

DEP SPECIFICATION

GAS TURBINE COMBUSTION AIR INTAKE AND EXHAUST SYSTEMS

DEP 31.29.70.32-Gen.

February 2011

DESIGN AND ENGINEERING PRACTICE



© 2011 Shell Group of companies

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, published or transmitted, in any form or by any means, without the prior written permission of the copyright owner or Shell Global Solutions International BV.

PREFACE

DEP (Design and Engineering Practice) publications reflect the views, at the time of publication, of Shell Global Solutions International B.V. (Shell GSI) and, in some cases, of other Shell Companies.

These views are based on the experience acquired during involvement with the design, construction, operation and maintenance of processing units and facilities. Where deemed appropriate DEPs are based on, or reference international, regional, national and industry standards.

The objective is to set the recommended standard for good design and engineering practice to be applied by Shell companies in oil and gas production, oil refining, gas handling, gasification, chemical processing, or any other such facility, and thereby to help achieve maximum technical and economic benefit from standardization.

The information set forth in these publications is provided to Shell companies 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 Units 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 such use, including the quality of their work and the attainment of the required design and engineering standards. In particular, for those requirements not specifically covered, the Principal will typically expect them to follow those design and engineering practices that will achieve at least 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.

The right to obtain and to use DEPs is restricted, and is granted by Shell GSI (and in some cases by other Shell Companies) under a Service Agreement or a License Agreement. This right is granted primarily to Shell companies and other companies receiving technical advice and services from Shell GSI or another Shell Company. Consequently, three categories of users of DEPs can be distinguished:

- 1) Operating Units having a Service Agreement with Shell GSI or another Shell Company. The use of DEPs by these Operating Units is subject in all respects to the terms and conditions of the relevant Service Agreement.
- 2) Other parties who are authorised 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 disclaims 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 or other Shell Company. The benefit of this disclaimer shall inure in all respects to Shell GSI and/or any Shell Company, or companies affiliated to these companies, that may issue DEPs or advise 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, 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. The copyright of DEPs vests in Shell Group of companies. Users shall arrange for DEPs to be held in safe custody and Shell GSI 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	5
1.5	SUMMARY OF MAIN CHANGES	6
1.6	COMMENTS ON THIS DEP	6
2.	GENERAL REQUIREMENTS FOR BOTH AIR INTAKE SYSTEMS AND EXHAUST SYSTEMS	7
2.1	SCOPE OF SUPPLY	7
2.2	OVERALL NOISE LIMITATIONS	7
2.3	QUALITY ASSURANCE	7
2.4	MATERIALS	7
2.5	FASTENERS	7
2.6	WELDING	8
2.7	ELECTRICAL	8
2.8	INSTRUMENTATION	8
2.9	UTILITY SERVICES	9
2.10	EXTERNAL INSULATION	9
3.	AIR INTAKE SYSTEM	10
3.1	SCOPE OF SUPPLY	10
3.2	OVERALL DESIGN	10
3.3	MECHANICAL DESIGN AND ARRANGEMENT	11
3.4	PRIMARY AIR INTAKE	12
3.5	MAIN AIR INTAKE FILTER	12
3.6	AIR INTAKE SILENCER	18
3.7	PLENUM CHAMBER	19
3.8	DUCTWORK	20
3.9	DOORS	20
3.10	ANTI-ICING SYSTEM	21
3.11	INSTRUMENTATION	21
4.	EXHAUST SYSTEM	23
4.1	SCOPE OF SUPPLY	23
4.2	GENERAL DESIGN	23
4.3	EXHAUST PLENUM CHAMBER	23
4.4	EXHAUST SILENCER	24
4.5	EXHAUST DUCTWORK	24
4.6	EXHAUST STACK	24
4.7	EXHAUST EXPANSION JOINTS	25
5.	DOCUMENTATION	26
5.1	TECHNICAL MANUALS	26
5.2	DATA/REQUISITION SHEETS	27
5.3	SPARE PARTS LISTS	28
5.4	OTHER DOCUMENTATION	28
6.	INSPECTION AND TESTING	29
6.1	GENERAL	29
6.2	INSPECTION	29
6.3	TESTS	30
6.4	REPORTS AND RECORDS	30
7.	REFERENCES	31

APPENDICES

APPENDIX 1	SUMMARY OF MONITORING AND PROTECTION INSTRUMENTATION	32
------------	--	----

1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and give recommendations for gas turbine combustion air intake systems and exhaust systems.

For the purposes of this DEP, gas turbine installations are divided into three categories:

- offshore;
- coastal (less than 15 km from the sea);
- inland.

This is a revision of the DEP of the same number dated December 1999; 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 in facilities related to offshore and onshore oil and gas production facilities. This DEP may also be applied in other similar facilities.

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 could 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 with regards to the 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, the objective being to obtain 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 authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

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 by this DEP are listed in (7).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a revision of the DEP of the same number dated December 1999. The following are the main, non-editorial changes.

Old section	New section	Change
3.5.2	3.5.2	Added filter selection for different environments.
3.5.3	3.5.3	Added allowance for a compact filter housing design.
4.6	4.6	Added use of AISI 409 lined exhaust duct.
4.7	4.7	Added use of fabric expansion bellows on square exhaust ducts.

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be sent to the Administrator at standards@shell.com, using the DEP Feedback Form. The DEP Feedback Form can be found on the main page of "DEPs on the Web", available through the Global Technical Standards web portal <http://www.shell.com/standards> and on the main page of the DEPs DVD-ROM.

2. GENERAL REQUIREMENTS FOR BOTH AIR INTAKE SYSTEMS AND EXHAUST SYSTEMS

2.1 SCOPE OF SUPPLY

Unless otherwise agreed in writing with the Principal, the Manufacturer/Supplier shall supply the complete air intake and/or exhaust system as specified by this DEP.

If specified, the scope of supply shall also include the turbine enclosure ventilation air system.

NOTE: Air intake systems and exhaust systems are normally purchased as part of a package including the gas turbine and driven machine. This DEP is primarily directed at the Manufacturer/Supplier(s) of the air intake and exhaust systems. The Manufacturer/Supplier of the package remains responsible for the overall engineering and performance of the package.

2.2 OVERALL NOISE LIMITATIONS

The noise generated by the complete gas turbine package, including the combustion air intake system, the exhaust system and the driven machine, shall not exceed the limits specified in the main package order/enquiry. The Manufacturer/Supplier of the air intake and/or exhaust system shall liaise with the turbine Manufacturer/Supplier to ensure that the design and arrangement of the intake and exhaust systems with silencers will allow the overall limits to be achieved as stated in sections 3.6.1 and 4.4.1.

2.3 QUALITY ASSURANCE

The Manufacturer/Supplier and any Sub-Manufacturer/Supplier shall maintain and operate a quality system which complies with the requirements of ISO 9001 and shall submit with his/their tender(s) a quality control plan for all equipment, listing sequentially all quality-related design, manufacturing, inspection and test activities.

2.4 MATERIALS

Unless otherwise specified, all construction materials including ductwork, all flanges, plenum chamber, filter housing and framework, panel stiffeners, louvers, silencers, doors and internal fittings shall be supplied as unpainted 304L or 316L stainless steel as a base option.

An easily weldable grade of austenitic stainless steel, such as AISI 316L, shall be used for plate materials, rolled sections and other parts that may require welding. If the plenum chamber is inside a turbine enclosure, painted steel may be used if approved by the Principal.

For air intake systems, Manufacturers/Suppliers may, in addition to the base quotation for stainless steel, offer an alternative quotation for aluminium material or non-metallic materials such as glass-reinforced plastic (GRP), indicating the possible weight saving and details of their experience with the alternative material.

If aluminium is offered, the corrosion resistance of that particular grade in a marine environment shall be demonstrated.

2.5 FASTENERS

Threaded and any other fasteners which could conceivably work loose during operation shall, where possible, be restricted to external flanges and brackets where such fasteners do not penetrate the internal surface of the ductwork or housing.

Unless absolutely essential, internal fasteners shall not be used in the air intake system downstream of the filter or in locations in the exhaust system where it is possible for them to fall back into the turbine. Where internal fasteners are absolutely unavoidable, they shall be retained by wire locking or tab washers or otherwise be positively secured. Wire locking shall be done through holes drilled in the nut and bolt heads. Wire shall be either austenitic stainless steel or Monel 400. Welding nut and bolt heads shall only be permitted where no

disassembly is required for maintenance and where wiring is not possible. Lock nuts or methods of securing nuts which rely on friction shall not be used.

Pop rivets shall not be used as fasteners.

2.6 WELDING

All welding shall be performed in accordance with properly documented and controlled procedures and in a planned sequence. Procedures shall be identified on Manufacturer/Supplier drawings against the appropriate joints and shall include any pre- or post-weld heat treatments as well as details of repairs, and the non-destructive testing to be applied.

Only weld repairs which are performed in accordance with properly documented and controlled procedures are permitted.

All welds (except those for external stiffeners) shall be continuous to avoid crevice corrosion of the stainless steel, unless otherwise agreed by the Principal.

All welds shall be inspected in accordance with (6.2.2). Defect acceptance levels shall be in accordance with (6.2.2). Vendors shall submit their welding procedures for review and approval.

2.7 ELECTRICAL

If necessary to meet hazardous area requirements, electrical equipment shall be certified for use in the appropriate zone and gas group conditions, in accordance with national and local industrial regulations.

2.8 INSTRUMENTATION

2.8.1 General

Unless otherwise specified, the monitoring and protection instrumentation as required by this DEP, summarised in (Appendix 1), shall be provided as a minimum.

All instrumentation shall be easily accessible from grade or from permanent elevated platforms.

Unless otherwise specified or agreed, the Manufacturer/Supplier of the air intake and/or exhaust system shall supply all locally mounted instruments, transmitters, micro-switches etc. When required for low emissions, the Principal shall approve the location and amount of ports needed for monitoring exhaust gas.

Remotely mounted instruments, alarm/shutdown switches etc. shall be supplied by the gas turbine Supplier.

The make/type of instruments shall be submitted for the Principal's approval. The Principal reserves the right to nominate the Manufacturer from whom certain instruments shall be obtained.

2.8.2 Pressure measurement

Differential pressure shall be indicated locally by diaphragm type instruments unless otherwise specified.

Remote indication of pressure and differential pressure and the provision of alarm and/or shutdown functions shall be achieved by the use of locally mounted electronic transmitters.

At least three tapings shall be provided for each pressure measurement point. They shall be located so that the possibility of blockage is minimised. The three tapings shall be manifolded together.

2.8.3 Temperature measurement

Air temperature measurement and temperature alarms and/or shutdown functions shall be realised by the use of thermocouples or resistance temperature detectors (RTDs) in

shielded thermowells, in conjunction with locally mounted amplifier/transmitters. As an alternate to a thermowell, the RTD may be inserted into a duct boss.

The thermowells shall protrude into the airstream to a sufficient extent (generally not less than 250 mm) to ensure representative temperature measurement and shall be adequately braced or otherwise supported to avoid aerodynamic excitation.

The arrangement shall be such that the thermocouples or RTDs can be replaced with the turbine in operation.

2.8.4 Position/status indication

If the position/status of doors or other items shall be indicated, this shall be achieved by the use of sealed limit switches or proximity type switches.

The switches shall be mounted externally to the duct, plenum chamber etc. and shall be so arranged that they can be replaced with the turbine in operation.

Mercury switches shall not be used.

2.8.5 Alarms and shutdowns

Alarm and shutdown functions shall utilise separate dedicated switches and/or transmitters.

The alarm and shutdown functions located on a panel indicator in the local turbine control room should be duplicated in the Installation Control Centre for manned installations and in the Local Control Centre for unmanned installations

The Vendor shall be responsible for providing data so that an IPF review can be performed by the Principal.

2.9 UTILITY SERVICES

The Contractor shall advise the Manufacturer/Supplier of available utility services such as AC and/or DC electrical power (giving available voltages), instrument/service air, cooling water etc. The Manufacturer/Supplier shall state the quantity of each utility required.

2.10 EXTERNAL INSULATION

If specified, acoustic and/or thermal insulation shall be provided. Suitable fixtures shall be provided for the attachment of external acoustic and/or thermal insulation to the ductwork.

3. AIR INTAKE SYSTEM

3.1 SCOPE OF SUPPLY

Unless otherwise specified, all gas turbine combustion air intake systems shall comprise the following Manufacturer/Supplier-supplied elements:

- a) Trash screen within inlet ducting
- b) anti-icing system (if specified in the order/enquiry)
- c) primary intake comprising inertial vanes, storm louvers or rain/snow hood, inertial panel separators;
- d) air intake filter system in a purpose-built housing;
- e) silencer section in a purpose-built housing;
- f) plenum chamber;
- g) interconnecting ductwork;
- h) expansion joints as required;
- i) supporting steelwork as defined in the order/enquiry;
- j) associated electrical equipment;
- k) associated instrumentation and safeguarding equipment;
- l) permanent access facilities including ladders, walkways, platforms and lifting davits.
- m) Offshore systems, water drain system up and down stream of filters if specified in the order/inquiry.

3.2 OVERALL DESIGN

If specified, and provided the specified margin between the turbine site power capability and the requirements of the driven machine is maintained, the Manufacturer/Supplier of the air intake system shall optimise the design of the air intake system in liaison with the turbine Manufacturer, taking account of the following:

- a) the effect of intake pressure drop on the performance of the turbine;
- b) the cost of fuel;
- c) the cost of the air intake system;
- d) in the case of offshore installations: the supporting platform costs associated with the weight and size of the equipment;
- e) in the case of onshore installations: civil and other installation costs;
- f) the predicated filter life;
- g) frequency of washing on/off line and filter replacement;
- h) provision for filtered air to supply the turbine enclosure with purge air;
- i) relative maintenance costs including the possible need for more frequent turbine maintenance.

If precise data are not available at the time of optimisation, the Contractor shall be consulted and any assumptions shall be documented.

The resulting total pressure drop of the optimised design at 110 % of the turbine rated airflow at the minimum specified site ambient air temperature shall be stated and guaranteed for new and clean conditions.