APPENDIX A

SUPPLEMENTAL INFORMATION –
SPECIAL HAZARDS FIRE EXTINGUISHING SYSTEMS AGENTS

Halon

A halogenated compound is one that contains one or more atoms of fluorine (F_2), chlorine (Cl_2), bromine (Br_2) or iodine (I). Generally, the presence of fluorine in the compound increases its inertness and stability; the presence of other halogens, particularly bromine, increases the fire extinguishing effectiveness of the compound.

Although a very large number of halogenated extinguishing agents exist, only the following two are usually found on the University of Michigan campus.

1. **Halon 1211** (**Bromochlorodifluoromethane**) $BrClF_2C$: usually found in <u>portable</u> extinguishers, and
2. **Halon 1301** (**Bromotrifluoromethane**) BrF_3C: usually found in <u>fixed</u> extinguishing systems.

Generally, Halon is a colorless, odorless gas with a density approximately five times that of air. It is non-corrosive, non-reactive with water, and stable up to 900°F (482°C). Halon is typically employed in areas such as computer rooms, data storage areas, libraries and museums, where the use of water or solid extinguishing agents could cause secondary damage exceeding that caused by the fire itself. The non-conductive nature of Halon enables it to be used for the protection of electrical and electronic equipment, and its low toxicity allows its use in areas where the egress of personnel may be undesirable or impossible

<u>Extinguishing Mechanism of Halon 1301:</u>

Halogenated fire extinguishing systems that contain a Halon agent will inhibit the chemical reaction of fuel and oxygen, i.e., bromine, iodine and chlorine atoms can act catalytically to inhibit the chemical reaction, with each atom participating, thus stopping the combustion chain reaction.

<u>Toxic Properties of Halon</u>:

The discharge of Halon to extinguish a fire may create a hazard to personnel from the Halon itself and from the products of decomposition. Exposure to the natural agent is generally of less concern than is exposure to the decomposition products. However, unnecessary exposure of personnel to either the natural agent or to the decomposition products should be avoided.

The toxicity of Halon 1211 and 1301 is very low; Halon is not considered a carcinogen or cancer-suspect agent. Since it is heavier than air (vapor density = 5.2), it could, however, cause suffocation by displacing oxygen and thereby reducing its availability. Effects from inhalation at levels between 4 and 10 percent may include mild CNS (central nervous system) effects such as dizziness, impaired coordination, light-headedness, increased heart rate, and ringing in the ears. Tingling in the extremities has also been reported. These types of effects are typically completely reversible upon removal from exposure.

<u>Decomposition Products of Halon</u>:

The main byproducts include;

- halogen acids: Hydrofluoric Acid (HF), Hydrobromic Acid (HBr), Hydrochloric Acid (HCl),
- free halogens: Bromine (Br_2), Fluorine (F_2), Chlorine (Cl_2), and
- possibly small amounts of Phosgene ($COCl_2$) or other Carbonyl Halides (COF_2, $COBr_2$).

These decomposition products have a sharp, acrid odor, even at very low concentrations of only a few parts per million. The amount of decomposition products will depend on the size of the fire, the concentration (quantity) of halon released, the length of time the agent is in contact with the flame or heated surface, and the volume of the room.

- Halon 1301 MSDS
- NIOSH Reference: Halon 1301
- RTECS Reference: Halon 1301

FM-200 (Heptafluoropropane)

Similar to Halon, FM-200 is typically employed in areas where the use of water or a solid extinguishing agent could cause secondary damage exceeding that caused by the fire itself and won't leave behind oily residue, particulates, or water. However, unlike Halon fire suppression systems, FM-200 systems are environmentally friendly, i.e., they have low atmospheric lifetimes, global warming, and ozone depletion potentials.

The U.S. EPA has accepted FM-200 for the use in occupied spaces at concentrations up to 9% by volume and up to 10.5% by volume for normally non-occupied spaces. Therefore, people can be evacuated from the protected area in the presence of FM-200 at design concentrations and is non-toxic when used in accordance to NFPA standards (NFPA 2001, Standard on Clean Agent Fire Extinguishing Systems).

Extinguishing Mechanism of FM-200:

FM-200 extinguishes fires through a combination of physical and chemical mechanisms, e.g., 80% of FM-200 fire fighting effectiveness is achieved through heat absorption and 20% through direct chemical means (action of the fluorine radical on the chain reaction of a flame).

Toxic Properties of FM-200:

In tests, the acute toxicity of FM-200 was shown to be equivalent to that of Halon 1301 and has not been listed by IARC, NTP, OSHA or ACGIH as a carcinogen. FM-200 has been evaluated for cardiac sensitization through test protocols approved by the US EPA and the US EPA classifies FM-200 as acceptable for use as a total flooding agent in occupied spaces.

Since it is heavier than air, it could, however, cause suffocation by displacing oxygen and thereby reducing its availability. Effects from inhalation may include mild CNS (central nervous system) effects such as dizziness, impaired coordination, light-headedness, nausea and increased or irregular heart rate. These types of effects are typically completely reversible upon removal from exposure. Direct eye or skin contact with the liquid or cold gas can also cause chilling or possibly frostbite.

If there was no fire event, the agent can be safely and quickly removed through conventional air handling (turn on the AC, open the doors and windows) and will pose no danger to the respondents or the employees working in the space. FM-200 is safe for people to breathe at normal design concentrations (≤ 9%), e.g., a typical design concentration of 7% (volume/volume) provides the required amount of gas to extinguish a flame.

Decomposition Products of FM-200:

The vast majority (>95%) of applications of FM-200 involve the protection of Class A hazards. Extensive testing shows that the levels of Hydrofluoric Acid (HF) produced in extinguishing typical Class A fires are well below hazardous levels based on the dangerous toxic load (DTL) of HF. Moreover, these levels present no threat to electronics or other sensitive equipment. For fast-growing Class B fires, HF levels may exceed the human DTL depending upon the size of the fire and the volume of the protected area, and HF levels may also present a threat to equipment. In most cases this is a moot point, as the temperatures and levels of toxic combustion products such as Carbon Monoxide, Carbon Dioxide, and smoke render the atmosphere toxic and corrosive even before the discharge of FM-200.

In addition to having the potential to generate HF, FM-200 may generate some Carbonyl Fluorides, Carbon Dioxide (CO_2) or Carbon Monoxide (CO) when exposed to elevated temperatures or open flames.

- FM-200 MSDS

Carbon Dioxide (CO_2)

At normal temperatures and pressure carbon dioxide is an odorless and colorless inert gas with a density of approximately 50 per cent greater than the density of air and will therefore collect in lower elevations and other low-lying areas. It is inert, non-corrosive with no harmful effect on most materials and will not contaminate foodstuff. It disperses leaving no material trace. It has great dielectric strength and can be applied safely to live electrical equipment and will not normally damage sensitive electronic equipment. When it is properly ventilated, the gas escapes to atmosphere after the fire has been extinguished. Carbon dioxide fire extinguishing systems typically store the agent in one of two different ways: in high pressure cylinders, or in low pressure CO_2 tanks.

Extinguishing Mechanism of Carbon Dioxide

Flame extinguishment by carbon dioxide is predominantly by a thermophysical mechanism by displacing oxygen in the atmosphere to extinguish the fire and by providing some cooling in the fire zone.

Toxic Properties of Carbon Dioxide:

Carbon dioxide vapor is heavier than air and can cause suffocation by reducing oxygen available for breathing. It is also physiologically active, affecting circulation and breathing. Breathing moderate to high concentrations may cause headache, drowsiness, dizziness, stinging of the nose and throat, excitation, rapid breathing and heart rate, shortness of breath, muscular tremors, weakness and unconsciousness. No harm is expected from skin exposure carbon dioxide vapor but cold gas, liquid or solid carbon dioxide may cause severe frostbite to unprotected skin.

Decomposition Products of Carbon Dioxide:

Carbon Dioxide when subjected to electrical discharges or high temperatures can decompose into Carbon Monoxide (CO) and Oxygen (O_2).

- Carbon Dioxide MSDS

AFFF

Aqueous Film Forming Foams are based on combinations of fluorochemical surfactants, hydrocarbon surfactants, and solvents. These agents require a very low energy input to produce a high quality fire fighting foam. Consequently, they can be applied through a wide variety of foam delivery systems, primarily extinguishing Class B (hydrocarbon liquid fuel) fires, e.g., gasoline, kerosene, diesel, etc., and may also be used on Class A fires. These agents are biodegradable and environmentally friendly and typically available as 1%, 3%, and 6% concentrates, for use at the proportioning rate of the product, e.g., 1% would be 1 part concentrate to 99 parts water

Extinguishing Mechanism of AFFF:

Fire fighting foam systems suppress fire by separating the fuel from the air (oxygen). Depending on the type of foam system, this is done in several ways:

- Foam blankets the fuel surface smothering the fire.
- The fuel is cooled by the water content of the foam.
- The foam blanket suppresses the release of flammable vapors that can mix with the air.

Toxic Properties of AFFF:

The toxicity varies with the exact AFFF formulation but is generally low for both acute and chronic exposures. Upper respiratory tract irritation may include coughing, sneezing, nasal discharge, headache, hoarseness, and nose and throat pain. While anesthetic or narcotic effects to the Central Nervous System (CNS) may include headache, dizziness, drowsiness, incoordination, nausea, slowed reaction time, slurred speech, giddiness, and unconsciousness.

Decomposition Products of AFFF:

AFFF when subjected to high temperatures or flame can decompose into Carbon Monoxide (CO), Carbon Dioxide (CO_2), Hydrogen Fluoride (HF), oxides of Nitrogen (NO_x) and oxides of Sulfur (SO_x).

- AFFF MSDS

FE-25 (Pentafluoroethane):

FE-25 is a clean agent fire suppressant, is safe for occupied spaces, does not leave a residue, and is electrically non-conductive and noncorrosive. It can be used for Class-A fires and can also be used to suppress Class-B fire hazards for areas that are not normally occupied or that have limited access.

FE-25 is an environmentally preferred alternative to halon, has zero ozone-depletion potential (ODP), does not contain chlorine or bromine and has relatively low global warming potential (GWP) compared with other commercially available agents.

Extinguishing Mechanism of FE-25:

FE-25 extinguishes fires through a combination of physical and chemical mechanisms, i.e., its fire fighting effectiveness is achieved through heat absorption and through direct chemical means by forming free radicals to chemically interfere with the chain reaction of the combustion process.

Toxic Properties of FE-25:

Similar to other clean agents, FE-25 exhibits very low toxicity, has not been listed by IARC, NTP, OSHA or ACGIH as a carcinogen, does not cause developmental toxicity and is not mutagenic.

Since it is heavier than air, it could, however, cause suffocation by displacing oxygen and thereby reducing its availability. Effects from inhalation may include mild CNS (central nervous system) effects such as dizziness, impaired coordination, light-headedness, nausea and increased or irregular heart rate. These types of effects are typically completely reversible upon removal from exposure. Direct eye or skin contact with the liquid or cold gas can also cause chilling or possibly frostbite