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Heat Exchanger Tube End Fixing

Group Instruction for Supply

**BP GROUP
ENGINEERING TECHNICAL PRACTICES**

Foreword

This is the first issue of Engineering Technical Practice (ETP) GIS 18-014. This Group Instruction for Supply (GIS) is based on parts of heritage documents from the merged BP companies as follows:

British Petroleum

GS 118-8

Heat Exchanger Tube End Fixing.

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Introduction

This GIS provides BP requirements for heat exchanger tube end fixing. Reliable, leak tight tube end joints are essential in shell and tube heat exchanges and air coolers for efficient operation. A controlled process of design, together with careful fabrication and inspection, are prerequisites for satisfactory service. Consequently, BP requires tube end fixing procedures to be qualified by test, and each tube end joint to be subject to a combination of nondestructive testing, leak testing, and pressure testing before shipping from manufacturer works.



1. Scope

- a. This GIS provides general requirements for tube end welding and/or expansion of ferrous and nonferrous tubes.
- b. The requirements apply to both shell and tube exchangers and air coolers having tube and tubesheet dimensions within the following size ranges:
 1. Nominal tube diameter 15 mm (0,5 in) to 40 mm (1,5 in).
 2. Tube wall thickness 1,6 mm (0,064 in) to 4 mm (0,160 in).
 3. Tubesheet thickness 15 mm (0,5 in) and greater.

Wall thicknesses of 0,875 mm (0,035 in) (20 BWG) and 1,25 mm (0,05 in) (18 BWG) are often used with titanium, zirconium, and nickel alloy tube in chemical processing. While in these cases weld joint details are approved by BP, typically, a strength weld design with first pass autogenous and second pass with filler metal is used.

This GIS is independent of any particular design code. However, it should be noted that BSI PD 5500, Appendix T, provides useful information on the design, fabrication, and testing of tube to tubesheet welds.

2. Normative references

The following referenced documents may, to the extent specified in subsequent clauses and normative annexes, be required for full compliance with this GIS:

- For dated references, only the edition cited applies.
- For undated references, the latest edition (including any amendments) applies.

BP

GIS 18-011	Welded Fabrication and Construction.
GIS 18-012	Storage and Control of Welding Consumables.
GIS 42-102	Fabrication, Assembly, Erection, and Inspection of Austenitic and Duplex Stainless Steel, Cupro-Nickel, Nickel Base Alloy, Titanium, and Zirconium Pipework (ASME B31.3).

British Standards Institute (BSI)

BS 4871-3	Approval testing of welders working to approved welding procedures - Part 3: Arc welding of tube to tube-plate joints in metallic materials.
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International Organisation for Standardization (ISO)

ISO 15614-8	Specification and qualification of welding procedures for metallic materials - Welding procedure test - Part 8: Welding of tubes to tube-plate joints.
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Tubular Exchanger Manufacturers Association (TEMA)

TEMA	Standards of the Tubular Exchanger Manufacturers Association.
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3. Terms and definitions

For the purpose of this GIS, the following terms and definitions apply:



Seal welded (tubesheet)

Supplied with tube to tubesheet welds, with a minimum throat thickness equal to or less than the tube wall thickness, the function of which is solely to seal between the tube and the tubesheet.

4. Symbols and abbreviations

For the purpose of this GIS, the following symbols and abbreviations apply:

GMAW	Gas metal arc welding.
GTAW	Gas tungsten arc welding.
HAZ	Heat affected zone.
LPG	Liquefied petroleum gas.
NDT	Nondestructive testing.
PWHT	Post weld heat treatment.
SMAW	Shielded metal arc welding.
WPS	Welding procedure specification.

5. General**5.1. General**

- a. Use of tube dimensions outside the range identified in 1 shall be subject to BP mechanical engineer approval.
BP mechanical engineer approval means approval by an engineer deemed competent by the BP entity EA.
- b. Approve/agree is used if BP requires an action to be notified and agreed in writing before commencement of any work, including procedure qualification.

5.2. Types of tube end joint

- a. The following combinations of tube expansion and tube end welding may be adopted, depending on service conditions:
 1. Expanded only.
e.g., cooling water duty, if leakage from the process side poses no risk.
 2. Strength welded only.
e.g., titanium tubes and carbon steel tubesheet clad with titanium.
 3. Expanded and seal welded.
e.g., corrosive fluid on tubeside with steam on shellside in austenitic stainless steel.
 4. Strength welded and lightly expanded.
e.g., same as expanded and seal welded but with high pressure or high temperature.
 5. Strength welded and expanded.
e.g., same as strength expanded and seal welded but tubeside erosion a possibility.



6. Back face welded.

e.g., high pressure unit that requires a fully inspectable butt weld or high temperature unit for which crevice needs to be eliminated due to thermal cracking or crevice corrosion.

In BSI PD 5500, Para. 3.9.6, and ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, Appendix A, strength factors are assigned to several of the above types of tube end joint. This is to check during design the strength of the joint for the axial loads that may be applied in service.

- b. The combination of welding and expansion required on each exchanger shall be as specified by or approved by BP. An adequate tubesheet ligament shall be provided for the specified fabrication technique.

For many applications, tube expansion into grooves in the tubesheet without welding is satisfactory and economical. In deciding whether tube end welding is necessary, an assessment is required of the likelihood of leakage and the potential consequences.

With properly applied strength welds, tube expansion is frequently unnecessary, as it does not significantly contribute to the mechanical strength of the tube end joints.

For certain service duties, intimate contact is needed between the outside diameter of the tubes and the bore of the tubesheet holes. This contact may be accomplished by light expansion of the tubes after both welding and successful leak testing but before final pressure testing. A light expansion avoids the buildup of corrosion products in the annular gap but does not guarantee that crevice corrosion will not occur. If light expansion is acceptable or specified, a full expansion as "additional insurance" should be avoided (because it is both unnecessary extra working of the tubes and makes pulling of them for replacement/repair considerably more difficult).

If service conditions preclude any crevice between the tubes and the tubesheet, back face welding is required (Annex A, Figure A.5). Back face welding is used if there is a high heat flux as the tubes enter the tubesheet and, therefore, concern that the tubes might crack. Back face welding is also used if the shell side fluid is corrosive such that no crevice may be allowed.

If the additional security provided by strength welds in combination with tube expansion is considered necessary, the sequence of operations and the technique used for tube location is important. Weld cracking may occur with expansion after welding. Porosity can occur in the welds if the tubes are fully expanded before welding because, if the tubes and tubesheet are not thoroughly cleaned, the expanding operation may increase the amount of dirt at the root of the weld.

In air coolers, access for tube end welding can only be through the header plug plate, and it is very limited. Tube end welding is usually performed by GTAW, with the torch and wire coming through separate holes in the plug plate, and the operator controlling through a third. This welding may be done manually or automatically. The principles on which the tube end preparation is selected are very similar to those for shell and tube exchangers, but the lack of access for welding and inspection greatly increases the complexity of the work.

Failure of tube to tubesheet attachments can be extremely costly. Selection of the optimum materials for tubes and tubesheet and specification of the correct combination of expansion and welding are both essential to ensure maximum integrity and service reliability.

