Fire Protection Leaflet

Interaction of Water Extinguishing Systems and Smoke and Heat Exhaust Ventilation Systems (SHEVS)

0 General

Regulations and recommendations missing from this leaflet do not entitle the operator to determine any provisions without prior consent by VdS.

The interactions described in the present leaflet apply to those systems only, which comply with the applicable VdS guidelines as amended.

1 Objective of fire protection engineering

Fire protection serves the purposes of life safety, protection of property, and environmental protection. Defining protection objectives is absolutely necessary to come up to this comprehensive idea of fire protection.

Fire protection systems, such as water extinguishing systems and SHEVS, work differently and, therefore, contribute at different points to achieving the protection objectives.

Water extinguishing systems use water as extinguishing agent to limit fire spread through cooling and surface wetting of the burning material and to extinguish the fire. This way they assist the firefighting actions taken by the fire brigade.

By contrast SHEVS act differently: They draw off smoke when the fire starts. When the fire develops and when it becomes a full fire, the heat exhaust can be used to temporarily relieve the components from the thermal burden. Furthermore, a SHEVS creates and maintains a low-smoke layer so as to enable the rescue of persons and allow the fire brigade to fight the fire more quickly and in a more targeted manner.

Generally, a combination of water extinguishing systems and SHEVS would be advantageous. However, a variety of influencing factors sets boundaries for such a combination.

2 Mechanisms of action, fields and limits of applications

2.1 Mechanisms of action of water extinguishing systems

The extinguishing effect of a water extinguishing system is the consequence of cooling down the seat of fire through withdrawal of heat, i.e. through the heat absorption capacity of the water. Partly, the evaporation of water can lead to local inerting of the actual fire zone.

Since heating and evaporation of water starts on the surface of the drop, a larger surface leads to faster heating and evaporation. Therefore, smaller drops have more effect than a water jet. Please take into account that large drops more easily penetrate rising fire gases and, therefore, reach the seat of fire more easily.

Wetting of adjacent areas by spraying small water drops beyond the seat of fire limits fire spread.

The sprinkler system is an extinguishing system that acts selectively and the nozzles of which are activated by tripping elements (glass bulbs or fusible links) tripped by the content of convection heat of smoke and fire gases.

Other than the selectively acting sprinkler system, the water spray system works with simultaneous supply of water to a group / section of nozzles. Any detectable fire characteristic can be used to trigger the fire extinguishing system.

Any of the aforementioned water extinguishing systems contributes to limiting fire spread, to reducing the released heat by cooling the surroundings of a seat of fire, and to reducing the formation of hazardous fire gases and hazardous substances, as well as to shielding the radiated heat by direct fire fighting – all this in combination with an immediate activation of the system for protection of life and property. Moreover, such a water extinguishing system normally releases an alarm automatically. This way it facilitates self-rescue and considerably reduces the response times of the fire service.

2.2 Fields and limits of applications of water extinguishing systems

Stationary water extinguishing systems are able to extinguish and/or control fires as required by the protection objective.

Since tripping of sprinkler systems depends on the temperature, the rise in temperature on the sprinkler itself shall be large enough. Normally, this is generated by the thermal uplift of smoke gases (plume). Thus, fires showing heavy smoke development and little heat development are adverse to an early activation. An extinguishing success is based on the condition that the water sprayed by the tripped sprinklers actually reaches the seat of fire.

The use of sprinkler systems in very high rooms provided with nothing else than ceiling protection is subject to reservation. In high rack storages additional in-rack sprinklers provide for protection.

ESFR sprinklers (Early Suppression Fast Response) use higher pressures and an increased design density compared to conventional sprinklers. By earliest activation the water shall reach the seat of fire at an early stage of development and suppress the fire.

Water spray systems can be used in high rooms, in areas of rapid fire spread, as well as in bulk stores.

Fine water spray systems generate small water drops thus improving the heat absorption. Local inerting of the seat of fire by evaporating water drops could be an additional effect. Pay attention to the fact that such systems with very small drops can become ineffective or be of a limited extinguishing effect only, should the air flow rate be higher.

2.3 Mechanisms of action of SHEVS

SHEVS remove the combustion products smoke and heat and thus create a low-smoke layer in the protection zone. Natural smoke exhaust is based on the thermal uplift of smoke gas (plume) arising as a result of the lower density of hot smoke gases compared to the colder ambient air. The heat development of the fire causes the smoke gas to rise towards the ceiling of the fire room. Both, the flow of smoke gas through the smoke and heat exhaust device and the air flow through the air inlet opening, are caused by the difference between the pressure in the fire room and the ambient air.

Powered smoke exhaust ventilation systems serve the same purpose as the natural smoke exhaust. However, here the smoke-free layer is not due to thermals only, but to the ventilating fans, which extract the smoke gases. Powered SHEVS shall be activated immediately upon the outbreak of fire, either by smoke detectors[1] or by staff members being permanently present and correspondingly instructed. The advantages of powered smoke exhaust ventilation systems are that they provide full volume within short and are effective with cold smoke, too. A disadvantage is that the mass flow transported by the fans is less with an increasing temperature of the smoke gases. Thus, efficiency of powered smoke exhausts at high temperature is less than that of a natural smoke exhaust.

Differential pressure systems keep the rooms, which are correspondingly specified in the fire protection concept (e.g. staircases, antechambers, corridors, escape tunnels), free from smoke by generating an overpressure, e.g. using fans.

Impulse ventilation systems are used to remove smoke from underground car parks or to ventilate them. Here, so-called jets are installed under the ceiling to thrust in an emergency against the fire smoke to guide it into a particular zone of the car park where appropriate fans exhaust it. Normally, activation is effected via the FDAS.

1 In addition to smoke detectors, multi sensor detectors can be used; those do not only respond to smoke, but also to other characteristics, such as heat, provided that their response behaviour is not disadvantageous compared to that of the detectors that respond only to smoke.

2.4 Fields and limits of applications of SHEVS

SHEVS are designed to transport the smoke developing in the case of fire and the released heat from the inside of the building outwards. In the beginning of the fire development, the exhaust of smoke is of utmost importance. With development of the fire or when it has become a full fire already, heat shall be exhausted, as well, to reduce the temperature effect on load-bearing structures.

Natural SHEVS are used in single-storey buildings as well as in rooms of multi-storey buildings where the ceiling is the roof. As an alternative, the smoke can be exhausted through the side panels, too. Here, a control system featuring an integrated wind detection unit shall ensure that in the case of fire only the ventilation openings on the downwind side are opened (see the planning instructions acc. to VdS leaflet 3530).

Generally, natural SHEVS can be triggered pneumatically, or electrically, or by combination of both. Pneumatic systems are normally triggered by thermal release elements (glass bulbs), whereas electrically controlled systems can be activated by smoke detectors, or heat detectors, or a combination of both. With the use of smoke detectors we do recommend activation by coincidence detection.

Take into account that with an increasing room height and size of smoke compartments the temperature of smoke gas decreases as it mixes with ambient air.

Powered SHEVS perform up to the limit even with moderately hot smoke. They are well suited in cases where the ceiling of the corresponding room is not the roof of the building (multi-storey buildings, rooms below ground level).

Early activation of powered smoke exhausts is ensured by an FDAS. With the use of smoke detectors we do recommend activation by coincidence detection.

To become operable, differential pressure systems shall be installed in zones without any fire load. Normally, those are not protected by extinguishing systems. This is the reason why the present leaflet does not deal with differential pressure systems.

Engineering of impulse ventilation system requires special attention to the flow conditions in the area of application. Furthermore, we should put on the record that the area behind the seat of fire seen in the direction of impulse will be completely filled with smoke shortly upon activation. Organisational measures shall be taken to guarantee that nobody stays in this zone.

3 Assessment of systems as to the protection objectives

The tables below show the positive contribution of a water extinguishing system and/or a SHEVS to achieve a particular protection objective. This contemplation is based on a reasonable use of the systems, i.e. taking the fields and limits of applications mentioned in Clause 2 into consideration.

Protection of property

	Water extinguishing systems	**SHEVS**
Damage due to fire heat	Limitation of fire spread and reduction in released heat by direct fire fighting by means of immediate system actuation Cooling of surroundings of the fire seat	Dissipation of convection heat and limitation to the smoke compartment
Damage by smoke	Reduction of formation of fire gases and hazardous substances by means of fire fighting	Exhaustion of fire gases and limitation of smoke spread by means of smoke compartments

Life safety

	Water extinguishing systems	SHEVS
Damage due to fire heat	Reduction of heat released by fire, slowing of the rate of fire spread in the room	Dissipation of convection heat and limitation to the smoke compartment
Assurance of escape and rescue routes	Limitation of fire and fire spread Reduction in formation of hazardous substances by means of fire fighting	Creation of low-smoke layer to facilitate self-rescue
Combustion residues	Reduction in formation of hazardous substances by means of fire fighting	Indirect contribution by supporting the actions taken by the fire brigade
Fire fighting	Direct fire fighting by early release of the system; limitation of fire and support of the actions taken by the fire brigade	Low-smoke layer supports the actions taken by the fire brigade
Release of hazardous substances	Reduction of fire gases hazardous to life by means of fire fighting	Exhaustion of fire gases hazardous to life and creation of low-smoke layer

4 Combination of system types

4.1 Basic factors

For any combination of different systems consider mutual effects. A possible effect mainly depends on the method of system actuation.

The release of sprinkler systems is caused by temperature. In addition to the release temperature, the response sensitivity of the sprinkler (RTI value) is decisive. Water spray systems are released by detection of several fire characteristics (smoke, heat, radiation).

The release sequence results from the combination of different release options of the smoke and heat exhaust (smoke detector, thermal element, manual triggering). Therefore, different protection objectives are achieved.

If the smoke exhaust is to be activated early, the SHEVS can be activated before the extinguishing system, e.g. by means of smoke detectors.

To prevent an aisle effect, i.e. deviation of hot fire gases away from the sprinkler nozzles located above the seat of fire, the applicable guidelines shall be complied with.

If protection of property gets top priority, the SHEVS ought to be triggered only selectively as a single unit when being activated by a smoke detector combined with a sprinkler system. In this case an automatic group-triggering of the SHEVS is not recommendable.

An almost simultaneous activation of both systems is possible, e.g. for the combination of a water spray system and a powered SHEVS and/or a SHEVS with smoke detectors, if realised by triggering of the powered SHEVS through the water spray valve station or by coupled triggering with smoke detectors, respectively.

The moment of activation after manual triggering is not defined. Only authorised persons shall manually trigger fine water spray systems and ESFR systems.

With powered SHEVS triggered by an FDAS, the aisle effect shall be avoided as well.

With powered SHEVS the hot fire gases are drawn off the fire room through fans and ducts. The resulting air velocity is higher than with natural smoke exhaust. Such air flows may adversely affect the extinguishing effect of an extinguishing system. If a powered SHEVS is installed, this ought to be activated manually by the fire service. If a powered smoke exhaust is required, activation ought to be connected to triggering of the sprinkler system. If triggering takes place via a CIE, it ought to be pointed out that this can impair proper functioning. If this is part of the overall concept, VdS takes for granted that the fire protection concept allows for the changes in the release behaviour.

To ensure that the sprinkler is always within a layer of hot smoke gases, smoke curtains for compartmentation are required where the smoke compartment exceeds a size of 2,000 sqm.

The air velocity resulting from a differential pressure system and sprinklers is not high. Therefore, this combination is considered to be uncritical.

The jets of impulse ventilation systems generate air flows of partly high velocities which could adversely affect the spray patterns of corresponding sprinklers or could trigger too many sprinklers around the seat of fire. This shall be taken into consideration for engineering of an impulse ventilation system. Furthermore, it is highly probable that around the suction unit sprinklers beyond the fire zone will operate, which could adversely affect the effectiveness of the sprinkler system. In addition, the geometry of the building and the installations in ceilings affect the air flow. So far VdS has not attended any fire tests under such conditions and, consequently, cannot make any concrete statement in this regard. Therefore, VdS recommends manual release of the impulse ventilation system by the fire service. From the point of view of VdS, an impulse ventilation system is no adequate substitute for an extinguishing system or any structural separation.

With ESFR, an adverse effect on the system by the smoke exhaust cannot be excluded. Therefore, a combination does not make sense either. Automatic release of the smoke exhaust in combination with ESFR sprinklers is not allowed. Powered smoke exhausts should always be activated manually by the fire brigade.

A combination of a fine water spray system with a SHEVS is critical. The proof of effectiveness of VdS-approved fine water spray systems has not covered any fire tests in combination with SHEVS, so far.

This combination involves the risk that the air flow leads to deviation of small drops and, this way, considerably reduces the system's effectiveness. This combination is possible if the SHEVS is triggered manually. On the basis of a corresponding proof of effectiveness (e.g. fire tests), exceptions are possible in particular cases.

4.2 Effects of water extinguishing systems on the effectiveness of SHEVS

Upon activation of a water extinguishing system, the following water distribution causes certain damping of the up-flow of hot gases around the seat of fire. The degree of cooling of the fire gases, particularly near the ceiling, is decisive for a thermal triggering of SHEVS and for natural exhaust of fire gases.

The degree of cooling of the fire gases depends on the corresponding spray patterns of the sprinklers or nozzles used. Among other things the size and the velocity of drops falling through the rising hot fire gases determine the spray pattern. Air friction and the thermal uplift of fire gases counteract the falling of drops. The size of drops, the operating pressure, and the geometry of nozzles damp the initial motion. As the drop is subject to heating and vaporisation, its mass and volume are changing continuously.

Using nozzles of downward spray pattern and conventional drop size leads to less cooling of the fire gases above the nozzles. Here, a heat flow of sufficient intensity reaches the ceiling area to cause early thermal release of the smoke and heat exhaust device and maintain convection of the fire gases through the SHEVS.

Fine water spray systems work with small drops emerging at high velocity and being of little mass which then are subject to quick slowing down. The resulting water mist causes considerable cooling of the fire gases close to the ceiling and thus prevents thermal triggering of the smoke and heat exhaust device. Cooling of the smoke gases reduces the volume, which again may have a positive effect on the effectiveness of the powered SHEVS.

The table below lists possible combinations for standard cases in consideration of the above.

4.3 Table of possible combinations

	Sprinklers	ESFR	Water spray	Fine water spray
Powered SHEVS FDAS	Combination possible[2]	Combination not permitted	Combination possible[2,3]	Prove effectiveness by fire tests
Powered SHEVS Manual activation	Combination possible[2]	Combination possible[2] Activation by fire brigade only[4]	Combination possible[2]	Combination possible[2] Activation by fire brigade only[4]
Natural SHEVS Detection via smoke detectors	Combination possible[1,2]	Combination not permitted	Combination possible[2,3]	Prove effectiveness by fire tests
Natural SHEVS Activation via thermal elements	Combination possible[2]	Combination not permitted	Combination possible[2]	Prove effectiveness by fire tests
Natural SHEVS Manual activation	Combination possible	Combination possible[2] Activation by fire brigade only[4]	Combination possible[2]	Combination possible[2] Activation by fire brigade only[4]

1 take into account when arranging sprinklers, e.g. by reducing distance to ceiling to max. 15 cm

2 take into account the air flow

3 smoke exhaust and extinguishing zone shall be identical, activation of powered/natural SHEVS via water spray alarm valve station, detailed case-by-case analysis necessary, if the overall area of operation of the extinguishing system comprises several group areas of operation, or if there are several extinguishing systems in one zone, e.g. sprinkler and water spray system

4 e.g. by key switch

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