

ExxonMobil DESIGN PRACTICES	EXTRACTION TOWERS PERFORATED (SIEVE) TRAY TOWERS	Section	Page
		IV-B	1 of 27
		December, 2001	

Changes shown by ↗

CONTENTS

Section	Page
SCOPE	3
REFERENCES	3
DEFINITIONS	3
APPLICATION	3
OPERATING LIMITS.....	4
BASIC DESIGN CONSIDERATIONS	4
SELECTION OF DISPERSED PHASE	4
TOWER DIAMETER.....	4
TRAY DESIGN	5
DOWNCOMER SIZING	5
DISPERSION AREA.....	5
DISPERSION HOLE SIZING.....	6
HOLE AREA LAYOUT.....	6
SEAL BOXES	6
TRAY SPACING.....	7
NUMBER OF TRAYS	7
TRAY EFFICIENCY.....	7
INLETS.....	7
OUTLET ZONES	8
INTERFACE DETECTION AND CONTROL.....	8
COALESCENCE MEDIA	8
DRAWING NOTES ON TRAY CONSTRUCTION	8
DETAILED DESIGN PROCEDURE	8
PHASE FLOW RATES AND PHYSICAL PROPERTIES (STEP 1)	8
SETTLING RATES FOR EACH PHASE (STEP 2).....	8
TRIAL TOWER DIAMETER (STEP 3).....	9
TOWER DIAMETER (STEP 4).....	9
TRAY SPACING (STEP 5)	9
DOWNCOMER SIZING (STEP 6)	9
HOLE AREA AND LAYOUT (STEP 7)	9
INLETS (STEP 8)	9
INTERFACE CONTROL ZONE (STEP 9)	9
TOTAL NUMBER OF ACTUAL TRAYS (STEP 10).....	9
NOMENCLATURE	10
COMPUTER PROGRAMS	11

**Documents**

Document Sharing Hub

Section IV-B	Page 2 of 27	EXTRACTION TOWERS PERFORATED (SIEVE) TRAY TOWERS	ExxonMobil DESIGN PRACTICES
December, 2001			

CONTENTS (Cont)

Section	Page
TABLES	
Table 1A	Perforated (Sieve) Tray Extraction Tower Calculation Form (Customary Units).....12
Table 1B	Perforated (Sieve) Tray Extraction Tower Calculation Form (Metric Units) 17
Table 2	Chord Lengths And Chord Areas Vs. Chord Heights.....22
FIGURES	
Figure 1	Conventional Perforated (Sieve) Tray Extraction Tower Design.....23
Figure 2	Single Dispersion Area Tray Hole Layout.....24
Figure 3	Dual Dispersion Area Sieve Tray Design.....25
Figure 4	Dual Dispersion Area Sieve Tray Seal Box Design 26
Figure 5A	Continuous Phase Inlet 27
Figure 5B	Dispersed Phase Inlet 27

Revision Memo

- 12/01** Highlights of this revision are:
- (1) Revised section on Stokes' Law, Intermediate Law and Newton's Law to be consistent with Design Practices Section V-B.
 - (2) Changed dispersion hole sizing calculation for consistency with customary and metric units.
 - (3) Typical overall tray efficiency reduced from 25% to 10-15%.
 - (4) Nomenclature updated.
 - (5) Hole area rating calculations for dual dispersion area trays (Table 1) have been updated to account for crest under seal weir, and head losses through seal box and weir areas.



ExxonMobil DESIGN PRACTICES	EXTRACTION TOWERS PERFORATED (SIEVE) TRAY TOWERS	Section IV-B	Page 3 of 27
	December, 2001		

SCOPE

This subsection covers procedures for designing conventional perforated (sieve) tray towers which are used in amine treating, caustic or Merox treating, and water washing for the removal of trace contaminants from light hydrocarbon products. Detailed mechanical design is normally handled by the tray and tower fabricators.

Special perforated tray designs used for lubes treating, aromatics (benzene, toluene, xylene) recovery and deasphalters, are not covered in this subsection.

REFERENCES

GLOBAL PRACTICE

GP 5-2-1 Internals for Towers and Drums.

OTHER REFERENCES

1. *Amine Treating Process and Operating Information Manual*, May 31, 1984.
2. Baird, R. S. and Fiocco, R. J., *Guide for Applying Coalescing Media to Debottleneck Extractors, Liquid-Liquid Settlers and Sand Filters*, EE.5E.93, January 1993.
3. Maloney, D. P., *Water Wash Sieve Tray Towers to Extract Methanol from C₄ Streams*, 91CET 290, October 1991.
4. See [Section IV-A](#) References.

DEFINITIONS

See also [Section IV-A](#).

Dispersion Area. The dispersion area of a tray is the hole area designed for the dispersed phase flow. Depending on the tray type, all or part of the dispersion area may be in use at a given dispersed phase flow rate.

Drop Holdup. Dispersed phase can hold up in extractors in three ways: (1) the layer below the trays, (2) drops rising in the continuous phase between trays, and (3) emulsion and coalesced layers at the dispersed phase outlet where the interface is controlled. The portion of dispersed phase holdup represented by drops in the continuous phase between trays is referred to as the drop holdup.

Emulsion Band. The emulsion band is the concentrated layer of dispersed phase droplets which accumulate at the interface between the continuous phase and the coalesced dispersed phase. The droplets accumulate at the interface until drainage of the film of the continuous phase which surrounds the droplets is adequate to permit coalescence.

Flooding. Flooding is a condition caused by operation of the extraction tower at dispersed or continuous phase flow rates exceeding the capacity of the tower. Typically, flooding is evidenced by a significant buildup of the dispersed phase within the extractor and/or by excessive entrainment.

Phase Inversion. Phase inversion refers to a condition where the dispersed phase droplets spontaneously coalesce, trapping the continuous phase which originally surrounded the droplets. This causes the continuous phase to become dispersed as fine droplets in the coalesced dispersed phase. This phenomenon primarily occurs in emulsion bands which have a high concentration of dispersed phase droplets.

Solvent Treat Ratio. The solvent treat ratio is the ratio of the volumetric flow rate of solvent to that of the feed. It is generally expressed as a percentage, e.g., 10% amine treat.

APPLICATION

Perforated (sieve) tray designs described in this section are for light hydrocarbon liquids, such as LPG and naphtha, from which trace contaminants, such as hydrogen sulfide and mercaptans, are to be removed. The liquid systems encountered in light hydrocarbon treating services generally have a high interfacial tension, e.g., greater than 30 dynes per centimeter (30 mN/m).

Figure 1 shows a conventional extractor design, with the light hydrocarbon feed introduced at the bottom and dispersed by sieve trays as it flows up the tower. The heavier solvent phase is the continuous phase and is introduced near the top of the extractor. Solvent treat ratios typically range from 10% to 20% for light hydrocarbon applications. The hydrocarbon flow rate through the tower is essentially constant since very little mass transfer occurs. The liquid phases separate readily at the top of the tower where the interface is controlled. Emulsion-stabilizing contaminants, such as surface active agents and fine solids, can significantly broaden the emulsion band at this interface and cause upsets.

Special tray designs are required for high mass transfer systems such as lubes and aromatics processes. These systems have very low interfacial tension and, therefore, tend to form very small droplets and emulsions which are difficult to separate. In addition, feed rates can vary considerably and solvent treat ratios are high, e.g., up to 250%. It is recommended that your FRACTIONATION SPECIALIST be consulted regarding these designs.



Section IV-B	Page 4 of 27	<i>EXTRACTION TOWERS</i> PERFORATED (SIEVE) TRAY TOWERS	 DESIGN PRACTICES
December, 2001			

APPLICATION (Cont)

OPERATING LIMITS

The table below, which is based on operating experience, lists the lower and upper operating limits for liquid-liquid extractors. If your case does not fall within these limits, contact your FRACTIONATION SPECIALIST.

TRAYED LIQUID-LIQUID EXTRACTOR OPERATING LIMITS

VARIABLE	LOWER LIMIT	UPPER LIMIT
Pressure	40 psia (275 kPa)	500 psia (3450 kPa)
Temperature	100°F (40°C)	200°F (95°C)
Diameter	12 in. (300 mm)	30 ft (9.1 m)
Physical Properties		
Interfacial tension	1 dyne/cm (1 mN/m)	50 dynes/cm (50 mN/m)
Liquid viscosity	0.05 cP (0.05 mPa·s)	10 cP (10 mPa·s)
Specific gravity differential	0.1	1.0
Tray Spacing	18 in. (450 mm)	30 in. (750 mm)
Hole Diameter	1/4 in. (6 mm)	1/2 in. (13 mm)
Dispersed Phase Tower Loading	n/a	10 gpm/ft ² (6.8 dm ³ /s·m ²)

BASIC DESIGN CONSIDERATIONS

SELECTION OF DISPERSED PHASE

The first consideration in designing an extraction tower is the selection of the phase to be dispersed. Normally the phase with the higher volumetric flow rate is dispersed since this will provide the larger number of drops, i.e., maximize the interfacial contact area between the two phases. Thus, sieve tray extractors treating light hydrocarbon systems for the removal of small amounts of contaminants typically operate with the hydrocarbon phase dispersed. In unusual cases where operation is being considered with the solvent phase dispersed, consult your FRACTIONATION SPECIALIST.

TOWER DIAMETER

Tower diameter is the key factor in avoiding flooding. Design is based on the smallest size drop which must be separated from each phase, and on the area required for coalescence of the dispersed phase droplets to avoid deep emulsion bands. Drop size also impacts mass transfer efficiency and, hence, tower height. Drop size, in turn, depends on hole size, hole velocity, interfacial tension, and other factors. Smaller drop sizes are generally more desirable for mass transfer and shorter towers, and larger drops more desirable for phase separation and narrower towers. Thus, overall extractor design involves a balance between mass transfer rates and phase separation rates.

Design Practices for the light hydrocarbon services covered in this subsection are based on sieve hole velocities above 1 foot per second (0.3 m/s) which can generate drop diameters down to about 0.005 in. (0.127 mm). Therefore, tower diameter is based on the settling rate for 0.005 in. (0.127 mm) diameter drops when essentially no entrainment can be tolerated in the outlet streams. In addition, tower diameter must be adequate for coalescence area requirements, i.e., a maximum of 10 gallons per minute of dispersed phase flow per square foot (6.8 dm³/s·m²) of tower cross-sectional area. This limitation is based on the potential for undesirably deep emulsion bands at the top of the tower and under each tray. Poor separation and/or phase inversions can result from deep emulsion bands, and lead to flooding and entrainment. As discussed later in this subsection, coalescence media may be desirable to promote separation in some applications.

Typically, extractors are designed for essentially no entrainment. For example, in amine treaters, entrained hydrocarbon in solvent could cause foaming in the amine regenerator, and entrained solvent in hydrocarbon product increases solvent makeup costs. Even when water washing facilities are provided after product treaters, it is generally desirable to minimize solvent losses to the water phase. For cases where some entrainment may be tolerable, such as extraction towers followed by entrainment removal facilities, a larger drop size may be used for calculating the limiting settling rate of that phase. It is recommended that your FRACTIONATION SPECIALIST be consulted in such cases.

 DESIGN PRACTICES	EXTRACTION TOWERS PERFORATED (SIEVE) TRAY TOWERS	Section	Page
		IV-B	5 of 27
		December, 2001	

BASIC DESIGN CONSIDERATIONS (Cont)

Droplet settling (or rising) rates may be calculated by the rigid sphere settling equations (given below) which apply to a single droplet settling in a stagnant liquid. Correction factors for hindered settling are generally not warranted when 0.005 in. (0.127 mm) diameter drops are used for design, since the fraction of droplets in the outlet streams, where separation is critical, is very small and only slightly affects settling. Tower diameter is set such that the velocity of the phase from which the droplets are settling (or rising) does not exceed the droplet velocity, in order to allow the droplets to separate at the outlet zones of the tower. Droplet settling between trays is normally not critical.

RANGE OF APPLICABLE REYNOLDS NUMBERS, Re

Stokes' Law:	$v = (C_1) \left(\frac{d^2 \Delta S}{\mu} \right)$	Re < 2	Eq. (1a)
Intermediate Law:	$v = (C_2) \left[\frac{d^{1.143} \Delta S^{0.714}}{\mu^{0.429} S^{0.286}} \right]$	2 ≤ Re ≤ 500	Eq. (1b)
Newton's Law:	$v = (C_3) \left(\frac{d \Delta S}{S} \right)^{0.5}$	Re > 500	Eq. (1c)
	$Re = C_4 \frac{d v S}{\mu}$		Eq. (1d)

where: v = Settling rate of droplet, ft/min (mm/s)
C₁ = Constant = 6.92x10⁴ for Customary units (544 for Metric units)
C₂ = Constant = 858 for Customary units (108 for Metric units)
C₃ = Constant = 171 for Customary units (172 for Metric units)
C₄ = Constant = 128 for Customary units (0.999 for Metric units)
d = Droplet diameter, in (mm)
S = Specific gravity of the phase through which the droplet settles, dimensionless
ΔS = Specific gravity differential between the two phases (absolute value), dimensionless
μ = Viscosity of the phase through which the droplet settles, cP (mPa·s)

TRAY DESIGN

Tray design guidelines are presented in this section. They are based on a balance of mass transfer and phase separation considerations, and aimed at providing flexibility to handle upsets and possible changes in operating conditions. When considering any design variations, such as in debottlenecking existing towers, it is recommended that your FRACTIONATION SPECIALIST be consulted. Proprietary sieve tray designs, such as those offered by UOP, have overflow weirs and downtubes (instead of downcomers) for the continuous heavy phase liquid. These proprietary designs should be reviewed with a FRACTIONATION SPECIALIST.

DOWNCOMER SIZING

Downcomer area and clearance are set primarily to avoid flow restrictions and, hence, high velocities for the continuous phase (see **Figure 2**). Downcomer area is sized for a maximum linear velocity of 0.15 ft per second (46 mm/s). To assure uniform flow of the continuous phase across the tray, the minimum downcomer chord length recommended is 65% of the tower diameter. This corresponds to a minimum area of 6.8% of the tower cross-sectional area and a minimum downcomer chord height of 12% of the tower diameter. The clearance under the downcomer is sized for a maximum velocity of 0.1 ft per second (30 mm/s) and should not be greater than one-half the tray spacing to provide a quiescent zone for drop settling and coalescence.

DISPERSION AREA

Either of two single pass sieve tray designs is generally used. Single dispersion area sieve trays (**Figures 1 and 2**) are the simplest to design and construct, and allow feed turndown ratios down to about 0.4, which is normally adequate for most applications. For turndown ratios less than 0.4, dual dispersion area trays are used (**Figure 3**). Unused dispersion hole area on these trays is segregated by a seal box and weir, which are sealed to the tower wall, to avoid bypassing of either the dispersed phase or the countercurrently flowing continuous phase. The layer of dispersed phase under the sieve trays provides both residence time for coalescence and driving force for flow through the holes.



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Section IV-B	Page 6 of 27	<i>EXTRACTION TOWERS</i> PERFORATED (SIEVE) TRAY TOWERS	 DESIGN PRACTICES
December, 2001			

BASIC DESIGN CONSIDERATIONS (Cont)

DISPERSION HOLE SIZING

Dispersion hole size and area are set primarily to assure satisfactory formation of dispersed phase droplets for efficient mass transfer and phase separation. For clean service, 1/4 in. (6 mm) diameter holes are recommended spaced on a triangular pitch of approximately 1 in. (25 mm). For dirty services where tray plugging is a concern, larger holes, i.e., 3/8 to 1/2 in. (10 to 13 mm) diameter, can be used, spaced on a triangular pitch 2 to 4 times the hole diameter. The holes should be punched in the direction of flow through the hole, leaving a lip on the drop discharging side of the tray, i.e., on the upper side when light phase is dispersed. Tray supporting structures should not obstruct the flow of either phase across the tray.

The dispersion hole area required may be calculated from the following equation:

$$\begin{array}{ll}
 \text{Customary} & \text{Metric} \\
 A_H = \frac{V_D}{60 C} \sqrt{\frac{S_D}{2 g b \Delta S}} & A_H = \frac{V_D}{1000 C} \sqrt{\frac{1000 S_D}{2 g b \Delta S}} \quad \text{Eq. (2)}
 \end{array}$$

where: A_H = Total hole area, ft² (m²)
 b = Depth of dispersed phase layer below holes, ft (mm)
 C = Coefficient of discharge = 0.7
 g = Gravitational constant = 32.2 ft/s² (9.81 m/s²)
 S_D = Specific gravity of dispersed phase at operating conditions, dimensionless
 ΔS = Specific gravity differential between the dispersed and continuous phases (absolute value), dimensionless
 V_D = Volumetric flow rate of dispersed phase, ft³/min (dm³/s)

For single dispersion area sieve trays, a 3 in. (75 mm) dispersed phase layer depth is normally used at the design dispersed phase flow rate. During operation the layer depth can range from about 0.5 to 6 in. (13 to 150 mm). The hole area for dual dispersion area trays is also calculated from [Eq. 2](#). The primary hole area (based on minimum tower feed rate) is placed outside the seal box, and the additional hole area (secondary) required to accommodate the maximum rate is located inside the seal box ([Figure 3](#)). The primary dispersion area is sized to hold a 2 in. (50 mm) layer beneath the tray during the low rate operation. When the dispersed phase rate increases, the layer builds up and flows under the baffle to utilize the secondary dispersion area. This area is sized to hold a 4 in. (100 mm) layer beneath the tray at the maximum dispersed phase rate.

HOLE AREA LAYOUT

Hole area layout is such that good contacting between the two phases occurs and bypassing of droplets into the downcomer is avoided. The holes are located at the opposite side of the tray from the downcomer of the tray, but should not be closer than 4 in. (100 mm) to the downcomer of the tray above. The holes should not extend to the sides beyond the length of the downcomer chord. Examples of hole layouts for single and dual dispersion area trays are shown in [Figures 2 and 3](#).

SEAL BOXES

Seal boxes for dual dispersion area trays are designed such that dispersed phase flow is not restricted and little or no bypassing of continuous phase occurs through the sieve holes which are not being used for dispersed phase flow. The area for flow of dispersed phase between the seal weir and the tray and between the seal weir and the underflow weir ([Figures 3 and 4](#)) is designed for a velocity of 15 ft per minute (76 mm/s), [minimum clearance = 2 in. (50 mm)], based on the maximum flow of dispersed phase into the secondary hole area. The seal weir clearance from the tray is normally 2 to 3 in. (50 to 75 mm), with the seal weir overlapping the underflow weir by 1/2 to 1 in. (13 to 25 mm). It is desirable that the dispersed phase layer extend to the seal weir at the minimum hydrocarbon flow rate to form a seal against bypassing of the solvent phase. This seal, however, is not absolutely necessary if the secondary hole area is less than approximately 10% of the downcomer area, since the solvent treat ratio can generally be increased at low hydrocarbon rates to compensate for solvent bypassing.

ExxonMobil DESIGN PRACTICES	EXTRACTION TOWERS PERFORATED (SIEVE) TRAY TOWERS	Section IV-B	Page 7 of 27
	December, 2001		

BASIC DESIGN CONSIDERATIONS (Cont)

TRAY SPACING

Tray spacing is such that satisfactory mass transfer and phase separation can take place. Greater tray spacings favor both phenomena, since the droplets have a longer rise path for mass transfer to occur between trays and the cross-flow velocity of the continuous phase is decreased. The cross-flow velocity of the continuous phase (measured at the widest part of the tray) should be less than 3 ft per minute (15 mm/s). Access to the trays is also a consideration. The following table should be used to select a trial tray spacing:

TOWER DIAMETER	MINIMUM TRAY SPACING
≤ 5 ft (1.5 m)	18 in. (450 mm)
5 to 8 ft (1.5 to 2.4 m)	21 in. (525 mm)
8 to 10 ft (2.4 to 3.0 m)	24 in. (600 mm)
10 to 17 ft (3.0 to 5.2 m)	27 in. (675 mm)
> 17 ft (5.2 m)	30 in. (750 mm)

If a manway is located between trays, the minimum tray spacing at that location is 24 in. (600 mm), or 6 in. (150 mm) larger than the manway diameter, whichever is greater.

NUMBER OF TRAYS

The number of trays used in the extractor is generally specified in the Process Design Basis Specification (DBS), and is based on plant experience. In general, the number of actual trays is equal to the number of theoretical stages divided by the overall tray efficiency.

TRAY EFFICIENCY

The mass transfer between the dispersed phase and the continuous phase may be divided into three separate and distinct zones:

1. Transfer during drop formation by the tray.
2. Transfer during drop rise through the continuous phase.
3. Transfer during drop coalescence at the interface of the next tray.

Therefore, overall tray efficiency is a complex function of tray design, which affects drop size and drop holdup, as well as of liquid-liquid system properties, such as interfacial tension, phase viscosities and diffusivities of the transferring component(s). At this time, generalized extraction efficiency correlations are inadequate to accurately predict tray efficiency without experimental data. For reference, however, a typical overall tray efficiency used by designers of light product treaters such as amine or caustic extractors is 10-15%. EMRE contact UOP for tray designs involving caustic extractors in low-sulfur mogas services. A 17% tray efficiency is used for water wash towers to extract methanol from C₄ streams (3). If information on overall tray efficiency is needed for a specific design, your FRACTIONATION SPECIALIST should be consulted.

INLETS

Inlets to extractors are designed to avoid premature dispersion of the dispersed phase below the bottom tray and to minimize disturbances to separation at the outlet zones. The continuous phase is introduced within a false downcomer one tray spacing above the top tray, simulating the flow from a typical tray downcomer within the tower (**Figure 5A**). The area and clearance under the false downcomer is the same as that of a normal tray downcomer. A 1/2 in. (13 mm) vent hole is provided at the top of the false downcomer.

The dispersed phase inlet is an inverted false downcomer which introduces feed below the bottom tray (**Figure 5B**). It is designed to discharge into the dispersed phase layer under the bottom tray at a velocity of 0.4 ft per second (122 mm/s). A minimum clearance of 1 in. (25 mm) to the bottom tray should be provided. If dual dispersion area trays are being used, the dispersed phase inlet is positioned under the seal box of the bottom tray. A 1/2 in. (13 mm) drain hole is provided at the bottom of the inlet.

Section IV-B	Page 8 of 27	EXTRACTION TOWERS PERFORATED (SIEVE) TRAY TOWERS	ExxonMobil DESIGN PRACTICES
December, 2001			

BASIC DESIGN CONSIDERATIONS (Cont)

OUTLET ZONES

Outlet zones at the top and bottom sections of the tower are designed to provide residence time for coalescence of dispersed phase and disengaging of entrainment in both phases (see **Figure 1**). The low interface level can be located at the top of the false downcomer. Capacity for a minimum of 4 minutes residence time based on dispersed phase flow should be provided in the interface control zone between the high and low interface levels. The interface control zone should also be able to provide a minimum of ten minutes based on continuous phase flow rate for control purposes. Capacity for at least 2 minutes of holdup of dispersed phase (4 minutes for amine systems) is recommended between the high interface level and the top tangent of the vessel. Emulsion-prone systems may require greater holdup capacity. For amine systems, there should be at least 3 ft (1 m) between the high and low liquid-liquid interface levels (1).

At the bottom section of the tower, a distance of three tray spacings should be provided between the bottom tangent and the bottom tray. The downcomer of the bottom tray is 50% longer than the typical tray downcomer to provide additional quiescent zone for disengagement of dispersed phase entrainment.

INTERFACE DETECTION AND CONTROL

Interface detection and control in extractors can be a problem, particularly when a wide emulsion band occurs at the interface. This emulsion build-up, and subsequent carryover, could be due to high dispersed phase flow rates, slow coalescence rates or contaminants such as surfactants or fine particles. Interface measurements in gage glasses will indicate an average composition (density) of emulsion and liquid phases between interface taps, rather than an actual interface. In order to better establish the location of the coalesced layer, the use of a series of gage glasses, approximately 14 to 42 in. (350 to 1050 mm) long and overlapping one another is recommended, rather than a single gage glass over the entire interface control zone.

COALESCENCE MEDIA

Coalescence media, such as dual media-crinkled wire mesh screen (DM-CWMS) pads, are not required for new extractor designs based on Design Practices criteria. They are used mainly in debottlenecking applications to promote coalescence of emulsion bands and separation of entrained droplets (2). Your FRACTIONATION SPECIALIST should be consulted regarding design criteria for specific applications. Often, for grass-roots towers, a support ring is specified between the top of the interface control zone and the tower top tangent for future installation of an 18 in. (450 mm) thick coalescence pad.

DRAWING NOTES ON TRAY CONSTRUCTION

In addition to the usual notes on the design pressure and temperature, materials of construction, manways, etc., the following notes regarding tray construction should be included on the tower drawing:

1. Tray supports shall be parallel to the direction of flow of hydrocarbon phase towards the dispersion hole area, so as not to obstruct hydrocarbon flow on the underside of the tray.
2. Dispersion holes shall be punched from the underside of the tray, in the direction of hydrocarbon flow through the holes, leaving a lip on the upper side of the tray.

DETAILED DESIGN PROCEDURE

The step-by-step procedure for designing conventional perforated (sieve) tray towers is given in **Table 1A** (**Table 1B** for metric) *Perforated (Sieve) Extraction Tray Tower Calculation Form*. Basically, the procedure involves calculating trial dimensions, checking them against potential operating limitations, and then modifying them as required to arrive at an operable tray design. The Basic Design Considerations already discussed provide guidance and background on the calculations. The calculation step numbers and equation numbers referred to below are those on the Calculation Form.

PHASE FLOW RATES AND PHYSICAL PROPERTIES (STEP 1)

This information is normally calculated as part of heat and material balances and design specifications. It is assumed that significant differences do not occur in these parameters as the phases flow through the tower. (Your FRACTIONATION SPECIALIST should be consulted if this is not the case.)

SETTLING RATES FOR EACH PHASE (STEP 2)

Settling rates are normally determined using the equation for the Stokes' Law region or Intermediate Law region, depending on the Reynolds number.

ExxonMobil DESIGN PRACTICES	EXTRACTION TOWERS PERFORATED (SIEVE) TRAY TOWERS	Section IV-B	Page 9 of 27
	December, 2001		

DETAILED DESIGN PROCEDURE (Cont)

TRIAL TOWER DIAMETER (STEP 3)

The trial diameter depends on the limiting phase separation rate, either for de-entrainment of dispersed phase from continuous phase (Eq. 3a) or of continuous phase from dispersed phase (Eq. 3b).

TOWER DIAMETER (STEP 4)

Using the larger of the two trial diameters from Step 3 as a minimum, the final diameter is set on the basis of the dispersed phase superficial velocity limitation of 1.34 ft per minute (6.8 mm/s), equivalent to 10 gallons per minute per square foot (6.8 dm³/s·m²) of tower cross-sectional area. This diameter is generally rounded up to the nearest 6 in. (150 mm).

TRAY SPACING (STEP 5)

Typical tray spacings as a function of tower diameter are listed in Basic Design Considerations. Greater tray spacings are used to limit inter-tray velocity of the continuous phase to 3 ft per minute (15 mm/s) (Eq. 5a).

DOWNCOMER SIZING (STEP 6)

The trial downcomer area is based on a maximum velocity of 0.15 ft per second (46 mm/s), (Eq. 6a), using geometric relationships given in Table 2. The minimum downcomer chord height is set by Eq. 6d.

Downcomer length is based on the clearance to the next tray required to limit continuous phase velocity to 0.1 ft per second (30 mm/s) (Eq. 6g). A minimum clearance of 3 in. (75 mm) is recommended. (If the calculated clearance is greater than one half of the tray spacing, consult your FRACTIONATION SPECIALIST.)

HOLE AREA AND LAYOUT (STEP 7)

Hole area required for dispersed phase flow is determined by the depth of the dispersed phase layer under the tray. For single dispersion area sieve trays (turndown ratio 0.4 or more), the depth of the layer is set at 0.25 ft (75 mm). Hole area is calculated by Eq. 7a. The number of 1/4 in. (6 mm) diameter holes is calculated by Eq. 7b.

For dual dispersion area trays (turndown ratio less than 0.4), total hole area is calculated (Eq. 7c) based on a 0.33 ft (100 mm) dispersed phase layer at the highest dispersed phase flow rate. Primary hole area is then calculated (Eq. 7d) based on a 0.17 ft (50 mm) layer at the lowest dispersed phase flow rate. The secondary hole area is determined by difference (Eq. 7f). After making a trial hole layout (Figure 4), appropriate checks on the dispersed phase velocities in the seal box are made (Eq. 7o and 7p). If these velocities exceed 15 ft per minute (76 mm/s), the calculation procedure is repeated using increased clearances and/or an extended seal box.

INLETS (STEP 8)

The continuous phase inlet (Figure 5A) is a false downcomer with dimensions the same as a typical downcomer.

The dispersed phase inlet (Figure 5B) is an inverted false downcomer. Clearance to the bottom tray is calculated by Eq. 8a, based on a 0.4 ft per second (122 mm/s) velocity, with a minimum clearance of 1 in. (25 mm). If dual dispersion area trays are being used, the inlet is positioned under the seal box of the bottom tray.

INTERFACE CONTROL ZONE (STEP 9)

The distance between the high and low interface level is calculated based on 4 minutes residence time of the dispersed phase at the maximum dispersed phase flow rate (Eq. 9a). The minimum distance is calculated based on 10 minutes residence time of the continuous phase at the maximum continuous phase flow rate (Eq. 9b). The distance above the high interface level to the top tangent line is based on 2 minutes (4 minutes for amine systems) holdup of dispersed phase (Eq. 9c).

TOTAL NUMBER OF ACTUAL TRAYS (STEP 10)

Normally the number of trays in the tower is specified in the process design basis specification. If the number of theoretical stages is specified, refer to the Basic Design Considerations and consult your FRACTIONATION SPECIALIST regarding the estimated overall tray efficiency. The total number of actual trays is calculated by Eq. 10a.