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Smoke Detector Spacing on Level Ceilings with Beams and Joists

Executive Overview

NFPA 72, The National Fire Alarm Code, recommends using 900 square feet (30 feet on center) as a guideline for spacing spot type smoke detectors on smooth ceilings. While this is only a recommendation, virtually all manufacturers of smoke detectors follow this guideline. There has always been a question of how detector spacing needs to change when the ceiling is not smooth, but is interrupted by beams or joists. The language in the 2002 edition of NFPA 72 code was based on the fire dynamics research reported in 1993-1994 and was considered the best available data at that time. However, recent advances in computational fluid dynamics (CFD) have allowed fire protection engineers to revisit the current guidelines and make concrete recommendations for changes in NFPA 72.

Industry Challenges

The 2002 edition of NFPA 72 requires that when beams project more than 12 inches below the ceiling and when ceiling heights exceed 12 feet, each bay (beam pocket) formed by the beams should/must be treated as a separate area. That is, each bay would need one or more detectors depending upon its physical size. When this requirement was first incorporated into the code, it was backed by the best CFD data available at the time. Subsequent to this code change, many fire alarm system designers discovered that following the literal code text could mean using a large number of detectors and incurring exorbitant installation costs in many common building designs. Historically, this part of the code has been a subject of contention in the fire protection industry and among NFPA 72 Initiating Devices Committee members.

Current Recommendations for Smoke Detector Spacing:

NFPA 72 requires different detector spacing depending upon whether the structural or ornamental members on the ceiling fall into the definition of a beam or a joist and the depth of those members. The code defines solid joist construction as members that are greater than 4 inches in depth and spaced 3 feet or less apart. Beam construction, on the other hand, is defined as members that are greater than 4 inches in depth that are spaced more than 3 feet apart. For the purposes of spot-type smoke detectors, the spacing rules are the same for ceilings with beams and solid joist construction.

For level ceilings, NFPA 72 currently requires spacing smoke detectors at one half their listed spacing, perpendicular to the run of the beams on a ceiling less than or equal to 12 feet in height, when the beams are less than or equal to 12 inches deep. When parallel to the beams, NFPA requires standard spacing for smoke detectors. In this case, the detectors may be mounted on the ceiling or on the bottom of the beams. If the beams exceed 12 inches in depth or the ceiling height of the space exceeds 12 feet, the detectors are required in every beam pocket on the ceiling.

Research

In April 2005, the Fire Protection Research Foundation funded new research using CFD computer modeling to reexamine smoke detector spacing on ceilings with beams and/or joists. The CFD analysis was performed by Schirmer Engineering Corporation

Following NFPA 72 2002 requirements could result in higher installation costs.

Ceilings with beams and joists affect detector spacing.

and Vision Systems Ltd. using Fire Dynamics Simulator and Smokeview Version 4¹ (developed by the National Institute of Science and Technology). The results of this research were published in a report entitled, “Smoke Detector Performance for Level Ceilings with Deep Beams and Deep Beam Pocket Configurations.”² The report was issued March 28, 2006 and was the basis for recommended changes to NFPA 72.

Based on a variety of modeled flaming fire scenarios, the results of this study indicate:

- There is no technical basis for the NFPA 72 2002 edition requirement for placing smoke detectors in every beam pocket when ceilings are greater than 12 feet in height and/or beams are greater than 12 inches in depth.
- The smooth ceiling 30-foot spacing guideline of NFPA 72, with permitted increases for narrow space geometry, allows smoke detectors to extend to approximately 41 feet on-center and along a corridor. For ceilings up to 24 feet in height, the deep-beam configurations do not negatively affect expected performance. This means that for corridor conditions, spot smoke detectors can be effectively used with deep beams at spacings for smooth ceilings.
- Standard 900-square-foot smoke detector spacing is adequate for waffle or pan type ceilings up to 24 feet in height and for beams up to 24 inches in depth that are spaced no greater than 12 feet on center.
- Spot smoke detectors may be placed on the bottom of the beams or in the beam pocket without any significant difference in performance.
- The concern about mounting smoke detectors a minimum of 12 inches from a ceiling-beam corner, per NFPA 72, is unsubstantiated. The CFD modeling showed no stagnant areas in the beam pockets that would preclude smoke detector activation. Although the modeling results showed no stagnant zones, it does not suggest that spot detectors can be installed in close proximity or contact to the wall or ceiling surface. The research report notes that such close mounting may impact the airflow characteristics into and around the detector housing, which could have a negative impact on how smoke flows into a detector’s sensing chamber.

A recent analysis shows no basis for many of the spacing requirements in the 2002 edition.

¹ The CFD software is available free of charge from the NIST web site: www.fire.nist.gov/fds.

² The full report is available on the National Fire Protection Association web site: www.nfpa.org.

Recommendations

Based on these findings, the report authors proposed language for addition to the body and annex of NFPA 72. The language clarifies how smoke detectors shall be placed on ceilings with beams and joists. These changes are expected to be incorporated into the 2007 edition of NFPA 72, which will be released in late 2006, to quell some of the debate surrounding the current requirements for smoke detectors on beam ceilings.

Conclusion

As a part of the National Fire Protection Association's mission to "reduce the worldwide burden of fire" by continually updating their consensus codes based on the latest research available, NFPA commissioned this study of smoke detector spacing. The results of this study and accompanying code changes are expected to reduce the overall cost of fire protection systems in beam ceiling applications while not comprising occupant safety.

Acknowledgement

This document was written with guidance from Schirmer Engineering Corporation.

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