PROTECTING CEILING POCKETS

By Roland Huggins, P.E.

A technical review of an industry theory leads to some surprising results.

BEFORE NFPA PUBLISHED the 2002 edition of NFPA 13, *Installation of Sprinkler Systems*, ceiling pocket guidance could only be found in formal interpretations of the 1978 and 1980 editions of the standard and published through the 1999 edition. The interpetations stated that fire sprinklers weren't required in 4-by-8-foot (1.2-by-2.4-meter) skylights because the skylights wouldn't delay the adjacent sprinklers' activation. This was a reasonable assumption since a 4-by-8-foot pocket is small and shouldn't capture the entire fire plume. However, the question of what to do with larger pockets that could capture an entire fire plume remained.

Under the theory that a skylight pocket must fill with heat from the top down before any heat escapes to activate adjacent fire sprinklers, the answer was to install fire sprinklers in the pocket. As it turns out, though, the theory didn't accurately depict the way ceiling features affect the ceiling jet or the part momentum plays in their interaction. This only became apparent when the American Fire Sprinkler Association (AFSA) used the National Institute of Standards and Technology's Fire Dynamics Simulator to evaluate sprinkler activation times in an effort to provide the technical basis for the proposed AFSA's criteria submitted to Technical Committee.

The base premise of the evaluation was that the maximum acceptable time to activation is the one a standard-response fire sprinkler produced in a flat ceiling. To be conservative, the height of the flat ceiling used was the same as that of the pocketed ceiling's lower level. This produces the shortest activation time for the standard response sprinkler and this is the reason why the allowance in 11.2.3.2.3 can't be used.

The evaluation produced some surprising conclusions. The first concerned the relationship between pocket depth and time to sprinkler activation. In shallower pockets 1 foot (0.30 meters) to 3 feet (0.91 meters) deep, the time to activation increases significantly. However, in ceiling pockets 3 feet (0.91 meters) to 7 feet (2 meters) deep, the activation time actually decreased, as shown in Figure 1. This finding shed some light on the way heat actually fills a ceiling pocket. Velocity vectors in a shallow pocket show that heat hits the edge of the pocket where its momentum triumphs against its buoyancy, causing it to turn and run down the edge, then turn out of the pocket. As the depth of a pocket increases to 3 feet (0.91 meters), the time to activation also increases. In a pocket almost 3 feet (0.91 meters) deep, heat loses enough momentum to allow its buoyancy to turn it back into the pocket, still bound by the pocket edge.

A circle effectively forms between the pocket edge and the fire plume, creating a fairly calm center, much like the eye of a hurricane, that's effectively excluded from the volume of the pocket. We now have a thermal barrier across the bottom of the pocket, giving us a reasonable explanation for the faster activation times. The hotter center portion of the fire plume will penetrate this barrier, but the cooler (better to say "less hot") outer portion won't, instead flowing out of the pocket. This is similar to the smoke stratification that sometimes occurs in high-ceilinged facilities such as enclosed stadiums, where the smoke spreads out well below the actual ceiling.

The second interesting finding was that the location of the fire in relation to the fire sprinkler doesn't affect activation time. In a flat ceiling, two fire sprinklers equidistant from a fire have a shorter activation time than four equally spaced fire sprinklers centered over the fire. This is a simple function of distance from the fire, which, in the evaluation, generated a 15 percent increase in activation time. In a ceiling pocket that captured the entire fire plume, changing the location of the fire produced no noticeable difference in activation times.

ILLUSTRATIONS: CHRIS MCCUSKER

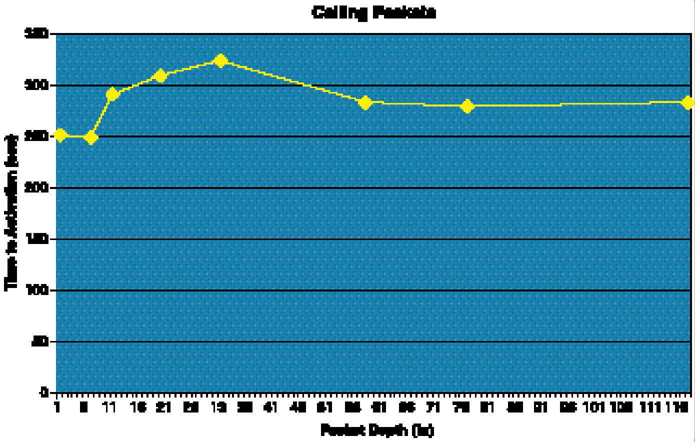

Figure 1.

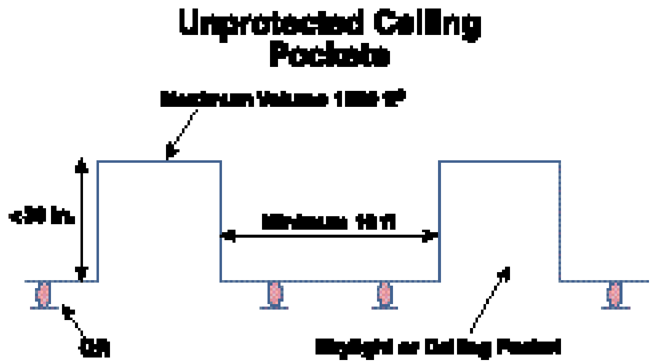

Figure 2.

Let's now focus on the criteria itself. Section 8.5.7, which addresses skylights, is a general requirement that, as stated in Paragraph 8.5.1.3, applies to all types of fire sprinklers unless modified by the more restrictive rules of Sections 8.6 through 8.12. Since no additional criterion in these sections addresses skylights, Section 8.5.7 applies to all types of fire sprinklers. However, this isn't the case for larger ceiling pockets, which are covered by Sections 8.6, "Standard Pendent and Upright Fire Sprinklers," and 8.8, "Extended Coverage Upright and Pendent Spray Fire Sprinklers." These are the only types of fire sprinklers that can be excluded from larger ceiling pockets.

There's no guidance for residential or sidewall fire sprinklers. This shouldn't be interpreted to mean that unsprinklered ceiling pockets would never be allowed in structures using residential or sidewall fire sprinklers, however. What it really means is that the initial evaluation focused only on pendent fire sprinklers. Since residential and sidewall fire sprinklers are particularly sensitive to ceiling features, it will be interesting to see what the continued evaluations will show.

The only other criteria we need to address is the requirement that each unprotected ceiling pocket be "separated from any adjacent unprotected ceiling pocket by a minimum of 10 feet [3 meters] horizontal distance." This seems fairly explicit, but being completely literal can produce a less conservative outcome than intended.

Take a ceiling pocket along an exterior wall that's used to increase the amount of natural light in the room. A single pocket measuring 2 feet (0.60 meters) by 3 feet (0.91 meters) by 30 feet (9 meters) falls within the criteria. On the other hand, the same pocket divided lengthwise by channel stops becomes two adjacent pockets to which the criteria no longer pertain, despite the fact that such an arrangement improves sprinkler response. The reason the criteria no longer pertain is the code developers' underlying concern that the heat has to pass through a second pocket before reaching the second ring-of-fire sprinklers (see Figure 2).

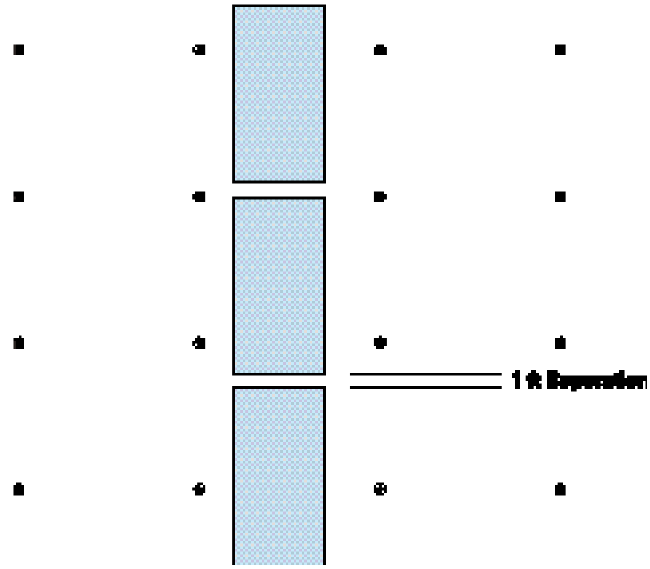

Figure 3.

Unfortunately, a lot of facilities have multiple ceiling pockets closer than 10 ft. When they are in a single line between a row of fire sprinklers as shown in Figure 3, there's no reason, from the standpoint of system performance, to require sprinklers within the pockets. We didn't want to make an issue of this, though, since it's a difficult concept to codify in a sentences or two and the need to make the initial step in addressing ceiling pockets outweighed the need to clarify this aspect.

Despite there being some minor refinements to be made on how NFPA 13 addresses ceiling pockets, the criteria in the new edition of the standard continues to improve and expand in response to changes in the built environment.

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