

DEP SPECIFICATION

AIR COOLED VACUUM STEAM CONDENSERS

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DESIGN AND ENGINEERING PRACTICE



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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 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.

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- 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 Shell GSI.

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1. INTRODUCTION

1.1 SCOPE

This new DEP specifies requirements and gives recommendations for design, materials, fabrication and inspection of A-frame (or V-frame) type air-cooled 2-stage vacuum steam condensers and auxiliaries as specified herein.

This DEP is not applicable to other types of air-cooled vacuum steam condensers, such as horizontal or single stage designs, typically used for small duty applications.

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 authorisation to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in facilities related to oil and gas production, gas handling, oil refining, chemical processing, gasification, distribution and supply/marketing. This DEP may also be applied in other similar facilities.

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 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.

1.3.2 Specific definitions

Term	Definition
2-stage ACC	Air-cooled steam condenser operating under vacuum which is achieved in two stages: in the first stage steam and condensate flow co-currently and the majority of steam is condensed; in the second stage steam and condensate flow in counter-current direction to collect the non-condensables using an air-removal system. The second stage can be in a dedicated tube bundle or combined with the first stage in one tube bundle.

1.3.3 Abbreviations

Term	Definition
ACC	Air-Cooled (Vacuum Steam) Condenser
HEI	Heat Exchange Institute
TEMA	Tubular Exchanger Manufacturers Association

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 referenced by this DEP are listed in (7).

1.5 SUMMARY OF MAIN CHANGES

This DEP is new.

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://swwww.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.

2. GENERAL INFORMATION

2.1 GENERAL

1. The design and construction of the ACC and auxiliaries shall conform to the latest edition of following standards and practices:
 - a. HEI 3087 "Standards for Air Cooled Condensers",
 - b. HEI 2866 "Standards for Steam Jet Vacuum Systems",
 - c. HEI 2854 "Standards for Vacuum Liquid Ring Pumps",
 - d. the requirements outlined in this DEP as well as in referenced DEPs.
2. Pressure vessels with design pressures in excess of 100 kPag (15 psig) shall be designed, manufactured, and tested in accordance with the applicable pressure design code and the requirements of DEP 31.22.00.30-Gen., and may be considered as category 3 pressure vessels.
3. When specified by the Contractor, the steam duct, distribution manifold, steam headers and ACC bundles shall be designed and supplied in accordance with the requirements of the applicable pressure design code.
4. The materials of construction, design and fabrication of the steam duct, distribution manifold, steam headers and ACC bundles shall be in accordance with HEI and Supplier's standards, and fit for purpose. The materials of construction and design methodology to be applied shall be provided in the proposal.

2.2 SPECIFICATION

1. Unless otherwise specified, the steam duct, manifold and ACC bundles shall be designed for a pressure of 100 kPag (15 psig) and full vacuum at a design temperature of 121 °C (250 °F). Deviations are subject to approval by the Principal.

The use of lower design pressures may be necessary due to limitations of the tube technology provided by the Supplier.

2. The Contractor shall supply foundations, erection of the supporting structure, and fireproofing of the structural steel.
3. The Contractor shall specify for the design and optimization of the ACC unit:
 - a. Pressure design code to be applied,
 - b. Turbine exhaust steam flow rate at design conditions,
 - c. Turbine exhaust steam enthalpy,
 - d. Design steam turbine exhaust pressure defined at the turbine exhaust flange. The specified design steam turbine exhaust pressure should be the highest exhaust pressure that can be routinely tolerated by the steam turbine during a hot summer day, which should take into account the economic impact on the steam turbine power output.
 - e. Design air inlet temperature, ambient pressure/altitude of site location,
 - f. Maximum/extreme design ambient air temperature,
 - g. Minimum design ambient air temperature,
 - h. Minimum and maximum permissible turbine exhaust pressures,
 - i. Information for economic optimization of fan power usage,
 - j. Turn-down requirements of the steam turbine generator and ACC, including minimum steam load and duration coinciding with minimum ambient temperature operation,
 - k. Relevant conditions in case the ACC is used as (bypass) steam dump cooler,

- l. Steam relief case for sizing of the relief device,
 - m. Plot layout with information about location and height limitations for installation of the ACC and auxiliary equipment, locations and sizes of surrounding buildings and other obstructions for free air flow to and from the ACC,
 - n. Prevailing wind direction, wind speeds as well as any other relevant environmental information (e.g., elevation, dust, pollen fluff, etc.) that is to be considered in the design of the ACC,
 - o. Dimensions of the steam turbine exhaust, including turbine exhaust flange detailed dimensions and bolting pattern when flange is supplied as an integral part of the turbine,
 - p. Dimensions, location, and enthalpy of the steam turbine bypass line including spargers, if applicable,
 - q. Dimensions, locations, orientations, pipe routing, quantity and details of feedwater heaters to be included in ACC Supplier's scope, if applicable,
 - r. Locations and design conditions (pressure, temperature, enthalpy and flow) of all service connections to be provided in the Supplier's scope including miscellaneous steam and water vents and drains, etc., along with service conditions (i.e. continuous or intermittent),
 - s. Size requirements, connections and elevation of condensate tank (hold-up time, levels, etc.),
 - t. Applicable piping class documents,
 - u. Cooling water supply and discharge conditions (if applicable),
 - v. Motive steam conditions and extent of motive steam piping, straining, and separating facilities,
 - w. Air-side cleaning strategy and associated cleaning equipment/auxiliaries that are an integral part of the ACC unit,
 - x. Scope of work split between the steam turbine Supplier, ACC Supplier and the Contractor.
4. Unless otherwise specified, the Contractor shall furnish condensate pumps and drivers, instrumentation, electric wiring and piping other than that which is an integral part of the ACC unit.

2.3 SCOPE OF SUPPLY

- 1. The ACC should include all features necessary for reliable and safe operation. These features should include adequate means of control to cope with the specified variations in operating conditions.
- 2. The Supplier should economically optimise their design relative to equipment costs and fan power consumption using electric power cost data, both demand and energy charges, that is provided by Contractor. In case there is "excess" electrical power available, it should be considered to increase the air-flow through the ACC at the expense of additional fan power consumption.
- 3. Unless otherwise specified, the scope of supply for the ACC, supporting auxiliary equipment and related services shall include the following items:
 - a. Main steam duct, distribution manifold, risers, steam headers, saddle supports and expansion joints, steam duct (inlet) flange, gaskets, bolting and transition pieces as necessary to connect the turbine exhaust flange with the ACC bundles;
 - b. If specified by the Contractor, the steam turbine exhaust flange (when not otherwise provided as an integral part of the steam turbine);

- c. Drain pot and close-coupled flash vessel for the steam duct, including interconnecting piping, valves and fittings;
- d. If specified by the Contractor, connection on steam duct for steam turbine bypass line;
- e. Atmospheric relief device(s) as required to protect the ACC against over-pressure;
- f. If specified by the Contractor, sectionalizing valves;
- g. Finned tube bundles for steam condensation and non-condensables collection;
- h. Fully functional fan and drive system, including fans, fan rings, inlet, fan guards, speed reducer, drive shafts, couplings, motors, and vibration detection devices;
- i. If specified by the Contractor, anti-bird protection gauze at fan inlet and steam relief exhaust pipe of the ACC;
- j. Freeze protection features (if required for the location);
- k. Condensate tank, including nozzle connections and interconnecting condensate piping within the specified ACC boundaries;
- l. Air-removal system furnished with interconnecting piping consisting of either:
 - i. one (1) set of twin element two-stage ejector unit furnished with shell-and-tube type inter-/after condensers (one for each stage) and hogging ejector complete with silencer and air flow meter on after-condenser vent stream, or
 - ii. two (2) sets of two-stage vacuum liquid ring pump units furnished with seal water tanks, shell-and-tube type vacuum pump coolers and, if required to achieve the specified vacuum, air ejectors.
- m. Steel support structure within ACC boundaries, including maintenance platforms, ladders, motor/fan supports, grounding connections, and condensate tank supports;
- n. Wind walls and cell-partition walls, completely furnished with access doors;
- o. If specified by the Contractor, fully functional air-side cleaning system for the finned tube bundles;
- p. All local instruments, control systems and alarm signals within the ACC boundaries;
- q. All bolting, seals, sealant and gaskets within the ACC boundaries;
- r. Special maintenance and erection tools;
- s. Lifting lugs for assemblies that are shipped to site and require a crane for handling;
- t. Shop priming/painting;
- u. Testing, inspection and examination as specified in this DEP;
- v. If specified by the Contractor, commissioning and start-up assistance;

2.4 PROPOSAL

1. The Supplier's bid shall indicate where the Supplier's construction supervision is required. This meets the guarantees/warranties as to when the Supplier does not assemble/finalize the construction of the ACC unit and auxiliaries on-site.

2. The proposal shall identify whether the ACC, fan, gear box, air removal system or any other component is a "first-time use". Such designs shall be subject to approval by the Principal.

*"First-time use" includes any design or component for which less than two years of successful operation at two separate installations can be demonstrated, with supporting data and/or references to be provided to the **Principal** upon request.*

3. The Supplier shall provide the following information in its proposal:
- Completed data sheet as per HEI 3087 - Appendix A or equivalent;
 - Design pressure limitations of the proposed tube technology, if less than 100 kPag (15 psig);
 - Design methodology to be applied for the mechanical design and fabrication of the steam duct, manifold and ACC bundles (for non-pressure vessel design code units);
 - Materials of construction to be applied (materials specification and grade) for steam duct, manifold, ACC bundle components, piping, and pressure vessels;
 - Installation requirements including required elevation of ACC above grade and free area necessary around ACC to ensure proper air flow supply and distribution to fans;
 - Completed data sheets for steam ejectors, pumps, condensate tank;
 - Description or (typical) drawing presenting the mechanical design of the tube bundle including details like bundle layout, tube-to-tubesheet joint (including weld geometry), tube end protection against air-side corrosion;
 - Description of steam duct design, including overall duct and header dimensions, expansion bellows, pressure drops, mitigation of possible erosion (e.g., erosion of bends by wet steam), and flow distribution;
 - Typical information about the e-motor (type and rating), speed reducer (type and rating), shaft, fan, bearings and hub design;
 - Noise level warranties;
 - Description of proposed air removal system, including minimum warranted time required to prepare the ACC for start-up;
 - Description of proposed ACC vacuum control philosophy;
 - Type and number of proposed safety relief devices (bursting disc or relief valve);
 - List of all instrumentation included in the Supplier's scope, along with a list of acceptable instrument Suppliers;
 - A list of main auxiliary components;
 - Drawings sufficient to evaluate plot plan, field erection requirements and a layout drawing of the proposed ACC cell design;
 - Details of the proposed (typical) thermal performance test procedure;
 - Details of the proposed (typical) tightness test procedure;
 - Reference list, showing bidder has manufactured similar size ACCs (minimum of two) that have been in successful operation for at least two years;
 - Detailed description of any exceptions to the specified requirements and standards (explaining where and why an exception is taken) or a statement mentioning that there is no exception;
 - Priced list of recommended spare parts for (a) start-up/commissioning and (b) two years of operation;

- v. Field rates for personnel to provide installation, erection, start-up and commissioning supervision.

2.5 DOCUMENT HIERARCHY

1. Equipment specified in this DEP shall meet the requirements from local code and regulations of the area where it is going to be installed.
2. In case of conflict between documents relating to an order, the following hierarchy applies:
 - a. Purchase order and documentation;
 - b. Project specifications and engineering data requisition sheets (EDRS);
 - c. This DEP;
 - d. Other referenced DEPs;
 - e. Heat Exchange Institute Standards.
3. In the event of a conflict, the Principal shall be consulted.

2.6 DOCUMENTATION

1. The Supplier shall submit to the Contractor, prior to commencing fabrication, the required number of the following documents for review and comments:
 - a. Outline drawings showing:
 - i. Overall dimensions, elevations, and arrangement of all main components provided;
 - ii. All nozzle and support attachment orientations and sizes;
 - iii. Location of all handling attachments, centre of gravity location;
 - iv. Allowable forces and moments on main piping/ducting connections;
 - v. Foundation loads due to empty, operating, and hydrotest weights (if applicable), wind and earthquake loads;
 - vi. Maximum vertical and horizontal loads (gravity and lateral loads-wind/seismic) at each column support based on the specified load combinations;
 - vii. Location of columns, and/or bolt settings and details;
 - viii. Stairway, platform, access doors and ladder locations, furnished with information about design live loads for stairways and platforms;
 - ix. Corrosion allowances for equipment, ducting, headers, nozzles, manways, and all supports and other accessories;
 - x. Code of Construction Division, edition year, addenda year and applicable Code Cases, as required;
 - xi. References to main supplementary drawings, standards and specifications;
 - xii. Equipment tag number.
 - b. Detail drawings showing:
 - i. Header boxes of tube bundles;
 - ii. Final tube layout, tube fining, tube-to-tubesheet joint;
 - iii. Corrosion allowance for internal components, where applicable;
 - iv. Operating and design pressures and temperatures of all services for which the equipment is designed;