

Preventing Warehouse Total Loss Caused By Excessive Ventilation

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Abstract

This paper will discuss seven major warehouse fires where excessive ventilation contributed to a total or near-total loss by causing the fire to accelerate rapidly. In all cases the sprinkler system had controlled or suppressed the fire prior to ventilation. It will cover techniques to accomplish the objectives of ventilation without risking rapid fire growth. Two case studies of successful ventilation are also discussed.

The National Fire Protection Association (NFPA) and FM Global design basis for warehouse sprinkler systems is that automatic smoke and heat vents are not used. Instead, it is intended that the fire service will ventilate using building systems, natural ventilation, or forced ventilation using fire service fans; after the sprinkler system has controlled or suppressed the fire. The aforementioned seven losses indicate a disconnect between design expectations and ventilation practices.

Smoke obviously has to be removed at some point and that point depends on several factors. Because of the high degree of success of warehouse sprinkler systems with resulting minimal loss, ventilation is obviously performed correctly most of the time. When it isn't, the results have been catastrophic. The frequency of the problem is similar to the problem of prematurely shutting off sprinkler systems. Premature sprinkler shutdown is a problem that has existed since sprinklers were first introduced.

This paper will discuss how these issues have been successfully addressed and will make recommendations to increase awareness.

Keywords: warehouse, sprinkler, ventilation, fire service, smoke

Introduction

That fire sprinklers offer an extremely high degree of reliable fire protection for warehouses is well known. Historically, the number one

cause of sprinkler system failure has been shut sprinkler valves. Well-managed facilities with sprinkler impairment programs have significantly reduced this failure mode. A relatively new issue has emerged; that of a fire that has been controlled or suppressed by the sprinkler system and then control is lost due to excessive automatic or manual ventilation.

Although the potential for excessive ventilation has always existed, the following factors seem to work in combination to increase the likelihood of this happening in the future:

- 1) Warehouses are more frequently located in areas with fewer fire suppression resources. If ventilation causes the fire to accelerate, the ability to regain control is diminished.
- 2) Early Suppression Fast Response (ESFR) sprinklers are now the norm. Because the design is typically for twelve operating sprinklers, there is less tolerance for opening additional sprinklers. Conversely, there is less need for ventilation for visibility because the suppressed fire generates less smoke than one that is controlled to a steady state with control mode sprinklers.
- 3) The fire service now has significantly more powerful fans available to them. Advanced mutual aid networks mean that ultra-powerful truck mounted fans are likely to be on the scene. Practical experience with them remains limited.
- 4) Warehouses are much larger than they were in the past. Fire service operational experience with them is limited.

Ventilation in non-sprinklered warehouses is not considered in this paper. The paper further assumes that assumes evacuation has already taken place before the fire service is ready to begin operations.

Design Basis for Sprinklered Warehouses

The NFPA and FM Global design basis for warehouse sprinkler systems is that automatic smoke and heat vents are not used. NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2016 edition [1] states (paraphrased):

- 12.1.1.1 manual vents and automatic vents with link temperatures greater than sprinkler link temperature are allowed,
- A12.1.1.1 the design based on vents not being used,
- 12.1.1.2 automatic vents are allowed with ESFR only if links have a temperature rating greater than the sprinklers and are also standard response.

FM Global Data Sheet 2-0, *Installation Guideline for Automatic Sprinklers*, January 2014 edition [2] 2.1.1.7.1 states “do not install automatic smoke and heat vents in facilities equipped with sprinkler protection; manual heat and smoke vents; however, are acceptable”. Where a local code requires them, Data Sheet 2-0 give three options that help ensure that vents will not interfere with prompt sprinkler activation.

The *International Fire Code*, 2015 edition [3], does not require smoke and heat removal when ESFR sprinklers and some other types of sprinklers are provided. Mechanical smoke exhaust systems are required to be manually operated only.

The design basis; therefore, anticipates manual ventilation by the fire service. Very little guidance on how the fire service is to accomplish this task is given. NFPA 13E, *Recommended Practice for Fire Department Operations in Properties Protected by Sprinkler and Standpipe Systems*, 2015 edition [4], provides some guidance for tire warehouse fires in Annex B. This guidance is generally applicable to all commodities. The document is not widely used by the fire service. The fire service is left to use its general experience to decide when and how to remove the smoke.

From Sprinkler Control to Total Loss

Although the fire service has been generally successful in smoke removal, there have been total losses or otherwise major losses where excessive ventilation was a major contributing factor. Sometimes the excessive ventilation was combined with shutting off the sprinklers either to improve visibility or because sprinkler operation was deemed no longer necessary. Table 1 outlines examples of this.

Only one case involved an automatic mechanical smoke exhaust system as required by local code. ESFR sprinklers were present and in service. In the remaining cases, the fire service determined the method to manually ventilate the building. The breakdown is as follows:

- two cases involved a high capacity mobile ventilation unit,
- two cases involved removing a large portion of the building wall with the assistance of non-fire service equipment,
- two cases involved opening multiple large doors. In one of these cases, building comfort fans were also in operation,
- in two and possibly three of these cases, the sprinklers were also turned off,
- when the sprinklers were turned off, in one case they were turned off to improve visibility. In one and possibly two cases, it was thought that the sprinklers were no longer needed.

This paper recognizes that at some point the sprinklers do have to be turned off and at some point the smoke must be removed.

Table 1. Major losses from excessive ventilation.

Incident	Nature of Excess Ventilation	Estimated Ventilation Contribution	Comments
Plastics Warehouse	Large wall opening by fire service	50%	Sprinklers shut down around the same time
Tire Warehouse	Wall removed by fire service	75%	Sprinklers had very marginal control
Retail Warehouse	All truck doors open	50%	Sprinklers turned off and the fire service left the scene
Home Goods Warehouse	Mobile Ventilation Unit	100%	
Food & Beverage Supply Warehouse	Mobile Ventilation Unit	100%	
Food & Beverage In-process Supplies	Rail doors and building ventilation fans by fire service	100%	Sprinklers possibly turned off when ventilation commenced
Electronics Warehouse	Automatic smoke removal system	100%	ESFR in service the entire time

Note: that the estimated contribution is solely the author's opinion based on his knowledge of these incidents.

Characteristics of Successful Smoke Removal

Two successful cases were also reviewed. In the first case, a fire occurred in a picking module in a large automotive parts distribution center. Three control mode ceiling sprinklers and one in-rack control mode sprinkler successfully controlled the fire. Final extinguishment was made with a single 45 mm hose line. Smoke conditions are best described as hazy with approximately 30 - 40 meters visibility.

Smoke was removed with two 34,000 m³/hr fire service positive pressure ventilation fans. It took approximately 20 minutes to clear the smoke. Fusible-link operated heat vents were provided but did not operate; presumably due to sprinkler control before they could operate.

The second case was a fire at a retail distribution warehouse. Control mode sprinklers successfully operated. Smoke conditions were reported as heavy. Successful ventilation was achieved as follows:

- controlled cross ventilation through facility doors,
- sprinklers were left in service,
- thermal imaging cameras were used to monitor fire growth,
- the fire service stayed on the scene for several hours to guard against flare-ups.

Conclusions and Recommendations

Ventilation needs to be done at some point. Eventually, the smoke has to be removed.

The above two incidents are those that the author is familiar with. These types of successes are the norm because the major loss fires previously described are not the typical outcome. The following lessons and observations can be applied to warehouse fires where the sprinklers have worked as intended:

1. Ventilation should be slow and methodical rather than rapidly creating every possible opening and operating every possible fan.
2. Sprinklers should be flowing and given time to work. When they are shut off, someone with a radio should be stationed at the valve and be prepared to reopen it immediately. This also implies that the valve should be in a safe location.
3. Charged and staffed hose lines should be ready to deal with any redevelopment of the fire.
4. The fire should be monitored with thermal imaging cameras.
5. Aerial reconnaissance via drone or an elevated platform should be done.
6. Irreversible operations, such as removing a wall section are undesirable.
7. The incident commander should be prepared to halt ventilation until control is regained.

By implementing these characteristics of success, the major losses outlined in this paper are less likely to occur.

The NFPA and or the SFPE should also seek to increase their outreach to the public fire service. Ways to do this could include:

1. Increased fire behaviour training for large buildings. This can build on the relatively successful residential fire behaviour training that has been and is currently being conducted by Underwriters Laboratories and NIST (National Institute of Standards and Technology).
2. Increased awareness of NFPA 13E and improve Annex B to include more building types.

With adequate understanding of ventilation influenced fire behaviour, these major losses can be avoided in the future.

References

- [1] NFPA 13, Standard for the Installation of Sprinkler Systems, 2016 edition, *National Fire Protection Association*, Quincy, MA, 2015
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- [4] NFPA 13E, *Recommended Practice for Fire Department Operations in Properties Protected by Sprinkler and Standpipe Systems*, 2015 edition, National Fire Protection Association, Quincy, MA, 2015