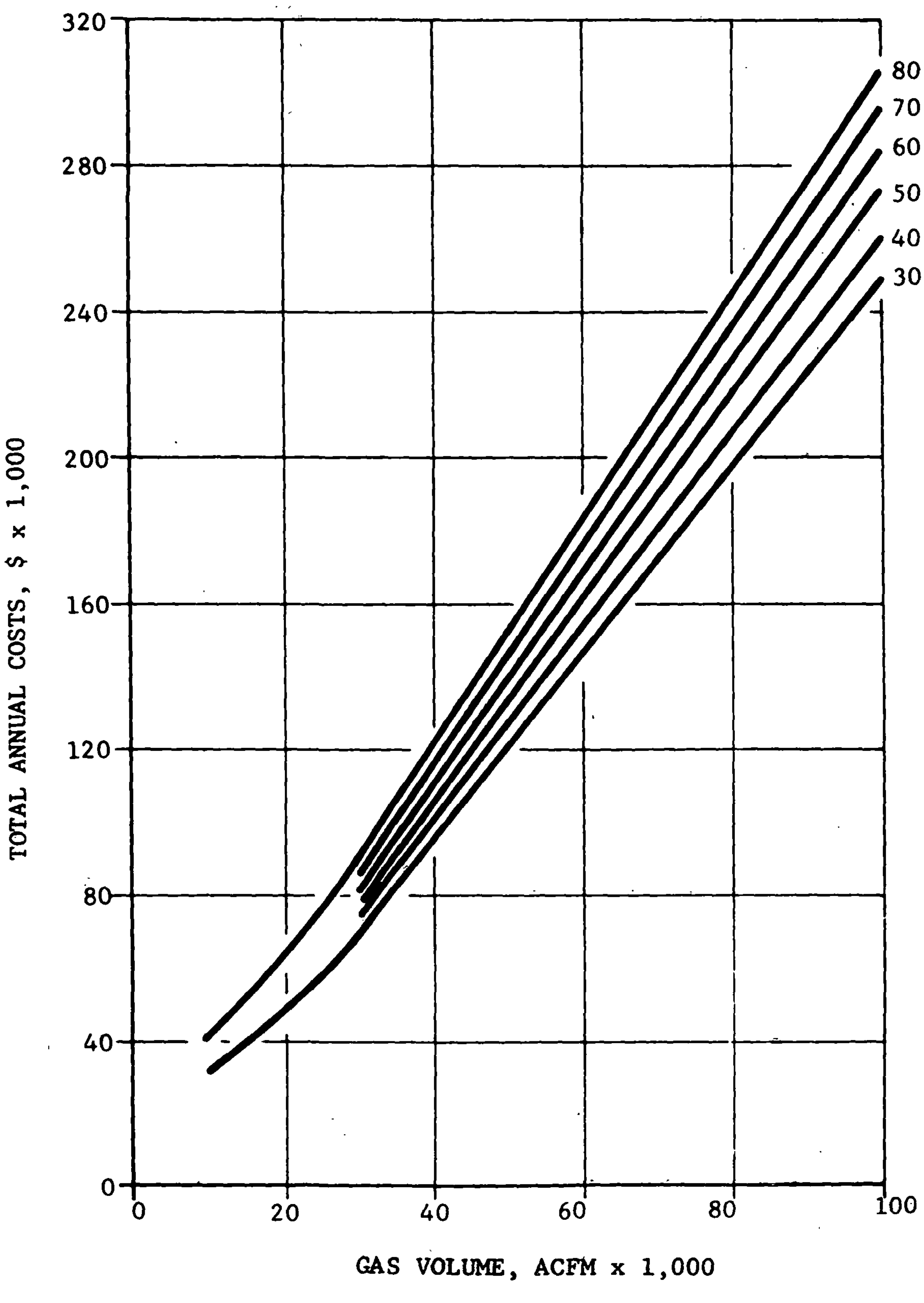


APPENDIX D
NUMBER 34

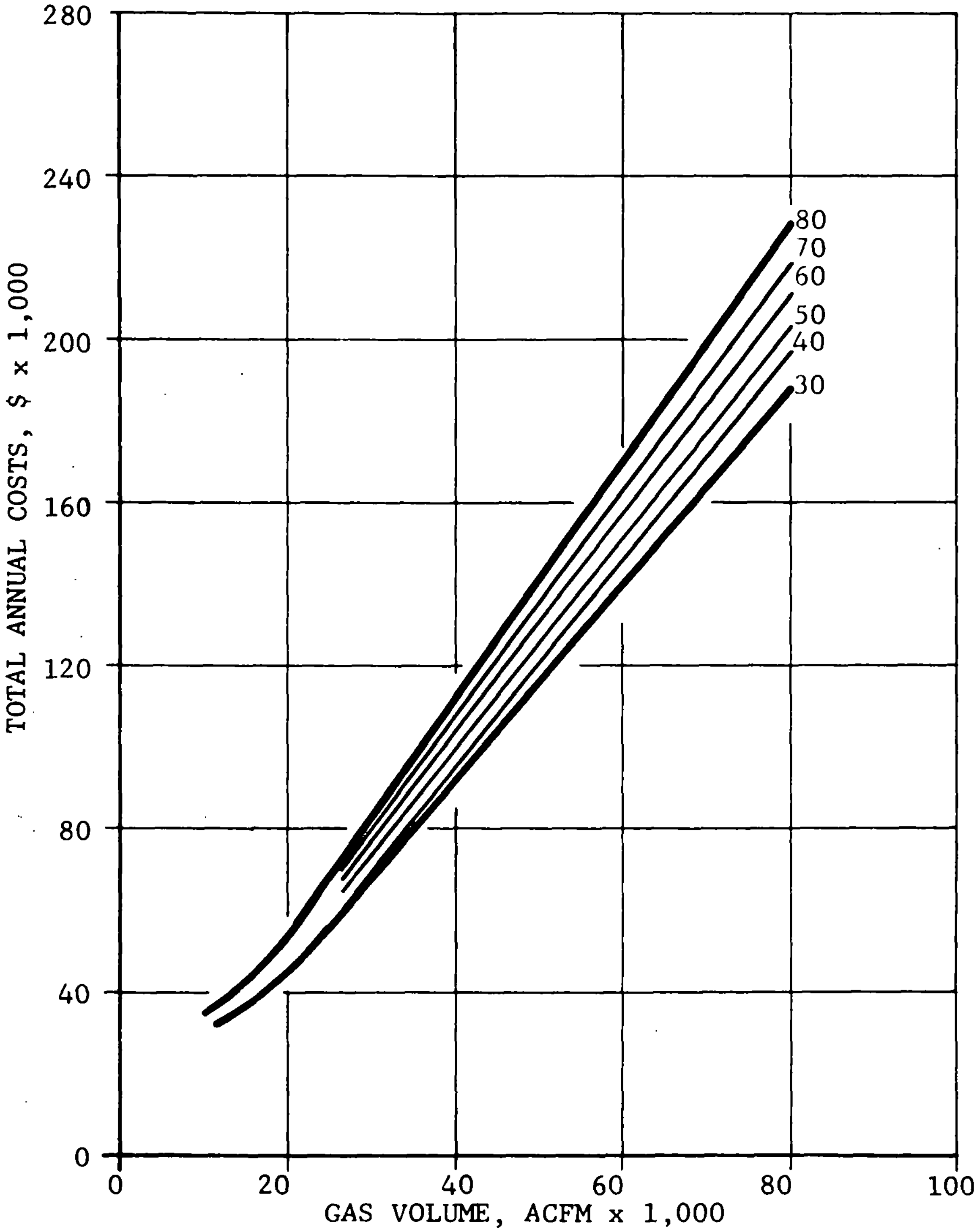
APPENDIX D
NUMBER 35



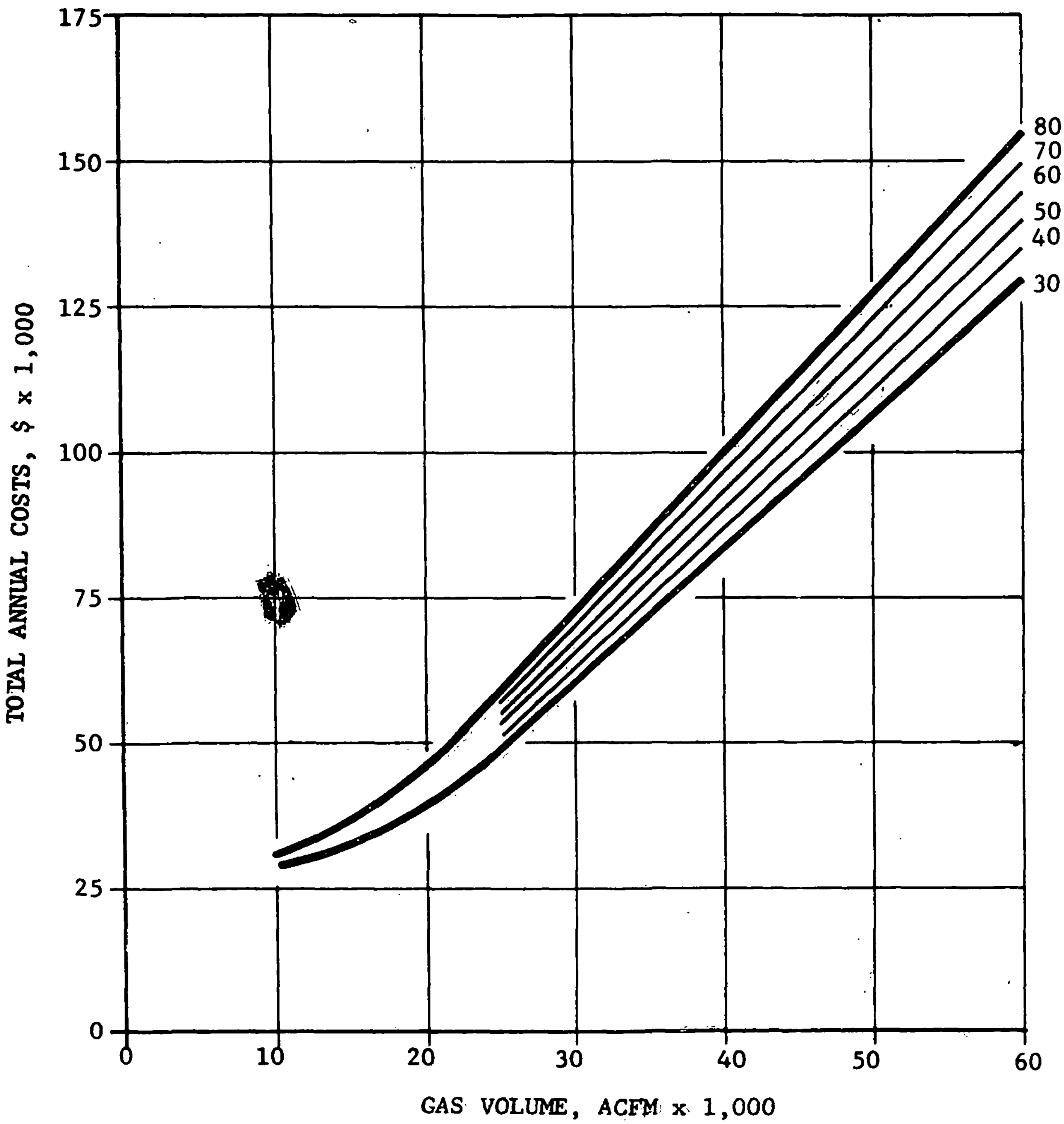
TOTAL ANNUAL COSTS FOR HIGH ENERGY WET SCRUBBER ON CUPOLA FOR DIFFERENT PRESSURE DROPS 2,000-HOUR YEAR



TOTAL ANNUAL COSTS FOR
HIGH ENERGY WET SCRUBBER
ON CUPOLA FOR DIFFERENT
PRESSURE DROPS 1,000-HOUR YEAR



TOTAL ANNUAL COSTS FOR
HIGH ENERGY WET SCRUBBER
ON CUPOLA FOR DIFFERENT
PRESSURE DROPS 500-HOUR YEAR



	C FURNA F N an
A. Buildings	
1. Cupola Building 500 & 1,000 Hours per Year, $25/Sq. Ft.	2,500
2. Cupola Auxiliary Building $10/Sq. Ft.	750
B. Scrapyard Equipment	
1. Scrapyard Crane	1-5T
2. Crane Runway	12,50(
3. Metal Trim Platform & Weigh Hopper	
4. Coke & Stone Weigh Hoppers & Feeders	
5. Coke & Stone Bins	
6. Coke & Stone Unloading Equipment	
7. Magnet	1-45"
8. Platform Scale	
C. Charging Equipment	
1. Skip Charger	
2. Charge Buckets	
D. Melting Equipment	
1. Cupolas @ 500 & 1,000 H/A	1-56"
2. Blower & Motor (SCFM Basis)	1-3,10
3. Air Piping, Piping, Valves & Weight Control	
4. Forehearth	
5. Runners	
6. Refractories for Cupola & Runners	
7. Slag Buckets	
8. Slag Disposal Equipment	
9. Piping, Header, & Sewer Connections	
E. Holding Equipment (Not Required)	
Subtotal #1 (B + C + D + E)	
F. Spares & Freight (3½% of B, C, D, E)	
Subtotal #2 (S.T. #1 + A + F)	
G. Engineering 5%	
Subtotal	
H. Contingencies 10%	
Total	
Cost/Ton	
500 Hours	
1,000 Hours	

A

EQUIPMENT REQUIREMENTS

CUPOLA, COLD BLAST, NO HOLDING FURNACE, FABRIC FILTER EMISSION CONTROL FOR 500 & 1,000 HOURS PER YEAR

	5 TPH		15 TPH		
	Number and Size	Cost	Number and Size	Cost	
per Year, $25/Sq. Ft.	2,500 Sq. Ft.	$ 63,000	4,000 Sq. Ft.	$100,000	8,0
Ft.	750 Sq. Ft.	8,000	1,800 Sq. Ft.	18,000	3,0
	1-5T	60,000	1-7½T	83,000	2-7
	12,500 Open	19,000	16,000 Covered	128,000	24,
r		20,000		55,000	
ers		-		95,000	
		15,000		-	
		10,000		40,000	
	1-45"	6,000	1-65"	8,000	2-6
		10,000		-	
	-	-	1-15 TPH	134,000	2-1
		24,000		-	
	1-56"	14,000	1-90"	34,000	2-9
	1-3,100	26,000	1-9,200	36,000	2-9
ht Control		25,000		40,000	
		5,000		6,000	
		3,000		4,000	
		10,000		29,000	
		5,000		-	
		-		21,000	
ns		10,000		20,000	
		$262,000		$733,000	
		$ 9,000		$ 25,000	
')		$342,000		$876,000	
		$ 17,000		$ 44,000	
		$359,000		$920,000	
		$ 36,000		$ 92,000	
		$395,000		$1,012,000	
		$158 79			$67.47

'MENT REQUIREMENTS

:OLD BLAST, NO HOLDING
:IC FILTER EMISSION CONIROL
: 1,000 HOURS PER YEAR

'PH	15 TPH		30 TPH		50 TPH	
Cost	Number and Size	Cost	Number and Size	Cost	Number and Size	Cost
$ 63,000	4,000 Sq. Ft.	$100,000	8,000 Sq. Ft.	$200,000	10,000 Sq. Ft.	$250,000
8,000	1,800 Sq. Ft.	18,000	3,000 Sq. Ft.	30,000	5,000 Sq. Ft.	50,000
60,000	1-7½T	83,000	2-7½T	166,000	2-10T	200,000
19,000	16,000 Covered	128,000	24,000 Covered	192,000	30,000 Covered	240,000
20,000		55,000		70,000		90,000
-		95,000		143,000		240,000
15,000		-		-		-
10,000		40,000		52,000		75,000
6,000	1-65"	8,000	2-65"	16,000	3-65"	24,000
10,000		-		-		-
-	1-15 TPH	134,000	2-15 TPH	238,000	2-30 TPH	330,000
24,000		-		-		-
14,000	1-90"	34,000	2-90"	67,000	2-108"	80,000
26,000	1-9,200	36,000	2-9,200	72,000	2-12,500	175,000
25,000		40,000		50,000		72,000
5,000		6,000		12,000		15,000
3,000		4,000		6,000		8,000
10,000		29,000		58,000		70,000
5,000		-		-		-
-		21,000		27,000		36,000
10,000		20,000		25,000		30,000
$262,000		$733,000		$1,194,000		$1,685,000
$ 9,000		$ 25,000		$ 42,000		$ 59,000
$342,000		$876,000		$1,466,000		$2,044,000
$ 17,000		$ 44,000		$ 73,000		$ 102,000
$359,000		$920,000		$1,539,000		$2,146,000
$ 36,000		$ 92,000		$ 154,000		$ 215,000
$395,000		$1,012,000		$1,693,000		$2,361,000
$158						
79		$67.47				

B

EQ

CUPOLA
FURN
FOR 2,0

	Increase For 2,000 & 4,000/ Hours per Year	Number and Siz
A. Buildings		
Cupola Building	80%	
C. Charging Equipment		
Swivel Skip Charger	15%	
D. Melting Equipment		
1. Cupolas	100%	
3. Air Piping & Valves	10	
6. Runners	50	
7. Refractories	100	
9. Slag Disposal Equipment	15	
5. Forehearth	100	
Subtotal #1 (C + D)		
E. Spares & Freight 3-1/2%		
Subtotal (#1 + A + E)		
Engineering 5%		
Subtotal		
Contingencies 10%		
Subtotal		
Total from 500 & 1,000 Hours Page 1.		
Grand Total		
Cost/Ton		
2,000 Hours		
4,000 Hours		

A

EQUIPMENT REQUIREMENTS

CUPOLA, COLD BLAST, NO HOLDING FURNACE, SUPPLEMENTARY COSTS FOR 2,000 & 4,000 HOURS PER YEAR

	Increase For 2,000 & 4,000/ Hours per Year	5 TPH		15 TPH		
		Number and Size	Cost	Number and Size	Cost	Numbe and Si
	80%		$ 50,000		$ 80,000	
	15%		3,000		20,000	
	100%		14,000		34,000	
	10		3,000		4,000	
	50		2,000		2,000	
	100		10,000		29,000	
	15		1,000		3,000	
	100		5,000		6,000	
			$ 38,000		$ 98,000	
			$ 1,000		$ 3,000	
			$ 89,000		$ 181,000	
			$ 4,000		$ 9,000	
			$ 93,000		$ 190,000	
			$ 9,000		$ 19,000	
			$102,000		$ 209,000	
e 1.			$395,000		$1,012,000	
			$497,000		$1,221,000	
			$49.70		$40.70 20.35	

IT REQUIREMENTS

) BLAST, NO HOLDING
UPPLEMENTARY COSTS
.000 HOURS PER YEAR

	15 TPH		30 TPH		50 TPH	
Cost	Number and Size	Cost	Number and Size	Cost	Number and Size	Cost
$ 50,000		$ 80,000		$ 160,000		$ 200,000
3,000		20,000		36,000		50,000
14,000		34,000		67,000		80,000
3,000		4,000		5,000		7,000
2,000		2,000		3,000		4,000
10,000		29,000		58,000		70,000
1,000		3,000		4,000		5,000
5,000		6,000		12,000		15,000
$ 38,000		$ 98,000		$ 185,000		$ 231,000
$ 1,000		$ 3,000		$ 6,000		$ 9,000
$ 89,000		$ 181,000		$ 351,000		$ 440,000
$ 4,000		$ 9,000		$ 18,000		$ 22,000
$ 93,000		$ 190,000		$ 369,000		$ 462,000
$ 9,000		$ 19,000		$ 37,000		$ 46,000
$102,000		$ 209,000		$ 406,000		$ 508,000
$395,000		$1,012,000		$1,693,000		$2,361,000
$497,000		$1,221,000		$2,099,000		$2,869,000
$49.70		$40.70		$34.98		$28.69
		20.35		17.49		14.35

ß

A.	**Buildings**	
	1. Melting Building @ $25/Sq. Ft.	2,00(
	2. Cupola Auxiliary Building @ $10/Sq. Ft.	1,00(
B.	**Scrapyard Equipment**	
	1. Scrapyard Crane	1-5T
	1A. Crane Runway & Stockyard	12,5(
	2. Metal Trim Platform & Weigh Hopper	Lump
	4. Coke & Stone Weigh Hoppers, Feeders, Scales & Bins	
	5. Coke & Stone Unloading Equipment	Lump
	6. Magnets	1-45'
	7. Platform Scale	Lump
C.	**Charging Equipment**	
	1. Skip Charger-Swivel Type	
	2. Charge Buckets	
D.	**Melting Equipment**	
	1. Cupola-Unlined-Water Cooled	1-36'
	2. Air Piping, Gates, Charge Indicator	Lump
	3. Blower & Motor	2,30(
	4. Forehearth-Lined	1
	5. Runners	Lump
	6. Refractories for Runners	Lump
	7. Gas Piping & Meter	Lump
	8. Hot Blast Heater	Lump
	9. Piping, Headers, Sewer Connections	Lump
	10. Slag Disposal Equipment	Lump
	11. Water Cooling Tower & Pumps	Lump
E.	**Holding Equipment**	
	1. Channel Induction Furnace & Controls	
	1A. Spare Furnace Body	
	3. Refractories for Holding Furnaces	
	Subtotal #1 (B + C + D + E)	
F.	Spares & Freight (3½% of B + C + D + E)	
	Subtotal #2 (St. #1 + A + F)	
G.	Engineering (5% of St. #2)	
	Subtotal #3 (G + St. #2)	
H.	Contingencies (10% of St. #3)	
	Total (St. #3 + H)	
	Cost/Ton	
	2,000 Hours	
	4,000 Hours	

EQUIPMENT REQUIREMENTS

CUPOLA HOT BLAST, WATER-COOLED,
CHANNEL INDUCTION HOLDING FURNACE,
WET SCRUBBER EMISSION CONTROL

	5 TPH		15 TPH		
	Number and Size	Cost	Number and Size	Cost	N an
:.	2,000	$ 50,000	1-2,500 Sq. Ft.	$ 63,000	1-4,0
510/Sq. Ft.	1,000	10,000	1,500 Sq. Ft.	15,000	1-3,0
	1-5T	60,000	1-7½ T-70'	83,000	2-7½
	12,500 Oen	19,000	16,000 Sq. Ft.	128,000	25,0C
lopper	Lump Sum	20,000	Lump Sum	55,000	Lump
'eeders, Scales & Bins		-	Lump Sum	95,000	Lump
nent	Lump Sum	10,000	Lump Sum	40,000	
	1-45"	6,000	1-65"	8,000	2 -65
	Lump Sum	10,000		-	
		-	1-15 TPH	134,000	1-30
		24,000		-	
	1-36"	40,000	1-66"	80,000	1-90"
licator	Lump Sum	50,000	Lump Sum	66,000	Lump
	2,300 SCM	25,000	7,700 SCFM	30,000	14,3C
	1	5,000	1	6,000	1
	Lump Sum	3,000	Lump Sum	3,000	Lump
	Lump Sum	1,500	Lump Sum	2,000	Lump
	Lump Sum	7,500	Lump Sum	10,000	Lump
	Lump Sum	65,000	Lump Sum	75,000	Lump
.tions	Lump Sum	15,000	Lump Sum	20,000	Lump
	Lump Sum	5,000	Lump Sum	21,000	Lump
	Lump Sum	20,000	Lump Sum	30,000	Lump
ontrols		-	1-13½T 500KW	100,000	1-20/
		-	Lump Sum	30,000	Lump
aces		-	Lump Sum	20,000	Lump
E)		$366,000		$1,036,000	
D + E)		$ 13,000		$ 36,000	
+ F)		$439,000		$1,150,000	
		$ 22,000		$ 58,000	
		$461,000		$1,208,000	
		$ 46,000		$ 121,000	
		$507,000		$1,329,000	
		$50.70		$44.30	
				22.15	

EQUIPMENT REQUIREMENTS

POLA HOT BLAST, WATER-COOLED,
NNEI INDUCTION HOLDING FURNACE,
WET CRUBBER EMISSION CONTROL

5 TPH		15 TPH		30 TPH		50 TPH	
Number and Size	Cost	Number and Size	Cost	Number and Size	Cost	Number and Size	Cost
	$ 50,000	1-2,500 Sq. Ft.	$ 63,000	1-4,000 Sq. Ft.	$100,000	1-5,000 Sq. Ft.	$125,000
	10,000	1,500 Sq. Ft.	15,000	1-3,000 Sq. Ft.	30,000	5,000 Sq. Ft.	50,000
	60,000	1-7½ T-70'	83,000	2-7½ T	166,000	2-10T	200,000
0 Oen	19,000	16,000 Sq. Ft.	128,000	25,000 Sq. Ft.	192,000	30,000 Sq. Ft.	240,000
Sum	20,000	Lump Sum	55,000	Lump Sum	70,000	Lump Sum	90,000
	-	Lump Sum	95,000	Lump Sum	143,000	Lump Sum	240,000
Sum	10,000	Lump Sum	40,000	Sum	52,000	Lump Sum	75,000
	6,000	1-65"	8,000	2 -65"	16,000	3-65"	24,000
Sum	10,000		-		-		-
	-	1-15 TPH	134,000	1-30 TPH	165,000	1-50 TPH	225,000
	24,000		-		-		-
	40,000	1-66"	80,000	1-90"	180,000	1-108"	265,000
Sum	50,000	Lump Sum	66,000	Lump Sum	84,000	Lump Sum	150,000
SCM	25,000	7,700 SCFM	30,000	14,300 SCFM	52,000	20,600 SCFM	120,000
	5,000	1	6,000	1	12,000	1	15,000
Sum	3,000	Lump Sum	3,000	Lump Sum	4,500	Lump Sum	5,000
Sum	1,500	Lump Sum	2,000	Lump Sum	3,000	Lump Sum	5,000
Sum	7,500	Lump Sum	10,000	Lump Sum	12,000	Lump Sum	15,000
Sum	65,000	Lump Sum	75,000	Lump Sum	112,000	Lump Sum	195,000
Sum	15,000	Lump Sum	20,000	Lump Sum	25,000	Lump Sum	30,000
Sum	5,000	Lump Sum	21,000	Lump Sum	27,000	Lump Sum	36,000
Sum	20,000	Lump Sum	30,000	Lump Sum	40,000	Lump Sum	50,000
	-	1-13½T 500KW	100,000	1-20/8 800KW	200,000	1-60T 1,200KW	350,000
	-	Lump Sum	30,000	Lump Sum	80,000	Lump Sum	125,000
	-	Lump Sum	20,000	Lump Sum	45,000	Lump Sum	90,000
	$366,000		$1,036,000		$1,680,500		$2,545,000
	$ 13,000		$ 36,000		$ 59,000		$ 89,000
	$439,000		$1,150,000		$1,869,500		$2,809,000
	$ 22,000		$ 58,000		$ 93,000		$ 140,000
	$461,000		$1,208,000		$1,962,500		$2,949,000
	$ 46,000		$ 121,000		$ 196,000		$ 295,000
	$507,000		$1,329,000		$2,158,500		$3,244,000
	$50.70		$44.30		$35.98		$32.44
			22.15		17.99		16.22

B

A.	<u>Buildings</u>	
	Melting Building $13/Sq. Ft.	10,
	Transformer Rooms $10/Sq. Ft.	1,2
B.	<u>Scrapyard Equipment</u>	
	1. Scrapyard Crane	1-5
	2. Crane Runway & Stockyard	1-3
	3. Platform Scales	
	4. Magnets	1-4
C.	<u>Charging Equipment</u>	
	1. Charge Bucket Transfer Cars & Track	
	2. Charge Buckets	2
	3. Charging Crane	
D.	Melting Equipment	
	1. Arc Furnaces	2-3
	2. Transformers	1-5
	3. Furnace Refractories	Lum
	4. Electrodes	Lum
	5. Power Feeders, Piping Headers, Sewer Connections	
	6. Slag Buckets	1
E.	<u>Holding Equipment</u>	
	1. Channel Induction Furnaces & Electrics	None
	2. Spare Furnace Body	
	3. Refractories for Holding Furnaces	-
	Subtotal	
F.	Spares & Freight	
	Subtotal	
G.	Engineering 5%	
	Subtotal	
H.	Contingencies 10%	
	Total	
	Cost/Ton	
	500 Hours	
	1,000 Hours	
	2,000 Hours	
	1,000 Hours	
	2,000 Hours	
	4,000 Hours	

EQUIPMENT REQUIREMENTS

ELECTRIC ARC FURNACE, CHANNEL
INDUCTION HOLDING, FABRIC FILTER
EMISSION CONTROL

	5 TPH		15 TPH		
	Number and Size	Cost	Number and Size	Cost	a
	10,000 Sq. Ft.	$ 130,000	18,000	$ 234,000	25,0
	1,200 Sq. Ft.	12,000	1,500 Sq. Ft.	15,000	2,10
	1-5T	60,000	1-7½T-80'	83,000	2-7½
	1-3T	19,000		128,000	
		15,000	1	20,000	
	1-45"	6,000	1-65"	8,000	2-65
ack		10,000	Lump Sum	15,000	
	2	10,000	3	18,000	3
			1-25/45	85,000	
	2-3T	410,000	2-11"-15T	830,000	3"-1
	1-5,000KVA	Included in D-1	2-7,500 KVA	Included in D-1	3-10
	Lump	9,000	Lump	20,000	Lump
	Lump	2,000	Lump	6,000	Lump
ewer Connections		10,000	Lump	20,000	
	1	3,000	2	8,000	3
ctrics	None	-	1-30T 600 KW.	325,000	2-40
		-	1	115,000	1
·s	-	-	Lump	45,000	Lump
		$554,000		$1,726,000	
		$ 19,000		$ 61,000	
		$715,000		$2,036,000	
		$ 36,000		$ 102,000	
		$751,000		$2,138,000	
		$ 75,000		$ 214,000	
		$826,000		$2,352,000	
		$330			
		165			
		82.50			
				$156.80	
				78.40	
				39.20	

EQUIPMENT REQUIREMENTS

LECTRIC ARC FURNACE, CHANNEL
UCTION HOLDING, FABRIC FILTER
EMISSION CONTROL

5 TPH		15 TPH		30 TPH		50 TPH	
mber Size	Cost	Number and Size	Cost	Number and Size	Cost	Number and Size	Cost
Sq. Ft.	$ 130,000	18,000	$ 234,000	25,000 Sq. Ft.	$ 325,000	30,000 Sq. Ft.	$ 540,000
Sq. Ft.	12,000	1,500 Sq. Ft.	15,000	2,100 Sq. Ft.	21,000	3,000 Sq. Ft.	30,000
	60,000	1-7½T-80'	83,000	2-7½T	166,000	2-10T	200,000
	19,000		128,000		192,000	30,000 Sq. Ft.	240,000
	15,000	1	20,000		30,000	2	50,000
	6,000	1-65"	8,000	2-65"	16,000	3-65"	24,000
	10,000	Lump Sum	15,000		20,000	2	25,000
	10,000	3	18,000	3	18,000	4	24,000
		1-25/45	85,000		100,000	1	130,000
	410,000	2-11"-15T	830,000	3"-15T	1,275,000	4-11'-15T	1,816,000
)KVA	Included in D-1	2-7,500 KVA	Included in D-1	3-10,000 KVA	Included in D-1	4-13,000 KVA	Included in D-1
	9,000	Lump	20,000	Lump	30,000	Lump	40,000
	2,000	Lump	6,000	Lump	9,000	Lump	12,000
	10,000	Lump	20,000		25,000		30,000
	3,000	2	8,000	3	9,000	4	12,000
	-	1-30T 600 KW.	325,000	2-40T 800 KW Ea.	700,000	2-[illegible]0T 1200 KW Ea.	800,000
	-	1	115,000	1	125,000	1	145,000
	-	Lump	45,000	Lump	90,000	Lump	180,000
	$554,000		$1,726,000		$2,815,000		$3,778,000
	$ 19,000		$ 61,000		$ 99,000		$ 132,000
	$715,000		$2,036,000		$3,260,000		$4,480,000
	$ 36,000		$ 102,000		$ 163,000		$ 224,000
	$751,000		$2,138,000		$3,423,000		$4,704,000
	$ 75,000		$ 214,000		$ 342,000		$ 470,000
	$826,000		$2,352,000		$3,765,000		$5,174,000

5 TPH	15 TPH	30 TPH	50 TPH
$330	$156.80	$62.75	$51.74
165	78.40	31.38	25.87
82.50	39.20		

B

CORELI
PREHE/
AI

		Numb... and S...
A.	Buildings	
	Melting Building $17/Sq. Ft.	5,000
	Transformer Building $10/Sq. Ft.	1,000 Sq.
B.	Scrapyard Equipment	
	1. Scrapyard Crane	1-5T
	2. Crane Runway	Open
	3. Platform Scales	
	4. Magnets	1-45"
	5. Charge Bucket Transfer Cars & Track	
C.	Charging Equipment	
	Charging Monorail	
D.	Melting Equipment	
	1. Coreless Induction Furnaces	2-10 Ton KW 2,100
	3. Preheater with Charge Bucket	1
	4. Slag Box	
	5. Piping, Headers, Sewer Connections	
E.	Holding Equipment - None Specified	
	Subtotal #1 (B + C + D + E)	
F.	Spares & Freight (3½% of B, C, D, E)	
	Subtotal #2 (ST. #1 + A + F)	
G.	Engineering (5% of ST. #2)	
	Subtotal #3 (G + ST. #2)	
H.	Contingencies (10% of ST. #3)	
	Total (ST. #3 + H)	

Cost/Ton
500
1,000
2,000

1,000
2,000
4,000

2,000
4,000

A

EQUIPMENT REQUIREMENTS

CORELESS INDUCTION FURNACES, WITH PREHEATERS, NO HOLDING FURNACES, AFTERBURNER ON PREHEATER

5 TPH Number and Size	5 TPH Cost	15 TPH Number and Size	15 TPH Cost	Nu and
5,000	$ 85,000	9,000 Sq. Ft.	$ 153,000	13,500
1,000 Sq. Ft.	10,000	1,200 Sq. Ft.	12,000	1,800
1-5T	60,000	1-7½T-80' Span	83,000	2-7½T
Open	19,000	Covered	128,000	Covere
	15,000	1	20,000	
1-45"	6,000	1-65"	8,000	2-65"
	8,000	Lump	10,000	
	40,000		50,000	
2-10 Ton KW 2,100 Each	400,000	2-20 Ton 4,100 KW Each	850,000	3-25 T 6,250
1	28,000	2	64,000	3
	2,000		5,000	
	10,000		20,000	
	$588,000		$1,238,000	
	$ 21,000		$ 43,000	
	$704,000		$1,446,000	
	$ 35,000		$ 72,000	
	$739,000		$1,518,000	
	$ 74,000		$ 152,000	
	$813,000		$1,670,000	

$325
162.50
81.25

$111.33
55.67
27.84

QUIPMENT REQUIREMENTS

SS INDUCTION FURNACES, WITH
TERS, NO HOLDING FURNACES,
TERBURNER ON PREHEATER

5 TPH		15 TPH		30 TPH		50 TPH	
r ze	Cost	Number and Size	Cost	Number and Size	Cost	Number and Size	Cost
	$ 85,000	9,000 Sq. Ft.	$ 153,000	13,500 Sq. Ft.	$ 230,000	20,000 Sq. Ft.	$ 340,000
Ft.	10,000	1,200 Sq. Ft.	12,000	1,800 Sq. Ft.	18,000	3,000 Sq. Ft.	30,000
	60,000	1-7½T-80' Span	83,000	2-7½T	166,000	2-10T	200,000
	19,000	Covered	128,000	Covered	192,000	Covered	240,000
						30,000 Sq. Ft.	
	15,000	1	20,000		30,000	2	50,000
	6,000	1-65"	8,000	2-65"	16,000	3	24,000
	8,000	Lump	10,000		15,000	2	20,000
	40,000		50,000		60,000		75,000
	400,000	2-20 Ton	850,000	3-25 Ton	1,600,000	4-30 Ton	2,200,000
Each		4,100 KW Each		6,250 KW Each		6,750 KW Each	
	28,000	2	64,000	3	129,000	4	172,000
	2,000		5,000		7,000	4	10,000
	10,000		20,000		25,000		30,000
	$588,000		$1,238,000		$2,240,000		$3,021,000
	$ 21,000		$ 43,000		$ 78,000		$ 106,000
	$704,000		$1,446,000		$2,566,000		$3,497,000
	$ 35,000		$ 72,000		$ 128,000		$ 175,000
	$739,000		$1,518,000		$2,694,000		$3,672,000
	$ 74,000		$ 152,000		$ 269,000		$ 367,000
	$813,000		$1,670,000		$2,963,000		$4,039,000
	$325						
	162.50						
	81.25						
			$111.33				
			55.67				
			27.84				
					$ 49.38		$ 40.39
					24.69		20.20

DIRECT M

Metallics	Cost per Pound	Lined Cupola Percent	Lined Cupola Pounds	Lined Cupola Cost	Perc
Pig Iron	$.03326	5%	104	$3.46	
#2 Heavy Melting Steel Scrap	.01451	30	623	9.04	37
#1 Heavy Melting Steel Scrap	.01813	5	104	1.89	5
Borings-Briquettes	.01506	15	312	4.70	15
Borings-Loose	.00924	-	-		-
Iron Scrap-Remelt	.02121	34	706	14.97	32
Iron, Cast Scrap	.02121	10	208	4.41	10
Sil Mn. Briquettes	.1050	.40	8	.84	.
Sil. Carb. Briquettes	.075	.40	4	.60	.
Fe. Si. 85%	.1945	.20	4	.78	.
Fe. Si. 50%	.1530	-	-		-
			2,077		
Nonmetallics					
Coke	.02475		360	$8.91	
Sil. Mn. Briquettes	.1050		1.5	.16	
Carbo-Graphite	.04		8.5	.34	
Soda Ash	.03		2.5	.08	
Limestone	.00388		60	.23	
Sil. Carb. Briquettes	.075		9	.68	
Cost per Ton				$51.09	

A

DIRECT MATERIAL COST

	Lined Cupola		Water-Cooled Cupola			Electric Furnace		
t	Pounds	Cost	Percent	Pounds	Cost	Percent	Pounds	
	104	$3.46						
	623	9.04	37	800	$11.61			
	104	1.89	5	104	1.89	50%	1,045	$
	312	4.70	15	312	4.70	-		
	-		-	-		15	300	
	706	14.97	32	706	14.97	33	680	
	208	4.41	10	208	4.41	-	-	
	8	.84	.40	8	.84			
	4	.60	.40	8	.60			
	4	.78	.20	4	.78	.4	8	
	-		-	-		1.4	30	
	2,077			2,150			2,063	
	360	$8.91		250	$6.19			
	1.5	.16		1.5	.16			
	8.5	.34		-			60	
	2.5	.08		2.5	.08			
	60	.23		60	.23			
	9	.68		9	.68			
		$51.09			$47.14			$

TERIAL COST

ater-Cooled Cupola			Electric Furnace			Induction Furnace		
nt	Pounds	Cost	Percent	Pounds	Cost	Percent	Pounds	Cost
	800	$11.61						
	104	1.89	50%	1,045	$18.95	27	550	$ 9.97
	312	4.70	-			15	302	4.55
	-		15	300	2.77	-		
	706	14.97	33	680	14.42	34	686	14.55
	208	4.41	-	-		22	445	9.44
0	8	.84						
0	8	.60						
0	4	.78	.4	8	1.56	.4	8	1.56
	-		1.4	30	4.59	1.4	30	4.59
	2,150			2,063			2,021	
	250	$6.19						
	1.5	.16						
	-			60	$2.40		60	$2.40
	2.5	.08						
	60	.23						
	9	.68						
		$47.14			$44.69			$47.06

SUMMARY OF C

CUPOLA, COLD BLAST
FABRIC FILTER

Costs Per Ton	Melt Rate 5 Tons Per Hour Operating Hours Per Year 500	1,000	2,000
Direct and Indirect Labor	$18.00	$16.00	$14.00
Salaried Personnel	4.32	3.60	2.88
Depreciation	16.00	8.00	5.00
Capital Charges (Interest, Insurance, Taxes)	20.40	10.20	6.50
Electrical Power	.07	.05	.04
Gas	.05	.05	.05
Supplies and Maintenance Material	3.00	3.00	3.00
Allocated Costs	4.00	4.00	4.00
Total	$65.84	$44.90	$35.27

SUMMARY OF CONVERSION COSTS

CUPOLA, COLD BLAST NO HOLDING FURNACE,
FABRIC FILTER EMISSION CONTROL

Melt Rate 5 Tons Per Hour			Melt Rate 15 Tons Per Hour			Melt Rate 30 Tons Per	
erating Hours Per Year			Operating Hours Per Year			Operating Hou	
00	1,000	2,000	1,000	2,000	4,000	2,000	4
8.00	$16.00	$14.00	$ 8.67	$ 7.33	$ 6.36	$ 5.83	$
4.32	3.60	2.88	1.92	1.92	1.44	.96	
6.00	8.00	5.00	6.73	4.07	2.03	3.50	
0.40	10.20	6.50	8.80	5.30	2.65	4.55	
.07	.05	.04	.05	.03	.03	.03	
.05	.05	.05	.05	.05	.05	.05	
3.00	3.00	3.00	3.00	3.00	3.00	3.00	
4.00	4.00	4.00	4.00	4.00	4.00	4.00	
5.84	$44.90	$35.27	$33.22	$25.70	$19.56	$21.92	$

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VERSION COSTS

NO HOLDING FURNACE,
MISSION CONTROL

Melt Rate 15 Tons Per Hour — Operating Hours Per Year 1,000	2,000	4,000	Melt Rate 30 Tons Per Hour — Operating Hours Per Year 2,000	4,000	Melt Rate 50 Tons Per Hour — Operating Hours Per Year 2,000	4,000
$ 8.67	$ 7.33	$ 6.36	$ 5.83	$ 4.58	$ 4.30	$ 3.35
1.92	1.92	1.44	.96	.72	.58	.43
6.73	4.07	2.03	3.50	1.75	2.87	1.44
8.80	5.30	2.65	4.55	2.28	3.73	1.87
.05	.03	.03	.03	.02	.02	.02
.05	.05	.05	.05	.05	.05	.05
3.00	3.00	3.00	3.00	3.00	3.00	3.00
4.00	4.00	4.00	4.00	4.00	4.00	4.00
$33.22	$25.70	$19.56	$21.92	$16.40	$18.55	$14.16

B

SUMMARY OF C(

CUPOLA, HOT BLAST, W
CHANNEL INDUCTION H
ENERGY WET SCRUBI

Cost per Ton	Melt Rate 5 Tons per Hour, Operating Hours per Year 2,000	4,000
Direct and Indirect Labor	$17.00	$15.00
Salaried Personnel	2.88	2.16
Depreciation	5.07	2.54
Capital Charges (Interest, Insurance, Taxes)	6.59	3.29
Electrical Power	.05	.04
Water	.20	.20
Gas	.25	.25
Supplies and Maintenance Material	2.00	2.00
Allocated Costs	4.00	4.00
Total	$38.04	$29.48

A

SUMMARY OF CONVERSION COSTS

CUPOLA, HOT BLAST, WATER-COOLED, UNLINED, CHANNEL INDUCTION HOLDING FURNACE, HIGH ENERGY WET SCRUBBER EMISSION CONTROL

Melt Rate 5 Tons per Hour		Melt Rate 15 Tons per Hour		Melt Rate 30 Tons per
›erating Hours per Year		Operating Hours per Year		Operating Ho
2,000	4,000	2,000	4,000	2,000
$17.00	$15.00	$ 7.33	$ 5.83	$ 5.50
2.88	2.16	1.92	1.44	.96
5.07	2.54	4.43	2.22	3.60
6.59	3.29	5.76	2.88	4.68
.05	.04	.62	.40	.52
.20	.20	.20	.20	.20
.25	.25	.25	.25	.25
2.00	2.00	2.00	2.00	2.00
4.00	4.00	4.00	4.00	4.00
$38.04	$29.48	$26.51	$19.22	$21.71

.PPENDIX D
NUMBER 45

VERSION COSTS

TER-COOLED, UNLINED,
LDING FURNACE, HIGH
R EMISSION CONTROL

Melt Rate 15 Tons per Hour		Melt Rate 30 Tons per Hour		Melt Rate 50 Tons per Hour	
Operating Hours per Year		Operating Hours per Year		Operating Hours per Year	
2,000	4,000	2,000	4,000	2,000	4,000
$ 7.33	$ 5.83	$ 5.50	$ 4.41	$ 3.90	$ 3.10
1.92	1.44	.96	.72	.58	.43
4.43	2.22	3.60	1.80	3.24	1.62
5.76	2.88	4.68	2.34	4.21	2.11
.62	.40	.52	.33	.45	.29
.20	.20	.20	.20	.20	.20
.25	.25	.25	.25	.25	.25
2.00	2.00	2.00	2.00	2.00	2.00
4.00	4.00	4.00	4.00	4.00	4.00
$26.51	$19.22	$21.71	$16.05	$18.83	$14.00

B

SUMMARY OF (

ELECTRIC ARC FURNACE WITH C
FABRIC FILTE

Costs Per Ton	Melt Rate 5 Tons Per Hour — Operating Hours Per Year			O
	500	1,000	2,000	I
Direct and Indirect Labor	$18.00	$14.00	$12.00	
Salaried Personnel	4.32	3.60	2.88	
Depreciation	33.04	16.52	8.26	
Capital Charges (Interest, Insurance, Taxes)	42.95	21.48	10.74	
Electrical Power	36.00	19.90	11.76	
Water	.05	.05	.05	
Gas	.05	.05	.05	
Electrodes	2.85	2.85	2.85	
Supplies and Maintenance Material	2.50	2.50	2.50	
Allocated Costs	4.00	4.00	4.00	
Total	$143.76	$84.95	$55.09	$

A

SUMMARY OF CONVERSION COSTS

ELECTRIC ARC FURNACE WITH CHANNEL INDUCTION HOLDING FURNACE,
FABRIC FILTER EMISSION CONTROL

	Melt Rate 5 Tons Per Hour			Melt Rate 15 Tons Per Hour			Melt Rate 30 Tons Per Hour	
	Operating Hours Per Year			Operating Hours Per Year			Operating Hours	
	500	1,000	2,000	1,000	2,000	4,000	2,000	4,
	$18.00	$14.00	$12.00	$7.66	$6.67	$5.50	$5.33	$
	4.32	3.60	2.88	1.92	1.92	1.44	.96	
	33.04	16.52	8.26	15.67	7.84	3.92	6.28	
ces)	42.95	21.48	10.74	20.40	10.20	5.10	8.17	
	36.00	19.90	11.76	19.68	11.86	7.92	11.25	
	.05	.05	.05	.05	.05	.05	.05	
	.05	.05	.05	.05	.05	.05	.05	
	2.85	2.85	2.85	2.85	2.85	2.85	2.85	
	2.50	2.50	2.50	2.50	2.50	2.50	2.50	
	4.00	4.00	4.00	4.00	4.00	4.00	4.00	
	$143.76	$84.95	$55.09	$74.78	$47.94	$33.33	$41.44	$2

SUMMARY OF (

ELECTRIC ARC FURNACE WITH C
FABRIC FILTE

Costs Per Ton	Melt Rate 5 Tons Per Hour Operating Hours Per Year 500	1,000	2,000
Direct and Indirect Labor	$18.00	$14.00	$12.00
Salaried Personnel	4.32	3.60	2.88
Depreciation	33.04	16.52	8.26
Capital Charges (Interest, Insurance, Taxes)	42.95	21.48	10.74
Electrical Power	36.00	19.90	11.76
Water	.05	.05	.05
Gas	.05	.05	.05
Electrodes	2.85	2.85	2.85
Supplies and Maintenance Material	2.50	2.50	2.50
Allocated Costs	4.00	4.00	4.00
Total	$143.76	$84.95	$55.09

A-

SUMMARY OF CONVERSION COSTS

TRIC ARC FURNACE WITH CHANNEL INDUCTION HOLDING FURNACE, FABRIC FILTER EMISSION CONTROL

Rate ns Per Hour ng Hours Per Year		Melt Rate 15 Tons Per Hour Operating Hours Per Year			Melt Rate 30 Tons Per Hour Operating Hours	
1,000	2,000	1,000	2,000	4,000	2,000	4,
$14.00	$12.00	$7.66	$6.67	$5.50	$5.33	$
3.60	2.88	1.92	1.92	1.44	.96	
16.52	8.26	15.67	7.84	3.92	6.28	
21.48	10.74	20.40	10.20	5.10	8.17	
19.90	11.76	19.68	11.86	7.92	11.25	
.05	.05	.05	.05	.05	.05	
.05	.05	.05	.05	.05	.05	
2.85	2.85	2.85	2.85	2.85	2.85	
2.50	2.50	2.50	2.50	2.50	2.50	
4.00	4.00	4.00	4.00	4.00	4.00	
$84.95	$55.09	$74.78	$47.94	$33.33	$41.44	$2

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NUMBER 46

ONVERSION COSTS

ANNEL INDUCTION HOLDING FURNACE,
EMISSION CONTROL

Melt Rate 15 Tons Per Hour — Operating Hours Per Year			Melt Rate 30 Tons Per Hour — Operating Hours Per Year		Melt Rate 50 Tons Per Hour — Operating Hours Per Year	
000	2,000	4,000	2,000	4,000	2,000	4,000
7.66	$6.67	$5.50	$5.33	$4.50	$4.10	$3.45
1.92	1.92	1.44	.96	.72	.58	.43
5.67	7.84	3.92	6.28	3.14	5.17	2.59
0.40	10.20	5.10	8.17	4.09	6.73	3.37
9.68	11.86	7.92	11.25	7.57	11.11	7.50
.05	.05	.05	.05	.05	.05	.05
.05	.05	.05	.05	.05	.05	.05
2.85	2.85	2.85	2.85	2.85	2.85	2.85
2.50	2.50	2.50	2.50	2.50	2.50	2.50
4.00	4.00	4.00	4.00	4.00	4.00	4.00
'4.78	$47.94	$33.33	$41.44	$29.47	$37.14	$26.79

B

SUMMARY OF C(

CORELESS INDUCTION FURN
NO HOLDING FURNACE, /

Costs Per Ton	Melt Rate 5 Tons Per Hour Operating Hours Per Year 500	1,000	2,000	] Op 1.
Direct and Indirect Labor	$18.00	$15.00	$14.00	$
Salaried Personnel	4.32	3.60	2.88	
Depreciation	32.52	16.26	8.13	]
Capital Charges (Interest, Insurance, Taxes)	42.27	21.14	10.57	]
Electrical Power	39.79	22.18	13.37	]
Water	.05	.05	.05	
Gas	.30	.30	.30	
Supplies and Maintenance Material	3.00	3.00	3.00	
Allocated Costs	4.00	4.00	4.00	
Total	$144.25	$85.53	$56.30	$

SUMMARY OF CONVERSION COSTS

CORELESS INDUCTION FURNACE WITH CHARGE PREHEATER, NO HOLDING FURNACE, AFTERBURNER ON PREHEATER

	elt Rate ons Per Hour iting Hours Per Year		Melt Rate 15 Tons Per Hour Operating Hours Per Year			Melt Rate 30 Tons Per Ho Operating Hours	
	1,000	2,000	1,000	2,000	4,000	2,000	4
0	$15.00	$14.00	$ 8.00	$ 7.00	$ 6.36	$ 4.84	$
2	3.60	2.88	1.92	1.92	1.44	.96	
2	16.26	8.13	11.13	5.57	2.78	4.94	
7	21.14	10.57	14.47	7.24	3.62	6.42	
9	22.18	13.37	14.86	9.40	6.64	9.64	
5	.05	.05	.05	.05	.05	.05	
0	.30	.30	.30	.30	.30	.30	
0	3.00	3.00	3.00	3.00	3.00	3.00	
0	4.00	4.00	4.00	4.00	4.00	4.00	
5	$85.53	$56.30	$57.73	$38.48	$28.19	$34.15	$

APPENDIX D
NUMBER 47

VERSION COSTS

E WITH CHARGE PREHEATER,
TERBURNER ON PREHEATER

Melt Rate			Melt Rate		Melt Rate	
5 Tons Per Hour			30 Tons Per Hour		50 Tons Per Hour	
rating Hours Per Year			Operating Hours Per Year		Operating Hours Per Year	
00	2,000	4,000	2,000	4,000	2,000	4,000
3.00	$ 7.00	$ 6.36	$ 4.84	$ 4.16	$ 3.90	$ 3.40
1.92	1.92	1.44	.96	.72	.58	.43
1.13	5.57	2.78	4.94	2.47	4.04	2.02
4.47	7.24	3.62	6.42	3.21	5.25	2.62
4.86	9.40	6.64	9.64	6.76	8.68	6.28
.05	.05	.05	.05	.05	.05	.05
.30	.30	.30	.30	.30	.30	.30
3.00	3.00	3.00	3.00	3.00	3.00	3.00
4.00	4.00	4.00	4.00	4.00	4.00	4.00
7.73	$38.48	$28.19	$34.15	$24.67	$29.80	$22.10

B

ANNUAL
FOR EMISSION CO

	5 Tons/Hour		
	500	1,000	2,000
1. Fabric Filter on Cupola (Cold Blast)			
Number Cupolas	1	1	1
ACFM Each	9,200	9,200	9,200
Annual Operating Cost	$25,000	$30,000	$35,000
Annual Tons	2,500	5,000	10,000
Cost/Ton	$10	$6	$3.50
2. Wet Scrubber on Cupola (Hot Blast)			
ACFM			6,800
Annual Operating Cost			$35,000
Annual Tons			10,000
Cost/Ton			$3.50
3. Fabric Filter on Electric Arc			
Furnace Diameter	7'3"	7'3"	7'3"
Annual Operating Cost/System	$28,000	$31,000	$37,500
Number Fabric Filter Systems	2	2	2
Total Annual Operating Cost	$56,000	$62,000	$65,000
Annual Tons	2,500	5,000	10,000
Cost/Ton	$22.40	$12.40	$6.50
4. Afterburner on Coreless Induction			
Annual Operating Cost	$1,150	$1,350	$1,730
Tons	2,500	5,000	10,000
Cost/Ton	$.46	$.27	$.17

A

ANNUAL OPERATING COSTS
FOR EMISSION CONTROL EQUIPMENT SYSTEMS

	5 Tons/Hour				15 Ton	
	500	1,000	2,000	4,000	1,000	2,C
Cold Blast)						
	1	1	1		1	
	9,200	9,200	9,200		27,300	27,
	$25,000	$30,000	$35,000		$60,000	$70,
	2,500	5,000	10,000		15,000	30,
	$10	$6	$3.50		$4.00	$2
ot Blast)						
			6,800	6,800		22,
			$35,000	$50,000		$60,
			10,000	20,000		30,
			$3.50	$2.50		$2
Arc						
	7'3"	7'3"	7'3"		11'	
ystem	$28,000	$31,000	$37,500		$41,000	$49,
stems	2	2	2		2	
Cost	$56,000	$62,000	$65,000		$82,000	$98.
	2,500	5,000	10,000		15,000	30.
	$22.40	$12.40	$6.50		$5.47	$3
nduction						
	$1,150	$1,350	$1,730		$3,040	$4.
	2,500	5,000	10,000		15,000	30.
	$.46	$.27	$.17		$.20	$

)PERATING COSTS
'TROL EQUIPMENT SYSTEMS

	15 Tons/Hour			30 Tons/Hour		50 Tons/Hour	
,000	1,000	2,000	4,000	2,000	4,000	2,000	4,000
	1	1	1	2	2	2	2
	27,300	27,300	27,300	27,300 Each	27,300 Each	37,200 Each	37,200 Each
	$60,000	$70,000	$80,000	$140,000	$160,000	$180,000	$200,000
	15,000	30,000	60,000	60,000	120,000	100,000	200,000
	$4.00	$2.33	$1.33	$2.33	$1.33	$1.80	$1.00
6,800		22,800	22,800	43,000	43,000	62,000	62,000
50,000		$60,000	$75,000	$110,000	$140,000	$165,000	$195,000
20,000		30,000	60,000	60,000	120,000	100,000	200,000
$2.50		$2.00	$1.25	$1.83	$1.17	$1.65	$ .98
	11'	11'	11'	11'	11'	11'	11'
	$41,000	$49,000	$64,000	$49,000	$64,000	$49,000	$64,000
	2	2	2	3	3	4	4
	$82,000	$98,000	$128,000	$147,000	$192,000	$196,000	$256,000
	15,000	30,000	60,000	60,000	120,000	100,000	200,000
	$5.47	$3.27	$2.13	$2.45	$1.60	$1.96	$1.28
	$3,040	$4,150	$6,380	$7,260	$11,640	$11,060	$18,280
	15,000	30,000	60,000	60,000	120,000	100,000	200,000
	$.20	$.14	$.11	$.12	$.10	$.11	$.09

EMISSION TEST PROCEDURES

A standard recommended procedure for testing particulate emissions from iron foundry cupolas did not exist until the end of 1970. At that time the "Recommended Practice for Testing Particulate Emissions from Iron Foundry Cupolas" was adopted by the American Foundrymen's Society and the Gray and Ductile Iron Founders' Society, Inc. This industry standard procedure, broadly based on the American Society of Mechanical Engineers Performance Test Codes 21-1941 and 27-1957, recognizes the unique problems of cupola testing and recommends procedures to deal with them in a satisfactory manner. The recommended practice is reproduced in Exhibit 1 of this appendix for information purposes only.

In a more specific manner, Exhibit 2 presents detailed sampling and analytical techniques for individual components of cupola emissions. These techniques are widely accepted by chemical and testing laboratories and used in analytical work. Techniques are included for identification and quantification of particulate matter such as arsenic, beryllium, cadmium, fluorides, lead, mercury, and zinc, and two gaseous components, nitrogen oxides and sulfer dioxide.

APPENDIX E
EXHIBIT 1

RECOMMENDED PRACTICE FOR TESTING

PARTICULATE EMISSIONS

FROM

IRON FOUNDRY CUPOLAS

Edited by

A Joint Committee of

American Foundrymen's Society

and

The Gray & Ductile Iron Founders' Society, Inc.

The recommended procedure discussed in this section has, as of this date, not been endorsed by any bodies other than A.F.S. and G.D.I.F.S. and is presented for information only.

INTRODUCTION

The iron foundry industry has had many air pollution studies conducted on cupola emissions at their various plants. Of great concern to the industry and to the individual firms that have conducted such testing are the many varied and diverse test methods and test procedures used by the variety of independent organizations conducting such tests. The diverse methods and equipment used in performing such tests have made comparison and evaluation of results impractical or a near impossibility. Many of the tests conducted have shown marked inconsistencies between individual test runs by the same test group and also in comparing the results on the same system by different testing organizations.

A number of the procedures used in cupola testing suffer from obvious inadequacies when they are carefully scrutinized. Consequently, it has been deemed desirable and necessary that a recommended test procedure and testing method be made available to assist the metalcasting industry in achieving the maximum in emission control with the minimum of wasted and misdirected effort and expense. Since the industry is unique in the large, nonproductive investments needed to gain compliance with air pollution control requirements, it is especially significant that its emissions be evaluated by test methods and procedures able to produce consistently reliable results detailing these emissions, but do not unnecessarily and unfairly penalize the plant.

Particulate emission tests of cupola stack gases are done under varied conditions and in several different locations, depending on the test objective. Both location and objective influence the test equipment employed although the two usual purposes will be:

1) to determine nature and/or quantity of emissions released in the raw cupola gases
2) to determine nature and/or quantity of emissions on the cleaned gas side of a control unit.

Raw gas test locations:

a) In cupola stack, above charging door. This is the most difficult location for testing. Gas flow is extremely uneven and the flow rate is relatively low; gas temperature is high - often 1200°-2200°F - and fluctuating; dust loading is extremely uneven because of channeling caused by indraft of much cold outside air drawn into the cupola stack through the charge door. This test location is necessary where a cupola has no control systems or has a wet cap type collector.

b) In inlet duct ahead of dust collector. This is an easier location if a reasonably straight duct run is available. Duct velocities and dust loadings are more uniform and confined in a smaller cross section. Normally gases will be cooled to 500°F or lower at the sampling point from evaporation of cooling water. The added volume of water vapor must be measured and considered in gas density calculations and dust loadings if reported in grains per standard cubic feet dry gas. Inlet and outlet samples should be supplemented wherever possible by using the catch as a check for the test data. Catch can be more readily obtained from dry collector types especially for a complete melting cycle.

c) Catch plus outlet loadings. Where dry collectors are employed, the entire test procedure is simplified by actual weighing of collected material. The higher the efficiency of the collecting device the more nearly the catch will represent the raw sample. Chances for error are diminished because of quantity of collected material available although it will be difficult to obtain accurate catch quantities except for a complete melting cycle - thus providing an averaging of the peaks and valleys of emission concentrations.

See comments for outlet loading under "Cleaned Gas Locations".

Cleaned Gas Locations:

a) After dry collector. Conventional dust sampling techniques will be satisfactory for such locations. Coarse particles will be removed by a dust collector so the importance of a large diameter sampling probe diminishes. Water vapor content of the gas should cause no condensation problems with 350° to 550°F gas temperatures. Collecting device in sampler can be influenced by intended analysis - gross weight, particle size distribution, chemical composition, particle count, etc.

b) After wet collector. Sampling problems are more complicated than after dry collectors because gas stream is saturated or nearly so. Close coupling of sampling components is essential and heating of the sampled air often required.
Exception: Wet cap type of collectors have too short a contact time to bring gas stream close to saturated conditions. Sampling after the collector will be questionable value unless gases are gathered in a discharge stack of several diameter lengths.

In recognition of these differences in purpose and location for testing emissions the following procedure is divided into three sections.

Section I deals exclusively with sampling raw particulate emissions in the cupola stack.

Section II deals exclusively with sampling raw particulate emissions in the inlet duct connecting the cupola to the dust collector.

Section III deals exclusively with sampling cupola gases after they have been cleaned.

REASONS FOR SAMPLING A CUPOLA

Basically sampling is done for three reasons:

1) to determine if a collecting device is of a high enough efficiency so that its effluent does not exceed a pre-determined level.
2) to meet regulatory requirements that specify a minimum efficiency of removal of particulate from the gas stream, expressed as a percentage of uncontrolled emission.
3) to obtain information regarding particulate emission which will be used for designing gas cleaning devices.

Officials of local, regional or state regulatory bodies should be consulted prior to testing except when the testing is being done for purely informational data for the cupola owner or operator.

If source testing is being done to determine compliance with legal requirements the appropriate control officials should be consulted. If the control body has experience and is equipped to perform cupola testing, they may wish to perform their own tests to determine compliance.

Generally control bodies will not accept the results of tests performed by the owners, operators or vendors of collection devices unless standard procedures were followed and test data and reports show evidence that experienced personnel conducted the tests.

In most cases it will be necessary for the owner or operator of a cupola to employ the services of an organization capable of performing these tests. When this is done the control authorities should have given prior approval of the testing organizations capabilities and acceptability of their test results. In any event, it is advisable to notify the proper authorities in advance so that they may have on site observers present if they so desire.

The foundryman should select a testing organization with proven capability, a good reputation and in whom he has complete confidence. As test data can have major economic consequences and as the foundryman usually cannot check the quality of the testing procedures confidence in the organization is a pre-requisite.

The next step is consultation with the appropriate control authorities. The foundryman along with the testing organization must involve themselves in this because regulations are sometimes not easily understood, and frequently interpretation is modified by political and community attitudes. Authorities will be aware of changes in enforcement policies, or pending changes in legislation, and the foundryman cannot expect outside testing organizations to be cognizant of these considerations.

The number and type of tests to be taken must be agreed on in advance by all parties concerned. Frequently, meeting the specifications of the pertinent code dictate the number and kind of samples to be run. At other times the purchase agreement between vendor and foundryman specifies testing methods. If discretion can be used the use of several short tests is recommended over one longer one. When several results can be compared, any large differences are evident. If these differences are not as a result of operational changes or adjustments they may indicate error in the test procedure or malfunction of the test equipment. One test of long duration gives only one answer with no basis for comparison. Accuracy and precision of testing is controlled as much by the care exercised and quality of the testing personnel as it is by the test procedure.

Errors in each manipulation such as weighing, measuring gas volume, and calculating results must not exceed 1 percent and should be kept under that if possible. In this way cumulative errors can be held to little more than 1 percent.

CUPOLA OPERATING AND TEST CONDITIONS

Due to the various possible modes of operation of cupolas and cupola systems, it is recommended that cupola emissions be evaluated under conditions that characterize normal or average cupola operations at any particular plant.

Particulate matter emitted via raw cupola stack gases consists principally of iron oxides and silica from the charge metal and impurities adhering to the charge metal plus combustible matter. Secondary combustion in the upper portion of a cupola stack will tend to reduce the combustible portion of the particulate emissions to ash if temperature and retention time are sufficient.

Cupola stack gas will also contain some vapor from substances which reaches the melting zone and is volatilized. These substances include silicon, zinc and silica (sand). The degree of volatilization will depend on melting zone temperature which is influenced by changes in the fuel (coke and/or gas) ratio, preheating of the blast air or scrap and enrichment of the blast air with oxygen. Consequently, it is of utmost importance that the factors affecting melt zone temperature be normal before testing begins. Equally as important, materials that can cause fuming, such as galvanized iron, sand, and silicon, for example, be added in normal amounts during the test period. Changes from normal melt process can result in emissions which are markedly better or worse than will be obtained during everyday operation. Either result will be unsatisfactory.

The particulate matter emanating from a cupola has a wide range of particle size distribution which influences the correct choice of stack testing method. For many cupolas, peaks in particle sizes can be found on distribution curves at three ranges. These are in the 200 to 500 micron range, the 20 to 50 micron range and the 5 micron and below range.

Many factors influence the particulate emission rates of a cupola system. These include the rate of cupola operation, the character, cleanliness and method of introduction of the charge material, the type, size and amount of the coke used, the frequency, length of time and number of periods when tuyere blast air is operative or inoperative during any period, the type of metal being melted, the method and type of alloy introduction, and other diverse factors.

It is necessary, therefore, that each cupola and cupola system be individually analyzed to determine conditions under which stack or source emission tests are needed to define the full range and character of its emissions.

One of the factors having a most profound effect in cupola emissions is the rate of cupola melting; as cupola blast air and coke input is increased to accommodate higher melting rates, cupola emissions increase significantly. It is important, therefore, that cupola source-emission tests be conducted at melting rates approaching the normal expected rate of cupola operation if the results are expected to characterize emissions for the system. Often times it is not practical to operate at maximum melting rates since melting rates must reflect current production and pouring schedules. It should be appreciated, however, that cupola charging and melting rates have a profound influence on cupola emissions.

If for any reason tests during either start-up or burn down periods are made such tests should be kept and evaluated separately from each other as well as all others.

If various metals are produced at various times from the same cupola (such as gray and cutile iron) it is desirable that the emissions be evaluated for each type produced if there is a difference in melting conditions. The melting conditions that would tend to require evaluation in terms of differences in emissions would be reflected by variations in blast air rates, coke rates and charge metal characteristics.

Prior to any field test period the testing firm should be consulted for recommendations as to the number of days and number of test runs to be conducted to define the full range of cupola emissions consistent with cupola operating practices and other pertinent considerations. It is important that the plant's full range of operations be evaluated consistent with the stated objectives of the emission test program.

OBTAINING MEANINGFUL TEST DATA

For short run jobbing cupolas, it is recommended that a minimum of three dustloading test determinations be conducted of cupola emissions as part of any emission study. A volumetric determination should be conducted for each of the three test periods. To make the emission data be the most meaningful it is necessary and desirable that detailed records be kept of cupola operating conditions concurrent with the emission studies.

The emission test program can usually be conducted in one to three days of field sampling by an experienced testing organization. The following minimum information is considered necessary in establishing and fixing cupola operating conditions. It is necessary that these cupola operating data be secured concurrently with stack emission studies:

1) Nature, weight and constituents of all cupola charges.
2) Number and time of all cupola charges made on the test date(s).

3) Cupola blast air record showing volume changes during test. Verify that records indicate volume introduced but not quantities diverted as a means of throttling.

4) Presence of, type, number, capacity and location of afterburners.

5) Existence of gas ignition in the stack.

Ample precedents exist for evaluating the emission performance of only one cupola in a bank of two cupolas that are operated on alternate days. This situation is particularly valid if both cupolas are of the same size, oerate from the same tuyere blast air supply, are used in the production of similar types of iron and are operated at the same approximate rates.

If there are marked variations or changes in the operation of a 2-bank cupola system, particularly with respect to the factors outlined above, it is recommended that each cupola be evaluated individually for its emission potential. The design of a single emission control system serving a dual bank of cupolas must be predicated on achieving conformance with regulations for the most severe conditions of cupola operation during the normal production part of the melt cycle. For the larger job-shop cupola-operators and for the production foundry it is recommended that a minimum of two days field testing of cupola emissions be conducted. This type of test program will permit the operation and evaluation of both cupolas in a two unit bank.

The cupolas themselves should be operated at normal melting rates during the test period. Test dates should be selected when foundry pouring schedules will permit normal operation.

It is not necessary to obtain a gas analysis to determine gas density from the cupola because the difference in weight between air and the combustion gases is insignificant for exhaust volume calculation purposes.

SAMPLING PROCEDURES AND EQUIPMENT

A major problem in sampling and analysis is that high accuracy and precision must be obtained in a working foundry, where conditions are not conducive to laboratory-type manipulations. To achieve effective installation and operation of a sampling train in a foundry requires someone who is not overly worried with minute detail. On the other hand, when the critical analytical measurements and manipulations are made, the greatest attention to cleanliness, accuracy, and detail is required.

The sampling equipment required for this work must fit the same pattern. It must be simple, rugged, and yet capable of high accuracy. In general, it must be highly portable. Reliable equipment is available from several vendors, and all qualified testing groups have their own.

a. Filtering Media

A good filtering medium is a prerequisite to accurate sampling. Efficiency of collection must be at least 99 percent for all particulates encountered. An ideal filter medium should be very light so that accurate weight differences can be obtained from small samples. The filter should also be strong and resistant to both heat and moisture.

No medium available has all these properties so a compromise must be made. Readily available media and some of their characteristics are listed below. Reliable suppliers will give the characteristics of their products on demand.

FILTER PAPER

Conventional filter paper, made from cellulose, comes in hundreds of grades; most of them are not suited to fine particulate filtration, but some are specially designed for this service. They have good mechanical strength, good resistance to moisture, and reasonable heat resistance. Conventional paper must be dried and desiccated before each weighing, and must weighed on a balance from which moisture can be excluded. Ideally the paper should be allowed to reach equilibrium in a constant-humidity room, and should be weighed there.

GLASS FIBER FILTER PAPER

Glass fiber filter paper will withstand higher temperature than conventional paper, but it should be remembered that a plastic binder is used in the manufacture of most of this paper and that the binder lowers temperature resistance. Some paper is made without binder and this is much more resistant to temperature. However, this material lacks mechanical strength, and the unbonded variety is particularly weak. Glass fiber filter paper has the great advantage that it is not sensitive to humidity and so can be used where a dessicator is not available.

THIMBLES

The Soxhlet thimble has been used widely in the past. The thimbles are made of two materials, paper and ceramics. The paper thimbles have the same strengths and weaknesses as ordinary paper, and the same precautions apply. The ceramic ones come in a variety of porosities. If the pores are small enough for this work, rates of filtration will be extremely small. In addition, ceramic thimbles are very heavy so that large samples must be weighed to obtain accuracy. Thimbles of any type are not recommended for this work.

A variety of cloth materials are used for filtering particulates. Usually efficient filtration results only after a coating of particulate has been built upon the cloth. This buildup occurs most rapidly when the sampled gases contain large amounts of particulate, hence sampling error is minimized.

When particulate loading is low, such as when sampling cleaned gas, significant error can be introduced unless the fabric is 99 percent efficient on the first material that deposits.

b. Weighing

The first steps in sampling is weighing the filter paper, or other medium. Each paper should be marked with a number before weighing. The common practice of writing the weight on the paper after it has been obtained creates an error equal to the weight of the ink used. Much larger errors can result from the handling required to write on the paper. Lastly, and most importantly, the practice is poor technique, and, if allowed, will encourage other slovenly practices. The atmosphere in an ordinary analytical balance can be dried to some extent if a small beaker of concentrated sulfuric acid or container of silica gel is placed inside and the doors are kept closed.

If filter papers are weighed on one balance initially, and on a second when loaded, the second balance should be checked for consistency with the first. This can best be done by checking the weight of pre-weighed paper, and applying a correction if required. Accuracy on the total weight is not vital, but the difference between initial and final weights, which represents the weight of the sample, is critical.

c. Flow Measuring

Volume flow rate measuring devices must be preceded by system components to minimize the surging or pulsating effects normal in cupola operation and sampling. The use of flow rate measuring devices in testing effluents from a dynamic system, such as a cupola, requires that frequent readings be taken (2 or 3 minutes reading cycle should be the maximum time period between readings) and that all readings must be conducted on a stopwatch timed basis.

It is recommended that sampling volume flow rate measurements be taken using two different flow measuring mechanisms in any high volume sampling train. The average of the two sampling volume rate measurements and computed sampling volumes should then be used in the subsequent dustloading calculations.

d. Flushing the Sampling Train

At the end of each dustloading test run it is imperative that the sampling train (nozzle, connecting tube or hose and sampler) be thoroughly cleaned and flushed. Distilled water should be used and introduced into the nozzle at high velocities to aid in scrubbing the sampling train.

The particulates flushed from the sampling train should be handled, weighed and separately determined. Significant quantities of particulates are deposited in any sampling train, so it is important that this material be included with the sampled catch when computing the dustloading test results.

e. Velocity-Volumetric Tests

An S-type pitot tube is preferred to a regular pitot tube because it is not as prone to plugging. Stainless steel, Iconel or other high temperature resistant material should be used in the pitot tube construction. A ruggedly constructed inclined draft gage is recommended for use in the velocity and dustloading tests. The pitot tube should be checked and calibrated according to the manufacturers recommendations at regular intervals to establish the proper correction factor to be used in the volumetric calculations.

f. Sampling Trains and Sampling Equipment

Few emission sources offer the trying field test conditions attendant to sampling as do cupola systems. The need also cannot be emphasized enough for rugged field sampling equipment for this testing. A schematic diagram of sampling apparatus for the static balanced tube method of sampling, incorporating recommendations for cupola effluent source emission sampling is presented in Fig. 1.

A possible commercial source for various components of the sampling train is indicated in Table 2. This is not to be construed as an endorsement of any particular manufacturer but is illustrative only of the rugged type of test equipment recommended for cupola source sampling.

When assembling sampling equipment, joint sealing materials should not be exposed to the sampled gas stream where adherence of the particulate could occur. Long-radius bends should be used instead of elbows to facilitate cleaning. The probe should be just long enough for the task at hand. The rest of the train should be assembled and tested for leaks. If the meter is a dry gas meter, it is to be calibrated before each use. If an orifice meter, or flow-meter type, is used it must also be calibrated each time, and it must, in addition, have enough sensitivity so that readings can be read to less than 1 percent. Finally, if volume is obtained by multiplying an instantaneous reading by the time of operation, fluctuations must be kept to 1 percent.

The vacuum pump or compound air ejector must be the last element of the sampling train unless it can be proved that there is no leakage through the packing, etc., under the worst conditions that can be visualized.

g. Analysis of Captured Particulate

It is recommended that the procedure for weighing and determining size distribution of the captured particulate be used as stated in the ASME PTC 27-1957 Section 4 Paragraphs 75-79 (see Appendix).

Fine particulate matter should be sized and analyzed within 24 hours after the sample is taken to minimize agglomeration and a possible change in character. It is most desirable if the sample is dried immediately after the test has been run to prevent degradation.

The minus 44 micron fraction of the collected particulate must be carefully handled and analyzed because of the strong tendency to agglomerate.

SECTION I - SAMPLING RAW PARTICULATE EMISSIONS IN THE CUPOLA STACK

Recommended Test Method and Procedures

A thorough and complete review of the available test methods and procedures used in the conduct of source emission studies has resulted in the recommendation of the following basic requirements as essential to an acceptable evaluation of the test methods:

1) In order to obtain a truly representative sample of coarse particulates from the gas stream a large volume sampling train should be used. The sampling nozzle should be constructed of stainless steel having a minimum inside diameter of 3/4 inches, since raw cupola emissions cover a broad range of particle sizes, with individual particles not uncommonly ranging up to 3/8 inch diameter or larger.

2) Particulate matter is defined consistent with the definition accepted by the dust collection industry and as adopted in the American Society of Mechanical Engineers Performance Test Code 21-1941, Dust Separating Apparatus and Performance Test Code 27-1957, Determining the Dust Concentration in a Gas Stream. See item 1 in the Appendix. In essence, this defines particulate matter as all filterable solids present at standard temperature in an effluent gas stream.

3) It is necessary that a truly "isokinetic" sample of gases and solids be secured by the sampling system. This requirement is a practical consideration dictated by the wide range of

particle sizes involved and, therefore, the special need for securing a truly isokinetic sample of the effluent solids.

4) When sampling in the cupola stack, water-cooled corrosion-resistant, sampling probes and sampling nozzles are required. This is a practical requirement since cupola temperatures in excess of 1200°F are common, and sample contamination by corrosion products formed in the nozzles and probes of the sampling system must be prevented. Water-cooling also serves to preserve the sampling probes from deterioration and distortion.

5) The American Society of Mechanical Engineers Performance Test Code 27-1957, Determining Dust Concentration in a Gas Stream, with modifications as outlined below offers the best and most practical test method and test procedures for the conduct of source emission studies from cupolas. The following are additional important considerations in the sampling of cupolas and cupola systems when utilizing as a broad base the test procedures and techniques embodied in ASME PTC 27-1957, Determining Dust Concentration in a Gas Stream. See item 2 in the Appendix. The criteria supplement the methods and procedures contained in ASME PTC 27, when applied to cupola source emission testing:

a. Test Location and Test Openings

A test location in a cupola stack must at best be a compromise. The location should be as far above the top of the charge door opening as practical but be at least one equivalent cupola inside daimeter below the top of the cupola stack. This location will require that protective shelter be provided since test personnel and equipment may be subjected to possible fallout of particles.

Test ports should consist of two six inch pipe nipples (schedule 40) installed radially in the cupola shell and cupola lining at 90 degrees to each other. Both 90 degree test ports must be accessible from the sheltered test platform. Six-in test ports are usually required to accommodate high volume sampling nozzles. An acceptable test platform can usually be constructed using temporary steel scaffolding. Corrugated metal sheeting can be used for the roof of the test platform. The six-inch pipe nipple test ports should protrude out a few inches from the cupola shell and should be flush with the inside of the cupola lining. The test port nipples should be fillet-welded to the cupola shell. The threads of the pipe nipples should be graphited and six-inch pipe caps installed hand tight so that they can be readily removed during the test period.

b. Method of Subdividing Cupola Stack

The cupola stack cross-sectional area should be measured at the test elevation. Due to refractory erosion and/or the buildup of slagged deposits which affect the cupola cross section, it is important that the cupola cross section and cross sectional area be determined at the test elevation. The ASME PTC 27 test code prescribed procedure (see item 2 in Appendix) should be followed in determining the location of the test points to be used in both the volumetric or pitot tube traverses and during the test runs.

A minimum of 12 points should be used as sampling locations in traversing a cupola stack in the dustloading test runs. Additional sampling points should be used when the maximum to minimum velocity variation in the velocity profile approaches, or exceeds, a 2 to 1 figure.

It is important that dust sampling be conducted at each test point and that the dustloading test-data sheet reflects the sampling conditions at each test point in traverse of the cupola from each test port. The practice of using a much smaller number of test points during the dustloading test runs, as compared to a large number of points used in the velocity checks, is almost certain to bias the test results and cause the results to be of a questionable nature with respect to securing a representative cupola sample.

c. Number and Duration of Test Runs

Test runs shall consist of a minimum of 60 minutes actual dust sampling. Based upon a minimum of 12 points of dust sampling of the cupola cross section from the two 90 degree test ports, an acceptable minimum sampling schedule would consist of sampling for 5 minutes at each of the 12 points. The field test data sheets and the test report must clearly reflect the location and the time of sampling at each of the sampling points used. A minimum of three sets of flow, temperature and pressure readings should be taken at each sampling point. The field data shall be logged and should reflect the dynamic conditions of cupola flows and sampling rates at each test point.

Readings of sampling flow rates, temperatures, pressures, gas analyses and other pertinent test data which are part of each dustloading test run should be taken on a 2 (maximum 3) minute cycle at each sampling point during each dustloading test run. The total sampling program should be conducted under stopwatch timing precision.

Three dustloading test runs and 3 velocity-volumetric test runs should be conducted in a single day of field sampling, as previously mentioned.

d. Sampling Probes

Sampling probes used in the dustloading test runs of raw gas should be of water-cooled, stainless steel construction. The sampling probes should be a minimum of 3/4 inch inside diameter, and preferably of larger inside diameter for tests conducted on raw gas emissions. Conventional smaller diameter test probes are suitable for use on the downstream side of dust collectors, but should not be used in raw gas sampling.

Either a standard or null type probe may be used for sampling raw cupola gases. Whichever probe is employed, a truly isokinetic sample must be taken at all test points during all test runs.

A null sampling probe of either the balanced static pressure type or balanced impact pressure type can be used. Null type probes are prone to introduce minimum error as their diameters increase and as the velocity of the flow system increases.

A null sampling probe must be calibrated and of such a size as to give the minimum sampling error (deviation from isokinetic) for the expected sampling velocity range.

Either type probe presents certain shortcomings which must be compensated for under the adverse, dynamic and widely varying flow conditions attendant to normal cupola operation.

Cupola velocities can be expected to range from 600 to 2400 ft/min. depending upon the size of the cupola and the rate of cupola operation. Normal operating velocity ranges can be expected to be 1000 to 1800 ft/min.

Fixed rate sampling trains, based upon an occasional velocity determination made at some fixed time, are unacceptable for cupola source sampling since such methods completely ignore the dynamic nature of the cupola melting process.

e. Filter Media

Due to the need for a large diameter sample probe and the necessity of isokinetically sampling the gas stream, a high volume sampling train is mandatory. The filtering media used for removing particulate from the gas stream must be of sufficient size to maintain the sampling rates necessary without imposing undue pressure drop restrictions on the sampling train.

The advantages and disadvantages of some of the various filtering media that can be used in removing the particulates from the sampled gas stream are stated in ASME PTC 27 Section 4 Paragraph 59 (See Appendix).

FOOTNOTE: Cloth is often used as the filtering media because of its high collection efficiency, good flow permeability, ability to be shaped or adapted to any sampler configuration, and freedom from plugging or excessive pressure buildup under minimum condensation conditions.

In the event that a cotton sateen fabric is selected it must be thoroughly washed and rinsed prior to use to be free of starch and sizing materials. This filter medium has as its most serious limitation a humidity or moisture pickup tendency. This problem can be adequately dealt with by proper and skilled weighing and handling techniques using an enclosed single pan desiccated analytical balance.

Sampler units housing the filter medium should be made or lined with corrosion resistant material and must permit ready and free insertion and removal of the filter medium. Sampler units must consist of airtight enclosures to ensure that all sampled gases pass through the filter medium, be capable of easy field cleaning and of conserving the sampled dusts with a minimum of sample loss in filter handling.

To facilitate transfer of collected material and prevent the possibility of incandescent particles from contacting the final filter medium it may be desirable to incorporate a small stainless steel cyclonic collector ahead of the ultimate filter medium. Such cyclones tend to remove the larger particulates and prolong the sampling period before the pressure buildup on the filter medium restricts isokinetic sampling, due to reduced sampling flow rate capability.

Such cyclones offer the additional advantage of providing a convenient method of measuring the gas sampling flow rate. This can be accomplished by calibrating the pressure drop across the cyclone collector unit entailing the measurement of the pressure differential across the cyclone, the temperature and the static pressure at that location.

FOOTNOTE: Scrubber (impinger) or condensing systems are considered unsatisfactory for particulate filtration in cupola sampling trains. Such systems promote and cause the formation of reaction products which were not present in the cupola gas stream. Since most available impinger or wet collecting apparatus, are associated with low volume sampling rates (not to exceed 1.0 cfm), it can be seen that they do not lend themselves well to high volume rate sampling without the use of multiple, parallel units.

While it may be of interest in some instances to determine if condensible material is present in cupola effluents such determinations are beyond the scope of this recommended practice for particulate.

When a gas analysis is desired it is recommended that a continuous carbon dioxide and/or a continuous oxygen analyzer be used to measure these gas constituents. Periodic checks can also be made using an Orsat gas analyzer to verify the performance of the continuous gas analyzer or to check on the total gas composition (CO_2, O_2, CO, N_2). The continuous gas analyzer should be read on a two or three minute cycle throughout each test run and the time noted. Results of each Orsat gas analysis conducted should be clearly indicated on the field data sheets and in the test report.

Sulfur oxide emissions from cupola systems are of such a low order that it is usually unnecessary to measure them in light of present day standards.

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f. Sampling Volume Flow Rate

The need for a high volume sampling system to secure representative samples from cupola raw gas effluents often mitigates against the use of an integrating gas meter for measuring the sample gas volume although such are available to handle the flow ranges covered by 3/4 to 2 inch inside diameter dust sampling nozzles. However, portability requirements for such meters leave much to be desired and adverse field conditions in cupola sampling often preclude the use of such meters.

Sampling volume flow rate measurements can be made by flowrator systems, calibrated pressure drop mechanisms such as orifices, venturis or other similar flow measuring devices.

SECTION II - RAW GAS TEST LOCATION IN DUCT AHEAD OF COLLECTOR

Tests are often conducted to determine performance of collectors installed for cupola gas cleaning. Often a sample location in the connecting duct will have advantages over that of a cupola stack location because -

1. Gases will be cooled, usually by evaporation of water, to temperatures below 500^{o}F.
2. Location more accessible.
3. Dustloadings and gas velocity more uniform thru cross section of sampling area.
   (Duct velocities usually in teh 3000 - 5000 fpm range.)
   In such locations:
   a. Number of sample points can correspond to ASME PTC 27 and need not be the minimum of 12 recommended for the cupola stack.
   b. Gas volume will include substantial proportion of water vapor and influence gas density.
   c. Some dust, especially of the coarser fractions, can bypass the sample area if there is substantial run-off of cooling water or for dust fallout in cooling towers, external combustion chambers, etc.

Whenever possible, catch from collector should be obtained and checked against calculated collected quantity from inlet and outlet samples. It is often difficult to get a sample covering only the test period, but often feasible to obtain quantity collected during a complete melting cycle. In the latter case, daily average data can be compared to short test runs of the sampling equipment.

Comparison of coarse fraction in the catch with the quantities reported by sampling will also give an indication of effectiveness of the sampling technique of such fractions. When indicated, catch from the collector needs to be augmented by inclusion of fallout in preceding system elements as noted in Item c.

SECTION III - SAMPLING CLEANED CUPOLA GASES

General

Sampling behind a gas cleaner alleviates some of the problems experienced when sampling raw cupola gases. Extremely large particles are no longer present permitting the use of conventional 1/4" or 3/8" diameter sampling probes and lower sampling volumes. The violent velocity fluctuations experienced in a cupola stack have been moderated; and the high temperatures of raw cupola gases have been reduced. On the other hand, a different problem is accentuated. Gas cleaning equipment is expensive, and is usually sold to meet a specified emission standard. Since performance curves for emissions become asymptotic, small changes in performance can cause large expenditures in equipment alteration, therefore accuracy of testing becomes more critical.

Because the gas sampled is hot and humid, the probe or filter holder must be heated to stop condensation on the walls of the apparatus from occuring. Such condensate will interfere with the filtration of particulate.

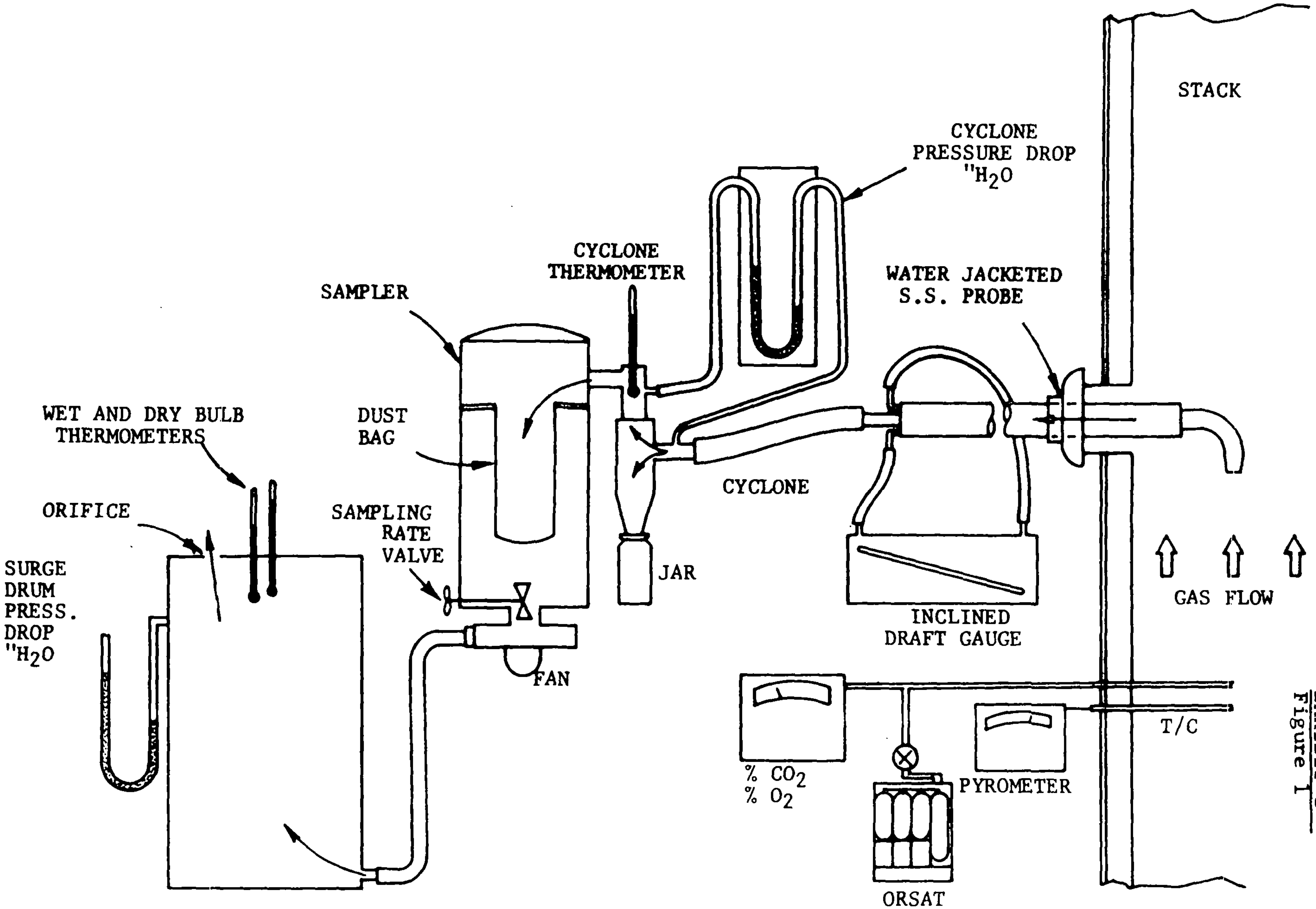
Cupola off-gases are almost always cooled by direct contact with water, so it can be a-sumed that they are humid after they have passed through a cleaning device, whether a wet scrubber or not. Consequently, a condenser must be inserted in the filtering train. This serves two purposes. First, it removes excess water which may condense and damage the gas meter. Secondly, and of vital importance, a condenser gives assurance that the gas passing through the train is saturated at an identifiable point. This provides the basis for exact calculation of the volume of dry gas metered, converted to standard conditions.

An acceptable procedure for testing is "Determining Dust Concentration in a Gas Stream", PTC 27-1957, published by the American Society of Mechanical Engineers.

While isokinetic sampling is not as critical for cleaned gases because of the small particle sizes involved, its use is recommended, following the same procedure of test locations, sample time, pitot traverse and data log recommended in Section I and II.

SCHEMATIC DIAGRAM OF SAMPLING APPARATUS

STATIC BALANCED TUBE METHOD OF SAMPLING



APPENDIX E
EXHIBIT 1
Figure 1

TABLE 2 - REPRESENTATIVE SOURCES OF COMMERCIALLY MANUFACTURED COMPONENTS

	Component	Source
1.	Stainless steel, water-cooled static balanced, tube sampling nozzle-3/4 in. minimum ID.	Individually designed and constructed to meet nozzle diameter and probe length needs. Fitted with 6 in. pipe cap and pipe sleeve. Nozzles are to be calibrated to effect isokinetic sampling with minimum sampling error at the optimum velocity range for each different probe diameter. An acceptable nozzlehead design is schematically illustrated in ASME PTC 27 (Fig. 2).
2.	Inclined draft gage and holder, pitot tube.	Industrial Engineering Instrument Co., Allentown, Pennsylvania
3.	Stainless steel cyclone	UOP Air Corrections Division Darien, Connecticut
4.	Sampler	Fabricate to meet filter media confinement and handling requirements.
5.	Manometer	The Meriam Instrument Co., Cleveland, Ohio
6.	Thermometer	Weston Electrical Instrument Corp., Newark, New Jersey
7.	Industrial exhauster	Clements Manufacturing Co., Chicago, Illinois
8.	Continuous gas analyzer	Thermco Instrument Corp., LaPorte, Indiana
9.	Orsat gas analyzer	Hayes Corp., Michigan City, Indiana
10.	Pyrometer and thermocouple	Alnor Instrument Co., Division Ill. Testing Laboratories, Inc. Chicago, Illinois

SAMPLING AND ANALYTICAL TECHNIQUES

INTRODUCTION

Sampling and analytical techniques for the determination of emission rates from industrial processes have been standardized for many specific particulate and gaseous materials. The techniques described in the following paragraphs are those most widely used in the testing of iron foundry emissions testing. The format and wording for most procedures correspond to the source indicated for each procedure.

SAMPLING TECHNIQUE

Scope

The primary objective of stack testing is to determine the nature and/or quantity of emissions being released into the atmosphere. Sampling procedures that follow are applicable to the cleaned gas side of the control unit.

Apparatus

The accuracy of emission testing results is dependent upon qualified personnel conducting the test and the use of the proper apparatus for the material to be collected. Figure 1 illustrates information on sampling locations and apparatus most commonly involved in stack testing.

Sampling Principles

The location and number of sampling points are based on size and shape of the duct, uniformity of gas flow in the duct, availability of an adequate sampling port, and the space required to set up the equipment. Unfortunately, ideal conditions are seldom found in field testing and agreement on these factors must be reached before conducting the test.

To insure constancy of test conditions and results, complete information must be developed as to continuous or cyclic operation; nature, weight and composition of materials; gas volume and fluctuations; pressure; temperature and humidity; presence of other devices such as afterburners; and related conditions affecting the operation and equipment. These factors will regulate the time, number and duration of test runs.

Stack Gas Velocity

To determine particulate concentration in an exhaust stack, isokinetic source sampling must be used. This is the condition that exists when the velocity in the nozzle of the sampling tube is exactly the same as that in the stack. Isokinetic sampling is not mandatory when only gaseous substances are to be assayed.

In isokinetic sampling, the traverse area of the duct must be divided into equal areas and a pitot traverse taken. The use of the S-type pitot is recommended where particulates are involved to avoid any possibility of partial plugging and faulty readings. The velocity at each point must be calculated, and the volume of flow required to maintain that velocity in the sampling tip should volume fluctuate. Provisions must be made so that the volume can be recalculated immediately each time the pressure changes at the meter. However, when sampling is downstream from a gas cleaner, the volume is controlled by the system's fan and remains relatively constant and this procedure may not be necessary.

Detailed procedures on conducting velocity measurements are given in Bulletin WP-50 of the Western Precipitation Company, ASME Performance Test Code 27-1957 and the Industrial Ventilation Manual of the American Conference of Governmental Industrial Hygienists.

Concurrent with conducting the pitot traverse, it is essential to determine the temperature of the stack gas. The measuring device will be dependent on the temperatures involved.

Sample Probe

In assembling the sampling probe, teflon tape should always be used instead of pipe dope to prevent adherences of particulates. Long radius bends should be used instead of elbows to facilitate cleaning. The probe should be just long enough for the task at hand. The rest of the train should be assembled and tested for leaks.

Temperature and Humidity

If the gas sampled is hot and humid, condensation may occur in the probe or in the filter holder. The probe or filter holder must be heated to stop condensation from occurring because the water formed will trap water on the walls of the apparatus and will interfere with the filtration of particulates. Temperature control baths may be required for gas absorbers. In some cases the probe can be provided with a water cooling jacket.

Condensation

A condenser in the sampling train is required if the gas is humid. This serves two purposes. First, it removes excess water which may condense and damage the gas meter. Second, and of vital importance, a condenser gives assurance that the gas passing through the train is saturated at an identifiable point. This provides the basis for exact calculations of the volume of dried gas metered and conversion to standard conditions.

Collection Devices

The characteristics of the material in the stack will determine the collection method required. Dry filter mediums, of a variety of types, are most commonly used for particulate matter. Although in some cases the wet impingement method followed by a thimble is used. Gases are collected in absorbers with a proper absorbing solution. Grab sample units are available for spot sampling.

Flow Meters

If a dry gas meter is used, it must be calibrated before each use. If an orifice meter, or flow-type meter, is used it must also be calibrated each time, and it must have enough sensitivity so that readings can be obtained to less than one percent. Finally, if volume is obtained by multiplying an instantaneous reading by the time of the operation, fluctuations must be kept to one percent.

Vacuum Source

A vacuum source is required to draw the sample from the stack through the sampling train. A variety of pumps or ejectors are available for this purpose. Their capacity must be sufficient to draw the gas through the sample train at the required volume. The range is from one liter to several cubic feet per minute.

Sampling time will be dependent upon the factor of obtaining a representative sample of the operation. It may vary from several long continuous integrated samples of 30 to 60 minutes or a number of short samples of 5-10 minutes.

ANALYTICAL PROCEDURES

Introduction

Analytical procedures for a number of materials are given in the sections that follow. All calculations must be according to standard procedures and the standard conditions of temperature at 70 degrees Fahrenheit and an atmospheric pressure of 29.92 inches of mercury.

Particulate Matter

(a) Scope

The definition of particulate matter accepted by the dust collection industry is given in the ASME Performance Test Codes 21-1941 and 27-1957. In essence, this defines particulate matter as all filterable solids present at standard temperature in an effluent gas stream.

(b) Auxiliary Apparatus

- Filter Media - Efficiency of collection must be at least 99% for all particulates encountered and must be resistant to both heat and moisture.
- Balance - Macro analytical balance or equivalent.
- Drying Oven - Suitable for drying filters for about 5 hours at 105° C.
- Desiccation - To retain dried filters before weighing.

(c) Sampling Procedure

The first step in sampling is to prepare the filtering medium. An identification number should be provided for each filter and recorded on a separate data sheet. Prior to weighing, the filter should be dried for about 5 hours at about 105° C and then weighed immediately. This weight should be recorded on the data sheets and not on the filter. In order to keep weighing errors at a minimum, careful handling of the filters is required.

Preferably the pitot traverse, temperature and humidity readings should be taken not more than one-half hour before sampling is begun. Assemble the sampling train as shown in Figure 1 and proceed with the sampling by inserting the probe into the test stack. Continual observation of the sampling train during the entire sampling period is required to record any changes in pressure, temperature and airflow. This information, along with barometric pressure, sampling time and rate, is recorded on the sampling data sheet. Complete information on the process should also be noted on the sampling data sheet.

Length of the sampling time, at any specific point in the stack, will be contingent upon changes, if any, in the process or fluctuations of air volume. The sampling time should at least cover a complete cycle and will vary from 30-60 minutes. If airflow is not uniform in the stack, 5- to 10- minute samples at each of the traverse points should be obtained. Samples taken during start-up and burn-down periods should, as a rule, be considered separately from those taken during the production cycle of the cupola.

After a run is completed the probe must be cleaned of retained particulate matter. An acceptable procedure is to brush with a long flexible brush while the sample train is pulling in clean air. For other contaminants, follow procedures, if any, indicated for the specific material.

(d) Sample Preparation

Collected samples should be dried and placed in a desiccator to reach equilibrium before weighing. The difference between the original weight and final weight is the total amount of particulate matter collected.

(e) Calculations

The total particulate matter collected is expressed in grams. From this value, calculations can be made to express the findings in grains/SCF, pounds/hour, or pounds/1,000 pounds of gas, using the following constants:

One (1) gram = 15.43 grains
One (1) pound = 7,000 grains
One (1) gram = 0.002205 pounds
One (1) standard cubic foot of air = 0.075 pounds

1. Grains/SCF

$$\text{Grains/SCF} = \frac{(\text{Grams})\ (15.43)}{\text{Total SCF sampled}}$$

2. Pounds/Hour

$$\text{Pounds/hour} = \frac{60\ (\text{grains/SCF})\ (\text{total gas volume to atmosphere - SCFM})}{7{,}000}$$

3. Pounds/1,000 Pounds Gas

$$\text{Pounds/1,000 Pounds gas} = \frac{(\text{grams})\ (2.205)}{(0.075)\ (\text{total SCF sampled})}$$

Arsenic

Source: American Conference of Governmental Industrial Hygienists.

(a) Scope

Stack sampling for arsenic is based on the reaction of arsine with silver diethyldithiocarbamate. The amount of arsenic, in the air sample, is read directly from the calibration curve.

(b) Auxiliary Apparatus

- Greenberg-Smith Impinger.
- Beckman DU Spectrophotometer with photomultiplier or equivalent
- Arsine Generator (See Figure 2)

(c) Reagents

Silver Diethyldithiocarbamate - a cooled solution of silver nitrate (1.7 g in 100 ml distilled water) is added to a cooled solution of sodium diethyldithiocarbamate (2.25 g in 100 ml distilled water). The lemon yellow precipitate is filtered off, washed thoroughly with distilled water and dried in a vacuum desiccator below 20^{o} C.

Pyridine - Mallinckrodt reagent grade pyridine is passed through an alumina column 1 inch in diameter and 6 inches in depth, at the rate of approximately 150 ml per hour. This process may remove a considerable quantity of colored material.

Arsine Absorbing Solution - Dissolve 1 g of silver diethyldithiocarbamate in 200 ml of chromatographed pyridine and filter the solution.

Hydrochloric acid - Baker's analyzed, specific gravity 1.19.

Potassium Iodide Solution - Dissolve 15 g reagent grade potassium iodide in 100 ml distilled water.

Stannous Chloride Solution - Dissolve 40 g stannous chloride dihydrate in 100 ml hydrochloric acid.

Zinc - Baker's analyzed; granular 20 mesh.

Lead Acetate - Dissolve 10 g reagent grade lead acetate in 100 ml distilled water.

Arsenic Standard Stock Solution - Dissolve 1.320 g arsenic trioxide in 10 ml of 40% sodium hydroxide and diluted to 1 liter with distilled water. (Various strengths of standard solutions are prepared by further diluting this stock solution with suitable volumes of water, triple distilled in glass.)

Nonag - Stopcock grease, Fischer Scientific Co.

(d) Sampling Procedure

Assemble sampling train of probe, impinger with 100 ml of distilled water, flow meter and vacuum pump. Sampling rate is at 1 CFM for a period long enough to provide a minimum of 30 cubic feet at standard conditions.

(e) Analytical Procedure

Calibration curve - known microgram amounts of arsenic (1-15 micrograms) in the form of standard arsenic solution are pipetted into 125 ml Erlenmeyer flasks. Distilled water is added to make the total volume 35 ml. To the flasks are added 5 ml hydrochloric acid, 2 ml 15% potassium iodide solution, and 8 drops of stannous chloride solution. The flasks are swirled and allowed to stand for 15 minutes.

Three ml of the pyridine solution of silver diethyldithiocarbamate are placed in the absorbing tube, which is attached to the scrubber containing glass wool impregnated with lead acetate. (See Figure 2.)

The ground joints are lubricated with "Nonag" stopcock grease, 3 g of granulated zinc are added to the solution in the flask, and the receiving tube is inserted immediately. Arsine evolution is completed in about 30 minutes.

At the end of this time, the absorbing solution is transferred to a 1 cm square cell and the absorbance measured at 560 millimicrons in the Beckman spectrophotometer. Plotting measured absorbances against micrograms of arsenic taken produces the standard curve.

Air samples, after the previously described preparation treatment, are treated in the same manner as the standards.

(f) Calculations

Arsenic, in the form of arsine, displaces an equivalent amount of silver from silver diethyldithiocarbamate.

$$\text{mg As/M}^3 = \frac{V \cdot Y}{1{,}000 \cdot v \cdot Va}$$

Where
v = aliquot (ml)
V = total sample (ml)
Y = micrograms in v
Va = gas sample volume, in cubic meters, at standard conditions

Beryllium

Source: Michigan Department of Public Health.

(a) Scope

This method describes a procedure for determining beryllium in stack gases.

(b) Auxiliary Apparatus

- Millipore filters and holder.
- Bausch & Lomb Large Littrow Emission Spectrograph or equivalent.

(c) Reagents

Platinum Internal Stock Solution - Purchase directly from Jarrell-Ash Company a 10% platinic chloride solution. This calculates out to be 57.88 mg platinum in 1 ml solution.

Platinum Internal Standard Working Solution - Pipette 1 ml of platinum stock solution containing 57.88 mg Pt per ml into a

25 ml volumetric flask, take to volume with water giving a solution containing 116 micrograms platinum/.05 ml.

Standard Beryllium Solutions:

1. Beryllium stock solution. Dissolve .0982 g of $BeSO_4 \cdot 4H_2O$ in 10 ml of redistilled 1:1 hydrochloric acid and dilute to 100 ml with distilled water. Solution contains 5.0 mg beryllium per 100 ml or 2.5 micrograms Be/.05 ml.

2. Working beryllium standard solutions. These should be prepared from the stock solution just before use. Suggested concentrations are from .003 to .5 microgram Be/.05 ml.

Nitric Acid - To clean all laboratory glassware.

(d) Sampling Procedure

Assemble sampling train of probe, millipore filter and holder, flow meter and vacuum pump. Sampling rate at 1 CFM for a period long enough to provide a minimum of 10 CF at standard conditions.

(e) Analytical Procedure

The millipore filter containing the sample is transferred to a chemically clean 125 ml beaker. The filter and sample are wet ashed with nitric acid. The residue is then dissolved in 3 ml of concentrated nitric acid and 1-2 ml of distilled water. Transfer to a graduated centrifuge tube, rinse the beaker with water and add the rinsing to the sample solution. Evaporate to a volume of 0.2 ml and if an appreciable amount of salt is present, a volume of more than 0.2 ml may be required.

The standard curve is plotted on log-log paper and micrograms Be per .05 ml is plotted versus the intensity ratio of Be 2348.6 line over Pt 2357.1 line. The standard curve is usually set up in the range of .003 microgram Be/.05 ml to .5 microgram Be/.05 ml. Six beryllium concentrations used to establish the working curve are prepared as follows:

For the first 3 concentrations, the stock solution containing 50 micrograms Be/ml is diluted 1 ml to 100 in distilled water giving a working solution of .5 microgram Be/ml.

1. .003 microgram Be/.05 ml. Pipette 1.2 ml of working standard beryllium solution (.5 microgram Be/ml) into a 10 ml volumetric flask and take to volume with water.

2. .005 microgram Be/.05 ml. Pipette 2 ml of working standard beryllium solution (.5 microgram Be/ml) into a 10 ml volumetric flask and take to volume with water.

3. .01 microgram Be/.05 ml. Pipette 4 ml of working standard beryllium solution (.5 microgram Be/ml) into a 10 ml volumetric flask and take to volume with water.

4. .05 microgram Be/.05 ml. Pipette .2 ml of stock beryllium solution (50 micrograms Be/ml) into a 10 ml volumetric flask and take to volume with water.

5. .1 microgram Be/.05 ml. Pipette .4 ml of stock beryllium solution (50 micrograms Be/ml) into a 10 ml volumetric flask and take to volume with water.

6. .5 microgram Be/.05 ml. Pipette 2 ml of stock beryllium solution (50 micrograms Be/ml) into a 10 ml volumetric flask and take to volume with water.

Spectrographic apparatus, materials and exposure conditions are as follows:

1. Optical conditions - 10 micron slit is used in the spectrograph.

2. Densitometer - Non-recording National Spectrograph Spec Reader.

3. Electrodes - Upper Electrode (cathode) United Carbon Products Company, 3/16" diameter, sharpened to a point in a regular de-leaded pencil sharpener. Lower Electrode (anode). United Carbon Products Electrode, catalog No. 100-L, 1/4" diameter, crater is 3/16" diameter and 5/32" deep.

4. Exposure conditions - 220 volts DC arc, operating at 7.5 amperes with a constant gap of 5 mm maintained between the anode and cathode, exposure time is until burn-out of lithium chloride buffer.

5. Photographic - Eastman Kodak Spectrum Analysis No. 1 Plate, developed 3.5 minutes in Eastman D-19 Developer at 68^{o} F and fixed for 8 minutes in Eastman Koda Fixer (National Spectrographic Developing machine). Emulsion is calibrated by use of the two-step filter in front of the slit. The density of

the filter section is given by Bausch and Lomb Company, makers of the filter.

6. Nitrogen - AirCo dry nitrogen, flow rate regulated by F. W. Dwyer Manufacturing Company flow meter, maximum flow rate 6 liters per minute, regulator 3,000 pounds. The nitrogen flow around the electrode is between 3-4 liters per minute.

Preparation of the electrodes for both standard curve and sample analysis is as follows: A 1/4" diameter electrode is waterproofed by immersion in Dow Corning silicone solution (2% in acetone), and air dried for at least 30 minutes. A 10 mg charge of lithium chloride-graphite buffer is placed in the electrode and packed by tapping gently on the table top.

Into the electrodes prepared as described above is pipetted .05 ml of the platinum internal standard working solution (116 micrograms/.05 ml). The electrodes are placed in a 60° C oven and allowed to dry. Upon removal from the oven, .05 ml of the standard beryllium solution is pipetted into the appropriate electrodes. From the centrifuge tubes, where the samples have been evaporated down, is pipetted .05 ml into the appropriate electrodes. The electrodes are then returned to the 60° C oven and maintained at that temperature until dry. The temperature is then brought up to 105° C and maintained at that temperature for 1 hour. The electrodes are now removed from the oven and are ready for analysis. After the spectrograph and power supply have been set as previously described, the electrodes are placed in the respective electrode holders. The nitrogen flow is turned on and set at a rate of between 3-4 liters per minute around the lower electrode. With the shutter open during the entire exposure the arc is lit and allowed to run until burn-out of the lithium chloride buffer which is indicated by a vanishing of the red lithium color.

After the plate has been developed and dried as described previously, it is placed on the densitometer and the percent transmission set to 100 on a clear portion of the plate. The percent transmittance value of Be 2348.6 and the background adjacent to this line is read. The percent transmittance value of Pt 2357.1 line is also read. Through the use of the gamma curve the percent transmission values of the bismuth line and the background adjacent to it and the Pt line are transformed to I values and a ratio taken of I value Be 2348.6 over I value Pt 2357.1 made. Each one of the varying concentrations of beryllium standard curve and of the sample is run in triplicate and an average of these taken for the final calculation. The amount of beryllium per .05 ml sample is read from the standard curve.

(f) Calculation

$$\text{micrograms Be/M}^3 = \frac{V \cdot Y}{v \cdot Va}$$

where v = aliquot (ml)
V = total sample (ml)
Y = micrograms in v
Va = gas sample volume, in cubic meters, at standard conditions

Cadmium

Source: Michigan Department of Public Health.

(a) Scope

Stack testing for cadmium can be accomplished by the polarograph method using a dropping-mercury electrode with the sample as the electrolyte.

(b) Auxiliary Apparatus

Sargent Polarograph - Model XXl, recording type or equivalent.

(c) Reagents

Standard Lead Solution - Dissolve approximately 25 grams of C.P. $Pb(NO_3)_2$ in minimum of hot water and cool with stirring. Filter with suction on small Buchner funnel. Repeat recrystallization. Dry crystals at 100°-110° C to constant weight, cool in desiccator and store in tightly stoppered pyrex bottle. The product has no water of crystallization and is not appreciably hygroscopic. Weigh exactly 0.1599 grams of recrystallized C.P. $Pb(NO_3)_2$, put into 500-ml volumetric flask, and take to volume with 0.1 N HCl. This gives a standard lead solution containing 200 micrograms Pb/ml with 0.1 N HCl as the electrolyte. The 0.1 N HCl should be prepared from constant boiling hydrochloric acid.

Standard Cadmium Solution - Weigh exactly 0.2744 grams of $Cd(NO_3)_2 \cdot 4H_2O$ into a 500-ml volumetric flask and take to volume with 0.1 N HCl. This gives a standard cadmium solution containing 200 micrograms cadmium per ml with 0.1 NHCl as the electrolyte. As in the lead solution the 0.1 N HCl should be prepared from constant boiling hydrochloric acid.

Oxygen Absorbent for Purification of Nitrogen - Pass nitrogen through a first scrubbing flask (a midget impinger) containing concentrated NH_4OH and copper turnings. Caution: Make certain hole in impinger is not plugged before turning nitrogen under pressure on. Then pass nitrogen through a second scrubbing flask containing concentrated sulfuric acid, again making certain this is not plugged before applying pressure.

0.2 N hydrochloric acid - Prepare this from constant boiling hydrochloric acid according to outline in Lange's Handbook.

Clean, Dry Mercury - Purchase from Eberback & Son

(d) Sampling Procedure

Assemble sampling train of probe, impinger with 100 ml of 5% nitric acrid, flow meter and vacuum pump. Sample at rate of 1 CFM for a period long enough to provide a minimum of 30 cubic feet at standard conditions.

(e) Analytical Procedure

Sample Preparation - Transfer the collecting solution from the impinger into a 250 ml beaker, wash out impinger with hot 5% nitric acid and all taken down to dryness on a hot plate. Cool and add 25 ml of 0.2 N HCl. Heat just to boiling and transfer to a 50 ml volumetric flask. Dilute to volume with distilled water which will dilute the 0.2 N HCl to 0.1 N HCl which is the electrolyte.

Transfer a 10-ml aliquot from the 50-ml volumetric flask into the polarographic cell, add 1 ml of 200 micrograms Pb per ml solution, and remove oxygen from the cell by bubbling nitrogen, which is being purified as described under reagents, through for three to five minutes. The initial voltmeter is set at .3 volts, the span voltmeter is set at .6 volts, thereby giving a range from -.3 volts to -.9 volts. This is sufficient as lead "comes off" at approximately -.44 volts and cadmium at approximately -.66 volts. The sensitivity setting might have to be found by trial and error; 0.020 suffices for most samples although if the cadmium is low the sensitivity will have to be increased (decreasing the number of microamperes/mm.).

If there is a possibility that Pb is present in the sample an aliquot of the sample should be run in the polarographic cell first, without any internal standard added. If there is Pb present in the sample, this must be taken into account when Pb, the internal standard, is added.

Standard Curve - Into the polarographic cell is introduced 1 ml of 200 micrograms Pb per ml solution, 1 ml of 200 micrograms Cd per ml solution and 9 ml of 0.1 N HCl. This gives a total amount of solution in the cell of 11 ml, thereby enabling a later removal of 10 ml of the sample and 1 ml of 200 micrograms Pb per ml internal standard solution. Also, there is an electrolyte in the cell of 0.1 N HCl. Both the volume of liquid in the cell and the electrolyte for standard curve and sample are critical for a proper analysis.

On the standard curve the heights of the Pb and Cd curves are measured in mm. The Cd to Pb ratio is found, which is divided by the number of micrograms of Cd used giving a factor for 1 microgram Cd versus 200 micrograms Pb. It is suggested that 200 micrograms Pb be used as an internal standard in each sample for Cd thereby simplifying the calculations. The factor for 1 microgram Cd versus 200 microgram Pb, found at the beginning of the series of samples being analyzed, will be used for the calculations throughout this series.

(e) Calculations

For the sample "polarogram" the heights of the Pb and Cd curves are measured in mm. and the Cd to Pb ratio found in the same manner as the standard curve. The ratio found here is divided by the factor found in the standard curve for 1 microgram Cd versus 200 micrograms Pb giving the number of micrograms of Cd in the aliquot put into the polarographic cell.

$$mg\ Cd/M^3 = \frac{V \cdot Y}{1{,}000 \cdot v \cdot Va}$$

Where v = aliquot (ml)
V = total sample (ml)
Y = micrograms in v
Va = gas sample volume, in cubic meters, at standard conditions

Fluoride

Source: Talvitie method modified by Michigan Department of Public Health.

(a) Scope

This method describes a procedure for determining fluoride in stack gases.

(b) Auxiliary Apparatus

- Standard impinger with fritted glass bubbler.
- 250 ml Claissen flasks.
- 100 ml Nessler Tubes.

(c) Reagents

Standard Sodium Fluoride - Make a solution containing 1 mg of fluoride per ml (2.21 g of sodium fluoride to 1 liter). Take 10 mls of this solution and dilute to 1 liter; 1 ml of this dilution contains .01 mg fluoride.

Color Forming Reagent - Dissolve 36.99 g of sodium sulfate in about 500 ml of hot distilled water and 17.7 g of sodium formate in about 200 ml of hot distilled water. Mix together and when cooled, add 0.1436 g thorium nitrate tetrahydrate and 11 ml of 90% formic acid.

Alizarin monosodium sulfonate indicator 128.25 mg dissolved in 1 liter of distilled water.

Nitric Acid - About 5 ml concentrated acid, diluted to a liter with distilled water.

Sodium Hydroxide - .5 N. (20 g dissolved in 1 liter of water).

Silver Sulfate.

Concentrated Sulfuric Acid.

(e) Sampling Procedure

Assemble sampling train of probe, impinger with fritted glass bubbler containing 100 ml of a 2% sodium hydroxide solution, flow meter and vacuum pump. Sample at a rate of 1 CFM for a period long enough to provide a minimum of 15 cubic feet at standard conditions.

(f) Analytical Procedure

Sample Preparation - Transfer the collecting solution from the impinger into a Claissen flask. Slowly add 35 ml of concentrated sulfuric acid (using small long stem funnel) to content, submerging and swirling flask in cool-cold water while adding the acid--this offsets the loss of HF. Add boiling chips and silver sulfate (to cover the end of a spatula). Close the flask with a two-hole rubber stopper, through which passes a thermometer and a 6 mm O.D. glass tube drawn to capillary size and extends down into the solution. Connect tube to a separatory funnel containing water. This is to slowly add water to both cool the flask and to replenish the water boiled off due to distillation in the Claissen flask.

The distillation flask should be placed on a pad of transite or asbestos, or on a plate of aluminum with a hole about 2 inches in diameter made to fit the flask perfectly.

Regulate the heat under the steam distillation flask so that the distillate being collected remains cool. Adjust the application of heat to the still so that a temperature of 165^{o} C is maintained. Collect the distillate in a 250-ml volumetric flask or in a 250-ml beaker, and then make up to exactly 250 ml in a volumetric flask. Stopper the flask and mix. Pipette 25 ml into a 100-ml-long form Nessler tube. Add 5.0 ml of alizarin indicator. Titrate carefully with a .5 N sodium hydroxide until the solution changes from yellow to a decided pink. Back titrate with the dilute nitric acid until the solution changes to a pure yellow. Dilute to about 90 ml, add 3 ml of thorium reagent, make up to exactly 100 ml and mix well. After 30 minutes, compare with the standards. If the same is beyond the range of the standards, use a smaller aliquot. If it is too close to the standard containing no fluorine, double or treble the aliquot.

A blank must be carried through all the steps of the procedure, using the same amounts of reagents as are used in the samples. An aliquot of 75 ml is usually necessary to determine the amount of fluorine present in the blank.

(f) Calculations

Calculate the total amount of fluorine present in the blank and subtract this from the total fluorine found in each sample.

$$\text{mg F/M}^3 = \frac{V \cdot Y}{1{,}000 \cdot v \cdot Va}$$

where v = aliquot (ml)
V = total sample (ml)
Y = micrograms in v
Va = gas sample volume, in cubic meters, at standard conditions

Lead

Source: Michigan Department of Public Health.

(a) Scope

Stack testing for cadmium can be accomplished by the polarograph method using a dropping-mercury electrode with the sample as the electrolyte.

(b) Auxiliary Apparatus

Sargent Polarograph - Model XX1, recording type, or equivalent.

(c) Reagents

Standard Lead Solution - Dissolve approximately 25 grams of C.P. $Pb(NO_3)_2$ in minimum of hot water and cool with stirring. Filter with suction on small Buchner funnel. Repeat recrystallization. Dry crystals at 100^{o}-110^{o} C to constant weight, cool in desiccator and store in tightly stoppered pyrex bottle. The product has no water of crystallization and is not appreciably hygroscopic. Weight exactly 0.1599 grams of recrystallized C.P. $Pb(NO_3)_2$, put into 500-ml volumetric flask, and take to volume with 0.1 N HCl. This gives a standard lead solution containing 200 micrograms Pb/ml with 0.1 N HCl as the electrolyte. The 0.1 N HCl should be prepared from constant boiling hydrochloric acid.

Standard Cadmium Solution - Weight exactly 0.2744 grams of $Cd(NO_3)_2 \cdot 4H_2O$ into a 500-ml volumetric flask and take to volume with 0.1 N HCl. This gives a standard cadmium solution containing 200 micrograms cadmium per ml with 0.1 N HCl as the electrolyte. As in the lead solution, the 0.1 N HCl should be prepared from constant boiling hydrochloric acid.

Oxygen Absorbent for Purification of Nitrogen - Pass nitrogen through a first scrubbing flask (a midget impinger) containing concentrated NH_4OH and copper turnings. Caution: Make certain hole in impinger is not plugged before turning nitrogen under pressure on. Then pass nitrogen through a second scrubbing flask containing concentrated sulfuric acid, again making certain this is not plugged before applying pressure.

0.2 N. Hydrochloric Acid - Prepare this from constant boiling hydrochloric acid according to outline in Lange's Handbook.

Clean, Dry Mercury - Purchase from Eberbach and Son.

(d) Sampling Procedure

Assemble sampling train of probe, impinger with 100 ml 5% nitric acid solution, flow meter and vacuum pump. Sample at rate of 1 CFM for a period long enough to provide a minimum of 30 cubic feet at standard conditions.

(e) Analytical Procedure

Sample Preparation - Transfer the collecting solution to a 250-ml beaker, wash out impinger with 5% hot nitric acid and all taken down to dryness on a hot plate. Cool and add 25 ml of 0.2 N HCl. Heat just to boiling and transfer to a 50-ml volumetric flask. Dilute to volume with distilled water which will dilute the 0.2 N HCl to 0.1 N HCl which is the electrolyte.

Transfer a 10-ml aliquot from the 50-ml volumetric flask into the polarographic cell, add 1 ml of 200 micrograms Cd per ml solution, and remove oxygen from the cell by bubbling nitrogen which is being purified as described under reagents, through for three to five minutes. The instrument used is a Sargent Polarograph - Model XXI and the settings are as follows: A.C. switch down (on), D.M.E. - up (negative), Damping - down (off), Initial E.M.F. - up (additive), D.C. E.M.F. - down (1.5 V span), Chart drive - up (on), Operation - up (E.M.F. increasing). The initial voltmeter is set at .3 volts, the span voltmeter is set at .6 volts, thereby giving a range from -.3 volts to -.9

volts. This is sufficient as lead "comes off" at approximately -.44 volts and cadmium at approximately -.66 volts. The sensitivity setting might have to be found by trial and error, 0.020 suffices for most samples although if the lead is low the sensitivity will have to be increased (decreasing the number of microamperes/mm).

If there is a possibility that Cd is present in the sample, an aliquot of the sample should be run in the polarographic cell first, without any internal standard added. If there is CD present in the sample this must be taken into account when Cd, the internal standard, is added.

Standard Curve - Into the polarographic cell is introduced 1 ml of 200 micrograms Pb per ml solution, 1 ml of 200 micrograms Cd per ml solution and 9 ml of 0.1 N HCl. This gives a total amount of solution in the cell of 11 ml thereby enabling a later removal of 10 ml of the sample and 1 ml of 200 micrograms Cd per ml internal standard solution. Also, there is an electrolyte in the cell of 0.1 N HCl. Both the volume of liquid in the cell and the electrolyte for standard curve and sample are critical for a proper analysis.

On the standard curve the heights of the Pb and Cd curves are measured in mm. The Pb to Cd ratio is found, which is divided by the number of micrograms of Pb used giving a factor for 1 microgram Pb versus 200 micrograms Cd. It is suggested that 200 micrograms Cd be used as an internal standard in each sample for Pb thereby simplifying the calculations. The factor for 1 microgram Pb versus 200 micrograms Cd, found at the beginning of the series of samples being analyzed, will be used for the calculations through this series.

(f) Calculations

For the sample "polarogram" the heights of the Pb and Cd curves are measured in mm and the Pb to Cd ratio found in the same manner as the standard curve. The ratio found here is divided by the factor found in the standard curve for 1 microgram Pb versus 200 micrograms Cd giving the number of micrograms of Pb in the aliquot put into the polarographic cell.

$$\text{mg Pb/M}^3 = \frac{V \cdot Y}{1{,}000 \cdot v \cdot Va}$$

where v = aliquot (ml)
V = total sample (ml)
Y = micrograms in v
Va = gas sample volume, in cubic meters, at standard conditions.

Mercury

Source: American Conference of Governmental Industrial Hygienists.

(a) Scope

Divalent mercury forms an orange-yellow complex with dithizone in dilute acid solution which can be extracted by chloroform. An additional extraction in the presence of chloride and bromide ions eliminates the interference of other metals.

(b) Auxiliary Apparatus

- Beckman DU Spectrophotometer or equivalent.
- Squibb separator funnels.
- Cuvettes.

(c) Reagents

HCl-0.1 N.

Meta Cresol Purple Indicator - Dissolve 0.05 g of the power in 6 ml of 0.05 N NaOH; then dilute to 100 ml with distilled water.

Buffer Solution - Dissolve 300 g anhydrous Na_2HPO_4 and 75 g K_2CO_3 in distilled water to make 2 liters of solution (MacIlvaine's Buffer Solutions).

Treated Chloroform - Chloroform treated with hydroxylamine hydrochloride as per the method of Hubbard, Industrial Engineering Chemistry, Anal. Ed., 9, 493 (1937).

Dithizone Solutions - Make up a stock solution containing 0.5 mg dithizone per ml of chloroform. Other strength dithizone solutions can be made up as needed. It is advisable to allow the dithizone solutions to stabilize overnight before use.

Potassium Bromide Solution - 40% KBr in distilled water.

Ammonium Citrate - 40%. Mix 40 g citric acid, monohydrate, with about 20 ml distilled water. Add sufficient ammonium hydroxide slowly with constant stirring to make solution alkaline to phenol red and make to volume with water. Purify by shaking with dithizone in chloroform and clear with pure chloroform.

Mercury Standard Solutions - Dissolve 0.1354 g mercuric chloride, C.P., special reagent grade in 1 N HCl and make up to 100 ml with the acid. This solution contains 1 mg Hg per ml and is quite stable. If any cloud or sediment develops, it should be discarded. Other strength solutions can be made by dilution with distilled water as the need arises.

Hydroxylamine Hydrochloride - 20% solution in distilled water.

(d) Sampling Procedure

Assemble sampling train of probe, impinger with 100 ml of 0.25% iodine in a 3% aqueous solution of potassium iodide. Sampling rate of 1 CFM for a period long enought to provide a minimum of 30 cubic feet at standard conditions.

(e) Analytical Procedure

Sample Preparation - The contents of the impinger flask and washings are made up to a known volume with distilled water. A proper aliquot is taken to place the mercury concentration within range of the method. Add 5 ml of ammonium citrate, 1 ml hydroxylamine hydrochloride and shake. Add 2 drops of phenol red indicator. (Always add the hydroxylamine hydrochloride before the phenol red.) Titrate with ammonium hydroxide to the full color end point pH of 8.5. Extract with 5 ml portions of 20 mg/liter dithizone solution, withdrawing the chloroform layers into another 250 ml Squibb separatory funnel, into which has been placed 50 ml of 0.1 N HCl. Continue to extract with and withdraw 5-ml portions until the dithizone in the chloroform layer does not change color.

Shake the above dithizone extract with 50 ml 0.1 N HCl for 2 minutes. Draw off the chloroform into a clean separatory funnel. Wash the aqueous phase with two, 3-5 ml portions of treated chloroform and add to the extracts. Discard the aqueous phase. To the chloroform extracts, add 50 ml of 0.1 N HCl and 10 ml of the 40% KBr reagent. Shake for 2 minutes. The Hg goes into the aqueous phase as H_2HgBr_4 while the Cu and Bi remains in the dithizone which is discarded. Wash the aqueous phase with a few ml of treated chloroform. Let the phases separate well and discard completely all chloroform droplets. An aliquot of the stripping solution may be taken if necessary so that the amount of Hg will fall on the standard curve. If an aliquot is taken, make up to 50 ml volume with 0.1 N HCl.

Add 10 ml buffer solution to bring the pH to 6, and 10 ml of 10 mg/liter dithizone solution. Shake well for 2 minutes. Avoid any exposure to direct sunlight or exceedingly bright artificial light.

NOTE: If the separatory funnel was not washed thoroughly with distilled water, the dithizone may be oxidized.

By means of a cotton swab on an applicator stick, remove any traces of moisture from the stem of the funnel after the stopcock has been opened for a second to allow the chloroform to fill the bore. Loosely insert a small cotton plug in the stem of the funnel. Rinse a cuvette twice with 1-2 ml portions of the chloroform layer and draw off the remaining dithizone into the cuvette. Place in the spectrophotometer and read at point of maximum light absorption (485 millimicron) against distilled chloroform. A blank on reagents should be carried through the entire procedure and this blank subtracted from the final result.

Standard curve - Suitable concentrations of mercury to give coverage over the entire range are used to establish a particular curve. Three or four points are sufficient.

Place 5 ml of the 40% KBr reagent, 10 ml of the buffer solution and the proper amount of standard mercury solution in a 125 ml Squibb separatory funnel. Add enought 0.1 N HCl to make the final volume 65 ml. Then add 10 ml of 10 mg/liter dithizone solution and shake for 2 minutes. Flush the stem of the separatory funnel and remove moisture by means of a cotton swab, withdraw the chloroform layer and read in the spectrophotometer as described above.

The 10 mg/liter dithizone solution is of sufficient strength to cover the range from 0 to 15 micrograms of mercury. By using 20 ml instead of the standard 10 ml of this reagent, the concentration range covered can be doubled. It is not recommended to add more than 20 ml of 10 mg/liter dithizone to any sample.

For only an occasional mercury analysis, it is better to bracket the sample with standard amounts rather than prepare an entire curve.

(f) Calculation

$$\text{mg Hg/M}^3 = \frac{V \cdot Y}{1{,}000 \cdot v \cdot Va}$$

where
v = aliquot (ml)
V = total sample (ml)
Y = micrograms in v
Va = gas sample volume, in cubic meters, at standard conditions

Zinc

Source: Michigan Department of Public Health.

(a) Scope

Stack testing for zinc can be accomplished by the polarograph method using a dropping-mercury electrode with the sample as the electrolyte.

(b) Auxiliary Apparatus

Sargent Polarograph - Model XXl, recording type, or equivalent.

(c) Reagents

Stock Zinc Solution - Weigh exactly 5.0 grams of dry reagent zinc (30 mesh or finer) into a 500-ml volumetric flask and add a minimum amount of constant boiling hydrochloric acid to get the zinc in solution. Boil until solution is complete and make up to volume with distilled water. The solution contains 10.0 mg zinc per ml.

Working Standard Zinc Solution - Pipette 5.0 ml of stock zinc solution (10.0 mg zinc per ml) into 500-ml volumetric flask and take to volume with 0.2 M KCl. The solution contains 100 micrograms zinc per ml with 0.2 M KCl as the electrolyte.

0.2 M KCl Solution - Weigh 14.9 grams reagent grade KCl into 1 liter volumetric flask and take to volume with distilled water.

Standard Cadmium Solution - Weigh exactly 0.2744 grams of $Cd(NO_3)_2 \cdot 4H_2O$ into a 500-ml volumetric flask and take to volume with 0.2 M KCl. The solution contains 200 micrograms Cd per ml with 0.2 M KCl as electrolyte.

Oxygen Absorbent for Purification of Nitrogen - Pass nitrogen through a first scrubbing flask (midget impinger) containing concentrated NH_4OH and copper turnings. Caution: Make certain hole in impinger is not plugged before turning nitrogen on under pressure. Then pass nitrogen through a second scrubbing flask containing concentrated sulfuric acid, again making certain this is not plugged before applying pressure.

Clean, Dry Mercury - Purchase from Eberbach & Son.

(d) Sampling Procedure

Assemble sampling train of probe, impinger with 100 ml 5% nitric acid solution, flow meter and vacuum pump. Sample at rate of 1 CFM for a period long enough to provide a minimum of 30 cubic feet at standard conditions.

(e) Analytical Procedure

Sample Preparation - Transfer the collecting solution from the impinger into a 250 ml beaker, wash out impinger with 5% hot nitric acid and all taken down to dryness on a hot plate. Add 2 ml concentrated nitric acid, wetting the sample thoroughly. Add 6 drops perchloric acid and swirl to mix. Evaporate to dryness on a hot plate at 350°-400° C. Repeat the acid treatment to obtain complete digestion. Cool and add 10 ml of 0.2 M potassium chloride solution. Loosen the solids with a rubber policeman, rinse policeman and beaker walls with 3-5 ml of 0.2 M potassium chloride solution. Cover with a watch glass and boil 2-3 minutes. Filter the solution into a 50-ml volumetric flask washing the filter with 0.2 M KCl. Dilute to volume with 0.2 M KCl giving the sample in 50 ml with 0.2 M KCl as the electrolyte.

Transfer 10 ml aliquot into polarographic cell, add 1 ml of 200 micrograms Cd per ml solution, and remove oxygen from cell by bubbling nitrogen through for three to five minutes. The initial voltmeter is set at .4 volts, the span voltmeter is set at 1 volt, thereby giving a range from -.4 volts to -1.4 volts. This is sufficient as cadmium "comes off" at approximately -.66 volts and zinc at approximately -1.05 volts. The sensitivity setting will vary depending on the amount of zinc present. The setting used for the standard curve is 0.02 microamperes/mm.

If there is a possibility that Cd is present in the sample an aliquot of the sample should be run in the polarographic cell first, without any internal standard added. If there is Cd present in the sample this must be taken into account when CD, the internal standard, is added.

Standard curve - Into the polarographic cell is introduced 1 ml of 100 micrograms Zn per ml solution, 1 ml of 200 micrograms Cd per ml solution, and 9 ml of 0.2 M KCl solution. This gives a total amount of solution in the cell of 11 ml thereby enabling a later removal of 10 ml of the sample and 1 ml of 200 micrograms Cd per ml internal standard solution. Also, there is an electrolyte in the cell of 0.2 M KCl. Both the volume of liquid in the cell and the electrolyte for standard curve and sample are critical for a proper analysis.

On the standard curve the heights of the Zn and Cd curves are measured in mm. The Zn to Cd ratio is found which is divided by the number of micrograms of Zn used giving a factor for 1 microgram Zn versus 200 micrograms Cd. It is suggested that 200 micrograms Cd be used as an internal standard in each sample for Zn thereby simplifying the calculations. The factor for 1 microgram Zn versus 200 micrograms Cd, found at the beginning of the series of samples being analyzed, will be used for the calculations through this series.

(f) Calculations

For the sample "polarogram" the heights of the Zn and Cd curves are measured in mm and the Zn to Cd ratio found in the same manner as the standard curve. The ratio found here is divided by the factor found in the standard curve for 1 microgram Zn versus 200 micrograms Cd giving the number of micrograms of Zn in the aliquot put into the polarographic cell.

$$\text{mg Zn/M}^3 = \frac{V \cdot Y}{1{,}000 \cdot v \cdot Va}$$

where v = aliquot (ml)
V = total sample (ml)
Y = micrograms in v
Va = gas sample volume, in cubic meters, at standard conditions

Nitrogen Oxides, Phenoldisulfonic Acid Method

Source: Public Health Service.

(a) Scope

When sulfur dioxide, ammonia, iron or other compounds that interfere with the hydrogen peroxide method are present in the gas to be sampled and/or the concentration of the nitrogen oxides is below about 100 ppm, this method is used. Accuracy below 5 ppm is questionable. This test is unsuitable for atmospheric sampling.

(b) Apparatus

- Sampling Probe - Stainless steel (type 304 or 316) or glass tubing of suitable size (1/4-inch-OD, 6-foot-long stainless steel tubing has been used).
- Collection Flask - A 2-liter round-bottom flask with an outer 24/40 joint for integrated samples or a 250-ml MSA sampling tube for grab samples.
- Orifice Assembly - The size of the glass capillary tubing depends on the desired sampling period (flow rates of about 1 liter per minute have been used). Use of this orifice is not mandatory.
- Adapter with Stopcock - Adapter for connecting collection flask to sampling "T".
- Three-way Stopcock.

- Manometer - A 36-inch Hg manometer or accurate vacuum gage.

- Spectrophotometer - Beckman Model "B" or equivalent.

(c) Reagents

Thirty Percent Hydrogen Peroxide - (reagent grade).

Three Percent Hydrogen Peroxide - Dilute 30% H_2O_2 with water at 1:10 ratio. Prepare fresh daily.

Concentrated Sulfuric Acid.

0.1 N (approximate) Sulfuric Acid - Dilute 2.8 ml concentrated H_2SO_4 to 1 liter with water.

Absorbing Solution - Add 12 drops 3% H_2O_2 to each 100 ml 0.1 N H_2SO_4. Make enough for required number of tests.

1 N (approximate) Sodium Hydroximde - Dissolve 40 gm NaOH pellets in water and dilute to 1 liter.

Concentrated Ammonium Hydroxide.

Fuming Sulfuric Acid - 15 to 18 weight percent free sulfuric anhydride (oleum).

Phenol (reagent grade).

Phenoldisulfonic Acid Solution - Dissolve 25 grams of pure white phenol in 150 ml concentrated H_2SO_4 on a steam bath. Cool and add 75 ml fuming sulfuric acid. Heat to 100° C for 2 hours. Store in a dark stoppered bottle. This solution should be colorless if prepared with quality reagents.

Potassium Nitrate (reagent grade).

Standard Potassium Nitrate Solution - Solution A: Dissolve 0.5495 gram KNO_3 and dilute to 1 liter in a volumetric flask. Solution B: Dilute 100 ml of Solution A to 1 liter. One ml of Solution A contains the equivalent of 0.250 mg NO_2 and of Solution B, 0.0250 mg NO_2.

(d) Sampling Procedure

Integrated Grab Sample - Add 25 ml freshly prepared absorbing solution into the flask. Record the exact volume of absorbing solution used.

Set up the apparatus as shown in Figure 3, attach the selected orifice. Purge the probe and orifice assembly with the gas to be tested before sampling begins by applying suction to it. Evacuate the system to the vapor pressure of the solution: this pressure is reached when the solution begins to boil. Record the pressure in the flask and the ambient temperature. Open the valve to the sampling probe to collect the sample. Constant flow will be maintained until the pressure reaches 0.53 of the atmospheric pressure. Stop before this point is reached. During sampling, check the rate of fall of the mercury in one leg of the manometer in case clogging, especially of the orifice, occurs. At the end of the sampling period, record the pressure, temperature, and barometric pressure.

An extended period of sampling can be obtained by following this procedure. Open the valve only a few seconds at regular intervals. For example: Open the valve for 10 seconds and close it for 50 seconds; repeat every 60 seconds.

Grab Sample - Set up the apparatus as shown in Figure 4 for high concentrations (200-3000 ppm) or the apparatus as shown in Figure 4 for low concentrations (0-200 ppm) but delete the orifice assembly. The same procedure is followed as in the integrated method except that the valve is opened at the source for about 10 seconds and no orifice is used.

Calibration curves are made to cover different ranges of concentrations. Using a microburette for the first two lower ranges and a 50-ml burette for the next two higher ranges, transfer the following into separate 150-ml beakers (or 200-ml casseroles).

1. 0-100 ppm: 0.0 (blank), 2.0, 4.0, 6.0., 8.0, 10.0, 12.0, 16.0, 20.0 ml of KNO_3 Solution B.

2. 50-500 ppm: 0.0 (blank), 1.0, 1.5, 2.0, 3.0, 4.0, 6.0, 8.0, 10.0 ml of KNO_3 Solution A.

3. 500-1500 ppm: 0.0 (blank), 5.0, 10.0, 15.0, 20.0, 25.0, 30.0 ml of KNO_3 Solution A.

4. 1500-3000 ppm: 0.0 (blank), 15.0, 30.0, 35.0, 40.0, 45.0., 50.0, 55.0, 60.0 ml KNO_3 Solution A.

Add 25.0 ml absorbing solution to each beaker. Follow as directed in the Analytical Procedure section starting with the addition of 1 N NaOH.

After the yellow color has developed, make dilutions for the following ranges: 50 to 500 ppm (1:10); 500 to 1,400 ppm (1:20); and 1,500 to 3,000 ppm (1:50). Read the absorbance of each solution at 420 millimicron.

Plot concentrations against absorbance on rectangular graph paper. A new calibration curve should be made with each new batch of phenoldisulfonic acid solution or every few weeks.

(e) Analytical Procedure

Shake the flask for 15 minutes and allow to stand over night.

Transfer the contents of the collection flask to a beaker. Wash the flask three times with 15-ml portions of H_2O and add the washings to the solution in the beaker. For a blank add 25 ml absorbing solution and 45 ml H_2O to a beaker. Proceed as follows for the bank and samples.

Add 1 N NaOH to the beaker until the solution is just alkaline to litmus paper. Evaporate the solution to dryness on a water bath and allow to cool. Carefully add 2 ml phenoldisulfonic acid solution to the dried residue and triturate thoroughly with a glass rod, making sure that all the residue comes into contact with the solution. Add 1 ml H_2O and four drops concentrated H_2SO_4. Heat the solution on the water bath for 3 minutes, stirring occasionally.

Allow to cool and add 20 ml H_2O, mix well by stirring, and add 10 ml concentrated NH_4OH, dropwise, stirring constantly. Transfer the solution to a 50-ml volumetric flask, washing the beaker three times with 4- to 5-ml portions of H_2O. Dilute to mark with water and mix thoroughly. Transfer a portion of the solution to a dry, clean centrifuge tube and centrifuge, or filter a portion of the solution.

Read the absorbance of each sample at 420 millimicron. If the absorbance is higher than 0.6, make a suitable dilution of both the sample and blank and read the absorbance again.

(f) Calculations

$$\text{ppm } NO_2 = \frac{(5.24 \times 10^5)\ (C)}{V_s}$$

Where C = concentration of NO_2, mg (from calibration chart)

V_s = gas sample volume at 70° F and 29.92 in Hg, ml.

Sulfur Dioxide and Sulfur Trioxide, Shell Development Company Method

Source: National Air Pollution Control Administration Publication 999-AP-13.

(a) Scope

This method describes a procedure for determining sulfur dioxide and sulfur trioxide in stack gases.

(b) Apparatus

- Sampling Probe - Glass tubing (preferably borosilicate or quartz) of suitable size with a ball joint at one end and a removable filter at the other (a 1/2-inch-OD, 6-foot-long tube has been used.)

- Filter - A filter is needed to remove particulate matter, which may contain metal sulfates and cause interference during analysis. Borosilicate glass wool, Kaolin wool, or silica wool are suitable filters for removing particulate matter.

- Adapter - Six plug-type connecting tubes T 24/40, one with a 90° bend and a socket joint.

- Heating Tape - An insulated heating tape with a powerstat to prevent condensation in exposed portion of probe and adapter. Alternative: glass wool or other suitable insulators.

- Dry Gas Meter - A 0.1-cubic-foot-per-revolution dry gas meter equipped with a fitting for a thermometer and a manometer. Alternately, a calibrated tank or a rotameter calibrated at the operating pressure may be used.

- Vacuum pump.

- Thermometers - One 10°-50° C, ± 1° C; and one 0°-300° C ± 5° C are suitable.

- Manometer - A 36-inch-Hg manometer

- Absorbers - Two U-shaped ASTM D 1266 lamp sulfur absorbers with coarse-sintered plates.

- Filter Tube	- One 40-mm-diameter Corning medium-sintered plate.
- Scrubber for Purifying Air	- An ASTM D 1266 lamp sulfur absorber with coarse-sintered plate.
- Teflon Tubing	- Teflon tubing, 1/4-inch ID, for connecting absorbers. Alternative: 8-mm pyrex tubing with butt-to-butt connections held together with Tygon.

(c) Reagents

Water - Distilled water that has been deionized.

Isopropanol, Anhydrous.

Eighty Percent Isopropyl Alcohl - Dilute isopropanol with water at a ratio of 4 to 1.

Thirty Percent Hydrogen Peroxide - (reagent grade).

Three Percent Hydrogen Peroxide - Dilute 30% hydrogen peroxide with water at a ratio of 10 to 1. Prepare fresh daily.

Barium Chloride - ($BaCl_2 \cdot 2H_2O$, reagent grade).

0.0100 N Alcoholic Barium Chloride - Dissolve 1.2216 grams $BaCl_2 \cdot 2H_2O$ in 200 ml of water and dilute to 1 liter with isopropanol. Standardize this solution with 0.01 N alcoholic sulfuric acid solution.

(As an alternate titrating solution to 0.01 N alcoholic barium chloride, in American Petroleum Institute Study Group uses 0.01 N alcoholic barium perchlorate because they believe that it gives a sharper end point during titration.)

Thorin Indicator - 1-(O-arsonophenylazo)-2 naphthol-3, 6-disulfonic acid, disodium salt.

0.2 Percent Thorin Indicator - Dissolve 0.2 gram thorin indicator in 100 ml water. Store in polyethylene bottle.

(d) Sampling Procedure

Set up the apparatus as shown in Figure 5. Place 30 ml of 80% isopropyl alcohol in the first absorber and 10 ml in the filter tube. The add 50 ml of 3% hydrogen peroxide to the second absorber. A light film of silicone grease on the upper parts of the joints may be used to prevent leakage. Wind the heating tape in a uniform single layer around the exposed portion of the probe and adapter and cover the heating tape with asbestos tape wound in the opposite direction. Place a thermometer between the heating tape and asbestos as near the adapter joint as possible. Connect the heating tape to a powerstat, switch on the current, and maintain the probe and adapter at a temperature at which no condensation will occur (about 250° C). Sample at 0.075 cubic foot per minute until 2 cubic feet or a suitable volume of gas has been sampled. Record the meter readings, temperatures and pressures at

10-minute intervals. Note the barometric pressure. Do not sample at a vacuum of more than 8 inches Hg.

Disconnect the asbestos tape, heating tape, probe, and adapter and allow them to cool. Connect the scrubber for purifying air to the inlet of the isopropyl alcohol absorber and add 50 ml of 3% hydrogen peroxide. Replace the water in the ice bath with tap water. Draw air through the system for 15 minutes to transfer residual sulfur dioxide to the hydrogen peroxide absorber. Disconnect the purifying air scrubber. (Although the use of air for removal of sulfur dioxide from isopropyl alcohol should not result in oxidation of sulfur dioxide to sulfur trioxide, the American Petroleum Institute Joint Study Group uses 99% nitrogen to preclude any possibility of oxidation.) Remove the filter and wash the probe and adapter with 80% isopropyl alcohol. Place the washings in the isopropyl alcohol absorber.

Disconnect the hydrogen peroxide absorber and transfer the contents and the water washings to a 250-ml volumetric flask. Dilute the water to the mark. Analyze for sulfur dioxide.

Stopper the isopropyl alcohol absorber and apply suction to the filter end. Remove the suction line and allow the partial vacuum in the absorber to draw the solution from the filter. Rinse the filter tube with 80% isopropyl alcohol before the suction is lost. Transfer the contents of the isopropyl alcohol absorber and its washings to a 250-ml volumetric flask and dilute to the mark with 80% isopropyl alcohol. Analyze for sulfur trioxide.

(e) Analytical Procedure

Sulfur Trioxide - Pipette a suitable aliquot to a flask and dilute to 100 ml with 80% isopropyl alcohol. Add a few drops of thorin indicator (enough to give a yellow color). Titrate with 0.01 N $BaCl_2$ to the pink end point. Make a blank determination in parallel.

Sulfur Dioxide - Transfer a suitable aliquot to a flask and add 4 times this volume of isopropyl alcohol. Dilute to 100 ml with 80% isopropyl alcohol, add enough thorin indicator to give a yellow color, an titrate with standard 0.01 N $BaCl_2$ to the pink end point. Run a blank determination in parallel.

(f) Calculations

$$\text{ppm } SO_2 \text{ or } SO_3 \text{ by volume} = \frac{24(A-B)\ (N)\ (F)\ (T)}{(V_o)\ (P)}$$

Where A = 0.01N $BaCl_2$ used for titration of sample
B = ml 0.01N $BaCl_2$ used for titration of blank
N = exact normality of $BaCl_2$
F = dilution factor
T = average meter temperature, °R
V_o = observed volume of gas sample, cu ft
P = average absolute meter pressure, in. Hg

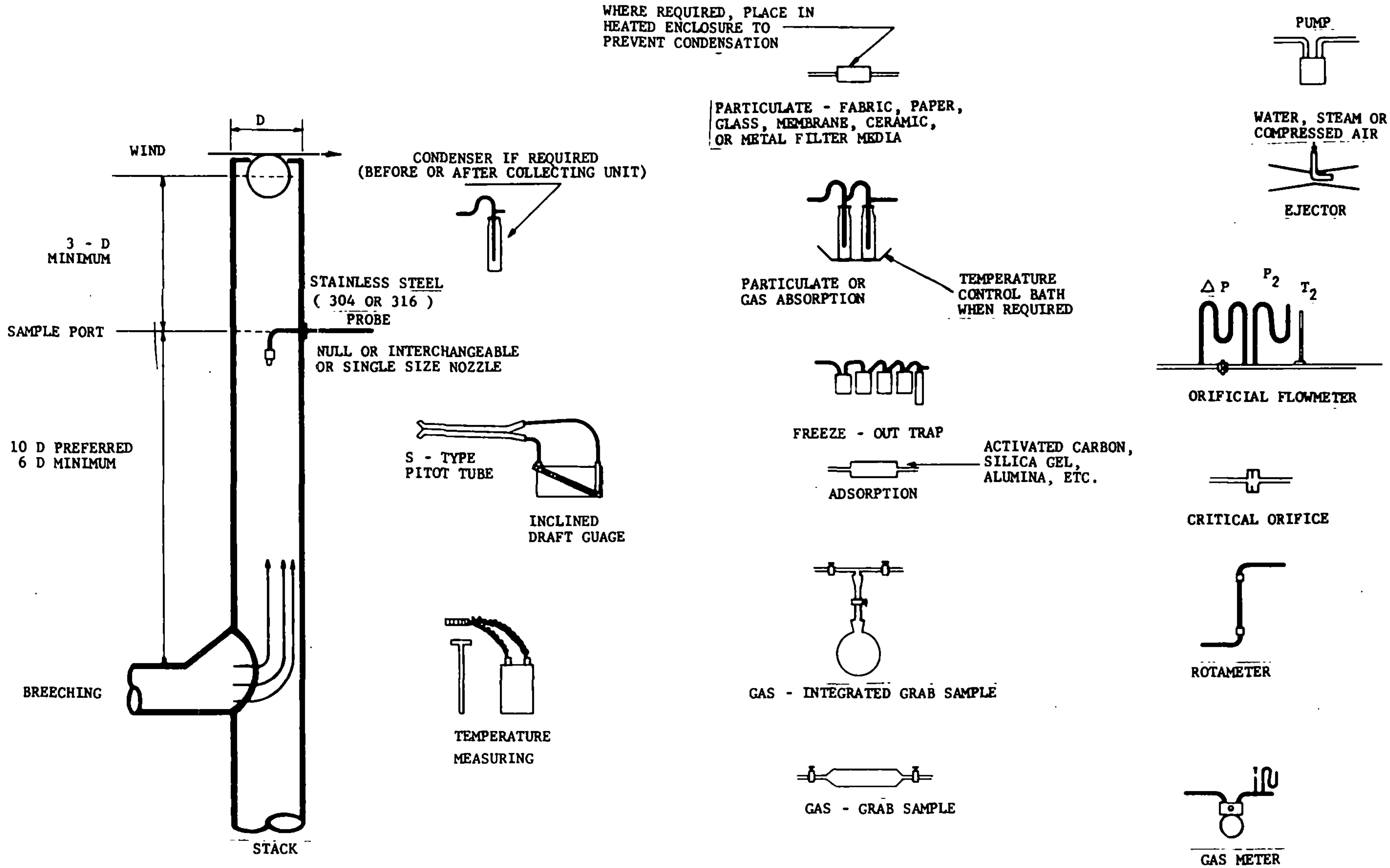
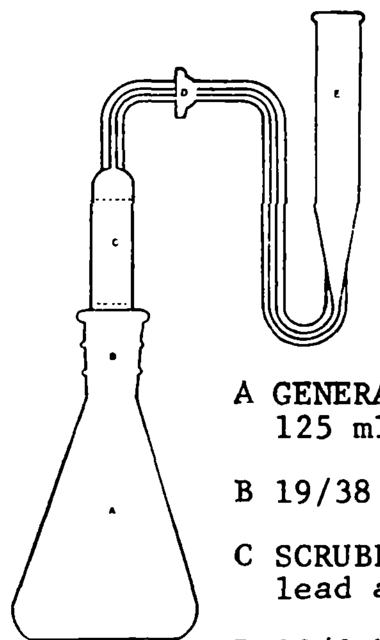


FIG. 1 SAMPLING LOCATION & TRAIN COMPONENTS

APPENDIX E
EXHIBIT 2
FIGURE 1



A GENERATOR
125 ml Erlenmeyer

B 19/38

C SCRUBBER
lead acetate on pyrex wool

D 12/2 ball joint

E ABSORBER
12 ml heavy wall
centrifuge tube

FIGURE 2

Arsine Generator

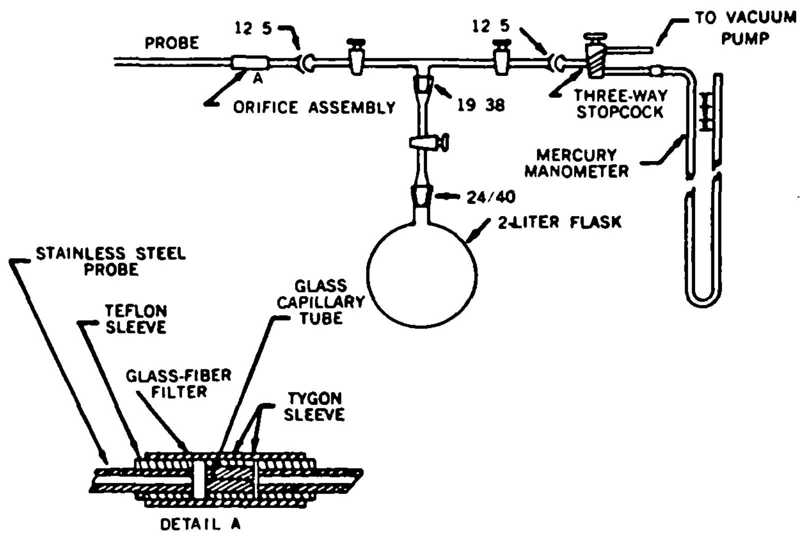


FIGURE 3

APPARATUS FOR INTEGRATED GRAB SAMPLES

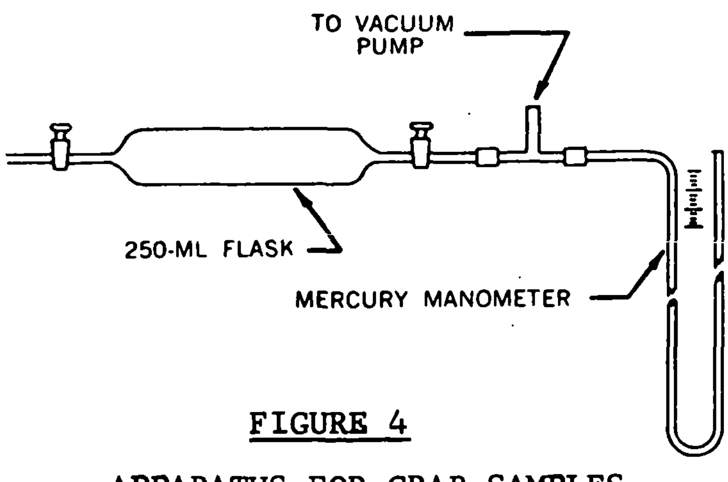


FIGURE 4

APPARATUS FOR GRAB SAMPLES

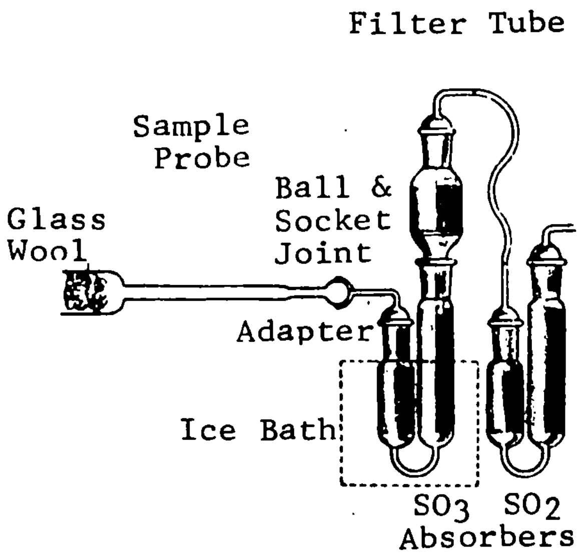


FIGURE 5

Sulfur dioxide - sulfur trioxide sampling train.

GLOSSARY OF TERMS

ACFM - Actual cubic feet per minute; refers to the volume of gas at the prevailing temperature and pressure.

Acid Lining - A refractory furnace lining essentially of silica.

Additive - A substance added to another in relatively small amounts to impart or improve desirable qualities, or suppress undesirable qualities. As additives to molding sand, for example, cereal, sea coal, etc.

Aerosol - Small particles, liquid or solid, suspended in the air. The diameters vary from 100 microns down to 0.01 microns or less; for example, dust, fog, smoke.

Afterburner - A device for burning combustible materials that were not oxidized in an initial burning process.

Agglomeration - Gathering together of small particles into larger particles.

Air Cleaner - A device designed for the purpose of removing atmospheric airborne impurities such as dusts, gases, vapors, fumes and smokes.

Air Filter - Any method used to remove gases and particulates from the environment and stack emission; it may be of cloth, fibers, liquid spray, electrostatic, etc.

Air Furnace - A reverberatory-type furnace in which metal is melted by heat from fuel burning at one end of the hearth, passing over the bath toward the stack at the other end.

Air Pollution - The presence in the outdoor atmosphere of one or more air contaminants or combinations thereof in such quantities and of such duration that they are or may tend to be injurious to human, plant or animal life, or property, or that interfere with the comfortable enjoyment of life or property or the conduct of business.

Anneal - A heat treatment which usually involves a slow cooling for the purpose of altering mechanical or physical properties of the metal, particularly to reduce hardness.

Baghouse - A large chamber for holding bags used in the filtration of gases from a furnace to recover metal oxides and other solids suspended in the gases. It's a form of dust collector and the bags may be constructed of natural, synthetic, or glass fibers.

Baked Core - A core which has been heated through sufficient time and temperature to produce the desired physical properties attainable from its oxidizing or thermal setting binders.

Balanced Blast - Arrangement of tuyeres in a cupola which provides for distributing or balancing the blast as required between upper and lower levels of the melting zone.

Basic Lining - In a melting furnace, the inner lining and bottom composed of materials that have a basic reaction in the melting process, usually either crushed burned dolomite, magnesite, magnesite bricks or basic slag.

Bed - Initial charge of fuel in a cupola upon which the melting is started.

Blast - Air driven into the cupola furnace for combustion of fuel.

Blast Volume - The volume of air introduced into the cupola for the burning of fuel. This volume governs the melting rate of the cupola and approximately 30,000 cubic feet of air is required per ton of metal melted.

Briquette - Compact cylindrical or other shaped block formed of finely divided materials by incorporation of a binder, by pressure, or both. Materials may be ferroalloys, metal borings or chips, silicon carbide, coke breeze, etc.

Burden - A collective term of the component parts of the metal charge for a cupola melt.

Burned Sand - Sand in which the binder or bond has been removed or impaired by contact with molten metal.

Canopy Hood - A metal hood over a furnace for collecting gases being exhausted into the atmosphere surrounding the furnace.

Cantilever Hood -	A counterbalanced hood over a furnace that can be folded out of the way for charging and pouring the furnace.
Cast Iron -	Essentially an alloy of iron, carbon and silicon in which the carbon is present in excess of the amount which can be retained in solid solution in austenite at the eutectic temperature.
Catalytic Combustion -	A device for burning combustible gases, vapors, aerosols and odorous substances, reducing them to water vapor and carbon dioxide.
Centrifuging -	A method of casting, employing a core and depending on centrifugal force to make the metal more dense and strong in the outer portion of the casting. The mold cavities are usually spaced symmetrically about a central sprue, and the whole assembly is rotated about that axis during pouring and solidification.
Cereal Binder -	A binder used in core mixtures and molding sands, derived principally from corn flour.
Charge -	The total ore, ingot, metal, pig iron, scrap, limestone, etc. introduced into a melting furnace for the production of a single heat.
Charging Door -	An opening in the cupola or furnace through which the charges are introduced.
Coke -	A porous gray infusible product resulting from the dry distillation of bituminous coal, which is used as a fuel in cupola melting.
Coke Breeze -	These are fines from coke screenings.
Convection -	The motion resulting in a fluid from the differences in density and the action of gravity due to temperature differences in one part of the fluid and another. The motion of the fluid results in a transfer of heat from one part to the other.
Cope -	The upper or topmost section of a flask, mold, or pattern.
Core -	A separate part of the mold which forms cavities and openings in castings which are not possible with a pattern alone. Cores are usually made of a different sand from that used in the mold and are generally baked or set by a combination of resins.

Core Binder - Any material used to hold the grains of core sand together.

Core Blower - A machine for making cores by blowing sand into the core box by means of compressed air.

Core Oven - Specially heated chambers for the drying of cores at low temperatures.

Core Sand - Sand for making cores to which a binding material has been added to obtain good cohesion and porosity after drying.

Crucible - A vessel or pot made of a refractory such as graphite or silicon carbide with a high melting point and used for melting metals.

Cupola - A cylindrical straight shaft furnace usually lined with refractories, for melting metal in direct contact with coke by forcing air under pressure through openings near its base.

Cupola, Hot Blast - A cupola supplied with a preheated air blast.

Cupola Stack - The overall top column of the cupola from the charging floor to the spark arrestor.

Cyclone - (centrifugal collector) A device with a control descending vortex created to spiral objectionable gases and dusts to the bottom of a collector cone for the purpose of collecting particulate matter from process gases.

Cyclonic Scrubber - Radial liquid (usually water) sprays introduced into cyclones to facilitate collection of particulates.

Density - Ratio of the weight of gas to the volume, normally expressed as pounds per cubic foot.

Desulfurizing - The removal of sulfur from molten metal by the addition of suitable compounds.

Direct Arc Furnace - An electric arc furnace in which the metal being melted is one of the poles.

Drag - The lower or bottom section of the mold, flask or pattern.

Ductile Iron - Iron of a normally gray cast type that has been suitably treated with a nodularizing agent so that all or the major portion of its graphitic carbon has a nodular or spherulitic form as cast.

Duplexing - A method of producing molten metal of desired analysis. The metal being melted in one furnace and refined in a second.

Dust - Small solid particles created by the breaking up of larger particles by processes such as crushing, grinding, drilling, explosion, etc.

Dust Collector - An air cleaning device to remove heavy particulate loadings from exhaust systems before discharge to outdoors.

Dust Loading - The concentration of dust in the gas entering or leaving the collector, usually expressed as pounds of particulate per 1,000 pounds of dry gas or grains per standard cubic foot.

Efficiency - With regard to dust collectors, it is the ratio of the weight of dust trapped in the collector to the weight of dust entering the collector. This is expressed as a percent.

Effluent - The discharge entering the atmosphere from the process.

Electrostatic Precipitator- A dust collector utilizing a high voltage electrostatic field formed by negative and positive electrodes; the positive, uncharged electrode attracts and collects the gas-borne particles.

Elutriation - The sizing or classifying of particulate matter by suspension in a fluid (liquid or gas), the larger particulates tending to separate by sinking.

Emission - The total pollutants emitted into the atmosphere usually expressed as weight per unit of time such as pounds per hour.

Endothermic Reaction - Designating, or pertaining to a reaction which occurs with the absorption of heat from the surroundings.

Equivalent Opacity - The determination of smoke density by comparing the apparent density of smoke as it issues from a stack with a Ringelmann chart. In effect, it is a measure of the light obscurity capacity of the plume.

Exothermic Reaction - Chemical reactions involving the liberation of heat; such as burning of fuel and deoxidizing of iron with aluminum.

Fabric Filter - A dust collector using filters made of synthetic, natural or glass fibers within a baghouse for removing solid particulate matter from the air or gas stream.

Facing Sand - Specially prepared molding sand mixture used in the mold adjacent to the pattern to produce a smooth casting surface.

Fines - A term the exact meaning of which varies.

1. Those sand grains that are substantially smaller than the predominating grain size.

2. That portion of sieved material that passes through the mesh.

Flask - Metal or wood frame without top or without fixed bottom used to retain the sand in which a mold is formed; usually consists of two parts, cope and drag.

Flux - Material or mixture of materials which causes other compounds with which it comes in contact to fuse at a temperature lower than their normal fusion temperature.

Fly Ash - A finely divided siliceous material, usually oxides, formed as a product of combustion of coke. A common effluent from the cupola.

Forehearth - Brick lined reservoir in front of and connected to the cupola or other melting furnaces for receiving and holding the melted metal.

Foundry Effluent - Waste material in water or air that is discharged from a foundry.

Fourth Hole Ventilation (Direct Tap) - In air pollution control, using a fourth hole in the roof of an electric furnace to exhaust fumes.

Fume - A term applied to fine solid particles dispersed in air or gases and formed by condensation, sublimation, or chemical reaction.

Gas - Formless fluids which tend to occupy entire space uniformly at ordinary temperatures and pressures.

Gate - The portion of the runner in a mold through which molten metal enters the mold cavity.

Gray Iron - Cast iron which contains a relatively large percentage of its carbon in the form of graphite and substantially all of the remainder of the carbon in the form of eutectoid carbide.

Green Sand - A naturally bonded sand or a compounded molding sand mixture which has been tempered with water and additives for use while still in a damp or wet condition.

Griffin System - A method operating in two stages, to recoup and preheat air by using the latent heat of cupola gases.

Heat Balance - A determination of the sources of heat input and the subsequent flow of heat usually expressed in equation form so that heat input equals heat output.

Heat Treatment - A combination of heating and cleaning operations timed and applied to a metal or alloy in the solid state in a manner which will produce desired properties.

Heel - Metal left in ladle after pouring has been completed. Metal kept in induction furnaces during standby periods.

Holding Furnace - A furnace for maintaining molten metal, from a larger melting furnace, at the proper casting temperature.

Hood - Projecting cover above a furnace or other equipment for purpose of collecting smoke, fume or dust.

Hot Blast - Blast which has been heated prior to entering into the combustion reaction of a cupola.

Indirect Arc Furnace - An electric arc furnace in which the metal bath is not one of the poles of the arc.

Induction Furnace - A melting furnace which utilizes the heat generated by electrical induction to melt a metal charge.

Inlet Volume - The quantity of gas entering the collector from the system it serves (in cubic feet per minute at a specified temperature).

Inoculant - Material which when added to molten metal modifies the structure changing the physical and mechanical properties of the metal.

Inoculation - The addition to molten metal substances designed to form nuclei for crystallization.

Ladle Addition - The addition of alloying elements to the molten metal in the ladle.

Latent Heat - Thermal energy absorbed or released when a substance changes state; that is, from one solid phase to another, or from solid to liquid or the like.

Lining - Inside refractory layer of firebrick, clay, sand or other material in a furnace or ladle.

Magnesium Treatment - The addition of magnesium to molten metal to form nodular iron.

Malleable Iron - A mixture of iron and carbon, including smaller amounts of silicon, manganese, sulfur and phosphorous, which, after being cast as white iron, is converted structurally by heat treatment into a matrix of ferrite containing nodules of temper carbon, and substantially free of all combined carbon.

Material Balance - A determination of the material input to the cupola and the output to fully account for all material.

Melting Rate - The tonnage of metal melted per unit of time, generally tons per hour.

Micron - A unit of measurement which is 1/25,000 of an inch or a millionth of a meter. Often designated by the Greek letter mu.

Mist - Visible emission usually formed by a condensation process or vapor-phase reaction, the liquid particles being sufficiently large to fall of their own weight.

Mold - The form, usually made of sand, which contains the cavity into which molten metal is poured to produce a casting of definite shape and outline.

Muller - A type of foundry sand mixing machine.

Nodular Cast Iron - (See Ductile Iron)

Opacity - The state of a substance which renders it partially or wholly impervious to rays of light. Opacity as used in an ordinance refers to the obscuration of an observer's view.

Outlet Volume - Quantity of gas exhausting from the collector (in cubic feet per minute at a specified temperature).

Oxidizing Atmosphere - An atmosphere resulting from the combustion of fuels in an atmosphere where excess oxygen is present, and with no unburned fuel lost in the products of combustion.

Oxidation Losses - Reduction in amount of metal or alloy through oxidation. Such losses usually are the largest factor in melting loss.

Particulate Matter - Solid or liquid particles, except water, visible with or without a microscope, that make up the obvious portion of an exhaust gas or smoke.

Parting Compound - A material dusted, brushed or sprayed on patterns or mold halves to prevent adherence of sand and to promote easy separation of cope and drag parting surfaces when cope is lifted from drag.

Pattern - A form made of wood, metal or other materials around which molding material is placed to make a mold for casting metals.

Plume - A visible, elongated, vertical (horizontal when windblown) column of mixed gases and gas-borne particulates emitted from a smoke stack.

Pollutant - Any foreign substance in the air or water in sufficient quantities and of such characteristics and duration as to be injurious to human, plant, or animal life or property, or which unreasonably interferes with the enjoyment of life and property.

Preheater - A device used to preheat the charge before it is charged into the furnace.

Process Weight - The total weight of raw materials, except air, introduced into any specific process, possibly causing discharge into the atmosphere.

Recuperator - Equipment for transferring heat from hot gases for the preheating of incoming fuel or air.

Reducing Atmosphere - An atmosphere resulting from the incomplete combustion of fuels.

Refractory - Heat resistant material, usually nonmetallic, used for furnace linings, etc.

Reverberatory Furnace - A large quantity furnace with a vaulted ceiling that reflects flame and heat toward the hearth or the surface of the charge to be melted.

Ringelmann's Scale - (chart) A system of optical charts reading from all clear to solid black for grading the density of smoke emissions.

Riser - An opening in the top of a mold which acts as a reservoir for molten metal and connected to the casting to provide additional metal to the casting as it contracts on solidification.

Rotary Furnace - A furnace using pulverized coal, gas or oil; of cylindrical shape with conical ends, mounted so as to be tipped at either end to facilitate charging, pouring and slagging.

SCFM - Units standing for Standard Cubic Feet per Minute. The volume of gas measured at standard conditions, one atmosphere of pressure and 70° F.

Sea Coal - A term applied to finely ground coal which is mixed with foundry sands.

Sensible Heat - That portion of the heat which changes only the temperature, but does not cause a phase change.

Shakeout - The operation of removing castings from a sand mold.

Shell Molding - A process for forming a mold from thermosetting resin bonded sand mixtures brought in contact with preheated metal patterns, resulting in a firm shell with a cavity corresponding to the outline of the pattern.

Shotblasting - Casting cleaning process employing a metal abrasive propelled by centrifugal force.

Slag - Nonmetallic covering which forms on the molten metal as a result of the flux action in combining impurities contained in the original charge, some ash from the fuel and silica and clay eroded from the refractory lining.

Smoke - A type of emission resulting from incomplete combustion and consisting predominantly of small gas-borne particles of combustible material present in sufficient quantity to be observable independently of the presence of other solids in the gas stream.

Spark Arrestor - Device over the top of the cupola to prevent the emission of sparks.

Sprue - The channel, usually vertical, connecting the pouring basin with the runner to the mold cavity. In top pour casting the sprue may also act as a riser.

Standard Air - Air with a density of .075 pounds per cubic foot, generally equivalent to dry air at 70° F and one atmosphere of pressure (14.7 psia).

Superheating - Heating of a metal to temperatures above the melting point of the metal to obtain more complete refining or greater fluidity.

Tapping - Removing molten metal from the melting furnace by opening the tap hole and allowing the metal to run into a ladle.

Tuyere - The nozzle openings in the cupola shell and refractory lining through which the air blast is forced.

Vapor - The gaseous form of a substance normally in the solid or liquid state and which can be returned to these states either by increasing pressure or decreasing temperature.

Ventilation System - In the foundry, the exhaust ventilation and dust control equipment for the health, safety, comfort and good housekeeping of those who work there.

Venturi Scrubber - In air pollution control, a high velocity gas stream directed into the throat of a venturi of a wet scrubber to separate out particulates.

Wet Cap - A device installed on a cupola stack that collects emissions by forcing them through a curtain of water. The device requires no exhaust fan but depends upon the velocity pressure of the effluent gases.

Wet Scrubber - In air pollution control, a liquid spray device, usually water, for collecting pollutants in escaping foundry gases.

Wind Box - The chamber surrounding a cupola through which air is conducted under pressure to the tuyeres.