Comparison of Aspirating Smoke Detector Codes and Standards

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Abstract

This article is focused on aspirating smoke detector codes and standards from European, National Fire Protection Association (NFPA) and Governmental Standard (GOST) point of view. An aspirating smoke detector (ASD) is a system used in active fire protection. These systems help detect a fire in a very early stage of fire. ASD systems' ability to detect smoke particles at much lower obscuration levels make them ideal for spaces that require the earliest possible smoke detection. Typical applications are museums, galleries, historically significant buildings, mission-critical facilities such as server rooms or data centers.

The installation, testing, and commissioning of aspirating smoke detection (ASD) systems is governed by several codes and standards according to the country of use. In the United States, it is mainly NFPA 72 and 76. In European Union, aspirating smoke detectors are governed by EN 54-20 and FIA Code of Practice. And in Russia it is GOST R 53325.

This article compares particular codes and standards requirements. And it clearly shows the main differences in these standards. Some standards have the same requirements, or requirements slightly differs. But in some cases the requirements are significantly different. For example, mention one case where energy of impact and numbers of hits during test methods are totally different for EN 54-20 and GOST R 53325.

Keywords: Fire detection, aspirating smoke detector, aspirating smoke detector system, test method, standards

Introduction

Many different standards are used for aspirating smoke detection systems worldwide. The presented comparison focuses on the standards used on the European, American and Euro-Asian continents. In this article, the technical requirements and test methods are compared.

EN Standard

European standards have the status of national standards of individual countries within the European Union. EN 54-20 is an European Standard released by the European Committee for Standardization (CEN). This Standard specifies the requirements, test methods and performance criteria for aspirating smoke detectors for use in fire detection and fire alarm systems. EN 54-20 defines 3 sensitivity Classes (Class A, class B, and Class C) and the requirements for each (see Table 1). This standard requires ASD systems to pass a series of Test fires (TF) to validate the classification of individual classes. Test fires according to EN 54-20 are stated in Table 2.

Table 1. EN 54-20 Classification table [1].

Class	Sensitivity	Example of application	Requirements (Test Fires)
A	Very high	Detection of very dilute smoke (atrium)	TF2A, TF3A, TF4, TF5A
B	Enhanced	Valuable, vulnerable, or critical items (computer or electronic equipment cabinets)	TF2B, TF3B, TF4, TF5B
C	Normal	Normal rooms or spaces	TF2, TF3, TF4, TF5

Table 2. EN 54-20 Test fire table [1].

Test Fire	Name of Test Fire	Fuel	End of test (EOT) conditions [dB m^{-1}]	Sensitivity class
TF2	Smouldering (pyrolysis) wood fire	10 wood sticks	2	Class C
TF2A	Reduced smouldering pyrolysis wood fire	3 (or more) wood sticks	0.05	Class A
TF2B			0.15	Class B
TF3	Glowing smouldering cotton fire	90 braided cotton wicks	2	Class C
TF3A	Reduced glowing smouldering cotton fire	30 (40) braided cotton wicks	0.05	Class A
TF3B			0.15	Class B
TF4	Flamming plastics (polyurethane) fire	3 polyuretan mats	1.27 < EOT EOT < 1.73	Class A, B, C
TF5	Flaming liquid (n-heptane) fire	650 g of a mixture of heptane with 3 % of toluene by volume	0.92 < EOT EOT < 1.24	Class C
TF5A	Reduced flaming liquid (n-heptane) fire	200 ml of n-heptane	0.1	Class A
TF5B		300 ml of n-heptane	0.3	Class B

FIA Code of Practice (FIA COP)

The Fire Industry Association (FIA) is a not-for-profit organisation and the largest fire protection trade association in the United Kingdom. Table 3 presents a matrix of performance tests according to the type of application and class of the system (Class A, Class B or Class C). These tests should be carried out during commissioning and maintenance of an individual ASD system. The detailed information for the performance tests can be found in Appendixes of the FIA COP.

Table 3. FIA COP performance tests [2].

Type	Application	Response Class A	Response Class B	Response Class C
primary	Clean room, telco, computer facility (ceiling < 3 m)	2 m PVC wire	1 m PVC wire	7 – 9 g pellet
	Other (in open areas high ceiling)	1 m PVC wire	7 – 9 g pellet	13 – 18 g pellet
secondary	Low ceiling (< 3 m)	2 m PVC wire	1 m PVC wire	7 – 9 g pellet
	Normal ceiling (up to 20 m unless other stated)	7 – 9 g pellet	13 – 18 g pellet	2 x 13 – 18 g pellet Poly´mat Lactose
	High ceilings (> 20 m)	N/A	2 x 13 – 18 g pellet	Lactose
localised	Ideally devise custom test to reflect risk - otherwise use	2 m PVC wire	1 m PVC wire	7 – 9 g pellet Poly´mat Lactose
In-cabinet	Vented/cooled	2x 12 ohm for 80 s	2 m PVC wire	1 m PVC wire
	Unvented (< 3 m^3)	12 ohm for 70 s	2x 12 ohm for 80 s	2 m PVC wire
	Unvented (> 3 m^3)	12 ohm for 8 s	12 ohm for 70 s	2x 12 ohm for 80 s
Duct	For smoke generated in the duct	2 m PVC wire	1 m PVC wire	7 – 9 g pellet
	For smoke generated in the room, or devised custom test	1 m PVC wire	7 – 9 g pellet	13 – 18 g pellet

GOST Standard

GOST is a set of standards managed by the Euro-Asian Council for Standardization, Metrology and Certification (EASC), a standardization organization operating within the Commonwealth of Independent States.

The Commonwealth of Independent States was formed following the dissolution of the Soviet Union in 1991. The requirements for ASD Systems are outlined in the GOST R 53325 (Fire techniques. Means of fire automatics. The general technical requirements. Test methods.). The sensitivity class requirements are in Table 4.

Table 4. GOST R 53325 Classification table [3].

Class	Sensitivity	Optical smoke density [dB.m^{-1}]	Transport time [s]
A	Very high	< 0.035	60
B	Enhanced	0.035 to 0.088	90
C	Normal	0.088 to 0.200	120

NFPA 72 and 76

The National Fire Protection Association (NFPA) is a global self-funded nonprofit organization, founded in The United States of America. The requirements for the ASD System are outlined in NFPA 72 and 76 Standards. NFPA 76 presents three levels of fire detection systems: Very Early Warning Fire detection (VEWFD) System, Early Warning Fire Detection (EWFD) System and Standard Fire Detection (SFD) System. The design requirements and maximum transport times for SFD system can be found in NFPA 72. The installation requirements for EWFD and VEWFD systems are presented in NFPA 76. Annex B to NFPA 76 outlines the performance test procedures, but it is not a part of the requirements of this standard and is included for informational purposes only. Heated wire test and lactose-potassium chlorate test are described in detail in Annex B. A summary of the requirements is shown in Table 5.

Table 5. NFPA 72 and 76 Classification table. [4] [5].

ASD system	Alert sensitivity*	Alarm sensitivity*	Transport time
VEWFD	0.65 % obs/m	3.3 % obs/m	< 60 s
EWFD	N/A	5 % obs/m	< 90 s
SFD	N/A	No greater than spot smoke detector	< 120 s

Note: It was considered that 1ft corresponds to 0.305 m when converting units to the metric system.

Test comparison

From the perspective of the test schedule, test methods and requirements, the methods stated in EN 54-20 and GOST R 53325 are compared in detail in Table 6. The main differences in test conditions are emphasizing in Table 7. The response threshold value (RTV) N shall be taken as the aerosol concentration at the time when the detector gives the alarm.

Table 6. Comparison of tests according to EN54-20 and GOST R 53325 [1] [3].

Test	Test No in the test schedule		Speciment No		Requirements N_{max}:N_{min}	
	EN	GOST	EN	GOST	EN	GOST
Repeatability	1	2	1	1 to 3	< 1.6	< 1.6
Reproducibility	2	3	1 to 8	1	< 1.33* < 1.5**	< 1.3
Variation of supply voltage	3	5	1	1	< 1.6	< 1.3
Dry heat (operational)	4	6	1	3	< 1.6	< 1.3
Cold (operational)	5	7	1	3	< 1.6	< 1.3
Damp heat, steady state (operational)	6	8	1	1	< 1.6	< 1.3
Damp heat, steady state (endurance)	7	N/A	2	N/A	< 1.6	N/A
SO2 corrosion (endurance)	8	N/A	3	N/A	< 1.6	N/A
Shock (operational)	9	N/A	4	N/A	< 1.6	N/A
Impact (operational)	10	9	4	3	< 1.6	< 1.3
Vibration (operational)	11	10	5	2	< 1.6	< 1.3
Vibration (endurance)	12	N/A	5	N/A	< 1.6	N/A
Electromagnetic compatibility, immunity tests	13	12	6 and 7	3	< 1.6	Annex B
Fire Sensitivity (fire tests)	14	1	8	1	transp. time: up to 60 s	Annex D
Air flow monitoring	***	4	N/A	2	fault signal up to 300 s	fault signal up to 300 s
Dielectric strength and insulation resistance	N/A	11	N/A	1	N/A	insulation resistance > 20 MΩ
Fire safety	N/A	13	N/A	2	N/A	GOST R IEC 60065

* N_{max} : N_{mean}

** N_{mean} : N_{min}

*** Air flow monitoring is not a test of test schedule, but it is a general requirement of EN 54-20.

Table 7. Comparison of test´s conditions according to EN54-20 and GOST R 53325 [1] [3].

	Test conditions	
	EN 54-20	GOST R 53325
Repeatability	measured 6 times, air velocity and aerosol density rate is not specified*	air velocity (0.2 ± 0.04) m/s, increase of aerosol density rate: 0.015 to 0.1 [dB m^{-1} min^{-1}]
Reproducibility	measured 8 times, calculated the mean (N_{mean})	measured 6 times, break minimal 1 hour
Variation of supply voltage	Three RTV measured for nominal, maximum and minimum supply voltage	RTV measured for 115 % and 75 % of nominal supply voltage (or for other specified supply voltage limit)
Dry heat (operational)	t: (+55 ± 2) °C duration: 16 h recovery time: 1 h	t: min. +55 °C duration: min. 2 h recovery time: 2 h
Cold (operational)	t: (-10 ± 3) °C t**: (+5 ± 3) °C duration: 16 h recovery time: 1 h	t: min. -10 °C duration: min. 2 h recovery time: 2 h
Damp heat, steady state (operational)	t: (+40 ± 2) °C RH: (93 ± 3) % duration: 4 days recovery time: 1 h	t: (+40 ± 2) °C RH: (93) % duration: 48 h recovery time: 2 h
Damp heat, steady state (endurance)	t: (40 ± 2) °C RH: (93 ± 3) % duration: 21 days recovery time: 1 h	N/A
SO2 corrosion (endurance)	Conditioning: t: (25 ± 2) °C RH: (93 ± 3) % no condensation; SO2: (25 ± 5) ppm by volume duration: 21 days Drying: t: (40 ± 2) °C RH: ≤ 50 % recovery time: 1 h	N/A
Shock (operational)***	Shock pulse type: half sine Pulse duration: 6 ms Peak acceleration: 10 x (100-20M) $m.s^{-2}$ Number of directions: 6 Pulses per direction: 3	N/A

Impact (operational)	Three blows Impact energy: (0.5 ± 0.04) J Number of impacts: 3	One blow Impact energy : (1.9 ± 0.1) J Number of impacts: 1 Hammer speed of impact: (1500 ± 0.125) m/s
Vibration (operational)	Acceleration amplitude: 5 $m.s^{-2}$ (≈ 0.5 g_n) Number of axes: 3 Sweep rate: 1 $octave.min^{-1}$ Number of sweep cycles: 1 per axis	Acceleration amplitude: (0.5 g) Number of axes: 3 Number of sweep cycles: 1 per axis The vibration frequency should be doubled in time of at least 60 s.
Vibration (endurance)	Frequency range: (10 to 150) Hz Acceleration amplitude: 10 $m.s^{-2}$ (≈ 1.0 g_n) Number of axes: 3 Sweep rate: 1 octave. min^{-1}	N/A
Electromagnetic compatibility, immunity tests	Consist of 7 tests.	Annex B
Fire Sensitivity	Consist of series of test fire held in fire test room. Initial conditions: T: (20 to 28) °C Smoke density (ionization): y ≤ 0.05 Smoke density (optical): m ≤ 0.02 $dB.m^{-1}$ The test fires are described in Annexes B to H.	Consist of series of test fire held in fire test room. Initial conditions: T: (18 to 28) °C RH: (30 to 80) % Smoke density optical: m ≤ 0.02 $dB.m^{-1}$ CO concentration: ≤ 5 ppm The test fires are described in Annex A.
Air flow monitoring	Volumetric airflow change of 20 % and greater, loss of 50 % and greater of sampling points	Volumetric airflow change of 20 % and greater, loss of 50 % and greater of sampling points

Dielectric strength and insulation resistance	N/A	For detectors with metal cover. A generator provides a sinusoidal voltage with a frequency of 40 to 60 Hz. Amplitude setting depending on nominal supply voltage: < 60 V: amplitude from 0 to 500 V > 60 V: amplitude from 0 to 1500 V insulation resistance > 20 MΩ
Fire safety	N/A	Analysis of electrical circuit and construction of the supply voltage Power output: min. 10 W If the ASD is not flammable, this test is not performed.

* Air velocity and increase of aerosol density rate can be found in EN 54-7 and correspond to GOST requirements (air velocity: (0.2 ± 0.04) m/s, increase of aerosol density rate: from 0.015 to 0.1 $dB.m^{-1}$ min-1) [6]

** If the detector cannot operate at less than 0 °C.

*** No test is applied to specimens with mass 4.75 kg according to EN 54-20.

Conclusion and outlook

The article introduced the requirements for aspirating smoke detectors pursuant to standards EN 54-20, NFPA 72, NFPA 76, GOST R 53325 and FIA COP. The article mentions the conducted operation and endurance tests and the values required for a valid completion of the tests. The aspirating smoke detector tests specified in regulation EN 54-20 and in GOST R 53325 were compared in detail. Standards NFPA 72 and 76 do not describe similar tests in detail and that is why only the requirements for the detector sensibility classes were presented. The classification of the aspirating smoke detectors into individual sensibility classes differs in individual regulations, not only by marking/class, but also by the requirements that must be fulfilled.

From the perspective of the test methods, the methods stated in EN 54-20 and GOST R 53325 were compared in detail, emphasizing their mutual differences. These standards particularly differ regarding the number of tested samples of the aspirating smoke detectors and in the number of conducted test pursuant to the schedule of tests. Pursuant to the EN regulation, a total of 8 samples of aspirating smoke detectors are tested, while pursuant to GOST, only 3 detectors are tested.

The schedule of tests in the European regulation specifies 14 tests, while GOST stated 13 tests. Some tests do not exactly correspond one to another and that is why they were compared based on their similarities.

The biggest differences can be seen in the procedures of the conducted tests and in the requirements for the test evaluations. From the evaluation perspective, most tests conducted pursuant to the EN regulation must have the ratio between the maximal sensitivity value and the minimal sensitivity value smaller than 1.6, while pursuant to the GOST regulation, this value must be smaller than 1.3.

From the test perspective, the biggest differences are in the operation impact test, for which the European regulation considers 3 blows with an impact energy of (0.5 ± 0.04) J, while the GOST regulation considers 1 blow with an impact energy of (1.9 ± 0.1) J, and additionally, also states the hammer speed at the moment of the impact. From the perspective of the fire tests, the comparison of the TF5A and TF5B tests is interesting, since both regulations state different details regarding the given test and the used mixture. The EN regulation prohibits the use of toluene in these tests, while the GOST regulation considers its use, provided its volume amounts to 3 % of the mixture.

Further work will focus on a detailed comparison of the test methods with the methods specified by the American regulation UL 268.

Acknowledgements

The paper has been supported by the Institutional support for the development of a research organization (CTU in Prague, Project RVO11000).

References

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