SAFETY ASSESSMENT FEDERATION

# Guidelines

# Pressure Systems

## Integrity Management of Protective Devices associated with Storage Tanks

**REFERENCE: IMG 02d**
**ISSUE: 01**
**DATE: 25/08/2016**

| DOCUMENT INFORMATION: | |
|---|---|
| REFERENCE: | IMG 02d |
| ISSUE: | 01 |
| DATE: | 25/08/2016 |
| PREPARED BY: | TC 1 |
| APPROVED BY: | TC 1 and TSC |

**DOCUMENT HISTORY RECORD:**

| ISSUE: | DATE: | CHANGE DETAIL: |
|---|---|---|
| 01 | 25/08/2016 | Initial Document |
| | | |

## CONTENTS



## 1. Introduction

SAFed Guide IMG01 provides specific information on the regulations applicable to storage tanks containing hazardous substances. IMG02 gives an overview of the inspection of storage tanks. IMG02a, b and c contain specific guidance for metallic, GRP and plastic tanks.

The primary cause of the fire and explosion at the Buncefield oil terminal depot on 11th December 2005 was a faulty level sensor, which allowed a large storage tank to overflow causing the incident. As part of the examination of a storage tank, the integrity of the protective devices including the level controls will therefore need to be ascertained.

## 2. Scope

This document provides guidance on managing, testing and examining protective devices associated with storage tanks. Although level controls are normally not considered a protective device, they are fundamental in ensuring that the tanks contents are contained at a safe level.

This document does not cover the inspection of the tank, pipework or bunding which are covered in separate guidance documentation.

If the tank contains or is likely to contain a relevant fluid it is a pressure system and is excluded from the scope of this document. It may need to be included within a written scheme of examination as required by the Pressure System Safety Regulations.

## 3. Types of Storage Tanks

There are many different designs of storage tanks and each installation is likely to require a specific inspection strategy for the associated protective devices. They are manufactured from various materials, the most common being low carbon steel and austenitic stainless steel.

There are two types of storage tanks that this guidance covers.

- Atmospheric storage tanks – These are designed with a maximum internal pressure of 7.5 mbar and a vacuum of 2.5mbar

- Low pressure storage tanks – These tanks are designed with a maximum internal pressure of 20 mbar to 140 mbar.

## 4. Integrity Management of open vents

The purchaser should specify the maximum filling and emptying rates and any special venting requirements to the manufacturer during the design phase of the tank. The vents must be suitable to prevent a build-up of pressure or overstressing of the roof deck or sealing membrane. The vents must be adequate to evacuate the sum of the air and gasses from the tank during product filling or withdrawal and any pressure build up due to changes in ambient temperature.

If the product being stored in the tank has a flash point below 38°C or it containes a product that is heated above its flash point the use of a pressure/vacuum (PV) valve or an open vent with a flame arrestor should be considered. This is due to possible ignition of the vapour owing to lightning strike or a discharge of static electricity at the vent location. Emergency vents should comply with relevant standards, such as API 2000.

Flame arresters should be included in preventative maintenance routines to ensure they do not become blocked by scale, paint, ice or other materials.

Second hand tanks should be assessed to ensure the venting arrangements are suitable for their intended new application.

For new and existing installations it is assumed that all protective devices, including relief streams, have been correctly designed to prevent a dangerous situation from occurring under the foreseeable operating and fault conditions.

## 5. Integrity Management of protective devices

### 5.1. Pressure / vacuum relief valves

Pressure/vacuum relief valves are protective devices specifically designed to protect tanks, process systems and equipment from excessive pressure and vacuum. They also minimise emission losses of gases or vapours to the environment due to evaporation or the filling operation. They must be capable of venting large volumes of vapour at low pressure.

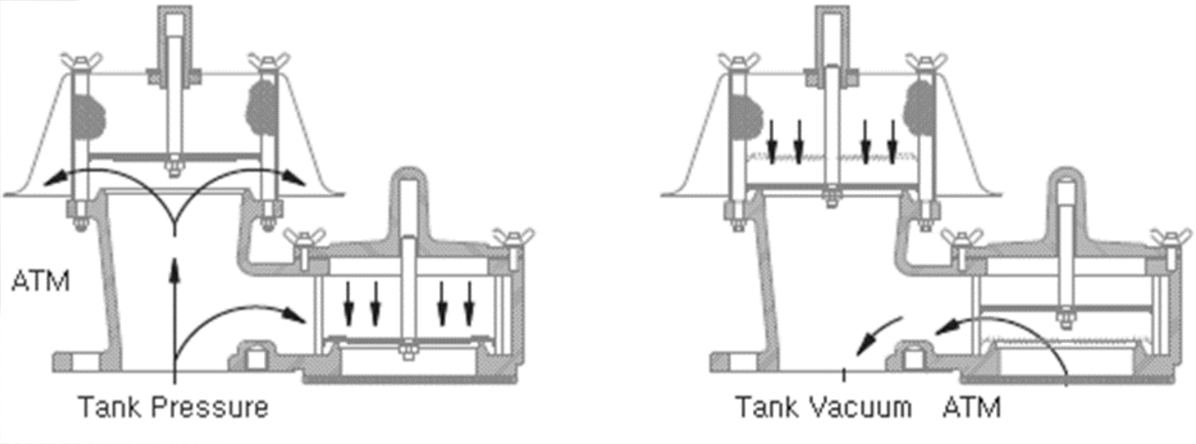
Pressure / vacuum relief valves are used extensively on bulk storage tanks, including fixed roof tanks with floating covers, to minimise evaporation loss. The valves prevent the build-up of excessive pressure or vacuum which can unbalance the system or damage the storage vessel. Due to the potential for blockage, conservation vents (vacuum and pressure relief) should not be fitted with flame arresters.

Under normal conditions, pressure-relieving devices must have sufficient flow capacity when operating to prevent the pressure from rising more than 10% above the maximum allowable working pressure. Under fire emergency conditions, the devices shall be capable of preventing the pressure from rising more than 20% above the maximum allowable working pressure.

The operation of the PV valves is described below.

1. If the tank pressure rises to the set value of the PV valve e.g. 56 mbar the valve will open allowing the excess pressure to be discharged at velocity. This discharge velocity of the gas exceeds the flame velocity of most hydrocarbon gasses which removes the need for a flame arrestor to be fitted to a PV valve.

2. If the tank is subjected to vacuum conditions due to the discharge of the product or cooling the vacuum valve opens allowing the ingress of air.



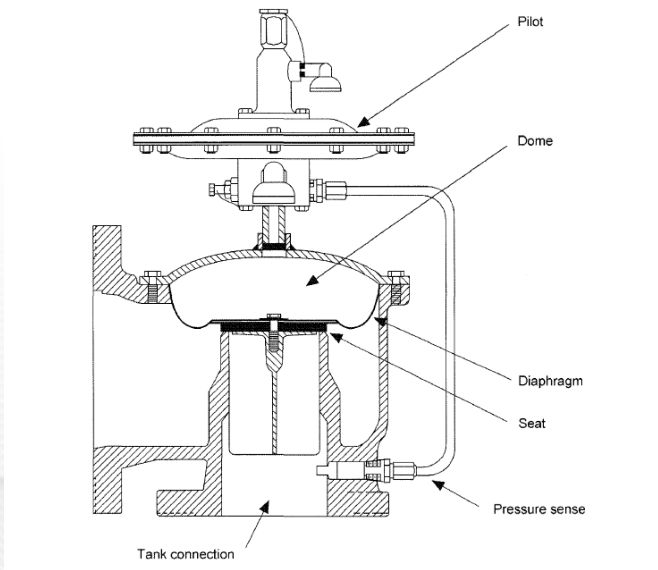

It is also possible to have either a purely pressure relief valve or vacuum relief valve fitted to the tank.

Vacuum relief safety valves are used most commonly on large tanks to prevent implosion during product discharge or cooling of the vapour. The valve itself is a spring safety valve arranged with the valve plug open to atmosphere. The operation of the valve is the same as the spring safety valve, with the plug and spindle moving when the internal vacuum overcomes the set spring force, allowing atmospheric pressure to enter the vacuum.

### 5.2. Pilot-Operated Vent Valves

Pilot-operated vent valves used for pressure and/or vacuum relief use the tank vapour pressure, not weights or a spring, to keep the valve seat closed. The valve seat is held in the closed position by the tank vapour pressure acting on a large area diaphragm. This tank pressure covers an area greater than the seat sealing area, so the net pressure force is always in a direction to keep the seat closed. The volume of vapour above the diaphragm is called the dome. Should the diaphragm fail, the dome pressure will decrease, and the vent valve will open due to the pressure in the tank acting on the underside of the seat.

The pilot is a small control valve that continuously senses tank pressure. When the tank pressure increases to set pressure, the pilot actuates to reduce the pressure in the dome volume, the force holding the seat closed is reduced, and the seat lifts to permit tank pressure to discharge through the vent valve. When the tank pressure decreases, the pilot closes, the dome volume re-pressurises, and the main seat closes.




**Typical arrangement of pilot operated valve**

## 6. Integrity Management of level controls and alarms

The level controls and alarms fitted to storage tanks are used to ensure that the contents of a storage tank are within safe limits and measure the quantity of product stored in the tank for inventory and stock control.

It is considered best practice and a requirement under certain guidance that high-level detectors and high-high-level detectors must be independent of each other that independently stop the filling operation by closing the filling valves. For example API 2350 Clause 1.3.4 (f) indicates that independent level detectors can be servo level gauges, radar level gauges, or a hydrostatic level gauging system.

Tank gauging systems should have a LAH (High Level Alarm) to alert operators to the status of the tank which gives sufficient time to interrupt the filling operation and the subsequent activation of the back-up overfill protection device LAHH (High-High Level Alarm). This should also take into account any thermal expansion of the fluid within the tank. It is important that LAH should not be used to control routine filling.

> **Note:** The investigation into the cause of the fire and explosion at the Buncefield oil terminal depot on 11 December 2005 resulted in a Safety Alert being issued by the HSE about the level controls used on the tank that overfilled in Buncefield. The type of level control is TAV level switches fitted with changeover (double throw) reed switches manufactured by Cynergy3 Components Limited. It is recommended that if any of these TAV level control switches are encountered the client is made aware of the HSE safety alert. http://www.hse.gov.uk

| Type of measurement | Application | Advantages | Disadvantage |
|---|---|---|---|
| Dip tape | Manual level measurements of tank ullage, Calibration of tank gauging systems<br><br>Accuracy ± 1mm | Simple, does not require power supply | Human error, lack of accuracy, non- continuous monitoring |
| Float operated, wire guided | Used in the fuel storage industry, ageing system that fail are upgraded to more reliable systems | Simple, cheap, | Reduced accuracy, float can stick on guides, Wear |
| Servo-operated float type | Used in petroleum storage industry | Continual measurement, accurate, can be used for alarms | High level of maintenance, fragile, can suffer from mechanical wear |
| Surface detector (plumb-bob) gauges | | Cheap, simple, easy to install | Non continuous, plumb can become jammed, wear, poor reliability |
| Radiation backscatter design (non-invasive) | Not used in petroleum storage industry | Can measure corrosive fluids, non-invasive | Expensive, radiation source, |
| Radar tank gauges | Used in petroleum storage industry<br><br>Accuracy ± 1mm | Very common, non-invasive, No wear, reliable, cost effective | Must have a gap between product and radar (Blocking distance), Problematic to install and set up, reduced accuracy at upper and lower tank limits |
| Capacitive tank gauges | | No operational degradation, no moving parts | Spurious high level readings, Contamination of the plate |
| Hydrostatic tank gauges | Accuracy ± 10mm | Cheap, no moving parts, good leak detection, possible to measure density | Not accurate, affected by temperature |

| Type of measurement | Application | Advantages | Disadvantage |
|---|---|---|---|
| Ultrasonic tank gauging | Is used in the water industry | Non-contact, cheap,<br><br>No moving parts | Tank must be clear of obstructions, can be affected by temperature, moisture and pressure. Readings can be erroneous when used in vacuumed nitrogen blanketed storage tanks. Not suitable for petroleum |
| Air bubbler level measurement | Suitable for open top tanks<br><br>Accuracy ± 10mm | No moving parts, suitable for hazardous areas, self-cleaning | Reduced accuracy, auxiliary components require careful maintenance, loss of air causes accuracy issues |
| Thermal differential | 0.1% to 5% | No moving parts, measuring flow of product is possible. | Monitoring not level detection system. |

## 7. Scheme of examination for the periodic examination and testing

Section 6.2 of SAFed Guidance IMG01 sets out the general contents for a written scheme of examination.

The testing of the level controls and alarms should be carried out and documented as part of the planned maintenance routine. These records should be viewed by the competent person at the time of the examination.

Pressure gauges should have in date calibration documents, which should be sighted by the competent person. If such documentation is not available, then the competent person shall check the gauge against a calibrated gauge.

All safety relief valves should be removed, overhauled and tested at set periodicities as defined in the WSE.

In lieu of the functional check of the protective devices called for under the written scheme of examination, the competent person should witness the setting on a test rig or at their discretion, accept documentary evidence that the protective devices have been recently tested and certified by an approved third party

The competent people should satisfy themselves that that organisation or people carrying out these tests are competent to carry out the necessary work.

Evidence of competency could be demonstrated through:

- ISO 9001 accreditation for the stated activity
- Witness of activity by the Competent person
- The Competent person has direct experience and is satisfied with the competence of the work carried out by the third party organisation
- UKAS accreditation for the stated activity.

The results of these tests, along with details of documented evidence of the test results shall be clearly referenced within the body of the report of examination produced by the Competent Person.

The relief stream should be verified as clear by suitable means and the documentation verifying the test sighted by the competent person.

## 8. Summary

This document highlights the main types of protective devices and level controls that could be fitted to storage tanks. It is possible for storage tanks to have very little protection with manual level controls or a high level of control dependent on the amount of product being sorted and the hazard rating of the content. Each tank needs to be assessed and subjected to a suitable risk assessment to determine if the level of control and protection is suitable.

Whilst these are general guidelines each individual storage tank is different and as such will need an individual assessment to confirm its pedigree, history, operating conditions, future loading etc. to determine an inspection strategy that best fits the risks encountered.

## 9. References

SAFed IMG01 – The Mechanical Integrity of Plant Containing Hazardous Substances

SAFed IMG02 – The Integrity Management of Storage Tanks

SAFed IMG02a – The Integrity Management of Metallic Storage Tanks

SAFed IMG02b – The Integrity Management of Glass Reinforced Plastic Storage Tanks

SAFed IMG02c – The Integrity Management of Thermoplastic Storage Tanks

ISO 9001 - Quality Management (QMS)

API 2000 - Venting Atmospheric and. Low-Pressure Storage Tanks

API 2350: Overfill Protection for Storage Tanks in Petroleum Facilities