DEP SPECIFICATION

FILTERS FOR REMOVING PARTICLES FROM HYDROPROCESSOR FEEDS - TYPE SELECTION AND DESIGN RULES

DEP 31.27.21.10-Gen.

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DESIGN AND ENGINEERING PRACTICE

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1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for the selection and design of feed filters for hydroprocessing units.

Feed filters remove solid particles from the liquid feed which would otherwise foul the hydroprocessing reactors or other equipment.

This is a revision of the DEP of the same number dated March 2001; see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

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This DEP is intended for use in facilities related to oil refining. 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
Separation (filtration) efficiency	A quantitative measure of how well a separator (or filter) retains particles in a separation (or filtration) process. Often expressed as the fractional or percentage retention of solids in the feed retained by the filter. It depends on the characteristics of the filter and the particle size distribution and nature of the solids.

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Term	Definition
Grade efficiency	The fraction of particles of a certain size retained by the separator. It is a function of particle size, and the curve obtained by plotting the grade efficiency versus particle size is called the grade efficiency curve. Many types of separators have grade efficiency curves which run from 100 % separation for relatively large particles to 0 % separation for relatively small particles. Particles between the minimum and maximum sizes have a probability of being collected by the filter equal to the value of the grade efficiency, which can be read directly from the graph. The grade efficiency curve can be seen as a characteristic curve of the separator, although it will depend on the nature of the solids (free flowing, sticky). It is commonly used to calculate separation efficiencies of continuously operated separators such as cyclones. The representation of the separation characteristics of a feed filter is complicated by the fact that the separation is a transient process depending on the cumulative amount of solids collected. The grade efficiency is expected to shift to smaller particles as the cumulative volume of retained particles increases. For the purpose of selecting a filter, “average” grade efficiencies should be used.
Filter rating	A relative measure of the size of particles retained by the filter, expressed in microns. It is usually only used consistently for one type of filter supplied by the same Manufacturer/Supplier One single Manufacturer/Supplier may use different ratings for different types of filters having the same particle removal efficiency. Different Manufacturers/Suppliers of the same type of filter may use different ratings for the same particle removal efficiency. Addition of the removal efficiencies for the specified filter rating makes it possible to compare the same type of filters from different Manufacturers/Suppliers. Different types of filters should be compared on the basis of the entire grade efficiency curve. The term absolute filter rating is used by a number of Manufacturers/Suppliers to indicate the particle size removed with an efficiency of 99.98 %. Other Manufacturers/Suppliers associate the term “absolute” with the invariance of the pore structure of the filter medium (some types of filter media release already collected particles beyond a certain pressure drop (“shedding”) due to rearrangement of the pore structure; pore structures can be made “invariant” by gluing, coating or sintering the particles making up the filter medium). However, more factors, such as the flow, fluid, type and size distribution of the test dust and the dust concentration, have an influence on the rating of a filter.
Solids holding capacity and potential solids holding volume	An important parameter used for separators without continuous removal of the solids. For separators suffering pressure drop increase due to fouling with solid particles, the actual solids holding capacity is the amount of solids the separator has collected at the maximum pressure drop increase across the separator that is recommended to trigger the change-out of the filter elements. This amount can be expressed both as mass and as volume and is expected to be a function of the flow and the properties of the separated solids such as dry bulk density and permeability. The potential solids holding volume is the maximum net volume (volume corrected for the volume used by internals) in the separator available for holding solids. The volume based actual solids holding capacity is always smaller than the potential solids holding volume.
Filtration area	The surface area of the filter medium used for filtration in parallel flow, independently of the porosity of the medium and the number of stacked medium layers. For multilayer pleated filters the unfolded surface area of a single layer

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Term	Definition
	should be used although a part of this area may be inaccessible for flow. In that case an effective filtration area can be defined as the filtration area accessible for fluid flow, but this may be difficult to quantify. Besides the filtration area, the open area is used for slotted and wire screen filter surfaces as the smallest cross sectional area accessible for flow. It is often expressed as a percentage of the filtration area.
Filtration time	The time needed for the pressure drop to increase (at given flux rate, fluid viscosity, solids characteristics and solids concentration) from the clean pressure drop to the maximum pressure drop recommended for initialising cleaning of the filter or replacement of the filter elements.

1.3.3 Symbols and abbreviations

Term	Definition
DBF	Deep Bed Filters
HSSE	Health Safety Security and Environment
ppmw	parts per million by weight
WTC	Westhollow Technology Center

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 (12).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a revision of the DEP of the same number dated March 2001. The following are the main, non-editorial changes.

Old section	New section	Change
		Split DEP into two parts: Specification and Informative
4.2.3	**4.2.3**	Updated standard methods for off-line solids concentration analysis
	4.2.4	Added a new section to describe available apparatus in Shell for standard solids concentration analysis
4.3	**4.3**	Added a test method for particle size distribution analysis recently developed by Shell (see Informative)
4.4	**4.4**	Added available methods for elemental composition analysis of solids
5.1	**5.1**	Rewrote and re-organized the section, expanded the section by adding new filtration technology development and best practice on deep bed filters
5.2	**5.4**	Expanded the section with a list of Manufacturers/Suppliers (see Informative)
	5.2	Added a new sections on mesh size selection
	5.3	Added a new sections on filter media selection
12	**12**	Removed unused references and verified/updated the titles of references

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1.6 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://sww.shell.com/standards and on the main page of the DEPs DVD-ROM.

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.

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2. BACKGROUND - PURPOSE OF FEED FILTERS

Intermediate oil products in a refinery often contain various types of solid particles, such as:

a) sand, clay
b) salts
c) coke
d) corrosion products
e) surfactants
f) oil oxidation products
g) oil polymerization products

These solid particles cause fouling of equipment and the requirement for cleaning, thus causing early shutdown of equipment or a whole processing unit.

Hydroprocessing plants use filters in the liquid feed ("feed filters") to remove the harmful solids. Normally, a cartridge or candle type of filter is used, but sometimes other types, such as deep bed filters, are used.

Translating the purpose of the feed filter into specifications requires the following knowledge:

a) the grade efficiency characteristics of the equipment to be protected (coalescer, heat-exchanger, reactor);

b) the grade efficiency characteristics of the filter, and;

c) the solids loading.

The grade efficiency characteristics of the equipment is dependent on other fouling abatement measures (graded layers, top bed filters, etc.).

The specification of feed filtering equipment should not be left to the filter Manufacturers/Suppliers, since they may not know the grade efficiency characteristics of the equipment.

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3. FEED FILTER SELECTION - OVERVIEW

Before considering the application of a feed filter, the following measures should be considered:

a) reducing the solids contamination of the feed by improved upstream process control and housekeeping;

b) achieving a better distribution of the solids over the reactor internals and the length of the catalyst bed.

Optimum selection of feed filters should take the following into account:

a) process conditions

b) solids characteristics

c) required performance efficiency

d) purchase cost

e) installation cost

f) operating costs (e.g. cartridge disposal and replacement)

g) depreciation

Figure 1 shows the general feed filter selection process. Each of these steps is discussed in more detail in subsequent sections.

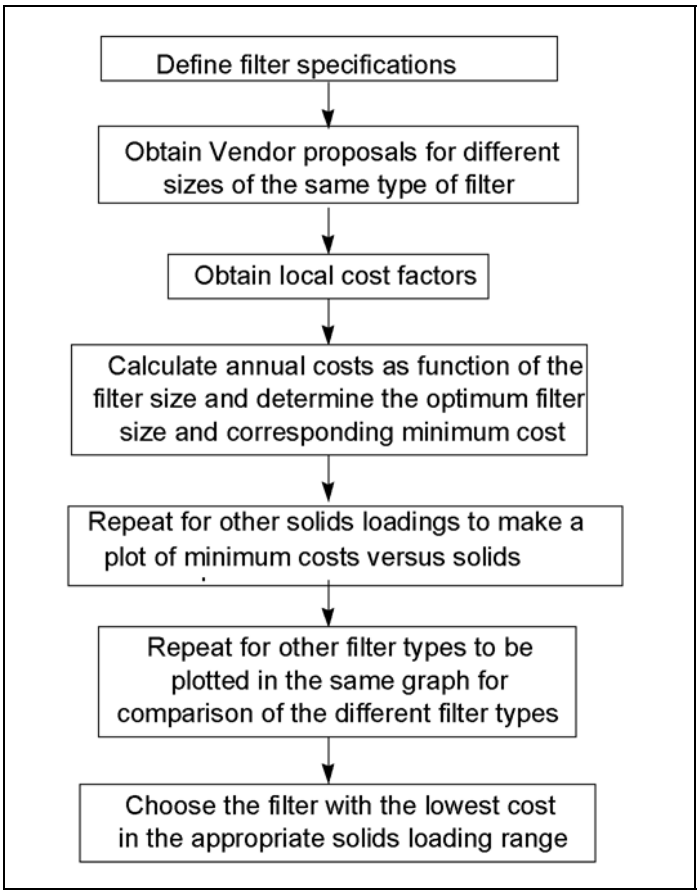

Figure 1 Overview of feed filter selection steps

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