High-expansion foam plant UNI EN 13565

Protection of an automated storage tank for flammable liquids by means of a foam suppression system

AUTHORS: Gianluca Galeotti – Fire Safety Engineer - FSE PROGETTI srl, Filippo Battistini – Fire Safety Engineer - FSE PROGETTI srl - Fabrizio Mosconi – Plant Engineer - FSE PROGETTI srl .

INTRODUCTION

The intensive storage of flammable liquids can be considerably dangerous for companies, as it entails fire risks. High-expansion foam systems are a possible a solution to the problem, allowing for a considerable reduction of this type of hazards.

Specifically, the aim is to analyse a project for the protection of an automated storage site with IBC tanks for flammable liquids: its height is 13 m in elevation on an overall area of 1,500 m^2. This site has also been included in the Seveso directive given the accident hazard that might result from dangerous working processes.

The protection by means of a foam system would produce two positive effects at the same time: it is possible to put out the fire quickly and reduce considerably the propagation of any toxic clouds to the surrounding environment, thus allowing emergency teams to operate in a safer environment than what it would be if a traditional sprinkler system was used.

PROJECT

The aim of the project is to develop a high-expansion foam suppression system to be used in an intensive storage site for flammable liquids.

The building consists of reinforced concrete pre-cast elements and was constructed in the early 60s. It is isolated and protected by external and internal fire hydrants. It is also equipped with an automatic smoke and heat detection system.

As per the high-expansion foam suppression system, the areas to be protected have been divided into four zones where liquids are stocked according to their level of flammability and toxicity.

The high-expansion foam suppression system has been designed in compliance with the European regulation UNI EN 3565-2 2009, Fixed firefighting systems - Foam systems - Part 2: Design, construction and maintenance.

Project parameters

The reference standard for the installation, specifically a total filling system, indicates the maximum submersion times allowed. The submersion depth shall not correspond to the height of the hazard increased by 3 m (other international standards mention 0.6 m), unless the closed space is completely filled with foam, as in this specific project.
One thing to consider in this project is that the high-expansion foam removes air from the closed space; so, no vent holes need to be created on the building ridge.
Foam generators shall be designed to work at expansion ratios ranging from 500:1 to 1000:1. This choice stems from the amount of spraying required and the stability of thermal updraughts generated by the fire and, in this case, the precise value used was 650:1.

The standard allows for two different methods to be used in order to calculate the filling capacity. The choice made in this specific case is the one of determining the maximum submersion time (three-dimensional hazard): point number 7 in the regulation provides for the maximum time allowed, that is 3 minutes for this system, and this time is set according to the type of hazard as well as to the type of building.
The regulation also recommends not to install sprinkler systems together with high-expansion foam systems.

The discharge flow rate is calculated by the following formula:

$$R = \frac{V}{T} \times CN \times CL$$

Namely:
R is the foam discharge flow rate (m^3/min)
V is the submersion volume (m^3)
T is the submersion time (min)
CN is the compensation factor for normal foam withdrawal, 1.15 minimum.
CL is the compensation factor for foam reduction resulting from leakages around doors and windows, 1.2 minimum.

Once foam rate has been determined on the basis of the type of pourer chosen (foam generated by one pourer according to the inlet pressure), the maximum number of pourers to be installed is also determined.
The next step is to calculate hydraulically the diameters of the water + foaming agent supply network towards the pourers. Finally, it is necessary to determine the volume of the foaming concentrate which must meet the operating requirements of the system, being four times as much as the submerging volume and not less than 15 minutes of continuous operation.

Operation procedure

In case of emergency, further to an alarm coming from the fire detection system, the pumping station - which is located at about 300 m from the rooms to be protected - is activated. By this operation, water is introduced into the vertical fluid displacement premixer, which will mix the foaming liquid with water in the right dosage, that is 3% in this case.

Moreover, suitable buttons will be set up for manual activation of the system and/or for the manual stop of the system, in order to avoid false alarms coming from the detection system, which are now less likely to occur thanks to the implementation of redundant detection technologies and to the introduction of intrinsically safe system control electronics.

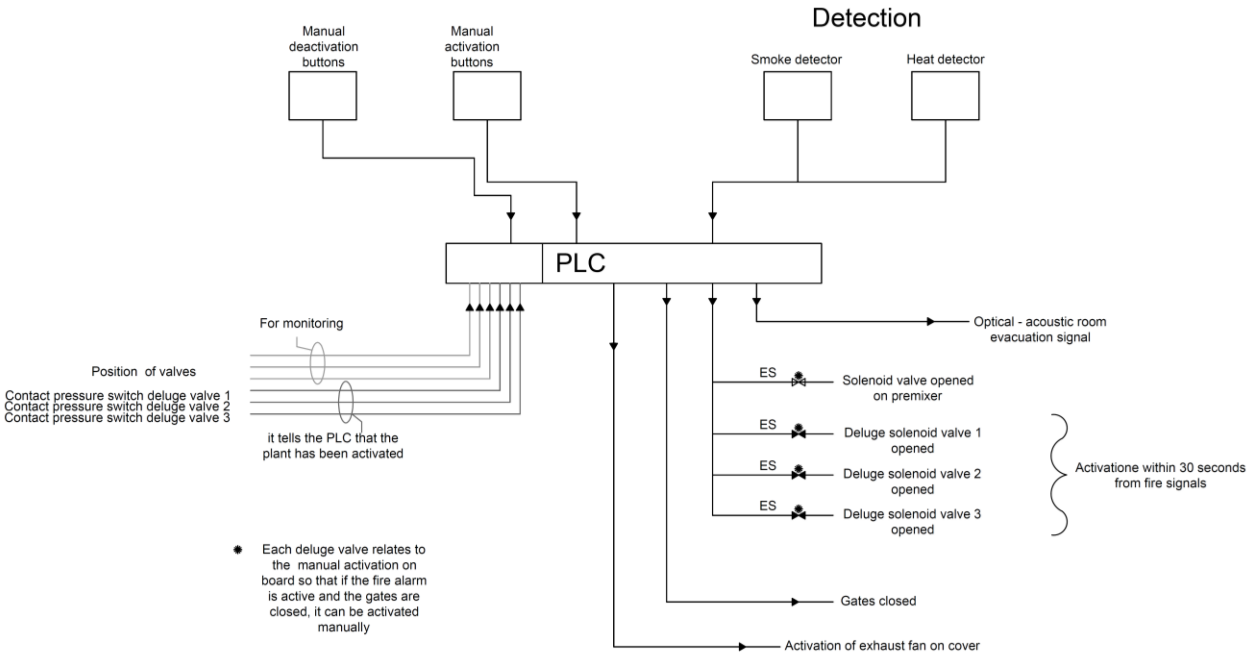
The mixture of water and foam will be sent to the hydraulic network placed at the top of the room, where foam will be generated by high-expansion generators with Venturi effect, so that it fills the room that has to be protected.

Further to an alarm signal, either manually activated or coming from the fire detection system, an optical/acoustic alarm system will be triggered, indicating that the staff must leave the premises.
The door closing procedure will start immediately after the alarm signal, while the deluge valve will be enabled after 10 seconds from the alarm, thus initiating the discharge cycle.

Automatic activation:
If fire is detected, the gates/doors shall shut and the room evacuation alarm system shall start. After 30 seconds from fire detection, consent will be given to open the deluge valves and the solenoid valve placed on the premixer.

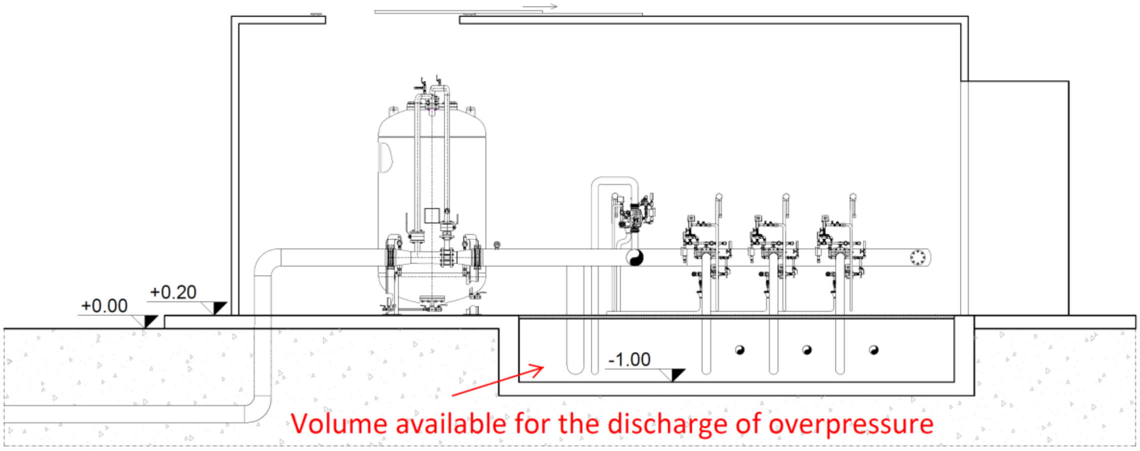
Manual activation:
Manual activation and deactivation devices must be placed on site and in an attended room.
This will allow operators to activate the system without waiting for the signal to come from the fire detection system. Once the command has been given, the system will be activated as described in the previous point.

Safety devices:
All valves and pressure switches have remote monitoring.
For the plant to be activated even in the event of electrical faults or failures, an appropriate operational procedure shall be set up: the deluge valves and the control valve which are placed on the premixer will be equipped with a manual mechanical activation system.

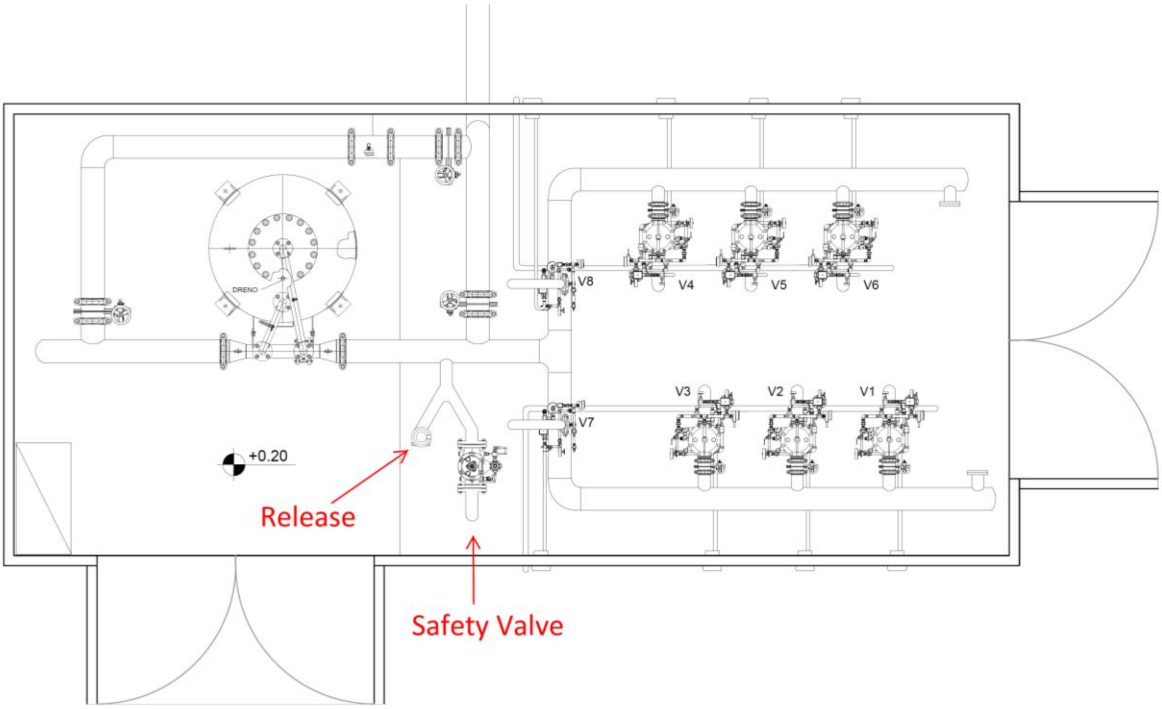


GENERAL DESCRIPTION OF THE PLANT

The sensitive parts of the plant will be placed in a suitable technical room, which must be insulated and have a fire resistance of 60 minutes: this is where the deluge valves and the premixer will also be placed.



Foam plant station system



Plant station foam system

List of the components

The plant will include the following essential components:
Membrane premixer
Deluge control valves
High expansion generators installed on the ceiling
Closure system for the side openings (gates, doors, flaps, etc.)
Optical/acoustic alarm system with room abandonment signal

Vertical Foam Bladder Tanks

High expansion foam generator

Plant activation and interference with other plants

The operation of the foam plant shall not be affected by that of other plants installed in the same building, used during the normal activity and/or in case of emergency.

Control panel

The control panel shall be able to perform and signal the activation cycle of the plant, in particular of all the active components of the same: closure of gates/doors.

Electric power system

The plant shall be provided with its own electric power system, in order to ensure that all active components are powered even in case of building power supply cut off for whatever reason.

The switches installed on the dedicated supply line will be labelled as follows:

"POWER SUPPLY FOR THE MOTOR OF..."
"DO NOT OPEN IN CASE OF FIRE"

The letters shall be white on a red background.
The power supply shall comply with UNI EN 2101-10.

Power cables

The cables to be used shall be “fire resistant”, complying with the Italian CEI 20-45 standard and with a duration of 90 minutes in case of fire.

Signal cables

The data transmission cables shall have a fire resistance determined according to the Italian CEI EN 50200 standard, for a duration of at least 30 minutes.

WATER HAMMER AND STRESSES

The term “water hammer” indicates the hydraulic phenomenon which occurs in a pipeline when a moving fluid, which is considered as incompressible, is forced to stop suddenly due to the quick closure of a valve. This determines an overpressure caused by fluid inertia, which presses against the valve. The main parameters affecting this phenomenon are the fluid speed and the geometric features of the pipes, such as their diameter and length. However, the essential parameter to take into account is the closure time of the valve.
The considered plant, which is a high expansion foam deluge system, needs to fill very big spaces in few minutes. In order to do that, it is necessary to introduce quickly large amounts of water, duly mixed with the high-pressure foaming agent (pressure needed for the optimum operation of the foam producing devices and to reach the correct coverage), thus generating considerable stresses on the pipes, which can break if not conveniently sized. If they are not correctly fastened, they generate movements which can determine the breaking of the pipes.

In the considered plant, the time needed for the valves to close completely, according to the manufacturer's estimations, amounts to 15 seconds. During this time, the pumping group has to close the delivery line in order to avoid introducing water in a closed system.

In order to solve this kind of issues, a section with two valves has been installed on the manifold of the foam mixing station: the first one is an automated safety valve, controlled by a diaphragm, with a resilient disk membrane activated by a diaphragm. When the pressure on the valve exceeds a pre-set value, the valve opens, modulating the flow rate automatically in order to generate a pressure drop, which is necessary to keep the required inlet pressure constant and, therefore, to reduce the pressure level in the plant. If the pressure level on site reaches a lower value than the pre-set one, the valve closes in a sealed state.

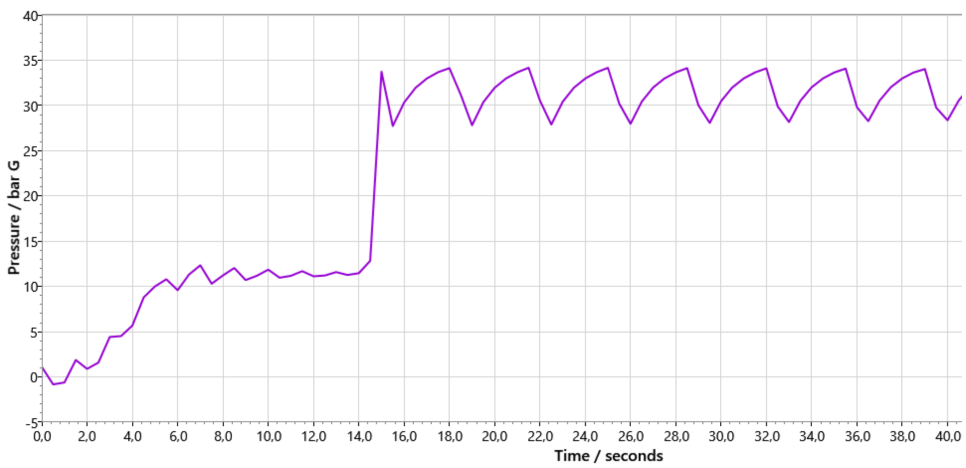
A second combined pneumatic valve (usually defined “release valve”) is arranged in parallel. It allows the air to enter the plant when internal pressure is lower than the atmospheric one, and it allows the air to be released from the pressurized pipe filled with water, thus reducing overpressure or vacuum conditions which may damage the pipelines.

DOROT 300 Series valve

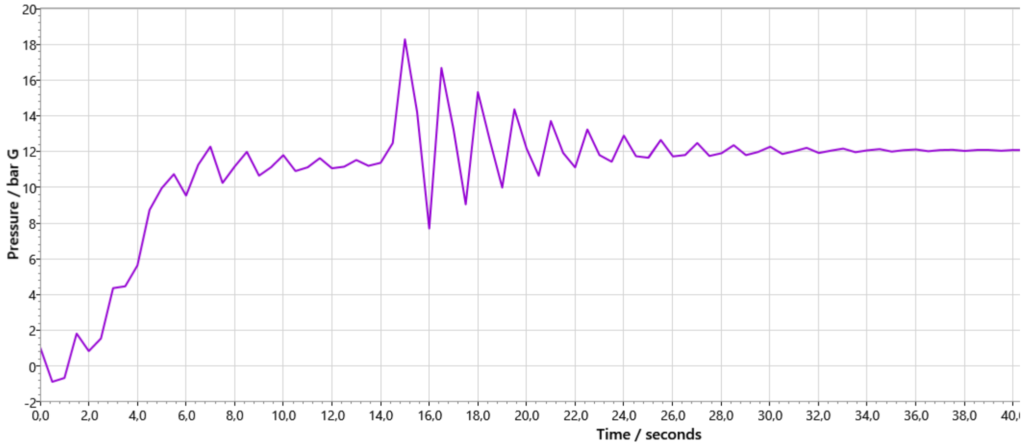
300 PS (R)

A very important factor to be taken into account when considering this plant is the dynamic stress created even during the activation phase when, at valve opening, the pressurized flow enters the empty pipes at high speed. Powerful stresses are created when the flow direction changes, similar to seismic stresses.

The following graph shows how the pressure level changes on the manifold when valves close without the provision of adequate devices to control the water hammer. It should be noted that an overpressure peak, characterised by an undulating trend which tends to damp down, is reached in connection to the valve closure at 15 seconds.



In case of a plant protected by a release and safety valve, we can observe that the overpressure peaks are considerably reduced and gradually damped down when valves close, and this happens more rapidly as compared to the previous model.



Hereunder are the images of the safety valve used to reduce the effects of the water hammer and the release valve.

Section 300 series valve

DAV-MP-1-KA

CONCLUSIONS

The installation of this foam plant will enable a safer storage of flammable liquids in the factory: this type of system features intrinsic high reliability, as it includes mainly mechanic components.
In addition, it should be noted that, since the filling time of the spaces is very low (amounting to few minutes), the storage of the water needed to produce the foam can be considerably reduced (on average to 1/4 as compared to a sprinkler system).

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