

DRY ELECTROSTATIC PRECIPITATORS

DEP 31.27.21.30-Gen.

November 2003
(DEP Circular 09/04 has been incorporated)

DESIGN AND ENGINEERING PRACTICE



This document is restricted. Neither the whole nor any part of this document may be disclosed to any third party without the prior written consent of Shell Global Solutions International B.V. and Shell International Exploration and Production B.V., The Netherlands. The copyright of this document is vested in these companies. All rights reserved. Neither the whole nor any part of this document may be reproduced, stored in any retrieval system or transmitted in any form or by any means (electronic, mechanical, reprographic, recording or otherwise) without the prior written consent of the copyright owners.

PREFACE

DEPs (Design and Engineering Practice) publications reflect the views, at the time of publication, of:

Shell Global Solutions International B.V. (Shell GSI)

and

Shell International Exploration and Production B.V. (SIEP)

and

Shell International Chemicals B.V. (SIC)

and

other Service Companies.

They are based on the experience acquired during their involvement with the design, construction, operation and maintenance of processing units and facilities, and they are supplemented with the experience of Group Operating companies. Where appropriate they are based on, or reference is made to, international, regional, national and industry standards.

The objective is to set the recommended standard for good design and engineering practice applied by Group companies operating an oil refinery, gas handling installation, chemical plant, oil and gas production facility, or any other such facility, and thereby to achieve maximum technical and economic benefit from standardization.

The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where DEPs may not cover every requirement or diversity of condition at each locality. The system of DEPs is expected to be sufficiently flexible to allow individual operating companies to adapt the information set forth in DEPs to their own environment and requirements.

When Contractors or Manufacturers/Suppliers use DEPs they shall be solely responsible for the quality of work and the attainment of the required design and engineering standards. In particular, for those requirements not specifically covered, the Principal will expect them to follow those design and engineering practices which will achieve the same level of integrity as reflected in the DEPs. If in doubt, the Contractor or Manufacturer/Supplier shall, without detracting from his own responsibility, consult the Principal or its technical advisor.

The right to use DEPs is granted by Shell GSI, SIEP or SIC, in most cases under Service Agreements primarily with companies of the Royal Dutch/Shell Group and other companies receiving technical advice and services from Shell GSI, SIEP, SIC or another Group Service Company. Consequently, three categories of users of DEPs can be distinguished:

- 1) Operating companies having a Service Agreement with Shell GSI, SIEP, SIC or other Service Company. The use of DEPs by these operating companies is subject in all respects to the terms and conditions of the relevant Service Agreement.
- 2) Other parties who are authorized to use DEPs subject to appropriate contractual arrangements (whether as part of a Service Agreement or otherwise).
- 3) Contractors/subcontractors and Manufacturers/Suppliers under a contract with users referred to under 1) or 2) which requires that tenders for projects, materials supplied or - generally - work performed on behalf of the said users comply with the relevant standards.

Subject to any particular terms and conditions as may be set forth in specific agreements with users, Shell GSI, SIEP and SIC disclaim any liability of whatsoever nature for any damage (including injury or death) suffered by any company or person whomsoever as a result of or in connection with the use, application or implementation of any DEP, combination of DEPs or any part thereof, even if it is wholly or partly caused by negligence on the part of Shell GSI, SIEP or other Service Company. The benefit of this disclaimer shall inure in all respects to Shell GSI, SIEP, SIC and/or any company affiliated to these companies that may issue DEPs or require the use of DEPs.

Without prejudice to any specific terms in respect of confidentiality under relevant contractual arrangements, DEPs shall not, without the prior written consent of Shell GSI and SIEP, be disclosed by users to any company or person whomsoever and the DEPs shall be used exclusively for the purpose for which they have been provided to the user. They shall be returned after use, including any copies which shall only be made by users with the express prior written consent of Shell GSI, SIEP or SIC. The copyright of DEPs vests in Shell GSI and SIEP. Users shall arrange for DEPs to be held in safe custody and Shell GSI, SIEP or SIC may at any time require information satisfactory to them in order to ascertain how users implement this requirement.

All administrative queries should be directed to the DEP Administrator in Shell GSI.

TABLE OF CONTENTS

1.	INTRODUCTION	5
1.1	SCOPE	5
1.2	DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS	5
1.3	DEFINITIONS	5
1.4	CROSS-REFERENCES	6
1.5	SUMMARY OF MAIN CHANGES	6
1.6	COMMENTS ON THIS DEP	6
2.	ESP DESCRIPTION	7
2.1	ESP FUNCTIONALITY	7
2.2	DUST DISPOSAL	8
3.	DESIGN AND ENGINEERING	9
3.1	GENERAL DESCRIPTION	9
3.2	ESP CASING, INCLUDING INLET AND OUTLET TRANSITIONS	10
3.3	GAS DISTRIBUTION DEVICES	10
3.4	ELECTRODE ASSEMBLIES	10
3.5	ELECTRODE CLEANING MECHANISM	11
3.6	DUST HOPPERS AND DISCHARGE SYSTEM	12
3.7	OBSERVATION AND ACCESS	13
3.8	SUPPORT STRUCTURE AND FOUNDATION	13
3.9	DESIGN OF DUCTING	14
3.10	PIPING AND PIPING CONNECTIONS	15
3.11	DAMPERS AND ISOLATORS	15
3.12	STEEL STACKS	17
3.13	FANS	17
3.14	CHEMICAL DOSING INSTALLATION FOR FLUE GAS CONDITIONING	17
3.15	GAS FLOW INDUCED VIBRATIONS	18
4.	SURFACE PREPARATION, PAINTING AND COATING	19
5.	INSULATION	20
6.	ELECTRICAL INSTALLATIONS	21
6.1	GENERAL DESCRIPTION	21
6.2	MAINS ELECTRICITY SUPPLY	21
6.3	MAINS VOLTAGE DISTORTION	21
6.4	ELECTRICAL CONTROL CUBICLE	21
6.5	TRANSFORMER RECTIFIER UNITS (T-R SETS)	22
6.6	HIGH VOLTAGE DISCHARGE SYSTEM	23
6.7	ELECTRIC MOTORS	24
6.8	ANTI-CONDENSATION AND HEATING SYSTEMS	24
6.9	LIGHTING AND POWER INSTALLATION	24
6.10	EARTHING SYSTEM	24
7.	INSTRUMENTATION AND CONTROL	25
7.1	GENERAL DESCRIPTION	25
7.2	INSTRUMENTATION	25
7.3	AUTOMATIC CONTROL UNIT	25
7.4	INSTRUMENTED PROTECTIVE FUNCTION	26
8.	NOISE LIMITATIONS	27
8.1	GENERAL DESCRIPTION	27
8.2	INFORMATION TO BE SUBMITTED WITH THE TENDER	27
9.	ADDITIONAL REQUIREMENTS	28
9.1	NAMEPLATES AND RATING PLATES	28
9.2	SPECIAL TOOLS	28
9.3	MAINTENANCE MANUAL	28
9.4	SPARE PARTS	28
10.	MATERIAL, FABRICATION AND CONSTRUCTION	29

10.1	GENERAL	29
10.2	CONSTRUCTION MATERIALS.....	29
10.3	WELDING	29
10.4	PIPING FABRICATION.....	29
10.5	GASKETS AND PACKING	29
11.	PACKAGING, TRANSPORT AND SHIPPING	30
12.	INSPECTION AND TESTING.....	31
12.1	INSPECTION AND TESTING OF MATERIALS AND EQUIPMENT	31
12.2	SCOPE OF INSPECTION WORK	31
12.3	REPORTING.....	31
13.	ERECTION, START-UP AND PERFORMANCE TESTING	33
13.1	MECHANICAL ERECTION.....	33
13.2	AIR LOAD TEST	33
13.3	START-UP	34
13.4	PERFORMANCE/ACCEPTANCE TESTING.....	34
14.	DOCUMENTATION	36
14.1	GENERAL.....	36
14.2	DATA/REQUISITION SHEETS AND DOCUMENTATION REQUIRED AT TENDERING.....	36
14.3	DOCUMENTATION AND INFORMATIONS REQUIRED AFTER CONTRACT AWARD.....	37
15.	GUARANTEE	39
16.	REFERENCES	40

APPENDICES

APPENDIX1	SCOPE OF SUPPLY AND TERMINAL POINTS	43
APPENDIX 2	TYPICAL RIGID FRAME ESP	44
APPENDIX 3	TYPICAL COLLECTING ELECTRODE DESIGNS	45
APPENDIX 4	AIR LOAD TEST PROCEDURE.....	46
APPENDIX 5	TYPICAL DISCHARGE ELECTRODE SUPPORT.....	47
APPENDIX 6	TYPICAL HAMMER RAPPER SYSTEM.....	48
APPENDIX 7	TYPICAL ELECTROMAGNETIC IMPACT RAPPER SYSTEM	49
APPENDIX 8	DANGER NOTICE.....	50

1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for the design, fabrication, assembly, erection, inspection, testing and commissioning of dry electrostatic precipitators (ESPs).

This DEP covers hot and cold ESPs of both horizontal and vertical construction. Wet collection ESPs are excluded from the scope of this DEP.

This DEP is a revision of the DEP of the same number dated December 1992; a summary of the main changes is given in (1.5).

The installation shall comprise the equipment listed on a sheet entitled 'Scope of Supply'. The limits of supply shall be listed and defined on a sheet entitled 'Terminal points'. For guidance, typical examples of a 'Scope of supply' and 'Terminal points' are given in Appendix 1.

To facilitate exchange and assessment of information by the Principal and the Supplier, use shall be made of data/requisition sheets DEP 31.27.21.94-Gen.; the purpose of these sheets is described in (14).

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI and SIEP, the distribution of this DEP is confined to companies forming part of or managed by the Royal Dutch/Shell Group, and to Contractors nominated by them.

This DEP is intended for use in oil refineries, chemical plants, gas plants and exploration and production facilities as well as distribution storage depots and installations. When DEPs are applied, a Management of Change (MOC) process should 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 which 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 which manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions and abbreviations

aspect ratio	ratio of the total collecting plate length over height
bus section	ESP portion that is independently energized
cells	bus sections arranged perpendicular to the gas flow
chamber	gas-tight longitudinal subdivision of the ESP
collecting electrode	particulate collecting surface
crest factor	ratio of the peak value to the rms value of the periodic wave form
discharge electrode	emitting and corona-establishing surface
efficiency	weight fraction of collected particles divided by the total particulates entering the ESP, as a percentage
electrodes	both the discharge and collecting electrodes
ESP	dry electrostatic precipitator
FCCU	fluidised catalytic cracking unit
fields	bus sections arranged in the direction of the gas flow. Each field is fully separated both electrically and mechanically from any adjacent field
IPF	instrumented protective function. A function comprising the initiator function, logic solver function and final element function for the purpose of preventing or mitigating hazardous situations. See DEP 32.80.10.10-Gen.
IPS	instrumented protective system. The electromechanical, electronic and/or programmable electronic logic solver component of the instrumented protective function, complete with input and output equipment.
T-R set	transformer and rectifier unit
velocity, face or gas	average velocity of the gas across the ESP

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. Other documents referenced in this DEP are listed in (16).

1.5 SUMMARY OF MAIN CHANGES

A summary of the main changes since the last revision of this DEP are as follows:

Section	Description
3.4.1	Wire-plate alignment tolerance added
3.6.2	Recommendation for taking dust sample added
3.6.5	Hopper level measurement added
6.10	Recommendation for earthing added
7.4	Instrument trip modified

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be sent to the DEP Administrator at standards@shell.com. Shell staff may also post comments on this DEP on the Surface Global Network (SGN) under the Standards/DEP 31.27.21.30-Gen. folder. The DEP Administrator and DEP Author monitor these folders on a regular basis.

2. ESP DESCRIPTION

2.1 ESP FUNCTIONALITY

ESPs are used to control air pollution (e.g. flue gas cleaning) by collecting solid particulates typically in the range of 10 μm and smaller.

ESPs are used for the exhaust gas cleaning of boilers, incinerators and regenerators of catalytic cracking units.

The electrostatic precipitation process can be either dry or wet. Dry collectors have certain advantages over wet collectors in that dry collection simplifies handling and saves costs of processing the particulates. Handling and disposal of the collected material shall be planned with account being taken of the need for cooling, ventilation or other precautions. Without cooling, the temperature limits of equipment will have to be considered and dry dusty material, if hygroscopic, may cause caking. Also, the precipitate may be pyrophoric.

Depending on the nature of the particulate in question (e.g. a liquid residue), wet collection may be required. Wet collection ESPs are not covered by this DEP.

Although ESPs are available in many types and configurations, they all work on the same principle, i.e.:

- electrical charging of the suspended particulates;
- collection of the charged particulates in an electric field;
- removal of the precipitated material.

The ESP efficiency depends on a number of variables including particulate resistivity, gas composition, plate area, gas residence time, electrical field strength and particle migration velocity. It is therefore of major importance to measure the resistivity, volatile content, particle size distribution, solids concentration and solids flow tests (a measure of the powder cohesiveness as indicated in Appendix 9) before selecting the type and size of ESP or selecting the solids transport and handling system for a representative sample of the dust that is to be removed. The migration velocity is an important parameter for the degree of efficiency and size of particles to be collected. The migration velocity of the particle is the result of the balance between the attracting Coulomb and retarding Stokes drag forces. It increases with particle diameter, particle charge and collecting field strength. Efficiencies are usually in the range of 85% to 95%.

Dry ESPs contain the following basic components, refer to Appendix 2.

- casing;
- gas distribution screens (inlet and outlet);
- high tension T-R set(s);
- field(s) with discharge electrodes and collecting electrodes;
- rappers;
- hoppers.

In refinery applications, ESPs are described either as 'hot' or as 'cold', depending on the operating temperature range. ESPs operating at temperatures above approximately 220 °C are classed as hot ESPs.

Since each type has its specific requirements and serves a particular purpose, selection shall be based on the process and particulate properties.

Where appropriate, further explanations are included in the general sections of the individual component descriptions.

2.2 DUST DISPOSAL

Depending on the nature of the separated dust, disposal of the dust shall be considered an integral part of the system design. In some cases there may be a market for the dust (e.g. the cement industry) as an alternative to disposal as chemical waste.

3. DESIGN AND ENGINEERING

3.1 GENERAL DESCRIPTION

For design, engineering, fabrication, inspection and testing, the Supplier shall adhere to internationally accepted industry standards and practices, supplemented by the requirements of this DEP. Specific standards or codes may be specified by the Principal if local conditions so dictate.

SI units shall be used throughout the design.

The ESP shall be of the dry plate type, suitable for continuous outdoor operation. Both 'European' and 'American' designs may be employed.

The design shall be proven in practice, robust and reliable. Safety, ease of operation, inspection, maintenance, repair and cleaning are of particular importance.

The design of the equipment shall be both technically and economically justified in such a way that the absolute minimum of operating personnel and maintenance is required for continuous operation.

The ESP shall be designed for the maximum specified throughput, i.e. for the combined peak flowrate and dust load specified by the Principal, and the equipment configuration shall have sufficient flexibility to cope with a fluctuating dust load and/or soot load, if applicable.

The aspect ratio of the ESP shall be at least 1.0.

The applicable local and national regulations shall be stated by the Supplier on the data/requisition sheets. The Supplier shall obtain all local approvals and certificates as needed.

The Supplier shall give full details of the chemical and physical properties of the construction materials.

All metal surfaces in contact with flue gases shall be at a higher temperature than the highest dew point (acid or water, as applicable) which may occur during any of the operating conditions in combination with any of the flue gas compositions specified in the data/requisition sheets.

There shall be sufficient space and access for inspection, cleaning, removal and maintenance of such parts as rapping gear, electrodes, insulators, T-R sets, valves, fans and electric motors.

Arrangements and written procedures for the removal of emitting electrodes and rapping gear shall be provided.

There shall be adequate protection to prevent personnel touching surfaces hotter than 70 °C.

Before the contract is awarded the Supplier shall satisfy the Principal that, at all loads, an even distribution of flue gas across the ESP passages is achieved and ESP efficiency is equal to or better than the specified emission limit. Flue gas flow model studies should be performed where limited available plot space requires difficult inlet and outlet configurations.

Under adverse conditions the flue gases entering the ESP may contain or consist of flammable mixtures. Although ESP operation is aimed at the non-sparking condition, regular sparks will occur and in combination with these flammable mixtures may present a potential explosion or fire hazard in the ESP. Any need for specific safety precautions shall be reviewed by the Supplier in consultation with the Principal.

3.2 ESP CASING, INCLUDING INLET AND OUTLET TRANSITIONS

The casing shall be designed for a combination of gas design pressure and temperature, and wind/snow/seismic loads, see DEP 34.00.01.30-Gen. The design pressure shall be based on the maximum operating pressure and/or vacuum in the casing.

The casing shall be all-welded and gas-tight, minimum 6 mm thick steel sheeting material, stiffened by steel sections. A corrosion allowance of 2 mm shall be included in the design.

There shall be no restriction to the free expansion of internals or insulation/sheeting.

The materials shall be adequate for the medium and temperature of service.

All elements and panels shall be sufficiently stiffened against damage during transport, erection, and mechanical vibration. Stiffening shall not interfere with the free expansion of the casing.

The casing design and construction shall facilitate the removal and/or installation, at site, of internals. The design shall further allow convenient access for removal and installation of discharge electrodes.

Thermal insulation of the casing shall be external (see 5).

3.3 GAS DISTRIBUTION DEVICES

An even gas flow distribution across the entire cross-section is critical in the design and operation of the ESP.

Gas velocities in the upstream duct may generally range from 6 m/s to 25 m/s and are too high for adequate particle separation. A swaged inlet plenum with gas distributors shall be used to create a uniform inlet flow profile. Gas velocities in the ESP passages are typically between 0.5 m/s and 2.5 m/s; the optimum gas velocity to achieve efficiencies of 90% and better is approximately 1.0 m/s.

Inlet and outlet plenums (transition sections) contain perforated plates and flow distribution devices, to guarantee even gas velocities throughout the treatment zone. Deviation from the average gas velocity at any point in a gas passage shall be not more than 20%. The inlet plenum shall be designed so that collected particles will be discharged into the first ESP hopper. Dedicated rappers are recommended for the inlet gas distributors.

3.4 ELECTRODE ASSEMBLIES

3.4.1 General description

The discharge electrodes ionise the flue gas, which charges the particulates and creates the electric field. The corona is established between high voltage fine wire or strip electrodes and the collecting plate electrodes at ground potential. A high voltage pulsating direct current produces a uni-directional but non-uniform electric field. The particulates passing through the corona field are subjected to intense bombardment by negative ions and become charged in 0.01 seconds or less, and are attracted to the collecting electrodes.

The resistivity of the particulates is such that a portion of the charge is retained. This contributes to the adhesive and cohesive forces which retain the particulates on the collecting plates. Dust layers can build up to a thickness of several millimetres. However, if the layers become too thick they will act as an insulator and reduce the strength of the field. Therefore, it is necessary to periodically remove deposited particulates from these collecting plates.

Precipitator performance is optimised by segregating the electrodes into fields. Separate fields are needed due to the differing power requirements in the ESP. High dust concentrations at the front end of the ESP tend to suppress corona current, therefore demanding high voltage inputs for particle charging. Further downstream in the ESP, where dust concentrations are lower, corona current flows more easily. Any excessive sparking in the downstream section would, if that section is equipped with only one power set, limit the

power input to the entire ESP. Therefore, ESPs shall have two or more fields and shall have some redundancy to cope with outages. The degree of sectionalisation of the high-tension sections shall be advised by the Supplier.

Collecting electrode spacing shall be minimum 200 mm and maximum 400 mm. The accepted tolerance for the wire-plate spacing is ± 12 mm.

3.4.2 Electrodes

Discharge electrodes shall be made from stainless steel strip or wire. In vertical ESPs these discharge electrodes may be secured by screws, with individual weight tensioning. In horizontal ESPs the discharge electrodes may be fitted with points and keyed into a tubular frame.

Collecting electrodes shall be made from cold or hot rolled thin plates with stiffeners, refer Appendix 3. In vertical type ESPs these collecting electrodes may be made as sections and welded in a frame as double sections. In horizontal type ESPs the collecting electrodes are normally executed as single plate sections.

The collecting electrodes shall have an 0.6 mm corrosion allowance, i.e. 0.3 mm on either side. The discharge electrodes do not require a corrosion allowance.

Electrodes shall be suspended from the roof, discharge electrodes shall be supported from insulators, refer Appendix 5.

Electrode types and supporting arrangements shall be selected for ease of construction, repair and access. The supporting construction shall ensure that electrode alignment is optimal during all specified operating conditions.

All internals shall be supported in a satisfactory manner so as to prevent distortion of electrodes. Internals shall not rest on cladding or any internal insulation.

The distance between collecting electrode edges and the inner walls of the casing shall be minimal and by-passing shall be eliminated.

Gas passages and the collecting electrode surface shall be so designed that re-entrainment of particulates will be kept to an absolute minimum and will not be a source of vortex shedding.

3.5 ELECTRODE CLEANING MECHANISM

3.5.1 General

Dust build-up on the collecting electrodes and also on the discharge electrodes has to be removed. Dust can effectively be dislodged from these surfaces by the shearing action of a sharp impulse.

Impact rappers or hammers or acoustic horns shall be used to shock or vibrate both the collecting and discharge electrodes, thereby dislodging the precipitated dust.

Zonal control of rapping shall be provided, as precipitation near the inlet zone will be much higher than that near the outlet zone.

The rapping frequency shall be adjustable and "impact" rappers shall also be provided with adjustable rapping intensity.

3.5.2 Rapping Gear

Rapping equipment, for cleaning the collecting and discharge electrodes, may be executed as:

- pneumatic impulse rappers;
- acoustic horns;
- mechanical rappers, e.g. cam driven hammers, refer Appendix 6;
- electromagnetic impulse rappers, refer Appendix 7.

For both the collecting and discharge electrodes, the electrode supplier shall indicate the following:

- number, arrangement, type, and size of rapping devices required;
- power requirements per rapping device and the installed power;
- frequency control (timer or pressure drop);
- range of frequency and intensity settings;
- typical filtration cycle with respect to the frequency of cleaning;
- time required for cleaning (downtime/year).

3.6 DUST HOPPERS AND DISCHARGE SYSTEM

3.6.1 General

The agglomerated dust drops into hoppers from where it will be removed via a dust discharge system.

Hopper plate thickness is not critical in FCCU applications, and a corrosion allowance is therefore not required. For other applications, a minimum wall thickness of 6 mm and 2 mm corrosion allowance shall be applied.

Hoppers shall be equipped with baffles to prevent gas by-passing and dust re-entrainment. Hopper insides shall be smooth (e.g. no weld beads) and clear from obstructions (e.g. no internal rungs).

Hoppers shall be adequately sized with sufficient over capacity to allow for maintenance and disturbances in the ESP operation. Hoppers shall provide for a 3 day storage capacity. Hopper sizes of ESPs fitted with continuous dust removal equipment may provide for shorter storage capacities subject to agreement by the Principal.

The free space beneath the hopper flanges shall be minimum 3 m, in order to create sufficient access for particulate removal.

Depending on the type of dust, hopper configuration and equipment layout the dust discharge system may be executed as a

- screw conveyor system,
- chain conveyor system,
- gravity dropout system,
- pneumatic conveying system.

The specification of the discharge system shall be subject to the approval of the Principal.

The Supplier shall state his recommendation and full details of the dust discharge system in the tender and shall specify the following.

- hopper type and geometry (e.g. valley angle and angle of repose), size, storage capacity for collected dust, number and location;
- dust removal system (type, capacity, protection against air in-leak and dust blow-back).

Hoppers shall be fitted with vibrators, acoustic horns and/or air cannons if self-emptying cannot be reasonably guaranteed.

The Supplier shall describe all special features and precautions taken to avoid exposure to air when dealing with pyrophoric dust.

3.6.2 Flushing assembly for dust hopper

Depending on the particulate properties, bridging may occur. The Supplier shall review the need for any of the following systems and state his recommendation or design standard in the tender:

- Ring flushing system to fluidize particulates;

- Rappers;
- Accoustic horns
- Poke holes;
- An air-shock system to break bridges

It is recommended that a representative dust sample from the FCC regenerator is taken, to establish a particle size distribution.

3.6.3 Heating for dust hopper

Hopper tips shall be fitted with electrical heat tracing, or heated by other means if agreed by the Principal or if otherwise specified in the data/requisition sheets.

For electric heating systems see (6.8).

3.6.4 Dust hopper outlet valves

Each pyramid hopper outlet shall be equipped with a manually operated slide valve and rotary star valve. Rotary star valves shall not be applied if condensation cannot be prevented (e.g. due to climatic conditions).

For all rotary star valves, data/requisition sheet DEP 31.25.40.93-Gen. shall be completed by the Manufacturer.

3.6.5 Dust hopper level measurement

ESP hoppers may be operated with some fines level inside the hoppers, to prevent flue gas break-through. A reliable level measurement is then essential, as overfilling the hoppers will lead to re-entrainment of collected fines. Gamma ray level indicators are recommended.

3.7 OBSERVATION AND ACCESS

Observation windows shall be provided at the ESP outlet and be equipped with high intensity illumination to allow light rapping puffs to be seen.

Windows shall not be provided on the ESP casing or particulate hoppers.

Where necessary, gas purging shall be provided to keep observation windows sealed, clean and cool. The glasses shall have external covers to prevent cracking.

There shall be a sufficient number of access and inspection doors. Adequate access space shall be provided for each zone or field in the ESP (with a maximum distance of 800 mm between fields). Each particulate hopper shall be provided with an access door. These doors shall be provided with a security catch to prevent inadvertent opening of the access door and unloading of the hopper contents if inadvertently opened.

Access doors shall have a free opening of at least 400 x 400 mm and shall be located on both sides of access spaces.

All access and inspection doors shall be key-interlocked for safety reasons. Padlock systems shall not be used.

3.8 SUPPORT STRUCTURE AND FOUNDATION

3.8.1 General

The ESP foundation shall not be included in the scope of supply and shall be provided by the Principal. The Supplier shall provide the Principal with all necessary information to allow proper foundation design and shall approve the foundation drawings.

The Supplier shall submit sufficient information regarding:

- foundations/piling;
- thermal expansion allowances;

- steel structure;
- access/platforms/stairs;
- access/inspection doors.

3.8.2 Steel structures

Supporting steel structures, platforms, stairs, ladders and railings shall be in accordance with DEP 34.00.01.30-Gen. and DEP 34.28.00.31-Gen.

The general arrangement of stairways shall be in accordance with Standard Drawing S 28.001 and the handrail design should be as shown on Standard Drawing S 28.006.

The steel structure design shall take into account testing and access positions as well as any restrictions imposed by manufacturing, transport or erection.

Further to the above requirements, stairs and platforms shall provide easy access to all valves, gauges, instrument process connections, observation points and access doors, and for all other operational purposes. Ladders may only be used for creating extra means of escape. All stairs, platforms and walkways shall be adequately safeguarded with handrails and toe plates.

All main platforms shall be provided with an emergency means of escape leading down to ground level.

Railings shall be mounted around the roof or roof sections of the ESP where no platforms are required but where access is possible or necessary.

3.9 DESIGN OF DUCTING

3.9.1 General

Ducting, including bends, shall be designed for the maximum operating conditions in the ducting, including vacuum, and a combination of wind/seismic/etc. loads, see DEP 34.00.01.30-Gen.

All ducting shall have a plate thickness of not less than 6 mm, and a 2 mm corrosion allowance shall be included in the design. For FCCU applications no corrosion allowance is required.

The ducting shall be gas tight and smooth, and bends shall have rounded profiles and, if necessary, be fitted with guide vanes. Guide vanes shall be designed to avoid resonance and the formation of eddies in the gas stream; hence they shall have a smooth tapered leading edge. Guide vanes shall be attached to the ducting by welding, and allowance shall be made for differential thermal expansion.

Ducting shall be sufficiently stiffened against mechanical vibration and distortion. Stiffening shall not restrict the free expansion of the ducting in any direction. Effective vibration isolation (e.g. from the ESP) shall be provided where necessary.

All ducting shall be designed so that the free cross sectional area provides stable, uniform, gas flow and acceptable pressure loss. For noise limitations, see (8).

For the design of ducting the average gas velocity shall be limited to a maximum of 25 m/s.

Flanged connections shall be in accordance with Standard Drawing S 24.301.

All ducting shall be self-draining when the inside is washed with water.

Transition pieces between duct sections of different cross-sectional area shall be provided as necessary. They shall be designed to prevent flow detachment from the duct wall and provide the most economic pressure loss.

Diverging sections shall have an included half angle of less than 7.5 degrees. If necessary, guide vanes shall be considered.

Expansion joints shall be provided in the flue gas ducting as necessary; they shall be of the bellows type and shall be gas tight. Expansion joints may be of high temperature fabric, multi-layered and reinforced with stainless steel wires, or steel-bellows type, both with inner smooth bore sleeves. Adequately ventilated rain shields shall be fitted to all expansion joints.

Access doors shall be provided in all sections of the ducting. Access doors shall have a free opening of at least 400 x 400 mm, and shall be in accordance with Standard Drawing S 24.304.

The duct floor shall be sufficiently strong to allow access by maintenance personnel.

Duct supports shall be designed to remove all loads from the ESP casing. Sliding supports shall be designed to allow lateral and axial expansion movements of the ducting.

Thermal insulation of flue gas ducting shall be external, see (5). Where insulation is for personnel protection only, heat shields are an acceptable alternative.

The ducting wall temperature shall be above the highest calculated dew point temperature of the gas for any of the specified operating conditions.

3.9.2 ESP inlet ducting

The ESP inlet ducting shall comprise the complete ducting from terminal point to ESP inlet and, if applicable, bypass ducting or ducting to the bypass stack.

3.9.3 ESP outlet ducting

The flue gas ducting shall comprise the complete ducting from ESP outlet to terminal point and, if applicable, bypass or stack.

3.10 PIPING AND PIPING CONNECTIONS

Piping shall be in accordance with DEP 31.38.01.11-Gen.

Piping nozzles on the ESP and ducting shall be in accordance with Standard Drawing S 10.101.

Instrument process connections shall be in accordance with DEP 31.38.01.12-Gen. unless stated otherwise in the data/requisition sheets.

Piping and piping components shall not be threaded.

Lap joint flanges (including special stub ends) and socket weld flanges shall not be used.

The following nominal pipe sizes should not be used:

DN 30, DN 60, DN 90 and DN 125.

All connections shall extend at least 100 mm beyond the insulation.

3.11 DAMPERS AND ISOLATORS

3.11.1 General

Where required or specified, (bypass) dampers and isolators shall be provided.

If safe access to the ESP is required for shut-down maintenance during normal operations, a plate type isolator shall be provided downstream of the damper. Safe access isolation of the ESP is defined as 100% sealing efficiency at all operating conditions.

Where a damper sealing efficiency of 100% is not specified, a vent valve and standpipe shall be provided on top of the ducting between the damper and the isolator. The standpipe outlet shall be at least 2 m above adjacent platforms or walkways. It shall be effectively protected against the ingress of rain water.