



INSTITUTE OF
CLEAN
AIR
COMPANIES

**Typical Installation Timelines
for
NO_x Emissions Control Technologies
on
Industrial Sources**

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About the Institute of Clean Air Companies

The Institute of Clean Air Companies (ICAC) is the national trade association of companies that supply air pollution control and monitoring technologies for stationary sources who provide solutions for a broad range of industrial applications as well as electric power plants. ICAC represents more than ninety of the leading manufacturers who provide emissions control solutions for affected industries as well as employment opportunities across the U.S. ICAC gives the air pollution control and monitoring industry a responsible and responsive presence in Washington, DC and throughout the country, which works constructively with government, business, public, and private groups to ensure that the air pollution control industry and its products are properly represented and understood.

Introduction

The following document provides information concerning the time needed for the installation of emissions control technologies for industrial sources. The document focuses on the deployment time of NO_x controls that are applied to various industrial categories including the following: low NO_x burners, selective non-catalytic reduction, selective catalytic reduction, and non-selective catalytic reduction. The information below can be used as a general guide for the typical time required to complete a typical NO_x control project from the initial bidding period through the start-up of the installed control technology. The level of retrofit difficulty and site specific conditions may increase or decrease the time required for the deployment of the control technology.

There are several points in the NO_x control technology deployment process where the end user dictates the amount of time consumed. For example, control technology manufacturers rely on the end user during the bid evaluation, project negotiation, review of engineering drawings, review of flow modeling studies (if applicable), scheduling the outage (if applicable), and compliance testing steps. For these steps, the end user is in control of the time required to complete each step as opposed to the emissions control manufacturer. For example, the timing of the initial bid evaluation and negotiation may vary depending on the amount of resources the end user has available to review and proceed with the decision making process or the amount of time prior the end user has prior to meeting a compliance deadline. The following deployment timelines have assumed that the affected source has decided to move forward with the installation of the control technology and is working with emissions control manufacturers to move the project forward in a reasonable timeframe.

Low NO_x Burners and Flue Gas Recirculation

There are a number of types of combustion control technologies that have been applied to industrial sources depending on the application and emissions requirement. The deployment times for two of the combustion control technologies including low NO_x burners (LNB) and LNB in conjunction with flue gas recirculation (FGR) are discussed below.

Low NO_x Burners - For coal-, oil-, and gas-fired boilers, low NO_x burners decrease the air introduced into the primary combustion zone thereby creating a fuel-rich environment and lower

combustion temperatures that work to lower NO_x formation. Conventional burners operate with excess combustion air when compared to the stoichiometric requirement for complete combustion. When applying low NO_x burners, the percentage of excess air is reduced in the primary combustion zone with the remaining air required for complete burnout of combustibles added where the temperature is sufficiently low so that additional NO_x formation is minimized. Ultra Low NO_x Burners are an advanced generation of low NO_x burners that provides additional NO_x reductions through improved designs.

LNB + Flue Gas Recirculation - Flue gas recirculation reduces NO_x emissions by recirculating and mixing 5-40 percent of the boiler flue gas with the combustion air prior to combustion in the main combustion chamber. This process reduces the peak combustion temperature and lowers the percentage of oxygen in the combustion air/flue gas mixture; thus retarding the formation of thermal NO_x caused by high flame temperatures. FGR is often used in combination with LNB to reduce NO_x emissions below levels that may be achieved by using LNB alone. FGR has been applied to natural gas, kerosene, distillate oil, and coal-fired boilers.

The deployment time for retrofitting an existing boiler with LNB or ultra-LNB is relatively short due to the simplicity of the technology and the small number of burners on most industrial boilers. The vast majority of oil- and gas-fired package boilers used for various industrial applications have just one or two burners making the retrofits less intensive. A complete LNB system retrofit typically includes the following major components: windbox, burner(s), and burner management system. LNB manufacturers typically design their systems to keep the retrofit cost to a minimum by replacing only critical firing components, while keeping most of the burner system intact. For example, a LNB manufacturer may design their LNB system to adapt to the existing windbox geometry, backup fuel firing system, and ignition equipment. By minimizing the changes of equipment, LNB manufacturers minimize the amount of time required for the retrofit.

Retrofitting an existing industrial boiler with flue gas recirculation involves installation of a system to extract the flue gas from the boiler unit, ductwork, and fan. The deployment of a complete LNB + FGR system will include: windbox, burner(s), burner management system, potentially larger fan for FGR, and ductwork for FGR. A fly ash control device is necessary for coal-fired applications in order to clean the flue gas of particulate matter prior to recirculation of the gases back into the boiler. Retrofitting existing oil- and gas-fired boilers with flue gas recirculation involves all of the same components except for the fly ash collecting device.

For a complete system, the typical deployment of LNB or LNB + FGR takes between 24-32 weeks (6 – 8 months) on a typical industrial boiler covering the bid evaluation through the start-up of the technology. The deployment schedule for complete LNB or LNB + FGR technology on a typical industrial boiler can be divided into the following timeframes:

- 4-8 weeks – bid evaluation and negotiation
- 4-6 weeks - engineering and completion of engineering drawings
- 2 weeks – drawing review and approval from end user
- 10-12 weeks – fabrication of equipment and shipping to end user site

- 2-3 weeks – installation at end user site (Most of the components of the technology can be installed while the boiler is operating. The boiler may be required to shut-down for 1-2 days for a simple burner change-out or as much as seven days for a complete system installation.)
- 1 week – commissioning and start-up of technology

Variations in the schedule may occur due to site specific conditions that may increase or decrease the typical deployment time. The typical deployment time is short for systems that can use the existing burner management system, windbox, and other components and replace just the burner(s). For these applications, the deployment schedule may be as little as 12-16 weeks if only the burner(s) are being replaced.

Selective Non-Catalytic Reduction

Selective non-catalytic reduction (SNCR) is a chemical process for removing NO_x from flue gas. In the SNCR process, a reagent, typically urea or anhydrous gaseous ammonia is injected into the hot flue gas and reacts with the NO_x, converting it to nitrogen gas and water vapor. The chemical reaction for this technology is driven by high temperatures, typically from 1,600 – 2,100 °F, normally found in combustion sources. SNCR is “selective” in that the reagent reacts primarily with NO_x.

SNCR may be combined with low NO_x burners (LNB), over-fire air (OFA), neural networks, rich reagent injection (RRI), selective catalytic reduction (SCR) systems, or with gas reburn technologies to provide additional emissions reductions. Combined SNCR/SCR systems are finding new applications allowing higher overall NO_x reduction than SNCR alone and lower ammonia slip.

The principal components of the SNCR system are the reagent storage and injection system, which includes tanks, pumps, injectors, distribution modules, and associated controls. The combustion unit acts as the reactor chamber simplifying the SNCR process. The reagent is generally injected within the boiler superheater and reheater radiant and convective regions, where the combustion gas temperature is at the required temperature range. The number of injection ports and location is determined by flue gas flow and temperature profiles.

SNCR is a proven and reliable technology. SNCR was first applied commercially in 1974 and has been installed on approximately 400 applications worldwide. Applications include utility boilers and a broad range of industrial applications including installations on the following: wood-fired boilers, coal-fired boilers, co-generation boilers, pulp and paper boilers, steel industry furnaces, refinery process units, process heaters, cement kilns, municipal waste combustors, glass melting furnaces, hazardous waste incinerators, and other combustion sources. Urea-based SNCR has been applied commercially to sources ranging in size from a 60 mMBtu/hr (gross heat input) paper mill sludge incinerator to a 640 MWe pulverized coal-fueled, wall-fired electric utility boiler.

Given the simplicity of the SNCR system components, installation of SNCR is relatively easy and can be done in a relatively short period of time. It typically takes between 42-51 weeks (10-

13 months) to complete the SNCR project going from the bid evaluation through start-up. Under special circumstances and during periods of lower SNCR manufacturer activity, SNCR installations are typically completed in eight (8) months. A typical timeline for the completion of an SNCR projection starting from the commercial request for quote (RFQ) to the compliance testing is given in Table 1 below. Certain steps in the SNCR installation process have prerequisite steps while others may occur simultaneously. Below is a brief description of some of the aspects of the SNCR project timing:

1) Initial Stages of Planning and Development

- a) Bid Evaluation – After the end user submits the request for quote (RFQ), the APC manufacturer will typically take between 2-4 weeks to submit the proposal. The APC manufacturer relies on the end user to provide the appropriate information concerning the application in order to provide the design proposal. Some end users have in-house engineering resources that make this process run more efficiently.
 - b) Initial Engineering – Once the bid has been accepted, the initial engineering for the site will typically take between 1-4 weeks and is typically completed 4-8 weeks from the commercial RFQ date. The initial engineering will include things like the design of any concrete work for the reagent storage tanks and distribution system, placement of control systems, siting power delivery, etc.
 - c) Modeling & Engineering Drawings – Computational fluid dynamic (CFD) modeling and engineering drawings are typically completed 18 weeks after the RFQ. The CFD modeling will help determine the number and location of the reagent injection ports that will be incorporated into engineering drawings. Initial engineering drawings are produced by the APC manufacturer and submitted to the end user for comment. The APC manufacturer addresses the comments and prepares the general arrangement drawings.
- 2) Procurement, Fabrication, Shipping** – The procurement, fabrication, and shipment of the various components of the SNCR system will typically be completed by the 34th week from the RFQ. It typically takes between 16-20 weeks for this phase of the project. Some of the typical components that will need to be procured for the SNCR system include: urea solutionizing equipment (if applicable), reagent storage tank, injection lances, reagent control system, reagent pumps, reagent distribution piping, etc. Once the items have been procured, some of the components will need to be assembled prior to shipment including: reagent distribution models and piping, pump skid, process control skid, etc. The equipment is usually small enough to be shipped by truck upon assembly. The timing for shipment depends on the relative distance from the fabrication shop to the end user's site.
- 3) Equipment Installation** – The equipment installation will typically be completed 42 weeks from the RFQ. Once the original engineering is complete at the end user site and the fabricated components arrive on-site, the equipment installation will take between 8-12 weeks not including the outage. Most of the equipment installation will be completed while the unit is operating. An outage of between 7-14 days may be required to install the reagent injection ports and lances in the combustion chamber. Usually, the work is done within an outage taken for other scheduled reasons. The amount of time taken for injection port installation will vary depending on the type of SNCR installation and the availability of existing ports on the combustion unit. If ports on the combustion unit are already in place, then the time needed to install the injection lances will be at a minimum.

- 4) **Equipment Start-Up** – Once all of the equipment has been installed, there will be a period of start-up, optimization, and compliance testing that will typically be completed some time between the 42nd and 51st week from the RFQ. It typically takes 2-4 weeks to complete the start-up after the installation; 2-4 weeks for the optimization; and approximately 3 weeks for the compliance testing.

SNCR Project Activity	Responsibility	Weeks from Commercial RFQ Date
RFQ Issued	Customer	0
APC Manufacturer Issues Proposal	Customer	2-4
Bid Evaluation and Negotiation	Customer	4-8
Receipt of Purchase Order	Customer	8
Begin Equipment Design	APC Manufacturer	9
Begin CFD/CKM Modeling ^a	APC Manufacturer	9
Submit P&ID Drawings ^b	APC Manufacturer	12
Customer P&ID Drawing Review and Comment	Customer	14
Submit General Arrangement Drawings	APC Manufacturer	16
Submit Modeling Report	APC Manufacturer	16
Customer Comments Received	Customer	18
Start Equipment Fabrication	APC Manufacturer	18
Equipment Shipment	APC Manufacturer	34
Installation Complete (Outage work for injection port installation)	TBD	8 to 12 weeks (Non-Outage) 1 to 2 weeks (Outage) ^c
Startup Complete	APC Manufacturer	42 to 46 weeks
Optimization Complete	APC Manufacturer	44 to 48 weeks
Compliance Testing Complete	Customer	47 to 51 weeks

^a - Computational fluid dynamic modeling provides in-depth analysis of a complex fluid flow, including detailed flow characteristics (velocity, pressure, turbulence, temperature, species concentration) for process optimization.

^b - P&ID drawings are process flow and instrument drawings that show process flow paths for liquids, solids, and electrical systems.

^c - The injection port installation is done within an outage taken for other scheduled reasons and typically takes from one to two weeks. The injection port installation may be performed at the same time as other equipment fabrication or during another period of the SNCR project and may not add more time to the overall length of the SNCR project.

Selective Catalytic Reduction

Selective catalytic reduction (SCR) technology has been practiced worldwide for over 50 years with hundreds of successful applications in a broad field of industrial applications. Selective catalytic reduction technology has been successfully applied to a wide variety of combustion and chemical process operations including: gas turbines, stationary spark ignition engines, stationary compression ignition engines, refinery heaters, packaged boilers, ethylene cracker furnaces, nitric acid plants, catalyst manufacturing processes, nitrogen fixation processes, and solid/liquid or gas waste incineration equipment. The experience with SCR on industrial applications has been throughout the United States, with high concentrations in California, New Jersey, and Texas due to their more stringent NO_x requirements. SCR has been used by itself and in combination with other technologies, such as SNCR, LNB, and FGR.

The principal of operation for an SCR system is to inject a reducing agent into the hot flue gas upstream of a catalyst. The catalyst accelerates the reaction of the reducing agent with NO_x and is used to broaden the range of operating conditions, market applications, and NO_x destruction efficiencies achievable. The catalyst promotes the selective reaction of NH₃ with NO_x, forming nitrogen and water. Depending on the manufacturer's system, the catalyst may be a packed bed of pellets, extrudates or other particulate shapes, or as rigid honeycomb or plate type cubes that are assembled to form the catalyst bed. The reducing agent for SCR can be anhydrous ammonia, aqueous ammonia, or urea. Care is taken to inject the amount of reducing agent equal to the amount of NO_x in the stream to avoid excess ammonia, or ammonia slip. On most SCR applications, the flue gas temperature for optimum NO_x reduction is typically achieved between 500-1,000 °F. Catalyst designs can be tailored for the applications specific temperature window. For gas-fired boiler applications, catalysts have been designed for optimum performance at lower temperatures between 300-700 °F.

For smaller applications where the exhaust flow rate is 20,000 SCFM or less, SCR systems are supplied in a ready-to-install SCR skid package. SCR skid packages are typically applied on packaged boilers, engines, some chemical processes, etc. In addition, standard SCR packaged systems are available for the complete range of firetube and watertube boilers as well. The primary components of the SCR system include: ammonia storage and delivery system, ammonia injection grid, and catalyst reactor. The ammonia injection grid and SCR catalyst can often be installed immediately before or in the stack, thereby avoiding any modifications to combustion or heat-recovery equipment or negative effects on other upstream plant operations.

For larger applications of 20,000 SCFM or greater, designs permit a modularly constructed system, providing a high degree of flexibility in the design of the SCR system for the specific application, particularly for retrofit applications. This has made the SCR technology a cost-effective retrofit technology for gas-fired industrial boilers, larger chemical installations, distributed generation facilities, and major waste incineration plants.

Installation timing for SCR often depends on the size of the application and will be discussed in terms of those units that have flue gas flowrates less than 20,000 SCFM and those greater than 20,000 SCFM. Since smaller systems are skid mounted and designed for quick installation in the field, the deployment process from bid through startup takes significantly less time than a larger

field erected system. The following table lays out the SCR deployment time from the request for quote issued by the end user to the optimization and compliance testing.

SCR Project Activity	Weeks From Commercial RFQ Date	
	<20,000 SCFM SCR System	>20,000 SCFM SCR System
RFQ Issued	0	0
APC Manufacturer Issues Proposal	1-3	2-4
Bid Evaluation and Negotiation	2-6	4-8
Receipt of Purchase Order	6	8
Client Kick Off Meeting	7	9
Customer GA ^a & P&ID Drawing Review and Comment	9-10	16-20
Drawing Review w/Customer	11-12	18-24
Start Equipment Fabrication	12-13	20-24
Equipment Shop Tested	22-23	36-40
Equipment Shipment	23-24	38-42
Field Installation Complete	26-30	44-52
Startup Complete	27-32	46-56
Optimization & Compliance Testing	28-36	48-58

^a GA – general arrangement drawings are scaled, dimensioned, and annotated to reflect a reasonable layout for the project.

In summary, smaller skid-mounted SCR systems can be supplied from RFQ to compliance testing in 7-9 months or in approximately six (6) months from the purchase order to startup. Most of this time is spent in engineering design, fabrication, and field installation. Larger SCR systems that are field erected from modular components are typically supplied from RFQ to compliance testing in 11-13 months or in 9-12 months from the purchase order to startup.

Non-Selective Catalytic Reduction (NSCR)

Stationary NSCR, as with the automobile sector, involves the use of a three-way catalyst technology to promote the reduction of NO_x to nitrogen and water and simultaneous oxidation of CO and HC to carbon dioxide and water. NO_x is reduced by the CO and H_2 over the catalyst under slightly rich or stoichiometric conditions to produce CO_2 and water with typical conversion efficiencies in the range 80-99 percent achievable together with corresponding decreases in HC and CO.

Non-selective catalytic reduction (NSCR) can be applied to various spark ignited internal combustion engines that are rich-burn, including natural gas-fueled engines. These types of engines are commonly found in the following applications: gas gathering and storage, gas transmission, power generation, combined heat and power, cogeneration/trigeneration, irrigation, inert gas production, and non-road mobile machinery. NSCR has been used routinely in the automotive industry to reduce vehicular carbon monoxide, hydrocarbons, and NO_x emissions with over a billion catalyst units equipped to automobiles since the mid-1970s. The application of NSCR to stationary gas engines for the control of NO_x and CO first became commercially available in North America in the late 1980s and have well over 5,000 stationary engine installations in service today.

In addition to catalysts and housings (converters), NSCR retrofits require installation of an oxygen sensor and feedback controller to maintain an appropriate air-to-fuel ratio under variable load conditions. The catalyst applied to NSCR typically contains active metals such as platinum, palladium, and rhodium and is typically in the form of highly durable metallic monolith elements. NSCR converters are available off-the-shelf for very short turn-around installations. The time required for the deployment of off-the-shelf NSCR products is 6 to 8 weeks and for standard products, 8 to 14 weeks with the following steps:

- 2-4 weeks - bid proposal and evaluation
- 4-6 weeks – engineering and shipping
- 1-2 weeks – installation
- 1-2 weeks – start-up

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