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IDENTIFICATION AND CHARACTERIZATION OF THE USE OF MIXED CONVENTIONAL AND WASTE FUELS

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IDENTIFICATION AND CHARACTERIZATION OF THE USE OF MIXED CONVENTIONAL AND WASTE FUELS

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ABSTRACT

This report presents the results of a study to determine types of mixed and waste fuels and the extent of their usage in stationary combustion equipment. Where possible, pollutant emission levels resulting from combustion of these fuels have been determined. Industries surveyed included Utilities, Petroleum Refineries, Petrochemical, Chemical Processing, Glass, Cement and Textiles. Of the industries surveyed, about 70% of the refineries, 45% of the utilities, 20% of cement, glass and textile manufacturers and 10% of petrochemical and chemical processing plants have reported using mixed fuels to some extent.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

SUMMARY AND CONCLUSIONS

Based on information received from the various industries studied, it appears that the burning of mixed fuels is not practiced on a scale large enough to classify Petrochemical, Chemical Processing, Cement, Glass and Textile industries as mixed fuel users. Petroleum Refineries and Utilities burn mixed fuels to some extent. Of the sources surveyed about 70% of the refineries, 45% of the utilities, 20% of cement, glass and textile manufactures and 10% of petrochemical and chemical processing plants have reported using mixed fuels.

Stationary sources utilizing mixed fuels are boilers (both for power generation and process steam), process heaters and furnaces, kilns and incinerators. Mixed fuels are used mainly for steam generation and heat. The use of mixed fuels in connection with waste disposal has been reported in only two instances.

Sufficient information required for calculating emission factors from mixed fuel firing was not generally available. Emissions data were not available from the industries which have reported using mixed fuels. In a few cases estimated emissions or average emissions have been provided. Only a few of these emissions have been matched with the source and the fuels. There are no indications whether any emission control devices are in operation. Another area of uncertainty is the ratio of fuels mixed. One textile manufacturer has stated that fuel ratio varies virtually from hour to hour depending on the availability of natural gas. To calculate emission factors it is imperative to have the stack gas analysis at constant fuel ratio and without any variations in fuel composition and other variables such as temperature and excess air. Unfortunately, this type of data was not available from the manufacturers, state air pollution control agencies and regional offices of the U.S. Environmental Protection Agency. Therefore, no conclusions can be made regarding emissions from the use of mixed fuels.

Petroleum refineries have not indicated any significant changes in fuel mixing trends. In all other categories manufacturers have expressed an inability to predict fuel mixing trends due to uncertainty in their fuels supply situation. One manufacturer of textiles reports that they would not mix fuels if an adequate supply of a single fuel was available. A glass manufacturer, currently mixing fuel on a very limited scale, has reported future plans to change facilities to handle mixed fuels, but no specific details were provided. One cement manufacturer has reported abandoning the use of mixed fuels (coal and petroleum coke) due to higher heat losses. At this time there are no indications of any definite changes in fuel mixing trend.

According to the reasons cited by manufacturers in all the industrial categories, supply of fuels is the dominant reason to burn mixed fuels. Supply is followed by economics and pollution standards as a rationale for mixing fuels. Apart from supply, more utilities have cited pollution standards than economics as a reason for burning mixed fuels. For example, utilities burn natural gas mixed with high sulfur fuel (oil or coal) to reduce total sulfur oxide emissions.

RECOMMENDATIONS

As indicated by the responses from manufacturers in the categories of Petrochemical, Chemical Processing, Cement, Glass and Textile, it does not appear worthwhile to carry out further general investigations of mixed fuel firing. As stated earlier, mixed fuels are used by only a very few manufacturers in these categories. It may be worthwhile to investigate mixed fuel firing for Petroleum Refineries and Utilities. However, changes in fuel supply or in pollution control standards may alter the situation in the future.

Two approaches are suggested to study the effect on emissions from firing of mixed fuels. Stack gas testing at utilities and refineries or experimentation with a pilot scale system can provide the data needed to evaluate emission factors and combustion control techniques.

Stack gas testing at the industrial installations will have the obvious advantage of being data from actual operating systems. However, there are some operational limitation regarding the range of fuel ratios, excess air and temperatures, particularly on large utility boilers. Stack gas testing is advantageous as far as mixing of refinery waste gases is concerned since the composition and amount of waste gas available changes from time to time and different fuel ratios would be available.

A pilot scale study can cover a wide ranges of fuel ratios, fuel composition, flame temperatures, excess air and other operating conditions. A pilot scale system would require devices to measure fuel and air rates, a combustion chamber with appropriate instrumentation, stack gas analyzers and accessories. Effects of variables can be studied over a wide range and it may be possible to optimize conditions for the lowest level of pollutant emissions. The data obtained from actual stack testing, either on industrial installations or on pilot scale system, would be more comprehensive and generally applicable than the limited amount of data made available from the industrial sources surveyed in this study.

INTRODUCTION

The major objective of this study was to identify and classify types and properties of mixed fuels presently in use, and types of stationary processes utilizing mixed fuels. A second objective was to determine present usage of mixed fuels and future trends. Emission factors for NO_x, SO_x, particulate and related pollutants were to be developed for various fuel combinations and processes. The rationale for burning mixed fuel was to be determined.

The purpose of this study was to provide some of the background information required to determine if there is a need for a research and development program to develop emission control technology for this source category.

Types of mixed fuels include mixed oils; oil and gas; coal and oil; coal and gas; by-product gases and fuels; by-product chemical waste; and mixtures of chemical wastes and conventional fossil fuels. The scope of the task covered industries in the category of Utilities, Petroleum Refineries, Petrochemical, Chemical Processing (excluding fertilizer), Glass, Cement and Textile. A list of manufacturers of mixed fuel burners was developed.

The EPA Task Officer approved a work plan which specified that data be collected from industries in each category and be supplemented with data from federal and state agencies and trade associations. Only the sources which burn mixed fuels on a regular basis were considered in this report. Alternate firing or supplementing fuels on an intermittent basis was not interpreted as burning of mixed fuels.

BASIS OF EVALUATION

Fuels Mixed

Coal, oil, natural gas and waste fuels (refinery gases or organic solutions) are used as mixed fuels. Petroleum refineries use oil, natural gas and waste fuels as constituents of mixed fuels and the use of coal has not been reported. Utilities do not indicate burning any waste fuel and only conventional fuels are used as mixed fuels. It is not possible to categorize the types of fuels mixed in Petrochemical, Chemical Processing, Glass, Cement and Textile industries because the majority of manufacturers in these categories do not burn mixed fuels. Glass and cement manufacturers who have reported mixed fuel burning mix only conventional fuels. Manufacturers reporting the use of mixed fuel in the category of Petrochemical, Chemical Processing and Textile mix waste fuel with conventional fuels.

Typical analyses of coal, oil, natural gas and waste fuels used as mixed fuels are as follows:

	Coal, wt% as fired	Oil, wt%
C	70.65	85.9
H	4.59	11.0
O	6.19	0.9
S	1.56	1.0
N	1.29	0.7
Moisture	3.72	0.2
Ash	12.00	0.3
HHV, Btu/lb	12519	18600

Natural Gas Analyses (Mole %)

	Florida Utility	Texas Refinery	Louisiana Petrochemical
CH_4	95.44	94.00	95.0
N_2	0.51	1.00	0.9
CO_2	0.51	1.50	0.9
C_2	3.44	3.30	2.2
C_3	0.10	0.20	0.5
C_4	0.00	0.00	0.2
HHV,Btu/SCF	1000	1018	1028

Waste Fuel Analyses for Petroleum Refineries (Mole %)

Location:	California	Illinois	Texas
CO	o.1	1.1	3
N_2	1.2	0.5	2
H_2	66.7	14.8	28
C_1	26.8	58.4	62
C_2	2.7	13.8	2
C_3	1.4	9.4	2
C_4	1.2	0.8	1
C_5	-	0.8	-
CO_2	-	0.3	-
S	-	0.3	100 ppm H_2S
HHV,Btu/SCF	600	1190	860

Waste Fuel Analyses for Textile Plants

Gaseous Waste, mole %		Liquid waste, wt %	
N_2	0.9	C	92.0
A	13.5	H	6.8
O_2	5.1	S	0.7
CH_4	43.1	Ash	0.01
C_2	30.3	HHV, Btu/lb	16,500
CO_2	6.8		
H_2O	0.3		
HHV, Btu/SCF	921		

DATA COLLECTION

An attempt was made to gather data on mixed fuels from federal agencies, trade associations, state air pollution control agencies, and manufacturers in the categories of Petroleum refinery, Utility, Petrochemical, Chemical Processing, Cement, Glass and Textile.

Regional offices of the U. S. Enviromental Protection Agency in Atlanta, Boston, New York, Philadelphia, San Francisco and Seattle indicated that data on mixed fuels were not available. U. S. Bureau of Mines data show only fuel consumption and not how fuels are fired. The American Petroleum Institute and American Textile Manufacturers Institute do not collect extensive data on fuel consumption and suggested that major manufacturers in these categories be contacted directly.

Air pollution control agencies in the states of California, Illinois, Louisiana, New Jersey, New York, Ohio, Oklahoma, Pennsylvania and Texas were contacted as potential data sources. Letters outlining the objectives of the study were forwarded to each agency and afterwards, agency personnel were contacted by phone.

Trips were made to the pollution control agency offices of Louisiana, New Jersey and Oklahoma. After consultation with the agency personnel and review of their permit files, it became apparent that data were never collected to show mixed fuel combustion. Moreover, data were collected for the entire plant (point source) and not by individual source.

Data were available by individual source at the pollution control agencies of Illinois, Ohio and Pennsylvania. Sample printouts were requested and received from agencies of Illinois and Pennsylvania. These date were filed by individual source. Their data did indicate if an individual source burned more than one fuel but did not specify the mode of firing - i.e., simultaneous, alternate or both. Moreover, the estimated emissions were based on the more polluting fuel. Therefore, the data available at Illinois and Pennsylvania air pollution control agencies were not suitable for this study. Ohio has data in 5 district and 13 regional offices and it was not pursued further because the time required would have been beyond the scope of this task.

State agencies of California, New York and Texas expressed their inability to provide data on mixed fuels.

Questionnaires were forwarded to major manufacturers in each industrial category with the hope of getting additional data. Questionnaire were usually addressed to Vice President of Manufacturing or Director of Fuel Purchases or General Manager. Samples of the questionnaires are included in the Appendix. From the responses obtained it appears that some individual companies either did not have the data or were less than willing to provide all the needed information. Most of the questionnaires were returned incomplete for various reasons. Some did not reply at all in spite of reminding them through letters and phone calls. The data collection from industrial sources was not adequate to classify industries, other than petroleum refineries and utilities, as mixed fuel users.

The tables that follow are a compilation of data received from the categories surveyed. Tables 1, 3, 5, 7, 9, 10 and 11 list the use of mixed fuels reported by the categories responding to the questionnaires. Shown is the annual fuel consumption by type for an individual plant and the percentage of that type fuel used as mixed fuel. Based on the amounts of fuels mixed, the percentage of total heat derived from mixed fuel burning has been determined. Fuel combinations, end use (e.g., heat, power or steam) and rationale for burning the fuel mixture is given.

Tables 2, 4, 6 and 8 list emissions reported by the manufacturers in the categories of Petroleum Refineries, Petrochemical, Cement and Textile. Listed are sources e.g., boiler, furnace, kiln etc., size of the unit where available; annual fuels consumption for the source and thus the mixing ratio and emissions for SO_2, NO_x, CO and particulates. In a few cases SO_2 emissions in $gm/10^6$ cal have been calculated from sulfur content and heating values of the fuel. All the emissions reported in terms of ppm have been provided by the manufacturers. Emissions in ppm have been converted to $gm/10^6$ cal wherever flue gas rates were provided.

Table 1

MIXED FUEL FIRING BY PETROLEUM REFINERIES

ANNUAL FUEL CONSUMPTION			% FUEL MIXED			% HEAT FROM MIXED FUELS	FUEL COMBINATION USED	MIXED FUEL USED FOR	RATIONALE
Oil in 1000 Bbls	Gas in MMCF	Waste Fuel in 10^9 Btu G-Gaseous L-Liquid	Oil	Gas	Waste Fuel				
465	29,200	1,552 (G)	100	100	100	100	O, G G, W	Heat, Power, Steam	Supply, Gas Curtailment
180	1,430	4,163 (G)	100	100	100	100	G, W O, G, W	Heat, Steam	Supply, Pollution Standards
160	1,013	2,372 (G)	100	90	100	96	O, G G, W O, G, W	Heat, Steam	Supply, Pollution Standards
-	1,258	2,255 (G)	-	50	100	82	O, G	Heat, Steam	Supply
86	2,108	2,788 (G)	100	100	100	100	G, W O, G, W	Heat, Steam	Supply
1,099	1,760	15,813 (G)	100	100	12	43	O, G O, W	Heat, Power, Steam	Supply
-	4,936	3,036 (G)	-	100	100	100	G, W	Heat, Steam, Waste Disposal	Supply

Table 1 (Cont'd.)

MIXED FUEL FIRING BY PETROLEUM REFINERIES

ANNUAL FUEL CONSUMPTION			% FUEL MIXED			% HEAT FROM MIXED FUELS	FUEL COMBINA-TION USED	MIXED FUEL USED FOR	RATIONALE
Oil in 1000 Bbls	Gas in MMCF	Waste Fuel in 10^9 Btu G-Gaseous L-Liquid	Oil	Gas	Waste Fuel				
1,952	74,470	331(L)	100	2	100	16	O, G O, G, W	Heat, Power, Steam	Supply
215	58,983	42,653(G)	100	84	96	88	G, W O, G, W	Heat, Power, Steam	Supply, Economic
-	23,292	92(G)	-	16	100	16.5	G, W	Steam, Power	Supply, Economic, Pollution Standard Energy Conservation
2,730	-	20,688(G)	98	-	45	69	O, W,	Heat, Power, Steam	Supply
608	-	4,196(G)	100	-	67	83	O, W	Heat, Steam	Supply, Economic
171	2,024	3,769(G)	100	87	100	96	G, W O, G, W	Heat, Steam	Supply
-	10,790	349(G)	-	21	100	22	O, G G, W	Heat, Steam	Supply

Table 1 (Cont'd.)

MIXED FUEL FIRING BY PETROLEUM REFINERIES

ANNUAL FUEL CONSUMPTION			% FUEL MIXED			% HEAT FROM MIXED FUELS	FUEL COMBINATION USED	MIXED FUEL USED FOR	RATIONALE
Oil in 1000 Bbls	Gas in MMCF	Waste Fuel in 10^9 Btu G-Gaseous L-Liquid	Oil	Gas	Waste Fuel				
-	18,831	28,515(G)	-	55	100	81	G, W	Heat	Supply
1,900	-	1,375(G)	90	-	90	90	O, W	Heat	Supply
390	130	4,953(G)	100	100	63	79	G, W O, G, W	Heat, Steam	Supply, Pollution Standards
-	4,300	21,000(G)	-	100	100	100	G, W	Heat, Steam	Supply
180	8,600	9,420(G)	100	76	75	89	O, W G, W O, G, W	Heat, Steam	Supply, Economic
1,742	9,585	1,131(G)	100	93	100	97	O, G, O, G, W	Heat, Power, Steam	Supply, Pollution Standards
-	31,164	9,649	-	100	100	100	G, W	Heat, Steam	Supply
3,832	5,256	-	51	29	-	47	O, G	Heat, Steam	Supply, Economic Pollution Standards

Table 2

REFINERY EMISSIONS FROM MIXED FUELS

SOURCE	SIZE OF UNITS MMBTU/Hr.	ANNUAL FUEL CONSUMPTION			% FUEL MIXED HEAT BASIS	EMISSIONS							
						SO_2		NO_x		CO		PARTICULATE	
		OIL IN 1000 BBLS.	GAS IN MMCF	WASTE FUEL IN 10^9BTU G-GASEOUS		GM/10^6CAS (LB/10^6BTU)	PPM	GM/10^6CAL (LB/10^6BTU)	PPM	GM/10^6CAL (LB/10^6BTU)	PPM	GM/10^6CAL (LB/10^6BTU)	PPM
Boiler	3455	3433	7844	330.5 (G)	Oil - 72 Gas - 27 Waste - 1	1.36 (0.756)	370	1.34 (0.744)	507	0.040 (0.022)	25	0.065 (0.036)	39
Process Furnace	213	311	113	-	Oil - 61 Gas - 39	1.77 (0.985)	475	0.96 (0.534)	359	0.041 (0.022)	25	0.085 (0.047)	49
Reboiler	62.7	-	348	213.7 (G)	Gas - 63 Waste - 37	0.688 (0.382)	200	0.040 (0.022)	16.3	-	-	0.042 (0.023)	26
Heater	46.2	-	354	218.3 (G)	Gas - 63 Waste - 37	0.778 (0.432)	200	0.040 (0.022)	14.4	-	-	0.039 (0.219)	22
Heater	43.2	-	291	178.7 (G)	Gas - 63 Waste - 37	0.718 (0.399)	200	0.040 (0.022)	15.6	-	-	0.039 (0.219)	22
Heater	52.5	-	208	128 (G)	Gas - 63 Waste - 37	0.494 (0.275)	100	0.040 (0.022)	11.4	-	-	0.042 (0.023)	26
Heater	200	-	1098	676 (G)	Gas - 63 Waste - 37	0.449 (0.249)	100	0.040 (0.022)	12.5	-	-	0.042 (0.023)	26
Heater	85	-	246	151 (G)	Gas - 63 Waste - 37	0.839 (0.466)	200	0.040 (0.022)	13.4	-	-	0.039 (0.022)	20
Heater	223	91.5	650	-	Oil - 40 Gas - 60	2.235 (1.241)	550	-	10	-	2	-	-

Table 2 (Contd.)

REFINERY EMISSIONS FROM MIXED FUELS

SOURCE	SIZE OF UNITS MMBTU/Hr.	ANNUAL FUEL CONSUMPTION: OIL IN 1000 BBLS.	ANNUAL FUEL CONSUMPTION: GAS IN MMCF	ANNUAL FUEL CONSUMPTION: WASTE FUEL IN 10^9BTU G-GASEOUS	% FUEL MIXED HEAT BASIS	EMISSIONS: SO_2 GM/10^6CAL ($LB/10^6BTU$)	EMISSIONS: SO_2 PPM	EMISSIONS: NO_X GM/10^6CAL ($LB/10^6BTU$)	EMISSIONS: NO_X PPM	EMISSIONS: CO GM/10^6CAL ($LB/10^6BTU$)	EMISSIONS: CO PPM	EMISSIONS: PARTICULATES GM/10^6CAL ($LB/10^6BTU$)	EMISSIONS: PARTICULATES PPM
Vacuum Heater	105	-	594	365.6 (G)	Gas - 63 Waste - 37	0.569 (0.316)	100	0.040 (0.022)	9.8	-	-	0.039 (0.021)	14.8
Steam Superheater	28.3	-	54	33.2 (G)	Gas - 63 Waste - 37	0.687 (0.382)	200	0.040 (0.022)	16.3	-	-	0.041 (0.023)	25.6
Heater	54.2	-	82	50.7 (G)	Gas - 63 Waste - 37	0.689 (0.382)	200	0.040 (0.022)	16.3	-	-	0.041 (0.023)	25.6
Boilers	437.2	-	1608	987.3 (G)	Gas - 63 Waste - 37	0.689 (0.382)	200	0.040 (0.022)	16	-	-	0.032 (0.018)	20
Furnaces	10 to 290	-	10340	28515 (G)	Gas - 41 Waste - 59	-	30	-	40	-	50	-	NIL
Furnace	50	50	-	162.5 (G)	Oil - 67 Waste - 33	2.409 (1.338)	800	0.141 (0.078)	65	-	5*	-	-
Heater	79	-	578	196.6 (G)	Gas - 75 Waste - 25	2.055 (1.142)	495	0.895 (0.497)	300	-	-	0.032 (0.018)	16.8
Boilers	840	-	3757	91.8 (G)	Gas - 98 Waste - 2	0.532 (0.296)	200	0.191 (.106)	100	-	-	.032 (0.018)	27

*Hydrocarbon

Table 3

MIXED FUEL FIRING BY PETROCHEMICAL PLANTS

ANNUAL FUEL CONSUMPTION				% FUEL MIXED				% HEAT FROM MIXED FUELS	FUEL COMBINATION USED	MIXED FUEL USED FOR	RATIONALE
Coal in Tons	Oil in 1000 Bbls.	Gas in MMCF	Waste Fuel in 10^9 Btu G-Gas L-Liq.	Coal	Oil	Gas	Waste Fuel				
-	-	5,200	49.7(G)	-	-	69	100	70	G, W	Steam, Power	Economic, Pollution Standards
64,000	9	305	87.2(G)	100	100	100	100	100	C, O, W G, W	Heat Steam	Supply Economic
-	17	7,500	-	-	100	10	-	11	O, G	Steam	Supply
-	60	1,700	17(G)	-	0	1	100	-	G, W	Waste Disposal	Pollution Standards
-	-	23,500	3598(G) 7045(L)	-	-	70	100	80	G, W	Heat, Steam	Supply, Economic, Pollution Standards

Table 4

PETROCHEMICAL PLANT EMISSIONS FROM MIXED FUELS

SOURCE	ANNUAL FUEL CONSUMPTION				% FUEL MIXED HEAT BASIS	EMISSIONS							
						SO_2		NO_x		CO		PARTICULATES	
	COAL IN TONS	OIL IN 1000 BBLS.	GAS IN MMCF	WASTE IN 10^9 BTU G-GASEOUS L-LIQUID		GM/10^6 CAL (LB/10^6 BTU)	PPM	GM/10^6 CAL (LB/10^6 BTU)	PPM	GM/10^6 CAL (LB/10^6 BTU)	PPM	GM/10^6 CAL (LB/10^6 BTU)	PPM
Boilers	-	-	3600	49.7 (G)	Gas - 98.7 Waste - 1.3	-	-	-	106	-	-	NIL	-
Boilers	64000	9	180	-	Coal - 92.3 Oil - 3.1 Gas - 4.6	6.889 (3.827)	- -	- -	- -	- -	- -	0.288 (0.160)	- -
Boilers	-	17	7500	-	Oil - 1.4 Gas - 98.6	0.047 (0.026)	-	-	90	-	-	NIL	-
Incinerator	-	-	21	16.9 (G)	Gas - 51 Waste - 49	-	260	-	-	-	130*	-	-
Boilers	-	-	4100	1208 (G) 7045 (L)	Gas - 31.8 Waste Gas -10.0 Waste Liquid -58.2	0.889 (0.494)	210	-	170	-	-	-	-
Furnaces	-	-	12400	2391 (G)	Gas - 83 Waste - 17	-	-	-	70	-	500	-	-

*HCl

Table 5

MIXED FUEL FIRING BY CEMENT PLANTS

ANNUAL FUEL CONSUMPTION			% FUEL MIXED			% HEAT FROM MIXED FUELS	FUEL COMBINATION USED	MIXED FUEL USED FOR	RATIONALE
Coal in Tons	Oil in	Gas in 1000 Bbls	Coal	Oil	Gas				
63,589	-	1,056	100	-	100	100	C, G	Heat	Economic
65,000	-	71	100	-	100	100	C, G	Heat	Economic
100,000	18	1,080	100	100	100	100	C, G	Heat	Supply, Economic

Table 6

CEMENT PLANT EMISSIONS FROM MIXED FUELS

SOURCE	ANNUAL FUEL CONSUMPTION			% FUEL MIXED HEAT BASIS	EMISSIONS							
					SO_2		NO_x		CO		PARTICULATES	
	COAL IN TONS	COKE IN TONS	GAS IN MMCF		GM/10^6 CAL (LB/10^6 BTU)	PPM	GM/10^6 CAL (LB/10^6 BTU)	PPM	GM/10^6 CAL (LB/10^6 BTU)	PPM	GM/10^6 CAL (LB/10^6 BTU)	PPM
Kiln	100000	32000	-	Coal - 69 Coke - 31	8.038 (4.465)	-	-	-	-	-	-	70
Kiln	41437	-	784	Coal - 55 Gas - 45	2.344 (1.302)	-	-	-	-	-	-	17.6
Kiln	22152	-	272	Coal - 63 Gas - 37	6.016 (3.343)	-	-	-	-	-	-	20
Kiln	65000	-	71	Coal - 95 Gas - 5	2.374 (1.319)	-	-	-	-	-	-	60
Kiln	100000	-	720	Coal - 74 Gas - 26	10.386 (5.770)	-	-	-	-	-	-	-

Table 7

MIXED FUEL FIRING BY TEXTILE PLANTS

ANNUAL FUEL CONSUMPTION				&% FUEL MIXED				% HEAT FROM MIXED FUELS	FUEL COMBINATION USED	MIXED FUEL USED FOR	RATIONALE
Coal in Tons	Oil in 1000 Bbls.	Gas in MMCF	Waste Fuel in 10^9 Btu G-Gas L-Liq.	Coal	Oil	Gas	Waste Fuel				
175,000	-	1,227	-	29	-	12	-	25	C, G	Steam	Supply, Economic
287,000	4	2,517	84(G)	0	0	17	100	6	G, W	Heat	Economic
-	-	14,172	870(L)	-	-	44	100	48	G, W	Steam, Waste Disposal	Economic
-	22	305	-	-	100	93	-	95	O, G	Heat, Steam	Supply
-	-	14,959	494(L)	-	-	15	100	18	G, W	Heat, Steam, Power, Waste Disposal	Economic
412,000	43	615	40.6(G)	-	-	29	100	24	G, W	Heat	Economic

Table 8

TEXTILE PLANT EMISSIONS FROM MIXED FUELS

SOURCE	ANNUAL FUEL CONSUMPTION			% FUEL MIXED HEAT BASIS	EMISSIONS							
					SO_2		NO_2		CO		PARTICULATES	
	COAL IN TONS	GAS IN MMCF	WASTE IN 10^9 BTU (L-LIQUID)		GM/10^6 CAL ($LB/10^6$ BTU)	PPM	GM/10^6 CAL ($LB/10^6$ BTU)	PPM	GM/10^6 CAL ($LB/10^6$ BTU)	PPM	GM/10^6 CAL ($LB/10^6$ BTU)	PPM
Boilers	50000	1.5	-	Coal - 99.9 Gas - 0.1	4.478 (2.488)	697	-	-	-	-	-	938
Boilers	-	6060	429.2 (L)	Gas - 93 Waste - 7	-	-	-	600	-	-	-	9.8
Incinerator	-	220	440.8 (L)	Gas - 33 Waste - 67	-	-	-	1000	-	-	-	1914
Boiler	-	1056	78.8 (L)	Gas - 93 Waste - 7	-	0.94 *	-	231	-	1.24	-	17
Boiler	-	1150	78.8 (L)	Gas - 94 Waste - 6	-	0.25 *	-	245	-	1.35	-	17.3

*Hydrocarbons

Table 9

MIXED FUEL FIRING BY UTILITIES

ANNUAL FUEL CONSUMPTION			% FUEL MIXED			% HEAT FROM MIXED FUELS	FUEL COMBINATION USED	RATED GENERATION CAPACITY IN MW	RATIONALE
Coal in Tons	Oil in 1000 Bbls.	Gas in MMCF	Coal	Oil	Gas				
834,400	-	15,006	100	-	100	100	C,G	486.6	Supply, Economic, Pollution Standards
47,705	-	1,515	100	-	100	100	C,G	48	Supply, Economic, Pollution Standards
77,521	-	579	100	-	100	100	C,G	46	Supply, Economic, Pollution Standards
-	162	1,067	-	100	100	100	O,G	75	Supply, Economic, Pollution Standards
963,966	25	6,238	20	100	64	32	C,G O,G	518	Supply, Pollution Standards
-	11425	7,990	-	100	100	100	O,G	1,540	Supply, Pollution Standards
-	1737	9,883	-	100	100	100	O,G	462	Supply, Pollution Standards
-	12393	4,262	-	100	100	100	O,G	1,826	Supply, Pollution Standards

Table 9 (Cont'd.)

MIXED FUEL FIRING BY UTILITIES

ANNUAL FUEL CONSUMPTION			% FUEL MIXED			% HEAT FROM MIXED FUELS	FUEL COMBINATION USED	RATED GENERATION CAPACITY IN MW	RATIONALE
Coal in Tons	Oil in 1000 Bbls.	Gas in MMCF	Coal	Oil	Gas				
-	690	13,868	-	67	100	92	O,G	346.25	Supply, Pollution Standards
-	2194	4,081	-	100	100	100	O,G	312.5	Supply, Pollution Standards
-	4102	15,112	-	100	100	100	O,G	739.6	Supply, Pollution Standards
-	4375	18,140	-	100	100	100	O,G	804.1	Supply, Pollution Standards
-	145	406	-	100	100	100	O,G	46	Supply, Pollution Standards
-	7559	27,217	-	100	100	100	O,G	1254.6	Supply, Pollution Standards
-	5749	8,850	-	100	100	100	O,G	804.1	Supply, Pollution Standards
676,348	41	12,361	100	100	100	100	O,G C,G	463.8	Supply, Economic Pollution Standards

Table 10

MIXED FUEL FIRING BY GLASS PLANTS

ANNUAL FUEL CONSUMPTION			% FUEL MIXED			% HEAT FROM MIXED FUELS	FUEL COMBINATION USED	MIXED FUEL USED FOR	RATIONALE
Oil in 1000 Bbls.	Gas in MMCF	Waste Fuel	Oil	Gas	Waste Fuel				
2	164	-	100	59	-	65	O,G	Heat	Supply
22	1,615	-	100	47	-	51	O,G	Heat	Supply, Economic
62	980	-	100	74.5	-	81	O,G	Heat, Steam	Supply, Economic
3	1,986	-	100	1.9	-	3	O,G	Heat, Steam	Supply, Economic
188	714	-	100	48.8	-	80	O,G	Heat, Steam	Supply, Economic
7	851	-	100	75.2	-	76	O,G	Heat	Supply, Economic
6	711	-	100	62	-	64	O,G	Heat, Steam	Supply, Economic

Table 11

MIXED FUEL FIRING BY CHEMICAL PROCESSING INDUSTRIES

ANNUAL FUEL CONSUMPTION			% FUEL MIXED			% HEAT FROM MIXED FUELS	FUEL COMBINATION USED	MIXED FUEL USED FOR	RATIONALE
Oil in 1000 Bbls.	Gas in MMCF	Waste Fuel in 10^9 Btu G-Gaseous L- Liquid	Oil	Gas	Waste Fuel				
120	8,600	1,100(L)	100	100	100	100	O,G,W	Steam, Power	Supply, Economic
-	8,500	15,700(G)	-	100	100	100	G,W	Heat, Steam	Supply, Economic
-	20,600	14,900(G)	-	100	100	100	G,W	Heat, Steam	Supply, Economic
-	15,600	6,400(G)	-	100	100	100	G,W	Heat, Steam	Supply, Economic

MIXED FUEL BURNER MANUFACTURERS

A list of mixed fuel burner manufacturers, along with a brief description and drawing of their burners, is provided below. The information contained herein has been supplied by the manufacturers.

Coppus Engineering Corporation

Coppus manufacture type DG combination gas-oil burners, which employ the FANMIX[R] principle. Gas is discharged from rotating driver arms, exerting sufficient reaction power to the fan to deliver the proper amount of air in relation to the fuel gas rate. A separate set of driver arms is provided for discharge of steam-atomized oil to give the reaction power required for the fan to deliver the correct amount of air in relation to the fuel oil rate. The two fuels may be fired simultaneously in any ratio; however, the manufacturer suggests using at least 10% gas when oil is the main fuel in order to keep the gas orifice clean. This burner is available in six different sizes ranging from 8 MMBtu/hr to 58 MMBtu/hr heat release capacity and can be mounted in either vertical or horizontal positions.

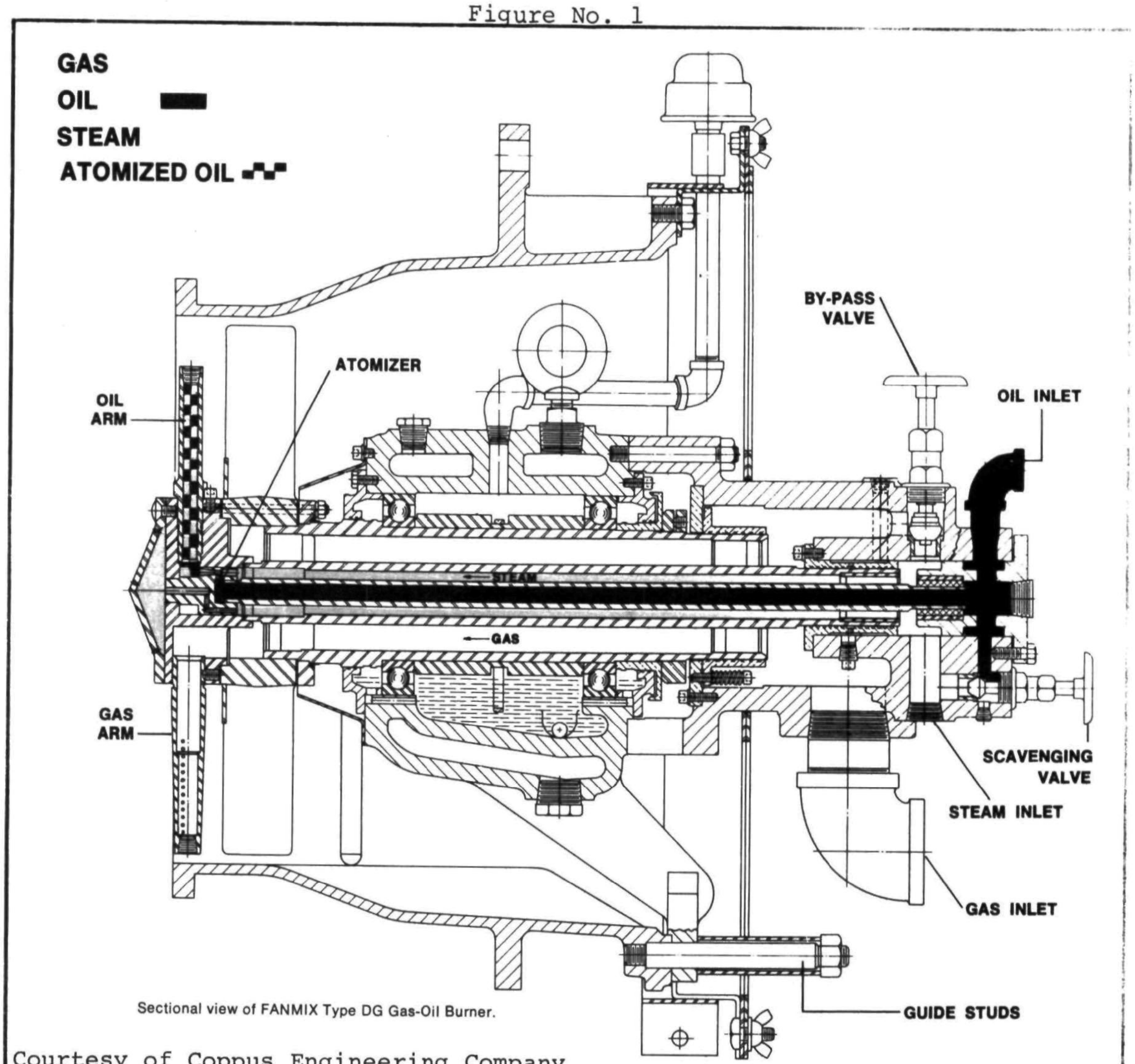
John Zink Company

Series M-A, DBA and FFC burners are manufactured to operate on gas, oil or gas-oil combination.

Series M-A burner can operate at excess air as low as 1%. The gas ports are so located in relation to oil ports, that even a severe upset in the oil burning cannot cause plugging of the gas ports. This burner will burn any oil that can be pumped and still burn any fuel gas. Series M-A burners are available in various sizes up to 18 MMBtu/hr heat release capacity.

Series DBA burner is similar to series M-A but is especially

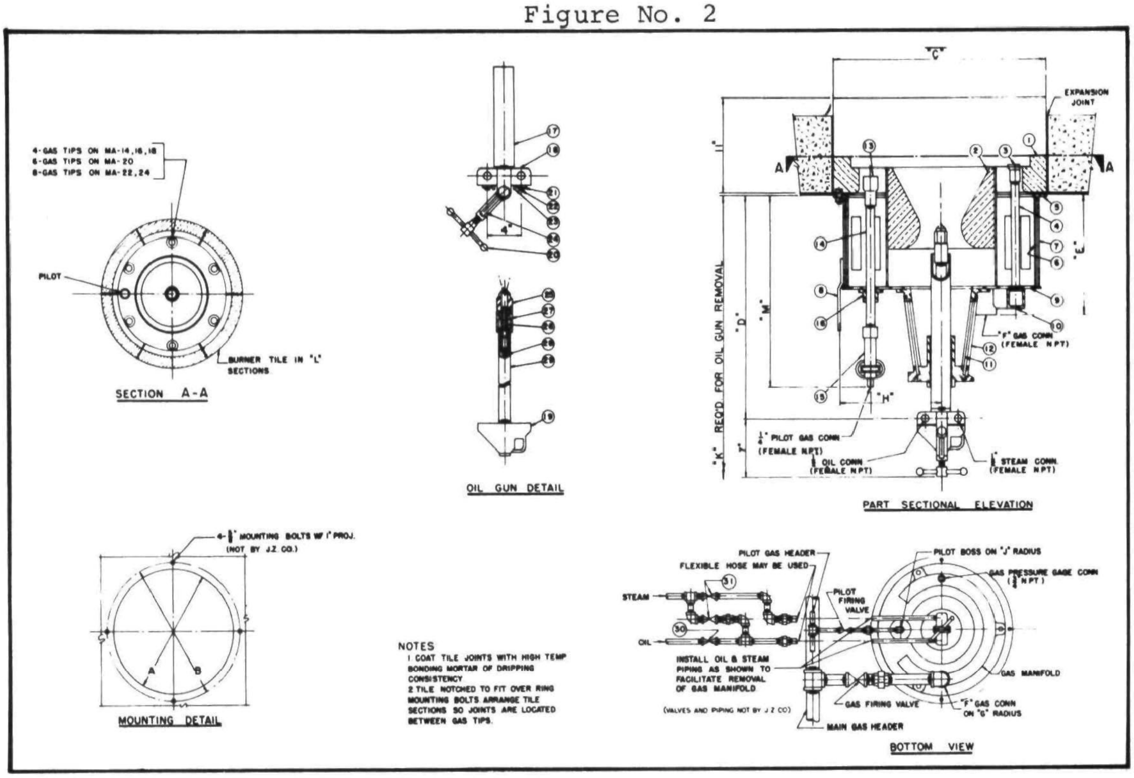
Figure No. 1



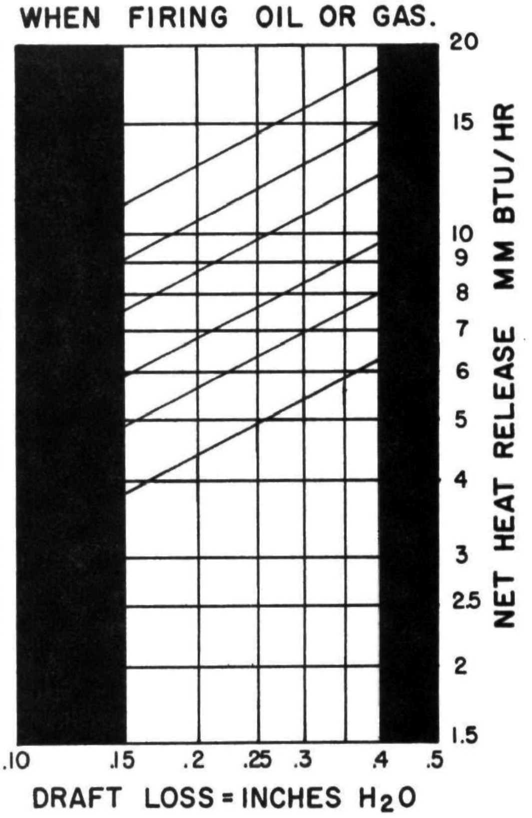
Sectional view of FANMIX Type DG Gas-Oil Burner.

Courtesy of Coppus Engineering Company

Figure No. 2



CAPACITY CHART FOR SERIES "MA" JOHN ZINK COMBINATION GAS & OIL BURNERS AT STANDARD CONDITIONS BASED ON 15% EXCESS AIR WHEN FIRING OIL OR GAS.



PARTS LIST PER BURNER

	ITEM	QUANTITY	DESCRIPTION	PART NO.	MATERIAL
	1	1	BURNER FLOOR TILE	MA-T-*A	B.C.F.
	2	1	RECON TILE	MAR-	REFR.
	3		GAS TIPS	MA-5	CR. NI.
	4		GAS NIPPLES	½" PIPE	STEEL
	5	1	MOUNTING RING	MA-1-*	STEEL
	6	1	AIR REGISTER STATOR	MA-S-*	STEEL
	7	1	AIR REGISTER ROTOR	MA-A-*	STEEL
	8	2	AIR REGISTER HANDLES	MA-6	STEEL
	9	1	FRONT PLATE	MA-2-*	STEEL
	10	1	GAS MANIFOLD	DB-82-*A	C.I.
	11	1	PRIMARY AIR STATOR	OB-1-	C.I.
	12	1	PRIMARY AIR ROTOR	OB-2-	DUCTILE
▲	13	1	PILOT TIP	J-6-¾"	CR. NI.
▲	14	1	PILOT NIPPLE	¾" PIPE	STEEL
▲	15	1	PILOT MIXER	HFC-¾"	C.I.
	16	1	PILOT BOSS		C.I.
	17	1	GUIDE TUBE (2⅜" O.D. x 1⅞" I.D.)	PIPE	STEEL
	18	1	OIL GUN RECEIVER	Z-56-1	DUCTILE
	19	1	OIL BODY	Z-56-2	DUCTILE
	20	1	CLEVIS HANDLE	Z-56-4	STEEL
	21	2	GASKETS	Z-56-6	COPPER
	22	2	GUIDE SLEEVES	Z-56-5	STEEL
	23	2	GUIDE PINS	Z-56-9	STEEL
	24	1	CLEVIS	Z-56-3	STEEL
	25	1	OIL TIP		CR. STEEL
	26	1	ATOMIZER		BRASS
	27	1	SLEEVE	225	CR. STEEL
	28	1	OIL TUBE	⅜" PIPE	STEEL
	29	1	STEAM TUBE	1" PIPE	STEEL
▲	30	1	OIL FIRING VALVE	SER. 500	STEEL
▲	31	2	STEAM FIRING VALVES	SER. 500	STEEL

* INDICATES BURNER SIZE
▲ OPTIONAL EQUIPMENT
NOTE: Devices shown by this drawing are covered by U.S. and Foreign Patents granted and pending.

DIMENSION LEGEND

SIZE	A	B	C	D	E	F	G	H	J	K	L	M
MA-14	16"	18½"	20½"	22¼"	14¼"	1½"	6⅛"	9¼"	7¼"	3' - 4"	8"	22¼"
MA-16	18"	20½"	22"	26¼"	14¼"	1½"	7"	10¼"	7¼"	4' - 0"	8"	22¼"
MA-18	20"	22½"	24"	26¼"	14¼"	1½"	8¼"	11¼"	7¼"	4' - 2"	8"	22¼"
MA-20	22"	24½"	26"	26¼"	14¼"	2"	8¾"	12¼"	8⅝"	4' - 2"	6"	22¼"
MA-22	24"	26½"	28"	28¼"	16¼"	2"	9¾"	13¼"	8⅝"	4' - 6"	8"	24¼"
MA-24	26"	28½"	30"	28¼"	16¼"	2"	10¾"	14¼"	8⅝"	4' - 6"	8"	24¼"

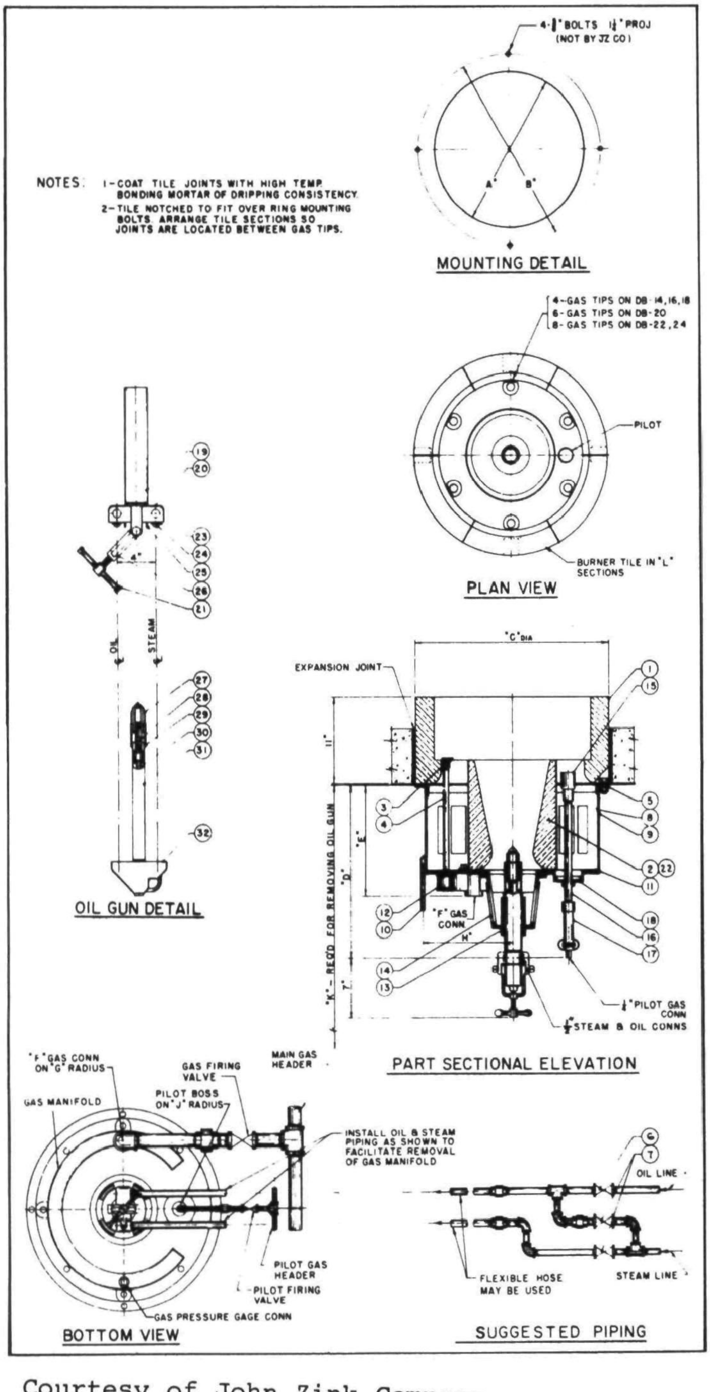
Courtesy of John Zink Company

Figure No. 3

DIMENSION LEGEND										
SIZE	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**J**	**K**	**L**
DBA-14	16"	18½"	20½"	22¼"	14¼"	1½"	6⅛"	9¼"	7 1/16"	3'-4"	8
DBA-16	18"	20½"	22"	22¼"	14¼"	1½"	7"	10¼"	7 1/16"	3'-4"	8
DBA-18	20"	22½"	24"	22¼"	14¼"	1½"	8¼"	11¼"	7 15/16"	3'-4"	8
DBA-20	22"	24½"	26"	22¼"	14¼"	2"	8 13/16"	12¼"	8⅝"	3'-4"	6
DBA-22	24"	26½"	28"	24¼"	16¼"	2"	9 5/16"	13¼"	8⅝"	3'-7"	8
DBA-24	26"	28½"	30"	24¼"	16¼"	2"	10 5/16"	14¼"	8⅝"	3'-7"	8

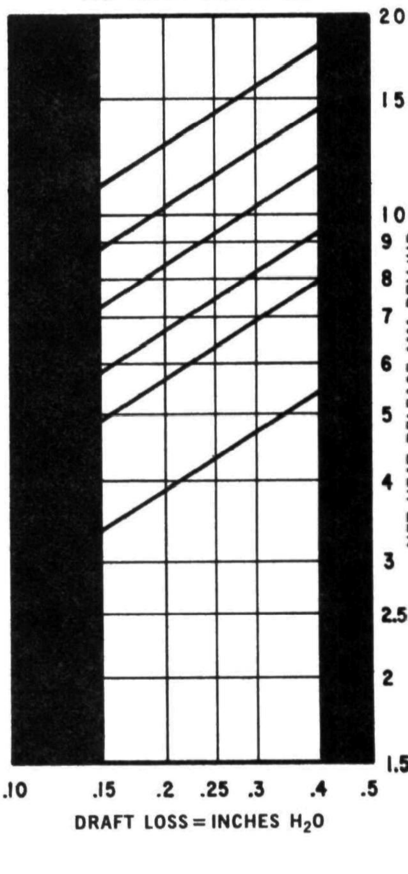
PARTS LIST PER BURNER				
ITEM	QTY.	DESCRIPTION	PART NO.	MAT'L.
1	1	BURNER FLOOR TILE	DBA-T-*	B.F.C.
2	1	RECON TILE	MAR-T-	B.F.C.
3		GAS TIPS	DB-5	C.I.
4		GAS NIPPLES	½" PIPE	STEEL
5	1	MOUNTING RING	DB-1-*A	STEEL
6	1	OIL FIRING VALVE	SER-500	STEEL**
7	2	STEAM FIRING VALVE	SER-500	STEEL**
8	1	AIR REGISTER STATOR	DB-S-*A	STEEL
9	1	AIR REGISTER ROTOR	DB-A-*A	STEEL
10	2	AIR REGISTER HANDLE	DB-6	STEEL
11	1	FRONT PLATE	DB-2-*A	STEEL
12	1	GAS MANIFOLD	DB-82-*A	C.I.
13	1	PRIMARY AIR STATOR	DB-1B	C.I.
14	1	PRIMARY AIR ROTOR	DB-2B	DUCTILE
15	1	PILOT TIP	J-6-¾"	CR.-NI.**
16	1	PILOT NIPPLE	¾" PIPE	STEEL**
17	1	PILOT MIXER	HFC-¾"	C.I.**
18	1	PILOT BOSS	PB-¾"	C.I.
19	1	GUIDE TUBE	2" PIPE	STEEL
20	1	OIL GUN RECEIVER	Z-56-1	DUCTILE
21	1	CLEVIS HANDLE	Z-56-4	STEEL
22	1	RECON TILE CYLINDER	RTC-	STEEL
23	2	GASKETS	Z-56-6	COPPER
24	2	GUIDE SLEEVE	Z-56-5	STEEL
25	2	GUIDE PINS	Z-56-9	STEEL
26	1	CLEVIS	Z-56-3	DUCTILE
27	1	OIL TIP		CR. STEEL
28	1	ATOMIZER		BRASS
29	1	SLEEVE	225	CR. STEEL
30	1	OIL TUBE	⅜" PIPE	STEEL
31	1	STEAM TUBE	1" PIPE	STEEL
32	1	OIL BODY	Z-56-2	DUCTILE

*INDICATES BURNER SIZE
**OPTIONAL



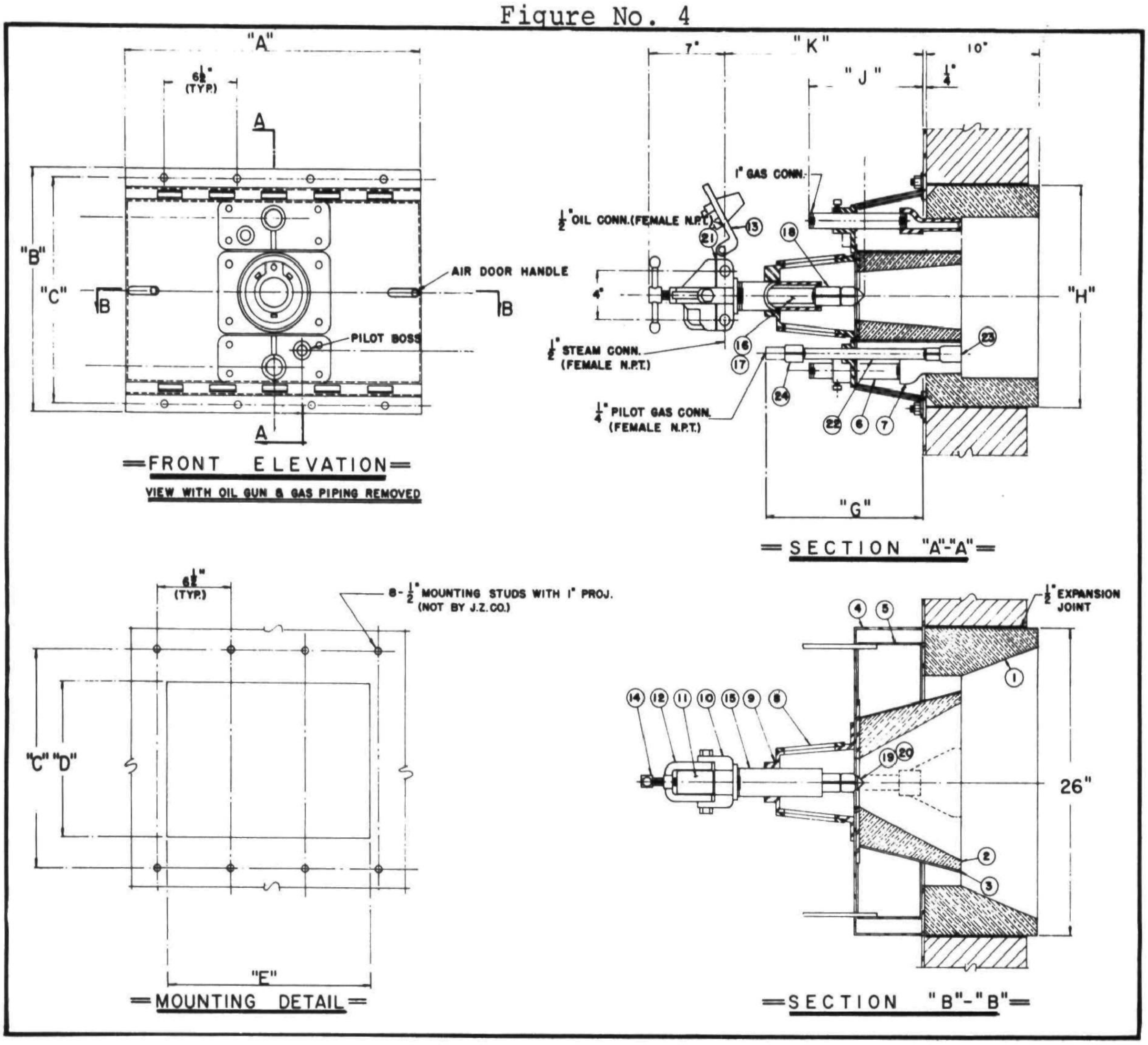
CAPACITY CHART FOR SERIES "DBA" JOHN ZINK COMBINATION GAS & OIL BURNERS AT STANDARD CONDITIONS

BASED ON 20% EXCESS AIR WHEN FIRING GAS AND 20% EXCESS AIR WHEN FIRING OIL



Courtesy of John Zink Company

Figure No. 4

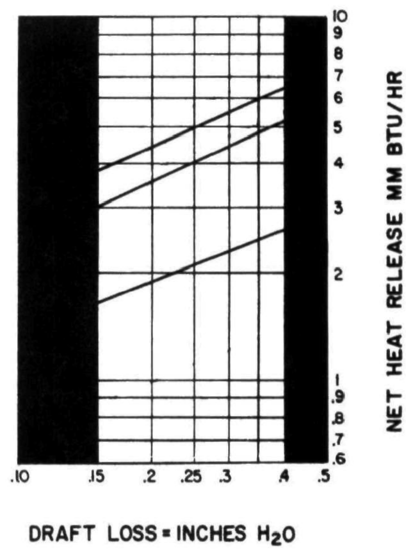


PARTS LIST PER BURNER

ITEM	QUANTITY	DESCRIPTION	MATERIAL
1	1	BURNER TILE	B.F.C.
2	1	RECON TILE	B.F.C.
3	1	RECON TILE CASE	STEEL
4	1	STATIONARY REGISTER	STEEL
5	1	ADJUSTABLE DOOR	STEEL
6	2	GAS TUBES	STEEL
7	2	GAS TIPS	C.I.
8	1	PRIMARY AIR ROTOR	DUCTILE
9	1	PRIMARY AIR STATOR	C.I.
10	1	OIL BODY RECEIVER	DUCTILE
11	1	OIL BODY	DUCTILE
12	1	CLEVIS	DUCTILE
13	1	OIL BODY SEAL	DUCTILE
14	1	CLEVIS HANDLE	STEEL
15	1	OIL GUN GUIDE TUBE	STEEL
16	1	STEAM TUBE	STEEL
17	1	OIL TUBE	STEEL
18	1	SLEEVE	CARBON STEEL
19	1	OIL TIP	CARBON STEEL
20	1	ATOMIZER	BRASS
21	2	GASKETS	COPPER
22	1	PILOT NIPPLE	STEEL
23	1	PILOT TIP	CARBON STEEL
24	1	PILOT MIXER	CARBON STEEL

NOTE: DEVICES SHOWN BY THIS DRAWING ARE COVERED BY U. S. AND FOREIGN PATENTS GRANTED AND PENDING

CAPACITY CHART FOR SERIES "FFC" JOHN ZINK COMBINATION GAS & OIL BURNERS AT STANDARD CONDITIONS BASED ON 20% EXCESS AIR



DIMENSION LEGEND

SIZE	A	B	C	D	E	G	H	J	K
FFC-10	26¼"	16"	14½"	9½"	16"	14"	14¼"	10"	18"
FFC-30A	26¼"	20"	18½"	13"	18"	14"	18"	10"	18"
FFC-45A	26¼"	23½"	22"	14"	18"	18"	19"	13"	22"

Courtesy of John Zink Company

suited to burn pitches or other heavy fuels. When burning oil it is desirable to have a viscosity of approximately 300 SSU (60 centistokes) at the burner. The gas burner is designed to handle either hydrogen or heavy hydrocarbon fuels with no adjustment. These burners are available in sizes up to 18 MMBtu/hr heat release capacity.

Series FFC burner is specifically designed to produce a thin, flat flame for process heaters. It can burn gas, oil or both. Gas burning ports are isolated from oil burners to prevent plugging or other interferences. FFC burners are available in sizes up to 6.5 MMBtu/hr.

Maxon Corporation

Model "500" ovenpak burner is designed to burn gaseous fuels and distillate oils separately or in combination. These burners also can fire fuels such as methanol, gasoline and different types of waste oils and are available in sizes up to 6 MMBtu/hr heat release.

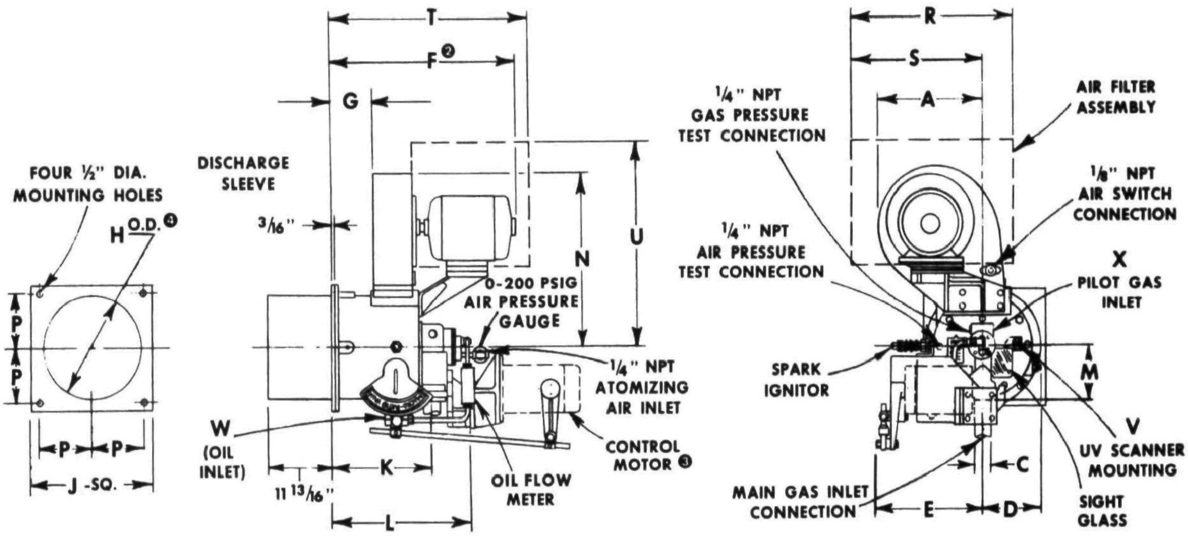
National Airoil Burner Company

NAO flat flame burner units are available for a single fuel or gas or a combination of these fuels. The unit for combination fuels comprises a centrally positioned oil atomizer plus a pair of gas manifolds having standpipe mounted gas tips. Gas tips are arranged to obtain a flat shape of flame. The oil burner is equipped with a yoke-type detaching gear which admits both the oil and atomizing steam. Oil and gas manifolds are removable. Combustion can be continued with the alternate fuel while either fuel element is withdrawn. This burner can be mounted for horizontal, vertical or intermediate angle firing and is available in sizes up to 8.5 MMBtu/hr. NAO dual stage oil burners atomize oil in two stages. First stage is mechanical and second

Figure No. 5

Model "500"
OVENPAK® Gas/Oil Burners

Dimensions



SIZE OVENPAK BURNER	MOTOR HP & FRAME		DIMENSIONS IN INCHES																			
			A	C❶	D	E	F❷	G	H❹	J	K	L	M	N	P	R	S	T	U	V❶	W❶	X❶
508	¾	56	$15\frac{1}{4}$	1	$5\frac{1}{16}$	$8\frac{11}{16}$	$19\frac{1}{16}$	$4\frac{5}{8}$	$6\frac{5}{16}$	$8\frac{7}{16}$	$8\frac{13}{16}$	$12\frac{1}{4}$	$4\frac{3}{8}$	$21\frac{11}{16}$	$3\frac{5}{8}$	$15\frac{3}{4}$	$14\frac{7}{8}$	$19\frac{5}{8}$	$18\frac{5}{8}$	$\frac{3}{4}$	$\frac{3}{8}$	$\frac{3}{8}$
515	¾	56	$15\frac{1}{4}$	$1\frac{1}{4}$	$5\frac{1}{16}$	$8\frac{11}{16}$	$17\frac{1}{4}$	$3\frac{7}{16}$	$8\frac{3}{16}$	$10\frac{3}{8}$	$8\frac{3}{4}$	$12\frac{3}{16}$	$4\frac{3}{8}$	$21\frac{11}{16}$	$4\frac{7}{16}$	$15\frac{3}{4}$	$14\frac{7}{8}$	$19\frac{1}{2}$	$18\frac{5}{8}$	$\frac{3}{4}$	$\frac{3}{8}$	$\frac{3}{8}$
525	¾	56	$15\frac{1}{4}$	$1\frac{1}{2}$	$5\frac{11}{16}$	$9\frac{5}{16}$	$18\frac{1}{16}$	$2\frac{5}{8}$	$10\frac{1}{4}$	$12\frac{1}{2}$	$9\frac{7}{8}$	$13\frac{11}{16}$	$5\frac{7}{16}$	$23\frac{9}{16}$	$5\frac{5}{8}$	$17\frac{5}{8}$	$15\frac{7}{8}$	$21\frac{1}{16}$	$29\frac{5}{8}$	$\frac{3}{4}$	$\frac{3}{8}$	$\frac{1}{2}$
535	1	56	$15\frac{1}{4}$	2	$5\frac{11}{16}$	$9\frac{5}{16}$	$18\frac{1}{16}$	$2\frac{5}{8}$	$10\frac{1}{4}$	$12\frac{1}{2}$	$9\frac{7}{8}$	$13\frac{11}{16}$	$5\frac{7}{16}$	$23\frac{9}{16}$	$5\frac{5}{8}$	$17\frac{5}{8}$	$15\frac{7}{8}$	$21\frac{1}{16}$	$29\frac{5}{8}$	$\frac{3}{4}$	$\frac{3}{8}$	$\frac{1}{2}$
550	3	145T	$17\frac{3}{4}$	3	$5\frac{11}{16}$	$9\frac{5}{16}$	$22\frac{3}{16}$	$5\frac{3}{16}$	$12\frac{1}{4}$	$14\frac{3}{4}$	$14\frac{3}{16}$	$18\frac{11}{16}$	$6\frac{1}{2}$	$25\frac{15}{16}$	$6\frac{11}{16}$	$18\frac{7}{8}$	$17\frac{11}{16}$	$26\frac{5}{8}$	$29\frac{5}{8}$	$\frac{3}{4}$	$\frac{3}{8}$	$\frac{1}{2}$

❶ NPT

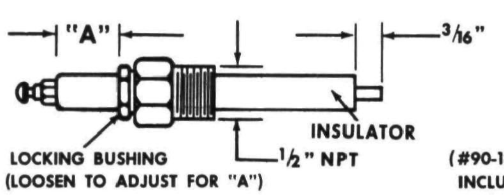
❷ NOT CERTIFIED, BUT ACCORDING TO THE MOTOR MANUFACTURER'S SPECIFICATIONS

❸ FOR CONNECTING BRACKET & LINKAGE ASSEMBLIES FOR ADAPTING CUSTOMER'S CONTROL MOTORS TO MAXON OVENPAK BURNER ASSEMBLIES, PLEASE SEE CATALOG PAGE 4104.

❹ ADD 1/4" MINIMUM TO DIMENSION "H" WHEN CUTTING OPENING FOR DISCHARGE SLEEVE.

OVENPAK BURNER CAN BE MOUNTED IN ANY POSITION (SUBJECT TO THE LIMITATIONS SET BY MANUFACTURER OF CONTROL MOTOR AND UV SCANNER).

#90-25663 SPARK IGNITOR



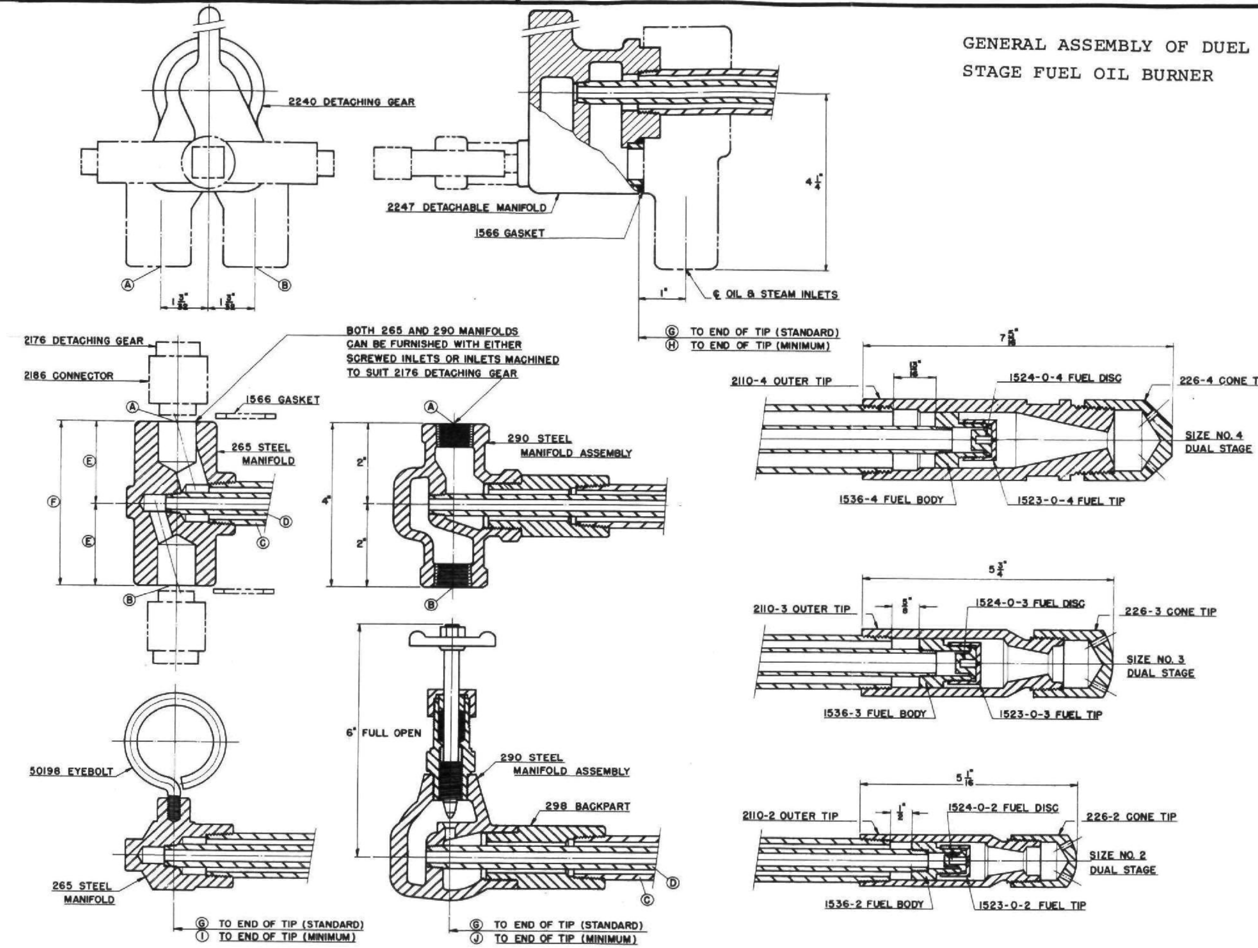
BURNER SIZE	"A"
508 & 550	1-5/16"
515	1-15/32"
525 & 535	1-7/32"

(#90-18722 PROTECTIVE RUBBER COVER INCLUDED WITH SPARK IGNITOR)

Courtesy of Maxon Corporation

Figure No. 6

GENERAL ASSEMBLY OF DUEL STAGE FUEL OIL BURNER



BURNER SIZE	A- STEAM INLET	B- OIL INLET	C- OUTER PIPE	D- OIL PIPE	E	F	G	H	I	J
NO. 2	$\frac{1}{2}$"	$\frac{1}{2}$"	$\frac{3}{4}$"	$\frac{1}{4}$"	$2\frac{1}{16}$"	$4\frac{1}{8}$"	2'-5"	8"	$7\frac{1}{8}$"	$9\frac{7}{16}$"
NO. 3	$\frac{1}{2}$"	$\frac{1}{2}$"	1"	$\frac{3}{8}$"	$2\frac{1}{8}$"	$4\frac{1}{4}$"	2'-11"	$8\frac{11}{16}$"	$7\frac{13}{16}$"	$10\frac{1}{8}$"
NO. 4	$\frac{3}{4}$"	$\frac{3}{4}$"	$1\frac{1}{4}$"	$\frac{3}{8}$"	$2\frac{1}{8}$"	$4\frac{1}{4}$"	3'-0"	$10\frac{1}{4}$"	$9\frac{3}{8}$"	$11\frac{11}{16}$"

Courtesy of National Airoil Burner Company stage is steam. Steam can be substituted by natural and by-product gases under pressure. Fuel gas for atomization, by reason of its contributing heat value, reduces the oil requirement by approximately one-third. Dual stage burners are available in four sizes from 60 to 500 GPH oil at 350 lb pressure.

Riley Stoker Corporation

Riley manufactures flare-type burners which can fire pulverized coal, gas or oil alone or in combination. Intertube burners are available for gas and oil firing. Flare type burners designed for combination firing are equipped with an oil gun utilizing mechanical or steam atomization and is inserted through the gas gun assembly. The special alloy steel gas gun complete with a nozzle, is installed and secured in the spreader tube of the coal firing equipment which is equipped with a inner spinner assembly of stainless steel. The end of the coal spreader nozzle is equipped with an outer spinner assembly. Flare-type burners for pulverized coal firing, when burning oil or center-fired gas in combination, are equipped to supply tertiary air to improve combustion of fuels and provide cooling air for the burner components. When a suitable gas supply is available these burners are furnished with a gas burner ring. When not in use the gas burner ring is adequately protected from high furnace heat by the flow of secondary air stream, and by the position of throat refractory. Flare-type burners for firing gas and oil are provided with separate oil and gas guns. A special diffuser of cast alloy attached at the nozzle end assures proper mixing of gas and/or oil and air. Both gas and oil guns are retractable when not in use. According to the manufacturer, heat liberations of over 150 MMBtu/hr have been obtained with the flare-type burners.

In addition to the above, Babcock & Wilcox have in service burners for almost every fuel combination. Their burner information is so extensive that it comprises a large volume of their standards, much of which is proprietary and cannot be divulged. They manufacture burners up to 200 MMBtu/hr size.

Combustion Engineering, Inc. has advised that they can design and manufacture burners to mix conventional and waste fuels in almost all combinations. They have a case where 13 different fuel streams are burnt together.

Appendix

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MIXED FUEL SURVEY QUESTIONNAIRE FOR PETROLEUM REFINERIES

1. Name of the company ______________________, Plant location ______________

2. Amount of crude processed for the year 19__: ____________, Plant capacity ______________

3. Annual fuel consumption for the year 19__:

   Coal __________ tons, Oil _________ BBLS, Nat. Gas _________ MMCF, Waste Fuel __________

4. Fuel used for generation of heat [], power [], steam [], waste disposal []

SR. NO.	SOURCE(1) IDENTIFICATION	SIZE OF UNIT MMBTU/HR	FUEL(S) DESIGNED FOR C-COAL, O-OIL G-NAT. GAS W-WASTE FUELS	ANNUAL FUEL CONSUMPTION				MAX. EXHAUST GAS FLOW IN MACFM	EXHAUST GAS TEMP. °F	STACK NO.
				COAL IN 1000 TONS	OIL IN 1000 BBLS	NAT. GAS IN MMCF	WASTE* FUEL			

(*) Specify waste fuel and its units

(1) Boiler, Furnace, Heater, Incinerator, etc.

5. Fuel Analysis (If there are more than one composition for any category of fuel, please match them with appropriate source number):

	COAL [] WT%	OIL [] WT% [] MOLE%	NAT. GAS [] WT% [] MOLE%	WASTE FUEL [] WT% [] MOLE%
Source No.:				
	C	C	CH_4	
	H	H	N_2	
	O	O	CO_2	
	S	S	C_2	
	N	N	C_3	
	H_2O	-	C_4	
	ASH	ASH	S	
	HHV	HHV	HHV	

6. Exhaust Gas Analysis in mole % (Please identify the source no. or stack no.)

Source/Stack No.:	________	________	________	________	________
CO_2					
CO					
N_2					
O_2					
H_2					
SO_2					
A					
HCl					
NO_x (ppm)					
Particulates					
Grains/SCF or Specify Units					

7. Rationale for mixed fuel burning: [] Supply [] Pollution Standards
[] Economic [] Others (Please specify)

8. What % of each fuel consumed for the whole plant was burned as mixed fuel?

	COAL %	OIL %	NAT. GAS %	WASTE FUEL %
In 1971				
1972				
1973				
Anticipated in				
1974				
1975				
1976				

9. For sources burning mixed fuels, they are burned:

(1) [] Simultaneously [] Separately
(2) [] Through Separate Burners [] Together through same burner

10. Remarks, if any:

Person to Contact______________________, Title___________________, Telephone__________________

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MIXED FUEL SURVEY QUESTIONNAIRE FOR PETROCHEMICAL INDUSTRY

1. Name of the company ______________________________, Plant location ____________________________

2. Major products: ____

3. Annual fuel consumption for the year 19__:

Coal __________ tons, Oil __________ BBLS, Nat. Gas __________ MMCF, Waste Fuel* __________

4. Fuel(s) used for the generation of heat [], power [], steam [], waste disposal []

Sr. No.	SOURCE(1) IDENTIFICATION	FUELS DESIGNED FOR C-COAL, O-OIL G-NAT. GAS W-WASTE FUEL	MODE OF FIRING FUELS(2)	ANNUAL FUEL CONSUMPTION			
				COAL IN 1000 TONS	OIL IN 1000 BBLS	NAT. GAS IN MMCF	WASTE FUEL*

*Specify waste fuel and its units. (1) Boiler, Furnace, Heater, Incinerator etc.
(2) Simultaneous - S, Alternate - A

5. Rationale for mixed fuel burning []Supply, []Economic, []Pollution Standards, []Others (Please Specify)

6. What % of each fuel consumed for the whole plant was burned as mixed fuel?

Coal %, Oil %, Nat. Gas %, Waste Fuel %

7. Fuel Analysis:

COAL [] WT%	OIL [] WT% [] MOLE%	NAT GAS [] WT.% [] MOLE%	WASTE FUEL [] WT.% [] MOLE %
C	C	CH_4	
H	H	N_2	
O	O	CO_2	
S	S	C_2	
N	N	C_3	
H_2O	-	C_4	
ASH	ASH	-	
H.H.V.	H.H.V.	H.H.V.	

9.

PAST & ANTICIPATED FUTURE USE OF MIXED FUELS				
YEAR	COAL %	OIL %	NAT GAS %	WASTE FUEL %
1972				
1973				
1974				
1975				
1976				

8. Exhaust Gas Analysis:

Sr. No.	MAX. EXHAUST GAS FLOW IN MACFM	TEMP IN °F	SERVED BY STACK NO.	COMPOSITION MOLE%						CONCENTRATION IN PPM				PARTI-CULATE (3)
				CO_2	CO	N_2	O_2	H_2O	A	SO_2	NO_x	HCl	H'C	

NOTE: If two or more sources have approximately the same fuel mixtures or ratios, there is no need to repeat the exhaust gas analysis; please identify repeated cases by serial no.

(3) Please specify units

Person to contact________________________, Title________________________Telephone________________________

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MIXED FUEL SURVEY QUESTIONNAIRE FOR CEMENT INDUSTRY

1. Name of the company ______________________, Plant location ______________________
2. Production for the year 19__: (preferably 73) ______________________
   i) Major Products:
   ii) Process Type:
3. Annual fuel consumption for the year 1973

   Coal ________ TONS, Oil ________ BBLS, Nat. Gas ________ MMCF, Waste Fuel ________ *
4. Fuel used for generation of heat [], power [], steam [], waste disposal []

SR. NO.	SOURCE IDENTIFICATION (1)	FUEL DESIGNED FOR (2)	TYPES OF BURNERS (3)	ANNUAL FUEL CONSUMPTION				MAX. EXHAUST GAS FLOW IN MACFM	EXHAUST GAS TEMP.	STACK NUMBER
				COAL IN 1000 TONS	OIL IN 1000 BBLS	NAT. GAS IN MMCF	WASTE FUEL*			

Type of Burners

C-Spreader (1)
  Underfeeder (2)
  Overfeeder (3)
  Pulverized (4)
  Other (5)

O-Air Atomizing (6)
  Steam Atomizing (7)
  Press/Mech. (8)
  Rotary (9)
  Other (10)
G-Atmospheric
  Injection (11)
  Power
  (a) Premix (12)
  (b) Nozzle Mix (13)
  Other (14)

(*) Specify waste fuel and its units
(1) Boiler, Furnace, Heater, Incinerator, Kiln etc.
(2) C-Coal, O-Oil, G-Nat. Gas, W-Waste Fuels
(3) Use numbers shown in parenthesis on right hand side

5. Fuel Analysis (If there are more than one composition for any category of fuel, please match them with appropriate source number):

COAL [] WT%	OIL [] WT% [] MOLE%	NAT. GAS [] WT% [] MOLE%	WASTE FUEL [] WT% [] MOLE%
Source No.:			
C	C	CH_4	
H	H	N_2	
O	O	CO_2	
S	S	C_2	
N	N	C_3	
H_2O	-	C_4	
ASH	ASH	S	
HHV	HHV	HHV	

6. Exhaust Gas Analysis in mole % (Please identify the source no. or stack no.)

Source/Stack No.:	________	________	________	________	________
CO_2					
CO					
N_2					
O_2					
H_2					
SO_2					
A					
HCl					
NO_x (ppm)					
Particulates					
Grains/SCF or Specify Units					

7. Rationale for mixed fuel burning: [] Supply [] Pollution Standards
[] Economic [] Others (Please specify)

8. What % of each fuel consumed for the whole plant was burned as mixed fuel?

	COAL %	OIL %	NAT. GAS %	WASTE FUEL %
In 1971				
1972				
1973				
Anticipated in				
1974				
1975				
1976				

9. For sources burning mixed fuels, they are burned:

(1) [] Simultaneously [] Separately
(2) [] Through Separate Burners [] Together through same burner

10. Remarks, if any:

Person to Contact________________________, Title____________________, Telephone____________________

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MIXED FUEL SURVEY QUESTIONNAIRE FOR TEXTILE INDUSTRY

1. Name of the company ______________________________, Plant location ________________________

2. Production for the year 19__: (preferably 73) ____

   i) Major Products:

   ii) Process Type:

3. Annual fuel consumption for the year 1973

   Coal__________TONS, Oil__________BBLS, Nat. Gas__________MMCF, Waste Fuel__________*

4. Fuel used for generation of heat [], power [], steam [], waste disposal []

SR. NO.	SOURCE (1) IDENTI-FICATION	FUEL (2) DESIGNED FOR	TYPES (3) OF BURNERS	ANNUAL FUEL CONSUMPTION				MAX. EXHAUST GAS FLOW IN MACFM	EXHAUST GAS TEMP.	STACK NUMBER
				COAL IN 1000 TONS	OIL IN 1000 BBLS	NAT. GAS IN MMCF	WASTE FUEL*			

(*) Specify waste fuel and its units
(1) Boiler, Furnace, Heater, Incinerator, Kiln etc.
(2) C-Coal, O-Oil, G-Nat. Gas, W-Waste Fuels
(3) Use numbers shown in parenthesis on right hand side

Type of Burners

C-Spreader (1)
  Underfeeder (2)
  Overfeeder (3)
  Pulverized (4)
  Other (5)

O-Air Atomizing (6)
  Steam Atomizing (7)
  Press/Mech. (8)
  Rotary (9)
  Other (10)

G-Atmospheric
  Injection (11)
  Power
  (a) Premix (12)
  (b) Nozzle Mix (13)
  Other (14)

5. Fuel Analysis (If there are more than one composition for any category of fuel, please match them with appropriate source number):

	COAL [] WT%	OIL [] WT% [] MOLE%	NAT. GAS [] WT% [] MOLE%	WASTE FUEL [] WT% [] MOLE%
Source No.:				
	C	C	CH_4	
	H	H	N_2	
	O	O	CO_2	
	S	S	C_2	
	N	N	C_3	
	H_2O	-	C_4	
	ASH	ASH	S	
	HHV	HHV	HHV	

6. Exhaust Gas Analysis in mole % (Please identify the source no. or stack no.)

Source/Stack No.:	________	________	________	________	________
CO_2					
CO					
N_2					
O_2					
H_2					
SO_2					
A					
HCl					
NO_x (ppm)					
Particulates					
Grains/SCF or Specify Units					

7. Rationale for mixed fuel burning: [] Supply [] Pollution Standards
[] Economic [] Others (Please specify)

8. What % of each fuel consumed for the whole plant was burned as mixed fuel?

	COAL %	OIL %	NAT. GAS %	WASTE FUEL %
In 1971				
1972				
1973				
Anticipated in				
1974				
1975				
1976				

9. For sources burning mixed fuels, they are burned:

(1) [] Simultaneously [] Separately
(2) [] Through Separate Burners [] Together through same burner

10. Remarks, if any:

Person to Contact____________________, Title__________________, Telephone__________________

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MIXED FUEL SURVEY QUESTIONNAIRE FOR ELECTRIC UTILITY PLANTS

1. Name of the company________________________, Plant location__________________________

2. Number of boilers ____, Number of generators ____, Number of stacks ____

3. Annual fuel consumption for the year 19__ :

Coal__________tons, Oil________BBLS, Nat. Gas________MMC.ft., Waste Fuel________ *

4. BOILER DATA:

BOILER NO.	FUELS DESIGNED FOR C-COAL, O-OIL G-NAT. GAS. W-WASTE FUELS	100% RATING DESIGN FUEL RATE				RATED GEN. CAPACITY MW	MAX. FLUE GAS FLOW IN ACFM	TEMP. OF FLUE GAS
		C TPH	O BBLH	G MSCFH	W *			

NOTE: Please use additional sheet if necessary *Please specify units.

5. How many boilers have the capability of burning more than one fuel?_____
**(If the answer to Q5 is 'None'. Please do not complete the rest of the questionnaire)

6. Boilers burning more than one fuel, burn different fuels:
(i) [] Simultaneously [] Separately, (ii) [] Through separate burners [] Together through same burner

7. Rationale for mixed fuel burning [] Economic, [] Supply [] Pollution Standards

8. Data for boilers having capability of burning more than one fuel

Data for the year _____ (preferably 73)

BOILER NO.	GENERATED KWH	ANNUAL FUEL CONSUMPTION				% OF EACH TYPE FUEL BURNED BY WT. OR BY BTU'S	TOTAL HOURS OF OPERATION	AVERAGE CAPACITY FACTOR	STACK NO.
		COAL IN 1000 TONS	OIL IN 1000 BBLS	NAT. GAS IN MMCF	WASTE FUEL (2)				

(2) Please specify the waste fuel

9. Fuel Analysis (If there are more than one composition for any category of fuels, please match them with appropriate source number):

	COAL [] WT%	OIL [] WT% [] MOLE%	NAT. GAS [] WT% [] MOLE%	WASTE FUEL [] WT% [] MOLE%
Boiler No.:				
	C	C	CH_4	
	H	H	N_2	
	O	O	CO_2	
	S	S	C_2	
	N	N	C_3	
	H_2O	-	C_4	
	ASH	ASH	S	
	HHV	HHV	HHV	

10. Flue Gas Analysis in mole % (Please match with appropriate boiler number(s)):

Boiler Number(s)	________	________	________	________	________
CO_2					
CO					
N_2					
O_2					
H_2O					
SO_2					
A					
HCl					
NO_x (ppm)					
Particulates					
Grains/SCF or Specify Units					

11. What % of each fuel consumed for the whole plant was burned as mixed fuel?

	COAL %	OIL %	NAT. GAS %	WASTE FUEL %
In 1971				
1972				
1973				
Anticipated in				
1974				
1975				
1976				

12. Remarks, if any:

Person to contact________________________, Title____________________, Telephone___________________

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MIXED FUEL SURVEY QUESTIONNAIRE FOR GLASS INDUSTRY

1. Name of the company________________________, Plant location____________________
2. Production for the year 19___: __________, Major Products________________, Process Type__________
3. Annual fuel consumption for the year 19___:
   Coal____________tons, Oil____________BBLS, Nat. Gas____________MMCF, Waste Fuel__________*
4. Fuel(s) used for the generation of heat [], power [], steam [], waste disposal []

Source Identification[1]	Fuels Designed For[2]	Types of Burners[3]	ANNUAL FUEL CONSUMPTION Coal In 1000 Tons	Oil In 1000 BBLS	Nat. Gas In MMCF	Waste* Fuel	Max. Exhaust Gas Flow In MACFM	Exhaust Gas Temp. °F

Type of Burners

C-Spreader	(1)
Underfeeder	(2)
Overfeeder	(3)
Pulverized	(4)
Other	(5)
O-Air Atomizing	(6)
Steam Atomizing	(7)
Pres/Mech.Atomizing	(8)
Rotary	(9)
Other	(10)
G-Atmosphere Injec.	(11)
Power (a) Premix	(12)
(b) Nozzle Mix	(13)
Other	(14)

(*) Specify waste fuel and its units
(1) Boiler, Furnace, Heater, Incinerator, Kiln, etc.
(2) C-Coal, O-Oil, G-Nat. Gas W-Waste Fuels
(3) Use numbers shown in parenthesis on right hand side

5. Fuel Analysis (If there are more than one composition for any category of fuel, please match them with appropriate source number):

	COAL [] WT%	OIL [] WT% [] MOLE%	NAT. GAS [] WT% [] MOLE%	WASTE FUEL [] WT% [] MOLE%
Source No.:				
	C	C	CH_4	
	H	H	N_2	
	O	O	CO_2	
	S	S	C_2	
	N	N	C_3	
	H_2O	-	C_4	
	ASH	ASH	S	
	HHV	HHV	HHV	

6. Exhaust Gas Analysis in mole % (Please identify the source no. or stack no.)

Source/Stack No.:	__________	__________	__________	__________	__________
CO_2					
CO					
N_2					
O_2					
H_2					
SO_2					
A					
HCl					
NO_x (ppm)					
Particulates					
Grains/SCF or Specify Units					

7. Rationale for mixed fuel burning: [] Supply [] Pollution Standards
[] Economic [] Others (Please specify)

8. What % of each fuel consumed for the whole plant was burned as mixed fuel?

	COAL %	OIL %	NAT. GAS %	WASTE FUEL %
In 1971				
1972				
1973				
Anticipated in				
1974				
1975				
1976				

9. For sources burning mixed fuels, they are burned:

(1) [] Simultaneously [] Separately
(2) [] Through Separate Burners [] Together through same burner

10. Remarks, if any:

Person to Contact______________________, Title___________________, Telephone__________________

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MIXED FUEL SURVEY QUESTIONNAIRE FOR CHEMICAL PROCESSING INDUSTRY

1. Name of the company____________________________, Plant location________________________________

2. Major products:____

3. Annual fuel consumption for the year 19___:

Coal__________tons, Oil__________BBLS, Nat. Gas__________MMCF, Waste Fuel*____________

4. Fuel(s) used for the generation of heat [], power [], steam [], waste disposal []

Sr.No	SOURCE (1) IDENTIFICATION	FUELS DESIGNED FOR C-COAL, O-OIL G-NAT. GAS W-WASTE FUEL	MODE OF FIRING FUELS (2)	(3) TYPE OF BURNERS	ANNUAL FUEL CONSUMPTION			
					COAL IN TONS	OIL IN 1000 BBLS	NAT.GAS IN MMCF	*WASTE FUEL

TYPES OF BURNERS

C-Spreader (1)
  Underfeeder (2)
  Overfeeder (3)
  Pulverized (4)
  Other (5)
O-Air Atomizing (6)
  Steam Atomizing (7)
  Pres/Mech. Atomizing (8)
  Rotary (9)
  Other (10)
G-Atmosphere Injection (11)
  Power (a) Premix (12)
  (b) Nozzle Mix (13)

*Specify waste fuel and its units.

(1) Boiler, Furnace, Heater, Incinerator etc.
(2) Simultaneous - S, Alternate - A
(3) Use numbers shown in parenthesis on right hand side

5. Rationale for mixed fuel burning []Supply, []Economic, []Pollution Standards, []Others (Please specify)

6. What % of each fuel consumed for the whole plant was burned as mixed fuel?

Coal % Oil % Nat. Gas % Waste Fuel %

7. Fuel Analysis:

COAL [] WT%	OIL [] WT% [] MOLE%	NAT GAS [] WT.% [] MOLE%	WASTE FUEL [] WT.% [] MOLE %
C	C	CH_4	
H	H	N_2	
O	O	CO_2	
S	S	C_2	
N	N	C_3	
H_2O	-	C_4	
ASH	ASH	-	
H.H.V.	H.H.V.	H.H.V.	

9.

PAST & ANTICIPATED FUTURE USE OF MIXED FUELS				
YEAR	COAL %	OIL %	NAT GAS %	WASTE FUEL %
1972				
1973				
1974				
1975				
1976				

8. Exhaust Gas Analysis:

Sr. No.	MAX. EXHAUST GAS FLOW IN MACFM	TEMP IN °F	SERVED BY STACK NO.	COMPOSITION MOLE%						CONCENTRATION IN PPM				PARTI-CULATE (3)
				CO_2	CO	N_2	O_2	H_2O	A	SO_2	NO_x	HCl	H'C	

NOTE: If two or more sources have approximately the same fuel mixtures or ratios, there is no need to repeat the exhaust gas analysis; please identify repeated cases by serial no.

(3) Please specify units

Person to contact ____________________, Title ____________________ Telephone ____________________

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15. SUPPLEMENTARY NOTES

16. ABSTRACT

The report gives results of a study to determine types of mixed and waste fuels and the extent of their usage in stationary combustion equipment. Where possible, pollutant emission levels resulting from combustion of these fuels have been determined. Industries surveyed included utilities, petroleum refineries, petrochemical, chemical processing, glass, cement, and textiles. Of the industries surveyed, about 70% of the refineries, 45% of the utilities, 20% of the cement, glass, and textile manufacturers, and 10% of the petrochemical and chemical processing plants have reported using mixed fuels to some extent.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group	
Air Pollution	Petrochemistry	Air Pollution Control	13B,	08G
Fuels	Chemical Industry	Stationary Sources	21D,	07A
Mixtures	Glass Industry	Mixed Fuels	07D,	11B
Wastes	Cements	Waste Fuels		13C
Flue Gases	Textile Industry		21B,	11E
Utilities				
Refineries				

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