MANUAL

STEAM JET VACUUM EJECTOR SETS

DEP 31.29.56.31-Gen.

December 1997
(DEP Circular 28/99 has been incorporated)

DESIGN AND ENGINEERING PRACTICE

PREFACE

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

Shell International Oil Products B.V. (SIOP)
and
Shell International Exploration and Production B.V. (SIEP)
and
Shell International Chemicals B.V. (SIC)

The Hague, The Netherlands,

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, national and international standards and codes of practice.

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 SIOP, 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 SIOP, SIEP or SIC. Consequently, three categories of users of DEPs can be distinguished:

1) Operating companies having a Service Agreement with SIOP, 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.

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.

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

NOTE: In addition to DEP publications there are Standard Specifications and Draft DEPs for Development (DDDs). DDDs generally introduce new procedures or techniques that will probably need updating as further experience develops during their use. The above requirements for distribution and use of DEPs are also applicable to Standard Specifications and DDDs. Standard Specifications and DDDs will gradually be replaced by DEPs.

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APPENDICES

1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for the design, engineering, fabrication, assembly, inspection and performance testing of steam jet vacuum ejector sets.

Excluded from the scope of this DEP is liquid ring vacuum equipment for which reference is made to DEP 31.29.42.30-Gen.

This DEP is a revision of the DEP of the same number dated December 1982.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIOP and SIEP, the distribution of this DEP is confined to companies forming part of the Royal Dutch/Shell Group or managed by a Group company, and to Contractors and Manufacturers nominated by them (i.e. the distribution code is "F", as defined in DEP 00.00.05.05-Gen.).

It is intended for use in oil refineries, chemical plants, gas plants and, where applicable, in onshore and offshore exploration and production facilities and supply/marketing installations.

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

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, technical documents/drawings 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.

1.4 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 (10).

2. GENERAL

Data/requisition DEP 31.29.56.93-Gen. shall be used for the exchange of information between the Principal, Contractor and Manufacturer. Where the sheets show alternatives, those items which are not applicable shall be deleted.

The Manufacturer shall provide all drawings, design details, operation and maintenance manuals, and other information necessary for the design assessment, erection, operation and maintenance of the installation. All information shall be clear and not open to misinterpretation and shall apply specifically to the equipment supplied.

2.1 DATA AND INFORMATION TO BE SUBMITTED WITH THE TENDER

The Manufacturer shall submit with the tender sufficient drawings and detailed information to enable a full evaluation of the steam jet vacuum ejector sets, including as a minimum:

- completed data/requisition sheets;
- fabrication and engineering documents schedule;
- estimated mass of the completely assembled ejector set;
- a list of all recommended spare parts for initial and normal operation, as specified in DEP 70.10.90.11-Gen., with detailed prices and delivery times;
- quality plan;
- a list containing all proposed deviations from the requisition and this DEP;
- general arrangement drawing (lay-out sketch);
- proposals for equipment test run programs, to be carried out both at Manufacturer's works and at site;
- names of all proposed sub-Manufacturers of main equipment, e.g. pumps, condensers, with a full description of the equipment being supplied by them;
- a process flow scheme showing all equipment, lines, valves and instrumentation and indicating limits of supply;
- noise requirements (see 6.2).

3. DESIGN AND ENGINEERING

3.1 GENERAL

Unless otherwise specified, the ejectors shall be designed in accordance with

- BS 5500 and DEP 31.22.10.32-Gen or
- ASME Section VIII, Division 1 and 2, and DEP 31.22.20.31-Gen

The most economical interstage pressures and temperatures shall be selected.

Each ejector shall be provided with a pressure connection on the suction chamber.

The Manufacturer shall obtain any local authority certificates that may be required.

3.1.1 'Scope of supply' and 'terminal points'

The installation equipment shall be listed by the Principal on a sheet entitled 'Scope of Supply' and the limits of supply on a sheet entitled 'Terminal Points', in accordance with the requirements of each project.

If necessary to define the terminal points (e.g. steam supply, etc.), a sketch should be attached to the Terminal Points list.

3.2 ECONOMIC CRITERION

Steam jet vacuum ejectors shall be designed or selected such that an optimum is obtained between capital and operating costs.

The following criterion shall apply:

[(F x A) + (B x Gs) + (C x Gw)] shall be minimised

in which F = Capital charge percentage

A = Quotation price

B = Steam cost per tonne

Gs = Steam consumption in tonnes per year

C = Cooling water cost per 1000 m^3

Gw = Cooling water consumption in 1000 m^3 per year

The capital charge percentage shall be specified by the Principal on the data/requisition sheets DEP 31.29.56.93-Gen. together with unit costs of steam (B) and of cooling water (C) which shall be the costs of incremental/decremental quantities (not the average cost of supply).

Where the range of size of ejector options is such that changes may be required in the supporting structure, the appropriate differential capital costs should be accounted for in the calculation.

3.3 CONDENSERS

Steam jet vacuum ejector sets may be equipped with upstream and interstage surface condensers.

Surface condensers shall be designed in accordance with DEP 31.21.01.30-Gen. or the 'Standards for Steam Surface Condensers' issued by the Heat Exchange Institute.

Air-cooled condensers in accordance with DEP 31.21.70.31-Gen. may be used if approved by the Principal.

3.4 VACUUM SYSTEM LINE-UP

3.4.1 Division of load over two parallel elements

If any stage of an ejector set line-up consists of two parallel elements (ejectors), the following shall apply:

- The two elements of the stage shall be designed to handle 1/3rd and 2/3rd respectively of the total design load of that stage. This will give better matching of ejector capacity to load, resulting in energy savings.
- Provision shall be made to isolate each ejector on the vapour side in order to prevent recycling of gas through an idle parallel set.

3.4.2 Discharge pressure

The discharge pressure of the ejector set (to be stated on the data/requisition sheets) should be selected to allow for the additional pressure drop of a flow measuring instrument located downstream of the ejector package.

3.4.3 Barometric legs

Barometric legs of sufficient height shall be installed to prevent air ingress and flooding of the condensers during normal operation. It shall also be ensured that the liquid content of the accumulator vessel is sufficient to fill up the barometric legs.

Barometric legs shall be run separately into a vertical header connected to the condensate vessel, see Appendix 1. This separation shall be maintained so that differing condensate rundown temperatures cannot disrupt the individual flows. Thermal insulation or steam tracing should not be applied unless needed to keep the product in a liquid state or if insulation is needed for personnel protection.

3.4.4 Condensate outlet temperature

The system shall be designed so that the condensate temperature at each condenser outlet does not exceed the cooling water temperature by more than 25 °C.

4. MATERIALS, FABRICATION AND STRUCTURES

4.1 MATERIAL SELECTION

All construction materials shall be selected according to DEP 30.10.02.11-Gen. For shell and tube heat exchangers the selection shall be based upon DEP 31.21.01.31-Gen.

All materials for pressure parts shall be delivered with certificates according to ISO 10474 type 3.1.B.

4.2 PIPING

All piping systems shall be designed, fabricated, erected, inspected and tested in accordance with ASME B31.3, DEP 31.38.01.11-Gen. and DEP 31.38.01.31-Gen.

The full material specifications of the piping shall be stated on the data/requisition sheets.

Manufacturer shall submit final pressure drop calculations based on final routing and dimensions of ejector interconnecting piping.

4.3 WELDED JOINTS

Joints shall be made by welding wherever possible, unless otherwise specified; all tube ends and pipework shall be suitably prepared for welding.

Welding details shall be in accordance with the relevant construction code and DEP (see 3.1).

4.4 FLANGED JOINTS

All flanges shall be in accordance with ASME B16.5.

Bolts and nuts for pipe flanges shall have UNC threads.

Gaskets shall be asbestos-free.

4.5 STEEL STRUCTURES

Supporting steel structures shall be in accordance with DEP 34.00.01.30-Gen. and DEP 34.28.00.31-Gen.

Bolts and nuts should have metric threads and, unless otherwise stated, should be ISO grade 8.8. Other threads may be used if approved by the Principal.

4.6 NAME PLATES

Each condenser and ejector shall be provided with a nameplate in accordance with Standard Drawing S 10.114.

5. PAINTING, PRESERVATION AND INSULATION

5.1 PAINTING

All painting shall be in accordance with DEP 30.48.00.31-Gen.

All equipment and connecting lines shall be cleaned prior to dispatch ex-works. All openings shall be closed to prevent foreign matter from entering during transport.

Flange facings shall be kept free from paint and provided with blanks or covers. Plain and bevelled pipe ends shall also be provided with plastic covers.

Components made of non-ferrous metal, galvanised steel or stainless steel shall not be painted.

5.2 INSULATION

Normally, insulation is not included in the scope of supply of the manufacturer/supplier.

Insulation and personnel protection shall comply with DEP 30.46.00.31- Gen.

6. NOISE CONTROL

6.1 LIMITS

The Contractor shall comply with DEP 31.10.00.31-Gen., and thereby communicate to the Manufacturer the specified equipment noise limitations by using data sheet DEP 31.10.00.94-Gen., which forms part of the requisition. The Manufacturer is responsible for assuring that these equipment noise limitations have been specified.

6.2 INFORMATION TO BE SUBMITTED WITH THE TENDER

The Manufacturer shall submit guaranteed sound power levels and sound pressure levels (including octave band spectrum) of the equipment, together with any other relevant information as specified in the data sheet DEP 31.10.00.94-Gen. The Manufacturer shall indicate what special silencing measures, if any, are proposed in order to meet the specified levels.

7. INSTRUMENTATION AND CONTROL

7.1 INSTRUMENTATION

Amended per Circular 28/99

For instrumentation requirements, see DEP 32.31.09.31-Gen. and DEP 32.31.00.32-Gen. Irrespective of whether instrumentation is to be supplied, the installation shall include all connections for mounting instruments, for both control and safeguarding as required by the control system.

The Manufacturer shall state in his tender such additions as are deemed necessary for good operation. The Manufacturer shall guarantee that the control scheme proposed will give sound reliable operation of the ejector system over the whole range of operation.

If the Manufacturer does not provide the control system, responsibility for the performance of the ejector system shall be based on the Manufacturer's agreement with the principles of the control system to be applied.

For control valve sizing, see DEP 32.36.01.17-Gen.

7.2 PROCESS CONTROL

If vacuum control is required, a reliable and economical method shall be selected from the following considerations:

- recycling, preferably from the discharge of the second stage back to the inlet of the first stage;
- injection of non-condensables (e.g. nitrogen, but not air) where recycling cannot be applied.

If the Principal has a preferred method of vacuum control, this shall be stated on the data/requisition sheets.

Alternative methods of control may be proposed by the Manufacturer for the approval of the Principal.

8. INSPECTION AND TESTING

Inspection and testing is the responsibility of the Manufacturer.

The inspection and testing of the equipment shall be in accordance with the applicable design code and DEP (see 3.1) and as specified on the data/requisition sheets.

Inspection shall be carried out before any paint, coating or lining is applied.

All required material certificates should be available during inspection or forwarded to the Principal before or with delivery of the ejector set.

The Principal shall specify whether, and to what extent, he may wish to witness the Manufacturer's inspections and tests.

8.1 HYDROSTATIC PRESSURE TESTING

Hydrostatic pressure testing shall be carried out in accordance with the relevant construction code and DEP (see 3.1).

Certificates of test shall be provided. After testing at works, the equipment shall be dried thoroughly before shipment.

8.2 DIMENSIONAL CHECK

A dimensional check shall be carried out on the completely assembled ejector set.

8.3 PERFORMANCE TEST

Test nozzles shall be provided on the suction lines of all ejectors downstream of the main suction valves. These test nozzles will be used to check the performance of the ejectors in the field.

The manufacturer shall test all ejectors and ejector sets at his works. Testing shall be done in accordance with the latest edition of the ‘Standards for Steam Jet Ejectors’ published by the Heat Exchange Institute. The results of these tests shall be forwarded to the Principal.

9. DOCUMENTATION

9.1 GENERAL

The Manufacturer shall provide all drawings, design details, operation and maintenance manuals, and other information necessary for the design assessment, erection, operation and maintenance of the installation. All information shall be clear and not open to misinterpretation and shall apply specifically to the installation supplied.

The number and type of documents shall be specified on the requisition for engineering documents DEP 40.10.01.93-Gen

9.2 DOCUMENTS TO BE DELIVERED

A complete set of engineering documents shall be submitted for approval to the Principal (purchaser), prior to commencement of any shop or construction work.

After approval, certified final documents/manuals and reproducible transparency drawings of the equipment shall be submitted to the Principal.

For the despatch of drawings and documents, approval drawing specification form DEP 05.00.54.81-Gen. and final drawing specification form DEP 05.00.54.82-Gen. shall be used, except that the Contractor's own despatch standard forms may be used if approved by the Principal.

9.3 OTHER INFORMATION TO BE SUPPLIED

- points under (2.1) which were not submitted during tendering;
- a list of all tools necessary for operation, maintenance, inspection and cleaning if not normally found in a refinery workshop;
- operation and maintenance manuals;
- the mass of the vacuum jet ejector assembly.

9.4 MANUFACTURING REPORT

Manufacturer to supply a manufacturing report in accordance with DEP 31.22.10.35-Gen.

This report shall include all material certificates as under 4.1.

10. REFERENCES

In this DEP, reference is made to the following publications:

Note Unless specifically designated by date, the latest edition of each publication shall be used, together with any amendments/supplements/revisions thereto.

SHELL STANDARDS

Index to DEP publications and standard specifications	DEP 00.00.05.05-Gen.
Index to standard drawings	DEP 00.00.06.06-Gen.
Approval drawing specification (ADS)	DEP 05.00.54.81-Gen.
Final drawing specification (FDS)	DEP 05.00.54.82-Gen.
Metallic materials - Selected standards	DEP 30.10.02.11-Gen.
Thermal insulation for hot services	DEP 30.46.00.31-Gen.
Painting and coating of new equipment	DEP 30.48.00.31-Gen.
Noise control	DEP 31.10.00.31-Gen.
Data/requisition sheet for equipment noise limitation	DEP 31.10.00.94-Gen.
Shell-and-tube heat exchangers (Amendments/supplements to TEMA standards)	DEP 31.21.01.30-Gen.
Selected construction materials for shell-and-tube heat exchangers	DEP 31.21.01.31-Gen.
Air-cooled heat exchange equipment (Amendments/supplements to API Std 661)	DEP 31.21.70.31-Gen.
Pressure vessels (Amendments/supplements to BS 5500)	DEP 31.22.10.32-Gen.
Pressure vessels (Amendments/supplements to ASME Section VIII, Division 1 and Division 2)	DEP 31.22.20.31-Gen
Manufacturing report for pressure vessels	DEP 31.22.10.35-Gen.
Liquid ring vacuum pumps and compressors	DEP 31.29.42.30-Gen.
Data/requisition sheets for steam jet vacuum ejector sets	DEP 31.29.56.93-Gen.
Piping - General requirements	DEP 31.38.01.11-Gen.
Shop and field fabrication of piping	DEP 31.38.01.31-Gen.

Amended per Circular 28/99

Instruments for measurement and control	DEP 32.31.00.32-Gen.
Instrumentation for equipment packages	DEP 32.31.09.31-Gen.
Control valves	DEP 32.36.01.17-Gen
Minimum requirements for structural design and engineering	DEP 34.00.01.30-Gen.
Steel structures	DEP 34.28.00.31-Gen.
Data/requisition sheet for Engineering documents	DEP 40.10.01.93-Gen
Spare parts	DEP 70.10.90.11-Gen

STANDARD DRAWINGS

NOTE: The latest issue of standard drawings is identified in DEP 00.00.06.06-Gen.

Nameplate with bracket for vessels and heat-exchange equipment	S 10.114

AMERICAN STANDARDS

Pipe flanges and flanged fittings	ASME B16.5
Chemical plant and refinery piping	ASME B31.3
ASME Boiler and Pressure Vessel Code: Rules for construction of pressure vessels	ASME VIII, Div. 1
ASME Boiler and Pressure Vessel Code: Alternative rules for construction of pressure vessels	ASME VIII, Div. 2

Issued by
American Society of Mechanical Engineers,
345 East 47th Street,
New York, NY 10017, USA

Standards for Steam Jet Ejectors	HEI Standard
Standards for Steam Surface Condensers	HEI Standard

Issued by
Heat Exchange Institute,
1230 Keith Building, Cleveland,
Ohio 44115, USA

BRITISH STANDARDS

Unfired fusion welded pressure vessels	BS 5500

Issued by:
British Standards Institution
389 Chiswick High Road
London W4 4AL
UK.

INTERNATIONAL STANDARDS

Steel and Steel Products, Inspection documents	ISO 10474

Issued by:
International Organization for Standardization
1, rue de Varembé
CH-1211 Genève 20
Switzerland.

Copies can also be obtained from national standards organizations.

APPENDIX 1 TYPICAL STEAM JET VACUUM EJECTOR SYSTEM LINE-UP