Post-combustion NOx Control for Fired Equipment in General Refinery and Petrochemical Services

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Introduction

Post-combustion NOx control systems reduce levels of NOx emissions by converting the NOx formed during the combustion process to nitrogen (N_2) gas. The chemical reactions required to convert the NOx to N_2 for the systems described in this standard are applied downstream of the combustion zone. These techniques introduce a reactant into the flue gas stream to react with the NOx. The reaction may be completed with or without the use of catalyst.

It may be necessary to combine more than one method of post-combustion control to achieve the desired level of NOx reduction.

The application of any NOx reduction technique and control technology is most often in compliance with an environmental regulation requirement, which include both instantaneous and time averaged performance criteria. Reliable and effective performance of the NOx control systems and related mechanical systems and components are critical in meeting regulatory requirements and environmentally responsible operation.

The fundamental elements that are required in order to provide the expected reliability and performance requirements for post-combustion NOx control systems specified and supplied through the use of this standard include the following:

— process definition;

— process performance expectations;

— system design selection;

— mechanical definition of systems and components.

The selected post-combustion NOx control systems and equipment should be capable of the specified performance for a design period for the run length specified in the data sheets without the need for an unplanned outage of the post-combustion NOx treatment control systems and equipment or the associated combustion equipment.

For new designs, the type of post-combustion NOx control system design selections and mechanical definition can be advanced using the requirements, guidance and recognized good industry practice that are identified in this document.

Users of this Standard should be aware that further or differing requirements may be needed for individual applications. This Standard is not intended to inhibit a vendor from offering, or the purchaser from accepting, alternative equipment or engineering solutions for the individual application. This may be particularly applicable where there is innovative or developing technology. Where an alternative is offered, the vendor should identify any variations from this standard and provide details.

In this Standard, the SI system of units is used. Where practical in this Standard, U.S. Customary units are included in brackets for information.

A bullet (●) at the beginning of a clause or sub-clause indicates that either a decision is required or further information is to be provided by the purchaser. This information should be indicated on data sheets (see examples in Annex N) or stated in the inquiry or purchase order.

Post-combustion NOx Control for Fired Equipment in General Refinery and Petrochemical Services

1 Scope

This standard specifies requirements and provides guidance for the selection, design specification, mechanical description, operation, maintenance, and test procedures for post-combustion NOx control equipment and related mechanical systems and components used for fired equipment in petrochemical and general refinery service.

This document covers the following methods of post-combustion NOx reduction for both new and retrofit applications:

— Selective Non-catalytic Reduction (SNCR), and

— Selective Catalytic Reduction (SCR).

This standard is primarily intended for direct application to fired process heaters, reformers, and industrial and power boilers used in petrochemical and general refinery services. The same fundamental NOx control technologies and systems may also be applied to Fluid Catalytic Cracking Units (FCCUs), incinerators, gas turbine exhaust, and other exhaust gas process systems; however, SCRs may require additional considerations beyond the scope of this standard to address unique aspects, such as high particulate content and corrosive chemicals, in the flue gas stream.

This document does not cover:

— reduced NOx formation through combustion controls and design techniques such as low-NOx burners, flue gas recirculation (FGR), and staged combustion; or

— non-selective catalytic reduction (NSCR) for the control of NOx and other pollutant emissions.

For further guidance on post-combustion NOx control process selection and the application of SNCR and SCR systems, refer to Annex A.

For further guidance on the process description of SNCR and SCR technologies and systems, refer to Annex B and Annex C, respectively.

For further guidance on reactant storage, distribution, control, and injection systems, and general design considerations, including purchaser decisions for SNCR and SCR systems, refer to Annex D and Annex E, respectively.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Standard 560, *Fired Heaters for General Refinery Service*

API Standard 620, *Design and Construction of Large, Welded, Low-pressure Storage Tanks*

AISC *Steel Construction Manual*[1]

AMCA 801:2001[2], *Industrial Process/Power Generation Fans — Specifications and Guidelines*

ANSI/ISA-5.1[3]; *Instrumentation Symbols and Identification*

ANSI/ISA-77.82.01; *Selective Catalytic Reduction (SCR) Control Systems*

ASME *Boiler and Pressure Vessel Code (BPVC)*, *Section VIII: Rules for Construction of Pressure Vessels; Division 1*[4]

ASME B31.3, *Process Piping*

ASTM A123[5], *Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products*

ASTM A143, *Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement*

ASTM A153, *Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware*

ASTM A384, *Standard Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies*

ASTM B633, *Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel*

AWS D1.1/D1.1M[6], *Structural Welding Code — Steel*

AWS D14.6/D14.6M, *Specification for Welding of Rotating Elements of Equipment*

CGA G-2.1/ANSI K61.1[7], *American National Standard Safety Requirements for the Storage and Handling of Anhydrous Ammonia*

EN 13480[8] (all parts), *Metallic industrial piping*

International Building Code (IBC)[9]

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[1] American Institute of Steel Construction, One East Wacker Drive, Suite 700, Chicago, Illinois 60601-1802, www.aisc.org.

[2] Air Movement and Control Association International, Inc., 30 W. University Drive, Arlington Heights, Illinois 60004, www.amca.org.

[3] The International Society of Automation 67 T.W. Alexander Drive, P.O. Box 12277, Research Triangle Park, North Carolina 27709, www.isa.org.

[4] ASME International, 2 Park Avenue, New York, New York 10016-5990, www.asme.org.

[5] ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.

[6] American Welding Society, 8669 NW 36 Street, #130, Miami, Florida 33166-6672, www.aws.org.

[7] Compressed Gas Association, 14501 George Carter Way #103, Chantilly, Virginia 20151, www.cganet.com.

[8] European Committee for Standardization, Avenue Marnix 17, B-1000 Brussels, Belgium, www.cen.eu.

[9] International Code Council, 500 New Jersey Avenue, NW, 6th Floor, Washington, D.C. 20001, www.iccsafe.org.

ISO 1461[10] *Hot dip galvanized coatings on fabricated iron and steel articles — Specifications and test methods*

ISO 8501-1, *Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness — Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings*

ISO 10684, *Fasteners — Hot dip galvanized coatings*

National Board Inspection Code Data Reports[11]

NFPA 70[12], National Electrical Code

SSPC SP 6[13]/NACE No. 3, *Joint Surface Preparation Standard: Commercial Blast Cleaning*

40 CFR Part 60[14]; *United States Code of Federal Regulations – Standards of Performance for New Stationary Sources*

UL[15], Underwriters Laboratories, Inc.

3 Terms, Definitions, and Abbreviations

3.1 Definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1
ammonium bisulfate
ammonium sulfate
Compounds formed when ammonia from ammonia or urea injection into a flue gas stream combine with sulfur trioxide. These compounds may foul heat transfer surface, deactivate the catalyst, and increase particulate emissions.

3.1.2
ammonia breakthrough
The point at which increasing the NH_3/NOx molar ratio does not significantly reduce the amount of NOx.

3.1.3
ammonia flow control unit (AFCU)
A unit, typically skid mounted, that is used to vaporize ammonia, pump air, and mix the ammonia and air prior to being sent to the ammonia injection grid (AIG). The AFCU is also known as the reactant control and dilution system (RCDS).

3.1.4
Ammonia/NOx ratio
The molar ratio of injected ammonia to the inlet NOx in the flue gas stream.

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[10] International Organization for Standardization, 1, ch. de la Voie-Creuse, Case postale 56, CH-1211, Geneva 20, Switzerland, www.iso.org.

[11] The National Board of Boiler and Pressure Vessel Inspectors, 1055 Crupper Avenue, Columbus, OH 43229, www.nationalboard.org.

[12] National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts, 02169-7471, www.nfpa.org.

[13] The Society for Protective Coatings, 40 24th Street, 6th Floor, Pittsburgh, Pennsylvania 15222, www.sspc.org.

[14] U.S. National Archives and Records Administration, 700 Pennsylvania Avenue, NW, Washington, DC 20408, www.archives.gov.

[15] UL LLC, 333 Pfingsten Road, Northbrook, Ilinois 60062 USA. www.ul.com.