

PETRONAS TECHNICAL STANDARDS

DESIGN AND ENGINEERING PRACTICE

TECHNICAL SPECIFICATION

FOULING RESISTANCES FOR HEAT TRANSFER EQUIPMENT

PTS 20.21.00.31

DECEMBER 2010



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PTS Title:	Fouling Resistances for Heat Transfer Equipment

This revision of PTS **20.21.00.31 – Fouling Resistances for Heat Transfer Equipment (November, 2010, Revision 1.0)** has been updated to incorporate PETRONAS Lessons Learnt, Best Practice and based on the updated information issued by relevant industry code and standards. All updates in the document are highlighted in *italic* font.

The previous version of this PTS **20.21.00.31 (December, 1998)** will be removed from PTS binder / e-repository from herein onwards.

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PREFACE

PETRONAS Technical Standards (PTS) publications reflect the views, at the time of publication, of PETRONAS OPU/Divisions.

They are based on the experience acquired during the involvement with the design, construction, operation and maintenance of processing units and facilities. 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 technical practice to be applied by PETRONAS' OPU in oil and gas production facilities, refineries, gas processing plants, chemical plants, marketing facilities or any other such facility, and thereby to achieve maximum technical and economic benefit from standardisation.

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1. INTRODUCTION

1.1 SCOPE

This PTS specifies requirements and gives recommendations for establishing fouling resistance values for new unfired heat transfer equipment. It may also be used as a common basis for comparison of measured fouling rates.

The fouling-resistance values given are based on average process conditions but shall be interpreted with judgement.

This PTS is a revision of the PTS of the same number dated December 1998.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Principle, the distribution of this PTS is confined to companies forming part of the PETRONAS or managed by a Group company, and to Contractors and Manufacturers/Suppliers nominated by them (i.e. the distribution code is "F" as defined in PTS 00.00.05.05).

This PTS is intended for use in oil refineries, chemical plants, gas plants, exploration and production facilities and supply/marketing installations.

If national and/or local regulations exist in which some of the requirements are more stringent than in this PTS, 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, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this document 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 PTS as closely as possible.

1.3 DEFINITIONS

1.3.1 General 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 or maintenance 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 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** indicate a requirement.

The word **should** indicate a recommendation.

1.3.2 Specific definitions

Fouling resistance A measure of the ultimate additional resistance to heat transfer caused by deposits on and corrosion of the heat transfer material surface. The fouling resistance depends on the type of fluid, the heat-transfer surface material, the temperature conditions, the flow velocities and the operating period between two successive cleaning actions.

Fouling coefficient The reciprocal of the fouling resistance.

NOTE: The use of the fouling coefficient has generally been abandoned, since it tends to be confusing that an increase in fouling results in a decrease in the fouling coefficient.

1.4 CROSS-REFERENCES

Where cross-references to other parts of this PTS are made, the referenced section number is shown in brackets. Other documents referenced in this PTS are listed in (5).

1.5 SUMMARY OF MAIN CHANGES

No change was made to this revision.

2. APPLICABILITY AND BASIS OF THE DATA

2.1 APPLICABILITY OF DATA

Fouling resistance values apply for shell and tube heat exchangers for both shell-side and tube-side fluids as well as for fluids flowing on tube side of air-cooled heat exchangers.

Other types of heat exchangers, non tubular, are not normally designed with these fouling resistance values.

2.2 BASIS OF DATA

The values given in (4) are the result of experience and common practice. Tables 1 to 21 are grouped by type of processing unit, since it is impossible to make a proper evaluation of all variables which affect fouling. Table 22 gives values for water and steam.

The values given are based on the assumption that flow velocities, temperature and fluid conditions are comparable in similar units.

The listed values generally do not take into account:

- i. The effect of shell-side or tube-side flow;
 - ii. The effect of flow velocities;
 - iii. Temperature limitations.
- a) For products containing sediments, cracked products and other unstable materials containing for example polymers, tube-side flow is preferred. Fouling is more pronounced on the shell side of heat exchangers than on the tube-side flow because of dead corners and the effect of bundle bypassing. Therefore for these products the values given are for tube-side flows only, if not otherwise stated.
 - b) *Flow velocities of fluids should be chosen as high as compatible with process requirements and acceptable power consumption, having regard to the effect of erosion and corrosion caused by this velocity. This may be aggravated by the presence of sediments. For tube-side flow the velocity should be not less than 1.0 m/s; for shell-side flow the effective velocity (taking due account of bypass streams) should be not less than 0.5 m/s.

Shell-side velocities can often be improved by the installation of more shells in series.

For cooling water the preferred tube-side flow velocity depends on the tube material as shown in Appendix 1. The minimum allowed velocities are also given in Appendix 1.
 - c) *For cooling water, either from a cooling tower or a once-through system, the maximum water-side skin temperature in clean condition shall be not higher than 52 °C (in view of increased fouling tendency), unless otherwise specified.

* For those exchangers where definite restrictions are applicable with regard to maximum or minimum skin temperature and minimum or maximum flow velocity, this shall to be specified in the applicable process specification and data/requisition sheets.

3. APPLICATION OF LOWER FOULING RESISTANCES

Lower fouling resistances may be appropriate if one or more of the circumstances described below apply. However, such lower values may be applied only where specifically approved by the Principal.

- In services where the surface requirements are significantly influenced by the degree of fouling, it may be advantageous to specify a lower resistance if a reduced period between two successive shutdowns is feasible. This can be achieved for instance by the installation of a spare exchanger in parallel with the one in operation, thus enabling cleaning at any time without plant shutdown. This is especially important where controllability/stability is influenced by fouling, e.g. in thermosyphon reboilers.
- The maximum allowable pressure drop generally limits the fluid velocity. This means that for designs where low pressure drops have to be applied the fluid velocities will often become low. When the specified fouling resistance is high, resulting in the installation of considerable over-surface in clean condition, the maximum attainable velocity may reduce appreciably. This, in turn, will increase the tendency of fouling. By taking a lower fouling resistance, a smaller heat exchanger will be adequate, thus making it possible to apply a higher velocity and still stay within the limits of allowable pressure drop.

NOTE: The selection of lower fouling resistances should be done with due regard to the drive to longer periods between shutdowns.

4. FOULING RESISTANCE TABLES

Table	Title
1	Distillation units
2	Luboil plants
3	Hydroprocessing units
4	Conversion units
5	Ethylene plant
6	Ethylene oxide plant
7	Cumene plant
8	Phenol plant
9	Di-phenylol propane plant
10	Epikote plant
11	C ₃ = solvent plant
12	C ₄ = solvent plant
13	Butadiene plant
14	Sulfolane plant
15	Aromatics plant
16	Xylenes plant
17	Urea wax plant
18	Wax cracking unit
19	Luboil hydrocracking unit
20	Treating units
21	Liquefied natural gas plant
22	Values for water and steam

Table 1 **DISTILLATION UNITS**

Fluid	Fouling resistance $\text{m}^2.\text{K/W}$
<i>Crude distilling unit</i>	
Crude, waxy	0.57×10^{-3}
Crude, non-waxy	0.43×10^{-3}
Atmospheric Column overhead vapours	0.17×10^{-3}
Gasoline and lighter products	0.17×10^{-3}
Kerosine	0.21×10^{-3}
Light gas oil	0.25×10^{-3}
Heavy gas oil	0.25×10^{-3}
Long residue	0.57×10^{-3}
<i>High vacuum unit</i>	
Vacuum column overhead vapours	0.34×10^{-3}
Vacuum gas oil	0.25×10^{-3}
Spindle oil	0.25×10^{-3}
Light machine oil	0.25×10^{-3}
Medium machine oil	0.29×10^{-3}
Cylinder oil	0.34×10^{-3}
Dirty wash oil	0.86×10^{-3}
Short residue	0.86×10^{-3}

Table 2 LUBOIL PLANTS

Fluid	Fouling resistance m ² .K/W
<i>Propane deasphalting unit</i>	
Prediluted short residue	0.86×10^{-3}
De-asphalted oil	0.34×10^{-3}
De-asphalted oil/propane mixture	0.29×10^{-3}
Asphalt/propane mixture	0.86×10^{-3}
Asphalt	0.86×10^{-3}
Propane	0.17×10^{-3}
<i>Furfural extraction unit</i>	
Charge oil	0.34×10^{-3}
Furfural	0.34×10^{-3}
Pseudo-raffinate	0.51×10^{-3}
Extract/furfural mixture	0.86×10^{-3}
Wet furfural	0.86×10^{-3}
Extract	0.51×10^{-3}
Raffinate	0.25×10^{-3}
Raffinate/furfural mixture	0.34×10^{-3}
<i>MEK de-waxing unit</i>	
Solvent	0.17×10^{-3}
Propane or ammonia	0.17×10^{-3}
Waxy oil/solvent mixture	0.25×10^{-3}
De-waxed oil/solvent mixture	0.25×10^{-3}
Slack wax/solvent mixture	0.25×10^{-3}
De-waxed oil, above 110°C	0.17×10^{-3}
De-waxed oil, below 110°C	0.34×10^{-3}
Slack wax	0.25×10^{-3}
<i>Common facilities</i>	
Hot oil	0.34×10^{-3}

(MEK = methyl ethyl ketone)