A global analysis on water-based fire extinguishing agent

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Abstract. Due to the superiority of the attribute of water, water-based fire extinguishing agent is considered as one of most effectively fire extinguishing agents. NFPA has developed two standards regarding to water-based fire extinguishing agents. ISO technical committee working group is also preparing for developing a standard about the subject fire extinguishing agent. China also has its own national GB standard about water-based standard. This paper aims at to elaborate standard requirements and methods in different technical documents and standards currently available around the world with a view to summarize the main concern in different standards, and trying to find out valuable information for readers in future research and development.

1. Need for the study on water-based fire extinguishing agent

Water has been recognized as a fire extinguishing agent in ancient times. This is because of the characteristics of strong heat absorption and cooling ability of ambient environment. At the same time, water could be transformed to large amount of steam after being vaporized, and the steam could prevent air from entering into the burning area, cut down the entering of combustion accelerator, and thus cut down the burning process. But it is also noted that water has some deficiencies in being applied as fire extinguishing agent. Water has high degree of fluidity, hard to stay on the surface of the burning item, and thus it cannot linger on the combusting item for a longer time and cannot cooling down the temperature and will probably lead to vapor explosion if more vapor accumulated within an enclosed space. Water has large value of surface tension, low wetting ability and these factors will reduce the efficiency of the fire extinguishing process. Under such circumstances, more research are conducted about the analysis to add water additives in water and to improve the performance of the fire extinguishing agents.

This paper aims at finding out relevant standards and technical documents about water-based fire extinguishing agents currently available and trying to elaborate the main contents and pinpoint the differences and pros and cons of different documents for later technical reference.

2. Standards review

2.1. General

In doing systematic review of fire extinguishing agents, it is found that some western countries have developed relevant standards regarding to the products, and some have already been developed for several editions. China also has national GB standard about water-based fire extinguishing agent, which was developed based on the products available in China's market and China's situations.

2.2. Elaboration of documents

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ISO/TC21/SC6 Technical committee for Foam and powder media and firefighting systems using foam and powder in International Standardization recently has launched standards review about water-based fire extinguishing agents currently available around the world. The research found out five main standards documents in the market

Based on the document table indicated, ISO and EN standards have only standards about chemical surface active agents rather than standards about water additives applied in fire extinguishing，while NFPA has two standards about wetting agents and water additives for fire control and vapor mitigation.

Table 1. Standards review on water-based fire extinguishing agents

No.	Standard/Document	Standard/Document Name
1	DIN EN 1772:2000	Surface active agents – Determination of wetting power by immersion (ISO 8022:1990,modified)
2	ISO 8022	Surface active agents – Determination of wetting power by immersion
3	NFPA 18-1995	Standard on Wetting Agents
4	NFPA 18A-2011	Standard on Water Additives for Fire Control and Vapor Mitigation
5	GB 17835-2008	Water based extinguishing agent

2.3. NFPA Standards

2.3.1. NFPA 18 Standard on wetting agents

This standard has been confirmed and updated in several editions since 1949. Currently, the most recent standard is 2011 edition. This edition has undergone extensive technical and editorial revision. Technical changes include limits for aquatic toxicity for parity and consistency with other product standards.

Regarding to technical performances, NFPA has many detailed requirements and many requirements are evaluated both for concentrations and solutions. About Concentrates pour point, it shall be determined in accordance with ASTM D97. Concentrates also shall meet the requirements of miscibility, separation and impact of low temperature of wetting agent concentrate on surface tension. Wetting agent concentrate shall be between 6 and 9 at 18℃±2.7℃.Viscosity of concentrate shall be measured. A Brookfield viscometer is recommended to use. Wetting agent has a server requirement of toxicity about both concentrate and solution. The toxicity shall be inspected on four levels, for acute oral toxicity, acute dermal toxicity, acute eye irritation and acute dermal irritation. All the test methods shall confirm to EPA OPPTS or their equivalents. Wetting agent concentrate shall also conform to requirement of biodegradability, which shall be in accordance with U.S.EPA OPPTS 835.3110 or equivalent.

Both concentrate and solution shall undergo severe corrosion test, which shall be in accordance with NACE TM 0169 or with ASTM G 1 and ASTM G31. Results shall be less than or equal to the values found in Table 2. Wetting agent and its solutions shall be tested for corrosion with samples of 4130 mild steel, 2024-T3 aluminum, and UNS C27000 yellow brass (65 percent copper, 35 percent zinc). The wetting agent and its solutions shall be tested at the maximum and minimum use concentrations specified by the manufacturer.

Regarding to fire tests, NFPA requires products listed for use on Class A fires shall pass all the fire tests specified regarding to Class A fire extinguishment tests in NFPA 18. The tests include wood crib fire test, deep-seated fire test and wood fibreboard penetration tests. These tests mainly test the penetration and deep seated ability of the wetting agent. NFPA also requires products listed for use on Class B fire shall pass all the fire tests specified regarding to Class B fire extinguishment tests in

NFPA 18. Wetting agent solutions at the concentrations specified by the manufacturer shall be evaluated to and comply with the requirements of UL 711/ULC S508 for Class B fires.

Table 2. Maximum allowable corrosion rates (Adopted from NFPA 18)

	2024-T3 Aluminum				4130 Steel				Brass[a]	AZ31B Magnesium			
	Total Immersion		Partial Immersion		Total Immersion		Partial Immersion		Partial Immersion	Total Immersion		Partial Immersion	
Application	21°C (70°F)	49°C (120°F)	21°C (70°F)	49°C (120°F)	21°C (70°F)	49°C (120°F)	21°C (70°F)	49°C (120°F)	49°C (120°F)	21°C (70°F)	49°C (120°F)	21°C (70°F)	49°C (120°F)
Wetting agent concentrates	2.0	2.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0[b]	5.0[b]	5.0[b]	5.0[b]
Wetting agent solutions	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Fixed-wing aircraft	2.0[c]	2.0[c]	2.0[c]	2.0[b]	5.0	5.0	5.0	5.0	5.0	—	—	—	—
Helicopter with fixed tank	2.0[c]	2.0[c]	2.0[c]	2.0[b]	5.0	5.0	5.0	5.0	5.0	4.0[c]	4.0[c]	4.0[c]	4.0[c]
Helicopter with bucket	2.0	2.0	2.0	2.0	5.0	5.0	5.0	5.0	5.0	—	—	—	—
Ground application[d]	2.0	2.0	2.0	2.0	5.0	5.0	5.0	5.0	5.0	—	—	—	—

Note: All values in milli-inches (mil) per year; for SI units, 1 mil = 2.54×10^{-2} mm.
[a]Composition of brass is 65 percent copper, 35 percent zinc.
[b]Required only if submitted for use in helicopters equipped with fixed tanks or if the concentrate is contained on board the helicopter.
[c]Intergranular corrosion tests also required; see 4.3.4.2 of NFPA 1150.
[d]Includes fire apparatus, portable pumps, backpacks, and other such devices.

2.3.2. NFPA 18A Standard on water additives for fire control and vapour mitigation

Initially, the committee responsible on water additives for fire control and vapor mitigation proposed to combine wetting agents and water additives under on standard. This effort was returned to the committee by Association action in June 2003. As a result, the committee decided to divide this work into two subject areas and standards, retaining and revising NFPA 18 and creating a new standard addressing water additives, NFPA 18A, the first edition of which was issued in 2007. Changes in the 2011 edition include a reorganization of Chapter 5 and 6, clarification of test procedures and criteria, and the removal of secondary (U.S.) units throughout much of the text.

This standard regulates that water additive concentrate shall be mixed only with water. Regarding to technical performances in NFPA 18A, they share with NFPA 18 in many items, i.e. toxicity and environment test (including mammalian toxicity, aquatic toxicity, and biodegradability), concentrate pour point, PH value and viscosity.

This standard highlighted the performance requirement of concentrate stability. Three 19L samples of water additive concentrate from a single production lot shall be stored in sealed containers. The samples shall be designated as Sample 1, Sample 2, and Sample 3. The three samples shall be treated in different conditions and be inspected the status of stability.

The standard also has more requirements about corrosion except for uniform corrosion regulated in NFPA 18. The standard asks for the test of intergranular corrosion test. There shall be no intergranular corrosion on aluminum 2024-T3 when tested if the solution is recommended for application by fixed wing aircraft and magnesium AZ31B for rotary-wing aircraft. The standard also required compatibility with nonmetallic materials. The tests include sample exposure tests, volume test and hardness of test. Regarding to fire test methods, water additive solutions for Class A fuels shall be tested in accordance with all of the following fire test procedure, including wood panel fire test and wood crib fire test. As far as Class B fire test methods are concerned, water additive solutions for Class B fuels shall be tested in accordance with one or more of the test procedures, including spill fire test, pool fire test, three-dimensional fuel fire test, polar solvent fire test, emulsification and fuel in depth fire test.

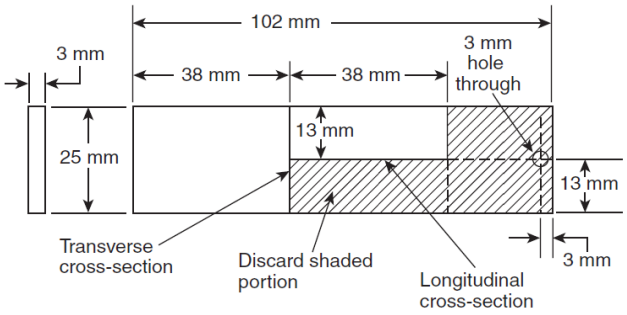

Figure 1.Intergranular Corrosion Test (Adopted from NFPA 18A)

2.4. China's GB Standard

China has its own national GB standard regarding to water-based fire extinguishing agent. GB 17835 has two editions with the current edition published in 2008. Most of the technical performances and test methods comply with GB 15308-2006 Foam extinguishing agent, including pour point, PH value, surface tension and corrosion test.

The GB standard has requirement about toxicity, but with comparatively less sever requirement. The test is to let zebra fish stay in solution mixed with water-based agent and prepared solution for 96 hours. Death rate shall be not more than 50%. Regarding to fire tests, GB standard has performance requirements for Class B and Class A fire tests. About Class B fire test, the agent shall extinguish solvent oil, and 99% acetone fire. As to Class A fire test, the agent shall extinguish wood crib with more than 1A grade.

3. Comparative research and limitation of this study

Based on the standards review of current standards available, the study found out that China's GB standard has many obvious differences with peer standards in US. China's standard is developed based on China's foam standard while NFPA standards have more severe requirements and test methods. There are longer specimen treatment process in NFPA standards and more requirements about corrosion, toxicity and wood fibreboard penetration. NFPA standard has many requirements about toxicity, including for mammalian toxicity, concentrate aquatic toxicity, and concentrate biodegradability. As to the status that chemical toxicity and environment problems have been highlighted, it is recommended to research on the possible solution to downgrade the toxicity to human beings and the earth while to realize the fire performance requirements in NFPA standards. ISO technical committee working group responsible for fire extinguishing agents has realized the same challenge and intend to add biodegradability as an important performance in future ISO water-based fire extinguishing standard.

Combining to the global concern and realistic status in China, the research suggest add more severe requirements about biological toxicity and relevant fire test performance in China's future research and standard development projects. Even if this research has accumulated most of standards about water-based extinguishing agent currently available, there may be some more standards and documents around world which need us spend more time to re-search. Due to limitation of time and research funding, this paper only review the same and differences of the content of the subject standards, while further experimental research need to be developed in future.

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