# ENGINEERING STANDARD

# FOR

# PROCESS DESIGN OF

# DOUBLE PIPE HEAT EXCHANGERS

## ORIGINAL EDITION

## JULY 1995

**This standard specification is reviewed and updated by the relevant technical committee on June 2000(1) and Apr. 2014(2). The approved modifications are included in the present issue of IPS.**

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## FOREWORD

The Iranian Petroleum Standards (IPS) reflect the views of the Iranian Ministry of Petroleum and are intended for use in the oil and gas production facilities, oil refineries, chemical and petrochemical plants, gas handling and processing installations and other such facilities.

IPS is based on internationally acceptable standards and includes selections from the items stipulated in the referenced standards. They are also supplemented by additional requirements and/or modifications based on the experience acquired by the Iranian Petroleum Industry and the local market availability. The options which are not specified in the text of the standards are itemized in data sheet/s, so that, the user can select his appropriate preferences therein

The IPS standards are therefore expected to be sufficiently flexible so that the users can adapt these standards to their requirements. However, they may not cover every requirement of each project. For such cases, an addendum to IPS Standard shall be prepared by the user which elaborates the particular requirements of the user. This addendum together with the relevant IPS shall form the job specification for the specific project or work.

The IPS is reviewed and up-dated approximately every five years. Each standards are subject to amendment or withdrawal, if required, thus the latest edition of IPS shall be applicable

The users of IPS are therefore requested to send their views and comments, including any addendum prepared for particular cases to the following address. These comments and recommendations will be reviewed by the relevant technical committee and in case of approval will be incorporated in the next revision of the standard.

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**GENERAL DEFINITIONS:**

Throughout this Standard the following definitions shall apply.

**COMPANY:**

Refers to one of the related and/or affiliated companies of the Iranian Ministry of Petroleum such as National Iranian Oil Company, National Iranian Gas Company, National Petrochemical Company and National Iranian Oil Refinery And Distribution Company.

**PURCHASER:**

Means the “Company” where this standard is a part of direct purchaser order by the “Company”, and the “Contractor” where this Standard is a part of contract documents.

**VENDOR AND SUPPLIER:**

Refers to firm or person who will supply and/or fabricate the equipment or material.

**CONTRACTOR:**

Refers to the persons, firm or company whose tender has been accepted by the company.

**EXECUTOR:**

Executor is the party which carries out all or part of construction and/or commissioning for the project.

**INSPECTOR:**

The Inspector referred to in this Standard is a person/persons or a body appointed in writing by the company for the inspection of fabrication and installation work.

**SHALL:**

Is used where a provision is mandatory.

**SHOULD:**

Is used where a provision is advisory only.

**WILL:**

Is normally used in connection with the action by the “Company” rather than by a contractor, supplier or vendor.

**MAY:**

Is used where a provision is completely discretionary.

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## 0. INTRODUCTION

"Process Design of Non-Combustion Type Heat Exchanging Equipment", is broad and contain variable subjects of paramount importance. Therefore, a group of process engineering standard specifications are prepared to cover the subject.

This group includes the following Standards:

| STANDARD | CODE STANDARD TITLE |
|---|---|
| IPS-E-PR-771 | "Engineering Standard for Process Requirements of Heat Exchanging Equipment" |
| IPS-E-PR-775 | "Engineering Standard for Process Design of Double Pipe Heat Exchangers" |
| IPS-E-PR-785 | "Engineering Standard for Process Design of Air Cooled Heat Exchangers (Air Coolers)" |
| IPS-E-PR-790 | "Engineering Standard for Process Design of Cooling Towers" |

This Standard Specification covers:

**"PROCESS DESIGN OF DOUBLE PIPE HEAT EXCHANGERS"**

Double pipe heat exchanger is one of the many non-combustion types which finds the most application fields in OGP industries.

In this standard, the subjects are adapted from GPSA Data Book “Gas Processors Suppliers Association”, sec. 9, 11th Edition, 1998.

## 1. SCOPE

This Standard Specification covers the minimum process design requirements, field of application and selection of types, design consideration for double pipe heat exchangers.

**Note 1:**

**This standard specification is reviewed and updated by the relevant technical committee on June 2000. The approved modifications by T.C. were sent to IPS users as amendment No. 1 by circular No. 106 on June 2000. These modifications are included in the present issue of IPS.**

**Note 2:**

**This standard specification is reviewed and updated by the relevant technical committee on Apr. 2014. The approved modifications by T.C. were sent to IPS users as amendment No. 2 by circular No. 417 on Apr. 2014. These modifications are included in the present issue of IPS.**

## 2. REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

**ASME (AMERICAN SOCIETY OF MECHANICAL ENGINEERS)**

ASME Code, Section VIII, Division 1

**TEMA (TUBULAR EXCHANGERS MANUFACTURERS ASSOCIATION)**

Section RCB-8

**IPS (IRANIAN PETROLEUM STANDARD)**

| | |
|---|---|
| IPS-G-ME-150 | "General Standard for Towers, Reactors, Pressure Vessels and Internals" |
| IPS-G-ME-230 | "General Standard for Double Pipe Heat Exchangers" |

## 3. SYMBOLS & ABBREVIATIONS

**A** = Total Exchanger area, ($m^2$)

**BWG** = Birmingham Wire Gage

**DN** = Diameter Nominal, (mm)

**K** = Temperature in Kelvin, (K)

**OGP** = Oil, Gas and Petrochemical

**U** = Overall duty heat transfer coefficient, $W/m^2$. °C ($W/m^2$.K).

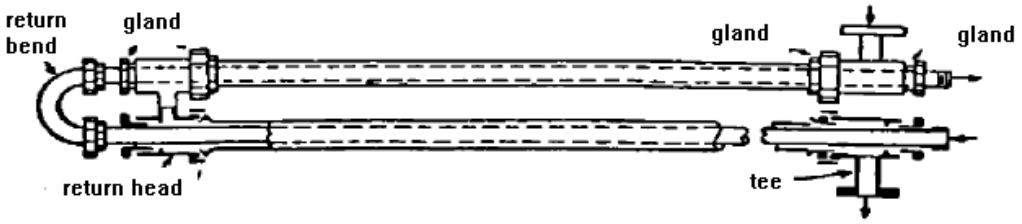
## 4. UNITS

This standard is based on international system of units (SI), as per IPS-E-GN-100 except otherwise specified.

## 5. GENERAL

**5.1** Double pipe heat exchangers are normally designed in a hairpin shape and are fabricated in accordance with ASME Code.

The principal parts are two sets of concentric pipes, two connecting tees, a return head, and a return bend as shown in Fig. 1.




**TYPICAL DOUBLE PIPE EXCHANGER**

**Fig. 1**

Double pipe exchangers are divided into two major types:

Single-tube and Multi-tube. The Single-tube type consists of a single tube or pipe, either finned or bare, inside a shell.

The Multi-tube type consists of several tubes, either finned or bare, inside a shell (see Fig. 2).

**5.2** Double-pipe sections permit true counter-current or true co-current flow, which may be of particular advantage when very close temperature approaches or very long temperature ranges are required.

**5.3** Double-pipe units are well suited for high pressure applications because of their relatively small diameters. This allows the use of small flanges and thin wall sections, as compared to conventional shell and tube equipment. Doublepipe sections have been designed for up to 165 bar (g) (2, 400 psig) on the shell side and up to 1033 bar (g) (15,000 psig) on the tube side, Metal-to metal ground joints, ring joints or confined Orings are used in the front end closures at lower pressures.

**5.4** Commercially available single tube double-pipe sections range from 50.8 through 101.6 mm (2 through 4-inch) pipe size shells with inner tubes varying from 19 to 63.5 mm (¾ to 2½ inch) pipe size. These can be justified economically if the equivalent shell and surface required is less than 27.8 m2 (300 ft2).

**5.5** In some cases where the thermal resistances of the two fluid film are essentially the same, it will be found for small heat loads that the installation of double pipe finned tube units are more economical than shell and tube units.

**5.6** The use of fin tubes in double pipe sections are normally economical if the annular heat transfer coefficient is less than 75% of the tube side coefficient.

The fin efficiency increases with decreasing annular coefficient and increasing fin thermal conductivity. In addition, shorter fins have higher fin efficiencies.

**5.7** The inner pipe may be bare or longitudinally finned. The fins, 16 to 48 per tube, are 12.7 to 25.4 mm (½ to 1 inch) high 0.9 to 1.3 mm (35 to 50 mils) thick.

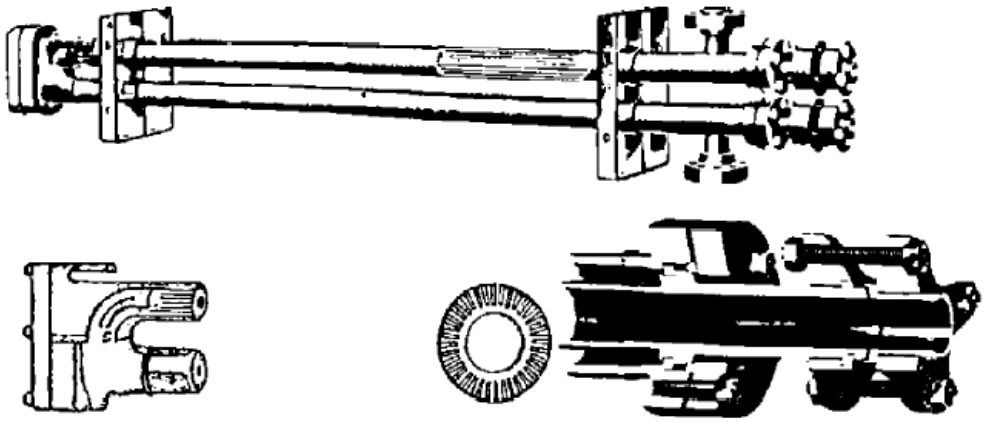
**5.8** Multiple tube double pipe sections contain from 7 to 64 tubes, bare or longitudinally finned,

within the outer pipe shell. Normally, only bare tubes are used in sections containing more than 19 tubes. Section shells normally range from 101.6-406.4 mm (4 through 16 inch) pipe sizes. The inner tubes are available with outside diameters of 15.9-25.4 mm (5/8 inch to 1 inch). The fins, 12 to 20 per tube, are nominally 6.3 mm (¼ inch) high and 0.9 mm (35 mils) thick.

**5.9** Sections containing 7 tubes are the most common. However, the economics of these sections are difficult to define due to the high surface area per section. One or two sections are normally more economical than the equivalent surface area in single tube sections. But, if the particular service requires fractional portions or short tube lengths of a multitube section, single tube sections are more economical.

**5.10** Section containing more than 7 tubes per section are rarely used since they have limited, if any, economic advantage for most services.

**SINGLE TUBE DOUBLE PIPE SECTION**

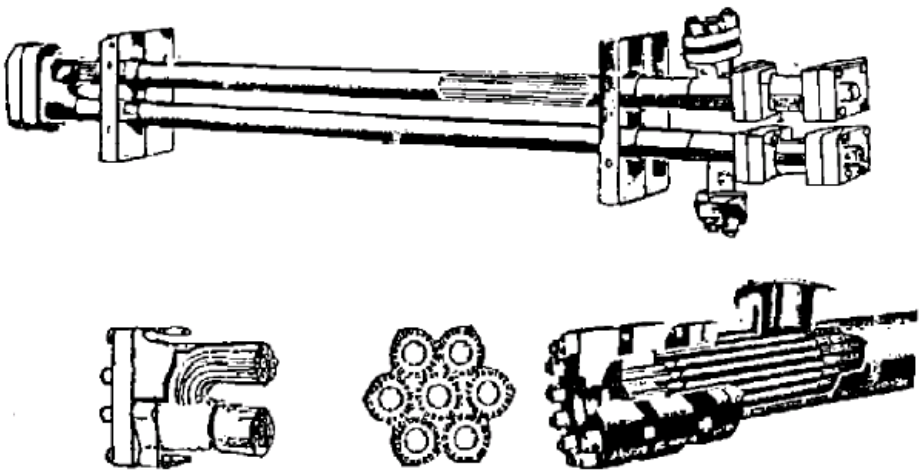


DETAIL A
Return bend housing and cover plate.

DETAIL B
Cross-section view of fin-tube inside shell.

DETAIL C
Shell-to-tube closure and tubeside joint.

**MULTIPLE TUBE DOUBLE PIPE SECTION**



**TYPICAL DOUBLE PIPE COMPONENTS/SINGLE TUBE DOUBLE PIPE SECTION & MULTIPLE TUBE DOUBLE PIPE SECTION**

**Fig. 2**

## 6. ADVANTAGES & DISADVANTAGES

### 6.1 Advantages

**6.1.1** The use of longitudinal finned tubes will result in a compact heat exchanger for shell side fluids having a low heat transfer coefficient.

**6.1.2** Counter current flow will result in lower surface area requirements for services having a temperature cross.

**6.1.3** Potential need for expansion joint is eliminated due to U-tube construction.

**6.1.4** Shortened delivery times can result from the use of stock components that can be assembled into standard sections.

**6.1.5** Modular design allows for the addition of sections at a later time or the rearrangement of sections for new services.

**6.1.6** Simple construction leads to ease of cleaning inspection and tube element replacement.

### 6.2 Disadvantages

**6.2.1** Hairpin sections are specially designed units which are normally not built to any industry standard other than ASME Code. However, TEMA tolerances are normally incorporated wherever applicable.

**6.2.2** Multiple hairpin sections are not always economically competitive with a single shell and tube heat exchanger.

**6.2.3** Proprietary closure design requires special gaskets.

## 7. DESIGN CONSIDERATIONS

**7.1** The heat transfer area and heat transfer coefficients shall be based on the total effective outside tube and fin surface. The effective tube wall and fin metal resistance shall be considered in calculating the heat transfer coefficient.

**7.2** The more viscous fluid is usually passed through the annulus. Cooling water is normally passed through the tube side.

**7.3** Fouling factors for circulating cooling water may be taken 0.35 $m^2$.°C/ kW or 0.00035 $m^2$.°C/W (0.002 $ft^2$.h.°F/Btu) when the water velocity is maintained at 1 meter per second or greater. No water velocity less than 1 meter per second shall be allowed without approval of the Company. Other fouling factors shall be as shown on the individual specification sheet.

**7.4** Tube elements shall be removable without cutting the shell or connecting piping and without disconnecting the shell piping.

**7.5** One end of the tube element shall be free-floating for thermal expansion.

**7.6** No internal screwed connections shall be allowed.

**7.7** Fins shall be longitudinal and may be attached to the outside of the inner tube or pipe either by welding or by mechanical bonding. Minimum thickness of the fins shall be 0.8 mm.

**7.8** Overall length shall be approximately 10 meters. Minimum outside tube diameter of the tube element shall be 25.4 mm (1 inch) and minimum thickness shall be equivalent to 12 BWG tubing or Schedule 40 pipe.

**7.9** Minimum corrosion allowance on pressurized steel pressure parts shall be 3 mm except for tubes.

**7.10** All pipe and tubing used in construction of the exchangers shall be seamless.

**7.11** Heat exchangers shall be designed to conform to specified shell side or tube side design pressure. Designs based on differential pressure of shell side and tube side will not be permitted.

**7.12** Minimum design temperature shall be 10% above maximum operating temperature, or maximum operating temperature plus 28°C whichever is greater.

**7.13** Minimum design pressure shall be 10% above the maximum operating pressure or maximum operating pressure plus 2 bar (200 kPa), whichever is greater.

**7.14** Double pipe sections can be combined in a variety of series/ parallel arrangements to provide the required surface area while maintaining pressure drop limitations. Sections installed in series are normally mounted one on top of the other. Sections connected in parallel are normally side by side series/parallel arrangements which are obtained using a combination of side by side and one over the other mountings.

**7.15** The following restrictions shall apply to double-pipe heat exchangers:

- Finned tubes should not be used where fouling is expected on the shell side.
- Finned tubes shall not be used where the fins are likely to be exposed to a corrosive medium.
- A hairpin exchanger is not permitted if fouling is expected on the tube side.

## 8. APPLICATION GUIDELINES *

The suitability of using hairpin exchanger in a given application is frequently evaluated by computing the UA product from the basic heat transfer equation:

UA = Q /LMTD

For preliminary evaluation UA = 79 000 may be considered to be the upper economical limit for applying hairpin type units.

UA = 79 000 W/°C

Above this value, the unit may be uneconomical for a hairpin type design. If a hairpin is applied, it may require multiple 400 mm multitube sections.

UA = 53 000 to 79 000 W/°C

In this range, one or more 300 mm to 400 mm multitube sections will normally be required.

UA = 26 000 to 53 000 W/°C

In this range, one or more 100 mm to 300 mm multitube sections will normally be required.

UA = 26 000 W/°C

Below this value, both double pipe and multitube sections should be evaluated.

Table 1 lists typical sizes for hairpin type exchangers.

**TABLE 1 - TYPICAL HAIRPIN EXCHANGER SIZES**

| | Double Pipe | Multitube |
|---|---|---|
| Shell Dia (mm) | 50 - 150 | 75 - 400 |
| Tube Dia (mm) | 18 - 100 | 18 - 75 |
| No. of Longitudinal Fins | 0 - 72 | 0 - 24 |
| Fin Height (mm) | 0 - 18 | 0 - 12 |
| Surface ($m^2$/6 m) | 1 - 4 | 7 - 140 |

* A typical specification sheet for double pipe heat exchangers is shown in IPS-G-ME-230 (Appendix A).