Sleeping Giants

Aboveground Storage Tanks For Non-hazardous Liquids

By Karen Fuentes and Peter Ellis

One of several identical roofless 76-foot diameter by 46-foot tall tanks in a stormwater control facility failed catastrophically in 2001, less than 10 years after it was constructed. The collapse (Figure 1) occurred after several days of rain had filled the tank nearly to capacity. The rupture extended the vertical height of the tank and ran around the circumference at the weld between the wall and floor. The 1.6-million gallon flood of suddenly released stormwater knocked two adjacent empty tanks of similar size off their foundations (Figure 2) and damaged nearby electrical trays and piping. As the walls of the collapsing tank unfurled, they impacted a third nearby tank, causing additional damage.

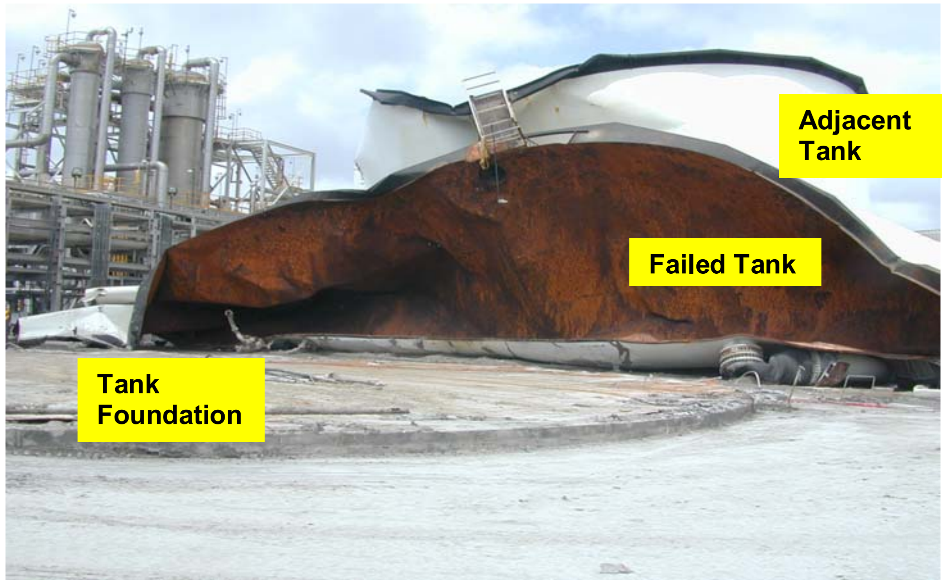

Figure 1. Sides of failed tank lying against adjacent tank.

A liquid fertilizer tank—approximately 32 feet tall by 60 feet in diameter with a vented roof was filled to capacity early each spring, kept about half-full during the growing season, and left nearly empty during the winters. The tank was approximately 20 years old when it was filled in the spring of 2003. The shell split vertically and tore from the bottom around the circumference of the tank, collapsing the tank (Figure 3), spilling 500,000 gallons of fertilizer, and damaging three surrounding storage tanks (Figure 4).

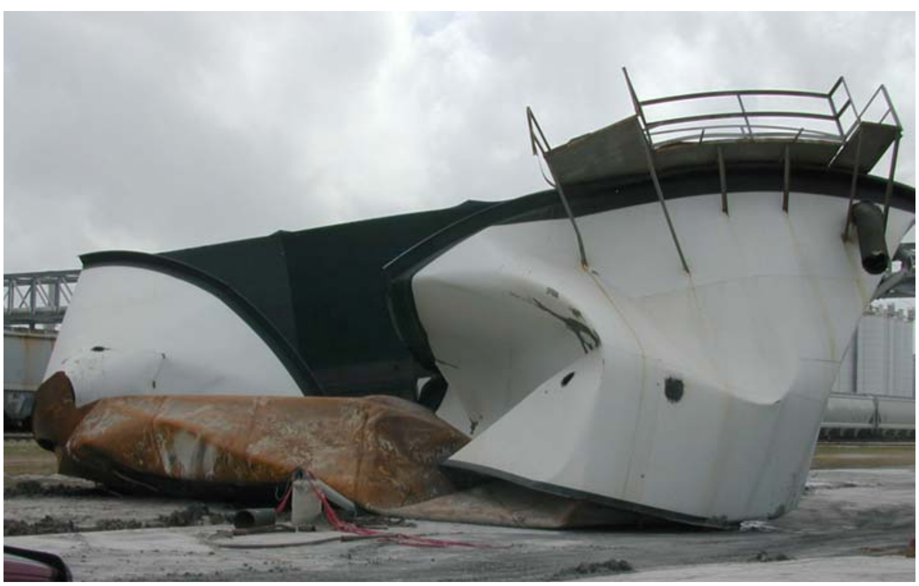

Figure 2. Tank near failed tank that was damaged by released storm water.

These sleeping giants— very large free-standing unlined carbon steel tanks used to store waters and other non-hazardous aqueous solutions—dot the landscape. An unknown number of these tanks have failed catastrophically far short of the conservative 30-yr design life typical of these tanks. Because the contents of such tanks are not flammable and are not considered to be environmentally hazardous, such ruptures pose no risk of fire or explosion, and very little risk of harm in any form to the general public. However, the split-second

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Figure 3. Failed liquid fertilizer storage tank.

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release of such huge liquid volumes can result in injury or death to personnel near the tank, as well as significant collateral damage as the above examples illustrate.

M&M Engineering's investigations of such failures have found a common pattern. In each case investigated the tanks were constructed with increasing wall thickness toward the floor to accommodate the weight of the contained liquid. The exteriors of the tanks were well maintained and the custodians of the tanks had conducted annual visual inspection of the interiors as well as UT inspections. M&M Engineering concluded that the failures were not related to any design or construction defect or obvious maintenance neglect.

The other commonality was that the failures occurred in tanks that were typically less than half-full much of the time. In each case the collapse occurred shortly after the tank had been filled to near capacity.

It is generally known that corrosion in the sorts of solutions stored in unlined carbon steel tanks may be three to ten times greater at the liquid line than elsewhere in the tank, resulting in a band of deeper corrosion and "rust ring" at the typical or average liquid level. In each of the failures investigated, M&M Engineering found that the rust ring was near the bottom of the tank (Figure 5). M&M Engineering found that the ruptures occurred because the remaining wall thickness in the "rust ring" could not support the weight of the liquid when the tank was filled. Once the rupture of the thinned area began, the crack ran the length of the tank wall and the circumference of the bottom weld before the potential energy of the stored liquid was spent.

Figure 4. Damage to an adjacent tank caused by the impact of the unfurling wall of the failed tank.

While stringent inspection and fitness-for-continued-service decision requirements for large aboveground petroleum and hazardous materials tanks are mandated by the Environmental Protection Agency (EPA) and National Fire Protection Association (NFPA) and other governing agencies, tanks containing "non-hazardous" materials have no such mandates. Organizations such as the Steel Tank Institute (STI), Underwriters Laboratories (UL) and American Petroleum Institute (API) have developed standards for the evaluation of tanks containing

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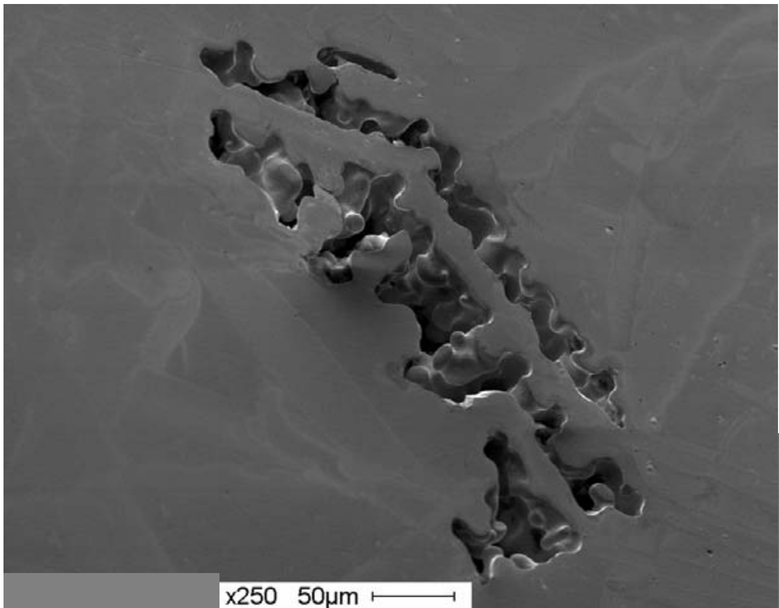
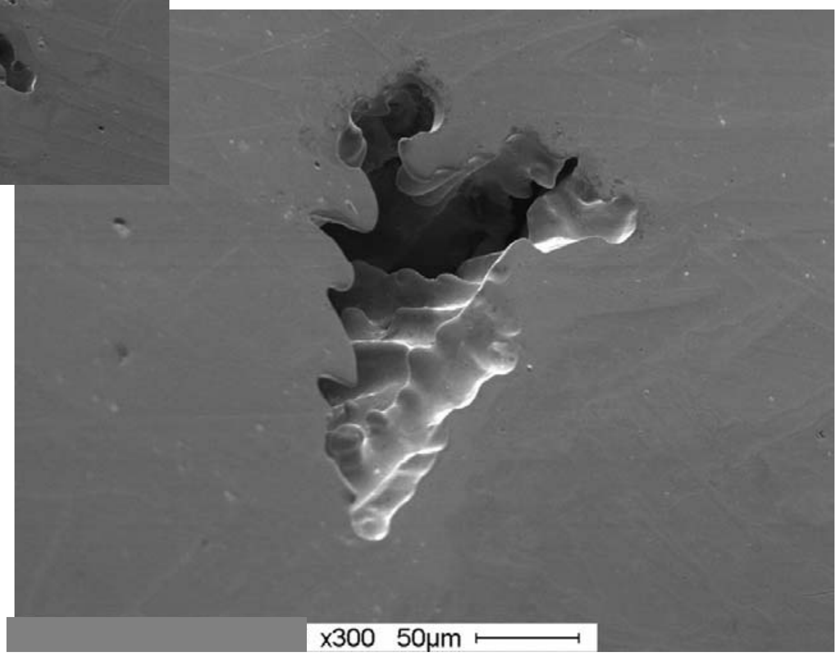
petroleum, hazardous or flammable materials, but M&M Engineering's survey of several State and National regulatory authorities found that no guidance exists specific to the inspection and continued fitness-for-service criteria for large non-petroleum, not-hazardous liquid storage tanks.

At this time, review of API and/or STI standards are recommended for organizations concerned about the inspection and evaluation of aboveground storage tanks containing non-hazardous materials.

Figure 5. Inner wall of a storm water storage tank.

Casting Shrinkage Porosity





Casting voids found in a ring during examination in a scanning electron microscope (SEM).