

NO<sub>x</sub> CONTROL TECHNOLOGY REQUIREMENTS UNDER  
THE UNITED STATES' 1990 CLEAN AIR ACT AMENDMENTS  
COMPARED TO THOSE IN SELECTED PACIFIC RIM COUNTRIES

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### Abstract

The 1990 Clean Air Act Amendments (CAAAAs) require reduction of nitrogen oxide (NO<sub>x</sub>) emissions under two provisions: Title I requires control of NO<sub>x</sub> from all source types for the purpose of attaining ambient air quality standards for NO<sub>x</sub> and ozone; and Title IV requires control of NO<sub>x</sub> from coal-fired utility boilers for the reduction of acid rain precursors. Title IV is the more straightforward of the two, and sets national emission standards for dry-bottom wall-fired and tangentially fired boilers based on low NO<sub>x</sub> burner technology (LNBT), defined by EPA to include separated overfire air (OFA). Emission standards for other boiler types are to be promulgated by 1997.

NO<sub>x</sub> controls under Title I are more complex, and are based on reductions necessary to reduce local and regional ambient levels of NO<sub>x</sub> and ozone. Control technology requirements under Title I are based on Reasonably Available Control Technology (RACT) as defined by EPA's Office of Air Quality Planning and Standards; however, emission levels are set by the states according to local conditions. Technologies defined as RACT include low NO<sub>x</sub> burner technology, selective non-catalytic reduction (SNCR), and selective catalytic reduction (SCR). These and other combustion modifications and flue gas treatment technologies are described. NO<sub>x</sub> emission regulations and technology requirements in the U.S. are compared to those in selected Pacific Rim countries.

### I. Introduction

The 1990 Clean Air Act Amendments (CAAAAs) were put into law in the United States on November 15, 1990,<sup>1</sup> resulting in air pollution control requirements that are applied to a much broader scope of sources and pollutants, and setting more stringent pollutant emission levels than previous air pollution control legislation. The CAAAs not only introduced the concept of trading emission credits in the case of sulfur dioxide (SO<sub>2</sub>) emissions, but also applied limits to emissions of both SO<sub>2</sub> and NO<sub>x</sub> to existing utility sources for the purpose of reducing acid precipitation. The CAAAs also require control of 189 hazardous air pollutants

(HAPs) from all sources, and require states to move more quickly to improve ambient air quality, both as a means of reducing risks to human health. Although the CAAAs have affected a much larger range of sources and pollutants than previous legislation, and have made some significant changes to the traditional approaches to regulating air pollution control, the CAAAs' provisions relating to NO<sub>x</sub> control are relatively straightforward.

Pollution control regulations for individual sources can take two primary approaches: setting limits on the amount of a pollutant that can be emitted, leaving the method of achieving these limits to the individual sources; or mandating the use of a particular control technology to ensure a certain percentage reduction in emissions. The first approach is "emissions-based," and the second is "technology-based." In addition to these approaches, agencies can also create regulations using two other approaches: "stack emission" regulation, which specifies technologies or emission limits at a particular source; or the setting of ambient pollutant levels, which specifies a certain level of pollutant in the environment of interest. The second "other" approach can lead to "stack emission" regulations, or to total mass emissions designed to prevent sources from emitting pollutants in such quantities that the desired ambient pollutant levels are exceeded.

The CAAAs incorporate to some degree each of these concepts into the NO<sub>x</sub> control provisions of the CAAAs. The acid rain provisions of the CAAAs are set forth in Title IV, and specify NO<sub>x</sub> emission limits for utility boilers. However, Title IV also bases the emission limits on a certain technology, giving the final regulation a combined "emission-based" and "technology-based" twist. NO<sub>x</sub> emissions are also subject to limitation under Title I, which is concerned with attaining ambient air quality. Title I can require sources to control NO<sub>x</sub> emissions to achieve air quality standards for both nitrogen dioxide (NO<sub>2</sub>) and for ozone (O<sub>3</sub>). Thus, Title IV is an example of the "stack emission" control strategy for a specific group of sources, while Title I is based on ambient air quality which implies control of all sources in a given area. Other differences between the two provisions and the implications for control technology requirements are discussed in the following sections.

In many Pacific Rim countries, NO<sub>x</sub> emission regulations are mainly emissions-based but, as in the case of the Title I requirements, are usually set with certain control technologies as the basis for the emission levels.

## **II. NO<sub>x</sub> Control Provisions of the 1990 Clean Air Act Amendments**

### **A. Title IV**

Title IV of the CAAAs provides for NO<sub>x</sub> emission reductions under Section 407, "Nitrogen Oxides Emission Reduction Program." Title IV requirements were designed to

reduce NO<sub>x</sub> and SO<sub>2</sub> emissions from coal-fired utility boilers for the purpose of reducing total national emissions of acid precipitation precursors. The mandated NO<sub>x</sub> emission reductions vary according to boiler type and compliance date, with compliance dates tied to the SO<sub>2</sub> reduction provisions. Boilers are categorized by two criteria under Section 407. First, 261 boilers (including 5 oil-fired units) are identified in the CAAAs as Phase I units based on their total SO<sub>2</sub> emissions, and are subject to emission limitations beginning January 1, 1995. All remaining coal-fired utility boilers greater than 25 MWe are defined as Phase II units, and are subject to emission limitations beginning January 1, 2000. Second, boilers are divided into Groups 1 and 2 based on the type of boiler. Group 1 boilers are defined as tangentially fired boilers and dry-bottom wall-fired boilers, excluding units that use cell burner technology. Group 2 is composed of all other boiler types (e.g., cyclones, wet-bottom wall-fired units, and cell burner units). Both Phase I and II units include both Group 1 and 2 boilers.

Under this section, the CAAAs place responsibility for regulating NO<sub>x</sub> emissions from utility boilers with the U.S. Environmental Protection Agency (EPA). The CAAAs also state that Phase I utility units are subject to maximum annual average emission rates of 0.45 lb/10<sup>6</sup> Btu (194 ng/J) for tangentially fired (T-fired) boilers, and 0.50 lb/10<sup>6</sup> Btu (215 ng/J) for dry-bottom wall-fired boilers, except for those applying cell burner technology. The final rule promulgated by EPA used these values in the subsequent regulation, making it appear to be an "emissions-based" regulation. However, the CAAAs also require that these limits are to be achieved using "low NO<sub>x</sub> burner technology" (LNBT), giving the regulation a combination emissions- and technology-based approach. This combination has resulted in significant disagreement over the exact definition of LNBT, with EPA determining that overfire air is appropriately included in the definition. This determination is being contested by the utility industry, and the case is scheduled to be presented to the U.S. Court of Appeals in October.

## B. Title I

Title I requirements are aimed at a significantly different problem, and therefore take a significantly different approach than does Title IV. Title I is designed to bring ambient air quality into attainment with the National Ambient Air Quality Standards (NAAQS), and therefore does not target specific sources for reduction, but seeks to reduce total emissions from all sources in order to reduce ambient levels of air pollution. In addition, since nonattainment of the NAAQS is localized, the resulting emission standards are also localized, and fall under the authority of regional, state, and local regulatory bodies. The role of the EPA under Title I is to set the NAAQS and to provide guidance to the regulatory agencies as to technologies that are reasonably available for application to the sources that require control. The state agencies must submit to the EPA for approval their State Implementation Plans

(SIPs), which are the regulatory requirements that each state feels will provide the means for attaining the NAAQS.

The control technology requirements under Title I are therefore determined not by EPA, but by the various state agencies. However, EPA plays a significant role in determining these requirements by publishing a guidance document that defines Reasonably Available Control Technology (RACT) that states use in setting their technology requirements.

### **III. Standards and Control Technology Requirements in the Pacific Rim Countries**

#### **A. General**

In general, NO<sub>x</sub> emission standards in Pacific Rim countries vary with source type and size, and in some instances with location. As in the U.S., NO<sub>x</sub> emission standards are set for reducing acid rain precursors and for control of ozone precursors, with standards set for ozone control typically being more stringent. Standards for ozone reduction are also typically more stringent in populated areas than in rural locations. The U.S., Canada, and Korea have set standards based on mass of NO<sub>x</sub> per unit energy input, while Japan, Australia, New Zealand, and Taiwan have based standards on NO<sub>x</sub> concentrations in the stack gases. Mexico's NO<sub>x</sub> standards are based on mass of emissions per volume of fuel consumed.<sup>2-9</sup>

For the most part, national NO<sub>x</sub> standards are not technology-based, but are emissions-based, leaving the decision as to the control technology to apply to the individual source. However, most standards are set to allow compliance by application of combustion modification, with the only requirements for post-combustion control being set in instances where local agreements have set lower emission levels. Table 1 summarizes emission standards for eight Pacific Rim countries. More detailed information is given below on emission standards in several of these countries.

#### **B. Japan**

As with the U.S. Title I requirements, NO<sub>x</sub> emission standards are based on available control technologies combined with economic considerations. For the most part, Japanese NO<sub>x</sub> control requirements are based on combustion modification technologies such as flue gas recirculation, staged combustion (or overfire air), and low NO<sub>x</sub> burners. There is no direct requirement in most cases for the installation of any particular control technology; however, the emission standards are set such that they can typically be met using low NO<sub>x</sub> burners or other combustion modification technique. For coal-fired plants, NO<sub>x</sub> emissions are set at 400 ppm (measured at 6% O<sub>2</sub>), while low NO<sub>x</sub> burners have been shown capable of emission levels of 150-200 ppm using Japanese low nitrogen coals and 200-280 ppm using imported coals.<sup>8</sup> More stringent control technology requirements may be established under local agreements,

and often require the use of a post-combustion control technology such as SNCR or SCR. In one case, the Electric Power Development Company met emission levels of 50-60 ppm using a combination of combustion modification and SCR.<sup>8</sup> More common are agreements that lower emission standards to 200-300 ppm, allowing compliance using combustion modification alone. An overview of Japanese emission standards is presented in Table 2.

### C. Australia

In Australia, the emission limits for NO<sub>x</sub> are structured similar to the U.S. Title I requirements, with one significant difference. While the U.S. government sets required ambient air quality standards that the states are responsible for meeting, the Australian federal government sets national *advisory guidelines* for ambient pollutant levels and emissions. As in the U.S. Title I, the Australian state and territorial governments are responsible for setting the actual limits for emissions.<sup>9</sup> Table 3 shows both the national guidelines and the mandatory state limits for NO<sub>x</sub> emissions in two of Australia's states. There is no control technology requirement for meeting these emissions; Australia relies on emissions-based rather than technology-based standards. However, the emissions-based standards are derived from the use of combustion modification control technologies (e.g., low NO<sub>x</sub> burners).

## **IV. Overview of NO<sub>x</sub> Control Technologies**

NO<sub>x</sub> control technologies can be divided into two primary types, combustion modifications and post-combustion controls. As the name implies, combustion modification controls act through changes in the combustion process, and have been very effective at control of NO<sub>x</sub> emissions from fossil fuels. Post-combustion controls do not change the combustion process, and can be applied to other than combustion sources. In general, combustion modification controls rely on changing the combustion process to reduce the formation of NO<sub>x</sub>, while post-combustion controls destroy the NO<sub>x</sub> that has been formed during the combustion process; this generalization does not hold for reburning, as explained below. In addition, the discussion below does not provide fuel-specific information, but is only a very general overview. For many of the technologies discussed below, the type of fuel can make a significant difference in the applicability and performance of the particular technology.

### A. Combustion Modification Controls

Combustion modification controls are based on changing the combustion process to reduce the formation of nitrogen oxide (NO) or, in the case of reburning, a combination of reducing formation of NO and destroying NO formed in the primary combustion zone. Preventing the formation or achieving the destruction of NO is important, since NO comprises most of the NO<sub>x</sub> emitted by combustion processes. Combustion modifications can be as

simple as reducing the level of excess air or can involve significant redesign of the combustion system. Combustion modifications are designed to achieve two primary objectives: (1) to minimize the peak flame temperature and thereby minimize the reaction of atmospheric nitrogen with atmospheric oxygen to form NO; and (2) to force solid fuels to devolatilize in an oxygen deficient atmosphere to minimize the oxygen available to react with nitrogen found in the fuel. In both instances, the net result is to reduce the formation of NO. The primary method used to accomplish these objectives is staging, or an incremental mixing of fuel and air, the most common form of which is staging of the combustion air (as opposed to staging of the fuel).

The simplest forms of combustion modification are low excess air (LEA) operation, burners out of service (BOOS), and biased firing. These modifications typically do not require any modification to the boiler, but are achieved by altering the air and fuel flows in order to reduce the oxygen available to react with fuel-bound nitrogen. LEA simply reduces the level of excess oxygen available by operating a boiler as near to stoichiometric conditions as possible, with the limiting factor being the level of unburned fuel that exits the furnace. LEA can be applied to most boilers without modification of equipment or significant changes in operability. LEA can achieve NO<sub>x</sub> reductions of about 15%.<sup>10</sup>

BOOS is effective in furnaces that have burners arranged in more than one horizontal row, and is accomplished by introducing only air through one or more of the upper row of burners. This requires that combustion conditions for the lower rows of burners range from slightly above to slightly below stoichiometric, with the remainder of the necessary combustion air being provided by the upper burners injecting only air. Biased firing is similar to BOOS, but does not eliminate all the fuel flow from the upper burners. Biased firing alters the individual stoichiometries to create more fuel-rich conditions in the lower burners and correspondingly fuel-lean conditions in the upper burners to achieve the desired overall furnace stoichiometry. A disadvantage of BOOS and biased firing can be a limit on the maximum load a unit is able to attain under these conditions. BOOS and biased firing are most commonly applied to wall-fired boilers, and can attain NO<sub>x</sub> reduction levels of about 20 to 30% compared to normal operating conditions.<sup>10</sup>

To minimize the impact on boiler load, dedicated air injection ports can be installed so that each existing burner can maintain its rated capacity. The use of these ports is most often referred to as overfire air (OFA). OFA can be applied to most dry-bottom boilers, and is particularly suitable for wall-fired and tangentially fired units. Some efforts are underway to apply OFA to wet-bottom units as well. OFA can achieve NO<sub>x</sub> reductions of 20 to 30% when compared to uncontrolled NO<sub>x</sub> levels.<sup>11-14</sup>

The combustion modification techniques described above rely on the entire furnace combustion zone for application of the staging process. This is similar to the low  $\text{NO}_x$  combustion modification most commonly applied to tangentially fired units, in which coal and air nozzles are placed in the corners of the furnace to create a large swirling flame in the furnace center. The interior section of this flame is fuel-rich, with the air necessary for completion of the combustion added at higher levels. This “rich fireball” concept is the basis for most low  $\text{NO}_x$  combustion systems commercially available for tangentially fired units, and the majority of improvements to the process have been in changes to the location of the upper air injection ports.

For wall-fired units, the application of aerodynamic burner staging has been the basis for most new combustion modification designs. Aerodynamic burner staging alters the flows of the coal and air from the cylindrical burners to create burner flames characterized by a fuel-rich core surrounded by increasing levels of air to achieve the desired overall stoichiometry. Creating this arrangement of combustion conditions within the more localized volume of the individual burner flames results in suppressing the formation of  $\text{NO}_x$ . In some applications, these low  $\text{NO}_x$  burners (LNBS) can be operated in conjunction with OFA as an integrated system to achieve further  $\text{NO}_x$  reductions. In these instances, the burners are operated substoichiometrically, with the necessary burnout air supplied by the OFA ports located above the burners.

LNBS are the most common form of combustion modification  $\text{NO}_x$  control technology. Many designs utilize OFA ports as an integral part of the design, particularly with tangentially fired units. Most LNB systems can achieve  $\text{NO}_x$  reductions of 35 to 40%, with reductions of over 50% achieved where baseline  $\text{NO}_x$  emissions are high. Greater reductions are possible when LNBS are combined with reburning or post-combustion controls (described below).<sup>11-14</sup>

Reburning is another combustion modification technique used for reducing  $\text{NO}_x$  emissions. Reburning is based on a different process than the staging of air, and acts to destroy  $\text{NO}_x$  already formed in addition to reducing its formation. The chemical process of reburning is complex, and is based on the reduction of  $\text{NO}$  by the addition of hydrocarbon combustion radicals. Such radicals are introduced into the furnace by breaking the combustion process into three stages. Stage 1 is primary combustion, in which the fuel and air are combusted under standard or low excess air conditions. Where possible, LEA or other combustion modification technique is used to minimize the formation of  $\text{NO}_x$  in this (primary) zone. Only a portion (usually 85-90%) of the total required heat input is generated in this region, with the remainder coming from the addition of the reburn fuel. Stage 2 is the

reburning zone, where an amount of fuel required to reach the total required heat input of the furnace is added. In this zone, no additional air is provided, resulting in high levels of hydrocarbon radicals that react with the NO present to form nitrogen ( $N_2$ ) and carbon monoxide (CO), water ( $H_2O$ ), or carbon dioxide ( $CO_2$ ). Because of the oxygen deficient, or reducing, conditions in the reburn zone, stage 3 (the burnout zone) is required to completely convert the CO and other combustibles to  $CO_2$  and  $H_2O$ . Natural gas is often used as the reburning fuel, since it contains no fuel-bound nitrogen and, therefore does not create any additional NO from the reaction of such nitrogen and combustion oxygen. However, demonstrations of reburning using coal or oil as the reburn fuel have shown that it is not necessary to use natural gas, and that nitrogen-containing fuels can be successfully used as reburning fuels. Reburning has consistently achieved  $NO_x$  reductions of 50%, with some applications showing reductions as much as 65%.<sup>15,16</sup>

In some applications, flue gas recirculation (FGR) is used to transport the reburn fuel and provide the momentum necessary to ensure adequate penetration of the fuel into the flue gases. Research is being conducted to develop advanced reburn designs, to eliminate the use of OFA and FGR. These design changes would greatly reduce the capital cost of reburn application. Other advanced reburn designs incorporate injection of reducing agents, such as ammonia, to provide further  $NO_x$  reduction. The goal of advanced reburn design is to improve the  $NO_x$  reduction potential to the 75-85% range and to reduce the cost of the systems.

### B. Post-Combustion Controls

Post-combustion controls are characterized by low-temperature conversions of NO to other compounds, i.e., temperatures below those typically found in the combustion zones of furnaces. The two most effective post-combustion controls are selective noncatalytic reduction (SNCR) and selective catalytic reduction (SCR). In both, the injection of a nitrogen-containing reagent is required. The term post-combustion controls should not be construed to mean that these technologies apply only to combustion sources. Since the emphasis here is on combustion sources of  $NO_x$ , the term post-combustion control provides a clear distinction between these technologies and combustion modification methods. However, both SNCR and SCR can be applied to other  $NO_x$  sources if the temperature and chemical composition of the exhaust gases are suitable for these technologies. In addition, both technologies can be applied to combustion sources other than large utility or industrial boilers. Both technologies can be used as a control technique for stationary diesel and gas-turbine engines, if the proper temperatures and residence times are available in the exhaust.



SNCR works by injecting the reagent into a relatively high post-combustion zone in the furnace, where the nitrogen in the reagent combines with the nitrogen in the NO to form  $N_2$  and other nonpolluting compounds (primarily  $H_2O$ ). A temperature range of 1600-2100°F (870-1150°C) is normally required for the reactions to occur. The amount of chemical required to convert the NO depends upon the reagent used, and is based on the ratio of nitrogen in the reagent to NO. Injection rates are usually less than  $N/NO = 2$ . SNCR typically uses ammonia, urea, or cyanuric acid as the reagent, although several vendors have developed proprietary reagents to improve levels of  $NO_x$  reduction or to modify the effective temperature window.  $NO_x$  reductions using SNCR are typically in the 40-60% range, depending upon the uncontrolled  $NO_x$  level, and the process variables such as injection rate and available time at the required temperatures; some demonstrations have achieved 70% reductions. Disadvantages to SNCR include the formation of nitrous oxide ( $N_2O$ ), ammonia slip (in which ammonia that does not react with NO is released), the deposition of ammonium bisulfates formed by the reaction of sulfur trioxide and ammonia, and the presence of a visible plume of ammonium chloride formed by the reaction of ammonia and hydrogen chloride.<sup>17</sup>

SCR relies on reactions similar to those with SNCR, and also requires the injection of a nitrogen-containing chemical. However, SCR operates at significantly lower temperatures, relying on a catalyst to increase the reaction rate. SCR can achieve  $NO_x$  reductions of up to 80% where the uncontrolled  $NO_x$  levels are high (> 800 ppmv). Such high reductions significantly reduce the catalyst life, however, and in instances where large reductions are required, the usual practice is to use SCR as the final step in a series of  $NO_x$  reduction processes beginning with some form of combustion modification followed by the use of SCR. The SCR system then acts as a polishing system to bring  $NO_x$  levels to the final desired level. SCR and SNCR are both applicable to sources in which the use of combustion modification methods is not feasible, or where combustion modifications cannot achieve the required  $NO_x$  reductions alone.

## V. Conclusions

Most of the  $NO_x$  emission standards in the Pacific Rim countries discussed here are not "technology-based," requiring specific equipment to be installed. Rather, they are "emissions-based," with emission limits often set such that certain technologies can be used to achieve those limits. It may appear that setting a standard so that one or more specific technologies must be applied to achieve that standard is the same as requiring its installation, but there is an important difference. When technology-based standards are used, there is little, if any, room for improving the state of the art beyond minimizing costs and performance impacts. When emissions-based standards are set, however, there is considerable flexibility allowed in achieving those standards over the long term. This can allow new technologies to be

developed and applied, which can significantly improve performance and reduce both capital and operating costs.

A significant portion of past research on NO<sub>x</sub> control technology has focused on coal and utilities. As the need to reduce NO<sub>x</sub> becomes more important as an ozone control strategy, the types of fuels and sources from which NO<sub>x</sub> must be controlled will become much broader. This will require combustion modification and post-combustion control technologies that are more flexible and less expensive in order to make their performance and economical application possible for very small sources as well as the larger coal and utility sources.

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Table 1. Summary of NO<sub>x</sub> emission standards from selected Pacific Rim countries.  
(Source: Refs. 2-9.)

Country/Source	Standard	ppm(a)	Control Technology
U.S. (b)			
Dry-bottom T-fired	0.45 lb/10 <sup>6</sup> Btu	400	LNBT (c)
Dry-bottom wall-fired	0.50 lb/10 <sup>6</sup> Btu	445	LNBT (c)
Japan (d)			
Boilers < 32 MWt (e)	720 mg/dscm	350	No requirement - use combustion controls and SCR
Boilers 32-560 MWt	515 mg/dscm	250	
Boilers > 560 MWt	410 mg/dscm	200	
Canada			
New coal-fired utility	0.395 lb/10 <sup>6</sup> Btu	350	No requirement - stds can be met using combustion modification
Oil-fired utility	0.300 lb/10 <sup>6</sup> Btu	250	
Gas-fired utility	0.200 lb/10 <sup>6</sup> Btu	200	
Mexico			
Coal- and oil-fired util.-	10.0 lb/m <sup>3</sup> coal(f)	890	LNBT (c)
South Korea			
Coal-fired utilities	0.4 lb/10 <sup>6</sup> Btu	350	No requirement - stds can be met using combustion modification
Oil-fired utilities	0.3 lb/10 <sup>6</sup> Btu	250	
Gas-fired utilities	0.4 lb/10 <sup>6</sup> Btu	400	
Australia (g)			
New industrial plants	535 mg/dscm	260	No requirement - stds can be met using combustion modification
New utility plants <30 MWt	535 mg/dscm	260	
New utility plants >30 MWt	860 mg/dscm	420	
New plants >250 MWt	535-2680 mg/dscm		
New Zealand			
Combustion plants	2050 mg/dscm	1000	No requirement
Taiwan			
New utility plants	720-1025 mg/dscm	350-500	No requirement
Existing utility plants(h)	720-1025 mg/dscm	350-500	

## Notes:

- (a) Approximate conversion from lb/10<sup>6</sup> Btu
- (b) Title IV requirements only
- (c) Low NO<sub>x</sub> Burner Technology
- (d) More stringent limits in some areas - see Table 2
- (e) Thermal MW
- (f) Estimated at approximately 1.0 lb/10<sup>6</sup> Btu
- (g) Limits vary by state - see Table 3
- (h) Proposed

Table 2. NO<sub>x</sub> emissions limits for Japan.<sup>8</sup>

Type of Boiler	Capacity (1,000 Nm <sup>3</sup> /h)	Emission Standard (ppm)
Coal-fired (6% O <sub>2</sub> basis)	< 40	300
	40-700	250
	> 700	200
Oil-fired (4% O <sub>2</sub> basis)	< 10	180
	10-500	150
	> 500	130
Gas-fired (5% O <sub>2</sub> basis)	< 10	150
	10-40	130
	40-500	100
	> 500	60

Table 3. NO<sub>x</sub> emissions guidelines and limits for Australia and the two most populous Australian states.<sup>9</sup>

	Standard (a)	ppm (at stated O <sub>2</sub> )
<b>National Guidelines</b>		
Steam boilers		
Liquid and solid fuels, units < 30 MW	0.5 g/m <sup>3</sup> (at 7% O <sub>2</sub> )	244
Liquid and solid fuels, units > 30 MW	0.8 g/m <sup>3</sup> (at 7% O <sub>2</sub> )	390
Gaseous fuels	0.35 g/m <sup>3</sup> (at 7% O <sub>2</sub> )	171
Gas turbines		
< 10 MW	0.09 g/m <sup>3</sup> (at 15% O <sub>2</sub> )	44
> 10 MW	0.07 g/m <sup>3</sup> (at 15% O <sub>2</sub> )	34
Other fuels		
< 10 MW	0.09 g/m <sup>3</sup> (at 15% O <sub>2</sub> )	44
> 10 MW	0.15 g/m <sup>3</sup> (at 15% O <sub>2</sub> )	73
<b>New South Wales</b>		
Any trade, industry, or process emitting NO <sub>x</sub>	2.5 g/m <sup>3</sup> as NO <sub>2</sub> (new installations subject to tighter limits by license conditions, typically 0.5 to 1.0 g/m <sup>3</sup> )	1218
<b>Victoria</b>		
Fuel-burning units (other than IC engines and glass manufacturing plants) heat input > 150,000 MJ/hr	1.0 g/m <sup>3</sup> at 7% O <sub>2</sub>	487
New units		
Gaseous fuels	0.35 g/m <sup>3</sup>	171
Liquid or solid fuels	0.5 g/m <sup>3</sup>	244
Power station boilers > 250 MWe	0.7 g/m <sup>3</sup> (may be relaxed to 0.78 g/m <sup>3</sup> depending on fuel, existing emission control technology, and safety)	341 (380)

(a) Volumes at 0°C and 101.325 kPa

TECHNICAL REPORT DATA		
<i>(Please read Instructions on the reverse before completing)</i>		
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16. ABSTRACT The paper compares nitrogen oxide (NO <sub>x</sub> ) control technology requirements under the U. S. 1990 Clean Air Act Amendments (CAAA) with those in selected Pacific Rim countries. The CAAs require reduction of NO <sub>x</sub> emissions under Titles I (requiring control of NO <sub>x</sub> from all source types for the purpose of attaining ambient air quality standards for NO <sub>x</sub> and ozone) and IV (requiring control of NO <sub>x</sub> from coal-fired utility boilers for the reduction of acid rain precursors). Title IV sets national emission standards for dry-bottom wall-fired and tangentially fired boilers based on low NO <sub>x</sub> burner technology, defined by EPA to include separated overfire air. Emission standards for other boiler types are to be promulgated by 1997. Title I controls, based on reductions necessary to reduce local and regional ambient levels of NO <sub>x</sub> and ozone, involve Reasonably Available Control Technology (RACT) as defined by EPA's Office of Air Quality Planning and Standards; however, emission levels are set by the states according to local conditions. Technologies defined as RACT include low NO <sub>x</sub> burner technology, selective non-catalytic modifications, and selective catalytic reduction. These and other combustion modifications and flue gas treatment technologies are described.		
17. KEY WORDS AND DOCUMENT ANALYSIS		
a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Pollution Boilers	Pollution Control	13B 13A
Nitrogen Oxides Catalysis	Stationary Sources	07B 07D
Emission Flue Gases	Acid Rain	14G
Ozone	Reasonably Available	
Coal	Control Technology	21D
Combustion	(RACT)	21B
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