

GUIDE TO THE DESIGN OF TANKS FOR FORCED-CIRCULATION OIL-LUBRICATION SYSTEMS

1. INTRODUCTION

The purpose of the tank is to provide storage for the oil, to allow settling of solid and liquid contaminants and to promote de-aeration and foam removal.

This Item gives guidance on the design of tanks for forced-circulation oil-lubrication systems. Also included is guidance on the design and function of the various constituent components used in tanks.

This Item has been divided into the following sections.

- (i) Tank Volume Required.
- (ii) Constituent Parts and their Function.
- (iii) Tank Construction.

2. TANK VOLUME REQUIRED

To determine the tank volume required the total oil flow rate required by the system has to be known. The tank volume is dependent upon,

- (i) the tank oil capacity,
- (ii) the free space above the oil,
- (iii) the internal fitments.

Tank Volume Required = Tank Oil Capacity + Free Space + Allowance for Internal Fitments.

2.1 Tank Oil Capacity

The quantity of oil in the tank when the equipment is stationary is termed the tank oil capacity. The quantity of oil in the tank is greater when the equipment is stationary than when it is running (when oil is being pumped round the system). There are three system conditions,

- (i) tank full – ready for initial start-up of new system *i.e.* system empty,
- (ii) system operating – pipework *etc.* full,
- (iii) system stationary – return lines drained but delivery lines, filters, coolers *etc.* primed.

$$\left\{ \begin{array}{c} \text{Tank} \\ \text{oil} \\ \text{capacity} \end{array} \right\} = \left\{ \begin{array}{c} \text{Volume of oil in tank} \\ \text{when equipment is} \\ \text{running} \end{array} \right\} + \left\{ \begin{array}{c} \text{Due allowance} \\ \text{for oil in} \\ \text{system} \end{array} \right\}$$

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The volume of oil in the tank when the equipment is running is determined by the desired dwell time.

2.1.1 Dwell time

It is desirable that for each pass through the system the oil remains in the tank for a specified time; this is termed the dwell time.

$$\text{Dwell Time} = \frac{\text{Volume of Oil in Tank when Equipment is Running}}{\text{Total Oil Flow Rate}}.$$

This delay permits the settling out of debris, sludge, water, water/oil emulsions and also provides time for entrained air bubbles to rise to the surface. The longest dwell time possible is therefore desirable. The settling rate of the contaminants decreases as the viscosity increases and/or as the oil becomes degraded (if the degradation does not reduce the viscosity).

An indication of the dwell time commonly used for various types of equipment is given in Table 2.1.

TABLE 2.1 Dwell time

<i>Equipment Served</i>	<i>Dwell Time (minutes)</i>
Aircraft gas-turbines	½
Aircraft piston engines	½ – 1
Reciprocating air compressors	1 – 8
Gas-turbines	5
Steam turbines and other large rotary machinery	5 – 10
Electric motors	5 – 10
Steel mill machinery	20 – 60
Paper mill machinery	40 – 60

2.2 Free Space above the Oil

The tank is not completely filled; some free space is left above the oil to enable it to free itself of entrained air and to provide space for any foam. Free space also allows for any rise in oil level due to operating temperature rise.

Generally the free space amounts to 10 – 25 per cent of the tank volume. An overflow can be provided to ensure that the intended free space is not encroached upon by overfilling. The overflow must be sited above the stationary oil level.

2.3 Internal Fitments

Allowance must be made for any internal fitments when determining the total tank volume.

3. CONSTITUENT PARTS AND THEIR FUNCTION

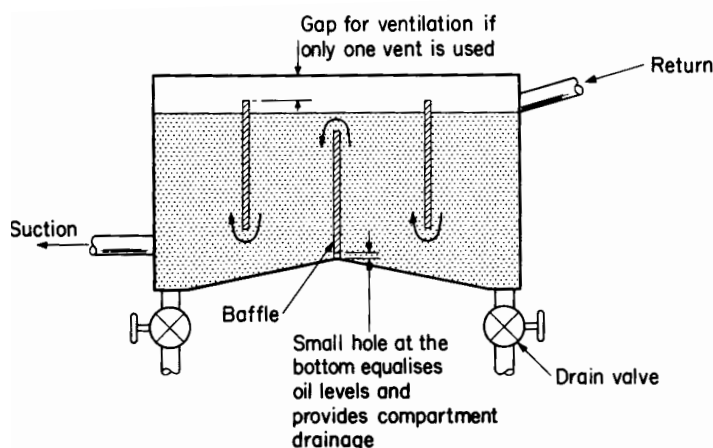
The various constituent parts used, when necessary, in tanks are given below together with their functions. Typical tanks are illustrated in Figure 1.

3.1 Baffles and Stiffeners

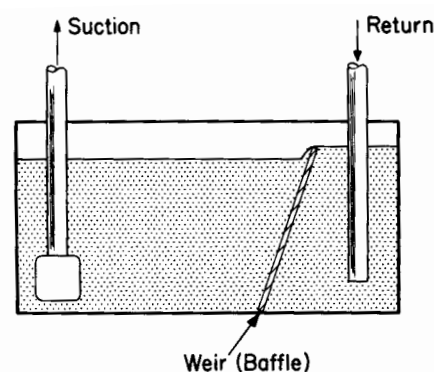
Both of these are included under the same heading as dual purpose is often possible.

3.1.1 Baffles

Baffles govern the internal flow of oil in a tank, see Sketch 3.1. They can be used as foam traps, to localise turbulence and to reduce sloshing in mobile systems. Baffles make the best use of the tank volume by providing a tortuous path between inlet and outlet; 3 to 5 changes of direction are normal, thus assisting de-aeration and settling of contaminants. The changes of direction prevent returned oil being sucked directly back into the system. Baffles are also used to direct the oil flow across a heat transfer surface, thus aiding heating or cooling. One baffle can be used to form a weir, see Sketch 3.2, to localise contamination and turbulence. The weir can be inclined in the direction of flow to avoid cascading and frothing. Attention must be given to the length of the weir, a small return compartment and short weir can result in a high velocity flow and contaminant carry-over.

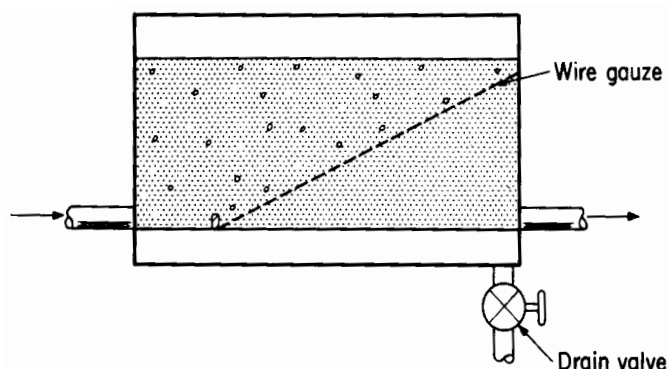


Sketch 3.1



Sketch 3.2

Entrained air bubbles can be prevented from recirculating by using a fine wire-gauze screen (say about 100-mesh) as shown in Sketch 3.3. The highest part of the screen should be well below the lowest oil level, since the surface of the oil can be covered with a layer of foam which will penetrate even the finest screen. This arrangement is useful where entrained air is a problem in a relatively clean system.



Sketch 3.3

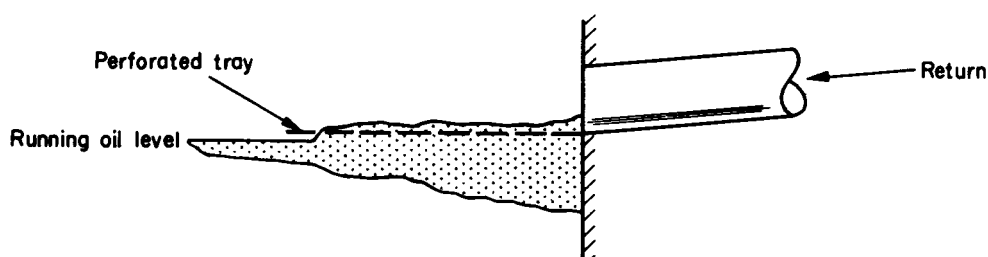
3.1.2 Stiffeners

These are used in large tanks to improve the rigidity of the tank structure. Wherever possible any stiffeners should be on the outside of the tank unless used in a dual function as baffles, in which case care should be taken that dead pockets of oil are not formed. However, external stiffeners increase overall dimensions. There is an economic compromise between the tank wall thickness and the amount of stiffening used. The thicker the tank wall the less stiffening required.

3.2 Return Lines

To minimise splashing and foam generation, oil is normally returned to the tank at the running oil level or just above. It is desirable that the return lines should be run only up to half full so that any foam and vapour can be drained into the tank with the oil.

With a high velocity return a perforated defoaming tray is used, see Sketch 3.4, to prevent plunging which entrains air and to aid de-aeration. When a full bore return is necessary the return line should drain below the normal oil level.



Sketch 3.4

Sometimes it is necessary to position the return line such that the return flow can be inspected. Often the return line run is determined after the equipment is designed or built, in which case the route and position of the return line are determined by extraneous considerations.

3.3 Suction Line

The oil is taken from the tank by means of the suction line. This is situated as far away as possible from the return.