

APPENDIX 6

TYPICAL DESIGN EXAMPLES

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This appendix contains worked examples of how to specify the oil-water separator needed on a typical site. Appendix 6.1 gives the calculations for an API interceptor; and Appendix 6.2, for a corrugated plate interceptor.

A6.1 Typical Retail Site - A.P.I. Interceptor Sizing

A6.1.1 Catchment

Impermeable area to be served: 166 m²
<=> 0.0166 hectares

A6.1.2 Design Flows

The rainfall intensity equating to 96% mean depth is: 15 mm/hr (ex NIWA)

$$Q_{\text{design}} = Q_m = \frac{C i_{\text{design}} A_c}{360}$$

Where:

Q_m is the design flow
 C is the runoff coefficient for an impervious area given the design rainfall intensity
 i_{design} design rainfall intensity
 A_c Catchment area
 360 Constant

Here:

C is 1
 i_{design} is 15 mm/hr
 A_c is 0.0166 ha

So: $Q_m = 0.000692 \text{ m}^3/\text{sec}$
 or $2.49 \text{ m}^3/\text{hr}$

A6.1.3 Size the Separator (60 micrometre oil droplet size)

Calculate the rise velocity (V_t) based on a 60 μm oil droplet of specific gravity of (s) for ADF.

$$V_t = \frac{gd^2(1-S)}{18\nu}$$

Where:

V_t is the rise velocity, m/s
 g is the acceleration due to gravity (9.81 m/s²)
 d is the diameter of the oil droplet, m
 S is the specific gravity for the oil droplet
 ν is the kinematic viscosity of water, m²/s

Here:

d	6.00E-05 m
S _{ADF}	0.83
v	at the average winter temperature of 9.00°C means:
v=	1.38E-06 m ² /s

So:

V _t =	0.000242 m/sec
or	
	0.869 m/hr

Through velocity $V_H \leq 15V_t$

Therefore $V_H = 13.04$ m/hr

Cross sectional area of API:

A _c =	0.191 m ²	0.191
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Therefore minimum width and depth requirements will determine area, ie., Depth = .75m, Width = 1.5,m

Which makes $V_H = Q_m/A_c$

Therefore $V_H = 2.21$ m/hr

Calculate surface area:

A _H =	FQ _m /V _t
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The F factor accounts for short circuiting and turbulence in the tank which degrades the tank performance. F is determined by the ratio of V_H to V_t.

Here:

V _H /V _t =	2.55
=> F =	1.26

So:

A _H =	3.61 m ²
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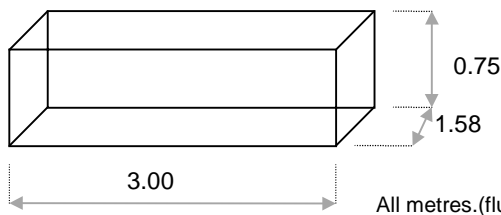
Length L = A_H/B (B = Width)

=>L =	2.41 m
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Allowing .6 m exit, overall length is:

L _{tot}	3.01 m	Catchment area	166 m ²
Width is	1.58 m	Design rainfall density	15 mm/hr
H1 is	0.75 m	Design flow	2.49 m ³ /hr

ie:



Upstream of the exit baffle,
 Hydraulic volume = 2844 litres
 Intercepted volume,
 = Hydraulic vol. 3346 litres
 S.G. of A.G.O.
 (these are minimum static vols.)

All metres.(fluid dimensions)

API Oily Water Separator Sizing

A6.1.4 Spill Retention

A separator having the “fluid” dimensions shown above would clearly be capable of retaining a spill volume of 2500 litres adequately.

A6.1.5 Sizing of Orifice Plate

$$A_o = \frac{Q_m}{\text{SQR} \cdot (h_g \cdot 2g / 2.6)}$$

- A_o is the area of the orifice
 h_g is the head behind the orifice
 g is the acceleration due to gravity (9.81 m/s²)
 D_o is the diameter of the orifice

h_o(metre)	Q_m(m³/hr)	A_o (mm²)	D_o(mm)
0.25	2.00	0.40	23
0.25	2.48	0.50	25
0.25	2.96	0.60	28
0.25	3.43	0.69	30
0.25	3.89	0.79	32
0.25	4.34	0.88	33
0.25	4.78	0.97	35

A6.2 Typical Site - Corrugated Plate Interceptor Design

A6.2.1 Catchment

Impermeable area to be served: 166.5 m²
<=> 0.01655 hectares

A6.2.2 Estimated Design Flows

The rainfall intensity equating to 96% mean depth is: 15 mm/hr (ex NIWA)

$$Q_{\text{design}} = Q_m = \frac{C i_{\text{design}} A_c}{360}$$

Where:

Q_{design} is the design flow
 C is the runoff coefficient for an impervious area given the design rainfall intensity
 i_{design} design rainfall intensity
 A_c Catchment area
360 Constant

Here:

C is 1
 i_{design} is 15 mm/hr
 A_c is 0.01655 ha

So:

Q_{design} = 0.000690 m³/sec
or 2.48 m³/hr

Therefore if a 4 m³/hr capacity device is used it should be adequate for most circumstances.

A6.2.3 Influent and Effluent Oil Concentrations

The Australian Institute of Petroleum has conducted testing which indicated influent oil concentrations of 750 mg/l are possible. Generally for retail fuel outlet applications system designs are based around 1000 mg/l. Each of the three scenarios listed is possible. Both 15 mg/l and 20 mg/l effluent qualities are achievable; however, approximately 25% more plates are required to reduce the effluent oil concentration from 20 to 15 mg/l.

A6.2.4 Flow Status

Gravity flow situations are preferred where there are no pumps to cause mechanical emulsification and that due to pipework is negligible. Any emulsification (mechanical) due to any pumps and piping must be taken into account.

A6.2.5 Maximum Spill

Generally procedures need to be implemented to handle maximum spill volumes; however, in this case a 100 litre spill will be easily contained by this type of system. (A 2500 litre spill will need a pre-treatment trap.)

A6.2.6 Developing an Appropriate Oil Droplet Distribution

Unless specific information provided by the client suggests otherwise, a normal distribution of oil droplets is assumed.

The normal distribution is specified by the mean and standard deviation.

For three given scenarios (gravity flow - 500, 750 and 1000 mg/l influent) oil droplet distributions are approximated by:

Influent Oil Concentration (mg/l)	Mean Diameter	Standard Deviation
500	177	2.5
750	188	2.5
1000	195	2.5

A6.2.7 Determine oil droplet size to be 100% removed

From these distribution curves and the required effluent quality the minimum size of the oil droplet to be 100% removed can be determined: e.g. for an influent concentration of 1000 mg/l and a required effluent concentration of 20 mg/l, it is necessary to remove 98% of the oil in the waste water.

Thus, using a normal distribution curve with a known mean and standard deviation we are able to determine the 98th percentile of the curve by volume and consequently the size of the oil droplet.

The size of the droplet to be 100% removed is a function of:

- 1 The influent oil concentration
- 2 The level of emulsification (mechanical)
- 3 The effluent quality required

Required Oil Droplet Removal for Gravity Flow Applications

Influent Concentration (mg/l)	Oil droplet to be 100% removed to achieve	
	20 mg/l	15 mg/l
500	50 μ	44 μ
750	45 μ	40 μ
1000	41 μ	37 μ

A6.2.8 Determine number of plates required

Once the droplet size (to be 100% removed) is determined, Stokes' Law is used to calculate the rise velocity of these droplets. Using this velocity and the maximum vertical distance between plates, the residence time required for this can be determined.

Calculate the rise velocity (V_r) based on a 60 μm oil droplet of specific gravity of (S) for ADF.

$$V_r = \frac{gd^2(1-S)}{18\phi}$$

Where:

- V_r is the rise velocity, m/s
- g is the acceleration due to gravity (9.81 m/s²)
- d is the diameter of the oil droplet
- S is the specific gravity for the oil droplet
- ϕ is the kinematic viscosity of water

Here:

- d 6.00E-05
- S_{ADF} 0.83
- ϕ at the average winter temperature in "Wherever" of 9.00°C means:
- $\phi =$ 1.38E-06

So:

$V_r =$ 0.000242 m/sec

or

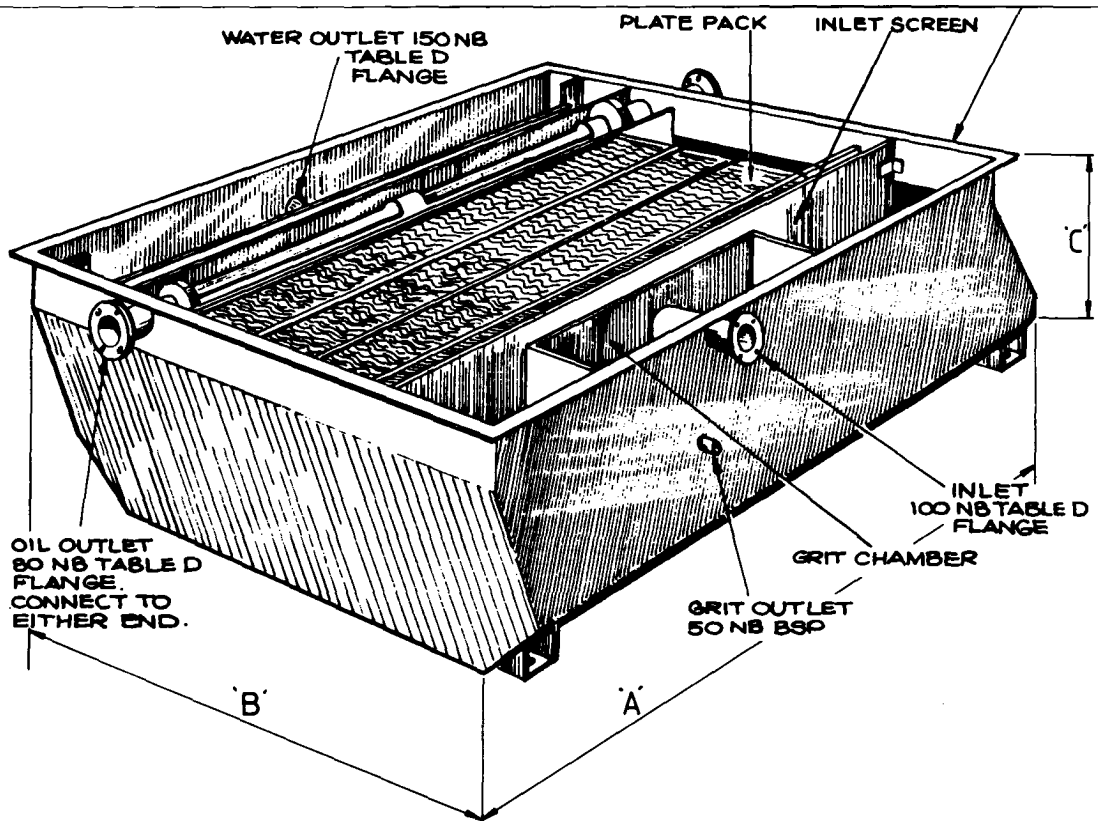
0.869 m/hr

A6.2.9 Configuration of System

The configuration of the system is not particularly important provided the correct volume of plates has been selected to provide the required residence time: e.g., if 1.7 cu metres of plates are needed it does not matter if the plates are arranged as 1 row 900 mm high, 600mm long or as 2 rows 900 mm wide, 450 mm high and 600 mm long. However, the system must be configured such that the flow through the plates will be laminar. This will ensure that oil droplets will not be re-entrained into the flow once they have been removed. Laminar flow is also imperative as Stokes' Law is only valid under these conditions, hence an accurate rise velocity of the oil droplets can only be predicted under laminar flow conditions.

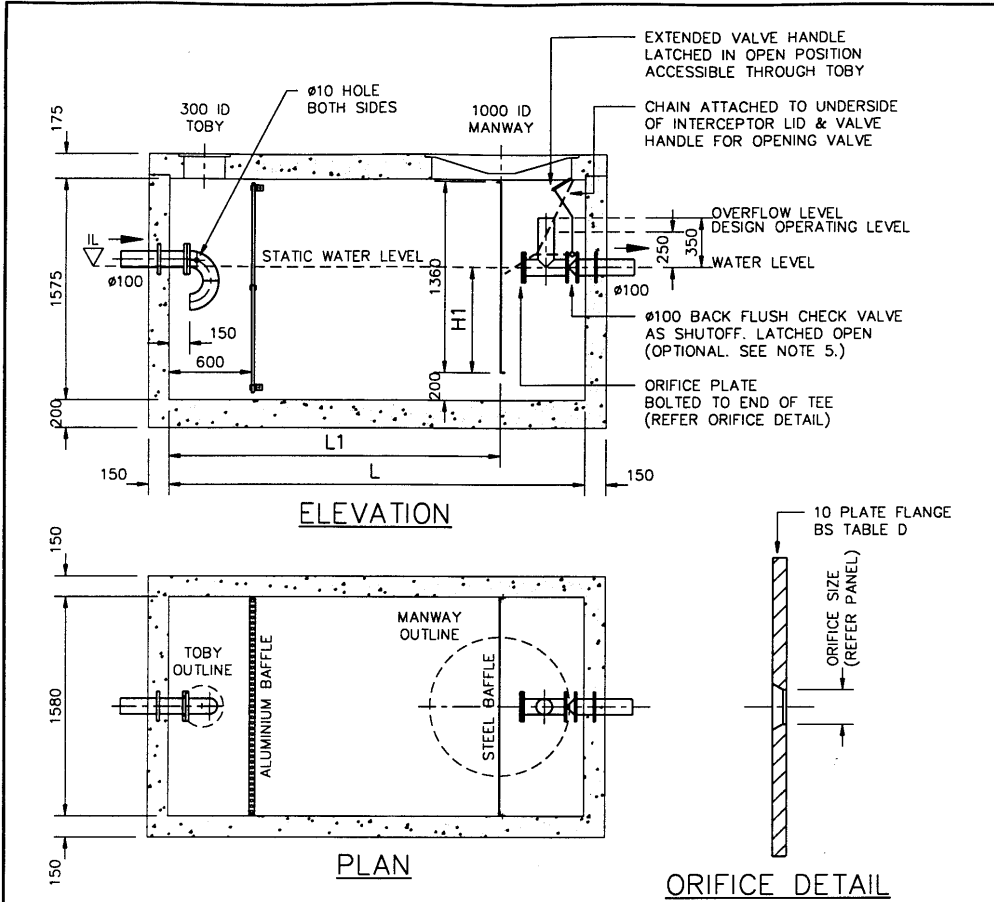
A6.2.10 Tank and Pit Sizing

Once the configuration of the plate packs has been selected the tank and pit dimensions can be calculated. For this a computer program is used which sizes the pit/tank based on the fluid velocity. A typical schematic is shown:



A6.2.1 Typical Corrugated Plate Interceptor

Appendix 6.1



NOTES :

1. INTERCEPTOR SPILL CAPACITY IS THE VOLUME OF HYDROCARBON RESTRAINED UPSTREAM OF THE BAFFLE UNDER STATIC FLOW CONDITIONS. $(L1 \times H1 \times \text{INSIDE WIDTH}) / \text{DENSITY OF HYDROCARBON}$.
2. DESIGN OPERATING LEVEL IS THE WATER LEVEL ON THE INLET OF THE ORIFICE AT THE INTERCEPTOR DESIGN FLOW.
3. OVERFLOW LEVEL IS DESIGNED THAT EVEN UNDER EXTREME FLOW CONDITIONS THE DESIGN CAPACITY OF MOTORSPIRIT WILL NOT OVER TOP THE BAFFLE OR WALLS.
4. UPON COMPLETION A SYSTEM TEST IS TO BE CARRIED OUT. CLOSE OUTLET VALVE AND WATER FILL SYSTEM TO CAPACITY, ANY LOSS OF WATER LEVEL OVER 4 HOURS MIN TEST PERIOD TO BE INVESTIGATED.
5. TEE PIECE IS ONLY REQUIRED WHERE SEPARATOR HAS RESTRICTED EXCESS STORM RETENTION CAPACITY ORIFICE PLATE IS MANDATORY IN ALL SITUATIONS.

MODEL REF	INTERNAL LENGTH (L) (mm)	INTERCEPTED LENGTH (L1) (mm)	APPROX WEIGHT (T)	CAPACITY FOR AGO (m ³)	DESIGN FLOW RATE (m ³ /hr)	ORIFICE SIZE (Ømm)	CATCHMENT AREA (m ²)		
							9mm/hr	12mm/hr	15mm/hr
APISNZ2.5	2500	1900	9.5	2.5	1.98	23	220	165	130
APISNZ3	3000	2400	11.0	3.16	2.48	25	275	205	165
APISNZ3.5	3500	2900	12.5	3.81	2.97	28	330	245	200
APISNZ4	4000	3400	14.0	4.48	3.42	30	380	285	230
APISNZ4.5	4500	3900	15.5	5.14	3.87	32	430	325	260
APISNZ5	5000	4400	17.0	5.79	4.32	33	480	360	290
APISNZ5.5	5500	4900	18.5	6.45	4.78	35	530	400	320