CONVENTIONAL BUNDS ARE SOMETIMES INADEQUATE

The phenomenon of bund overtopping has implications for the protection of health and safety as well as environmental protection. Colm Leahy and Don Menzies outline some solutions.

Received wisdom in industry is that bunds should be constructed such that capacity is 110 percent of the capacity of the largest tank in the bund, or 25 percent of the capacity of all tanks, whichever volume is greater. Indeed, this practice is endorsed by the Environmental Protection Agency (EPA) through its IPPC Guidance Note on Storage and Transfer of Materials for Scheduled Activities [1] and in CIRIA [2] [3] [4] publications. Empirical evidence from the laboratory and industrial incidents shows that such bunds are inadequate when it comes to retaining releases from instantaneous tank failures. The freeboard allowed by the traditional bund design capacity purportedly allows for containment of fire fighting agents applied to a bund fire, rainwater in the bund and the risk of wind causing the polluting material to wash over the bund wall.

However, instantaneous tank rupture can create a surge of material, a fraction of which, depending on the bund wall height and distance from tank, can overtop the wall creating a potential requirement for further containment beyond the bund. This is known as 'tertiary containment' (primary and secondary containment being the tank and the bund respectively).

Examples of industrial accidents where secondary containment failed to retain the lost contents of a primary container include the incidents at the Floreffe oil storage facility in Pennsylvania and at the Umm Said refinery, Qatar. In January 1988, a four-million gallon oil storage tank ruptured at an oil storage facility in Floreffe, Pennsylvania [5]. Diesel oil overtopped the tank's bund walls, surged across a car park on an adjacent property and into a surface water drain that emptied directly into the local river.

At Umm Said, Qatar, a 260,000-barrel refrigerated propane tank failed massively [6]. The resulting wave of liquid propane swept over the bund and into a process area before igniting. Most of the process area was destroyed. The fire burned out of control for two days and was extinguished after eight days.

Research

Several correlations have been developed for predicting bund overtopping. Most show that the fraction of liquid that overtops the bund is mainly a function of the ratio of the bund wall height to the height of liquid in the tank (h/H) (refer to **Figure 1**) [7]. The fraction of stored liquid that escapes the secondary containment generally increases if h/H is reduced and the bund wall is moved further from the tank to maintain the same bund volume. These correlations indicate that only a bund wall of the same height as the tank would contain 100 percent of the tank contents in the event of a catastrophic rupture. This is impractical and would be unsafe in most cases. In practice, bund wall height is determined by the 110 percent of tank capacity constraint and other considerations such as access for fire fighting, emergency escape and ventilation in the bund. The EPA recommends that, in general, bund walls should not exceed 1.5 m.

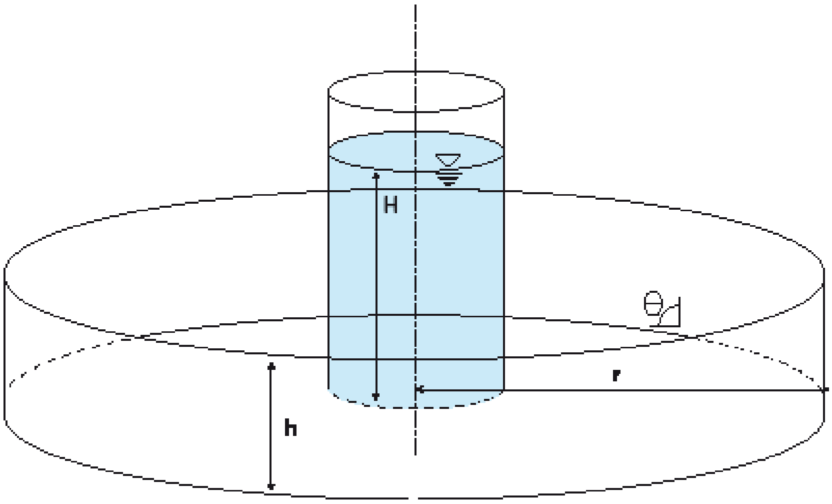

Figure 1. Circular Bund Nomenclature. (Image courtesy of Arup.)

Implications for operators

Existing facilities may be hindered in their implementation of measures to mitigate bund overtopping effects due to space constraints. However measures may be implemented to reduce the quantity of released material that would escape the secondary containment. Overtopping reduction measures identified by CIRIA [3] include inclining the bund wall away from the primary tank, incorporating a 'throwback' lip into the bund wall and providing internal bund walls between the tank and the main bund wall to act as baffles. New build sites should be able to take cognisance of this phenomenon in the design stage of the project, if not at the site procurement stage. Developers may be required to demonstrate assessment of risk and incorporation of tertiary containment into design considerations where shown to be necessary.

Facilities subject to the Seveso Regulations - the European Communities (Control of Major Accidents Involving Dangerous Substances) Regulations 2006 (S.I. No. 74 of 2006) are obliged under the Regulations to limit the consequences of major accidents for people and the environment and to identify 'all major accident hazards in the establishment, including an assessment of the extent and severity of the consequences of such accidents'. Therefore, a robust risk assessment for such a facility should include a prediction of any likely overtopping of bund walls by dangerous substances in the event of tank failure.

The creation of an uncontained pool of dangerous material outside the bund wall has implications for the fire and explosion risks associated with flammable materials or for the dispersion of toxic vapours or both. Failure to account for the possibility of bund overtopping could, therefore, lead to an inaccurate assessment of the possible effects of an incident on other parts of the site, on neighbouring facilities and on the environment.

Risk assessment

A two-step approach to consideration of the question of bund overtopping is proposed. Firstly, the maximum quantity of material that could brim over the containing wall should be established with reference to published correlations. Provided the bund wall is designed, built, operated and maintained to appropriate standards, it may not be necessary to consider structural failure of the bund.

The risks associated with the loss of containment should then be established. The risk of a given event is the product of the likelihood and the severity of the consequence. The likelihood of the initiating event (the loss of containment) can readily be determined through reference to tank failure statistics. The associated consequences should be defined in terms of damage to human health, property and the environment. While tank failure statistics will be broadly applicable, the consequence element of the risk will be site specific. Variables will include land use in the vicinity of the site, surrounding topography, groundwater vulnerability and the proximity of watercourses or environmentally sensitive areas. Appropriate risk assessment methodologies abound. Having established the risk associated with bund overtopping for a site, consideration should turn to a proportionate design response.

Tertiary containment options

Local tertiary containment surrounding secondary containment e.g. a further bund or embankment.

Combined local and remote systems - CIRIA[3] describes the use of combined local and remote secondary containment. Local containment is provided by a bund and remote containment by a tank or lagoon. Where the local component of a combined system provides full retention, the remote component can be considered tertiary containment. Remote tertiary containment may serve more than one secondary containment system, as long as it is designed to be capable of accommodating total foreseeable flows and predicted quantities. In some facilities, the risk of environmental pollution from contaminated firewater in the event of a fire has been judged to be sufficient to require the provision of firewater containment facilities. The capacity of such containment facilities is more than sufficient to contain the spillage resulting from bund wall overtopping. It may be possible to use such firewater containment facilities to provide tertiary containment.

Sacrificial land - CIRIA[3] describes how sacrificial areas may be used as secondary containment. The same principles apply to the use of these areas as tertiary containment for retention of secondary containment overflow. Examples include landscaped areas and sports fields. These areas should be designed such that the sacrificial area soaks up the contaminant, containing the spill within a layer of permeable soil or other porous medium. After the incident, the permeable material can then be excavated and disposed of, or treated as appropriate. Where sacrificial areas used for tertiary containment serve a dual purpose, e.g. roadways and car parks, such areas are normally routinely drained to surface water drainage systems. Therefore, to be considered for emergency tertiary containment, such areas must be capable of manual or automatic isolation of drains and interception of pollutants. Furthermore, arrangements must not compromise emergency access and egress and should not compromise day-to-day operations.

Tertiary containment design

Based on the site-specific risk assessment, tertiary containment should be designed to:

- be independent of secondary containment and any associated risks of catastrophic tank failure - existing secondary containment systems could be used to provide tertiary containment for other secondary containment assuming that catastrophic rupture scenarios of the respective primary containment units are mutually exclusive;
- be capable of containing foreseeable liquid volumes - what is now deemed 'foreseeable' includes the volume of material that could breach the secondary containment in the event of a surge caused by catastrophic failure of the primary containment;
- be impermeable to water and potentially dissolved pollutants; and
- facilitate fire fighting and other emergency operations and clean-up and restoration activities.

To sum up, a body of evidence clearly indicates that a conventional bund will not retain the contents of a storage vessel where the vessel fails catastrophically. Therefore, where the possibility of bund overtopping exists, it should be demonstrated that adequate additional containment is provided or the risk is such that additional containment is not necessary. Φ

References

[1] Environmental Protection Agency (2004). **IPPC Guidance Note on Storage and Transfer of Materials for Scheduled Activities**

[2] CIRIA (2003). **C598 Chemical storage tank systems – good practice**

[3] CIRIA (1997). **Report 164 Design of containment systems for the prevention of water pollution from industrial incidents**

[4] CIRIA (1997). **Report 163 Construction of bunds for oil storage tanks**

[5] http://www.epa.gov/emergencies content/learning/floreffe.htm

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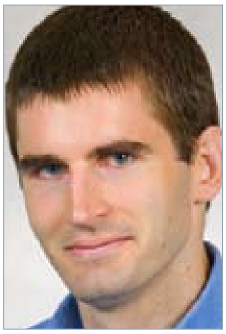
[7] HSE (2005). An experimental investigation of bund wall overtopping and dynamic pressures on the bund wall following catastrophic failure of a storage vessel, prepared by Liverpool John Moores University for the **Health and Safety Executive 2005, Research Report No 333**



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