Reservoir design – upstream and downstream thinking

Introduction

For any new reservoir design to remain 'fit for purpose', a complete understanding of the upstream and downstream functions must be taken into account. This means tank designers need to be fully conversant with water treatment processes to cater for the upstream knowledge, as well as having a complete understanding of all the maintenance issues involved and distribution system functionality – the downstream component. Would you have confidence to buy a particular brand of car if you were aware that the designer could not drive and had no mechanical ability? Why should storage tank designers be any different? And finally we need to consider the future – how will evolving environmental, OH&S and distribution requirements be met if a tank is only designed to meet today's standards and not those that will be in place in 20, 50 and 80 years' time? Like a car, tanks need to have 'upgradable' capabilities to enable them to remain relevant and functional throughout their expected design life.

Access & Security

Access begins with the tank site and ease of movement for maintenance vehicles. Cranes and Elevated Work Platform (EWP) equipment will need a decent set down area for outriggers and also solid, level ground to move around on. The greater the space available, the easier it is to avoid underground pipe work. Maintenance personnel also require close access to the main ladder for moving gear up and down to the roof platform area.

Figure 1 Restricted access for EWP equipment

Figure 2 Security measures easily by-passed

The tank site should be selected with consideration for future growth - the original structure may have fantastic access and tick all the boxes, but a second, future installation may not. Good site access then leads to security - this often, underrated feature will become the 'elephant in the room' for future generations if it is not adequately addressed and factored into the initial design. Consumer confidence that water is safe and healthy to drink can be lost if a security event were to occur, so all reasonable steps must be taken to maintain that confidence. Simple measures, like eliminating features that assist unauthorised climbing, installing motion detecting cameras and ensuring that all roof hatches and other openings are fully sealed and locked against natural or deliberate contamination events.

Design considerations for site access & security:

- Can the reservoir be fully accessed by EWP's, cranes and maintenance vehicles?
- Security fences and motion detecting cameras should be set up to prevent and monitor public access around the whole reservoir site.
- Tower type external ladder systems to access the reservoir roof should be built instead of spiral stair cases which are easy to by-pass.

Platforms and hatches

The most commonly used areas of a tank are the platform and entry hatch. The platform needs to fulfil a number of needs - there should to be sufficient space for storage of equipment, adequate guard railing for fall prevention, all surface areas to be self-draining (to prevent ponding, slip hazard and material corrosion) and it must be fully sealed to protect the water quality.

Many existing entry hatch covers have been slotted to allow for ladder stiles to extend through and the front edges have been removed in many cases to eliminate trip hazards – this misguided OH&S interpretation results in a significant contamination entry point, as the hatch is not effectively sealed. When water quality is often being compromised on a daily basis, and the entry hatch may only be accessed once a year, frequency must be the over-riding factor in deciding which issue is the more important one.

Figure 3 Unsealed entry hatch area

Figure 4 Good platform and hatch design

Some design considerations for platforms and hatches:

- Ensure that water can drain away from the platform and not into the reservoir –closely fitted kick rails around the edges are the main culprit for debris accumulation and water ponding occurring.
- Have sufficient space for people and equipment to work safely.
- Fit two hatches into a tank where possible – one roof mounted for diver entry, with a vertical, uncaged ladder mounted below. A second, wall mounted hatch at ground level will allow for a dry-tank, low category confined space entry.
- Handrails to extend around the practical working area.
- Remove bird roosting spots such as telemetry aerials and fixed, overhead safety systems.

Roofs

The primary function of a roof is to prevent contamination of the water supply. Many older reservoirs have had roofs retrofitted around existing fittings – this design compromise has not always been successful. Routine inspections have shown a number of recurring issues arising with both new and old roofing systems, which all have the potential to contaminate the water supply they should be protecting:

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- Non-draining surfaces and ponding behind fixtures such as vents, hatches and platforms.
- Ridge capping not correctly fitted which allows for debris and stormwater entry.
- Guttering which cannot be cleaned safely, is unsealed or which allows back flow events to occur during heavy rain fall events.
- Materials not compatible with humid environments, leading to structural failures.

Figure 5 Collapsed roof gutter

Figure 6 Debris build-up under roof flashing

Where improvements can be made:

- Removal of all gutters – this reduces reservoir maintenance and eliminates the risk of a gutter collapse or back flow event.
- Eliminate ponding – roof fixtures such as platforms, hatches, ventilators or pipe penetrations should be installed so that water can pass around.
- Reduce ridge capping – this prevents build-up of contaminated materials underneath.
- Use suitable materials – the humid area below the roof will accelerate corrosion of unprotected materials. This includes the 'fall protection' mesh, sometimes used during roof sheet installation, or the uncoated edges of rolled 'zincalume' type purlins. Many roof fixing screws are also failing prematurely due to poor quality standards.

Pipework

The primary function of pipework is to deliver into or carry water away from the reservoir. Effective delivery is a balance between blending the new water with the existing product as opposed to disturbing the residual sediments found across the floor. Sediment should be allowed to settle within the tank, as it is more cost effective to clean a tank rather than the distribution system pipework.

Many positions for inlets have been tried over the years; through the roof, through the wall and set into the floor. Roof mounted inlets may result in ponding when roof drainage cannot flow around the penetration area and floor sediments can be re-suspended during filling if water levels become too low. Wall inlets generally force water across the floor to re-suspend sediments already settled out. An inlet coming through the floor will push water upwards, but blending is often limited. A directional nozzle fitted to both wall and floor penetrations, provides good water blending, without stirring up the bottom layer with sediment. Directional

nozzles can also provide an effective separation of inlets and outlets which are close by and thereby reduce short circuiting of the water.
Effective outlets should be raised up off the floor to avoid drawing sediments into the reticulation system. They should also be screened to protect divers or robots, however many screens are too large and cannot be cleaned internally (especially by robots!). Safety screens should be made from non-corroding materials such as HDPE and be close fitted to the penetration. Their holes should total no more than 120% of surface area of the pipe being covered, so that they do not become 'passive' – this would allow sediments to collect on their external surfaces and then be drawn in when high flows occur.


Figure 7 Through the wall, external overflow


Figure 8 Directional nozzles – good results

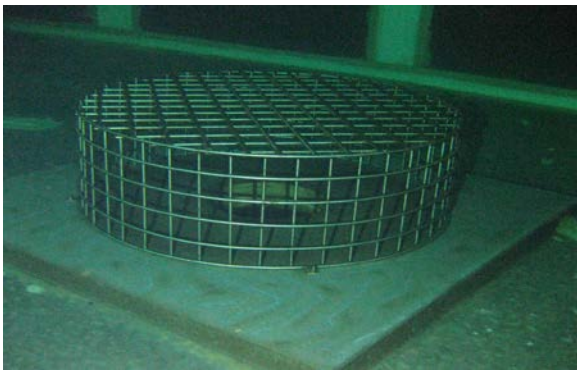
Figure 9 Outlet area cannot be cleaned


Figure 10 HDPE outlet screen – close fitted, good result

Reducing the amount of exposed pipework within a reservoir, such as overflow and inlet risers, has a two-fold benefit. Less pipe work reduces the chlorine demand due to corrosion (if un-coated ductile pipe is used) and secondly, there are fewer obstacles for divers (or robots!) to navigate around when cleaning the internal areas.

Some pipe design considerations:

- Minimize the amount of pipe within the reservoir to prevent corrosion.
- Protect steel pipe work with a coating or use HDPE/Poly/FRP for internals.
- Ensure bolts are of a similar material or are insulated to prevent localised corrosion.
- Raise the outlet off the floor to prevent sediment pick up.
- Screens should be small enough to fit neatly over penetrations but large enough to not impede water flow. Screens should also have a solid base section (no holes) up to approximately 150mm in height to prevent sediment falling into the outlet.

- Overflows can be a simple ‘through wall’ pipe with the riser external to the reservoir.

Internal issues

Like the pipework considerations, internal fittings and fixtures should be kept to a minimum or simplified if they do have to be installed. Tank cleaning will likely be a robotic outcome in the future, so let’s make things achievable now instead of creating complications for the next generation of maintenance personnel. Roof support posts can be reduced in favour of larger roof framing members, post bases can be included into the sub-floor foundations and not be exposed above the floor level. Wall floor areas should have no steps or rounded edges, and floor seals should be neat and cleanable.

Conclusion

There are many aspects to reservoir design needing consideration for future maintenance activities and growth. Drawing from field observations, many issues are recurring throughout the industry that could easily be solved during the design phase of a project. A different view (other than cost cutting) should be taken when designing reservoirs that are ‘fit for purpose’ for the future – what are future maintenance requirements, safety standards and water quality standards likely to be? Think upstream and downstream and maybe the next generation will remember us for something worthy…and not being short sighted and limited in our designing endeavours.