

# AEROSOL FIRE EXTINGUISHING TECHNOLOGY

气溶胶灭火技术

GUO Hongbao  
YUE Dake



Chemical Industry Press

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## Preamble

Aerosol fire extinguishing technology was newly developed from military pyrotechnics. In the 1960s, the oil tank smoke fire extinguishing technology developed by the Tianjin Fire Research Institute of the Ministry of Public Security was the earliest developed aerosol fire extinguishing technology. It did not draw wide attention at that time. At the beginning of the 1980s, due to the environmental problem of the halon fire extinguishing agent, therefore, seeking a replacement of halon became an important research subject. By the end of the 1980s, a technology of total flooding extinguishing with aerosol was first developed in Russia, which blazed a new way for the research of halon replacement. After that, aerosol fire extinguishing technology has attracted international attention, including China, US, Australia, Malaysia, etc.

Fire extinguishing mechanism of aerosol is that: solid particles produced by burning interact chemically and physically with the active radicals O, H and OH in flame, cutting off the chain reaction of burning, thus fulfilling the purpose of fire extinguishing. Aerosol fire extinguishing technology has five advantages: ① High efficiency in fire extinguishing, generally from  $30\text{g/m}^3$  to  $150\text{g/m}^3$ , and typically  $100\text{g/m}^3$  in engineering application, at least three times higher than that of Halon 1301, and five times higher than that of HFC-227ea and IG-541, and nine times higher than that of carbon dioxide, being the most efficient fire extinguishing agent for the time being;

② Environment friendly, with no damage to atmospheric ozone layer, zero value of ODP, low value of GWP, and no other substances significantly detrimental to environment and human health; ③ Saving weight and volume. There is no need for pressure vessel since it is stored in form of solid mixture at atmospheric pressure prior to extinguishing operation; ④ Manufacturing cost for aerosol fire extinguisher is at least 25% lower than that for other gas fire extinguishers, free of leakage under high pressure, and low maintenance and repair cost; ⑤ No harmful substances such as hydrofluoric acid, etc are disintegrated out at the time of exposure to high-temperature flame.

These advantages attract the world's attention for its development and application. Aerosol fire extinguishers have been developed in UK, Australia, US, Russia, Malaysia, etc, and widely used in oil, communication, automobile, aircraft, ship, and other industries, and also have great application potential in military and aviation sectors. So far, EPA SNAP has officially approved the use of several aerosol fire extinguisher products as halon replacement, such as US-made AERO-K, Australia-made PROGEN, UK-made FIREPRO and the forth.

ISO, NFPA, IMO, CEN, etc. have begun to formulate the standards for aerosol application. Australia, Russia and China have promulgated related standards. The establishment and publication of these standards, in turn, further promotes the application and development of aerosol fire extinguishing technology.

At present, there are more than twenty enterprises engaging in the development and production of aerosol fire extinguishing system in China with annual production of more than 200 tons, mainly used in oil storage tank, electronic equipment, communication equipment, power transformation and distribution facility, locomotive and other aspects. More than 3,000 oil storage tanks and over 10,000 communication equipment rooms and computer rooms have been provided with aerosol fire extinguishing system. Currently, China is in top position in aerosol fire extinguishing technology in the world. Particularly, aerosol products have been first classified according to its chemical composition in our country. This represents our deep and mature understanding of aerosol fire extinguishing technology.

At present, more and more attention is paid to aerosol fire extinguishing technology as a halon replacement in the world. The book of Aerosol Fire Extinguishing Technology makes a systematic introduction to the technology from the aspects of basic concept, fire extinguishing theory, construction of fire extinguishing device, engineering design and construction, etc. Publication of the book is helpful for the fire control designers, constructors and managers correctly understanding aerosol and properly using aerosol. No doubt, the book will play an active role in promoting the development of aerosol fire extinguishing technology in our country.

**FENG Changgen**  
**March 2008**

## **Foreword**

With dramatic characteristics and performance such as high efficiency in fire extinguishing, environment friendly ( $ODP=0$ ,  $GWP=0$ ), solid storage at atmospheric pressure, and low use and maintenance cost, aerosol fire extinguishing agent stands out from numerous halon replacements under the background of halon fire extinguishing agent being phased out and banned globally. Apart from China, US and Russia, UK, Australia, and New Zealand are taking active part in the research and development of aerosol fire extinguishing technology. So far, several products have come into the world, and widely used in ship, oil extraction, communication, military, electric power and other industries. Aerosol fire extinguishing technology has been approved by EPA SNAP as primary halon replacement. To further promote and normalize the development of aerosol fire extinguishing technology, ISO, IMO, CEN, NFPA, etc have begun to formulate the standards for aerosol application. China, Russia, Australia, New Zealand, etc have promulgated related standards. As an excellent replacement of halon, aerosol fire extinguishing technology attracts more and more international attention.

The book makes a systematic introduction to aerosol fire extinguishing technology in respect of basic concept; theory, development process and product design, and particularly gives a detailed description for the difference between various aerosol fire extinguishing technologies and applicable



locations in conjunction with the latest development. We hope the book can provide the fire control managers, researchers, designers and operators with some basic reference.

Preparation of the book obtained great support and help from the Fire Control Department of the Ministry of Public Security, the Tianjin Fire Research Institute of the Ministry of Public Security, the 213th Research Institute of China Ordnance Industry, and the Beijing Institute of Technology. Some data and graphics in the book are cited from many research institutes and manufacturing plants engaged in aerosol or other gas fire extinguishing technologies. We, hereby, extend our deep appreciation to all of them.

There may be omissions in the book due to limited time in preparation and our limited knowledge. We hope that readers could give us your precious comments on the book.

**Writers**  
**March 2008**

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# **Chapter I Halon Phaseout Program**

## **Section I Damage and Hazard to Ozone Layer**

### **I . Composition and Structure of the Atmosphere**

#### **( I ) Important Roles of the Atmosphere**

The atmosphere around the earth is composed of gases. a great deal of gasses is massed around the earth due to great gravitation, forming the atmospheric layer as thick as thousands of kilometers. There is still rarefied atmosphere at the height of 3000km as probed by sounding rocket. Existence of the atmosphere around the earth is due to the gravitational attraction of the earth. If no such attraction, the atmosphere would leave the earth rapidly, and spread into cosmic space. The closer to the earth the air is, the higher the air density is. 90% of the atmosphere is within the range from sea level up to 10km.

The atmosphere is an important component of natural environment. Any part of the atmosphere has direct or indirect impact on human subsistence and development. Its main functions are as follows:

- 1) Serves as a protection layer for the subsistence of living creatures on earth, blocking harmful radiations from the space and the sun;
- 2) Provide various gases required for the earth creatures to support their lives;
- 3) Have a significant impact on earth's natural environment, such as temperature rise and drop, blowing and raining and other atmospheric phenomenon.

Over the long geologic time, the atmosphere molds the earth's surface shape continually.

#### **( II ) Composition of the Atmosphere**

Naturally, the atmosphere is composed of clean and dry air, water vapor and solid impurities. See Table 1-1.



**Table 1-1 Various Composition of Lower Atmosphere and Their Functions**

Composition	Content	Function
Clean and dry air		
Nitrogen	78.09%	A basic component of the organisms on earth
Oxygen	20.94%	A substance required for human and all living things to sustain their vital movement
Carbon dioxide	0.03%	A basic material for the photosynthesis of plants, and keeping the atmosphere warm.
Ozone	Very little	Absorption of solar ultraviolet, protecting the living creatures on earth
Water vapor	Very little	Producing various weather phenomenon such as cloud, rain and fog, and affecting surface and atmospheric temperature
Solid impurities	Very little	As condensation nucleus, they are a necessary condition for forming cloud and rain

(1) Clean and dry air. The air free of moisture and impurities is called “clean and dry air”, which is mainly composed of 78.09% nitrogen, 20.94% oxygen and 0.93% argon. The content of the three gases accounts for 99.96% of the total. That of other various gasses totals less than 0.1%. These micro gases include rare gases such as neon, helium, krypton, xenon, etc. as well as carbon dioxide and ozone. The contents of all these gases vary very little at near-surface atmospheric layer, and can be considered as constant composition.

(2) Water vapor. It is a necessary condition for forming cloud and rain, and can absorb infrared.

(3) Solid impurities. As condensation nucleus, they are a necessary condition for forming cloud and rain.

Due to the existence of the atmosphere, the incoming sunlight is deflected from its original direction and scattered at the time of its collision with atmospheric molecules. Lower atmospheric molecules mainly scatter blue light, hence enabling the sky to be blue. It is the atmosphere that allow us to enjoy iridescent morning glow and golden sunset when night and day alternate.

However, the composition of the atmosphere isn't changeless. Natural disasters or man-made influence shall create new substances in the atmosphere. When the content of certain composition is much more or less than the average value at natural state, the creatures' growth will be affected, cau-