

DEP SPECIFICATION

**POST COMBUSTION NO_x CONTROL FOR
FIRED EQUIPMENT
(AMENDMENTS/SUPPLEMENTS TO API RP 536)**

DEP 31.24.00.10-Gen.

February 2015

DESIGN AND ENGINEERING PRACTICE



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PART I INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for design, materials, fabrication, inspection, testing, preparation for shipment, and erection of Post Combustion NOx Control for Fired Equipment. It includes related equipment such as ammonia injection system, ammonia control and dilution system components and flue gas ducts.

This DEP is based on API Recommended Practice 536, Second Edition, December 2006. Part III of this DEP amends, supplements and deletes various clauses of API RP 536. Part III follows the clause numbering of API RP 536 for easy reference.

All clauses of API RP 536 not modified by this DEP remain valid as written.

This DEP specifies requirements for new SCR and SNCR equipment, as typically encountered. Typical installations that are included are fired heaters for general refinery service as covered in API 560/ISO 13705, FCCUs, ethylene cracking furnaces, boilers, HRSG installations, incinerators and waste incineration plants.

This is a revision of the DEP of the same number dated February 2014; see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorised access to DEPs does not for that reason constitute an authorization to any documents, data or information to which the DEPs may refer.

This DEP is intended for use facilities related to oil and gas production, gas handling, oil refining, chemical processing and gasification. Application in other facilities may also apply.

When DEPs are applied, a Management of Change (MOC) process shall be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this DEP the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned with the object of obtaining agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant authorized to act for, and on behalf of, the Principal.

The word **shall** indicate a requirement.

The word **should** indicate a recommendation.

1.3.2 Specific definitions

Term	Definition
AFCU	Ammonia Flow Control Unit
AIG	Ammonia Injection Grid
CFD	Computational Fluid Dynamics
EPA	(US) Environmental Protection Agency
FCCU	Fluid Catalytic Cracking Unit
HRSG	Heat Recovery Steam Generator
IPF	Instrumented Protective Function (safeguarding by instrumentation)
LEL	Lower Explosion Limit
PEFS	Process Engineering Flow Schemes (also known as Process and Instrumentation Diagrams, P&IDs)
RCDS	Reactant Control and Dilution System
Reactor	The housing that contains the catalyst modules and support structure
RMS	Root Mean Square
SCR	Selective Catalytic Reduction
SNCR	Selective Non Catalytic Reduction
TSOV	Tight Shut Off Valves (safety shut off valves)
VS	Vaporization System

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section or clause number is shown in brackets (). Other documents referred to in this DEP are listed in (Part IV).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a minor revision of the DEP of the same number dated February 2014. The following are the main, non-editorial changes.

- Revision of several 'shall' statements into 'should' statements
- A few requirements deleted as they were repeated in other sections
- Additional sub text provides clarity and gives better explanation to some specifications
- Some clarifications to specific requirements have been deleted from the Specification and moved to DEP 31.24.00.10-Gen. Informative.

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be submitted to the Administrator using one of the following options:

Shell DEPs Online (Users with access to Shell DEPs Online)	Enter the Shell DEPs Online system at https://www.shelldeps.com Select a DEP and then go to the details screen for that DEP. Click on the "Give feedback" link, fill in the online form and submit.
DEP Feedback System (Users with access to Shell Wide Web)	Enter comments directly in the DEP Feedback System which is accessible from the Technical Standards Portal http://www.shell.com/standards . Select "Submit DEP Feedback", fill in the online form and submit.
DEP Standard Form (Other users)	Use DEP Standard Form 00.00.05.80-Gen. to record feedback and email the form to the Administrator at standards@shell.com .

Feedback that has been registered in the DEP Feedback System by using one of the above options will be reviewed by the DEP Custodian for potential improvements to the DEP.

1.7 DUAL UNITS

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

1.8 NON NORMATIVE TEXT (COMMENTARY)

Text shown in italic style in this DEP indicates text that is non-normative and is provided as explanation or background information only.

Non-normative text is normally indented slightly to the right of the relevant DEP clause.

1.9 DECISIONS

A bullet (•) is shown in the margin of this DEP where further decisions or information are to be provided by the Principal or Contractor. Refer to Standard Form DEP 31.24.00.83-Gen. for recording decisions on the bulleted items indicated in this DEP.

PART II GENERAL REQUIREMENTS

1.1 GENERAL

1. (Part III) of this DEP is written as amendments and supplements to API RP 536.
2. For ease of reference, the clause numbering of API RP 536 has been used throughout (Part III) of this DEP.
3. Clauses in API RP 536 that are not mentioned in this DEP shall remain valid as written.
4. Unless specified otherwise in this DEP, all occurrences of the word “should” in chapter 5 (Design Considerations) and chapter 6 (Operational Considerations) of API RP 536 shall be replaced with the word “shall”.
5. Where API RP 536 makes reference to API 560, it shall be replaced with DEP 31.24.00.30-Gen. ISO 13705 is a replacement to API 560.
6. For water-tube boilers and auxiliary installations located in the EU, EN 12952-14 is applicable in addition to this DEP. This European Standard covers the safety requirements regarding the storage and use of:
 - a. liquefied pressurized ammonia for steam boiler plants;
 - b. liquid ammonia water solution for the reduction of NO_x in the flue gas from boiler plants.

PART III AMENDMENTS/SUPPLEMENTS TO API RP 536

2 Applicable Environmental Regulations and References

2.4 NATIONAL STANDARDS & PUBLICATIONS

Add to this clause:

EN 12925-14 Water-tube boilers and auxiliary installations - Part 14: Requirements for flue gas DENO_x systems using liquefied pressurized ammonia and ammonia water solution

CGA G-2.1 American National Standard Safety Requirements for the Storage and Handling of Anhydrous Ammonia (ANSI K61.1)

Add new clause:

2.5 OTHER REGULATIONS

- Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control): Best Available Techniques (BAT) Reference Document for the Refining of mineral oil and gas
- IFC (International Finance Corporation), World Bank Group, Welcome to the Environmental, Health, and Safety (EHS) Guidelines
- Shell HSSE & SP Control Framework, Section 06 Environment

4 Processes Description, Considerations, and Applications

4.2 SELECTIVE CATALYTIC REDUCTION

4.2.2 Catalyst Types

4.2.2.1 Platinum Based Catalysts

Add to this clause:

1. Platinum based catalysts should not be applied when total SO_x content in the flue gas is above 35 mg/Nm³ (3% Oxygen, dry).

4.2.2.3 Zeolite Catalyst

Add to this clause:

1. Zeolite catalysts should not be applied unless approved by Principal.

4.3 PROCESS CONSIDERATIONS

4.3.3 NO_x Reduction from Initial NO_x Values

4.3.3.2 SCR Technology

Add to this clause:

1. Except for HRSG installations, the design of SCR system, AIG and related ductwork shall be supported via either 3-dimensional CFD flue gas flow modeling, or physical cold flow modeling. This modeling shall be conducted to ensure proper temperature, velocity and NH₃ distribution is achieved. The results from this modeling will also define the requirements for static mixer and/or flow straightener devices.
2. Flue gas should be distributed evenly over the AIG and catalyst, to meet the desired NO_x and NH₃ emissions requirements as specified.
3. Maximum maldistribution allowed shall be as follows: ±5% RMS in NH₃/NO_x ratio, ±20 °F for temperature, ±15 % RMS for velocity or flow distribution, for each load.

4. Maximum maldistribution should not exceed the Supplier's flow distribution requirements with respect to flue gas emissions.

5 Design Considerations

5.1 GENERAL

5.1.1 Typical Design Considerations

Add to this clause:

1. The SCR/SNCR design shall be proven in practice, robust and capable for a minimum of 3 years, or at least for the duration of a full turn around period of the plant.
2. The guaranteed catalyst life (performance) shall be a minimum of 3 years, or at least for the duration of a full turn around period of the plant.
3. Safeties, ease of operation, inspection, maintenance, repair, cleaning and long term reliability are of major importance.
- 4. The Principal shall specify whether the SCR/SNCR equipment need to be designed for outdoor or indoor conditions. The catalyst reactor maybe part of fired equipment installation located outdoor while other equipment like AFCU and VS maybe located indoor.
5. If there is danger of freezing during operation to equipment, parts, piping or drainage systems, protection against such freezing need to be provided.
- 6. The Principal shall specify whether direct liquid ammonia will be injected in the flue gas or whether the ammonia will first be vaporized and mixed with a carrier gas before injection in the flue gas. For HRSG installations ammonia shall be vaporized and mixed with a carrier gas before injection in the flue gas.
7. Urea shall not be used as source of reactant, unless approved by Principal.
- 8. The Principal shall specify whether aqueous or anhydrous ammonia will be used for the process and in case of aqueous ammonia what solution quality will be used.

Note that in the US, aqueous ammonia is frequently delivered at 19 % NH_4OH solution. This is due to the regulations requiring a Risk Management Plan and a Process Safety Management Plan if the solution of ammonia is greater than 20 %.
9. The ammonia solution shall contain less than 50 ppm impurities, e.g., chlorides, sodium, phosphates and potassium.
- 10. The Principal shall specify the required NO_x removal efficiency, NH₃ slip and limit for SO₂ to SO₃ conversion, which will set design targets for the catalyst.
 - a. In case of high concentration of NH₃ and SO₃ in the flue gas downstream SCR equipment, fouling from ammonium (bi) sulphate will occur on cold (heating) surface that is below condensation temperature of ammonium (bi) sulphate.
 - b. In such case, the location of SCR equipment relative to any downstream heating surface and/or air preheater should be carefully selected, including; ID fans, ductwork, analysis equipment, etc.
- 11. The Principal shall specify space requirements and provisions to install future catalyst layers that need to be provided. The Manufacturer/Supplier shall advise in the proposal, the number of additional modules or catalyst volume which may be accommodated and the predicted operational consequences (i.e., dP, flow distribution, SO₂ to SO₃ generation, etc.).
- 12. A NH₃ slip analyser can be deployed directly downstream the catalyst to detect over-injection of ammonia into the flue gas, but is not part of the control system. The Principal shall specify whether NH₃ slip analyser is required and the type/model to be applied.