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NISTIR 6196-1: CEILING TEMPERATURE DATA TEST P-1 ANALYSIS

By Richard Schulte

> "*Where temperature differences of less than 110°C [198°F] are expected, vent flows might be reduced significantly; therefore, consideration should be given to using powered exhaust. . .*"

> "*Mass flow through a vent is governed mainly by the vent area and the depth of the smoke layer and its temperature. Venting becomes more effective with smoke temperature differentials between ambient temperature and an upper layer of approximately 110°C or higher. Where temperature differences of less than 110°C [198°F] are expected, vent flows might be reduced significantly; therefore, consideration should be given to using powered exhaust. . .*" Section A.4.4.3, Annex A, NFPA 204, 2002 edition

> "*For example, in sprinklered fires, it would not be unreasonable for smoke layer temperatures to be 70°C (158°F).*"

> "*It is well known that vent flow rate is reduced at temperatures below 200°C (392°F) [Hinkley 1995] and that sprinklers can cause cooling of upper layer smoke to well below this level. For example, in sprinklered fires, it would not be unreasonable for smoke layer temperatures to be 70°C (158°F). At such a temperature, the theoretical flow rate relative to the maximum possible high temperature flow rate would be halved. . .Despite these results, it must be acknowledged that there may be a reduction in vent flows due to sprinklers both in terms of reduced temperatures and direct spray effects.*" "*Interaction of Sprinklers With Smoke and Heat Vents*", Craig L. Beyler and Leonard Y. Cooper, Hughes Associates, Inc., February 1999, Pages 22 and 23.

In 1997/1998, research on the interaction of sprinklers, roof vents and draft curtains was conducted at Underwriters Laboratories (UL). The results of this research are documented in a report titled "*Sprinkler, Smoke & Heat Vent, Draft Curtain Interaction – Large Scale Experiments and Model Development*" dated September 1998. This report is referred to as NISTIR 6196-1.

As part of this research project, five large-scale tests involving fires involving Group A plastics stored in double-racks with a storage height of 20 feet were conducted. Of particular interest in this series of large-scale tests is Test P-1. The reason Test P-1 is of interest is that no roof vents activated, hence, the ceiling temperature measurements recorded in the test were not affected by the opening of vents.

In each of the large-scale tests, ceiling temperature readings were taken at each of the 100 sprinklers involved in the test. The data provided in NISTIR 6196-1 provides of a time-temperature plot of the ceiling temperature at each sprinkler, as well as a maximum ceiling temperature recorded at each sprinkler.

Based upon the ceiling temperature data provided for Test P-1, the average maximum ceiling temperature for this test was 178.3°F (81.3°C).

Based upon the ceiling temperature data provided for Test P-1, the average maximum ceiling temperature for this test was 178.3°F (81.3°C). Given that the maximum temperature recorded at each sprinkler did not occur at the same point in time, the average temperature computed would necessarily be a conservative estimate of the actual average maximum ceiling temperature. It should also be noted that it would be expected that the average maximum ceiling temperature recorded would exceed the average maximum temperature of the layer of the hot gases which collected under the ceiling. It would be expected that the lower portions of the hot gas layer would be at a lower temperature, hence it can be stated that the average maximum ceiling temperature indicated above would be an extremely conservative estimate of the average maximum temperature of the hot gas layer.

With an average maximum ceiling temperature of 178.2°F, it is clear that the temperature differential between the smoke layer and ambient was less than 110°C (198°F) throughout the test. Hence, per the recommendation of NFPA 204, the use of a powered exhaust system, rather than smoke/heat vents, would be appropriate.

This code change proposal is referred to as code change F144-09/10.

Given this data, the ICC Code Technology Committee (CTC) roof vent study group developed a code change proposal which removes the requirement for roof vents in one-story industrial and storage buildings provided with a sprinkler system and substitutes a manually-activated mechanical smoke removal system. This code change proposal is referred to as code change F144-09/10.

It should be noted that a sprinkler discharge density of 0.50 gpm/SF was utilized in all five of the large-scale tests conducted at UL and that the water supply to the system was controlled to maintain this density. Per NFPA 13, a minimum density of 0.60 gpm/SF would be required to protect the storage array utilized in the test. If the required density had been utilized in the tests, it is likely that the sprinkler system performance would have been improved and the ceiling temperatures recorded in the test would have been even lower.

Based upon the temperature-time data collected in Test P-1, it seems reasonable to conclude that the use of roof vents in buildings provided with sprinkler protection is questionable based upon the information provided in NFPA 204.

In Test P-1, a total of 20 sprinklers operated during the course of the test. Of course, not every fire in an industrial or storage building will operate 20 sprinklers. Many fires will be controlled by the operation of 1 or 2 ceiling or in-rack sprinklers. In seems obvious that the average temperature of the hot gas layer which collects under the roof will be much lower than indicated above where sprinkler protection is particularly effective (*e.g.*, systems which include in-rack sprinklers). In this scenario, automatic roof vent installations would essentially be useless assuming that the vents even open.

It seems reasonable to conclude that the installation of roof vents in buildings protected by a sprinkler system will be ineffective if the sprinkler system design is adequate for the hazard protected and the system is operational.

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