ALLTEC
FIRE EXTINGUISHING SYSTEMS
'The fastest way to extinguish fire!'

PHYSICAL PROPERTIES FOR CONDENSED AEROSOL FIRE EXTINGUISHING AGENT AND APPLICATIONS

Preamble

Aerosol fire extinguishing technology has been recently been developed from the space program. At the early years of development, not much attention was given but in the beginning of the 1980s, due to the environmental problems using halon fire extinguishing agent, lead to the need for the replacement of halon and has became an important research subject. By the end of the 1980s, the technology for total flooding extinguishing using aerosol was first developed in the Russian space program, which ignited a new era for the research of halon replacement. Since then, aerosol fire extinguishing technology has attracted international attention i.e. US, Russia, China, Germany, Italy, UK, South Africa, Saudi Arabia, Australia etc.

The fire extinguishing mechanism for aerosol fire extinguishers is produced by the solid particles produced by the internal burning of the extinguishing agent which interact chemically and physically with the active radicals O, H and OH in the flame, cutting off the chain reaction of burning, thus fulfilling the purpose of fire extinguishing process. Aerosol fire extinguishing technology have five major advantages:

(1) High efficiency in fire extinguishing, generally from 67g/m^3 to 150 g/m^3, and typically 100 g/m^3 in engineering application, which is at least three times higher than that of Halon 1301, and five times higher than that of HFC-227ea and IG-541, and ten times higher than that of carbon dioxide, therefore, can be considered being the most efficient fire extinguishing agent for our present time;
(2)Environment friendly, with no damage to the atmospheric ozone layer, zero value of ODP, low value of GWP, and no other substances significantly detrimental to the environment and human health.
(3) Saving weight and volume. There is no need for pressured cylinders, aerosol fire extinguishing agent is stored in solid form 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; No harmful substances such as hydrofluoric acid, etc.
(5) Lower installation costs since no pressurized pipes, exit nozzles and no storage facility for the pressurized cylinders are needed.

These advantages have attracted the world's attention for its development and application. Aerosol fire extinguishers are now been developed in Russia, Italy, Australia, US, China, Cyprus etc, and widely used in the oil, communication, automobile, aircraft, ship, chemical plants and other industries, and also have great application potential in the military and aviation sectors. EPA SNAP has officially approved the use of aerosol fire extinguisher products as halon replacement.
And now, ALLTEC are now introducing the latest technology of aerosol fire extinguishers with high safety ignition temperatures to prevent false activation and with a highly reliable complete turn-key systems which will be manufactured in compliance to the below standards developed for Aerosol technology.
To further promote and for international normalization, ISO, IMO, NFPA, CEN, AUS, SABS, BS, SASO etc. have formulated the standards for the aerosol application. Russia and China have promulgated related standards. The *establishment and publication* of *these* standards, in turn, allows further promotions in the application and development of aerosol fire extinguishing technology.
The explanation gives a systematic introduction to aerosol fire extinguishing technology in respect of basic concept; theory, development process and product design, and applicable locations in conjunction with the latest development. We hope the explanation herewith can provide the fire control managers, researchers, designers and operators with some basic reference.

At present, with a annual production of more than 200 tons, mainly used in oil storage tank, electronic equipment, communication equipment, power transformation and distribution facility, locomotive and many other applications. 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.

Now more than ever before, more and more attention is paid to aerosol fire extinguishing technology as a halon replacement in the world. This explanation for Aerosol Fire Extinguishing Technology makes a systematic introduction to the technology from the aspect of a basic concept, fire extinguishing theory, construction of fire extinguishing device, engineering design and construction, etc. The information given herewith will prove useful for the fire control designers, constructors and managers correctly understanding aerosol and its beneficial properties using aerosol. No doubt, with the explanations given will play an active role in the development of the aerosol fire extinguishing technology internationally.

With dramatic characteristics and performance such as high efficiency in fire extinguishing, environmentally 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 which are being phased out and banned globally. It is also very apparent that Italy, US, Russia, China, UK, Cyprus and Australia 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.

The Preparation of the text obtained has been compiled with great support. Some data and graphics in this text are cited from various 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 text due to limited time in preparation. We hope that we have given the readers further insight to the superior specifications & application of the aerosol fire extinguishing technology.

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Chapter I Halon Phase-out 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 the gasses are found massed around the earth due to the earth's gravitation forces formed in the atmospheric layer, which is thousands of kilometers thick. There is still rarefied atmosphere at the height of 3000km as probed by sounding rocket. The Existence of 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 we are to the earth, the higher the air density, *90%* of the earth's atmosphere which is within a 10km range from sea.
The atmosphere is an important component of natural environment. Any part of the atmosphere has direct or indirect impact on human existence and development. Its main functions are as follows:

1) Serves as a protection layer for life sustenance on earth and blocking harmful radiations from outer space and the sun;
2) Provides various other gases required for the earth to support life;
3) Has a significant impact on earth's natural environment, such as temperature rise and drop, wind and rain and other atmospheric phenomenon.

Over the long geologic time, the atmosphere molds and the earth's surface is reshaped continually.

(II) Composition of the Atmosphere

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

Chapter II Aerosol Fire Extinguishing Agent .

Section I Basic Concepts

I. Aerosol Extinguishing Agent

The aerosol forming solid particles are capable of fire fighting, it can be used to put out a fire; we call it aerosol fire extinguishing agent.
Aerosol is different from of foam, dry powder or gas in fire fighting. Aerosol particles are usually smaller than 2μm, so the agent is characterized by two features: one is it's high efficiency due to the large surface area; the other is that it can also be used as gas extinguishing agent as total flooding extinction for the reason that the small particles characteristic of gas shall be *free from direction and obstructer* and can reach any corner of the protective space.

Section II Extinguishing Mechanism of Aerosol Extinguishing Agent

I. Combustion Mechanism

Understanding of the extinguishing mechanism of aerosol extinguishing agent begins with understanding of combustion mechanism.

1. Combustion

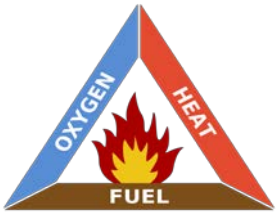
Exothermic reaction is generated by the combustibles and oxidants that forms a flame, glowing and fuming, which is called combustion.

2. Prerequisite of combustion

Combustion of anything should meet three prerequisites: combustible, oxidant, temperature (fire source).

Table 2-3 Bond Energy of Different Covalent Bonds

The relation of the three prerequisites shall be illustrated as in the combustion triangle;



The above combustion triangle represents only flameless combustion, but at normal times, combustion means, flaming combustion which must meet the prerequisites: combustible, oxidant, temperature and unsuppressed chain reaction.

3. Sufficient condition of combustion

Combustion prerequisites do not necessarily result in combustion, so it must have the four sufficient conditions: certain combustible concentration, certain oxygen content, certain ignition heat and unsuppressed chain reaction. These are prerequisite and sufficient conditions for combustion and the fire extinguishing mechanism of fire suppressive agent, is to eliminate one or more of the conditions mentioned above for fire to be extinguished.

4. Combustion mechanism

Take polymers as an example, to illustrate the combustion mechanism and process. Combustion of an organic polymer shall be in five stages:

(1) Heating process: external heat source provides heat for the polymer to increase its temperature; the temperature rise rate depends on the amount of heat quantity provided by the external heat source, volume of contact, temperature of the flame, the specific heat and heat conductivity of polymer.

(2) Degradation process: degradation occurs when the weakest bond in the polymer molecule breaks at a certain temperature, this depending on the bonding energy of the bond. For the magnitude of the covalent bond energy, please refer to Table 2-3. From the Table 2-3, we know that O—O bond is the weakest, amiable to breakage; C=N bond is the strongest, unable to breakage.

5. Decomposition process: crack occurs when strong bonds bread as well as weak ones at a certain temperature, generating low molecular compounds including:

a) Inflammable gas: H_2, CH_4, C_2H_6, CH_20, CH_2COCH_2 and CO;
b) Noncombustible gas: $C0_2$, HCl and HBr;
c) Liquid produce; Liquid produce of polymer de-polymerization;
d) Solid produce: Polymer shall be burnt into coke or produce a harmful smog by incomplete combustion.

Different polymers shall generate different products, but most products are combustible hydrocarbon or toxic and corrosive gas.

6. Ignition process: flame starts when inflammable gas is generated in a decomposition process that reaches a certain concentration while the temperature reaches a burning point or flash point and where their exists an adequate amount of oxygen or oxidant. This is the ignition that starts up combustion.

7. Combustion process: the energy from the combustion shall make active free radicals, which in turn gives rise to a chain reaction, continuously providing combustible sub-

stances to spread the combustion, making the flame more sizable, the reaction process of which shall be expressed in the equation below:

$$RH \text{ ---------- } >R\bullet + H\bullet$$
$$H\bullet + 0_2 \text{ ---------- } >HO\bullet + 0\bullet$$
$$RCH\bullet + 0_2 \text{ ---------- } >RCHO + HO\bullet$$
$$HO\bullet + RH \text{—►} R\bullet + H_20$$

II. Fire Extinguishing Mechanism of Aerosol

Different extinguishing agents have different fire suppressive mechanisms. Eliminating one or more of the four conditions for combustion to occure, one or more of the five stages, namely cutting off the source of a stage or discontinue a chain reaction to stop generating the free radical, this shall be achieved in its purpose of fire suppression. According to the four elements for combustion, the suppressive mechanism of exting- uishing agent can be divided into-, isolation, suffocation, cooling and chemical inhibition.

$C0_2$,IG-541,N_2 :- Suffocation
Water :- Cooling
Foam :-Isolation, Cooling
Halogen alkyl such as FM200,1301,1211,Fluoroform methane Cold ;- Chemical inhibition
Aerosol made by dry powder, Ultra-fine dry powder: - Cooling, Isolation, Chemical inhibition.

1. Fire suppressive mechanism of heat-absorbing temperature reduction.
Solid particles of aerosol product mainly include K_2O, K2CO3 and $KHCO_3$, which shall generate intense heat-absorbing reaction on the flame.
K_2O shall decompose at a temperature higher than 350°C ; K2CO3 with a melting point of 891°C shall decompose if temperature exceeds this point; $KHCO_3$ shall decompose at 100°C and completely decompose at 200°C. Besides, K_2O and C may generate a following heat-absorbing reaction at high temperature:

$$K2O + C \text{ ---------- } > 2K + CO$$
$$2K_20 + C \text{ ---------- } > 4K + C0_2$$

Prior to generating above chemical reaction, these solid particles shall absorb a big quantity of heat from the flame to generate a physical heat-absorbing process as heat is melting and followed by gasification to reach the temperature needed for above reaction. The quantity of heat released by any fire shall be limited to a short time, so the flame temperature shall be reduced if the solid particles of aerosol can absorb partial heat of the flame, and the heat radiated on combustible surface shall be reduced for combustible molecular gasification and splitting gasified molecule into free radical, thus combustion reaction speed shall be inhibited; this shall be more obvious in an fire.

2. Chemical inhibition extinguishing mechanism
Gas phase chemical inhibition: after aforesaid heat-absorbing reaction, the K^+ (Potassium) released from the aerosol solid particles shall exist in the form of vapor or positive ion that has lost a electron. Its compatible competence with active radical group H • , O • and • OH in combustion is larger than that among these radical groups, and it shall generate a chain reaction with these radical groups;

$$K^+ + \bullet OH \rightarrow OH$$
$$K^+ + O \rightarrow KO$$
$$K^+OH^- + \bullet OH \rightarrow KO + H_2O$$
$$KOH + H\bullet \rightarrow K + H_20$$

Such considerable consumption of active radical groups and inhibition of exothermic reaction among the radical groups shall discontinue the chain reaction of combustion to inhibit the combustion process.
3. Solid phase chemical inhibition:

In the previous chapters, aerosol solid particle has a very small diameter (10^{-9}~10^{-6}μm) with a big surface area and surface energy, belonging to typical thermodynamic instable system, and has the trend to reduce its surface energy to a relatively stable state. Therefore, it shall adsorb selectively some charged ions to compensate for the surface of non-saturation force field to reach a certain relatively stable state. As small as they are, these particles are much larger than the cracked products size of free radical and combustibles, so it is adsorptive to active free radical and to combustible cracked products. With collision of combustible cracked products and free active radical group,- the particles shall adsorb these products immediately, and exert a chemical reaction with an active radical group on its surface:

$$K2O+2 \bullet H \rightarrow 2KOH$$
$$KOH + \bullet H \rightarrow HKO+H2O$$
$$KO+ \bullet H \rightarrow KOH$$
$$K2CO3+2 \bullet H \rightarrow 2KHC0_3$$

The above chemical reaction and the combustion of active free radicals shall be consumed as combustible cracked products of particles that are not gasified but shall be adsorbed to make a combustible cracked low molecule product away from the reaction that generates active free radicals, therefore the combustion speed shall be inhibited.
Generally speaking, the suppressive mechanism of hot aerosol is based on cooperation of above two mechanisms, mainly on chemical inhibition.

Section III Performance of Aerosol Extinguishing Agent

I. Ingredients
The ingredients of extinguishing agent shall determine its effectiveness; the quantity, property and granularity of solid phase products shall exert direct effect on the suppressive performance of the extinguishing agent and on the toxicity and environmental protection function; therefore, the study of compositions of aerosol extinguishing agent is the basis of performance of the aerosol extinguishing agents.

Theoretical analysis
For aerosol, the combustible agent and adhesive are substances that can be completely burnt, whose composition elements are mainly C, H, O and N, so in the gas phase, products shall only be all or partial N_2, $C0_2$, CO, NH_3, NO_2.
But in solid phase compositions are only formed by reacting products of oxide agent and other auxiliary agents; due to the small content of other auxiliary agents, these products can be ignored. Solid phase ingredients can be generated by following reaction:

$$KN0_3 \rightarrow K_20 \rightarrow K_2C0_3 + KHC0_3 + CO_2$$

III. Extinguishing Efficiency

1. Definition of extinguishing efficiency
Extinguishing efficiency is an index used to measure actual extinguishing ability of extinguishing agent. Gas agent extinguishing efficiency refers to gas agent quantity needed to suppress a specified type of fire in a unit confined space, expressed as cubic percentage. The Aerosol fire extinguishing agent differs from other gas agents in that it is stored prior to application in the form of a solid mixture of aerosol extinguishant generating agent, therefore, for the sake of convenience in the design calculation, the extinguishing efficiency of aerosol extinguishant generating agent is defined as generating agent mass needed to suppress a specified type of fire in unit confined space, express in the unit of g/m^3, of which, "specified fire" refers to a fire of specific combustible type such as, fire caused by gasoline, diesel oil, cable, crude oil and timber. For different combustible types,

combustion behavior and suppressive difficulty degree shall be varied, therefore, for every extinguishant, its efficiency on different combustible types vary.

2. Review on extinguishing efficiency

In general, different aerosol extinguishants with different brand and recipes have different extinguishing efficiency on different fire sources, usually at 67-150g/m^3. But for common combustible liquid fire, electric fire and combustible solid surface fire, the extinguishing efficiency ranges from 67-100g/m^3. In practical application, for common fires, engineering design quantity is usually 67-100g/m^3 after consideration of safety coefficient in terms described in ISO 15799, EN15276 and NFPA 2010.

IV - Toxicity Index

From the below Table 2-7, the aerosol as a fire extguishant has a far better extinguishing efficiency than any other extinguishing agent.

(1) Theoretical analysis

Table 2-7 Extinguishing Efficiency of Several Common Extinguishing Agent

Name of Extinguishant		1301	1211	HFC-227ea	IG-541	HFC-23	CO_2	Aerosol
Extinguishing Efficiency	g/cm^3	330-470	290—410	530—760	1220	280	1,000-1500	67-100g
	% (Vol. Fraction)	5—7	5—7	7—10	38	3. 2	34	>1

Theoretically, 40% of the solid particles in aerosol extinguishant include mainly metal oxide and carbonate. At present, all aerosol medicament recipes contain no heavy metal salt, so these particles are nontoxic. 60% of the extinguishant product contained in the gas phase as elements are N_2, a small amount of CO_2, H_2O, and O_2 - Due to the uncertainty of the combustion reaction, it may generate minimal toxic gases such as (NO_x , C_nH_{2n+2} and CO). N2 , H_2O and O_2 are nontoxic. When its concentration (volume fraction) exceeds 9%, CO2 shall generate distinct suffocation to humans and animals, but CO2 concentration generated by aerosol products in protective space usually *does not exceed 1%, which is much lower than the 9%,* thus generating no threat to humans and animals. However, the NO_x, C_nH_{2n+2} and CO generated by the incomplete combustion are toxic. The toxicity of NO_2 and CO are as follows:

The effects of CO concentration to the human body is as follows; headache, dizziness and vomit at *1600ppm/20min*. After one hour, coma occurs with danger of death. Headache, dizziness and vomiting with *3200ppm/20min*, and unconsciousness in 30min with danger of death. Headache, dizziness and vomiting at *6400ppm* in 5~10min, and unconsciousness in 10~15min with danger of death.

The effects of NO_2 concentration to human body: toxicity of NO2 is 4-5 times as that of NO Smell at 4.1~12. 3ppm; airway resistance is increased in exposure for 10 min in 20.6ppm; the spread effect in the upper respiratory tract at 53. 4ppm; and pneumonia and pulmonary edema at 267~411ppm.

Based on above toxicity levels which are harmful to human, a safety concentration limit has been worked out; CO < 1000 ppm, NO < 100ppm and NO2 < 80ppm.

(2) Research on a global level on toxicity of aerosol extinguishants

Like other gas extinguishants, the toxicity of aerosol extinguishant is a universally concern. Therefore, a huge amount of experiments have been conducted by researchers from all countries to verify the toxicity of aerosol extinguishant.

The American navy had made experiments with animals exposed to aerosol products. The subjects were exposed to 700L test chamber, aerosol mass concentration at 50g/m^3, exposure time 15~60min, conclusion; no toxic extinguishing agents were present on exposure with the animals, no stimulus or pathological damage to eyes and skin, the only

effect noted was the increased of CO concentration in animal blood which resulted also to the increase of carbonyl heme protein.

Experiments have also been carried out in Russia to determine the toxicity of aerosol extinguishant. In 1 m^3 of fire-extinguishing test chamber, aerosol with different concentration were used to suppress vinyl alcohol

fire in a test chamber; after that, aerosol smog was released in the animal test chamber tank, the animals were lead into a chamber for 12min, and found no obvious toxic reaction.

The American ocean poison detachment of Ohio White-Patson Air Force Base also had conducted deep and systematic study on the toxicity of aerosol. They made use of the many kinds of equipment and methods (such as gas chromatograph, mass spectrograph, infrared spectrometry and x-rays diffraction) to test the samples of aerosol particles and gases, including gas compositions inside test chamber after aerosol extinguishant cooling, non-

Compositions	Numerical Value	Compositions	Numerical Value
N_2/%	78-79	HCl/ppm	0. 0001
O_2/%	18—20	KCl/%	0. 082
$C0_2$/%	2.3	MgCl/%	0. 01
CO/ppm	1520—4480	U_20/%	0. 1
$C_{„}$ H_{n+2} / ppm	1—300		

V. ODP Value

1. *ODP value*

ODP (abbreviated form of ozone depletion potential) value is used to measure destructive ability of ODS (ozone depletion substance) to destroy ozonosphere. It is based on CFC-11 (CCI3F) , set at ODP = l, and ODP value of other ODS is based on how much the fraction value of the ozone depletion ability in proportion to the CFC-11 is, such as 10 for 1301, 3 for 1211, 0.008 for HFC-23, and 0 for HFC-227ea, IG-541 and water mist. Substances with ODP larger than *0. 2 must be banned* from use.

Eight sorts of two substance classifications (CFCs and Halon) that deplete the ozone-sphere, in *The Montreal Protocol* in September 1987 have been extended to ninety-five sorts of seven classifications of substances (CFCs, Halon, CCI4,methyl chloroform, HCFC, HBFC and methyl bromine).

2. *Ozone-sphere and its depletion*

Ozone-sphere lies in the upper atmosphere (stratosphere) 10-50km above the earth surface, most concentrations at 25km are up to 11ppm(mg/ m^3) and forming ozone-sphere with thickness of 3km. It absorbs ultraviolet radiation from the sun, provides a natural shield to prevent ultraviolet radiation and stores energy in the upper atmosphere to regulate the climate. Breakage of ozone-sphere leads to, excessive ultraviolet radiation on earth surface and health risk; temperature change in stratosphere leads to abnormality of earth's climate, affecting plants growth and ecological balance. In recent years, big amounts of NO_2 is generated by alkyl halides compound and human activities. Random discharge of compounds leads to the reduction in ozone-sphere concentration, arousing major concerns for the public. The entrance of the two classifications of compounds, especially alkyl halides into atmosphere, shall be stable and exist with no change in the lower atmosphere (troposphere), and shall cause photochemical reaction when it disperses into ozonosphere to generate two free radicals CI • and Br • , which shall create a radical chain of reaction with the ozone, taking 1301 for an example:

$$CF_3Br + H_2O \rightarrow CF_3 \cdot + Br \cdot$$
$$Br \cdot + O_3 \rightarrow BrO \cdot + O_2$$
$$BrO \cdot + O \rightarrow Br \cdot + O_2$$
$$BrO \cdot + O_3 \rightarrow Br \cdot + 2O_2$$

Experiments show that one Br • or CI • Shall deplete 100,000 ozone molecules to reduce the ozone concentration and destroying the ozonosphere. It is estimated that ultraviolet radiation shall increase *by 2%* if the ozone concentration is reduced by 1%, which may result in 2%~5% increase in morbidity rate of skin cancer. So protection of ozonosphere should be an urgent global mission.

3. ODP value of hot aerosol extinguishing agent

The present aerosol extinguishing agent belongs to non-halogenated agent with no halogen elements in medicament, so it shall not generate halogen free radicals and thus eliminates the condition of destroying ozone; its ODP value is 0, which is completely nondestructive to the ozonosphere.

VI. GWP Value

1. GWP value

The GWP (global warming potential) value is used to illustrate and compare warming effects by all kinds of greenhouse gases on the global climate, which is based on CO_2, so the GWP if other than greenhouse gases depends on the fraction value of its warming ability on global climate and CO_2. For instance, 5800 for 1301, 2050 for HFC-227ea, 5 for FHC-23 and 0 for IG-541.

2. Greenhouse effect and greenhouse gases

Increasing the content of some gases in atmosphere shall elevate the average temperature of the earth, which is called greenhouse effect, and these traces of gases are called greenhouse gases, mainly including more than 30 types, such as, CO_2, CH_4, O_3, N_2O and Freon, etc. Small quantity of solar radiation is absorbed when it permeates through the atmosphere; the rest shall be absorbed by the earth's surface and radiate forth in the form of infrared radiation. This heat shall be absorbed by greenhouse gases in atmosphere (the absorption band of CO2 is 12. 5~17. 0 mm and the other greenhouse gases range between 7~13 mm, all in infrared area), thus preventing the earth heat from emanating to the outer space which in turn elevates the temperature on the earth. Like glass or plastic film cover used in a greenhouse, the effect keeps infrared rays inside the greenhouse from the out-ward radiation, elevating the internal temperature, so the heat preservation and elevation of greenhouse is called greenhouse effect.

Greenhouse gases come mainly from chemical fuel combustion, plant photosynthesis (generating CO_2), muddy pond, swam, fermentation of organics in stock farm (generating CH_4) , incineration (generating N_2O) of nitrogen fertilizer, trees and crops. At present, CO_2 is in the first of primary greenhouse gases, CH_4 and O_3 are the second. Increasing the use of chemical fuel enhances the quantity of CO_2, and in-turn destroying of plantation reduces the CO_2 consumption by plant photosynthesis, thus causing rapide rise of CO_2 content in the atmosphere. According to a investigation, in 1880, CO2 concentration was 284ppm(mg/m^3) , but now it has grown to be 330ppm(mg/m^3) and still increases by 0. 7ppm (mg/m^3) per year. It is estimated that it shall rise by 30% in the next 50 years, elevating the average temperature in extra-tropic region by 2- 3°C , polar temperature by 6-10°C , and causing a global warming climate. In the northern and southern hemisphere, the winter days shall be shorter and damper, summer will be longer and drier. It will also become much drier in the subtropical zone, and much damper in the tropical zone. Oceans shall generate much more heat and evaporate more moisture which will accelerate the air flow, leading to stronger tropical storms by 50% in the near future, tornado's reaching more than 350km/h and with more frequent occurrences. Besides, due to the warming climate, unexpected change shall occur in agriculture and to the ecology of the environment. Some animals and plants shall be endangered to extinction due to in-adaptation to the changing climate. What's more important, the warming climate shall melt the ice and snow and thereby resulting to elevated sea levels. According to calculations, the sea level shall rise by 20~165cm as the global temperature rises by 1. 5~ 4. 5°C , leading to submerge coastal cities and islands and threatening the survival of 1/3 of global population as well as a series of irreversible consequences. Therefore, it should become a common task for the human race to prevent further damage to the greenhouse effect.

3. GWP value of aerosol extinguishing agent
In the gas phase compositions of discharged of hot aerosol extinguishing agent, greenhouse gases CO_2 and N_2O shall generate a greenhouse effect, but their contents are so minor, that is, GWP is 0, equivalent to IG-541.

VII. ALT Value

1. ALT value
The ALT (atmospheric life time) value is used to express the natural life of organics in atmosphere, usually per year as a unit or per day or week for short life, such as 110 years for 1301, 31 years for HFC-227ea, 1 day for HFC -23 and 0 for IG-541.
2. Substance degradation
Degradation refers to the organic decomposition or disintegration process under natural condition by microbe or chemical reaction. Organic is degraded to inorganic and prefabricated into kinds of organic by life activity, which is the basic loop of biogeochemistry in nature. Non-disintegrated substances shall generate damage after being condensed by the food chain, or cause pollution to the environment through various kinds of routes which are destructive to the environment and to the ecology due to the persistence of vast decentralism. On the contrary, degradable or degradation-free substances shall be much less harm full to the environment due to its fast decomposition.
3. ALT value of aerosol extinguishing agent
Very small amount of hydrocarbon compounds exist in aerosol extinguishing agents and the rest is above *99. 9%* of inorganic products which does result to degradation of the environment, in the basic loop of biogeochemistry, their life-time in the environment is only 6-14 days, causing minor pollution to environment, so its ALT value is 0.
Therefore, ODP, GWP and ALT values are the main criterion to evaluate if a product is going to be considered environmentally sound.
The Table 2-15 shows the environmental performance parameters for all kinds of Halon substitutes.

Table 2-13 Environmental performance of aerosol and other common Halon substitutes

Extinguishing Agent	1301	1211	FM-200	IG 541	HFC-23	$C0_2$	Aerosol
ODP	10	3	0	0	0. 008	10	0
GWP	5800	—	2050	0	<5	1	0
ALT	110a	—	31a	0	1 day	120a	0

From Table 2-13, we can determine that ODP, GWP and ALT of aerosol extinguishing agent are equally zero, a perfect Halon substitute.

Comparison of Toxicity Characteristics

The extinguishing mechanism of CO_2 is as follows: discharge bulky CO_2 into enclosed space, reduce oxygen content in air from normal 21% to below 15% to achieve suffocation and discontinuance of combustion. However, the suffocation of CO_2 shall cause deadly harm to human body, due to its designed minimum extinguishing concentration 34%(volume fraction)] much larger than fatal concentration, so inapplicable in places often with people. If it is used, personnel must evacuate from the scene prior to gas release.
The toxicity and cancer-likely property of hepta-fluoro propane is at issue, and whether its side effect is smaller than 1301 awaits further investigation. But FM-200 shall give off hydrofluoric acid in extinguishing process, and its sour gas generation quantity is 8-10 times as that of 1301

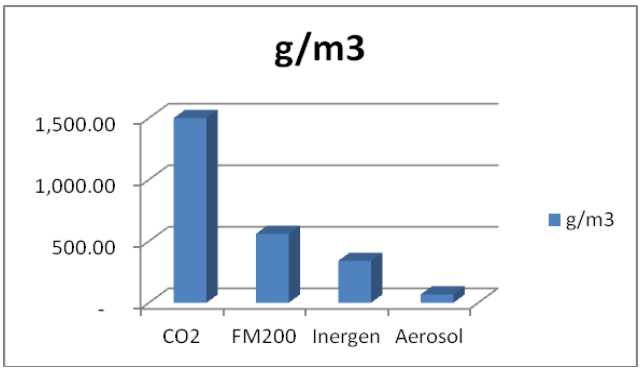
while its factual sour gas generation quantity is about 300ppm(mg/m^3) , much larger than international standard that contact with 50ppm(mg/m^3) hydrofluoric acid in short time is dangerous concentration. We will be at life risk in such environment for l min.
Though the toxicity of trifluoro methane is less than trifluoro methane, its decompositions shall also generate hydrofluoric acid harmful to humans, LOAEL<50%.

Aerosol extinguishing technology depends on the aerosol generated by its combustion reaction to suppress fire. The recipe of aerosol generating agent contains oxidant, consuming no oxygen in air in reaction; there is minimum CO and NO2 in its resultant, slightly toxic to human body. Though the extinguishing mechanism of IG-541 similar to CO2, discharging medicament to enclosed space to reduce oxygen concentration and suffocate combustion for extinguishment, its medicament composed of 52% nitrogen, 40%argon and 8%C02 is mixed with appropriate gas mixture to enable people breathe in anoxic atmosphere, so it actually enhances absorption of oxygen. Under normal circumstances, oxygen content in room air is 21% and CO2 content about 1%. When spraying IG-541 extinguishing agent, oxygen content in room air decreases to about 12.5% while CO2 content increases to 2%-5%; Those people who remain in fire place shall depend on their faster and deeper breath for oxygen, which is slightly harmful to them. From toxic characteristics, only aerosol and IG-541 have minimal toxicity to human body.

Comparison of Effects on Protective Objects
After extinguishment, aforesaid four extinguishing agents shall generate no pollution or leftovers in protective area as well as stable performance and compatibility with equipment, but slightly harmful to some equipment.
According to different storage pressure, CO_2 can be divided into high- pressure and low-pressure CO_2 extinguishing system. As CO_2 discharged, it shall reduce surrounding temperature ("chill" phenomenon) , moisture in air condensed into thick water fog ("dew forming" phenomenon) , and cause defilement to expensive electric equipment. CO2 and carbonic acid dissolved in water shall generate damage to magnetic medium. Meanwhile, the high-pressure of CO2 has high storage pressure, filling density 60% — 68%, design pressure at 15.0 MPa, apt to damage on building enclosure and protective objects.
The hydrofluoric acid, though it is weak acid, generated by heptafluoro propane and trifluoro methane in extinguishing process, is of highly cor- rosivity, easy to cause great damage to specific substance. Like CO_2, heptafluoro propane has low environmental temperature at its nozzle when discharged, moisture in air condensed into thin water fog, slightly destructive. When IG-541 is discharged, the generated gases shall produce no fog or dew, so it causes no damage to protective equipment, property and humans. But, IG-541 belongs to high pressure storage, container pressure up to 15.0 MPa, easy to generate damage on building enclosure and protective objects when the extinguishing agent is discharged.
Aerosol extinguishing agent causes no corrosion or moisture absorption or conductance and thus non-destructive to all electronic equipment in protective areas. As far as damage to protective objects is concerned, aerosol is a perfect Halon substitute.

IV-Extinguishing Efficiency Comparison

The extinguishing efficiency of extinguishing system depends on the extinguishing concentration and extinguishing time. Different extinguishing mechanisms of extinguishing agents result in different extinguishing concentration and time.
CO_2 and IG-541 achieve their fire-suppression by filling inert gases into protective space to reduce the oxygen content; trifluoro methane reaches its extinguishment by oxygen content reduction to suffocation and chemical inhibition; and heptafluoro propane and aerosol achieve their extinguishment purpose by chemical inhibition to terminate combustion reaction.
We can know that the minimum design extinguishing concentration of CO_2 and IG-541 is relatively larger, dosage higher than capacity ratio; the larger the dosage, the slower the extinguishing speed; minimum extinguishing concentration of trifluoro methane is about half that of CO_2; with larger dosage, extinguishing speed is faster compared with CO_2 ; and the extinguishing speed of heptafluoro propane and aerosol is apparently faster. Practice proves that aerosol extinguishing efficiency is highest, 4~6 times as that of Halon 1301.



V- Integrated Costs Comparison

Diversity of integrated costs includes one-time project investment of extinguishing system and operating maintenance costs such as expenses of managerial staff, yearly periodical inspection cost of equipment, medicament replenish installation cost and parts replacement cost. The more complex the system is, the more the equipment there are and the higher the project investment and maintenance cost will be. We can also determine that compared with the other four types of extinguishing systems, the aerosol extinguishing system has its merits; zero storage pressure, simple system, low construction cost and zero maintenance cost, so its integrated cost is superior to that of other four extinguishing systems.

In conclusion, for the environmental protection, toxicity characteristics, extinguishing efficiency, storage and cost, as well as effects on protective objects of the aerosol extinguishing agents and extinguishing systems, the indicator of aerosol extinguishant and extinguishing system is excellent, so it can be believed that with continuous improvement and human awareness of aerosol extinguishing system, it shall become the main and vital force of Halon substitute technology and play its important role in Halon substitute field.

Chapter III Application Area of Aerosol Fire Extinguishing Product

Aerosol, as the new substitute for Halon series having the characteristics of high fire extinguishing efficiency, environmental protection, and now we analyze and discuss the application area of aerosol fire extinguishing product as follows.

Section I Application in Information Industry

I. Communication Base Station

1. Applicable of aerosol product type condensed aerosol fire extinguishing product
2. Analysis of location applicability

Mobile communication base station , as an important location for modern wireless communication network, has been popularized on a large scale in the recent decade, and the products have mainly been adopted in Europe, Australia, US, Russia, China Telecommunication companies for their base stations which have the following main characteristics:

The product is stable in performance and with high efficiency in fire extinguishing and good in insulation, without corrosion; therefore, it shall ensure the safety operation of the communication equipment to the maximum extent, thus, it is an ideal fire extinguishing product.

II. Data Exchange Room, Communication Room

1. The aerosol product type condensed aerosol fire extinguishing product.
2. Analysis of location applicability

The data exchange room (see Fig. 3-2) has many and important data storage devices, if the data is missing, it shall cause great loss. Aerosol fire extinguishing product has become the preferred product in such locations due to its non-absorption of moisture and conductivity and without corrosion.

The communication exchange (see Fig. 3-3) is an important fire extinguishing area requiring heat rejection, the aerosol is able to swiftly extinguish the fire but shall not bring damage to the equipment and instrument in the area.

III. Computer Room and Safety Monitoring Room in Many Fields

Applicable aerosol fire extinguishing product.
Analysis of location applicability Such location is relatively
closed with fewer operators, but with high value of instrument and equipment and high requirement of fire extinguishing, therefore, the aerosol fire extinguishing equipment is applicable to the fire protection;
Such locations are widely distributed among universities and colleges, scientific research institutions, military, property management companies, hotels, operation, government offices etc.

Section II Application in Electric Power Industry

I. Narrow Spaces such as Cable Tunnel (Including underground) Gallery, Cable Trench

1. Applicable aerosol product type Condensed aerosol fire extinguishing product
2. Analysis of location applicability

Power cable is an important part to ensure normal operation of power
plant, substation, and the electric power department and fire-extinguishing organization and scientific research institution attach importance to cable fire protection due to wide distribution of cable in power plants and substations, inflammability of cable, fire spreading performance of cable, fire consequence. The cable tunnel, cable interlayer and cable trench has become difficult in the fire extinguishing due to their narrow space and hidden trouble in fire hazard.
According to the requirement of *"Fire protection design for thermal power plant and substation"* (EN15276) , the cable tunnel, cable interlayer, cable trench fire extinguishing system shall have automatic spray system. Through comprehensive comparison and practice in recent years, the gas fire extinguishing system especially aerosol fire extinguishing product shall have excellent protection for the protective effect on the protected area. Although water fire fighting system has simple structure with less investment, under the cable interlayer, there is distribution device room or other electric equipment room; therefore, there is special water-resistant requirement, hence, the expenses of aerial water fire fighting system and water proofing on the floor and drainage design shall be very high. In addition, after the fire has been extinguished, the cable with damaged part shall be dismounted and changed due to its poor insulation performance, which shall increase expenses in this scenario. The aerosol fire extinguishing system is convenient in construction, low in cost, having high fire extinguishing effectiveness, and shall be harmless to cable, after the fire has been extinguished, only the damaged part of the cable shall be changed, in this way, the cleaning work time and expense after the fire has been extinguished shall be saved, therefore, as to resume the production and bring about huge

social benefit and economic benefit, this advantage has been proved by practical application of aerosol in power industry in recent years and this is due to it's Di-electric properties which can effectively be used on 20-132 kV of high voltage cabling.

II. Important Substation, Switch-Gear Equipment Location

1. Applicable aerosol fire extinguishing product.
2. Analysis of location applicability

The locations include: workshop, substation, transformer room, reactor room, distribution room, accumulator room, high voltage switch room, full enclosed high voltage box substation, relay room, electric de-dusting control building.
The importance of the locations in power plant and power network shall go without saying, through practical test, the aerosol has intrinsic advantage in these locations, especially the full enclosed high voltage box substation unmanned, the aerosol has the advantage beyond compare: automatic starting, total flooding smoke fire extinguishing, high fire extinguishing effectiveness, harmless to equipment, convenient installation, low cost, easy maintenance, high safety etc.

III. Control Device Location

1. Applicable aerosol fire extinguishing product shall be applicable.
2. Location applicability analysis The locations include unit control room, central control room, hoist room, elevator room, and computer room.

The central control room is the heart of the power plant or power network, in which the valuable and high precision electronic equipments are placed, with high fire protection requirement. The aerosol has a high fire extinguishing effectiveness, non-corrosiveness, non-conductance (di-electric), non-toxic and meets the fire protection requirement, with the development in power industry; aerosol fire extinguishing system shall rapidly develop in many other fields of power generation.

IV- Insulation Oil Storage & Turbine Oil Storage

1. Applicable aerosol product type

Hot aerosol fire extinguishing product shall be applicable.

2. Location applicability analysis

The insulation oil and turbine oil storage are important assurance to make the power generator to operate normally, they are also very important in the fire extinguishing field. The aerosol fire extinguishing system shall be started automatically with the characteristics of convenient installation, and storage under atmospheric pressure and easy maintenance, which have solved the problems of narrow and unmanned spaces. The aerosol fire extinguishing system in this case shall also be the best choice.

Section 1 Application in Petroleum Industry

V. - Oil Storage & Oil Tank

1. Applicable aerosol product type Hot aerosol fire extinguishing product.
2. Location applicability analysis

The petroleum storage contains a variety of oil tanks worth millions of EUR's, it is the explosion and fire hazard, and these locations are with strict requirements for safety and fire protection. The aerosol smoke fire extinguishing device has the characteristics of using no water and quick fire extinguishing, therefore it is applicable to oil storage and oil tank area lacking of water resource and power supply with an obvious advantage compared with other

products in the market. In recent years, some practical cases have proved, that aerosol fire extinguishing product is an excellent protector for oil tank. See Fig. 3-9.

VI. Important Control Device Location in Petroleum Industry

1. Applicable aerosol fire extinguishing product shall be applicable.
2. Location applicability analysis

The locations include compressor room, line block valve chamber, and sub-transmission stations and compressor station control room in petroleum transmission pipeline as well as electronic equipment room, computer room, crude oil pump room and turbo-compressor room in oil field and oil refinery.
Compressor room, line block valve room, sub-transmission station, computer room, crude oil pump room and compressor station control room have characteristics of relative closure, unmanned, many precision instruments, important location, therefore, aerosol fire extinguishing units are applicable in these locations.

VII. Offshore Oil Platform

1. Applicable aerosol fire extinguishing product.
2. Location applicability analysis

Offshore oil platforms have many crude oil treatment equipments, automatic monitoring and testing instruments, they are also many unmanned areas, therefore, the aerosol fire extinguishing product shall be the best, applicable to these locations

VIII. Oil and Gas Field

1. Applicable aerosol product type Cold aerosol fire extinguishing product.
2. Location applicability analysis

The locations are open, if they catch fire, the fire behavior shall be impetuous, the gun-fed type and delivery type cold aerosol fire extinguishing product are applicable, in this way, the particles in the product shall quickly absorb the burning free radical to implement chemical fire retardation, and dilute and isolate the oxygen for burning so as to implement the quick fire extinguishing.

Section IV Application in Aerospace

IX. Cargo Compartment

1. Applicable aerosol fire extinguishing product.
2. Location applicability analysis

In general, the aircraft's cargo compartments are against the bottom of the passenger cabin of fuselage, they are separated by fireproof sealing liner material. In a special cargo area of the air-plane, the deck may be used for cargo storage. In passenger and cargo plane, the cargo shall be in part of main cabin, and the movable partition wall shall be adopted to separate the cargo from passenger. Such as the cargo compartment of transporter.

International aviation airworthiness rule requires that the large-sized *cargo compartment* of the commercial aircraft shall have fire extinguishing system. Although the Halon 1301 extinguishing system is not mandatory, in order to meet the requirements in terms of design, testing and appraisement specified in International aviation airworthiness rule, Halon 1301 extinguishing system must be adopted. In practical application, the large-sized cargo compartments of all commercial aircrafts adopt 1301 extinguishing system for fire protection. In addition, the large sized cargo compartments of many military aircrafts also adopt 1301 extinguishing system. For the small compartments (smaller than 28. $3m^3$) , the sealing oxygen

consumption method shall be adopted to retard fire. But, the conclusion based on the accidents in recent years is that even the smaller compartment must have fire extinguishing system.

At present, the relevant organizations and research institutes in the world are adopting the full size aircraft model to conduct test and research to evaluate the halon substitute and substitute technology, including aerosol fire extinguishing system and HFC-125, HFC-227ea as halon substitute. According to the above-mentioned analysis, it is more practical to use aerosol fire-extinguishing system in cargo compartment.

Other Compartment

1. Applicable aerosol fire extinguishing product.
2. Location applicability analysis

The use of halon fire extinguishing system in military aircraft is to protect the compartment between the aircraft fuel tank and the shell to prevent the fuel tank from burning and/or explosion when it is attacked by enemy.
Regarding the halon substitute, Wright Paterson is carrying out a plan program to evaluate halon substitute supported by US Air Force and US Navy, and the selected substitute is HFC-125. And in some test programs, the aerosol fire extinguishing device is also adopted.

X. *Aircraft Fuel Tank*

i. Applicable aerosol fire extinguishing product.
ii. Location applicability analysis

The aircraft fuel tank adopts halon fire extinguishing system for inerting, which is a unique usage mode of military aircraft. Its function is to inert the upper space of the fuel tank before the combat aircraft enters the combat zone to prevent the fuel tank from explosion hazard due to attack during a combat process. In these area's the military have started adopting the halon substitute, the work is arranged and implemented by US Department of Defense, and the aerosol product is also under consideration.

XI- Satellite and Aircraft Tracking Base

1. Applicable aerosol fire extinguishing product.
2. Location applicability analysis

The tracking station has a remote control tracking and tracking antenna. The remote control tracking tower is generally built away from a city, and since the tracking station is unmanned and without external rescue, therefore, it shall have an automatic fire-extinguishing system. Due to water shortage, water fire-extinguishing system shall not be applicable. The tracking antenna is composed of pedestal device, antenna house and parabolic antenna. The tracking antenna is unmanned during normal operation period. And the building on the tracking antenna is movable; its internal space is very narrow. A majority of satellite and aircraft tracking bases adopt halon 1301 fire- extinguishing system for protection. At present, the protection method including aerosol fire extinguishing units as a substitute for halon is under consideration. The locations also includes military monitoring workstation with high safety standards.

XII. Aerospace Launching Control Room, Ignition Chamber, Launching Rack and Launching Platform.

a. Applicable aerosol fire extinguishing product.
b. Location applicability analysis

The aerospace launching control room and ignition chamber have computer system worth hundreds of millions EUR's. The *launching* rack *and* launching platform have electronic equipment and control system for launching work. The most important work in launching

process is "ignition" and "detachment" .The emergency in "ignition" and "detachment" or failure in "detachment" is likely to be disastrous. The equipment and system are considered to be at a maximum "critical state" in the automatic trouble shooting mode, if there is any failure, it may lead to loss of life, damage to control equipment, time-loss, local environment devastation, loss of control program, therefore, these locations shall be protected by halon fire extinguishing system.

Since there shall be a huge investment and potential safety hazard and loss of time, it is important to adopt halon alternative technology in these locations. But the launching center of National Aeronautics and Space Administration (NASA) have already dismounted its halon 1301 fixed fire extinguishing system and adopted halon alternative system. With the development of aerosol fire extinguishing technology, it shall be used in these locations in the near future.

XIII. Wind Tunnel

a) Applicable aerosol product type Hot aerosol fire extinguishing product.
b) Location applicability analysis.

The largest wind tunnel (>24m x 36m) in the world is in Ames research center of NASA, it has 6 fans whose diameter is 12.2m, and 6 motors whose power is 1650kW for driving fans. The power engine compartment of the wind tunnel (see Fig. 4-13) is narrow, which requires regular maintenance by operator. Therefore, the compartment has Halon fire extinguishing system. The location has already considered adopting Halon alternative system including aerosol fire extinguishing product.

Section V Application in Military Field

XIV. Communication Movable Compartment

a) Applicable aerosol fire extinguishing product.
b) Location applicability analysis.

The operating space is relatively narrow with valuable equipments and instruments, the hanging type fire extinguishing device in manual emergency discharge mode may be adopted. At present, the special product has been successfully developed and shall be put into operation in the near future.

XV. Important Control Equipment and inflammables in Submarines and Warship

a) Applicable aerosol fire extinguishing product.
b) Location applicability analysis

These locations include the power engine room and data base room, auxiliary engine room, electronic and electric equipment zone and inflammable liquid storage of warship etc. since these locations have valuable precision instruments and inflammables and explosives in a closed spaces, the fire in which shall be extinguished immediately, therefore, the aerosol fire extinguishing product may be adopted for their protection.

XVI. Electronic Control System and Power Room in Armored Car

a) Applicable aerosol fire extinguishing product.
b) Location applicability analysis

The engine, gear box, transmission shaft and control lever are in the rear of the armored car adopting thermal baffle for sealing, if they catch fire due to attack by enemy, the fire shall be extinguished quickly, therefore, the aerosol fire extinguishing product shall be adopted.

Section III Application in Transportation Field

I. Locomotive, Fuel Oil Engine Room &Generator Room

1. Applicable aerosol fire-extinguishing product.
2. Location applicability analysis

The locomotive has relatively complex space structure; it is difficult to extinguish the fire inside it. Since the aerosol fire extinguishing system adopts total flooding fire extinguishing, after the fire-extinguishing agent has been activated, it shall immediately generated fire extinguishing smoke, and the smoke shall flood the fire space, its fire extinguishing principle is to interrupt the chain reaction, namely the chemical fire extinguishing. In this way, the fire-extinguishing agent shall quickly go round the barrier to fulfill the quick fire extinguishing process. In addition the aerosol fire extinguishing unit is small snd therefore, it is more convenient to install it in the narrow space adopting individualization design.

II. Signal Station and Power Substation along the Railway Line

Applicable aerosol fire extinguishing product.

Location applicability analysis of the aerosol fire extinguishing product, has the characteristics of non- corrosion, non-conductance, harmless to equipment, therefore, it shall meet the requirement of fire protection in these locations. See Fig. 3-16

III. Command Room, Monitoring Room, Communication Building, and Signal Cabin

a) Applicable aerosol fire extinguishing product.
b) Location applicability analysis

The communication building has many valuable precision electronic types of equipment, and the aerosol product is able to quickly extinguish the fire and there shall be minimal residue after the fire has been extinguished, and it shall not corrode the electronic equipment, therefore, the aerosol product shall be the first choice for these locations. See Fig. 3-18 below.

IV. Motor Transport Corps

a) Applicable aerosol fire extinguishing product.
b) Location applicability analysis

The aerosol fire extinguishing product may also be used on auto engine (see Fig. 6-18 above), since the motor shall be kept running, the high temperature and heat inside the engine are likely to lead to fire. The aerosol fire extinguishing product is able to extinguish the fire immediately and protect the vehicle and personnel safety effectively.

V. Ocean Going Fleet and Water Transport Fleet, Container

1. Applicable aerosol fire extinguishing product.
2. Location applicability analysis

The aerosol fire extinguishing product is mainly used in engine chamber, pump room, power engine compartment, control room, cargo compartment of ocean going fleet. The possible scene of fire of the ocean going fleet (see Fig. 3-19) is generally under the deck, with narrow spaces and a complex structure and with many obstacles and the fire in some locations cannot be extinguished by water, for example, oil pipeline etc. the aerosol fire extinguishing system is nontoxic, which shall be in favor of escape of the crew in case of fire on ship and extinguishing of fire is quick and effective, the total flooding fire aerosol extinguishing shall extinguish the fire within the shortest possible time and minimize the damage. The aerosol fire extinguishing system is simple and convenient in installation and is low in maintenance cost with automatic start or manual start modes set in different protected areas, so, it is very convenient to the installer and operator.

Section IV Application in Metallurgy Field

I. Conveyer Belt Channel

a) Applicable aerosol fire extinguishing product.
b) Location applicability analysis

It is difficult to extinguish the fire in the conveyer belt channel due to its narrow space, the common fire extinguishing system can not go into the channel, therefore, it cannot fulfill the fire extinguishing task properly. The fire extinguishing agent discharged by aerosol fire extinguishing system can immediately reach the scene of the fire and extinguish the fire immediately.

II. Electric Basement, Cable Interlayer, Cable Tunnel, Transformer Room, High and Low Voltage Distribution Room

a) Applicable aerosol fire extinguishing product.
b) Location applicability analysis

Safety procedure for steel rolling specifies: motor room building, distribution room, main cable tunnel and cable interlayer should have automatic alarm, smoke fire signal device, monitoring device and fire extinguishing device and fire wall, fire door and self-sealing cable hole,
Regarding new and large sized extension steel mill, its motor room building shall have central monitoring and displaying of a fire signal center.
Oil storage, hydraulic station, lubrication station shall have automatic alarm and fire extinguishing units.
The application of aerosol fire extinguishing system in these locations is the same with that in power industry, the total flooding fire extinguishing, non-corrosion, non-conductance, high fire extinguishing effectiveness and harmless to equipment are the advantages of the aerosol fire extinguishing system. In addition, it is low in installation & construction cost, convenient in installation and low in maintenance cost, which shall be superior to other fire extinguishing systems.

III. Hydraulic Station and Lubrication Oil Storage

a) Applicable aerosol fire extinguishing product.
b) Location applicability analysis

Hydraulic station and lubrication oil storage are class B fire hazard locations in metallurgy industry, and the key fire protection locations, their space is relatively closed and unmanned, therefore, the aerosol fire extinguishing system shall properly protect these locations.

IV. Rolling Unit Room

a) Applicable aerosol fire extinguishing product.
b) Location applicability analysis

Rolling unit room is the location having heavy machinery in steel rolling
field, its space is relatively closed, and the aerosol automatic fire extinguishing product shall be applicable to the location.

V. Ground Electronic Instrument Control Room and Data Bases

a) Applicable aerosol fire extinguishing product.
b) Location applicability analysis

Ground electronic instrument control room and data bases have many precision instruments and some important data, the aerosol automatic fire extinguishing system shall be widely used in these locations due to its quick, effective fire-extinguishing speed and non-corrosion and non-moisture absorption.

Section V Application in Other Fields

The aerosol fire extinguishing product is widely used in many fields, apart from the above-mentioned fields; it is also widely adopted in other fields, since the aerosol fire extinguishing agent is capable of extinguishing fires of Class A, B, C, E & F, that is flammable solids, flammable liquids and flammable gas simultaneously which is also non-corrosive and dielectric.

a) Library and artwork show room
Library and artwork show room have their respective particularity, they contain many valuable articles with non-reproducibility, once these articles are damaged, they shall not be reproduced, and therefore, these locations have particular requirement in fire protection. The liquid fire extinguishing agent and solid fire extinguishing agent are not suitable to these location in fire protection. The aerosol fire extinguishing system shall effectively prevent these locations from fire hazard.

b) Bank data base, state treasury, computer room and monitoring room
Banking system has strict requirement of fire protection, the aerosol fire extinguishing product shall be able to quickly and effectively extinguish the fire and are harmless to the equipments.

c) Fuel oil, gas-fired boiler room
The space of fuel oil, gas-fire boiler room is relatively closed, it is inflammable and in a explosive location, the aerosol fire extinguishing product shall be able to effectively protect these locations.

d) Computer room and monitoring room in hotel, entertainment, food beverage industry
Computer room and monitoring room in hotel, entertainment, and food beverage industry contain many valuable equipment, the aerosol fire extinguishing product is widely used in these locations due to its quick and effective fire extinguishing and non-corrosion and non-moisture absorption properties.
In addition, the aerosol fire extinguishing product is also applicable to kitchen and some local fire extinguishing fields.

I. Ground Electronic Instrument Control Room and Data Bases

a) Applicable aerosol fire extinguishing product.
b) Location applicability analysis

Ground electronic instrument control room and data rooms have many precision instruments and important data, the aerosol automatic fire extinguishing system shall be widely used in these locations due to its quick, effective fire-extinguishing speed and non-corrosion and non-moisture absorption.
Also take note, that this document is part of a dynamic progress were further revisions to follow and information to be added;