1.5 Sump design

Sumps are located within or at the end of the paved surface of dairy yards or feedpads to collect washdown water and rainfall runoff for gravity discharge or for pumping. The collected effluent is then diverted to a land application area, to storage or to a treatment facility. These sumps can be small to ensure entrainment of solids or large to serve as a pre-treatment facility and even emergency storage. As sumps are generally in-ground and can be confined spaces, they need to be designed for secure and safe access.

The rational design of sumps for collecting dairy washdown effluent is limited by the variability of effluent characteristics: although volumes are predictable, the amount and type of solids contained in them varies seasonally and diurnally, warranting flexibility in sump design. The principal objectives need to be either:

- the entrainment of solids through maintenance of agitation and elevated velocity by using a relatively small chamber and sometimes a mechanical agitator with rapid pumped removal of effluent, or
- the separation of solids through deposition in a chamber or series of interconnected chambers, or filtration via grilles with periodic dewatering by pumps or gravity release (see chapter 2.1 'Solid–liquid separation systems').

Stormwater diversion is dealt with in chapters 2.2 'Direct application systems' and 2.6 'Effluent storage requirement'.

There are few hard and fast rules for sump configuration, but experience indicates that they need to be structurally sound, able to withstand impact and make use of gravity wherever possible. Although large-diameter pipes or even circular water troughs can be placed vertically as sumps, this practice does not encourage ease of cleaning or maintenance, and does create confined entry conditions, requiring special OH&S consideration.

Large sumps should have:

- an overflow to divert effluent to a bunded area
- no sharp corners or dead spots
- stone traps and debris grilles which can be removed
- stormwater diversion
- sloping or conical floors to assist desilting, desludging and emptying
- adequate mass or restraint in high-water-table environments
- a secure cover or fence which can be unlocked for access but cannot trap personnel
- warning signs if confined entry conditions dictate
- agitation if retention of effluent exceeds 30 min
- footholds or a ladder for access, particularly if smoothed-walled
- ramped access to facilitate the removal of solids with a front-end loader.

As there are a variety of dairy yards with different inlet conditions, effluent characteristics and approach velocities, there need to be a range of sump configurations. Some sumps work successfully on one farm but not on another, and slight changes in dimensions have often been counterproductive. Field observations show that you should not rely on grilles and weeping walls in isolation for solids removal. If a pump is used, provide adequate storage for effluent in the event of a power failure. The duration of an outage depends on the local power grid, but 48 h is possible in some rural areas, and 24 h is not uncommon.

Sump configuration

Small sumps collecting effluent without an agitator should be designed with sloping floors (45°) to direct settled solids directly to the pump inlet. The depth of the sump should allow the pump casing to either readily rest on the bottom when there are supports, or to be suspended 30 to 50 mm above the sump floor.

According to Vanderholm (1984), larger sumps can range in shape from long rectangular to deep cylindrical tanks; for efficient mixing, cylindrical tanks are better. The liquid depth should be about half the diameter or length of the sump. Avoid cylindrical sumps of small diameter with snug-fitting pumps.

Useful guidelines for determining the configuration of sumps and pump intakes are provided in APMA (2001); these guidelines aim at maintaining the life of pumps, but assume minimal solids in the effluent to be discharged.

Pump manufacturers recommend a maximum number of pump starts per hour. Therefore, the minimum sump volume is set by the flow rate into the sump. A one-duty fixed-speed pump starts most frequently when the flow rate is half of the pumping rate, where the cycle time equals:

$$240 \times \text{sump volume (L)} / \text{pumping rate (L·s}^{-1}\text{)}$$

Float switches are commonly used to operate pumps servicing a sump. Load cells are used as an alternative on newer installations.

If direct application is allowed (see chapter 2.2 ‘Direct application systems’), the sump can be designed to impound effluent for up to a week to cater for wet weather, pump malfunction or power outages. Under these conditions, odour is likely.

Sumps and pumps

The minimum depth of submergence of a pump inlet in a circular sump should be 1.5 × D (diameter of the suction line), and the inlet should be located off-centre, 0.25 × D from the sump wall and 0.5 × D from the floor level. Further rules for the hydraulic design of sumps are provided in various texts (APMA 2001, Dicmas 1987, Karassik *et al.* 1976, Sanks 1989, Stepanoff 1976, Yedidiah 1980). The geometry of a sump is important for conveying effluent and avoiding vortex action and the deposition of solids. The sump must be large enough to meet the requirement for the number of pump starts per hour but not too large that solids can settle out (unless agitation is provided).

Waterborne debris and pumps are incompatible. Solids such as gravel, fencing wire, baling twine, sticks and horns can destroy pumps. To ensure the longevity of an effluent pumping system, it is essential to screen out debris or remove it via a grille, trafficable sump or settling chamber before the effluent enters a pumped sump.

Many vertically and horizontally mounted effluent pumps are mounted on beams above or next to the sump for stability and to provide ideal inlet flow conditions. These beams must be rigid and fixed in place to maintain the pump in the correct plane of operation. Avoid cantilevered beams for pump support unless they are very rigid and preferably propped. A poor design will very likely:

- restrict the performance of the pump
- contribute to, or cause, severe damage to the pump, transmission system, electric motor or switchgear
- shorten the useful working life of the pump.

Adoption of the following guidelines should ensure a successful pump sump:

- Avoid turbulence of cascading flows from the inlet pipeline, channel or stream to minimise air entrainment, as this can reduce pump and delivery line performance.

1.5 Sump design

If a long fall cannot be avoided, there must be sufficient length and depth to the pump inlet to compensate.

- Where inlet pipes are <0.5 m in diameter, which is usually the case unless a floodwashing system is used, the installation of a down-turned vertical suction line is good practice.
- The entrance velocity at the mouth of the inlet should not exceed 1 $m{\cdot}s^{-1}$, and the maximum velocity of water in the suction pipe should not exceed 1.5 $m{\cdot}s^{-1}$.
- The approach velocity of effluent in the sump should be <0.3 $m{\cdot}s^{-1}$.
- The pump inlet needs to be adequately submerged to avoid vortex formation.
- Avoid locating the pump inlet in the middle of a small circular sump with a high entry flow rate.
- Avoid sump designs that promote rotational movement of effluent, the possibility of vortex formation or the entrainment of air.
- Keep the inlet submerged to reduce friction losses, maintain submergence, and reduce the risk of cavitation (the rapid formation and collapse of vapour pockets in regions of low pressure—a frequent cause of serious structural damage to pumps).

References

APMA 2001, *Australian pump technical handbook*, Australian Pump Manufacturers Association, ACT.

Dicmas, J.L. 1987, *Vertical turbine mixed flow & propeller pumps*, McGraw Hill, New York.

Karassik, I.J., W.C. Krutzch, W.H. Fraser & J.P. Messina 1976, *Pump handbook*, McGraw Hill, New York.

Sanks, R.L. 1989, *Pumping station design*, Butterworths, Boston, MA, USA.

Stepanoff, A.J. 1976, *Centrifugal and axial flow pumps*, John Wiley and Sons, New York.

Vanderholm, D.H. 1984, *Agricultural waste manual*, NZAEI project report No. 32, NZAEI, Lincoln College, Canterbury, NZ.

Yedidiah, S. 1980, *Centrifugal pump problems*, Petroleum Publishing Company, Tulsa, OK, USA.