

DEP SPECIFICATION

WELDED PLATE-BLOC HEAT EXCHANGERS – APPLICATION, DESIGN AND FABRICATION

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DESIGN AND ENGINEERING PRACTICE



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PART I INTRODUCTION

1.1 SCOPE

This new DEP specifies requirements and gives recommendations for the selection, application, design and fabrication of Welded Plate-Bloc Heat Exchangers (WPBHEs) with an integral welded core of alternating stream corrugated plate flow channels and removable cover panels on both stream sides. Other types of welded plate type heat exchangers are excluded.

Part II of this DEP provides information on selection and application of welded plate-bloc heat exchangers.

Part III of this DEP provides information on design and fabrication of welded plate-bloc heat exchangers.

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.

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 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 with regard 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 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 Abbreviations

Term	Definition
BPVC	Boiler and Pressure Vessel Code
PMI	Positive Material Identification
PTFE	polytetrafluoroethylene
QA	Quality Assurance
UT	Ultrasonic Testing
WPBHE	Welded Plate-Bloc Heat Exchanger

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 (Part IV).

1.5 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.

1.6 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.

PART II SELECTION AND APPLICATION

1. THERMAL AND HYDRAULIC DESIGN CONSIDERATIONS

1.1 SCOPE

The heat transfer and pressure drop correlations and methods required for a satisfactory thermal and hydraulic design shall reside with the Manufacturer.

1.2 TEMPERATURE AND PRESSURE LIMITATIONS

The maximum design pressure and temperature that can be accommodated in a WPBHE can vary by Manufacturer. The Manufacturer should be consulted at an early stage of the process design to determine the highest pressure and temperature that is feasible for the applicable WPBHE(s).

Identical operating pressures for both streams in a WPBHE shall be avoided to prevent pressure inversion/fluctuations which may create fatigue and damage the plate-pack and cause leaks between the plates. A minimum differential pressure of 1 barg (15 psig) should be maintained between the operating pressures of each stream.

The Manufacturer shall be responsible for acquiring all the design requirements on the data sheets from the Contractor. The design shall satisfy all operating cases and design conditions specified by the Contractor on the data sheets and supporting specifications.

1.3 SIZE LIMITATIONS

The Manufacturer should be consulted at an early stage of the process design to determine the largest size and highest heat transfer area that can be accommodated in a single heat exchanger.

1.4 FLOW RATE

Cold circuit flow stoppage which may lead to partial vaporization and recondensation shall be prevented. Such frequently repeated operation can damage the exchanger.

1.5 MINIMUM TEMPERATURE APPROACH

For demanding applications, temperature approaches down to 3°C (5°F) can be obtained in a WPBHE, however these should be used with caution because small upsets in process conditions, changes in process stream physical properties or non-linearity in heat release curves could prevent achieving the required thermal duty; this caution is especially important for two-phase flow applications. Temperature approach refers to the difference between the hot and cold stream bulk temperatures at the terminal ends of the heat exchanger, where normally the lower of the two approach temperatures (hot or cold end of the exchanger) is taken as the temperature approach.

1.6 MAXIMUM TEMPERATURE DIFFERENTIAL

The maximum temperature difference of process streams between adjacent plates in any point in the heat exchanger should typically be limited to 80°C to 100°C (144°F to 180°F). Should higher temperature differences be required, the Manufacturer should be consulted for limitations in operation, e.g. in warm-up and cool-down rates.

1.7 THERMAL FATIGUE

The highest thermal stresses due to temperature differentials are likely to occur during start-up, shutdown or upset conditions. The Contractor shall inform the Manufacturer of the number of anticipated start-up, shutdown and identified upset conditions to be considered, along with a definition of the operation under each case, so that the Manufacturer may consider this in the mechanical design of the WPBHE.

Care should also be taken to avoid excessive flow fluctuations as these might cause thermal fatigue. If flow of one or both streams is intermittent or is not in a steady state, the Manufacturer shall be consulted for limits in operation. Expected or potential cyclic duties shall be communicated by the Contractor to the Manufacturer as part of the specification of the WPBHE.

WPBHE shall not be used for high cyclical heat duties having sudden temperature changes exceeding 60°C/hour (108°F/hour). High cyclical temperature and/or pressure conditions can create fatigue leading to a reduced lifetime of the exchanger.

The Manufacturer shall be consulted at an early stage of the process design to determine the suitability of selecting WPBHE for cyclic conditions.

1.8 PERFORMANCE MONITORING

To ensure continued, trouble-free performance of WPBHE, the following instrumentation should be installed and monitored:

- pressure drops across the heat exchanger for both streams;
- inlet and outlet temperatures of both streams;
- flow rates of both streams;
- pressure drop across the strainers for both streams.

1.9 CORROSION

The plate material shall be selected based on nil corrosion rate, unless otherwise approved by the Principal.

1.10 PARTICULATES

If particulates of a size greater than 50 % of the gap between plates are likely to be present in the process stream, upstream straining of the process stream shall be provided by the Contractor unless otherwise approved by the Principal. In general, a filter or strainer of mesh size 2 mm to 3 mm (0.08 in to 0.12 in) is recommended to be installed at the inlets of process streams.

During commissioning, to prevent construction debris (mill scale, rust, welding electrode etc) from accumulating in the WPBHE a temporary filter strainer of mesh size 1 mm (0.04 in) or below is recommended.

The use of instrumentation to measure differential pressures across the filter to give an early indication of blockage should be considered. Otherwise, the collapse of the filter would pass additional debris to the WPBHE. Two parallel filters can be installed so that one is always online, and have a pressure drop measurement [typically with a range of 0.1 bar (1.5 psi) to 0.5 bar (7.0 psi)] across the filters so they can be cleaned at proper intervals.

1.11 FOULING

Rapidly fouling process streams should not be used with the WPBHE. Low to medium fouling streams can be tolerated if the fouling is not likely to be rapid enough to block flow channels and the fouling can be removed relatively easily either by hydro-blasting or with chemical solvents that are compatible with both the process and the materials used for the construction of the WPBHE.

Care should also be exercised with deposits that may be formed with high temperatures (e.g. carbonisation, polymerisation) or low temperatures (waxes, hydrates). The thermal design of the exchanger should ensure that there are no spots within the exchanger that are excessively hot or cold, and that skin temperatures on the heat transfer surfaces have sufficient margin to avoiding fouling deposition.

1.12 FLUID VELOCITIES

Fluid velocities are typically governed by pressure drop or thermal design criteria. If not otherwise governed, the fluid velocities must be limited to a level that avoids potential erosion problems.

1.13 DEPRESSURISATION

Depressurisation procedures, as applicable, shall be developed by the Contractor so as to prevent the WPBHE from experiencing temperatures or conditions, including the cooling medium utility fluid, that could freeze and cause damage to the plate-pack core.

2. MECHANICAL DESIGN CONSIDERATIONS

2.1 GENERAL

If a number of operating cases and design conditions are specified, the Manufacturer shall select the most stringent case or combination of cases, as required, so that all design conditions are met. These conditions extend to all pressure containing parts including panels, linings, upper and lower heads, girders, nozzles and the plate pack.

The mechanical design shall be based on a standard pressure vessel code.

In addition to the steady state design operating condition(s), the mechanical design shall satisfy all operating conditions, including transient conditions that might impose significant stresses on the welded plate-bloc heat exchangers.

2.2 DESIGN PRESSURE AND TEMPERATURE

Each Manufacturer has their own maximum limits for mechanical design pressure and design temperature and these shall be checked during selection of WPBHE.

2.3 LOAD CASES

The Manufacturer shall take into account external forces arising from nozzle loads, wind loads, blast loads and reaction forces at supports and seismic and transportation accelerations in the design of the WPBHE.

2.4 PRESSURE AND THERMAL CYCLING

Pressure and thermal cycling can lead to fatigue and shall be considered in the mechanical design. Pressure vessel codes provide a basis for determining the need for fatigue analysis and the procedure to be adopted when it is required.

2.5 STRUCTURAL INTEGRITY

The structural integrity of a WPBHE designed to a suitable pressure vessel code such as ASME Section VIII is acceptable provided that the established design parameters within the code are adhered to.

Standard non-destructive examination techniques may be employed to confirm satisfactory welding.

The laser or plasma welded plate-pack integrity is basically analogous to automatic welding integrity. The procedure is qualified similar to a welding procedure qualification. Production bonding shall then be carried out in accordance with the qualified procedure, so specific production tests are unnecessary.

If requested, the WPBHE welded plate-pack integrity shall be confirmed by production testing, as follows:

- Prepare a tensile specimen by cutting-off the corner of the plate-pack;
- Make a test sample of a separate sandwich of a few corrugate plates to be laser or plasma welded with a production block.

The fully assembled and pressure tested WPBHE shall be subjected to a helium leak test to further confirm welding and bonding integrity.

The nozzles shall be designed considering the standard loads and moments as per ISO 15547 Part 1. These standard loads and moments shall ensure nozzle and nozzle weld integrity and include a safety factor for the exchanger stability.

2.6 VENTS AND DRAINS

Based on Manufacturer, certain small size WPBHE models are categorised as self-venting and self-draining which means there is no necessity to provide separate vent and drain connections for the WPBHE. For non-self venting and self-draining types, a dedicated vent

and drain shall be installed on the panels and piped to appropriate destinations (e.g. vent and drain circuits that allow the draining and venting as required).

2.7 INTERSTREAM LEAKAGE

Repair of inter-stream leakage in a WPBHE typically should be carried out in a workshop having equipment suitable for hot cutting and welding of WPBHE plate materials, and equipment for helium leak and pressure testing. Welders and welding procedures must be qualified to the appropriate code. Radiography of new welds may be required.

2.8 PRESSURE TESTING

The preferred method for pressure testing the WPBHE is hydrostatic. This should be carried out prior to a leak test. The test pressure and method shall be derived from the applicable pressure vessel code.

For some applications, if the WPBHE is not adequately dried, residual liquid that may have been trapped in the unit after a hydrotest could lead to subsequent damage to the unit in service. The Principal should consult the Manufacturer on this subject as part of selecting and defining the pressure test method(s).

The Principal shall agree on the test method to be used for a particular installation.