ONE GAUGE, DOUBLE THE PROTECTION

Radar level gauges with two separate and independent electrical units and a common antenna can provide a cost-effective solution for tank overfill protection. Emerson's Johan Sandberg explains how, in terms of independence and technology diversification, devices using this 2-in-1 technology are compliant with IEC 61511 and API 2350.

The potential overfilling of tanks or vessels is a major safety concern within the process industry, especially in bulk liquid storage applications where spills can have catastrophic consequences.

The incidents at Buncefield, Jaipur, Puerto Rico and West Virginia are just a few examples of where the overfilling of tanks storing chemicals and petroleum have caused major environmental harm including water pollution, fires and explosions, resulting in large-scale asset and property damages, injuries and fatalities.

The need for reliable overfill prevention technology installed on these vessels is obvious, yet there are still many old and poorly maintained storage tanks in service, often with non-existing, non-functioning or obsolete overfill prevention equipment.

However, the industry is working hard to increase safety at tank terminals, as evidenced by the demands of the IEC 61511 standard for safety instrumented systems, and the stringent global overfill prevention standard API 2350, created by more than 40 users and manufacturers in the petroleum industry.

INDEPENDENT PROTECTION LAYERS

It is widely recognised that, when implementing a suitable protection system for storage tanks, there is a need to employ a multitude of independent protection layers to minimise the risk of overfills.

The primary layer is an automatic tank gauge (ATG) for continuous high-accuracy level measurement. This is connected to a distributed control system or separate tank gauging system, and its purpose is to monitor and control product movement, and ensure that the facility is running smoothly, day in and day out.

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If functioning correctly, the ATG will prevent the need for the other layers to become active.

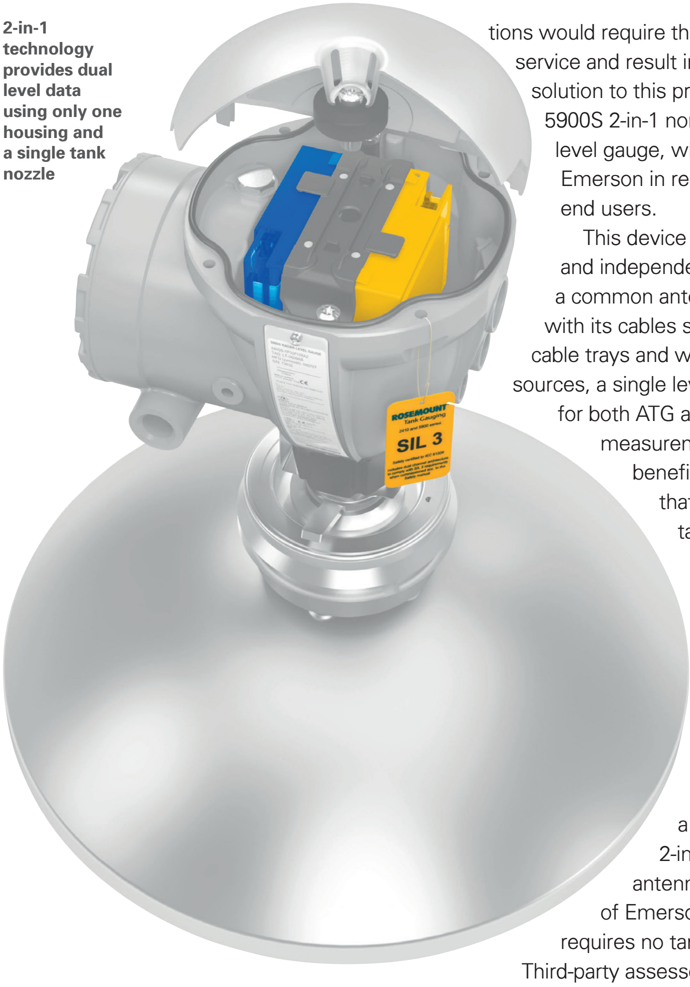
The second layer of protection is the safety layer, which takes the form of a level sensor connected to a manual or automatic overfill prevention system (OPS). This must remain separate and independent of the ATG to provide redundancy. This layer should prevent an overfill incident from occurring should there be a failure or problem with the ATG.

A passive protection layer provides secondary containment, such as dikes or concrete walls. Finally, there is the emergency response layer, which involves alerting the emergency services. The ATG and the OPS are installed to prevent overfill, but should an incident occur the passive protection and emergency response layers are there to minimise the consequences.

OVERFILL PREVENTION TECHNOLOGY

Level switches have historically been the technology of choice for the OPS sensor. This type of sensor has a lower initial purchasing cost than continuous level measurement technology, but it does not provide any online measurement, and it is therefore virtually impossible to know whether it is functioning correctly or not. Level switches consequently require frequent on-tank proof-tests. This not only

The two radar level units in the Rosemount 5900S 2-in-1 are galvanically separated and fully independent



2-in-1 technology provides dual level data using only one housing and a single tank nozzle

increases the safety risk to workers who need to climb tanks to perform the tests, but is also a labour-intensive procedure that results in tank (and possibly also process) downtime. These are some of the key reasons why the industry is rapidly transitioning from level switches to continuous level gauges for the OPS sensor as well as the ATG.

The dominant level measurement technology for ATGs in bulk liquid storage tanks has for a long time been non-contacting radar. New installations often employ two radar level gauges, to provide both level and independent overfill prevention measurements. This is a well-proven technology and it provides high reliability. The latest radar level gauges can offer remote proof-testing capabilities, helping to improve safety and reduce maintenance costs compared with both point-level sensors and less sophisticated continuous level gauges such as servo and float & tape. Also, the use of two radar level gauges allows for fewer device types, which equals fewer spare parts and a reduction in the need for device-specific training. Reducing complexity in this way minimises the potential for human error, which plays a part in many industrial accidents.

RADAR LEVEL GAUGES WITH 2-IN-1 TECHNOLOGY

Some tanks can have practical limitations that make safety upgrades with two separate level gauges cost-prohibitive, including where no tank opening is available, and where modifications would require the tank to be taken out of service and result in additional costs. One solution to this problem is the Rosemount 5900S 2-in-1 non-contacting radar level gauge, which was developed by Emerson in response to demand from end users.

This device consists of two separate and independent electrical units and a common antenna. When connected with its cables separated in different cable trays and with separate power sources, a single level gauge can be used for both ATG and separate OPS sensor measurements. The most obvious benefit of this configuration is that it requires only a single tank opening. This allows for cost-efficient safety upgrades of existing tanks by replacing a single existing ATG (or OPS sensor) with two continuous level measurements with a minimum of tank modifications. Often, a radar level gauge with 2-in-1 technology fits the antenna of earlier generations of Emerson devices and therefore requires no tank modifications at all.

Third-party assessor Exida has verified that the Rosemount 5900S 2-in-1 fulfils the requirements of IEC 61511 to be used simultaneously as a BPCS and SIL 2 AOPS, as it overcomes the two potential deviations of independence and technology diversification.

INTERPRETATION OF INDEPENDENCE

Although the concept of independence is used in the process industry, it is practically impossible to fulfil with a literal interpretation. Most users believe that an overfill solution consisting of an ATG and an 'independent' point-level sensor fulfils the requirements for primary and safety levels of protection. However, when the requirement for independence is investigated more carefully, the two layers will not fulfil a literal interpretation. An earthquake, tsunami, flooding, aircraft crash, fire, explosion, power loss or tank failure could affect both layers and are examples of common cause failures (CCF). Modern safety standards such as IEC 61508 and IEC 61511 recognise the existence of these CCFs and allow for an interpretation of independence which focuses on minimising CCFs to maximise total risk reduction.

This evolution in the interpretation of independence is an indication of the ongoing development in the process industry. The original intention is fulfilled while at the same time being more practical and possible to implement in practice. It still requires consideration of CCFs, but puts these in perspective against an even more important performance metric, the risk reduction factor (RRF). This change in focus has been critical for the development of increased safety in the process industry because it has allowed equipment manufacturers to develop novel solutions that focus on risk reduction rather than fulfilling an impossible theoretical requirement.

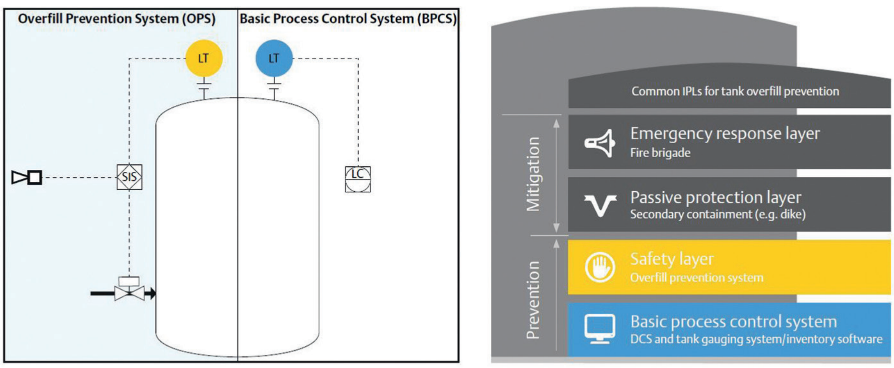
When evaluating the CCFs associated with 2-in-1 technology, there needs to be perspective when it is compared with the alternative of using two separate radar level gauges as the ATG and independent OPS sensor. The 2-in-1 technology is based on a single antenna which theoretically is a source of CFF. Consequently, it can be argued that it is better to use two separate level gauges if possible. However, the likelihood of the antenna failing is very low, and all failures are detected by the electronics. The influence on the overall risk for an overfill is therefore usually negligible.

Therefore, it can be concluded that radar level gauges using 2-in-1 technology fulfil any practically viable definition of independence, and the risk associated with the common antenna is smaller than the risk associated with most storage tanks themselves. Ultimately, it is up to the owner or operator of a facility to decide if the small gain in risk reduction that can be obtained by using two separate level gauges rather than one 2-in-1 gauge is worthwhile, given the extra costs that would be incurred.

TYPES OF FAILURE

Failures which could affect an OPS can be split into two basic categories:

- Systematic failures – these are failures produced by human error during system



A multitude of independent protection layers are needed to minimise the risk of overfills

2-in-1 technology offers substantial cost savings for tank terminals, compared to using two separate level sensors

development and operation, and will always appear when the circumstances are the same. Examples include, but are not limited to, software bugs, incorrectly designed products and misapplications.

- Random failures – these are the result of factors such as corrosion, thermal stressing and wear-out, which apply to simple hardware components within a system. These failures appear randomly and can be described with a probabilistic model. Random failures are typically addressed by using hardware fault tolerance (redundancy), whereas systematic failures are the result of human error and therefore need to be addressed differently.

TECHNOLOGY DIVERSIFICATION

A commonly employed technique to minimise the likelihood of systematic failures is product and technology diversification. This is, however, only one of several methods. For example, IEC 61511 uses a lifecycle approach where some of the key components to minimise the likelihood of systematic failures are qualified personnel, written and agreed procedures and specifications, proper planning, thorough reviews, management of change and testing. The measures that have been undertaken to avoid systematic failures are described as 'systematic capability' and are quantified according to IEC 61508 and IEC 61511 in safety integrity levels (SIL) 0-4 just as random hardware failures.

Technology diversification is not a requirement according to API 2350 or IEC 61511. Nevertheless, extensive measures have been taken during the design of the Rosemount 5900S 2-in-1 to minimise systematic failures and to ensure compliance with this (non-existing) requirement.

The electrical units employ diverse technologies, and the device contains different circuit boards, internal signal paths, firmware and signal processing algorithms for the two electrical units used for ATG and OPS. Also, the common antenna has been thoroughly evaluated and designed in such a way to minimise the probability of systematic failure. Its 'systematic capability' fulfils SIL 3, which equals a higher RRF (1,000) than any of the claimed total RRFs when using the Rosemount 5900S 2-in-1 for both primary and secondary protection layers.

CONCLUSION

The Rosemount 5900S 2-in-1 radar level gauge is a new technology that allows a single tank opening to be used for both level (ATG) and separate overfill prevention (OPS) measurements. This solution offers substantial cost savings compared to using two separate level sensors. For any practical purpose, it can be concluded that the Rosemount 5900S 2-in-1 technically qualifies to be used as the sensor in two independent protection layers, if connected properly.

FOR MORE INFORMATION

www.emerson.com/OverfillPrevention