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Survey of New Industrial Boiler Projects — 1981-1984

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Emission Standards and Engineering Division

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EXECUTIVE SUMMARY

This report presents an analysis of data collected through a written survey of firms purchasing new industrial boilers between 1981 and 1984. The purpose of the survey was to collect data which could be used to assess the reasons for new industrial boiler purchases, the percentage of these boilers which are used for new applications versus replacement of existing boilers, and the impact of new boiler purchases on SO_2 emissions.

A total of 168 surveys covering 229 new industrial boilers with 47,750 million Btu/hour heat input capacity were collected and entered into a computerized data base. Of these, 151 units were equal to or larger than 100 million Btu/hour and designed to fire coal, oil, natural gas, or wood as the primary fuel; aggregate heat input capacity of these boilers was 38,657 million Btu/hour. Most of the analysis in the report is based on these 151 units. Comparison with boiler sales data gathered by the American Boiler Manufacturers Association (ABMA) suggests that these units represent greater than 95 percent of the industrial boilers in this category sold between 1981 and 1984.

Analysis of the data identified five primary reasons for installation of new boilers: 1) desire to use fuels other than those currently used by existing boilers (34 percent of the total), 2) need for additional boiler capacity at an existing plant (22 percent), 3) poor condition of an existing boiler (16 percent), 4) need for steam at a new plant (14 percent), and 5) desire to cogenerate electricity (14 percent). Factors affecting the design of the new boiler and the cost sensitivity of the boiler purchase decision were evaluated as a function of these five reasons. Less than 10 percent of the purchasers indicated they would have changed the project if costs had increased by 10 percent; if costs increased by 30 percent roughly one-half of the boiler projects would have been changed. Boilers installed for the primary purpose of fuel switching and cogeneration were the most cost sensitive, while boilers installed due to poor condition of the existing boiler were the least sensitive.

Data on 291 existing boilers that were in some way affected by installation of the new boilers were also examined. These boilers tend to be much smaller in size and fire relatively greater amounts of oil and natural gas than the new boilers. Roughly 50 percent of the existing boilers were shutdown or dismantled as part of the new boiler project while the remaining 50 percent continued operating, generally at reduced load. Of the 50 percent reported as shutdown or dismantled, the boiler owners indicated that about one-third could have been rebuilt to extend their useful life.

The above five reasons were also used to classify boilers as replacement versus new application and as mandatory versus discretionary purchases. Based on this analysis, the number of replacement and new application boilers are almost equal (50 percent each) while discretionary purchases account for roughly 60 percent of sales versus 40 percent for mandatory purchases.

Analysis of SO_2 emissions found that although the new coal- and oil-fired boilers have average emission rates that are 40 to 50 percent lower than the existing boilers firing the same fuel, the average emission rate for all boilers remained virtually unchanged because of changes in the mix of fuels fired, specifically increased use of coal and decreased use of natural gas. This fact combined with the overall increase in total boiler capacity results in an increase in total annual SO_2 emissions of roughly 70 percent compared to baseline emissions before the new boilers were installed. This increase results from 1) installation of new boilers that are not replacing existing boilers, 2) replacement of existing boilers with new boilers that are significantly larger, 3) fuel switches from natural gas and oil to coal, and 4) continued operation of the existing boilers, although at reduced load.

Of the total annual SO_2 emissions occurring after installation of all the new boilers (i.e., replacement and new installations), roughly one-fourth were emitted by existing boilers that remained in operation after installation of the new boilers. Of the emissions increase, roughly one-half came from projects where the new boiler was installed as a replacement, with the other half coming from new applications. If only

those boilers defined as mandatory (i.e., driven by factors largely independent of boiler cost) were installed, emissions would have increased by roughly 20 percent.

Based on current fuel prices, the number of coal-fired boiler purchases associated with fuel switching is expected to be lower in the future than in the 1981-84 time period. To evaluate the impact of lower oil and natural gas prices on potential SO_2 emissions, data from projects installed for reasons other than fuel switching projects were tabulated. Significantly, when fuel switching is exluded from the analysis, the percentage of new boilers installed as replacements for existing boilers decreases from roughly one-half (as discussed above) to about one-fourth and the increase in emissions declines from about 70 percent to about 40 percent. If current low fuel prices were to also discourage construction of cogeneration boilers (also found to be sensitive to project economics) as well as fuel switching boilers, replacement boilers would represent roughly one-third of new boiler installations; total SO_2 emissions would be about 20 percent higher than from the existing boilers alone.

In summary, under all of the situations examined, the survey data indicates that total emissions of SO_2 are higher after installation of new boilers than they were previously. Major reasons for this are 1) installation of new boilers to satisfy increased steam demands at new and existing plants, 2) changes in the relative use of coal versus natural gas, and 3) continued operation of many existing boilers (although at reduced loads) after the new boilers are installed. Because of this increased steam demand (and associated energy use), total annual SO_2 emission increase despite the fact that new coal- and oil-fired boilers have lower average emission rates per million Btu of fuel fired than did the existing boilers.

SURVEY OF NEW INDUSTRIAL BOILER PROJECTS 1981-1984

1.0 INTRODUCTION

This report presents the analysis of data collected through a written survey of firms purchasing new industrial boilers between 1981 and 1984. The purpose of the survey was to collect data which could be used to assess the reasons for new industrial boiler purchases, the percentage of these boilers which are used for new applications versus replacement of existing boilers, and the impact of new boiler purchases on SO_2 emissions.

Section 2 of the report reviews the data collection and management procedures. Section 3 summarizes general statistics on the boilers surveyed; this information includes boiler size, fuel use, fabrication methods, and methods of SO_2 control. A comparison of the surveyed boilers relative to boiler sales data gathered by the American Boiler Manufacturers Association (ABMA) for the same time period is also presented. Section 4 presents an analysis of why these new boilers were built, factors influencing boiler decisionmaking, the sensitivity of the boiler purchase to increased costs, and the impact of the new boiler on existing boilers at the same site. Section 5 evaluates changes in SO_2 emission rates and total annual emissions resulting from the overall new boiler project, including operational changes in existing boilers already at the site. Section 6 examines possible impacts on the survey's findings resulting from current energy prices which are lower than those during the 1981-84 time period.

2.0 COLLECTION OF DATA

Information on boiler replacements was collected using a written survey form sent to recent purchasers of industrial boilers. The following three sections describe the survey form used to obtain data, the development of a mailing list of recent boiler purchasers, and data management procedures used to handle the survey forms after they were completed.

Description of the Survey Form

A survey form (Appendix 1) was developed to collect data on each new boiler project; a project can consist of one or more new boilers. The survey form is divided into four major sections:

- Part I, containing general information on the boiler purchaser;
- Part II, describing the reason(s) for undertaking the new boiler project;
- Supplement A, providing detailed information on each new boiler installed as part of the overall project; and,
- Supplement B, providing detailed information on each existing boiler located at the site of the new boiler project (or an adjacent site in the case of several "third-party" cogenerators) which was affected in some way by installation of the new boiler(s).

Parts I and II were completed for the entire project, while separate Supplements A and B were completed for each individual boiler included in the project.

Development of the Mailing List

Information on new boiler orders was obtained from two data listings collected by the U. S. Department of Energy (DOE): Form ERA-97 (Boiler Manufacturers Report) and Form EIA-97 (Boiler Order Report). These two reports contain essentially the same information; EIA-97 is the more recent of the two and has superseded ERA-97.

These forms are used by DOE to collect quarterly data from U. S. boiler manufacturers, their foreign affiliates and subsidiaries, and U. S. boiler rental companies on orders received from electric utilities and industrial firms operating in the U.S. (including territories and administered areas). Information is required to be submitted for all boilers having a rated capacity of 40,000 or more pounds of steam per hour (approximately 50 million Btu/hr heat input capacity) and includes: boiler function, rated capacity, fuels burned, date ordered, date delivered, and the name and address of the purchasing/operating company.

A list of the name, address, and telephone number of companies ordering boilers rated at 80,000 pounds of steam and larger between January 1982 and

September 1984 was obtained from the Form EIA-97 database. Similar information was obtained from Form ERA-97 for boilers ordered between January 1977 and March 1982. Both data sets were presorted to eliminate non-industrial purchasers (e.g., electric utilities and institutional users such as hospitals and universities) and waste heat boilers. For use in the survey, the database was further sorted to eliminate boilers ordered prior to January 1981.

As an additional check, the boiler inventory was screened to eliminate boilers sold to rental companies, which would not be permanently installed at a site. Information on the remaining boilers was confirmed through telephone calls to each purchaser listed. This was done to verify installation of the boiler and to obtain a correct name and address for survey mailout purposes. Survey forms were then sent to 185 companies.

Data Management Procedures

Responses were received from all 185 companies receiving the survey form. Several of the respondents did not complete the survey, indicating that the boiler was ordered prior to 1981, had been cancelled, or was below the 100 million Btu per hour threshold established for the survey. Data from the remaining 168 survey forms were entered into a computerized data base, and then manually reviewed for missing data and keypunch errors to eliminate possible problems in subsequent analysis. Statistical analyses of the data were conducting using MICRO-SAS software developed by SAS, Inc. (located in Cary, NC).

3.0 DESCRIPTION OF NEW BOILER PROJECTS

Description of All Projects Surveyed

A total of 168 surveys were entered into the data base, covering 229 boilers with a total heat input capacity of 47,750 million Btu/hour (assuming 1,176 Btu of fuel fired per pound of steam generated). Summary statistics for the new boilers included in these projects are provided in Table 1. Note that 7 percent of the total capacity and 23 percent of the number of boilers surveyed are less than 100 million Btu/hour. Coal-fired

TABLE 1. DESCRIPTION OF ALL NEW BOILERS COVERED BY SURVEY

-	Total Number of Projects:		168
-	Total Number of New Boilers:		229
-	Total New Boiler Capacity (MMBtu/hr heat input):		47,750
-	Average Size of New Boiler (MMBtu/hr heat input):		209
-	Frequency Distribution (Percentage) by:		
--	Capacity (MMBtu/hr):	Capacity (%)	No. Units (%)
	<100	7.0	23.1
	100-150	12.7	25.3
	150-200	12.4	17.0
	200-250	5.8	6.6
	250-400	13.8	10.0
	400-600	21.0	10.9
	≥600	27.3	7.0
--	Primary Fuel:		
	Coal	42.6	39.0
	Oil	2.0	3.9
	Natural Gas	23.4	29.8
	Wood	16.6	13.6
	Other	15.2	13.6
--	Fabrication Method:		
	Package	--	36.8
	Field	--	63.2
--	Number of Boilers Per Project:		
	1	--	76.2
	2	--	16.7
	3	--	2.4
	4	--	4.2
	5	--	0.6
--	Method of SO2 Control:		
	Low-Sulfur Fuel	--	74.2
	Flue Gas Desulfurization	--	1.7
	Fluidized Bed Combustion	--	13.5
	No Response	--	10.5

boilers predominate (accounting for 43 percent of the capacity and 39 percent of the units). These were followed in decending order by natural gas, wood, other (consisting primarily of byproduct fuels such as black liquor and refinery off-gas), and oil. Almost 90 percent of the respondents indicated they practiced some form of SO_2 control, primarily use of low-sulfur fuels (74 percent of the boilers) followed by fluidized bed combustion (14 percent).

A subset of the data base was constructed containing only those projects (hereafter referred to as Category I projects) that included one or more new boilers equal to or greater than 100 million Btu/hour heat input capacity (85,000 pounds of steam/hour) and that burned coal, oil, natural gas, or wood as the primary fuel. The Category I data base is summarized in Table 2. It includes 158 new boilers with a total capacity of 38,657 million Btu/hour. Of these 158 boilers, 151 meet the above size and primary fuel criteria. The remaining seven boilers were installed as part of projects involving one or more of these 151 units, but are smaller than 100 million Btu/hour or fire byproduct fuels. Units greater than 250 million Btu/hour account for 64 percent of the capacity and 34 percent of the new boilers by number. Fuel use is generally similar to the larger data base, but contains a somewhat larger percentage of coal and wood-fired units. Sulfur dioxide control statistics are also similar to the larger data base.

Representativeness of Data Base

The survey was designed to gather information on new industrial boilers sold between 1981 and 1984. To evaluate the completeness of the survey, the Category I data base (excluding the seven new boilers smaller than 100 million Btu/hr capacity) was compared to boiler sales data compiled by the American Boiler Manufacturers Association (ABMA) for the corresponding time period (January 1981-September 1984). The ABMA data were adjusted to exclude electric utility auxilliary boilers and rental boilers (estimated at 20 and 15 boilers, respectively, based on information provided by ABMA) to provide a common basis for comparison.

The adjusted ABMA sales data includes a total of 156 boilers: 79 coal-fired, 50 oil- and gas-fired, and 27 wood-fired. The Category I boilers for the same fuels total 151: 76 coal-fired, 49 oil- and gas-fired,

TABLE 2. DESCRIPTION OF NEW BOILER PROJECTS ≥100 MMBTU/HR AND USING COAL, OIL, NATURAL GAS, OR WOOD AS PRIMARY FUEL

-	Total Number of Projects:		115
-	Total Number of New Boilers:		158
-	Total New Boiler Capacity (MMBtu/hr heat input):		38,657
-	Average Size of New Boiler (MMBtu/hr heat input):		245
-	Frequency Distribution (Percentage) by:		
	-- Capacity (MMBtu/hr):	Capacity (%)	No. Units (%)
	<100	0.6	1.9
	100-150	12.9	30.4
	150-200	15.4	24.7
	200-250	7.2	9.5
	250-400	14.0	12.0
	400-600	21.5	12.6
	>600	28.5	8.9
--	Primary Fuel:		
	Coal	49.2	48.1
	Oil	2.3	5.1
	Natural Gas	24.6	27.2
	Wood	19.9	16.5
	Other	3.9	3.2
--	Fabrication Method:		
	Package	--	25.3
	Field	--	74.7
--	Number of Boilers Per Project:		
	1	--	76.5
	2	--	15.7
	3	--	2.6
	4	--	4.3
	5	--	0.9
--	Method of SO2 Control:		
	Low-Sulfur Fuel	--	72.2
	Flue Gas Desulfurization	--	1.9
	Fluidized Bed Combustion	--	15.8
	No Response	--	10.1

and 26 wood-fired. Based on these almost identical numbers, results derived from the survey data are expected to closely reflect the total population of industrial boilers sold between 1981 and 1984.

4.0 ANALYSIS OF NEW BOILER PROJECTS

Primary Reasons for New Boiler Projects

One of the principal questions in the survey dealt with why the boiler was purchased. This question was asked both as an "essay" question (Question II-6) and by asking respondents to rank a list of factors on a scale of 0 (unimportant), 1 (somewhat important), and 2 (very important) (Question II-9). Based on review of the responses to these two questions, five primary reasons were identified that accounted for all of the projects surveyed:

- o desire to change base fuel;
- o need for additional boiler capacity at an existing plant;
- o condition of the existing boiler;
- o need for steam at a new plant site; and
- o desire to cogenerate electricity.

Each of these primary reasons is briefly described below. Tables 3 and 4 present the percent of boilers falling into each primary reason category for the entire data base and Category I boilers, respectively.

Fuel Switching--

Given relative fuel prices and availability during the time period covered by the survey, many boiler owners were faced with the decision to continue operation with a fuel considered to be expensive and unreliable (e.g., oil) or convert to a fuel considered cheaper and more secure (e.g., coal). As shown in Tables 3 and 4, respectively, the survey respondents indicated 28 percent of all projects and 34 percent of the Category I projects were for the primary reason of fuel switching--the most frequent response given for any of the above reasons.

TABLE 3. PRIMARY REASON FOR PROJECT (ALL PROJECTS)

	Number of Projects	Percent of Total
1. Fuel Switch	47	28.0
2. Additional Capacity Needed - Primary (36) - Backup (7)	43	25.6
3. Boiler Condition - Unreliable (29) - Unsafe (2) - Unable to Comply with Air Regs (3)	34	20.2
4. New Plant	25	14.9
5. Cogeneration	19	11.3
	168	100.0
REPLACEMENT (Fuel Switch, Boiler Condition)	81	48.2
NEW APPLICATION (Additional Capacity, New Plant, Cogeneration)	87	51.8
	168	100.0
DISCRETIONARY (Fuel Switch, Backup Capacity, Repairable Boiler Condition, Cogeneration)	86	51.2
MANDATORY (Primary Capacity, Unrepairable Boiler Condition, New Plant)	82	48.8
	168	100.0

TABLE 4. PRIMARY REASON FOR PROJECT (CATEGORY I PROJECTS)

	Number of Projects	Percent of Total
1. Fuel Switch	39	33.9
2. Additional Capacity Needed - Primary (19) - Backup (6)	25	21.7
3. Boiler Condition - Unreliable (16) - Unsafe (2) - Unable to Comply with Air Regs (1)	19	16.5
4. New Plant	16	13.9
5. Cogeneration	16	13.9
	115	100.0
REPLACEMENT (Fuel Switch, Boiler Condition)	58	50.4
NEW APPLICATION (Additional Capacity, New Plant, Cogeneration)	57	49.6
	115	100.0
DISCRETIONARY (Fuel Switch, Backup Capacity, Repairable Boiler Condition, Cogeneration)	67	58.3
MANDATORY (Primary Capacity, Unrepairable Boiler Condition, New Plant)	48	41.7
	115	100.0

Additional Capacity--

The need for additional boiler capacity--either to meet increased steam demand at an existing industrial plant (defined as primary capacity in Tables 3 and 4) or to increase the flexibility/reliability of steam generation at the plant (defined as backup capacity)--was the second most frequent reason for installing new boilers.

Boiler Condition--

Replacement of existing boilers due to their condition was the third most frequent reason given for new boiler projects. This category includes projects in which the existing boiler was unreliable (e.g., high percentage of downtime, high O&M costs), unsafe (e.g., unable to pass a safety inspection), or unable to comply with existing environmental regulations. This category was further subdivided into six projects in which the boiler owner said the existing boiler could have been repaired or rebuilt (but was replaced with a new boiler anyway) and thirteen projects in which the boiler owner stated repair or rebuild was not economically feasible (Question B-10).

New Plant--

The fourth most frequent reason for installation of new boilers was steam demand at new manufacturing plants where a boiler did not previously exist.

Cogeneration--

Partially as a result of economic incentives provided under the Public Utility Regulatory Policy Act (PURPA), the desire to cogenerate both electricity and process steam was the fifth most frequent reason given for constructing new boiler projects.

Boilers installed for these five reasons were then combined and redivided according to two alternative groupings: first, whether the new boiler replaced an existing boiler or was a new application and second,

whether installation of the boiler was discretionary (i.e., decision was based on the economics of a new versus existing boiler) or mandatory (i.e., required by factors other than boiler economics). The first of these alternative groupings was made based on the following interpretation of the primary reason for each project:

- Replacement--fuel switching and boiler condition,
- New application--additional capacity, new plant, and cogeneration.*

The second of these alternative groupings was based on the following interpretation of the primary reason:

- Discretionary--fuel switching, backup capacity, repairable boiler condition, and cogeneration,
- Mandatory--primary capacity, unrepairable boiler condition, and new plant.

As shown in Table 3, of all the projects surveyed, replacement projects and new application projects were roughly equal in number (48 percent versus 52 percent). A similar split also occurred between discretionary versus mandatory projects (51 percent versus 49 percent). For the Category I projects (see Table 4), the split between replacement versus new application remained roughly equal (50.4 percent versus 49.6 percent) while the frequency of discretionary projects increased to 58 percent versus 42 percent for mandatory projects.

Factors Affecting Boiler Decisions

Information was also provided by the survey respondents on the factors affecting the design of the new boiler project (Question II-10). This information was provided by ranking the listed factors as either 0, 1, or 2 (using the same definitions discussed above). The individual responses on each factor were then averaged for the projects within each of the five

*NOTE: In a few cases, existing boilers were affected by cogeneration, but in most cases were not. In all cases, however, a primary factor in the project design was the production of electricity, rather than simply replacement of existing boilers.

primary reasons discussed above. The results of this analysis are presented in Table 5.

Capital cost and fuel cost were among the three highest rated factors for each of the primary reason categories except boiler condition. Compatibility with existing fuel handling facilities was the primary factor affecting the design of projects undertaken due to poor condition of the existing boiler (this factor was also important--scoring fourth--for additional capacity projects). Frequently mentioned as unimportant were corporate policy* and environmental regulations.

Cost Sensitivity of Projects

To estimate the economic sensitivity of projects to changes in project cost, the respondents were asked whether their decision to build the project would have changed if the projected cost of steam increased by 10, 20, 30, or 50 percent (Question II-8). The data in Table 6 indicate the percentage of industrial boiler projects that would continue as designed even if the costs were increased by these percentages.

In general, most projects were insensitive to a 10 percent increase in cost (only 7 out of 89 projects--8 percent--would have changed their decision). If costs increased by 20 to 30 percent, an increasing number of projects would have changed; roughly one-half of the projects would have been altered if project costs increased by 30 percent. However, additional increases in cost up to 50 percent resulted in few additional changes.

The two most cost sensitive project groups were those undertaken primary to fuel switch (60 percent would have changed their decision if costs increased by 30 percent) and cogeneration (64 percent). The least cost sensitive were those undertaken primarily because of the condition of the existing boiler (35 percent). These results tend to support the view that fuel switching and cogeneration are highly discretionary, and are therefore most sensitive to cost increases. On the other hand, boiler projects tied to the existing boiler condition or need for additional

*NOTE: The low rating of corporate policy may have reflected the lack of corporate policies related to boiler purchase decisions, rather than the unimportance of policies which did exist.

TABLE 5. FACTORS AFFECTING BOILER DECISIONS FOR CATEGORY I PROJECTS

Reason	Top Three Factors	Bottom Three Factors
New Plant	Fuel Costs Fuel Security/Reliability Capital Costs	Existing System Components Compatibility w/Existing Fuels Space/Land Available
Additional Capacity	Fuel Costs Operating Flexibility Capital Costs	Interest Rates Corporate Policy Space/Land Available
Boiler Condition	Compatibility w/Existing Fuels Maintenance Costs Boiler Efficiency	Corporate Policy Interest Rates Environmental Regulations
Fuel Switch	Capital Costs Fuel Costs Corporate Funds Availability	Corporate Policy Environmental Regulations Existing System Components
Cogeneration	Capital Costs Fuel Costs Boiler Efficiency	Corporate Policy Environmental Regulations Minimize Personnel

NOTE: The low rating of corporate policy may have reflected the lack of corporate policies related to boiler purchase decisions, rather than the unimportance of policies which did exist.

TABLE 6. PERCENT OF PROJECTS THAT WOULD HAVE PROCEEDED AS DESIGNED IF COST INCREASED

Primary Reason	Number of Projects (100%)	Percent of Projects Proceeding If Costs Increased By			
		10%	20%	30%	50%
New Plant	12	92	67	42	42
Additional Capacity	19	100	79	53	47
Boiler Condition	17	94	71	65	65
Fuel Switch	30	90	77	40	30
Cogeneration	11	82	64	36	36
TOTAL	89*	92	73	47	43

*26 of the 115 respondents did not answer this question.

capacity are undertaken for mandatory reasons, and as a result were the least sensitive to cost increases. These results are consistent with the results presented previously in Table 5.

Existing Boiler Data and Status Changes

A total of 115 projects make up the Category I data base. These projects include 158 new boilers and 291 existing boilers that were in place and affected in some way by the new boiler. Data on these existing boilers are presented in Table 7. These data include existing boilers affected by "third-party" cogenerators who sold steam to an existing plant.

Although most of the existing boilers (53 percent) covered by the survey are over 100 million Btu per hour, their average size is significantly smaller than the new boilers--109 million Btu/hour for the existing boilers versus 245 million Btu/hour for the new Category I boilers. Also, a much greater percentage of the existing boilers fire oil and natural gas. Oil-fired boilers make up only 5 percent of the new boilers, but comprise 24 percent of the existing boilers. Natural gas was used in 27 percent of the new boilers and 56 percent of the existing boilers. Correspondingly, coal-fired boilers comprise only 10 percent of the existing boilers compared to 48 percent of the new boilers.

Of the existing plants installing new boilers, 86 percent had existing boilers which were in some way affected by installation of a new boiler. Table 8 presents data on how and why the status of the existing boilers changed as a result of the new boiler installation. The summation of individual percentages to more than 100 percent reflects respondents checking more than one answer. Almost 50 percent of the existing boilers that were affected were either shut down without being dismantled (20 percent) or were dismantled (29 percent). The remaining 50 percent continued operating after installation of the new boiler, but generally for fewer hours or at lower load than before.

The major reason given for changes in the status of existing boilers was the need to reduce fuel costs associated with the operation of the existing boiler (63 percent). Thirteen percent of the existing boilers had their status changed due to high operating and maintenance costs. Excess

TABLE 7. EXISTING BOILER INFORMATION FOR CATEGORY I PROJECTS

- Total Number of Projects: 79
- Total Number of Existing Boilers: 291
- Total Existing Boiler Capacity (MMBtu/hr heat input): 31,617
- Average Size of Existing Boiler (MMBtu/hr heat input): 109
- Frequency Distribution (Percentage) by:

-- Capacity (MMBtu/hr):	Capacity (%)	No. Units (%)
<100	17.8	46.7
100-150	22.3	22.7
150-200	18.7	13.7
200-250	15.9	8.9
250-400	12.0	4.8
400-600	8.0	2.1
≥600	5.3	1.0
-- Fuel type:		
Coal	13.1	9.6
Oil	28.5	23.7
Natural Gas	42.9	56.0
Wood	7.4	6.5
Other	8.0	4.1
-- Fabrication Method:		
Package		40.2
Field		59.8

- Number of existing boilers per project:

Number of Boilers Per Project	Freq	Percent
1	10	12.7
2	23	29.1
3	21	26.6
4	14	17.7
5-10	8	10.0
>10	3	3.8

- Percent of existing plant projects that involved changes in one or more existing boilers: 86.0

TABLE 8. CHANGES IN STATUS OF EXISTING BOILERS (CATEGORY I PROJECTS)

- How did status change (for boilers that did change)

	% Yes*
- Shutdown (w/o dismantling)	19.6
- Dismantled	29.2
- Used as backup/peaking boiler	43.0
- Reduced hours of operation	3.1
- Switched fuels	1.0
- Other	8.2

- Why did status change (for boilers that did change)

	% Yes*
- High fuel costs	62.5
- High O&M Costs	13.0
- Excess boiler capacity	12.4
- Mechanical problems	7.9
- Obsolete (age, operating pressure, size, poor reliability)	6.5
- Environmental restrictions	5.2
- Inadequate space	2.4
- Other	1.7

- For those boilers that were shutdown/dismantled percent that could have had useful life extended:

34.7

* % by number of units.

boiler capacity after installation of the new boiler was the reason for 12 percent of the changes. Environmental restrictions, primarily related to SO_2 emissions, accounted for another 5 percent. Other individual responses accounted for less than 10 percent of the changes.

In order to gain some insight as to the options available to the boiler owner/operator, a question (Question B-11) was posed as to whether those boilers that were shut down or dismantled could have had their useful life extended. According to the survey respondents, only about one-third (35 percent) of the existing boilers that were shut down or dismantled could have been economically repaired or rebuilt to extend their useful life.

5.0 SULFUR DIOXIDE EMISSIONS FROM CATEGORY I BOILER PROJECTS

Sulfur dioxide emissions from both the new and existing boilers involved in each project were estimated on a "before project" and "after project" basis. Emission estimates are presented in two ways: pounds per million Btu of heat input and total annual emissions (i.e., tons/year). Calculation of annual emissions from each boiler is based on the quantity and sulfur content of both the base fuel and backup fuel.

Emission Rate

Table 9 summarizes sulfur dioxide emission rate data for the existing and new Category I boilers firing coal, oil, and all fuels (whether firing coal, oil, natural gas, or wood) as a base fuel. Average emission rates for the existing coal-fired boilers after completion of the new boiler projects were lower than they were before the projects: 2.49 compared to 2.89 lbs SO_2/MMBtu. Whether this decrease resulted from shutting down existing boilers with high emission rates or changing the quality of the coal used in the existing boilers was not examined. New coal-fired boiler emission rates averaged 1.47 lbs SO_2/MMBtu, significantly lower than the average emission rate for the existing boilers. Of these new boilers, 67 percent have an emission rate equal to 1.2 lbs SO_2/MMBtu or less (this rate equals the federally regulated limit [40 C.F.R. Part 60, Subpart D] then in effect for SO_2 emissions from coal-fired industrial boilers $\geq$250 million Btu/hour). Another 26 percent have an emission rate of 1.3-2.4 lbs SO_2/MMBtu. The

TABLE 9. SO_2 EMISSION RATES FROM NEW AND EXISTING BOILERS (CATEGORY I PROJECTS)

	Number of Boilers	Average Emission Rate (#SO2/MMBtu)
- Coal-Fired Boilers		
-- Existing Boilers		
--- Before the Project	28	2.89
--- After the Project	16	2.49
-- New Boilers	76	1.47
- Oil-Fired Boilers		
-- Existing Boilers		
--- Before the Project	73	1.99
--- After the Project	37	1.92
-- New Boilers	7	1.14
- All Boilers (Coal, Oil, Natural Gas, and Wood)		
-- Existing Boilers		
--- Before the Project	279	0.81
--- After the Project	141	0.79
-- New Boilers	151	0.80

- Frequency Distribution (Percent) of New Boilers by Emission Rate:

#SO2/MMBtu	Coal*	Oil*
<0.8	5	43
0.9-1.2	62	29
1.3-1.8	17	0
1.9-2.4	9	29
2.5-3.0	1	0
3.1-4.0	5	0

NOTE: See Appendix 2 for discussion of calculation procedures and number of boilers included in analysis.

* Percentages do not sum to 100 due to independent rounding.

remaining 7 percent have an emission rate greater than 2.4 lbs SO_2/MMBtu.

Average emission rates for the existing oil-fired boilers after the projects were also lower than they were before the projects: 1.92 compared to 1.99 lbs SO_2/MMBtu. New boiler emission rates averaged 1.14 lbs SO_2/MMBtu, with 43 percent (three out of seven boilers) at 0.8 lbs SO_2/MMBtu or less (this rate equals the federally regulated limit [40 C.F.R. Part 60, Subpart D] then in effect for SO_2 emissions from oil-fired industrial boilers $\geq$250 million Btu/hour) and 72 percent at 1.2 lbs SO_2/MMBtu or less. None of the new oil-fired boiler emission rates exceeded 2.4 lbs SO_2/MMBtu.

As noted in Section 4, however, the primary fuels fired by the new boilers is significantly different from that of the existing boilers. Specifically, natural gas-fired boilers (which cause essentially no SO_2 emissions) decrease from 56 percent of the existing boilers to 27 percent of the new boilers. At the same time, the percentage of coal-fired boilers, which represented 10 percent of the existing boilers, increased to 48 percent of the new boilers. As a result, although new coal- and oil-fired boilers have lower emission rates than existing boilers firing the same fuel, the average emission rate for all the new boilers (i.e., the composite emission rate for boilers firing coal, oil, natural gas, and wood) is virtually the same as for the existing boilers.

Total Annual Emissions

Table 10 summarizes the number of new and existing boilers included in the analysis and the total annual SO_2 emissions before and after the projects as a function of primary reason for the project, fuel type, and new versus existing boiler classification. The number of boilers is classified by base fuel type, whereas SO_2 emissions are based on the fuel's use both as the base and backup fuel. For example, SO_2 emissions from oil reflects both its firing as a base fuel as well as a backup fuel in boilers primarily firing coal, natural gas, or wood. The far right column of Table 10 indicates the net change in the SO_2 emissions. The number of new boilers and the annual emissions associated with replacement versus new application and discretionary versus mandatory boiler projects (as previously defined) are summarized at the bottom of the table.

TABLE 10. ANNUAL SO_2 EMISSION IMPACT (CATEGORY I PROJECTS)

REASON	BOILER	FUEL	NO. OF BOILERS	-------TONS SO2/YEAR------ BEFORE	AFTER	CHANGE
NEW PLANT	NEW	COAL	13	0	18676	
		OIL	0	0	248	
	EXISTING	COAL	0	0	0	
		OIL	0	0	0	
	TOTAL		13	0	18924	18924
ADDITIONAL CAPACITY	NEW	COAL	7	0	9458	
		OIL	1	0	130	
	EXISTING	COAL	17	42854	33427	
		OIL	1	2512	1034	
	TOTAL		24	45366	44049	-1317
BOILER CONDITION	NEW	COAL	5	0	9633	
		OIL	6	0	2871	
	EXISTING	COAL	10	16331	7540	
		OIL	23	9051	250	
	TOTAL		44	25382	20294	-5088
FUEL SWITCH	NEW	COAL	39	0	60816	
		OIL	0	0	10756	
	EXISTING	COAL	0	0	0	
		OIL	44	30037	2325	
	TOTAL		83	30037	73897	43860
COGENERATION	NEW	COAL	10	0	15720	
		OIL	1	0	28	
	EXISTING	COAL	1	2720	2047	
		OIL	2	333	1	
	TOTAL		14	3053	17796	14743
ALL	NEW	COAL	74	0	114303	
		OIL	8	0	14033	
	EXISTING	COAL	28	61905	43014	
		OIL	70	41933	3610	
	TOTAL		178	103838	174960	71122
REPLACEMENT			--	55419	94191	38772
NEW APPLICATION			--	48419	80769	32350
DISCRETIONARY			--	49828	111223	61395
MANDATORY			--	54010	63737	9727

NOTE: See Appendix 2 for discussion of calculation procedures and number of boilers included in analysis.

Overall SO_2 emissions increased by 71,122 tons of SO_2 per year--a net increase of 68 percent as a result of new boiler projects.* Of the total emissions after the projects were completed, 73 percent (128,336 tons) was from the new boilers; the remaining 27 percent (46,624 tons) was from continued operation of the existing boilers. Emission changes associated with each of the primary reasons for the projects are discussed below.

New Plants--

New plants are a major source of sulfur dioxide emissions. Because boilers installed at new plants are not replacements for existing boilers, they add capacity and emissions where none existed previously. The total SO_2 emissions from the surveyed new plants is 18,924 tons per year; this represents 26 percent of the total SO_2 emission increase from all boiler groups.

Additional Capacity--

New boilers were installed primarily to increase the steam capacity of existing plants; in most cases, the fuel choice for the new boiler was the same as that of the existing boilers at the same plant. Several of these projects also consolidated or otherwise modified the operation of existing boilers, thereby reducing emissions from the existing boilers. In more than half the cases, the existing boiler remained in operation. The net change in emissions from the new and existing boilers was a reduction of 1,317 tons of SO_2 per year, or roughly 3 percent less than the emission level existing before installation of the new boiler.

Boiler Condition--

These projects installed one or more new boilers because of the poor condition of the existing boilers. Of the 33 existing boilers affected, only 6 continued operation after the new boiler was installed. Although the new boilers generally fire the same fuel as the original boiler and have

* See Appendix 2 for example calculations of SO_2 tonnages and percentages.

lower emission rates per million Btu of heat input, they are also generally larger than the boilers they replaced. Overall, net emissions from this category decreased by 5,088 tons of SO_2 per year, or roughly 20 percent.

Fuel Switch--

The largest single category of boiler projects were undertaken to change the base fuel of the plant. In most cases, the change was from oil or natural gas to coal or coal-wood mixtures. The net result was an increase of 43,860 tons of SO_2 per year, representing 61 percent of the total annual emissions increase and an increase of 152 percent relative to the emissions of the existing boilers before these projects were undertaken. (See Section 6 for additional discussion of this issue.)

Cogeneration--

Cogeneration projects generally involved adding a new boiler and increasing fuel consumption at the plant (or at an adjacent site in the case of third-party cogenerators). Coal was the primary fuel. In some cases, steam production from existing boilers was replaced in whole or in part by the new cogeneration boiler. The net change in emissions was an increase of 14,743 tons of SO_2 per year, representing about 21 percent of the total increase in annual SO_2 emissions from all categories. This represents an almost six-fold increase in emissions compared to the existing boilers that were affected by the cogeneration projects. (See Section 6 for additional discussion of this issue.)

New Application vs. Replacement Boilers--

The annual emissions were also categorized for new application boilers versus those primarily installed to replace existing boiler capacity. As mentioned above, new applications include new plants, cogeneration facilities, and boilers built to satisfy additional steam demand at an existing plant. Of the total net increase in SO_2 emissions, new application boilers accounted for 32,350 tons of SO_2 per year (45 percent) compared to 38,772 tons of SO_2 per year (55 percent) for replacement boilers.

Discretionary vs. Mandatory Boilers--

Annual emissions impacts were also calculated on the basis of discretionary versus mandatory boiler projects. Discretionary projects (fuel switching, backup capacity, replacement of a repairable boiler, and cogeneration) accounted for 61,395 tons (86 percent) of the total net increase in annual SO_2 emissions. Mandatory projects (addition of primary capacity, replacement of an unrepairable boiler, and new plants) accounted for the remaining 9,727 tons (14 percent) of net annual SO_2 emissions. If only those projects defined as mandatory had been built, SO_2 emissions would have increased by 18 percent. Discretionary boiler projects increased emissions by 123 percent relative to the total before the project.

6.0 IMPACT OF LOWER ENERGY PRICES

Two of the major reasons given in the survey for new boiler purchases were fuel switching and cogeneration, in aggregate accounting for 48 percent of all Category I projects (see Table 4). Both of these reasons were heavily influenced by the perceptions of future energy prices and national energy policies during the 1981-1984 time period. During this period, future oil and natural gas prices were generally expected to be quite high--and the reliability of their supply low. In addition, economic incentives under the Public Utility Regulatory Policies Act (PURPA) made cogeneration projects attractive to many investors.

Given current perceptions of lower oil and natural gas prices in the future, construction of new boilers for reasons of fuel switching is expected to be significantly reduced. Lower fuel prices will also reduce the economics of some cogeneration projects and thereby decrease the number of new cogeneration boiler installations. To aid in interpreting the future direction of boiler replacement decisions and SO_2 emissions, this section briefly summarizes the survey results if fuel switching projects singly and in combination with cogeneration projects are excluded from the analysis.

First, if only fuel switching projects are excluded, the total number of Category I projects decreases from 115 to 76 (see Table 4). The split between replacement and new application boilers changes from roughly 50/50

to 25 percent for replacement (due to boiler condition) and 75 percent for new applications (new plants, capacity additions at existing plants, and cogeneration). Elimination of fuel switching projects reduces total SO_2 emissions to 73,801 tons before the projects and 101,063 tons afterward. Of these 101,063 tons, 56,764 tons (56 percent) are from new boilers and 44,299 tons (44 percent) are from existing boilers.

Excluding fuel switching projects, the net increase in emissions is 27,262 tons (37 percent). The emissions increase attributable to boilers that were built for mandatory reasons (primary capacity, unrepairable boiler condition, and new plants) is 9,727 tons (35 percent). Emissions from the remaining discretionary boilers (backup capacity, repairable boiler condition, and cogeneration) increased by 17,535 tons.

Second, if both fuel switching and cogeneration projects are excluded from the analysis, the total number of Category I projects decreases from 115 to 60 (see Table 4). The split between replacement and new application boilers changes from roughly 50/50 to 33 percent for replacement and 67 percent for new applications. Total annual SO_2 emissions increase from 70,748 tons before the projects to 83,267 tons afterward. Of the 83,267 tons of SO_2 afterward, 41,016 tons (49 percent) are from new boilers and 42,251 tons (51 percent) are from existing boilers.

The net increase in emissions from new projects excluding fuel switching and cogeneration projects is 12,519 tons per year (18 percent). The emissions increase attributable to boilers that were built for mandatory reasons is 9,727 tons (74 percent). Emissions from the remaining discretionary boilers (now limited to backup capacity and repairable boiler condition) increased by 2,792 tons.

Thus, although the increase in SO_2 emissions is smaller when fuel switching by itself or fuel switching in conjunction with cogeneration are excluded from the analysis, the remaining new boilers would still result in net SO_2 emission increases of 18 to 37 percent compared to emission levels prior to their installation.

APPENDIX 1

BOILER REPLACEMENT SURVEY QUESTIONNAIRE

OMB Clearance No.
2060-0136

GENERAL INSTRUCTIONS

1. This questionnaire is designed to obtain information about industrial boiler projects. It focuses on the factors that influence the decision to undertake a boiler project and the factors that are considered in the selection of boiler type and fuel. Therefore, it is important that the individual(s) completing this questionnaire be the person(s) who actually made these kinds of decisions [or as close to the person(s) as possible for the project covered by this questionnaire]. If this person is not you, please route this questionnaire to the most appropriate individual in your organization.

2. The questionnaire is designed to obtain information on each boiler project. For the purposes of this survey, a boiler project is defined as a series of activities that were begun due to a decision and plan to alter, expand, or in some way modify the boiler facilities at a particular plant site. Consequently, a boiler project may involve a number of boilers and may include construction of several new boilers as well as reconstruction or rebuilding of several existing boilers.

   If you have undertaken more than one boiler project over the last five years (since January 1, 1981), please fill out a separate questionnaire for <u>each</u> boiler <u>project</u>.

3. This questionnaire consists of two parts and two supplements. It is necessary to carefully review both parts and both supplements of the questionnaire. Please read the introduction to each part and each supplement carefully and follow the instructions included in the questionnaire itself. Items a-d below address each of these sections.

   a. Part I covers general information. Even though the Part I information will not be used in the analysis, the information requested is necessary if additional communication is appropriate to understand or clarify answers to various questions involved in the questionnaire.

   b. Part II is the main part of the survey. Please answer each question completely. Where space is provided for comments or additional information, please take the time to provide information that will provide a good understanding of the reasons for your decision to undertake a boiler project.

   c. Supplement A is to provide detailed information about each <u>new</u> boiler involved in the boiler project. Supplement A has one general information page (page A-1) and a one-page questionnaire (page A-2) for each new boiler involved in the project. Please complete Supplement A by filling out the general information page and then photocopying and completing a page A-2 for <u>each</u> <u>new</u> boiler in the project.

d. Supplement B is to provide detailed information about each existing boiler which may have been reconstructed, rebuilt, modified, or changed in any way as part of the overall boiler project. Even if an existing boiler was only operated in a different manner or just shutdown, as a result of the boiler project, please identify and include this boiler in Supplement B. Supplement B has a general information page (page B-1) and a three page questionnaire (pages B-2 through B-4) for each existing boiler involved in the boiler project. Please complete Supplement B by filling out the general information page and then photocopying and completing pages B-2 through B-4 for each existing boiler involved in the boiler project.

4. The questionnaire should be completed and returned by July 18, 1986.

5. If you have any questions or anticipate difficulties in either fully responding or responding within the allotted time, please call the following individual:

Ms Dianne Byrne
Environmental Protection Agency
(919) 541-5578

6. When the questionnaire is completed, please mail to:

Ms Dianne Byrne
Environmental Protection Agency
OAQPS, ESED, SDB (MD-13)
Research Triangle Park, NC 27711

OMB Clearance No.
2060-0136

PART I: SURVEY OF INDUSTRIAL BOILER PROJECTS

This survey questionnaire is being sent to firms who have undertaken one or more boiler projects within the last five (5) years. The results of this survey are intended to provide information on why boiler projects are undertaken, the factors influencing the selection of the type of boiler and the fuel, and whether existing equipment can be used in these projects.

Please read the general instructions carefully before completing the questionnaire.

Please complete the following questions. This information is necessary if additional communication is required to clarify answers provided to various questions in the questionnaire. The link between the name of the particular plant and the information in the survey will not be provided to the public in any type of summary report that may be generated from the responses.

1. Name of firm: _____

2. Two-digit Standard Industrial Classification (SIC) Code: _____

3. Name of person completing form: _____

4. Phone Number (include area code): (___) _____

5. Position: _____

6. Plant site address

   Street address: _____

   City: _____ State: _____ Zip Code: _____

7. Project number [As mentioned in the general instructions, a complete questionnaire needs to be completed for each separate boiler project (i.e., not each boiler but each project).] Consequently, if you are completing more than one questionnaire, identify separate projects by a project number, i.e., 1, 2, 3, etc. _____

PART II: SURVEY OF INDUSTRIAL BOILER PROJECTS

1. Project number (See instructions in Part I): _____

2. Is this new boiler located at a new "greenfield" manufacturing plant? ____ Yes ____ No

3. Please complete Supplement A for each new boiler(s) included in the boiler project.

4. Did this boiler project involve or include reconstruction, rebuilding, modifying, or changes of any sort in any existing boilers, including operation of existing boilers at lower capacity or shutting down of existing boilers? ____ Yes ____ No

   If yes, how many existing boilers were affected in some way as a result of this boiler project? _____

5. Please complete Supplement B for each existing boiler that was changed or affected in any way as a result of this boiler project.

6. Please describe your main reason for building a new boiler:

7. If your decision was based on a cost analysis, please include a copy of the cost analysis if one is available. If your decision was based on cost considerations, but an analysis isn't available, please describe the major cost considerations that influenced your decision.

8. Would your decision to build a new boiler change if projected costs to produce steam increased by:

10%	_____ Yes	_____ No
20%	_____ Yes	_____ No
30%	_____ Yes	_____ No
50%	_____ Yes	_____ No

9. To supplement your answer to question 6, Which of the following factors were also considered in deciding that there was a need for this boiler project? Please rate EACH factor from 0 to 2 (0 - not considered or relatively unimportant; 1 - moderately important; 2 - very important). If you considered factors that are not on the list, please add them to the bottom of the list and rate them.

Factor	Rating
a. additional boiler capacity was needed over and above what the existing boilers could provide	____
b. insurance companies were no longer willing to provide insurance coverage for existing boilers	____
c. existing boiler(s) could not be operated safely without extensive repairs	____
d. existing boiler(s) could not be operated reliably without extensive repairs	____
e. existing boiler(s) could no longer be operated in compliance with air pollution regulations	____
f. the boiler project allowed us to change our base fuel (e.g., coal, oil, natural gas, wood, waste fuels, etc.)	____
g. the boiler project allowed us to use multiple fuels	____
h. boiler allowed us to consolidate boiler operations (ie., replace several smaller boilers with one or more large boilers)	____
i. new boiler provides us with more backup boiler capacity	____
j. the mode of operation for the boilers changed (bigger load swings, more baseload, etc.)	____
k. steam quality (pressure, temperature) requirements changed	____
l. desire to cogenerate electricity for on-site use or resale	____
m. other (specify): _____	____
_____	____

PART II (continued)

10. In considering a boiler project or selecting the type of boiler/fuel to use, a number of factors are weighed in the decision. Some of the most commonly considered factors are listed below. Please rate how important each of these factors were in your boiler project. Please rate EACH factor from 0 to 2 (0 - not considered or relatively unimportant; 1 - moderately important; 2 - very important). If you considered factors that are not on the list, please add them to the bottom of the list and rate them.

Factor	Rating
a. operating costs excluding fuel	____
b. maintenance costs excluding fuel	____
c. fuel costs	____
d. interest rates	____
e. capital cost of project	____
f. availability of corporate funds for capital improvements	____
g. operating flexibility or backup boiler capacity	____
h. boiler efficiency	____
i. compatibility with existing fuels at plant	____
j. security or reliability of fuel supply	____
k. space or land availability	____
l. ability to use existing system components	____
m. ability to minimize need for additional operating or maintenance personnel	____
n. corporate policy (specify): _____	____
o. environmental regulations (specify): _____	____
p. other (specify): _____	____
_____	____

11. Of the following system components that were present on-site at the time of construction of the boiler project, which could continue to be used to service either new boilers involved in the boiler project or existing boilers that were modified or changed in any way as part of the boiler project. (0 - could not be used at all; 1 - could use as is or with minor modification; 2 - could use only with major modification)

If the boiler project was part of a new "greenfield" plant, skip this question.

System Component	Can Service New Boilers Added	Can Continue to Service Existing Boilers Changed or Modified in Some Way
a. fuel storage	____	____
b. fuel handling	____	____
c. boiler house	____	____
d. boiler feedwater treatment	____	____
e. condensate return	____	____
f. boiler blowdown and treatment	____	____
g. solid waste handling and disposal	____	____
h. air pollution control equipment	____	____
i. waste water treatment system	____	____

SUPPLEMENT A -- NEW BOILERS INVOLVED IN BOILER PROJECT

This supplement is intended to collect information about the new boiler or boilers included in the project covered by this questionnaire. This Supplement A consists of two (2) pages. This page (page A-1) contains questions about all the new boilers installed. The following page (page A-2) requests information about each new boiler. Consequently, please photocopy and complete as many copies of page A-2 as necessary to identify and describe each new boiler. For each new boiler, please complete a separate page A-2.

1. Project number (same as Question #6 of Part I): _____

2. Number of new boilers included in this project: _____

3. Maximum (design) capacity of each new boiler:

   Boiler #1 _____ thousand pounds steam/hr

   Boiler #2 _____ thousand pounds steam/hr

   Boiler #3 _____ thousand pounds steam/hr

   Boiler #4 _____ thousand pounds steam/hr

   Total _____

   NOTE: If more than four new boilers were installed, please identify at the bottom of this page the maximum design capacity of each additional new boiler.)

4. What was the total capacity of the boilers that were shut down or modified in any way as a result of the new boiler project?
   _____ thousand pounds steam/hr.

SUPPLEMENT A -- INFORMATION FOR EACH NEW BOILER

(For each new boiler, please answer the following questions. Use one page for each boiler.)

1. This page is for boiler number: _____
   [If you have more than one new boiler in this project, identify each new boiler by a separate number (i.e., 1, 2, 3, etc.)]:

2. Type of boiler: _____ Package or _____ Field-erected

3. Maximum capacity of this boiler: _____ (thousand pounds steam/hr)

4. Base fuel for this boiler (coal, oil, natural gas, wood bark, etc.):
   _____

5. Base fuel characteristics:

   a. Weight % ash _____

   b. Weight % sulfur _____

   c. Heat content _____
      (Btu/lb, Btu/gal, or Btu/scf - please state)

   d. Annual fuel consumption :
      tons coal _____
      tons other solid fuel _____
      gallons oil _____
      cubic feet gas _____

6. Backup fuel for this boiler (coal, oil, natural gas, wood bark, etc.)
   _____

7. Backup fuel characteristics:

   a. Weight % ash _____

   b. Weight % sulfur _____

   c. Heat content _____
      (Btu/lb, Btu/gal or Btu/scf - please state)

   d. Average annual fuel consumption
      tons coal _____
      tons other solid fuel _____
      gallons oil _____
      cubic feet gas _____

8. Regulatory limit for SO_2 that applies to this boiler: _____

9. Emission control technique used to control SO_2 emissions: (please check)

   a. Low sulfur fuel _____

   b. Flue gas desulfurization _____

   c. Other (please specify) _____

10. If this is a coal boiler, type of fuel firing system:

    a. Pulverized coal _____ b. Stoker coal _____ c. Other (specify) _____

SUPPLEMENT B -- EXISTING BOILERS INVOLVED IN BOILER PROJECT

This Supplement is intended to collect information about the existing boiler or boilers that were involved in the boiler project in some way. This may have been reconstruction or rebuilding of an existing boiler or a change in the manner of its operation. Consequently, even if an existing boiler was only operated at a lower capacity, shutdown, or placed in a standby or back-up position, as a result of the boiler project, please identify and include this existing boiler in completing this supplement.

This first page (page B-1) contains questions about all the existing boilers that were involved in the boiler project in some way. The remaining pages (pages B-2 through B-4), request information about each existing boiler that was involved in the boiler project. Consequently, please photocopy and complete as many copies of pages B-2 through B-4 as necessary to identify each existing boiler involved in the boiler project. For each existing boiler, please complete a separate set of pages B-2 through B-4.

1. Project number (same as Question #6 of Part I): _____

2. Number of existing boilers involved in this boiler project: _____

3. Maximum (design) capacity of each existing boiler affected by the boiler project:

   Boiler #1 _____ thousand pounds steam/hr

   Boiler #2 _____ thousand pounds steam/hr

   Boiler #3 _____ thousand pounds steam/hr

   Boiler #4 _____ thousand pounds steam/hr

   Total _____

NOTE: If more than four existing boilers were involved in this boiler project in some way, please identify the maximum design capacity of each additional existing boiler that was involved at the bottom of this page.

4. At the conclusion of the boiler project, what percent of this total capacity was replaced, shut-down, or placed in a stand-by position:

   _____ % replaced or shut-down

   _____ % placed in stand-by position

SUPPLEMENT B -- INFORMATION FOR EACH EXISTING BOILER

(For each existing boiler, please answer the following questions. Please photocopy and complete as many copies of the following pages (i.e., B-2, B-3, and B-4) to provide information on each existing boiler.)

1. This page is for boiler number: _____
   (If you have more than one existing boiler which was involved in the boiler project, please identify each boiler by a separate number, i.e., 1, 2, 3, etc.):

2. Age of boiler: _____

3. Type of boiler: _____ Package or _____ Field-erected

4. Maximum capacity of this boiler: _____ thousand pounds steam/hr

5. Base fuel for this boiler (coal, oil, natural gas, wood bark, etc.):

   a. Before project: _____ b. Following project: _____

   c. Base fuel characteristics:

	Before Project	After Project
i. Weight % ash	_____	_____
ii. Weight % sulfur	_____	_____
iii. Heat content (Btu/lb, Btu/gal or Btu/scf - please state)	_____	_____
iv. Annual fuel consumption		
tons coal	_____	_____
tons other solid fuel	_____	_____
gallons oil	_____	_____
cubic feet gas	_____	_____

Supplement B (continued)

6. Backup fuel for this boiler (please identify):

   a. Before project: _____ b. After project: _____

   c. Backup fuel characteristics:

	Before Project	After Project
i. Weight % ash	_____	_____
ii. Weight % sulfur	_____	_____
iii. Heat content (Btu/lb, Btu/gal or Btu/scf - please state)	_____	_____
iv. Annual fuel consumption		
tons coal	_____	_____
tons other solid fuel	_____	_____
gallons oil	_____	_____
cubic feet gas	_____	_____

7. Regulatory limit for SO_2 that applies to this boiler: _____

8. Emission control technique used by boiler to meet SO_2 emission limit: (Please check control technique used.)

	Before Project	After Project
a. Low sulfur fuel	_____	_____
b. Flue gas desulfurization	_____	_____
c. Other (please specify)	_____	_____

9. How did the status of this boiler change because of the boiler project? (You may check more than one)

_____ Shut down

_____ Used as backup boiler only

_____ Used as a peaking unit only

_____ Reduction in hours of operation

_____ Change to a different fuel

_____ Dismantled

_____ Other (specify: _____)

10. Why was this boiler's status changed (You may check more than one)?

_____ Boiler failed safety inspection

_____ Insurance could not be obtained

_____ Maintenance costs too high
_____ Estimated annual costs (optional)

_____ Non-fuel operating costs too high
_____ Estimated annual costs (optional)

_____ Fuel costs too high
_____ Estimated annual costs (optional)

_____ Other (specify: _____)

11. For a boiler that was dismantled or completely shut down, could this boiler have been rebuilt to extend its useful life?

_____ Yes _____ No

If yes, what kind of repairs would have been necessary?

12. (Optional)

Please provide any additional information about this boiler project that you believe would be helpful for us to know in order to fully understand the nature of the project.

_____

_____

_____

_____

_____

_____

_____

_____

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APPENDIX 2
EMISSION CALCULATION PROCEDURES

TABLE 9

Average emission rates for coal- and oil-fired boilers were calculated by dividing the fuel sulfur content for each boiler by its heat content and then multiplying by two to convert pounds of sulfur to SO_2. Emission rates for individual boilers were then summed and divided by the number of units to obtain average rates for coal- and oil-fired boilers. Average emission rates for all boilers were calculated by multiplying the average emission rates for for each fuel (coal, oil, natural gas, and wood) by its percentage of the total boiler capacity (from Tables 2 and 7) after excluding "other" fuels; natural gas and wood were assumed to be sulfur free.

TABLE 10

Annual emissions from coal and oil firing as both a base and backup fuel were calculated for each boiler by converting fuel sulfur content to the equivalent amount of SO_2 and then multiplying by the quantity of fuel used (to convert the quantity of oil from gallons--as reported on the survey form--to pounds, a conversion factor of eight pounds per gallon was used).

CALCULATION OF EMISSION CHANGES BEFORE AND AFTER THE PROJECTS

Annual emissions are subdivided in Table 10 by fuel type (coal and oil) and age (new and existing). Many of the key numbers used in the text are composites of these subsets. For example, the reported total emissions from new boilers at the top of page 22 of 128,336 ton is the composite of emissions from new coal- and oil-fired boilers (114,303 plus 14,033, respectively). Percentage changes were calculated by subtracting the "before" emissions from the "after" emissions and then dividing by the "before" level. For example, the 68 percent increase in total emissions resulting from the new projects was calculated by dividing the difference in emissions "before" and "after" (174,960-103,838=71,122) by the emissions "before" (103,838).

NUMBER OF BOILERS INCLUDED IN ANALYSIS

Because of incomplete fuel data on three survey forms (representing six boilers), small differences exist in the number of boilers reported on Tables 9 and 10. For five of these six units (two new coal-fired boilers and three exisitng oil-fired boilers included on Table 9, but not Table 10), fuel sulfur content needed to estimate the SO_2 emission rate per million Btu was reported, but the quantity of fuel used was omitted. The sixth boiler (included on Table 10, but not Table 9) was a new oil-fired boiler installed as emergency backup for two existing coal-fired boilers; on this unit, oil sulfur content was omitted while the fuel usage was reported as zero. Emissions from this unit were assumed to be zero.

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16. ABSTRACT

This report presents an analysis of new industrial boilers sold between 1981 and 1984. The analysis focuses on 151 new coal-, oil-, natural gas-, and wood-fired boilers larger than 100 million Btu/hour and 291 existing boilers. Specific issues examined in the report include the reasons for purchasing new industrial boilers, the percentage of new boilers used for new applications versus replacement of existing boilers, and the impact of new boiler purchases on sulfur dioxide emissions.

17. KEY WORDS AND DOCUMENT ANALYSIS

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