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**Empirical Validation of Detection Systems Equivalency for
Coincidence Suppression Actuation**

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EXECUTIVE SUMMARY

In the fire industry, codes and standards play a vital role in ensuring building and life safety. Many NFPA codes also include risk-based provisions to safeguard critical and valuable businesses and assets, by taking into account specific risk profiles in these environments. NFPA 130, NFPA 75 and NFPA 76 for instance, are excellent examples of how the codes are developed to address higher protection objectives. With the wide adoption of Performance-Based Design (PBD) methods around the world, innovative fire safety system design solutions are permitted, and actively encouraged, but are often beyond the boundaries of the existing prescriptive code provisions.

Much effort has been put into code development and enhancement, to accommodate designs where (1) existing technologies are used for new applications, (2) different technologies are considered for the same application and (3) new technologies are adopted. One common denominator for all of these is how the system performance (implied or explicitly stated) can be benchmarked to the accepted norms (conventional technologies for common applications), knowing that the alternative designs will be at least equivalent to, if not better than, conventional technologies designed to the prescriptive codes.

For the purpose of this paper the following definitions, in the context of fire safety system design, apply:

1. Equivalency: Equal or better in value, amount, function or performance
 - If congruency in meeting design objectives can be established
 - Then alternative design is deemed to be equivalent to the conventional method in the context of performance

2. Coincidence Detection:
 - The presence of ionizing particles or other objects in two or more detectors simultaneously or
 - The presence of two or more signals simultaneously in a circuit

When a fire detection system is used to actuate suppression such as a clean agent system, a coincidence detection scheme is recommended as good practice in many codes and guidelines, to prevent unwanted suppressant agent discharges.

The excerpt below, taken from FM Datasheet 5-14 (2007), outlines the two possible coincidence detection arrangements:

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“...actuating the protection system by (a) VEWFD (Very Early Warning Fire Detection) or (b) an FM approved cross-zoned smoke detection system...

1. For VEWFD, At the pre-alarm setting, the control system should automatically shut off air conditioning and close fire dampers. At the alarm setting, it should discharge the extinguishing agent ...
2. For cross-zoned smoke detection, actuate an alarm in a constantly attended location. Shut off air conditioning and close fire dampers on actuation of the second detector. Discharge extinguishing agent ...”

However, contrary to the above FM datasheet, many codes and guidelines provide only qualitative statements about the coincidence detection idea for conventional spot-type detectors. There is very little explanation of how an ASD coincidence detection scheme should be designed.

This paper presents the concept of a new system design tool, “The **ASD Suppression Actuation Threshold (ASAT) Calculator**”. It also describes the results of two independently conducted test programs to verify and validate the design tool functions, in terms of detection equivalency between ASD systems and traditional technologies designed in accordance with prescriptive codes or conventional practices. Empirical testing involved in-situ testing and lab testing.

In-situ Testing: Mock-up full-scale tests

Full-scale fire tests were conducted in a mock-up laboratory, to validate and verify different ASD coincidence detection schemes against the same design principle using spot-type smoke detectors (Figure 1).



Figure 1 Datacom Facility Mock-up (In-situ Testing)

The tests took into account factors that would affect fire detection performance: room air change rate, air ventilation design and airflow patterns. Different fire scenarios, combustibles and fuel loads were also investigated to assess the performance of the different detection technologies.

Various configurations of ASD devices, for a coincidence detection scheme, were tested and assessed. One of these schemes, the “alternating ASD detector zones”, is presented in Figure 2.

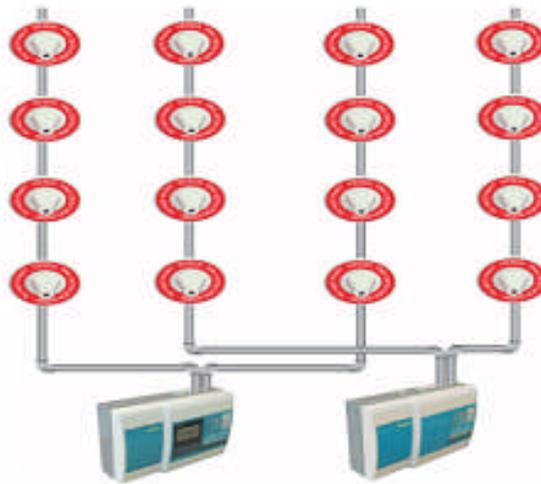


Figure 2 ASD Coincidence Detection Scheme (Alternating Detector Zones)

Table 1 shows the experimental parameters for one testing scenario and the ASAT calculated **Fire** alarm threshold, corresponding to different airflow conditions (10, 30 and 45 air change rate/hour), in the room with the 'Alternating ASD detector zones' coincidence detection scheme.

Table 1 Experimental Parameters & ASAT Values (In-situ Testing, Main Space)

Experimental Parameters		Calculated ASAT Fire Alarm	
Parameter	Value	ACH	Fire Alarm (%Obs/ft)
Area	4356 ft ²	10	0.531
Ceiling Height	9.5 ft	30	0.351
Ventilation Scheme	CRAC	45	0.265
SD Nominal Sensitivity	1.7 %/ft		
Fuel Type	Cable, Cardboard		
Fuel Location	Main Space		
ACH	10, 30, 45		
ASD sampling hole spacing (NFPA 72)	10 ACH: 30.0 ft 30 ACH: 15.8 ft 45 ACH: 11.5 ft		

Figure 3 illustrates the combined test results for the fuel types assessed (cable, cardboard). The solid line represents the ASAT **Fire** alarm threshold corresponding to different air change rates and the solid dots represent ASD smoke measurement at the time spot detectors alarmed for coincidence detection.

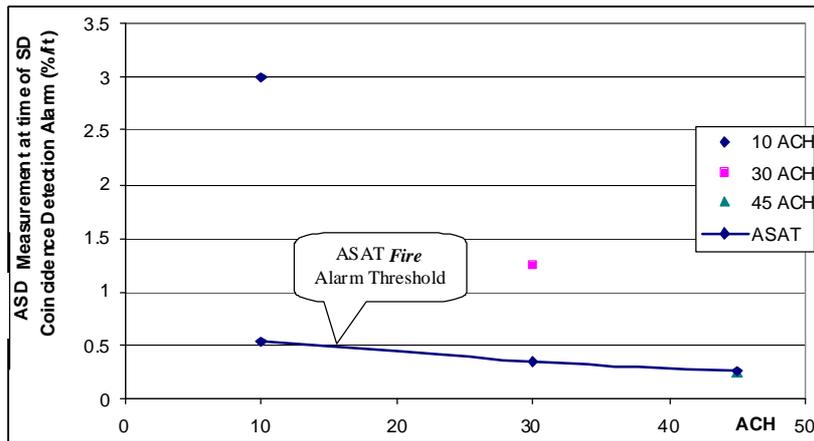


Figure 3 Test Results - Combined Fuel Types (In-situ Testing)

Lab Testing: smoke chamber tests

Testing apparatus and parameters were as follows (Figure 4):

- Standard smoke chamber, fitted with reference obscuration meter.
- Spot-type smoke detectors with different 'nominal' sensitivity levels.
- ASD detectors.

All detection systems were subject to the same gradual increase in smoke level and various air velocities.



Figure 4 Test Setup (Lab Testing)

Figure 5 shows the alarm response times for spot detectors (coincidence detection arrangement) and for an ASD system with its **Fire** alarm threshold calculated by the ASAT Calculator tool. The test result is for ASD equivalence detection with a 1.7%Obs/ft spot detector nominal sensitivity and approximately 40 fpm airflow across the spot detectors. The illustration does not take into account design factors such as system alarm delay, etc.

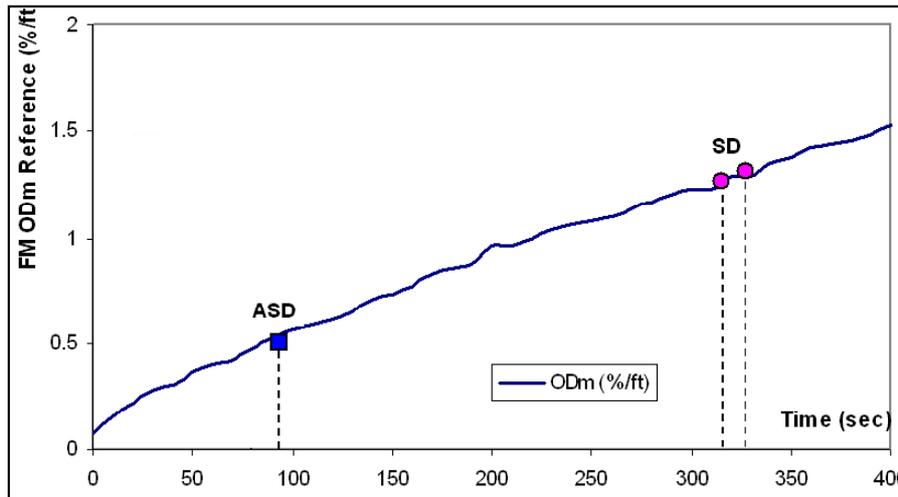


Figure 5 Test Results (Lab Testing)

Conclusions

- Equivalency is fundamentally important in prescriptive code development and performance-based designs, when adopting existing technologies for new applications:
- The basis of design equivalency includes both qualitative and quantitative measurements of system performance.
- Advanced modeling tools are available for evaluating and establishing the equivalency of fire detection system design. Simple system design tools can be developed following proven engineering methodologies.
- The “ASD Suppression Actuation Threshold (ASAT) Calculator”, is an advanced modelling tool for establishing and evaluating ASD fire detection system equivalency to conventional technologies, designed in accordance with prescriptive codes.
- Just like any other design tools, robust validation tests are critical to the success of a tool like The **ASAT Calculator**.
- A complete fire detection system design tool must address matters concerning all aspects of design, verification and commissioning.