MEETING THE EPA'S NSPS REQUIREMENTS FOR INDUSTRIAL BOILERS

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WORCESTER, MASSACHUSETTS

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INTRODUCTION

The U.S. Environmental Protection Agency (EPA) will eventually establish National Ambient Air Quality Standards (NAAQS) for six "pollutants." These include particulate matter (PM), NO_x, SO_2, hydro carbons, carbon monoxide, and photo chemical oxidants. Federal New Source Performance Standards (NSPS) do not currently address the latter three nor are the new regulations expected to either. This paper will concern itself with the particulate matter, NO_x, and SO_2 emission levels for industrial coal fired units and what can be done designwise for compliance. Riley Stoker Corporation and some of its U.S. Filter "sister" companies can provide industrial units to meet compliance levels in all three categories. While the NAAQS address residual oil, distillate oil and natural gas, the Fuel Use Act (FUA) will force most new industrial units to burn coal, either pulverized or stoker fired.

CURRENT REGULATIONS

Existing NSPS limit NO_x emissions from coal fired units to 0.5 pounds per million BTU's for sub-bituminous and 0.6 pounds per million BTU's for bituminous coals. The NSPS limitation on SO_2 emissions for coal fired units is 1.2 pounds per million BTU's. Total particulates are currently limited to 0.1 pounds per million BTU. These emission regulations are applied to boilers whose capacities exceed 250 million BTU per hour heat input. State Implementation Plans (SIP) currently provide emission regulations for all steam generating units under 250 million BTU per hour input. The current regulations are shown in Table 1.

Fuel Type	Boiler Size (MM Btu/hr)	POLLUTANT SO_2	PM	NO_x
Coal	+250	1.2 lbs/MM Btu	.10 lbs/MM Btu	.5/.6 lbs/MM Btu
Residual Oil	+250	.8 lbs/MM Btu	.10 lbs/MM Btu	.3 lbs/MM Btu
Distillate Oil	+250	.8 lbs/MM Btu	.10 lbs/MM Btu	.3 lbs/MM Btu
Natural Gas	+250	—	—	.2 lbs/MM Btu
Coal, Oil Natural Gas	−250	SIP's	SIP's	SIP's

Table 1 Existing Regulations for Coal, Oil and Natural Gas Firing

The EPA is proposing to divide industrial boilers into three size categories for future regulations: 10-100, 100-250, and greater than 250 million BTU per hour heat input. The ABMA recommended size ranges are 10-50, 50-250, and those larger than 250 million BTU's per hour heat input. Similar to ABMA, we feel economics justify excluding boilers not only under 50 million but even units under 100 million BTU's per hour heat input from compliance with the New Source Performance Standards. The cost for equipment to remove SO_2 and particulate matter is so great as to deter prospective customers from purchasing new generating capacity.

ANTICIPATED CONTROL LEVELS

The work of the EPA resolved itself down to three cases for Air Emission Regulations which were presented in draft form in a publication entitled, "Impact Analysis of Selected Control Levels for New Industrial Boilers." One of the cases favors energy and environmental concerns over cost impacts, one mitigates cost impacts at the expense of air quality and the third falls between the other two. The current emission regulations serve as the base case from which all impacts are measured.

It is our opinion that the EPA will opt for the most stringent case as far as particulate matter, NO_x, and SO_2 emission levels are concerned. These values are shown in Table 2.

Fuel Type	Boiler Size (MM Btu/hr)	POLLUTANT		
		SO_2	PM	NO_x
Coal	10-100	1.2 lbs/MM Btu and 90% reduction. If emissions ≤ .5 lbs/MM Btu, 70% reduction required	.05 lbs/MM Btu	.3 lbs/MM Btu
	100-250		.03 lbs/MM Btu	.5/.6 lbs/MM Btu
	+250		.03 lbs/MM Btu	.5/.6 lbs/MM Btu
Residual Oil	10-100 100-250 +250	.8 lbs/MM Btu	.03 lbs/MM Btu	.3 lbs/MM Btu
Distillate Oil	10-100	.2 lbs/MM Btu	—	.15 lbs/MM Btu
	100-250		—	
	+250		—	
Natural Gas	10-100	—	—	.15 lbs/MM Btu
	100-250	—	—	
	+250	—	—	

Table 2 Anticipated Control Levels for New Industrial Boilers for Coal, Oil and Natural Gas Firing

Should the floor remain the same, particulate matter level limitations are expected to be 0.05 pounds per million BTU for boilers in the 10-100 million BTU per hour size range. The figure for boilers from 100-250 as well as for those greater than 250 million BTU per hour is expected to be 0.03 pounds per million BTU. The 0.03 pounds per million BTU is approximately ⅓ the present emission standard for boilers which are greater than 250 million BTU per hour size capacity.

The NO_x emission level is anticipated to be 0.3 pounds per million BTU for boilers in the 10-100 million BTU per hour heat input size range. Boilers in the 100-250 million BTU per hour heat input range are expected to have the same NO_x emission level regulations as the present utility units which are greater than 250 million BTU per hour heat input. These are 0.5 pounds per million BTU for sub-bituminous coal and 0.6 pounds per million BTU for bituminous coal.

Limits for SO_2 emission levels are expected to be 1.2 pounds per million BTU and a 90% reduction. If the 90% reduction results in emissions equal to or less than 0.5 pounds per million BTU, less reduction is required. In this case, the reduction can vary between 70% and 90%, depending on the input sulphur content of the fuel.

ABMA PROPOSED LEVELS

The ABMA, in the supplement to its July 9th, 1980 statement before the National Air Pollution Control Techniques Advisory Committee (NAPCTAC), recommended emission levels as shown in Table 3. Some of the reasons given for these recommendations were:

1. On small units, space available for clean-up equipment is severely restricted due to their application (e.g., commercial buildings, small plants, institutions).
2. No underfeed stokers are used above 50 million BTU per hour.
3. For units with inputs below 50 million BTU per hour, economics will not support the use of fabric filters or electrostatic precipitators.
4. Economics on small units will not support a percentage reduction requirement which arbitrarily requires flue gas desulphurization systems for SO_2 removal.

		POLLUTANT (lbs/MMBTU)		
Fuel Type	**Boiler Size Range MMBTU**	**NO_x ABMA rec'd**	**PM ABMA rec'd**	**SO_2 ABMA rec'd**
Coal	10-50	0.6	.15	2.0
	50-250	0.6	.05	2.0
	>250	0.5-0.6	.05	1.2
				1.2
Residual Oil	10-50	0.5	.15	.8
	50-250	0.3	.15	.8
	>250	0.3	.05	.8
Distillate Oil	10-50	0.2	—	.2
	50-250	0.3	—	.2
	>250	0.3	—	.2
Gas	10-50	0.15	—	—
	50-250	0.2	—	—
	>250	0.2	—	—

Table 3 ABMA Recommended Emission Levels

REAGAN ADMINISTRATION EFFECT

The preliminary draft of the EPA's "Economic Analysis of Selected Control Levels for New Industrial Boilers" was presented to NAPCTAC in July of 1980. Heated discussions and requests for more time to fully analyze the report led NAPCTAC to schedule a second meeting in January of 1981 to allow all concerned to delve into the matter more deeply. This meeting was subsequently delayed to February of 1981, and more recently, to some date in June or July of this year. The last postponement is to allow Reagan Administration forces time to review the proposal.

Advisers to President Reagan have stated that trimming of Federal Regulations, including those concerned with environmental control, is necessary to improve the economy, spur industrial investment in new plants and equipment, reduce inflation and expand domestic energy resources. Less stringent pollution control standards or delays in implementing new standards may accomplish these goals, but would have an adverse effect on members of the pollution control industry.

EFFECT OF NSPS

If the most stringent emission levels are promulgated, then boiler furnaces will be more conservatively designed, made larger to combat NO_x generation. See Figure 1. SO_2 removal will require the use of wet scrubber flue gas desulphurization equipment. The collection of particulate matter under the most stringent emission restrictions would dictate the use of baghouses and electrostatic precipitators. All of these will have a dramatic effect on new power plant sales as capital costs will increase dramatically.

DESIGN FOR NO_x EMISSION

Long before the EPA presented its recommendations to NAPCTAC, Riley was developing two lines of industrial boilers to provide the most up-to-date technology for the design of coal fired units. These cover sizes from 40,000-500,000 pounds of steam per hour. One is called the S.A.M. or Shop Assembled Modular boiler (see Figure 2) while the other is simply called the VR Series (see Figure 3).

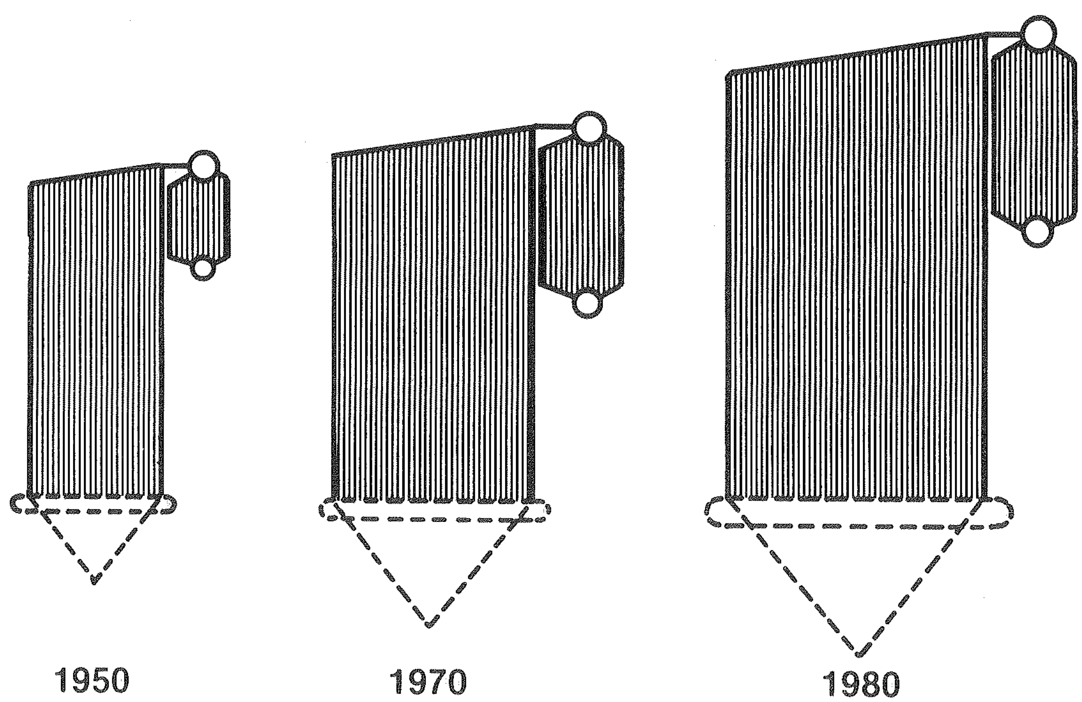

Figure 1 Comparison of Furnace Sizes

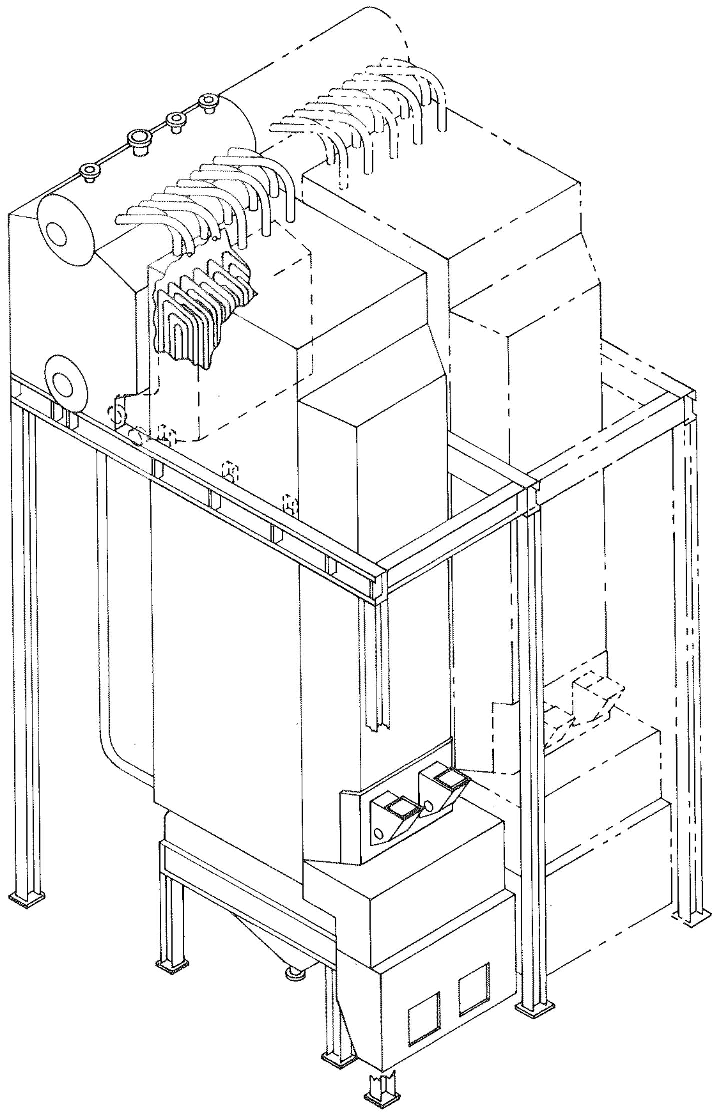

Figure 2 Shop Assembled Modular Boiler

The S.A.M. boilers are made up of four basic shop assembled modules — furnace, boiler bank, superheater, and stoker. In units of 80,000 to 150,000 pounds per hour, two furnace modules are connected to a single boiler bank module. This provides two additional walls for the reduction of flame temperatures due to radiation and corresponding reduction in NO_x levels compared to a single furnace of the same capacity.

The VR Series of boilers encompasses conservative furnace design heat release rates and a completely welded wall furnace construction. The VR is as close to a standardized boiler as possible while still retaining design flexibility. Design data and computer generated drawings are used as a basis in tailoring the boiler to specified requirements.

The EPA/ABMA sponsored stoker fired boiler tests were a step toward understanding the full impact of stringent NSPS on industrial boilers. Data taken on Riley stoker fired units, both during these tests and other independent tests performed by Riley, indicate that NO_x levels were in all cases less than 0.65 pounds per million BTU. The mass fed Riley units show NO_x levels less than 0.5 pounds per million BTU. See Figure 4. These data are being supplemented so that more information can be obtained on operational effects such as low excess air and overfire air.

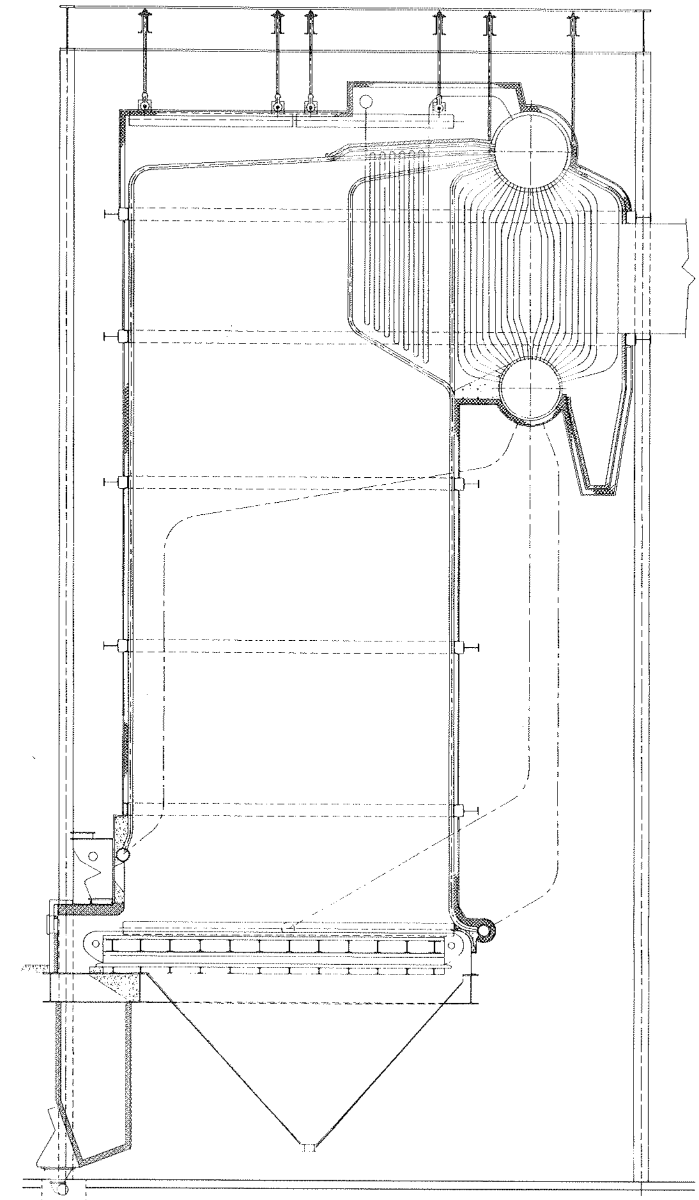

Figure 3 VR Boiler Series

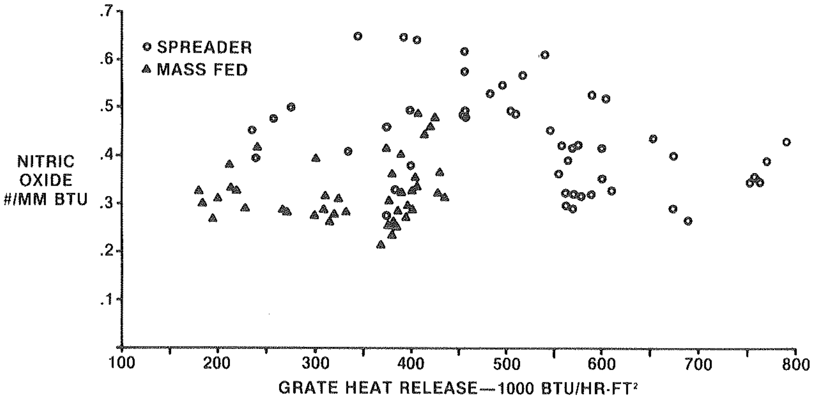

Figure 4 Nitric Oxide Emission Levels
Riley Traveling Grate Stoker Units

In an effort to meet the demand for data necessary for unit performance analysis and special diagnostic testing, Riley utilizes an automated Data Aquisition System. This system can monitor, transmit, alarm and record data from as many as 1,000 thermocouples, pressure transducers, flow meters and speed indicators as well as any other devices which can represent their output as an electrical signal, such as gas analysis equipment.

The general effect of increase in NO_x with increase in oxygen is shown in Figure 5. In stoker firing as in pulverized coal firing, the higher the oxygen or excess air levels, the higher the NO_x produced. By the same token, the higher the grate heat release, the higher the NO_x levels produced. See Figure 6.

With stoker firing, the best correlations are obtained utilizing grate heat release as one of the parameters. For wall firing, a basket area heat release is calculated and emission levels and design criteria are plotted against this.

The design of the furnace and the firing equipment is all important in the reduction of NO_x levels. This is not necessarily true with SO_2 and particulate matter, although furnace geometry can have a great deal to do with carry over of carbon and ash particles.

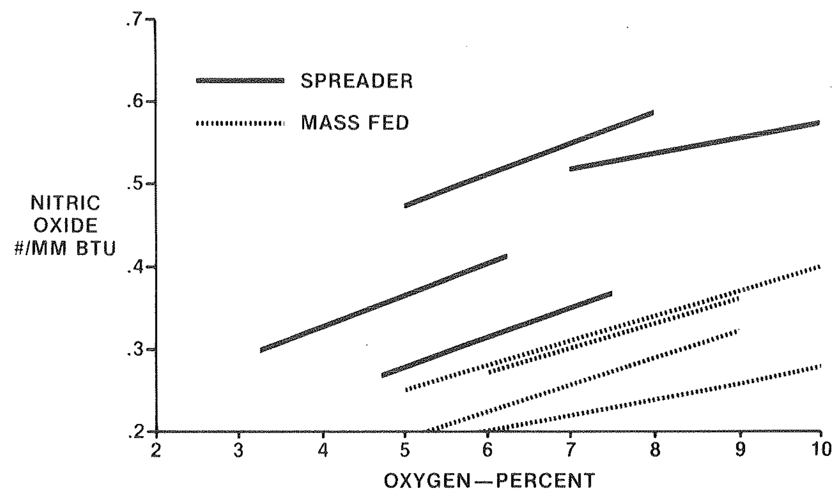

Figure 5 Nitric Oxide versus Oxygen Content in Flue Gas Riley Traveling Grate Stoker Units

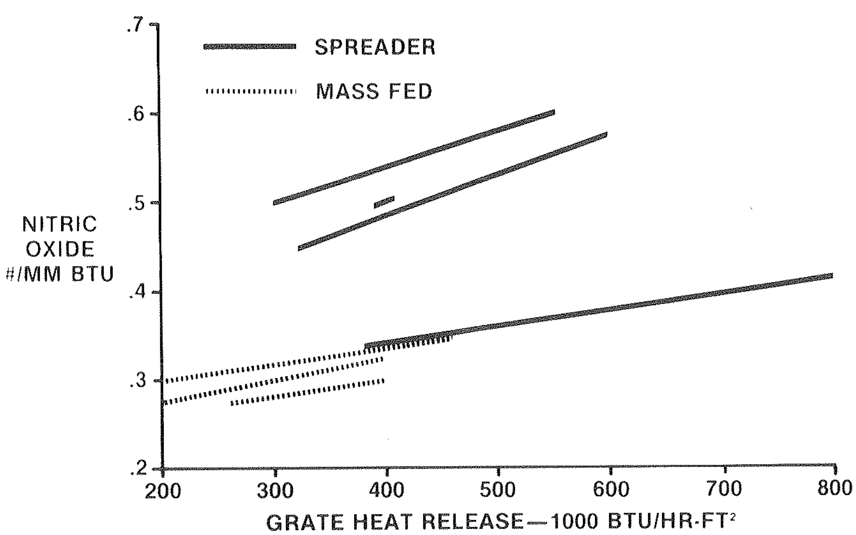

Figure 6 Nitric Oxide versus Grate Heat Release Riley Traveling Grate Stoker Units

PARTICULATE MATTER

In the past, a stoker fired boiler has had a definite advantage in controlling particulate matter emissions. This type of firing produces larger particles that could be easily removed with inexpensive mechanical dust collectors. More expensive electrostatic precipitators or equivalent systems were almost always required to collect the smaller particles emitted by a pulverized coal fired boiler.

There are many types of equipment available for the removal of particulate matter from the flue gases. These would include, but not be limited to: mechanical dust collectors, electrostatic precipitators, fabric filters, and wet scrubbers. As stated earlier, to meet the most stringent particulate matter emission levels, equipment with removal efficiencies in the high 90% bracket would be required. This indicates the use of fabric filters and electrostatic precipitators. Mechanical dust collectors have efficiencies which range from 80-90%. Electrostatic precipitators and fabric filters can remove greater than 99% of the particulate matter in the gas stream. Typical collection efficiencies are shown in Figure 7. Efficiency values will vary with ash contents, particle size, gas volume etc.

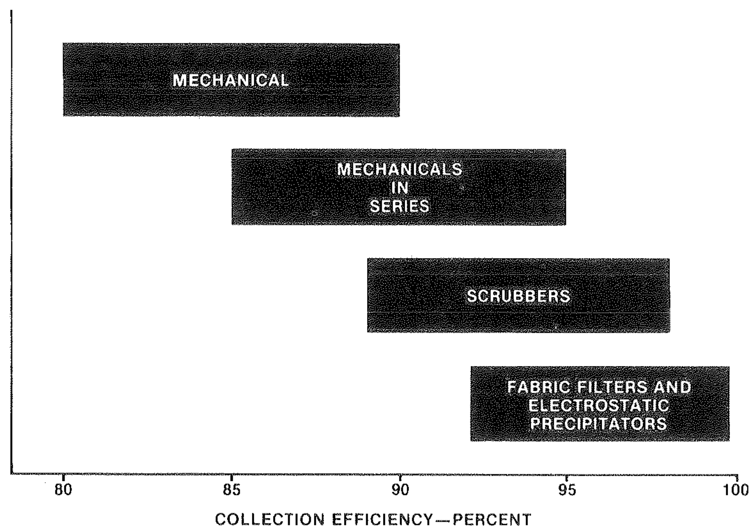

Figure 7 Collection Efficiencies for Various Types of Particulate Collectors

The design of the furnace on an industrial boiler has an effect on the amount of particulate carry over which can occur. Riley units have greater height to allow larger particles to drop back on the grate surface and also to allow greater burn-out of carbon before the flue gases proceed to the convection passes and heat recovery areas of the unit.

Data from stoker fired units indicate that the amount of particulate matter carry over is between 5 and 10 times as great on a spreader stoker as it is on a mass burning stoker. This is due to lower grate heat releases and the obvious difference in the method of putting the fuel on the grate. Figure 8 indicates these differences in particulate matter leaving the boiler. Leaving the dust collectors the values are much closer together, but the mass fed stokers still have less particulate.

SO_2 REMOVAL

Sulphur dioxide is formed by the direct conversion of the sulphur in the fuel during the combustion process. It is difficult and expensive to remove prior to firing so the best means of obtaining compliance is by the use of flue gas desulphurization systems, either wet or dry scrubbers. Dry scrubbers can meet most state implementation plan requirements of 1.1 pounds per million BTU's. The dry scrubbers require a bag house following them in the line of gas flow to remove the particulate matter and the sulphur compounds

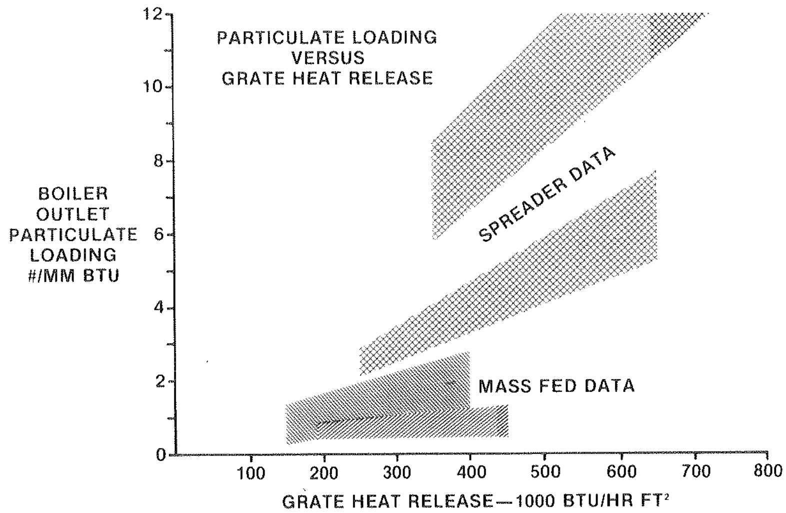

Figure 8 Particulate Loading versus Grate Heat Release

which are formed in the process. Dry scrubbers have removal efficiencies of approximately 70%. At a small (70,000 pounds per hour) Riley paper mill boiler in Massachusetts burning 2.5% sulphur coal, a dry scrubber system was able to reduce inlet SO_2 concentrations of 1000-1200 ppm down to 300-400 ppm.

Wet scrubbers have removal efficiencies in the 90% range. They can meet the most stringent requirements for SO_2 emission levels, but are expensive in terms of initial and operating costs. Schematic equipment configurations are shown in Figure 9.

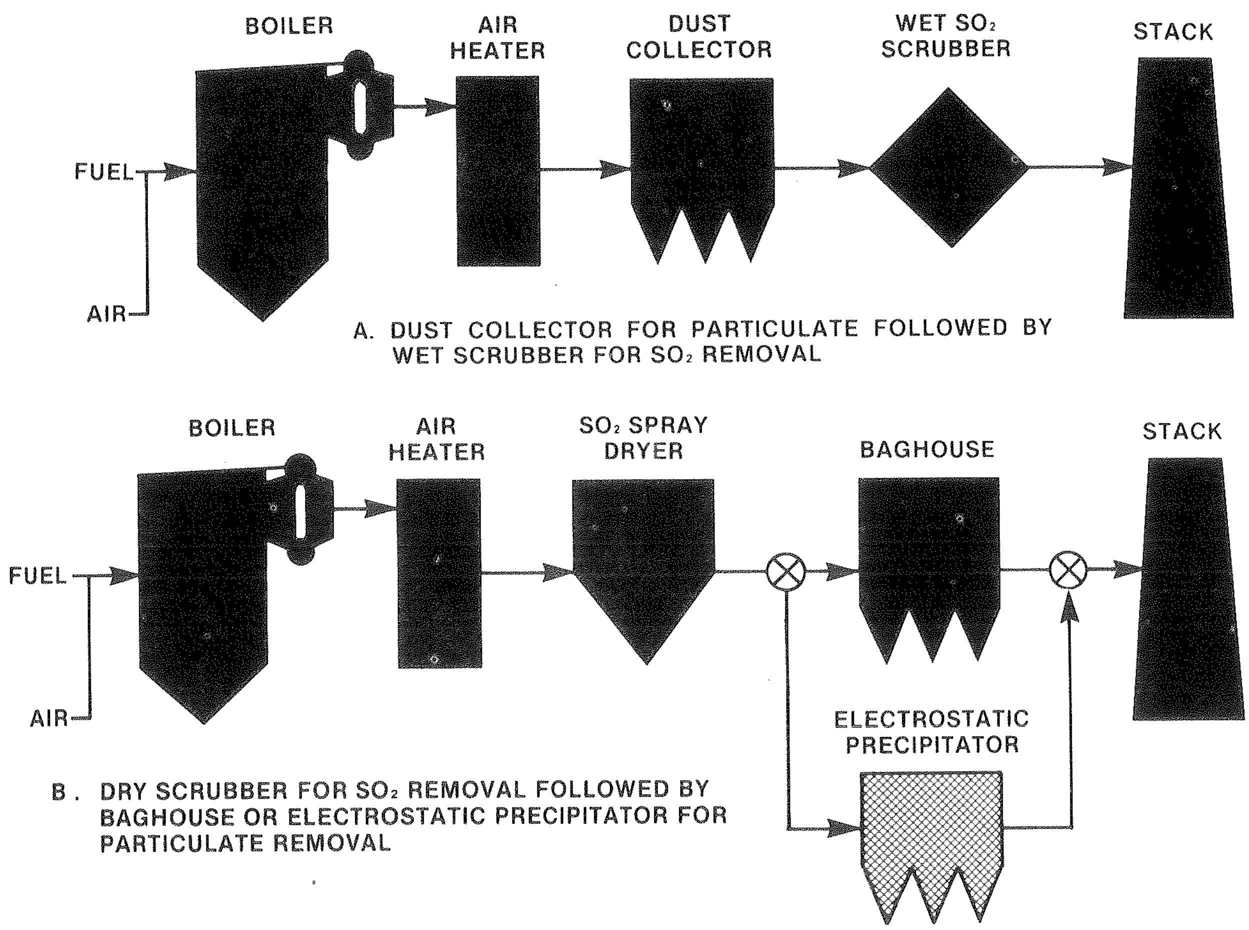

Figure 9 Equipment Configuration Schematics

Both wet and dry scrubbers have the additional problem of disposal of the products which result from cleaning the gases. It is easier to dispose of the dry scrubber's products, especially for a small plant, which is one benefit of the dry process.

PULVERIZED COAL

Riley has developed a low NO_x burner to meet the demands of a stringent NSPS. It uses a distributed mixing principle whereby each particle of fuel burns at or under stoichiometry. Air and fuel mixing is slowed down to produce cooler flames and reduce thermal NO_x formation. The coupling of this burner to the newly developed S.A.M. boiler has added benefits in that the burner flame can radiate to four water cooled walls which aid in cooling the flame and reduce thermal NO_x values to extremely low numbers. Large utility boilers with a multiplicity of burners do not have this advantage.

CONCLUSIONS

Government regulations will, if they have not already, force industrial steam generating plants to burn or at least consider burning coal as their primary fuel. New regulations will also dictate that gas clean-up trains be more sophisticated than they have been in the past. The use of bag houses and electrostatic precipitators for particulate matter removal and some form of SO_2 removal system will be evident on new plants. Boiler designs will also be changing with larger furnaces and fuel combustion systems producing lower oxides of nitrogen than yesterday's and today's boilers. Steam generating unit manufacturers will furnish not only the furnaces, fuel combustion systems, and heat recovery apparatus, but also equipment for flue gas clean-up to meet air emission regulations. This can all be accomplished with available technology but at an increased capital outlay by the industrial customers.