VIKING®

Technical Article

PROTECTION OF RUBBER TYRE STORAGE USING OPEN HIGH CHALLENGE NOZZLE

Dr. Joachim Böke
Nicholas D. Groos

October 30, 2006

TABLE OF CONTENTS

PROTECTION OF RUBBER TYRE STORAGE USING OPEN HIGH CHALLENGE NOZZLE

1. Risk classification and identification

Different generic types of rubber exist. The FM (Factory Mutual) Datasheet 8-1 gives as for the heat contents a range from 23.260 kJ/kg to 46.520 kJ/kg. The upper level is very similar to unexpanded "group A plastics" like Polypropylene or Polyethylene.

In addition, rubber products normally have a very smooth surface which does not absorb water. Pre-wetting with water, which is possible with non-coated products like paper or wood, is not possible with rubber products. Because of this, the effect of a water extinguishing system stopping the fire by wetting the products in the neighborhood of the fire does not occur with rubber products. In addition rubber products loose their stability in case of fire, collapse, and can create pool fires.

A very spectacular rubber tyre fire happened in September 1999 in Wesley, California, USA. 5 Million tyres stored outside burned over 35 days. Because of the high fire load of the rubber tyres a rubber tyre fire will create an incredible amount of heat, making manual fire fighting nearly impossible. (Sicherheitsberater, HDI, Hannover 2005)

As shown in the NFPA (National Fire Protection Agency) rules and FM Datasheets different types of storage require different protection concepts. The following picture (Figure 1) shows the different types of storage.

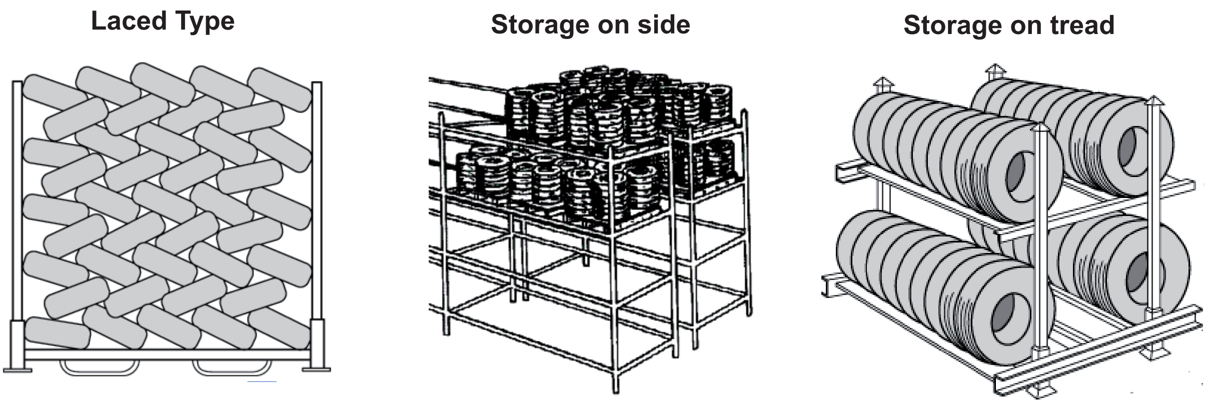


Figure 1: Types of rubber tyre storage

Whereas laced tyre storage is the most efficient form of storage with regards to space utilization, it creates particular challenges with regards to fire fighting since water has difficulty penetrating the densely arranged tyres and fighting the fire. An NFPA database includes three successful fire tests with palletized rubber tyres. The tests are carried out with a maximum stack height of about 7 m (23ft) protected with ESFR sprinklers. The water density mentioned in the database is 48 mm/min (1,2 gpm/ft²).

Another critical aspect of rubber fire is the generated smoke, which hinders manual fire fighting and causes damage in its own right.

All of these factors go to show that the protection of rubber tyres against fire requires special consideration.

2. Protection requirements

Because the height of a standard “on-tread” tyre storage box (see Figure 2Figure 2) is more than 2 m, a concept for the protection of rubber tyre storage of more than 8.5 m was needed. Fire extinguishment was an important performance criteria for the fire protection concept. Because of the size of area to be protected and the building type a high expansion foam system using outside air was not possible to install.

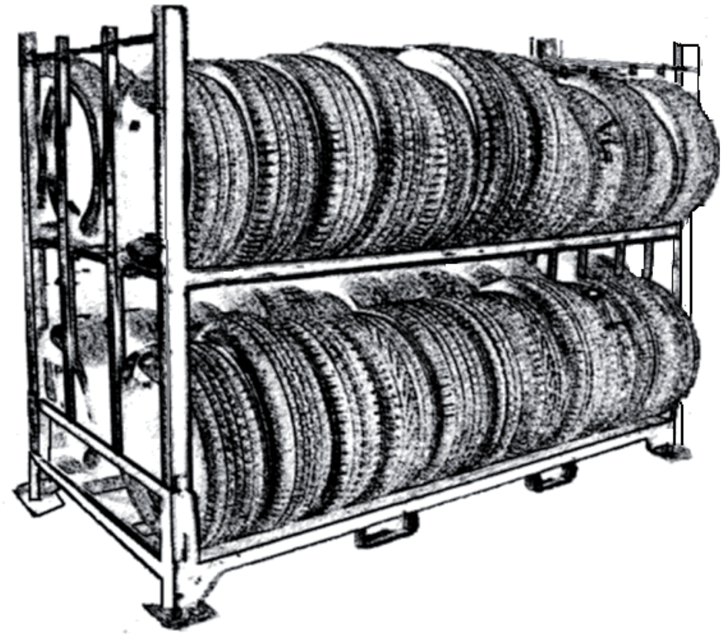


Figure 2: Storage box

For this reason an inside air high expansion foam system was tested. The high expansion foam system using inside air failed the tests because the inside air generators were not able to generate foam.

AFFF foam concentrate adheres to surfaces better than plain water. This will provide some “pre wetting” of the rubber tyres.

Effective fire fighting and extinguishment requires an early activation. The fire load requires a higher amount of water. To penetrate the fire plume, an open nozzle or sprinkler with an orifice having a bigger K factor should be used because it will create bigger droplets.

Because of these requirements, a deluge system with AFFF concentrate activated by smoke detectors is needed.

The deluge system shall be designed such that the zone protected by one deluge installation shall be not less than 100 m². All zones protected by a separate deluge installation, which are within a radius of 7 m from the most unfavourable possible location of a fire (see Figure 3Figure 3) shall be designed to discharge water simultaneously

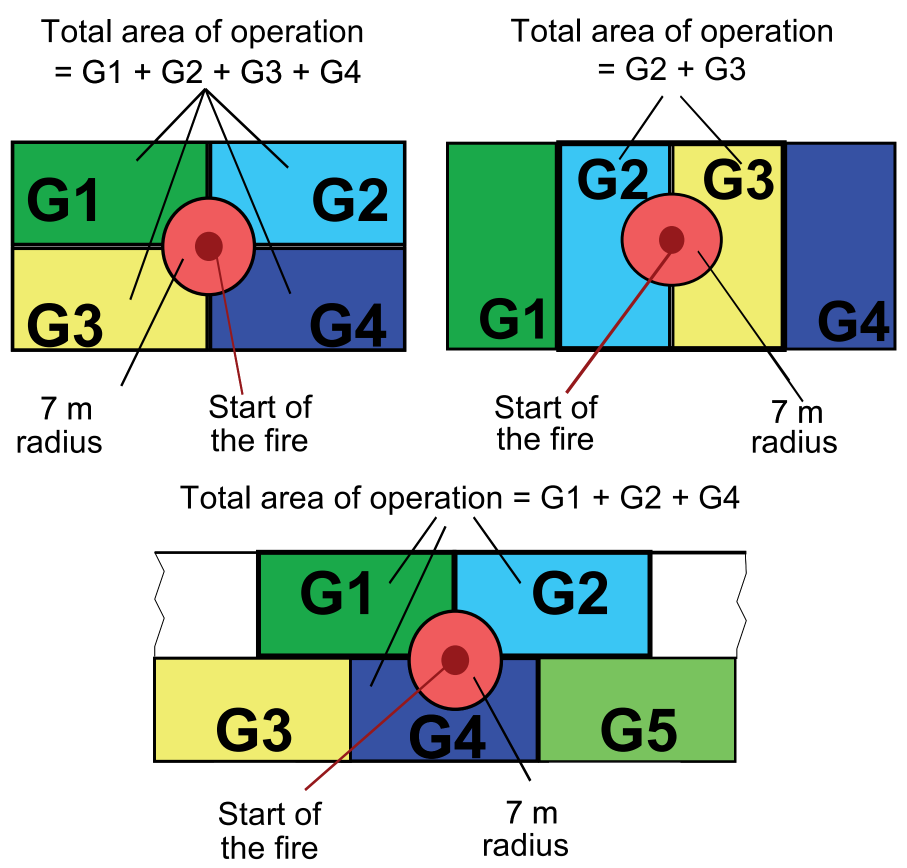


Figure 3: Area of operation

For deluge systems of this type, it is important that an alarm of the needed fire detection system is clearly linked to a section of the deluge system. Air current should be avoided so that the fire alarm system will not trigger the wrong deluge section.

3. Approval Procedure

3.1 General requirements

Based on the VdS rules (VdS Schadenverhütung, Cologne, Germany) for the approval of new extinguishing technology, the approval of the system and protection concept is based on fire tests showing the effectiveness in combating the fire. In addition, system components must also be subjected to laboratory testing in order to prove reliability in the long term. Another important part of the approval procedure is the planning and installation manual published by the manufacturer.

For the fire tests the following criteria are set up:

- The fire has to be extinguished.
- In 2 m distance from the front of the test setup the temperature has to be lower than 350 °C.
- At the outer side of the test setup there should be no damage from the fire.

Because the fire has to be extinguished and limited to the test setup, the system will also work in those cases where the surface area of the storage is larger. The detection and extinguishing system must work together such that the extinguishing system will be activated after the activation of the detection system. An additional delay is added to represent the time required to fill the system piping with the foam/water

solution, plus a minimum additional delay of 30 seconds as a safety factor.
An additional safety factor is employed at the time of system design. The density required to extinguish the fire in the successful fire tests is increased by 30%. This higher density is then applied in the installed system.

3.2 Fire tests

The fire tests were carried out and documented at the IdF "Institute for fire brigades Sachsen Anhalt" and witnessed by VdS.

The ceiling was set up at 14 m with a storage height of 8,8 m. The detection system was located at the ceiling. The fire was ignited with 1 l heptane in a 0,5 m² pan.

Two test were carried out. The following table shows the results of the two tests:

The following Figure 4 shows a part of the storage arrangement at the fire tests:

Figure 4: Storage arrangement during test

	Test 1	**Test 2**
Alarm of two detectors	32 secs.	30 secs.
Activation of deluge system	1 min. 13 secs.	1 min. 15 secs.
Fire extinguished	1 min. 51 secs.	2 mins. 45 secs.

The following picture (Figure 5) shows the fire during the pre-burn phase before the deluge system has been activated:

Figure 5: Fire in the test during pre burn phase

The water foam concentrate mixture created by the deluge system was able to cover the rubber tyre stored on tread.

Figure 6: Tyres after the fire tests

The water foam concentrate was also in the tyres.

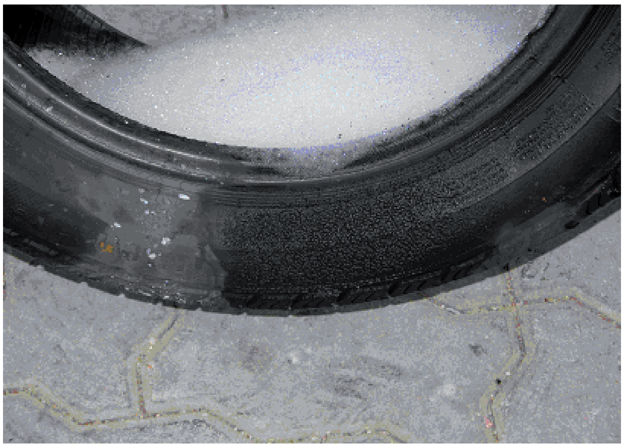


Figure 7: Water foam concentrate in a tyre after the fire test

During the tests temperatures were measured at different locations as well as the system pressure, oxygen and CO2 concentration and the system flow.

The ceiling temperature stayed below 100 °C during both tests and the temperatures measured at different heights in 2 m distance from the storage stayed below 50 °C.

The following figures (Figure 8, Figure 9) show the measured temperature at ignition level for the two tests.

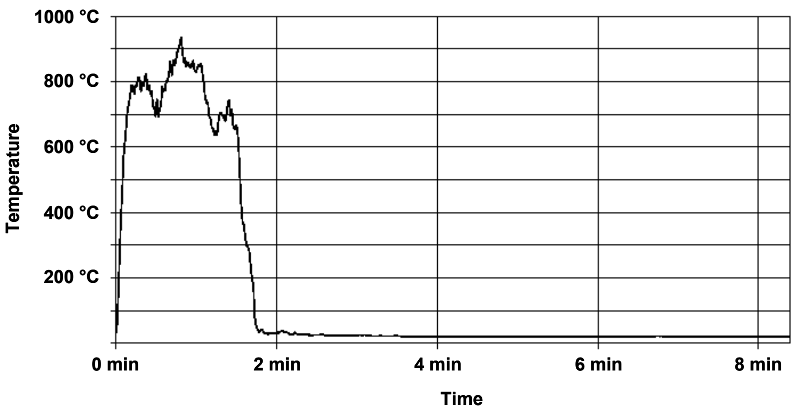


Figure 8: Temperature measured at ignition level, test 1

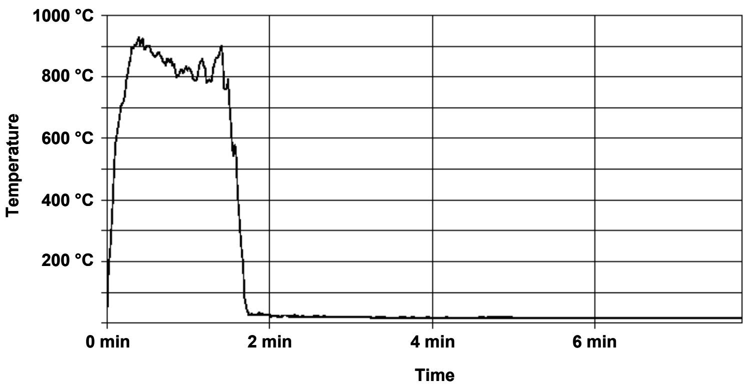


Figure 9: Temperature measured at ignition level, test 2

The conclusion of the “Institute for fire brigades Sachsen Anhalt”, IdF is that the system has shown in the tests that the fire was extinguished very early. It was pointed out that both tests turned out very similar.

The tests and the results were accepted by VdS as the basis for the approval.

4. Installation and design requirements

Each section of the deluge system is connected to a Viking deluge valve or a Viking flow control valve if remote reset is required.

4.1 Design

The design density shall be not less than 30 mm/min. Viking “High Challenge Large Drop” open nozzles must be used.

The maximum pressure at the nozzle shall not exceed 12 bar. In the case that additional nozzles are needed because of obstacles the minimum pressure at a nozzle shall be 1,7 bar even if the protected area per nozzle is in that case less than 7,4 m².

The protected area per nozzle has to be between min. 7,4 m² and max. 9,0 m² at a distance between the nozzles from max. 3,0 m and min 2,4 m.

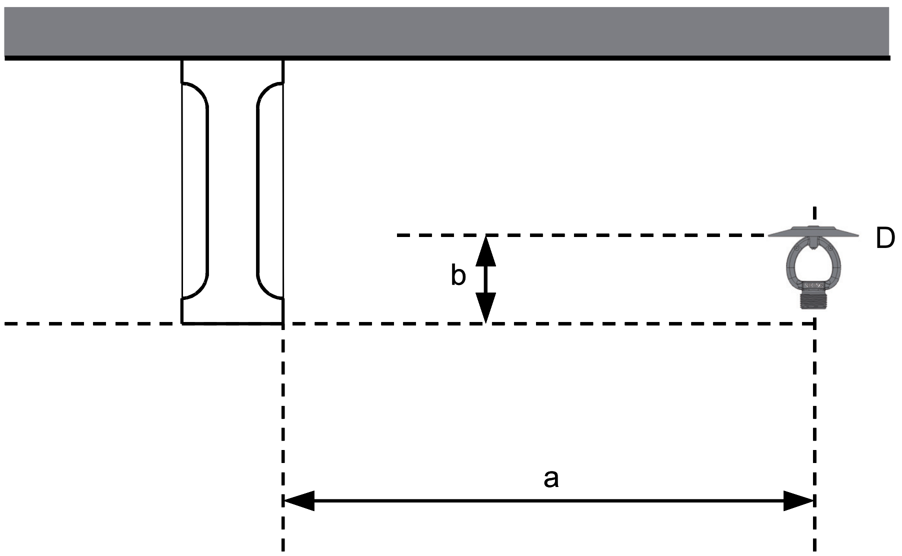
The maximum time to fill the system is 25 s.

4.2 Installation of nozzles

Concerning the installation and the positioning of the nozzles the rules specifications for “Large drop nozzles” shall be followed.

4.2.1 Obstructions Located at the Ceiling

Where nozzle deflectors are located above the bottom of an obstruction located at the ceiling, position the nozzles so that the maximum distance from the bottom of the obstruction to the deflectors (b) does not exceed the value specified in Table 1. Use Figure 10 in conjunction with Table X2 in positioning nozzle deflectors.



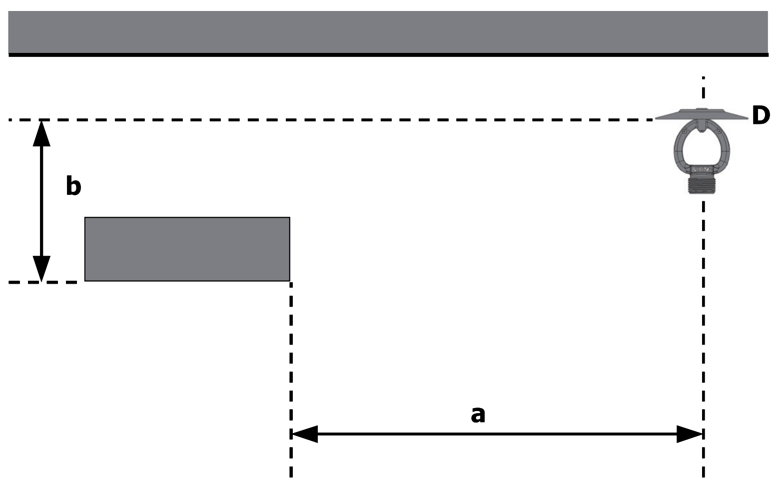
Key
D Deflector
a Distance from beam/joist
b Distance from underside of beam/joist

Figure 10: Position of deflector when located above bottom of beam or other obstruction located at the ceiling

Table 1: Position of deflector when located above bottom of beam or other obstruction located at the ceiling	
Distance from beam/joist	**Maximum Distance from underside of beam/joist**
Less than 0.3 m	0 mm
0.3 m to less than 0.5 m	38 mm
0.5 m to less than 0.6 m	76 mm
0.6 m to less than 0.8 m	140 mm
0.8 m to less than 0.9 m	203 mm
0.9 m to less than 1.1m	254 mm
1.1 m to less than 1.2 m	305 mm
1.2 m to less than 1.4 m	381 mm
1.4 m to less than 1.5 m	457 mm
1.5 m to less than 1.7 m	559 mm
1.7 m to less than 1.8 m	660 mm
1.8 m	787 mm

4.2.2 Obstructions Located Below the Nozzles

Position nozzles with respect to obstacles like e.g. fluorescent lighting fixtures, ducts, located entyrely below the nozzles so that the minimum horizontal distance from the near side of the obstruction to the center of the nozzle is not less than the value specified in Table 1, as illustrated in Figure 11.

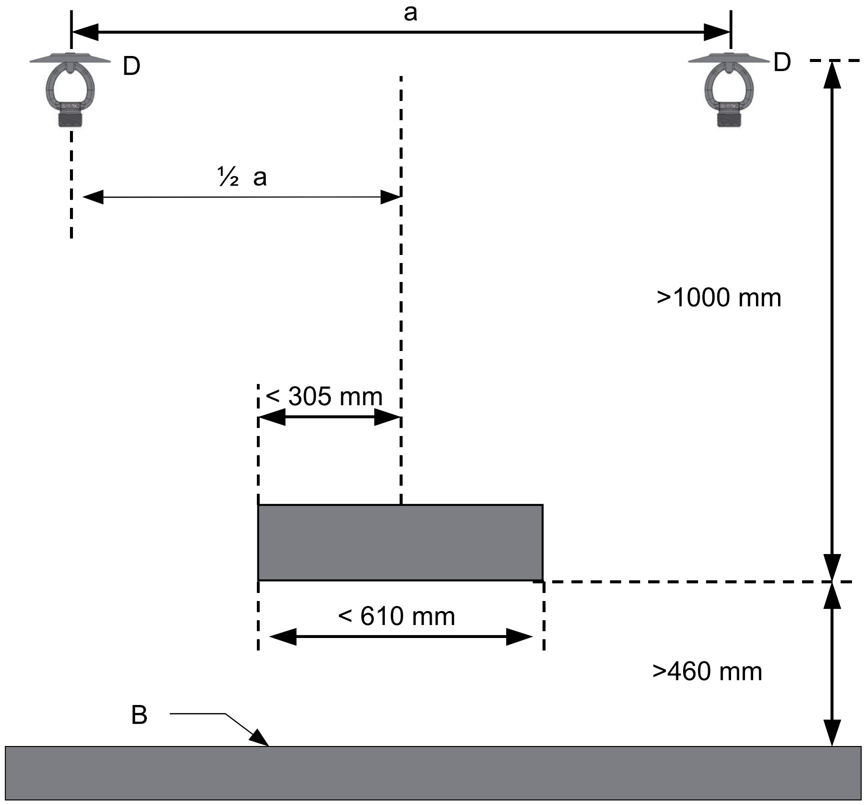


Key
D Deflector
a Distance Deflector Above Bottom of Obstruction
b Distance to Side of Obstruction

Figure 11: Position of nozzle in relation to obstructions located entyrely below the nozzle

Table 2: Position of Nozzles in Relation to Obstructions Located Entyrely Below the Nozzles	
Distance Deflector Above Bottom of Obstruction	**Minimum Distance to Side of Obstruction**
Less than 152 mm	0.5 m
152 mm to less than 305 mm	0.9 m
305 mm to less than 457 mm	1.2 m
457 mm to less than 610 mm	1.5 m
610 mm to less than 762 mm	1.7 m
762 mm to less than 914 mm	1.8 m

When the bottom of the obstruction is located 1000 mm or more below the nozzle deflectors, position the nozzles so the obstruction is centered between adjacent nozzles, as shown in Figure 12. Limit the obstruction to a maximum width of 610 mm. The extension to either side of the midpoint between nozzles may not exceed 305 mm. Maintain at least an 460 mm clearance between the top of storage and the bottom of the obstruction. Install one or more lines of nozzles below obstructions with a width greater than 610 mm, or which otherwise do not meet the maximum 305 mm extension requirements of this paragraph.



Key
D Deflector
a Distance between sprinklers
B Top of the storage

Figure 12: Position of nozzles in relation to obstructions located 1000 mm or more below detectors

4.2.3 Obstructions Parallel to and Directly Below Branch Lines

In the special case of an obstruction running parallel to and directly below a branch line, locate the nozzle at least 1000 mm above the top of the obstruction, as illustrated in Figure 13Figure 13. Limit the obstruction to a maximum width of 305 mm and a maximum extension of 152 mm to either side of the centerline of the branch line.

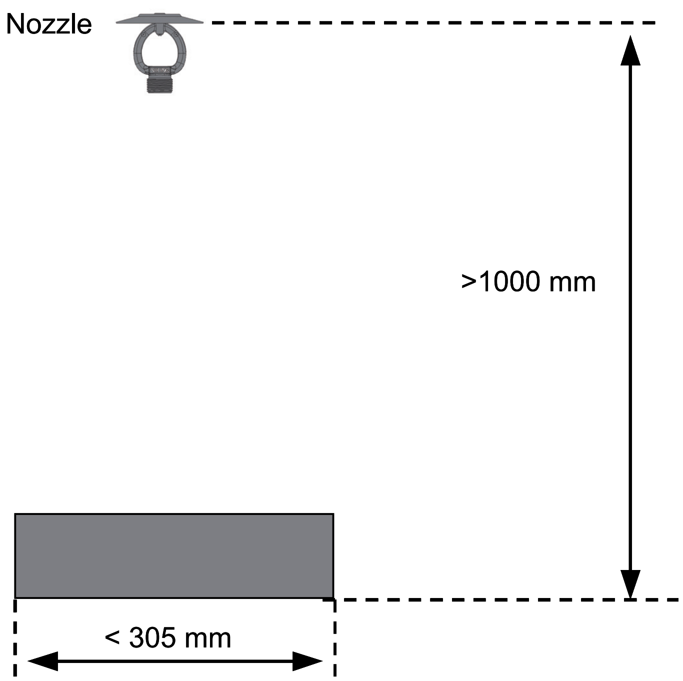


Figure 13: Position of nozzles in relation to obstructions running parallel to and directly below branch lines

Limit the nominal diameter of branch line (including riser nipples) to not less than 32 mm nor greater than 50 mm, except starter pieces, which may be 64 mm.

Branch lines 64 mm, 75 mm and 100 mm are acceptable when riser the deflectors have above the centerline of the pipe a distance of

330 mm for 64 mm pipe,

380 mm for 76 mm pipe,

460 mm for 100 mm pipe.

4.3 Detection system

It is normally required that 2 detectors shall be activated before the extinguishing system will be activated. To avoid false activation of the deluge system 3 detectors should be activated before the deluge system will be activated. Minimum two detectors, which are crossing, are needed to identify the correct section. The beam detectors should be located such that the crossing of two detectors is clearly inside one deluge section.

In accordance with the fire tests the detector type SF-SP/100-100, manufacturer Ardea, shall be used. The design manual of the manufacturer shall be taken into account. The distance between two detectors should not exceed 7 m.

Remark:

The setting considering the background should be 300 for fire and 500 for smoke.

After activation of the complete area of operation the other valves should be blocked.

5 Conclusion

A system is developed and successfully tested which is able to extinguish fires when rubber tyres are stacked “on tread” with a maximum stack height of 8.8 m. The building height is limited to 14 m.

Because of the huge fire load and the burning characteristic of rubber tyres this system provides a high level of protection because it is specifically designed and approved to rapidly extinguish the fire.

As a result, the first VdS approved installations have already been installed at the time of writing of this document.

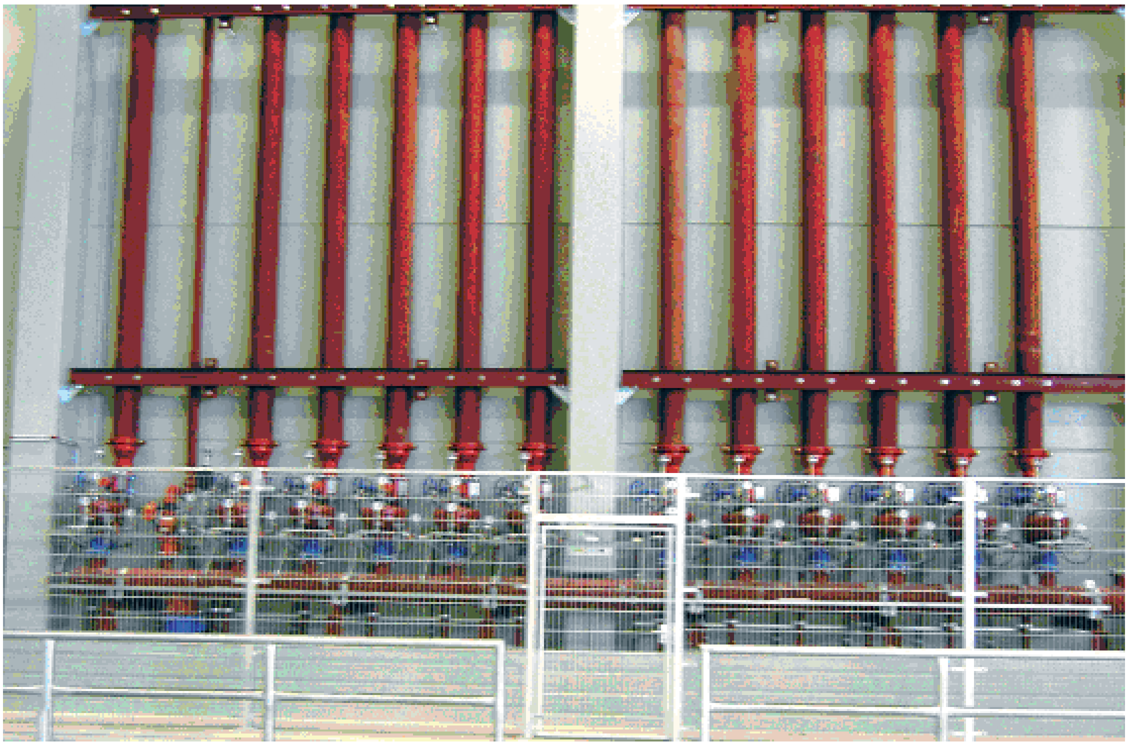


Figure 14: Part of an installation for rubber tyre protection

Literature:

NFPA13 Standard for the Installation of Sprinkler Systems
FM 2-7 Installation rules for sprinkler systems using control mode special application ceiling sprinklers for storage applications.
FM 8-3 Rubber Tyre Storage

---END OF THE DOCUMENT---