TO CLOSE OR NOT to CLOSE?

The decision to keep roof tank drains open or closed is an operating dilemma faced by tank farms worldwide. **Michael Sprung and Mark Rauch, EnviroEye, LLC, USA, and Chris Chase, InterOcean Systems, USA,** outline a newly developed system that can help operators to safely and effectively monitor floating roof drainage.

Floating roof aboveground storage tanks (ASTs) are the most widely used method for storing petroleum products. Crude and refined petroleum products are volatile and evaporate under normal conditions, producing combustible vapours. The need for a storage solution to remedy this issue was a challenge in the early 20th century.

Initially employed by the Chicago Bridge & Iron (CB&I) Company in 1923, floating roof ASTs provided a safe and effective way to reduce volatile product evaporation. For this reason, they are still in use today. With respect to safely controlling emissions and water drainage from ASTs, Terry Gallagher, Product Design Manager at CB&I in 2000, noted that, "the first floating roof designs were stiffened pans. The roof deck was sloped to the centre for water drainage and to permit vapour to pass from under the deck to the perimeter rim space. The need for improved rim seals, roof drains, manual and automatic bleeder vents, rolling ladders and other tank equipment has never stopped. Floating roof systems are complex structures when it comes to design, analysis and construction. Weather and environmental concerns and issues resulted in adaptations to the floating roof design to eventually

Figure 1. Bad weather scenario with AST.

Figure 2. Inside an AST – articulated floating roof drain line.

Figure 3. AST with floating roof.

enable their use with a fixed cover. Applications that require absolute control of all emissions from the storage tank now demand the most advanced type of installation, with options for both closed and open roof design."

Preventing incidents and failure

Indeed, product emission control and the risk of catastrophic tank roof failure has always been, and continues to be, an issue that must be confronted by all AST operators, and which challenges even the most compliant and well run storage facilities. The examples below highlight incidents involving the failure of storage tanks, as well as reports that emphasise relevant historical data.

One of the most notorious, catastrophic failures of a storage tank occurred in Boston, Massachusetts, on 14 January 1919, prior to floating roof tank implementation. A wall of molasses killed 21 people – the result of poor design, construction and testing.

Many factors contribute to failures, whether the issue is tank construction, human error, torrential rains, earthquakes, hurricanes, or any number of other actors. A tank farm operator has to measure and de-risk the likelihood and frequency of occurrence with the consequences of possible occurrence.[1]

Historically, there have been many notable events and catastrophic AST roof failures that resulted from heavy rainfall or poor weather conditions; however, the following examples are notable:

- Heavy rainfall was the culprit in a catastrophic roof sinking incident on 17 October 1987 in Kurashiki, Okayama, Japan, where a floating roof sank after little more than an hour and a half of rainfall during a typhoon. The rate of rainfall was estimated to be 38 mm/hr (as a rule of thumb 1 mm/hr of rainfall is equivalent to 1 l/m^2 of water). In the case of Kurashiki, the primary cause of the accident was attributed to the plugging of the ball check valve cover and inadequate management.
- A well known event on 18 July 2007 impacted a crude oil tank in Petit-Louronne, France, resulting in an irreversible sinking of its floating roof. Heavy rain, coupled with weakened tank weld caissons caused by sediment accumulation over time, were identified as the primary contributing factors.

In the Study of Storage Tank Accidents from the Department of Safety, Health and Environmental Engineering, Chang and Lin provide an analysis of 242 tank accidents over 40 years.[2] Their summation contains extensive empirical data and facts related to tank management. They conclude that the

majority of tank accidents can be avoided by implementing best practices throughout the design, engineering, construction, operation and maintenance processes. Furthermore, they emphasise the importance of properly implemented and executed operational and safety management programmes.

With respect to maintaining AST roof integrity and buoyancy, W. Atherton and J. W. Ash, Liverpool John Moores University, conducted a review of the various causes of failures "to highlight the extent of the problems which have occurred in the bulk storage industry together with the environmental and human impact of such incidents. Through a process of spill modelling, the magnitudes of such losses have been identified across a range of scenarios. Recent results have indicated that the losses incurred during less dramatic modes of failure can ultimately be significant. This gives rise to the conclusion that suitably practicable means of mitigation have to be identified and implemented if the levels of potential risks are to be suitably controlled."[3]

Ongoing developments in AST floating roof technologies are important from structural integrity and operational perspectives, as well as from a regulatory compliance standpoint. Thus, new equipment developments are being designed on an ongoing basis to improve safety and operational function, and reduce the environmental impact of AST floating roof tanks, and their stored products and byproducts.

To open, or to close?

When inclement weather hits a facility that stores petroleum products, maintaining a safe site can be a very complex task. When an AST storage facility operator is asked how the water drain valves on floating roof storage tanks should be positioned, almost all sites will provide a different response, and their own unique rationale.

While it would seem to be a fairly straightforward issue, this is actually an age old dilemma, which has challenged operators and management for many years – there is apparently no standardised approach, and no universal solution. While the need for both a management tool and a risk reduction device have long been recognised by industry professionals, the development of a reliable, simple to use, complete solution has proven to be very elusive to date.

Tank farm owners and operators have waited for a solution that could efficiently detect hydrocarbons, close or open a valve, turn a pump on or off, and simultaneously send a real time remote alert to personnel for immediate attention. Previous systems were able to detect hydrocarbons in water, but were deemed by the market to have numerous shortcomings, including high rates of failure, false detection, the need to be submerged in liquid in order to operate (contact sensors), moving parts and breakable wires, and a reputation for 'junking up' the works downstream, or for sealing an opening only when catastrophic amounts of petroleum are detected (i.e. not sheen sensitive). Though these system concepts attempted to address the ongoing issues, in most cases they proved unable to cope with the head pressure of a 40 ft tank, were shown to be unreliable, required significant maintenance, and were not sufficiently sensitive.

When leaving the roof drain open, with the expectation of slight or torrential rains, all rainwater immediately drains from the roof through and out of the tank. The risk in this scenario is, if the internal roof drain line fails, the stored product drains through the failed line onto the ground, causing hazardous material to discharge into the tank dike.

Alternatively, if a facility's standard operating policy is to keep AST roof drains closed during light or heavy rainfall, it is essential for facility personnel to respond immediately and manually open the roof drain line, thereby relying upon an individual's senses (sight, smell, education, intuition and experience) to observe and determine the presence of product in inclement conditions, day or night. If personnel do not respond during a given rain event, excess rainwater will accumulate on the floating roof, and loss of buoyancy may occur. This may result in a sinking roof, damage to the tank wall, fire from the vapours, or the release of stored product into the environment. This potentially places personnel at a higher level of risk. Both scenarios expose a facility to possible contamination, permit violations, media attention, tank failures, extended downtime and loss of revenue. The constant movement of the drain line creates wear and tear, resulting in the potential for failures, servicing and/or costly replacement.

Efficient roof drainage

In an attempt to solve this dilemma, the EnviroEye system has been developed by a group of AST storage facility operators, offering a potential solution for the long standing 'open or closed' quandary. EnviroEye has created a flow chamber that slows the escaping liquid from roof drains, while subsequently creating an ideal point for monitoring and detecting any hydrocarbons present in the stormwater discharge from AST roofs, and for automatically containing accidental leaks or spills. The EnviroEye system attaches by flange directly to the roof drain flange – a bypass valve is recommended at this junction. Between the tank and the unit, an automated valve is used to automatically stop the flow any time hydrocarbons are detected.

Figure 4. EnviroEye system.

Figure 5. Slick Sleuth SS100 oil detector.

Sensor signal and event alerts can be output to a facility control room via industrial I/O (relays/4-20), and a text message can simultaneously be sent to designated managers and facility personnel to trigger immediate action.

During preliminary installations of EnviroEye at select tank farms, the system has validated the ability to continuously monitor liquids that discharge from tank roofs. Unforeseen benefits have also been realised, including improved tank management and insight into the condition of the drain inside the tank. This information can help managers predict which tank(s) may need servicing soonest, and improve the operator's ability to make cost and time saving decisions.

As important as it is to be notified when a valve is activated, when severe storm conditions are imminent reasonable notification becomes paramount. Personnel need to be notified in a timely fashion when a valve is activated. Electronic communication capabilities, e.g., text messages, internet/cloud interface, typical industrial I/O, visual and audible alarms, are available options of the EnviroEye system, and enable the appropriate level of real time awareness of system status and alerts. If the drain system has a failure, the system activates, closes a motor operated valve, and alerts personnel to the issue. This may also provide a view 'upstream', providing a warning/prediction that a tank requires surveillance, and may be a candidate for earlier rotation to undergo its API 653 inspection.

Inside the flow chamber, the use of magnets to trap scale from the inside of the tank line becomes an additional early warning mechanism. When scaling/rust particles are captured, and subsequently analysed, tank operators can determine the origin of the problem. The origin of the scale could be the nozzle, the drain pipe, or the tank shell. The EnviroEye Drain Guard System helps to facilitate visibility and simplify this routine maintenance function.

The system also has applications beyond the monitoring of AST floating roof drain lines. All facilities dealing with diked areas, retention ponds, sumps, etc., and that store, process or transport petroleum products, may realise cost benefits by utilising the EnviroEye system and real time oil
leak/spill monitoring, improving awareness and the control of potential catastrophic events, as well as the protection of the environment through effective management of stormwater. This proactive approach translates to large savings, as it prevents loss of product, may result in fewer insurance claims, and reduces the probability of fines and the likelihood of 'undue' scrutiny by government regulators.

During initial trial installations of the EnviroEye system over the course of the past two years, it has proven to be an invaluable tool for both risk reduction and for identifying problems and at-risk floating roof ASTs. These installations have substantiated the system design's intent to ensure that rainwater is kept separate from stored product, and to notify facility management/personnel in real time if the discharge contains levels of product that exceed a determined threshold, automatically containing the polluted discharge and prompting immediate response and corrective action.

System integration

EnviroEye has teamed and collaborated with InterOcean Systems, the manufacturer of the Slick Sleuth oil spill detector. The Slick Sleuth

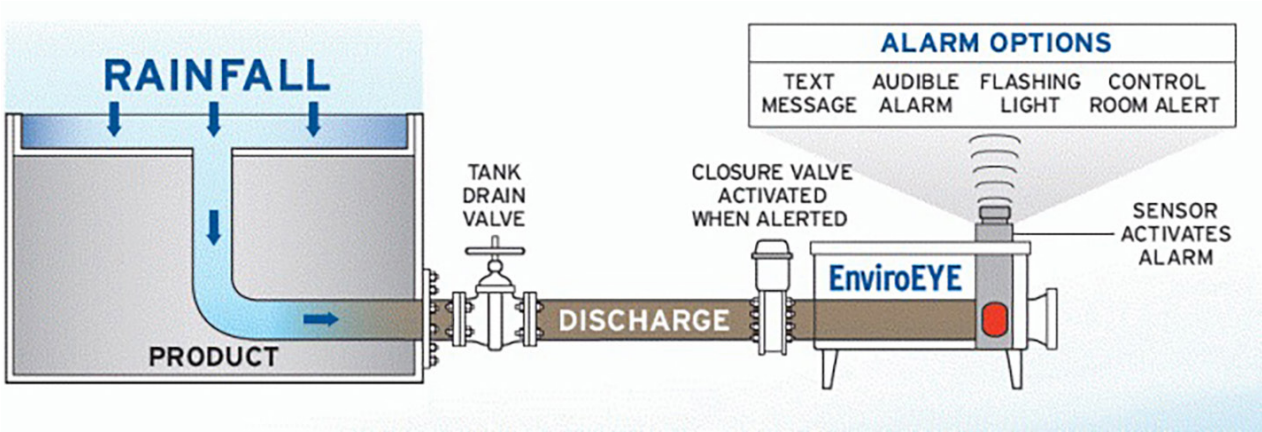

Figure 6. Diagram of EnviroEye system.

sensor is mounted at the end of the flow chamber, where water flows through a controlled path and passes within view of the optical sensor. The sensor itself uses UV-fluorimitry to detect the presence of petroleum and hydrocarbon-based products on the surface of the water, activating an audible, visual, text or cloud-based message that can be investigated by designated facility personnel. This optical method of detection is highly sensitive to both sheens and slicks, and offers adjustable sensitivity thresholds that can be set by operators. Furthermore, because it is a non-contact system (no contact with water or product), there is very little need for maintenance.

Overall, the EnviroEye system has been developed to provide tank farm operators with a tool to manage stormwater discharge from floating roof ASTs; however, the system can be customised with different components, depending on its intended use. There are bypass valves and additional actions that can send the contaminated liquids into sump/holding areas. The design and size of the flow chamber, as well as other component details and specifications, are determined by the tank diameter, height, drain line size, climate and operator protocols. Whether the requirement is for AST floating roof tanks, for stormwater runoff, water retention-containment ponds for oil-related sites, or diked areas surrounding hydrocarbon tanks, there is an arrangement that can be configured to meet any given set of application and location requirements. EnviroEye uses only Class 1 Division 1 Explosion Rating (NFPA 70) components on the flow chamber.[4]

Conclusion

In the current era of heightened environmental awareness, many changes have been incorporated and implemented in order to protect storage facility operators' interests, as well as the workers who manage the petroleum products, and the environment and community at large. With much sacrifice, the industry has produced methods to predict potential failures, minimise risks, and protect facilities and the operators that run them. This article has provided a brief synopsis pertaining primarily to AST floating open roof tanks and safe storage practices, to help eliminate the risk of oil-laden discharge from roof drains. EnviroEye's Drain Guard System helps to better manage storm drains on open floaters. The cost of the system is minimal compared to the possible exposure of just one catastrophic spill. The patent-pending technology provides: a reduction in the need for constant human supervision; drainage solutions that utilise hands-free electronic monitoring; and the ability to activate motorised valves. The system is currently in operation at several tank farms, with key benefits including low maintenance costs, no service interruption, and mitigated costs of catastrophic events, such as a sunken roof or product loss.

References

1. As noted by the Fire Chief, Chris Bowcock, in an interview during a KinderMorgan case. Copyright: Burnaby Now.
2. CHANG, J. I. and LIN, C. C., Study of Storage Tank Accidents, Department of Safety, Health and Environmental Engineering, Kaohsiung, Taiwan, 26 May 2005.
3. ATHERTON, W. and ASH, J. W., Liverpool John Moores University.
4. Florida does not require tank farm operators to obtain department approval to use EnviroEye.


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DRAIN GUARD SYSTEM
4635 SW FRWY, STE 910
Houston, Texas 77027
713-627-1700
michael.sprung@enviroeye.net | www.enviroeye.net