INDUSTRIAL FIXED AEROSOL
FIRE SUPPRESSION SYSTEM

DESIGN, OPERATION
& MAINTENANCE
MANUAL

July 2000

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### Document Revision Control Schedule

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FOREWORD

This Manual is intended for use with Pyrogen Industrial Fire Suppression Systems. The systems are designed as fixed systems for unoccupied and normally unoccupied areas.

Pyrogen systems for total flooding applications shall comply with the requirements of the following Standards:

- AS/NZS 4487:1997 Australia/New Zealand Standard Pyrogen Fire Extinguishing Systems; and


For the protection of a specified risk area a specific advice and approval may be required from an appropriate Approval Authority.

Those who design, operate, own and maintain these systems should read the entire Manual. Specific sections would be of particular interest depending on one's responsibility. If there should be any questions regarding this manual, please contact our representatives from a Pyrogen office below or contact the nearest Pyrogen Authorised Representative.

Where required persons who install and commission Pyrogen systems must be approved by the Appropriate Authorities. System Design Approval Certificates must be completed and sent to a Pyrogen office for endorsement prior to supply and installation of a Pyrogen Fire Suppression System.

Approved companies may also be required to supply details to the Approval Authority prior to each installation and provide a Commissioning Certificate upon completion of the installation in the specified risk areas.

The Pyrogen Fire Suppression System requires minimal maintenance, mainly supervision of electrical circuitry, however the system should be inspected at regular intervals to provide maximum assurance that your fire suppression system will operate effectively and safely. Inspection and maintenance should be conducted in accordance with the inspection and maintenance schedule included in this Manual.

This Manual is limited for use with Pyrogen Industrial Fire Suppression Systems and within the requirements and limitations detailed within this Manual.
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FIXED AEROSOL FIRE SUPPRESSION SYSTEM

SECTION 1

GENERAL
SECTION 1. GENERAL

1.1 Terminology

The following definitions apply to this document:

**Actuating mechanism**: automatic or manual activation leading to the physical discharge of the extinguishant.

**Aerosol**: an extinguishant consisting of finely divided solid particles and gaseous matter, these being combustion products of solid aerosol-forming composition.

**Aerosol generator**: same as Pyrogen generator

**Aggressive environment**: where environmental variables such as temperature and/or vibration undergo cycling at or close to the extreme limits of the Pyrogen generator. Corrosive atmosphere may also be a factor.

**Appropriate authority**: a Minister of the Crown, a government department, or other public authority having power to issue regulations, order or other instructions having the force of law in respect of any subject covered by an Industry Standard or, in the case where none of these apply, the owner or the owner’s agent.

**Approved and approval**: approved by, or the approval of, the appropriate authority.

**Automatic**: performing a function without the necessity of human intervention.

**Automatic/Manual Switch**: a device that can be operated before a person enters a space protected by Pyrogen fire suppression system to prevent automatic release of fire extinguishing aerosol. Normal detection sequence is unaffected.

**Class A fires**: fire involving solid materials, usually of organic nature. Can be further categorised into surface burning fires and deep-seated fires. Deep-seated fires smoulder and may combust slowly beneath the surface of the hazard.

**Class B fires**: fires involving liquids or liquefiable solids.

**Class C fires**: fires involving gases.

**Class E fires**: electrically energised fuels.

**Class F fires**: fats and cooking oils.

**Combustion reaction**: a reaction resulting from the activation of a solid aerosol-forming composition, which produces fire extinguishing aerosol.
**Control device:** a device to control the sequence of events leading to the release of the extinguishant.

**Cooling element:** a heat absorbing medium.

**Design concentration (g/m^3):** the mass of Pyrogen aerosol per m^3 of enclosure volume required to extinguish a specific type of fire, including a safety factor.

**Design Factor (g/m^3):** the mass of Pyrogen solid aerosol-forming composition per m^3 of enclosure volume required to achieve the design concentration.

**Design quantity:** the mass of Pyrogen solid aerosol-forming composition necessary to extinguish a fire in a particular risk, including a safety factor.

**Extinguishant:** aerosol produced from Pyrogen generator.

**Generator:** same as Pyrogen generator.

**Holding time:** the period during which the extinguishant is required to maintain a minimum effective concentration.

**Hot Work:** grinding, welding, thermal or oxygen cutting or heating and other related heat-producing or spark-producing operations.

**Inerting:** the prevention of ignition of a flammable or explosive atmosphere by establishing a suitable concentration of extinguishant.

**Location drawing:** a plan of the risk clearly indicating the as-installed location of all Pyrogen generators, controls and maintenance isolate switch.

**Manual:** requiring human intervention to accomplish a function.

**Monitoring:** the supervision of the operating integrity of an electrical control feature of a system.

**Normally occupied area:** an area where, under normal circumstances, humans are present.

**Normally unoccupied area:** an area that is not occupied by humans under normal circumstances but may be entered occasionally for brief periods.

**Operating device:** any component involved between actuation and release.

**Primary release:** release of extinguishant initiated by detection system or manual operation under normal conditions.
**Pyrogen generator:** a device capable of generating the Pyrogen aerosol extinguishant when activated either electrically or thermally. Consists of an electrical and/or thermal activation device, solid aerosol-forming element and cooling element enclosed within a corrosion-resistant casing incorporating an end-plate nozzle.

**Release:** the action leading to the physical discharge or emission of the extinguishant into the enclosure.

**Shall:** indicates that a statement is mandatory.

**Should:** indicates a recommendation.

**Smouldering:** slow combustion of material without visible light and generally evidenced by smoke and an increase in temperature.

**Solid aerosol-forming element:** a mixture of combustible component, potassium salt based oxidant and technical admixtures producing fire-extinguishing aerosol upon activation.

**System isolate switch:** see Automatic/Manual switch.

**Thermal activation device:** a linear fuse, which automatically activates at a rated temperature or when exposed to a naked flame and arranged to activate the solid aerosol forming element.

**Total flooding system:** a fixed fire suppression system, which distributes the extinguishing medium throughout the protected enclosure.
1.2 Pyrogen Product Standards/Testing

Standards/Testing on Pyrogen include the following bodies:

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Description</th>
<th>Date</th>
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| Australian/New Zealand Standard             | AS/NZS 4487:1997 Standard for Pyrogen Fire Suppression Systems  
| US EPA                                      | Listed under SNAP program for total flooding applications in normally unoccupied areas.                                                                                                                   | 21 Jul. 1995   |
| Scientific Services Laboratory (SSL), Australia | File FD41-003 Design Factor Testing  
XF1150/R1  30 day Elevated Temperature Test and Salt Spray Corrosion Test to UL 1058(2nd Edition) -- Standard for Halogenated Agent Extinguishing System Units | 12 Nov. 1996  
Jan. 1995       |
| Waterways Authority Australia               | Pyrogen Fire Protection Acceptance 02/98 Approval for use in commercial marine vessels                                                                                                                       | 4 Aug. 1998    |
| Maritime & Coastguard Agency (MCA)-UK       | Small Boat Machinery Spaces:  
- Codes of Practice for the Safety of Small Commercial Motor or Sailing Vessels up to 21 m Load Line Length;  
- Code of practice for the Safety of Small Workboats and Pilot Boats;  
- Code of Practice for Police Boats;  
| Scientific Services Laboratory (SSL), Australia | Full Listing – Listing Number: afp – 1317                                                                                                             | 11 Apr. 2000   |

1.3 What is Pyrogen?

Pyrogen is a self-generated Aerosol Fire Extinguishing Agent, and is one of the most efficient Halon Alternative products currently available.

The principle of extinguishing action employed by Pyrogen is unique - a special solid chemical, when electrically or thermally activated, produces combustion products - micron sized dry chemical particles and gases. Dry chemical particles - mainly potassium carbonates, and gases - mainly carbon dioxide, nitrogen and water vapour, mix together into an uniform aerosol, which represents an actual extinguishing medium.
Before being released into a protected area, the aerosol propels itself through a solid chemical element, which decomposes absorbing heat, thus ensuring a low temperature discharge and uniform distribution of the aerosol within the area.

As aerosol is self-generated it requires **no pressure cylinders** and does not need to be stored. The aerosol generating chemical reaction provides a sufficient driving force for a rapid discharge and efficient distribution of the aerosol. **No piping is required.**

The solid aerosol-generating element, together with the solid chemical element and activation devices is contained in a small non-pressurised canister with one or two end-plate delivery nozzles. The canisters are called MAG generators and vary in size depending on the mass of solid aerosol-generating element contained in the generator. MAG canisters are very compact and normally placed inside the protected enclosure. Operation of the generator is either electrical automatic, electrical manual or thermal automatic.

When an electric current is applied to the electric activation device or alternatively naked flame or temperature above 175°C activates the thermal activation device, it activates the solid aerosol-generating element, which undergoes a chemical reaction of combustion to produce Pyrogen aerosol. The aerosol propels itself through the chemical element and out of the delivery nozzle into the protected area.

Pyrogen aerosol is whitish gas-like medium that is close in density to air. **Small particle size ensures three-dimensional distribution qualities and long suspension times.**

**Pyrogen aerosol is non-conductive and non-corrosive.**

As Pyrogen aerosol stays in suspension for extended periods, it can be removed from the protected area by any airflow. Solid fraction of the aerosol that has settled can easily be brushed, blown or washed away.

**1.4 Pyrogen Chemical Identity**

The secret to Pyrogen’s power is in two unique formulations contained in Pyrogen canister - the solid aerosol-generating element and the solid chemical element.

The solid aerosol-generating element is a thermoplastic mixture consisting of an oxidiser, a combustible binder and technological additives. The oxidiser is a solid potassium nitrate (KNO$_3$(s)), the combustible binder is a solid plasticised nitro-cellulose (C$_{n}$H$_{m}$N$_{p}$O$_{q}$(s)) and technological additives include carbon (C$_{(s)}$) as an activator of the oxidiser’s decomposition, chemical and mechanical stabilisers and some other ingredients.

When activated the solid-generating element undergoes a combustion reaction, which can schematically be represented as follows:
KNO₃(s) + CₙHᵐNᵖOᵱ(s) + C(s) = KHCO₃(s) + K₂CO₃(s) + CO₂(g) + N₂(g) + H₂O(g)

Combustion products consist of potassium carbonates (KHCO₃, K₂CO₃), carbon dioxide gas (CO₂(g)), nitrogen gas (N₂(g)) and water vapour (H₂O(g)) and represent the actual extinguishing agent.

As the reaction temperatures are high, potassium carbonates are formed in the gas phase, but as the vapour cools, the potassium carbonates condense to a liquid and then a solid. As solid potassium carbonates are produced by condensation, **the particle size is very small - approximately from 1 to 10 microns.** Micron sized solid particles mix with the gaseous carbon dioxide, nitrogen and water into a uniform homogeneous gas-like phase - an aerosol.

Thus, Pyrogen extinguishing aerosol is a suspension of the micron sized solid particles, mainly potassium carbonates, in the gas mix of carbon dioxide, nitrogen and water vapour.

Being a combustion product of the aerosol-generating chemical, Pyrogen aerosol is hot upon formation. Although, Pyrogen aerosol is the most effective in terms of the actual fire extinguishment when in its hottest state, the negative impacts of very high temperatures are obvious.

That is where a second unique formulation - the chemical coolant - comes into action.

When the hot Pyrogen aerosol passes through the cooling element, the coolant decomposes absorbing heat.

Pyrogen chemical element is a polymer composition highly impregnated with endothermic ingredients - substances that decompose at 200-300 °C without melting, generate gases and absorb approximately 400 Cal of heat per one kilogram of their mass.

Application of the Pyrogen cooling element enables provides uniform distribution of the aerosol within the area, which certainly contributes to the reliability and safety of the extinguishment. Moreover, additional amounts of inert gases are formed due to a thermal decomposition of the coolant, which contribute to the effectiveness of the extinguishment.
PYROGEN GENERATOR: CONSTRUCTION

Diagram 1-1
1.5 Pyrogen Extinguishing Action

Pyrogen aerosol is an exceptional fire suppressant.

Pyrogen extinguishing action is achieved primarily by interfering chemically with the fire reaction. Two chemical mechanisms can be underlined:

1. **Removal of flame propagation radicals** - “chain carriers” OH, H and O in the flame zone:

   As it has been mentioned above, the main component of Pyrogen aerosol - potassium carbonates - are formed in the gas phase. In the flame zone they dissociate producing potassium radicals K. Potassium radicals are very active and react with “chain carriers” OH, H and O removing them from the fire zone, and as such disrupting the fire reaction. The chemical action of potassium radicals in Pyrogen is similar to that of bromine radicals in Halons and can be schematically represented as follows:

   \[ \text{K} + \text{OH} = \text{KOH} \]
   \[ \text{KOH} + \text{H} = \text{K} + \text{H}_2\text{O} \]

2. **Recombination of flame propagation radicals** - “chain carriers” OH, H and O on aerosol particle surface:

   Gaseous potassium carbonates condense to a liquid and then a solid form producing a large number of micron sized particles. Being so small, the particles produce a large surface area, where recombination of “chain carriers” takes place:

   \[ \text{O} + \text{H} = \text{OH} \]
   \[ \text{H} + \text{OH} = \text{H}_2\text{O} \]

Secondarily, Pyrogen extinguishing action is achieved by lowering fire temperature to a temperature below which the fire reaction cannot continue (thermal cooling). Several physical mechanisms can be underlined:

1. **Heat absorption** via endothermic phase changes:

   \[ \text{K}_2\text{CO}_3(\text{s}) \rightarrow \text{K}_2\text{CO}_3(\text{l}) \rightarrow \text{K}_2\text{CO}_3(\text{g}) \]

2. **Heat absorption** via endothermic decomposition reaction:

   \[ 2\text{KHCO}_3(\text{s}) \rightarrow \text{K}_2\text{CO}_3(\text{s}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{g}) \]
3. *Dilution of the fire combustion zone by the aerosol cloud* (additional fuel molecules cannot participate in the combustion process); physical hindrance to flame propagation (aerosol particles slow down velocity of a flame front propagation) and etc.

The extremely high surface area of the micron-size aerosol particles increases the likelihood of radical recombination and heat absorbing reactions, thus ensuring rapid extinguishment with a small amount of agent.

*Pyrogen has the lowest extinguishing concentration known among commercially available agents* - flammable liquids (class B fires) are extinguished at the design factor of 100 g/m$^3$ compared to 330 g/m$^3$ for Halon 1301.

*The high rate of aerosol discharge ensures a tremendous knockdown effect.*

*Micron sized aerosol particles exhibit gas-like three-dimensional qualities* that allow the agent to rapidly distribute throughout enclosure and reach the most concealed and shielded locations. Homogeneous distribution is achieved in a matter of seconds, while long holding times all help to prevent fire re-ignition.

Pyrogen aerosol is suitable for the protection of a variety of potential fire hazards, including those involving flammable liquids, combustible solids, oils and energised electrical equipment. Like all total-flooding agents, *Pyrogen aerosol is most effective when used in an enclosed risk area.*
### 1.6 Pyrogen and Competitive Products

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<th>ATMOSPHERIC LIFETIMES (years)</th>
<th>TOXICITY</th>
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<td>H₂O</td>
<td>100%</td>
<td></td>
<td></td>
<td>NIL</td>
<td>-</td>
<td>PHYSICAL</td>
</tr>
<tr>
<td>CHEMICAL POWDERS</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>LOW</td>
<td>- 1400-1800</td>
<td>CHEMICAL OR PHYSICAL</td>
</tr>
</tbody>
</table>
1.7 Pyrogen Applications and Limitations

Pyrogen may be used as a total flooding fire suppressant for unoccupied and normally unoccupied areas to fight fires of classes A, B, C, E and F.

For class C fires consideration should be given to the use of vapour detection, explosion venting or explosion suppression systems where an explosion potential may exist, owing to the possible presence of gaseous, volatile or atomised fuels either before or following a fire. It may be dangerous, under certain conditions to extinguish a burning jet of flammable gases without first shutting off its supply.

The design factor required to suppress normal fires involving flammable gases and liquids at atmospheric pressure shall apply if it can be shown that a potentially explosive atmosphere cannot exist in the enclosure either before or as a result of the fire.

The minimum design factor for Classes C, E and F fire hazards shall be determined by test as part of a listing program.

An unoccupied area is an area that is not occupied by humans under any conditions.

A normally unoccupied area is an area that is not occupied by humans under normal circumstances but may be entered occasionally for brief periods.

Total Flooding Applications: May be used where the hazard is within an enclosure that will permit the establishment of the required concentration and the maintenance of that concentration for the required period, for example, for-

- **Marine**: machinery spaces, engine rooms.
- **Transport**: engine compartments.
- **Aviation**: aircraft dry-bays, cargo compartments, engine nacelles.
- **Industrial**: enclosed flammable liquid storage, storage tanks & processing areas.
  - enclosures such as rooms, warehouses, garages, control rooms, engine rooms, vaults.
  - enclosed machines, data processing equipment, mining equipment.
  - enclosed electrical hazards such as transformers, control cubicles, switchboards, circuit breakers & rotating equipment.
  - security boxes (ATM, tender & post boxes) & remote locations.
**Pre-engineered Packaged Systems:** Designed and tested for a specific application.

- *Modular package system:* up to 10 m³.
- *Four wheel drive package system:* up to 3 m³.
- *Marine package system:* up to 20 m³ with dedicated electrical manual release panel.

**Limitations of Pyrogen Systems:**

Pyrogen systems are not suitable for fires involving the following:

- Certain chemicals or mixtures of chemicals such as cellulose nitrate and gunpowder, which are capable of rapid oxidation in the absence of air.
- Reactive metals such as sodium, potassium, magnesium, titanium, zirconium, uranium, and plutonium.
- Metal hydrides or metal amides.
- Chemicals capable of undergoing auto-thermal decomposition such as certain organic peroxides and hydrazine.
- Pyrophoric materials such as white phosphorous or metal-organic compounds.
- Oxidising agents such as nitric oxides and fluorine.

**Non Enclosed and Local Applications**

Where a fire hazard requires a local application, due to the protected area being an open space or one with high leakage rates, special application and engineering of the Pyrogen product will be required. In these instances the local main Pyrogen office should be contacted.

**Electrical Machinery/Equipment:**

*In the event of fire due to electrical hazards, power to the electrical machinery/equipment must be cut-off prior to operation of the fire protection system for effective suppression of fire.*
1.8 Pyrogen Safety Data

Visibility: Pyrogen is intended to be used in normally unoccupied areas principally due to the high obscuration caused by the aerosol during and after discharge.

Oxygen Levels: Pyrogen chemically attacks the fire, breaking the flame chain reaction. It does not extinguish fires by oxygen depletion. After discharge, oxygen levels will remain at or about normal.

Toxicity: Inadvertent exposure to Pyrogen aerosol should always be avoided. Toxicoological information refers to an inadvertent exposure to the aerosol in the event of accidental discharge in a non-fire situation.

The main ingredients of the Pyrogen aerosol are solid potassium carbonates, nitrogen gas, carbon dioxide gas and water vapour. At normal extinguishing concentrations these products present little health hazard to personnel. However, small amounts of potentially hazardous by-products of the aerosol-generating combustion reaction, such as carbon monoxide and nitrogen oxides will be produced. Their actual concentrations depend on Pyrogen design factor used and type of enclosure under protection. Their toxicoological characteristics depend upon the actual concentrations achieved and duration of exposure.

Exposure to a Pyrogen design factor of 100 g/m³, which is typical for class B fires in total flooding applications, for up to 5 minutes, is normally considered to represent a minor risk to personnel and may cause only moderate local irritation of the upper respiratory tract and to the eyes.

Post Fire Exposure: One of the key advantages of Pyrogen over Halon 1301 and over some of the replacement agents available, is that Pyrogen does not produce toxic and highly corrosive halogen acids when exposed to fire or hot surfaces. Safety requirements dictate, however, that unnecessary exposure to post-fire atmospheres should be avoided. CAUTION! Venting of the post-fire atmosphere should be to an open-air area, where possible, to prevent the inadvertent exposure of personnel to any combustion products of the fire and aerosol-generating reaction.

Thermal Hazard: There is a potential hazard of high temperatures (250°C+) of Pyrogen aerosol at the end-plate nozzle, but within the minimum clearance (Xm) from the discharge nozzle as specified for every type of MAG generator, the temperature does not exceed 75°C. Those distances should be observed during installation. For further information please see Section 2.10.

Immediately after discharge the generators can be hot, therefore, protective gloves should be worn before handling generators up to 15 minutes after discharge.
**Hot Work:** As naked flame or prolonged exposure to temperatures above 400°C may cause activation of the generators, *hot work must not be carried out within the vicinity of any generator*. If so they shall be removed prior to any hot work being carried out.

**Thermal automatic operation:** *Pyrogen thermal initiating device (fire conducting cord) may be used in unoccupied areas only.*

**Re-entry:** Following the use of Pyrogen, *personnel should not enter the protected area until it has been thoroughly ventilated.* Exposure to the fire by-products and extinguishant mixture should be avoided. Wearing a respirator or other available means of protection may be required should it be necessary to enter the area before it is fully ventilated.

**Clean-up:** Following a system discharge the aerosol particles that have settled should be vacuumed, blown, brushed or, if appropriate, washed away. *Protective gloves and goggles should be worn.* A respirator or mask may be required.

Large amounts of residue that is allowed to absorb moisture may become electrically conductive over a period of time.

**Dangerous Goods Classification:** Pyrogen is a Class 4.1 article in accordance with the United Nations Dangerous Goods Classification Code.

**CoSHH Statement:** A by-product of Pyrogen aerosol-generating combustion reaction are fine potassium carbonate particles, small enough to be respirated by persons not wearing RPE. *There are no known toxicological long term effects* of these soluble micron sized particles, and physiological effects of deep lung penetration are usually a concern for *insoluble* sub-micron particles as they can interfere with pulmonary functions.

However, there are clear European guidelines controlling the exposure of persons to fine particles, irrespective of their nature. Further information is available in BS EN 481:1993 & BS EN 451:1993, and in CoSHH supportive documents EH40/98 & EH44 and MDHS 14/2.

**Noise.** *The sound output & frequency at the time of activation and during discharge is similar to that produced by other extinguishing agents.* Consequently, *no specific precautions need to be taken.*
1.9 Pyrogen Environmental Characteristics

*Pyrogen does not affect earth’s ozone layer*, since it does not contain chlorine or bromine in its molecular structure.

Ozone Depleting Potential (ODP) is a calculated ozone depletion per unit mass of material released relative to a standard, normally CFC-11 (CCl₃F).

**Ozone Depleting Potential (ODP) of Pyrogen is zero.**

Contribution of Pyrogen to global warming is negligible, since the only one component that could contribute to global warming - carbon dioxide - is present in minor quantities at normal extinguishing concentrations.

Global Warming Potential (GWP) is a calculated change in warming resulting from the emission of a unit mass of a chemical relative to that of a reference. In the past CFC-11 was often used as a reference; carbon dioxide is now typically used.

The GWP depends on three variables:

1) the integrated infrared radiation absorption spectrum band strength.

2) the location of the infrared bands; and

3) the atmospheric lifetime

*Global Warming Potential (GWP) of Pyrogen relatively to carbon dioxide is zero.*
### 1.10 Pyrogen Technical Characteristics

**Chemical Composition of Solid Aerosol-generating Chemical**

- potassium nitrate: 62.3 mass %
- plasticised nitro-cellulose: 22.4 mass %
- carbon: 9 mass %
- technological admixtures: 6.3 mass %

**Chemical Composition of Aerosol**

- solid phase (potassium carbonates mainly): 7 g/m³
- nitrogen gas: 70 vol. %
- carbon dioxide: 1.2 vol. %
- carbon monoxide: 0.4 vol. %
- nitrogen oxides: 40-100 ppm.

**Min System Design Factor**

- class B and surface class A fires: 100 g/m³
- dense cable fires: 200 g/m³

**Min Particle Size**

- 1 micron

**Min/Max Suspension of Aerosol**

- 30 / 60 min

**ODP**

- 0

**GWP**

- 0

**Obscuration**

- high

**Toxicity**

- low

**Temperature range of application**

- from -50°C to + 65°C

**Humidity range of application**

- 0-98 %, non-condensing

**Electric activation:**

- nominal resistance: 2.5 - 4.5 Ohms
- activation current: 400 milliamps
- maximum test current: ≤ 50 milliamps / 5 min
- supervisory current: less than 5 milliamps
- actuation time: 2 milliseconds

**Dangerous Goods Classification**

- 4.1 class, category C

**Service Life**

- 5 - 10 years
SECTION 2:

SYSTEM DESIGN FOR TOTAL FLOODING APPLICATION
SECTION 2. SYSTEM DESIGN FOR TOTAL FLOODING APPLICATIONS

2.1 General

The Pyrogen system of aerosol generators distributed within the risk eliminates the complications associated with traditional gaseous agent systems. Pyrogen does not require pressurised cylinders of liquefied gas, traditional pipe and nozzle networks, or engineered hydraulic calculations to determine nozzle orifices.

The Installer only needs to determine the size and number of Pyrogen generators required as well as their location within the enclosure. A System Design Approval Certificate has been included in Appendix A (Form 1) which gives a step by step guide on how to carry out these simple design calculations.

2.2 Design Methodology

The outline for the design of a Pyrogen total flooding fire suppression system generally involves the following at a minimum:

1. Identify all possible hazards within the protected enclosure. Please refer to Section 1.7 for the list of fire hazards/fuel types that are unsuitable for use with Pyrogen. For fire hazards/fuel types not covered in Section 1.7, please refer the query to an Authorised Pyrogen representative.

2. Identify possible points of agent loss within the protected enclosure

3. Determine volume of the protected enclosure. It may be necessary to derive the net protected volume in enclosures containing large impermeable structures/machinery. Identify if the required coverage extends to the ceiling void and/or raised floor and determine the protected volume for these.

4. Calculate the quantity of agent required for the hazard and fuel type within the enclosure. Factors such as non-closable openings, forced ventilation, low altitude, low temperature and other conditions may affect the quantity of agent required.

5. Select the model and quantity of generators required to achieve the minimum design quantity.
2.3 Design Factor

Pyrogen design calculations refer not to the design concentration of the actual extinguishing agent - aerosol, but to the design factor, which is the mass of solid aerosol-generating element per unit of enclosure volume required to extinguish a specific type of fire, including a safety factor.

Pyrogen design factor is expressed in g/m³.

Pyrogen minimum design factor for Class B fires, involving flammable liquids such as petrol, diesel, hydraulic oil and automotive distillate is 100 g/m³.

Pyrogen minimum design factor for Class A surface fires, involving non-smouldering combustible solids such as wood, textile and ordinary plastics is 100 g/m³.

Pyrogen minimum design factor for Class A non-surface fires, involving dense cables is 200 g/m³.

Advice from Pyrogen Corporation or authorised Pyrogen Representative should be sought for any fire/fuel type not covered by the above minimum design factors.

2.4 Design Quantity

For normal total flooding applications based on a static volume enclosure with all openings sealed and all ventilation systems shut down prior to Pyrogen discharge, the total flooding quantity is determined as follows:

\[ \text{Total Flooding Quantity (g)} = \text{Design Factor (g/m³)} \times \text{Enclosure Volume (m³)}. \]

Total Flooding Quantity refers to the total mass of solid aerosol-forming composition required to suppress fire in a given volume, including safety factor.

2.5 Number of MAG generators

For normal total flooding applications based on a static volume enclosure with all openings sealed and all ventilation systems shut down prior to Pyrogen discharge, the number of MAG generators is determined as follows:

\[ \text{Number of MAG} = \frac{\text{Total Flooding Quantity (g) [as calculated in Section 2.4]}}{\text{The mass of the solid aerosol-forming composition in one MAG generator} \times \text{efficiency Coefficient of MAG generator}} \]
The above calculation refers to the same size of MAG generators only. However, different sizes of MAG generators may be selected, in which case the total mass of aerosol-forming element shall be not less than the Total Flooding Quantity.

Please refer to Section 2.6 for a complete list of Pyrogen MAG generators available.

The type of MAG generator selected is typically based on several considerations as follows:

1. **Height of Protected Enclosure**: MAG generators chosen must be appropriate for the height of the protected enclosure. Please refer to Section 2.10 for the height limitation list.

2. **Minimum Clearance**: minimum clearance is an essential criteria to ensure that the possibility of damage due to heat of the discharge is minimised. Please refer to Section 2.10.

3. **Distribution of Aerosol**: Although Pyrogen aerosol has the three-dimensional distribution of a gas, the even and rapid attainment of the minimum extinguishing concentration throughout the protected enclosure would obviously be desirable. E.g. In applications such as the protection of cable ducts and trenches, which are typically long and narrow, it would be appropriate to select several smaller units and spread them out evenly along the protected volume although one large unit may fulfil the agent quantity requirement.

4. **Mounting Locations**: Certain protected enclosures may have very specific permissible mounting locations. This may influence the quantity and orientation of the units selected.

5. **Cost Factors**: The price/m$^3$ of the different MAG units may differ. The best cost option without sacrificing technical requirements are the elements of good design.
2.6 Pyrogen Range

Pyrogen comes in a form of small non-pressurised canisters with one or two end-plate delivery nozzles. The canisters are called MAG generators and vary in size depending on the mass of solid aerosol-generating element contained in the generator. Technical parameters of the current range of MAG generators are as follows:

| Parameter                                  | MAG  \\
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mass of generator, g</td>
<td>02</td>
</tr>
<tr>
<td></td>
<td>125</td>
</tr>
<tr>
<td>2. Mass of aerosol-forming element, g</td>
<td>20</td>
</tr>
<tr>
<td>3. Efficiency Coefficient of unit</td>
<td>1</td>
</tr>
<tr>
<td>4. Max protected volume m³, class B fires</td>
<td>0.2</td>
</tr>
<tr>
<td>5. Nozzle outlet</td>
<td>bi</td>
</tr>
<tr>
<td>6. Length of generator, B (mm)</td>
<td>120</td>
</tr>
<tr>
<td>7. Diameter of generator, A (mm)</td>
<td>30</td>
</tr>
<tr>
<td>8. Discharge time, s</td>
<td>&lt;3.5</td>
</tr>
</tbody>
</table>

* Based on Design Factor of 100g/m³
Diagram 2-1: Typical Construction of Pyrogen Generators
Mag-11, Mag-12, Mag-13, Mag-14, Mag-15, Mag-16 & Mag-17
Diagram 2-2: Typical Construction of Pyrogen Generators
Mag-1, Mag-2, Mag-3, Mag-4 & Mag-5
2.7 Minimum Holding Time

Upon Pyrogen discharge a minimum holding time of 3 minutes should be allowed for fires involving flammable liquids (class B fires) and non-smouldering combustible solids (class A surface fires).

For fires involving electrical cables and smouldering solids the minimum holding time should be extended to 10 minutes.

2.8 Enclosure Requirements

The area of non-closable openings shall be kept to a minimum. The presence of unclosable openings in the ceiling should be avoided. The total area of unclosable openings should not exceed 1 % of the total area of the protected enclosure.

Air-handling systems serving the protected area should generally be shut down or isolated by dampers.

Any services within the enclosure, such as fuel valves and pumps, heating appliances and others which if left running would impair the efficiency of Pyrogen, shall be shut down prior to or simultaneously with the release of the extinguishant.

For tight enclosures, venting of an enclosure may be necessary to relieve pressure build-up due to the discharge of large quantities of extinguishant. For calculations to determine the minimum area necessary for free venting, the following formula may be used:

\[ X = 0.3 \times Q \times v' / \left( \Delta P \times v \right)^{0.5} \]

Where:
- \( X \) = free venting area, in \( m^2 \);
- \( Q \) = Pyrogen discharge rate, in kg/s (should be taken as a total flooding quantity over discharge time);
- \( v \) = specific vapour volume of Pyrogen at 101 kPa absolute pressure and enclosure temperature, in \( m^3/kg \) (0.7 at 50 °C);
- \( v' \) = specific vapour volume of Pyrogen/air mixture being vented at 101 kPa absolute pressure and enclosure temperature, in \( m^3/kg \) (0.89 at 50 °C);
- \( \Delta P \) = pressure drop across a venting area, in kPa (normally 0.6 for strong enclosures, 0.4 for medium strength enclosures)

Taken \( \Delta P = 0.6 \) kPa, the above formula can be simplified as follows:

\[ X = 0.287 \times Q = 0.287 \times m/ t \]

Where:
- \( m \) = mass of aerosol-forming composition, kg
- \( t \) = discharge time, s
2.9 Design Quantity Calculations - Special Conditions

The Pyrogen design quantity shall be adjusted to compensate for any special conditions such as un-closable openings, forced ventilation, altitude substantially below sea level, temperatures substantially below 0°C or other causes of extinguishant loss.

Sealed Enclosures

Most applications of Pyrogen are based on a static volume enclosure with all openings sealed and all ventilation systems shut down prior to Pyrogen discharge.

Often the ventilation system does not shut down but instead is dampened to allow recirculating air (without make-up air) to continue cooling equipment and promote the mixing of Pyrogen aerosol and air. Total flooding quantities are still based on a static volume for these applications. However, in this instance, it may be necessary to include the volume of the ventilation ductwork in addition to the volume of the enclosure.

Effects of Altitude

Unlike gaseous extinguishants, where volumetric concentrations are used for design calculations, Pyrogen total flooding applications refer to mass concentration only. As such, altitude has no effect on the design factor calculations. However, the parameter that may be affected by altitude is the extinguishants’ gas-like three-dimensional distribution in a given enclosure.

At elevations above sea level, Pyrogen aerosol expands to a greater specific volume because of the reduced atmospheric pressure. Hence, a system designed for sea-level conditions will provide, at the same design factor, a higher coverage at elevations above sea level. However, a reduction in extinguishant quantity is not recommended as it may result in lower extinguishant performance.

For elevations below sea level, Pyrogen may compress to a lessor specific volume because of increased atmospheric pressure. This may result in lower coverage compared to that achieved under sea-level conditions, the likelihood of this should be low due to a high velocity and elevated temperature of aerosol being released.

At elevations substantially below sea level, the quantity indicated at sea-level conditions could be increased to compensate for a lower coverage. Design factor determined at sea level shall be multiplied by correction factor given in Table 2-1 to obtain correct values.
### TABLE 2-1

**ATMOSPHERIC CORRECTION FACTORS FOR DEPTHS BELOW SEA LEVEL**

<table>
<thead>
<tr>
<th>Depth (M)</th>
<th>Correction factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>750</td>
<td>1.130</td>
</tr>
<tr>
<td>1 000</td>
<td>1.176</td>
</tr>
<tr>
<td>1 250</td>
<td>1.225</td>
</tr>
<tr>
<td>1 500</td>
<td>1.276</td>
</tr>
<tr>
<td>1 750</td>
<td>1.330</td>
</tr>
<tr>
<td>2 000</td>
<td>1.385</td>
</tr>
<tr>
<td>2 250</td>
<td>1.441</td>
</tr>
<tr>
<td>2 500</td>
<td>1.502</td>
</tr>
<tr>
<td>2 750</td>
<td>1.565</td>
</tr>
<tr>
<td>3 000</td>
<td>1.629</td>
</tr>
<tr>
<td>3 250</td>
<td>1.698</td>
</tr>
<tr>
<td>3 500</td>
<td>1.767</td>
</tr>
<tr>
<td>3 750</td>
<td>1.842</td>
</tr>
<tr>
<td>4 000</td>
<td>1.916</td>
</tr>
<tr>
<td>4 250</td>
<td>1.996</td>
</tr>
<tr>
<td>4 500</td>
<td>2.079</td>
</tr>
</tbody>
</table>

**NOTE:** Main formula used for calculation is –

\[
\frac{P_h(V_h)}{P_o(V_o)} = e^{-\rho_o gh/P_o} \quad \text{...(Eq. 2.2)}
\]

where

- \( P_h(V_h) \) = pressure (volume) occupied by Pyrogen at altitude \( h \)
- \( P_o(V_o) \) = pressure (volume) occupied by Pyrogen at sea level
- \( \rho_o \) = density of Pyrogen at sea level (taken at 1.68 kg/m\(^3\)).
- \( \rho_o = \frac{P_o}{RT} \), rated thermodynamic value of \( R \) for Pyrogen aerosol is 220 J/kg K
Effects of Temperature

Similar to altitude, temperature has no effect on Pyrogen design factor calculations, but it affects the extinguishant’s spatial distribution.

At elevated temperatures, Pyrogen expands to a greater specific volume. A system designed for standard conditions will therefore develop, at the same design factor, a higher distribution at elevated temperatures. Reduction in quantity of extinguishant is, however, not recommended, the reason being as explained above for the effects of altitude.

At lower temperatures, Pyrogen may compress to a lessor specific volume. This may result in lower coverage compared to that achieved under standard temperature conditions. The likelihood of this should be low due to a high velocity and the elevated temperature of aerosol being released.

At temperatures substantially below zero, the quantity indicated at room temperature could be increased to compensate for a lower coverage. Design factor C, determined at room temperature shall be multiplied by the correction factor given in Table 2-2 to obtain correct values.

### Table 2-2

<table>
<thead>
<tr>
<th>Temperature °C</th>
<th>Correction factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>-10</td>
<td>1.042</td>
</tr>
<tr>
<td>-20</td>
<td>1.075</td>
</tr>
<tr>
<td>-30</td>
<td>1.124</td>
</tr>
<tr>
<td>-40</td>
<td>1.172</td>
</tr>
<tr>
<td>-50</td>
<td>1.224</td>
</tr>
</tbody>
</table>

**NOTES:**

1. Main formula used for calculations is –
   \[ V_T = V_o (1 + BT) \]  \hspace{1cm} \ldots (Eq. 2.3)

   where
   
   \( V_T \) = volume occupied by Pyrogen aerosol at temperature, T
   
   \( V_o \) = volume occupied by Pyrogen aerosol at zero temperature
   
   \( B \) = coefficient of expansion taken as \( 3.665 \times 10^{-3} \text{K}^{-1} \) equal to that of air

2. At lower temperatures, a higher degree of aerosol precipitation on cold surfaces should be considered.
**Effects Of Ventilation**

*Pyrogen is recommended for applications in enclosures in which all ventilation systems are shut down prior to extinguishant discharge.*

However, the possibility of Pyrogen discharge into a total flooding enclosure that is ventilated should also be considered. In such enclosures, some extinguishant will be lost with the ventilating air. Assuming that ventilation must continue during and after discharge, a greater amount of extinguishant is required to develop a given concentration. Also, to maintain the concentration at a given level requires continuous extinguishant discharge for the duration of the soaking period.

If an enclosure initially contains pure air, the Pyrogen discharge rate required to develop a given design factor for extinguishant at any given time after the start of discharge is –

\[
Q = \frac{CE}{1 - e^{-Et/V}} 
\]

(Eq. 2.4)

where

- \(Q\) = Pyrogen discharge rate, g/s
- \(C\) = Pyrogen design factor, g/m³
- \(E\) = ventilation rate, m³/s
- \(e\) = natural logarithm base (~2.71828)
- \(t\) = time from the end of discharge to compensate for losses, s
- \(V\) = enclosure volume, m³

The Pyrogen discharge rate necessary to maintain a given design factor of extinguishant is –

\[
Q = CE \quad \text{ ...(Eq. 2.5)}
\]

After the extinguishant discharge is stopped, the concentration versus the time relationship is given by the following equation:

\[
C = C_o e^{-Et/V} \quad \text{ ...(Eq. 2.6)}
\]

where

- \(t'\) = time after stopping discharge
- \(C_o\) = initial concentration (design factor)
**Example 1:**

Develop Pyrogen aerosol concentration adequate to a design factor of 100 g/m³ in 10 s for an enclosure volume of 20 m³, with a ventilation rate of two air changes per minute, as follows:

\[ C = 100 \text{g/m}^3 \]
\[ E = 20 \times \frac{2}{60} = 0.67 \text{ m}^3/\text{s} \]
\[ V = 20 \text{ m}^3 \]
\[ t = 10 \text{ s} \]
\[ Q = \frac{100 \times 0.67}{(1-e^{-0.67 \times 10/20})} = 235 \text{ g/s} \]

Quantity required therefore, 235 g/s \times 10 \text{ s} = 2350 \text{ g}.

Possible quantity and types of Pyrogen generators therefore, 2 MAG-4 + 1 MAG-5. As minimum discharge time of MAG-4 is 7 s and the MAG-5 is 5 s, the generators have to be activated in series to keep the total discharge time at 10 s.

**Example 2:**

Calculate the discharge rate and total quantity of Pyrogen required to maintain the concentration as achieved in Example 1 for 3 min.

\[ C = 100 \text{ g/m}^3 \]
\[ E = 0.67 \text{ m}^3/\text{s} \]
\[ Q = CE = 100 \times 0.67 = 67 \text{ g/s} \]

The quantity required is therefore, 67 \times 180 = 12,060 \text{ g or 12 kg}.

At least 12 additional Pyrogen generators MAG-4 would be required to be activated in series to maintain aerosol concentration adequate to 100 g/m³ design factor for 3 min.

**Compensation for Leakage through Enclosure Openings**

Occasionally, a Pyrogen total flooding system is designed for an enclosure with openings that cannot be closed. An example may be a conveyor belt penetrating an enclosure wall, yet even these openings can sometimes be closed using inflatable seals. Pyrogen discharged into an enclosure for total flooding will result in an air/extinguishant mixture that has a lower specific gravity than the air surrounding the enclosure. Therefore, any openings especially in the ceiling and higher portions of the enclosure will allow Pyrogen aerosol to flow out. There are two methods of compensating for unclosable openings; extended discharge and initial overdose.
Extended discharge involves a continuous addition of Pyrogen at a rate, which will compensate for leakage out of the enclosure during the required soaking period. The initial overdose method provides for an adequate overdose of Pyrogen to assure a pre-established minimum of extinguishant at the end of the desired soaking period.

**IMPORTANT! CARE SHOULD BE TAKEN TO PREVENT ANY POSSIBILITY OF PERSONNEL EXPOSURE TO THE HIGH INITIAL CONCENTRATIONS OF PYROGEN AEROSOL.**

Estimation of Pyrogen leakage through enclosure openings during the soaking period, and hence, the amount of extinguishant required for compensation, could be effected by using the following equation:

\[ m(t) = m_o (1 - e^{-\frac{2RTAGt}{V}}) \]  

…(Eq. 2.7)

where

- \( m(t) \) = mass of Pyrogen leakage out of the enclosure through the openings by the end of the soaking period, in kilograms
- \( m_o \) = initial mass of Pyrogen discharged into the enclosure, in kilograms
- \( e \) = natural logarithm base (\( \approx 2.71828 \))
- \( R \) = gas constant, 220J/kg K for Pyrogen
- \( T \) = ambient temperature inside the enclosure after Pyrogen discharge, in K (323 K (50°C) as shown by practical tests)
- \( A \) = leakage area, in m²
- \( t \) = soaking period, in s
- \( V \) = volume of the enclosure, in m³
- \( G \) = geometric constant (see Equation 2.10)

**NOTE: Equation 2.7 has been derived based on the following general formulas and assumptions:**

(a) \( \frac{dm}{dt} = GA\sqrt{2\rho\Delta P} \)  

…(Eq. 2.8)

where

- \( m \) = mass flow in kilograms
- \( G \) = geometric constant (see Equation 2.10)
- \( A \) = leakage area in m²
- \( \rho \) = density in kg/m³
- \( \Delta P \) = pressure difference across the flow path (excessive pressure build up due to the discharge of Pyrogen) in Pa.

(b) Ideal gas behaviour of Pyrogen aerosol, and as such applicability of the ideal gas equation –
\[ PV = mRT \] \hspace{1cm} \text{...(Eq. 2.9)}

(c) \( \Delta P, m, p \) are time dependant parameters so that leakage diminishes with time.

Geometric constant G depends on the geometry of the flow path and openings dimensions as well as on the turbulence and friction.

Geometric constant G is given by the following equation:

\[ G = \frac{KW}{3V} \sqrt[3]{2g_nH^3} \] \hspace{1cm} \text{...(Eq. 2.10)}

where

- \( K \) = orifice discharge coefficient (assumed equal to 0.66 for normal doors, windows, and the like)
- \( W \) = width of opening, in m
- \( g_n \) = gravitational acceleration (standard value), 9.81 m/s\(^2\)
- \( H \) = height of opening, in m
- \( V \) = volume of enclosure, in m\(^3\)

**Example 3:**

Calculate the leakage of Pyrogen aerosol after 30 s in a 10 m\(^3\) enclosure having an opening 20 cm wide by 30 cm high along one wall.

To protect the above volume, one Pyrogen generator MAG-4 with a mass of solid aerosol forming composition being 1 kg is generally required, as follows:

\[ V = 10 \text{ m}^3 \]
\[ M_0 = 1 \text{ kg} \]
\[ W = 0.2 \text{ m} \]
\[ H = 0.3 \text{ m} \]
\[ t = 30 \text{ s} \]
\[ A = HW = 0.06 \text{ m}^2 \]
\[ T = 323 \text{ K} \]

According to (Eq. 2.10) geometric constant G is –

\[ G = \frac{KW}{3V} \sqrt[3]{2g_nH^3} = \frac{(0.66 \times 0.2 \times \sqrt[3]{2 \times 9.81 \times 0.3^3})}{(3 \times 10)} \]

\[ = 0.003202 \] \hspace{1cm} \text{...(Eq. 2.11)}
According to (Eq. 2.7) the leakage of Pyrogen aerosol would be –

\[ m(t) = m_0(1-e^{-\sqrt{\frac{2 RTAG}{V}}}) = 1(1-e^{-\sqrt{(2 \times 220 \times 323) \times 0.06 \times 0.003202 \times 30/10}}) \]

= 0.195 kg

**2.10 Design Limitations**

**Height Limitations**

The Pyrogen extinguishant, being a hot aerosol, has a tendency to rise upward on its release due to buoyancy forces. As such, the aspect of spatial distribution needs to be addressed.

This requires that a height limitation for the protected enclosure be set for each individual Pyrogen generators:

<table>
<thead>
<tr>
<th>MAG-1</th>
<th>MAG-2</th>
<th>MAG-3</th>
<th>MAG-4</th>
<th>MAG-5</th>
<th>MAG-11</th>
<th>MAG-12</th>
<th>MAG-13</th>
<th>MAG-14</th>
<th>MAG-15</th>
<th>MAG-16</th>
<th>MAG-17</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 m</td>
<td>1.25m</td>
<td>2.5m</td>
<td>3.0m</td>
<td>3.0m</td>
<td>3.5m</td>
<td>3.5m</td>
<td>4m</td>
<td>4m</td>
<td>4.5m</td>
<td>4.5m</td>
<td>5m</td>
</tr>
</tbody>
</table>

For large enclosures where several generators are distributed evenly throughout the area, the total height shall not exceed the height limitations for a single generator, unless uniformity of the aerosol distribution within accepted time period has been proved for the greater height by a discharge test.

**Minimum clearances**

Due to a potential hazard of high temperatures (250-600°C) of Pyrogen aerosol at the end-plate nozzle, the minimum clearances from the discharge nozzle for each type of MAG generator should be observed during installation:

<table>
<thead>
<tr>
<th>MAG-02</th>
<th>MAG-1</th>
<th>MAG-2</th>
<th>MAG-3</th>
<th>MAG-4</th>
<th>MAG-5</th>
<th>MAG-11...MAG-17</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 mm</td>
<td>300 mm</td>
<td>400 mm</td>
<td>700 mm</td>
<td>1000 mm</td>
<td>700 mm</td>
<td>1500...2000 mm</td>
</tr>
</tbody>
</table>
2.11 Pyrogen Discharge

Pyrogen aerosol extinguishes the fire chemically by reacting with the flame chain carriers and thereby interfering with the process of combustion. (Please refer to Section 1.5 for a full treatise on the process of flame extinguishment). As Pyrogen does not rely on halogen compounds to react with the flame, it **does not produce corrosive halogen-acid by-products when in contact with flame.**

In order to minimise damage due to the fire, however, the system should be designed to attain its design concentration within the shortest time possible upon actuation of the aerosol generators. An important factor to achieving a rapid and even distribution of the extinguishant depends upon the placement/distribution of the Pyrogen generators within the protected enclosure.
SECTION 3:

SYSTEM DESIGN FOR LOCAL APPLICATIONS
SECTION 3. SYSTEM DESIGN FOR LOCAL APPLICATIONS.

3.1 PYROGEN PACKAGED SYSTEMS.

Local application of Pyrogen fire suppression systems requires preliminary testing to determine quantity of agent, particular size and number of MAG generators as well as their location in relation to the identified hazard.

*In many cases, due to excessive leakage rates and insufficient hold times, special design requirements will need to be considered. In these cases contact your local Pyrogen office for technical assistance.*

For some specific local applications, such as engine compartments of small passenger and commercial cars, design criteria have already been established. Data sheets for Pyrogen pre-engineered Packaged Systems are available from authorised Pyrogen distributors.

Pyrogen Packaged Systems contain a full set of system components required for a specified application.

Pyrogen Packaged Systems may be configured within the range specified with each package and may include all of the operation options.

*Packaged Systems must not be used for any purpose other than its specific applications.*

Packaged Systems can be made up for any type of standardised risks, including some of total flooding applications as well as most of local applications.
SECTION 4:

SYSTEM OPERATION
SECTION 4. SYSTEM OPERATION

Operation of Pyrogen MAG generator is either electrical automatic, electrical manual or thermal automatic.

4.1 Electrical automatic operation

Electrical automatic operation is performed upon activation of the detection circuit initiating a voltage source from the Fire Control / Alarm Panel to the generator(s) electrical activation device.

4.2 Electrical manual operation

Electrical manual operation is performed electrically by manual release point located outside the protected enclosure.

4.3 Thermal automatic operation

Thermal automatic operation is provided by action of an in-built thermal activation device - a linear fire conducting cord, which automatically activates at 175 °C or when exposed to a naked flame and propagates activation to the solid aerosol-forming composition.

For some applications, such as vehicle engine compartments, electrical switchboards and etc, the fire conducting cord may also serve as an automatic detection line connecting MAG generators and running through the most hazardous locations.

For some applications, such as marine, where operation is manual only, the thermal activation device shall be removed.

4.4 System isolate switch

The discharge of electrical automatic Pyrogen generators shall be capable of being prevented by means of a system isolate switch that shall be manually operated when personnel are present in the protected area or the adjacent area which could be rendered hazardous by the discharge of extinguishant.

The system isolate switch shall be situated outside the protected area or adjacent to the main exit from the area and protected from accidental operation.

While the system isolate switch is active and the discharge of the system is inhibited, the fire detection and alarm systems shall continue to function and the system shall return to full automatic control when the switch is reactivated.
The operation of the system isolate switch shall electrically isolate and earth each conductor of the wiring to the extinguishant discharge device and initiate a yellow or amber visual indicator at the Local Control Station and Control and Indicating Equipment.

The purpose of this requirement is to provide a level of protection equivalent to a gas lock-off valve.

4.5 Operating devices

Operating devices such as system isolate switches and ancillary equipment, including shutdown equipment, dampers and door closures, required for successful system performance shall be considered integral parts of the system. All ancillaries shall incorporate manual reset facilities.

4.6 Detection, alarm and control systems, indicating equipment, warning devices

Automatic fire detection, alarm and control systems for Pyrogen as well as indicating equipment and warning devices shall comply with the standard requirements established for a specified risk as specified in AS/NZS 4487:1997.

4.7 Post-fire procedure

After discharge of Pyrogen allow a minimum holding time of 3 minutes for fire hazards involving flammable liquids (Class B) and non-smouldering combustible solids (Class A surface fires). Allow a 10 minutes holding time for fires involving PVC electrical cables and smouldering solids.

Ensure first aid portable fire extinguishers are at hand.

Ventilate the area by operating ventilation system or opening doors. Avoid exposure to the fire by-products and extinguishant mixture. Wearing a respirator or other available means of protection may be required should it be necessary to enter the area before it is fully ventilated.

Enter the area when it is clear of agent and fire by-products, to inspect and ensure that the fire is fully extinguished and there is no danger of re-flash from hot spots or damaged equipment.

Should any residue be left, blow, brush or, if appropriate, wash it away. Be aware, that any residue that is allowed to absorb moisture may become electrically conductive.

Contact your Pyrogen Distributor for a replacement of MAG generators.
SECTION 5:

SYSTEM COMPONENTS
SECTION 5. SYSTEM COMPONENTS

The Pyrogen Fire Suppression System comes complete with MAG generators of a specified size/s, mounting brackets, bracket supports, bolts, nuts and fire conducting cord.

Pyrogen MAG generators are made of marine grade aluminium-alloy, powder coated red. Generator’s mounting brackets are manufactured from mild steel and powder coated red. The MAG-1, MAG-2, MAG-3 and MAG-5 generators are supplied with one bracket for normal use, while the larger MAG-4 generators are supplied with two brackets.

Generators MAG-11-MAG-17 come without brackets as they have mounting clamps welded to their casings.

The Pyrogen generators have been designed to operate in a wide range of temperature and humidity conditions. Operating temperature range for MAG generators is from -50 °C to + 65 °C. Operating humidity range is up to 98 % humidity.

For installations where fire-conducting cord is used, the lowest temperature of application has been limited to -15 °C and the highest to a maximum of +175 °C.

**Generators shall not be subjected, however, to severe weather conditions or to mechanical, chemical or other damage. Where excessive climatic or mechanical exposures are expected, suitable protection or enclosures shall be provided.**

The following Pyrogen accessories are optional and designed to complete Pyrogen System Supply for specific installations, where other components besides those supplied by manufacturer may be required:

- **Fire Conducting Cord** - Designed for an automatic thermal detection of fire and subsequent simultaneous thermal operation of Pyrogen generators. Available in a shielded form, where cord is protected with a special textile braiding.

- **Directional Nozzles** - Designed to constrict and direct the original aerosol flow in a specified application, such as Pyrogen Shut-Down Strangler System

- **Fire Stop Cable** - Shall be used in Pyrogen electrical wiring to prevent shorting of circuitry in an event of fire as well as accidental discharge due to an induction or electromagnetic interference.

- **System Isolate Switch** - Designed for normally unoccupied areas. Is a guarded switch, which prevents a discharge of electrically operated Pyrogen generators. Operated manually. Located outside the protected area.

- **Pyrogen Signs** - Designed for normally unoccupied areas. The following signs are available:
  - Label displayed at the entrance to the enclosure;
  - Instruction Label displayed inside the enclosure;
  - System Isolate Switch Label;
  - Instruction Label displayed at manual release point.

*For more information on Warning and Instruction signs, please refer to Section 7.2.*
SECTION 6:

SYSTEM INSTALLATION
SECTION 6. SYSTEM INSTALLATION

6.1 Prior to installation

- Integrity and resistance of the electric activation circuit

It is important that prior to the installation of MAG generators the integrity and resistance of the electric activation circuit for each MAG generator be checked with the use of a digital multi-meter. The maximum test current shall not exceed 50 milliamps for a period of 5 minutes. The monitoring current shall not exceed 5 milliamps.

Resistance of the electric activation circuit shall be within 2.5-4.5 Ohms.

It is also important to check earth fault of every MAG generator. Earth fault resistance must not be less than 10 MOhm.

- Thermal initiating device

Should automatic thermal operation of the Pyrogen MAG generator be required in addition or alternatively to automatic/manual electric operation, ensure the thermal initiating device has been incorporated in the generator. Please refer to Figure 6-1(b).

Should automatic thermal operation of the Pyrogen MAG generator not be required in addition or alternatively to automatic/manual electric operation, ensure the thermal initiating device has not been incorporated in the generator. Please refer to Figure 6-1(a).
6.2 Incorporation of the Thermal Initiating Device

Prior to commencing any activity with the Pyrogen fire conducting cord please refer to Section 10.5 “Handling Fire Conducting Cord”.

Incorporation procedure for the thermal initiating device is as follows (Fig 6-1):

1) Pull a piece of the fire conducting cord of a desired length through a narrow inlet of a holder (3) so that approximately 50-70 mm of the cord has been inserted.

2) Insert a cone-shaped stopper (4) into the holder so that the fire conducting cord is pulled through a groove in the stopper. Ensure the groove of the stopper is in one line with a groove of an attached catch ring.

3) Knot the fire conducting cord behind the stopper. Ensure the knot secures a firm position of the stopper.

4) Attach one or more tags “Braided fire conducting cord. Avoid naked flame” to the outside portion of the fire conducting cord. Ensure tags are clearly visible.
6.3 Spacing and Location

Once the size and number of Pyrogen MAG generators has been determined, they should be securely mounted on to a bulk head or similar location, observing the following:

- **Even distribution**

**Generators should be evenly distributed within the risk area**, to achieve an unhindered distribution of the agent discharge.

- **Orientation of aerosol discharge**

Aerosol discharge should not be orientated across any route of exit.

Generators should be so oriented to reduce possible thermal damage caused by hot generators and extinguishant discharge. There should be no flammable or highly combustible materials or equipment within a specified minimum clearance from the generator’s nozzle.

If there are any un-closable openings that cannot be avoided such as exits, doors and apertures, aerosol discharge should be directed across the likely fire zone and towards those openings, but not away from them.

- **Clear obstructions**

While Pyrogen aerosol is an extremely penetrating extinguishing agent, severe obstruction of the aerosol discharge pattern should be avoided. Several small generators may be preferable to one large generator, should design limitations for smaller units allow such a replacement. If it is not possible, the distance from the nozzle to the obstacle shall be not less than the minimum distance as specified below:

<table>
<thead>
<tr>
<th>TABLE 6-1</th>
<th>Minimum clearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAG-02</td>
<td>150 mm</td>
</tr>
<tr>
<td>MAG-1</td>
<td>300 mm</td>
</tr>
<tr>
<td>MAG-2</td>
<td>400 mm</td>
</tr>
<tr>
<td>MAG-3</td>
<td>700 mm</td>
</tr>
<tr>
<td>MAG-4</td>
<td>1000 mm</td>
</tr>
<tr>
<td>MAG-5</td>
<td>700 mm</td>
</tr>
<tr>
<td>MAG-11...MAG-17</td>
<td>1500...2000 mm</td>
</tr>
</tbody>
</table>

In case of multiple obstacles the design factor shall be increased, such increase to be determined by preliminary tests conducted in the premises concerned.
- Environment

Temperature range of application for MAG generators is from -50 °C to +65 °C.

Humidity range of application for MAG generators is up to 98 % humidity, non-condensing.

For installations where fire-conducting cord is used, the lowest temperature of application has been limited to -15 °C.

Generators shall not be subjected to severe weather conditions or to mechanical, chemical or other damage. Where excessive climatic or mechanical exposures are expected, suitable guards or enclosures shall be provided.

6.4 Mounting Methods

Pyrogen generators could be mounted in any orientation without affecting its aerosol-forming capability. It is important to bear in mind that the resultant aerosol being warm would tend to rise at the onset. Pyrogen has been tested successfully, however, in the lateral mounting position on the ceiling i.e. under a most unfavourable orientation. Please refer to Diagram 6-2 and 6-3.

Diagram 6-2
Typical Mounting Layout
- Horizontal Mount

- MAG 4

- Concrete Ceiling

- Side View

- Wall Plug, Steel, M5
- Bolt, Nut & Washer, Steel, M5
- Bracket, Steel, M5
- Hydrogen Generator Mounting Bracket
Typical Mounting Layout
- Within Ceiling Void, Vertical Mount

Diagram 6-3
6.5 Electric Wiring

Up to ten Pyrogen MAG generators may be connected on a single discharge circuit with one power source. Should more than ten generators be required for one enclosure, two circuits with two separate power sources should be used.

*Wiring between generators shall be by parallel configuration only.*

- **Cable**

*Cables should be fire-resistant.* Conductors should be of copper, each having a cross-sectional area of not less than 1 mm\(^2\), or if stranded, not less than 0.5 mm\(^2\) should be used.

The cable shall be screened and the care taken when the cable runs through a high frequency energy zone, such as a two-way radio, a sonar, etc.

Should the cabling run alongside electric magnetic fields of high intensity, such as high voltage transformers in power substations or cable tunnels, the cables shall be enclosed into a steel conduit.

Cable screen and steel conduit shall be grounded in accordance with standard requirements.

Should there be any possibility of the mechanical damage, the cables shall be enclosed into a plastic or metal conduit.

- **Power Sources**

A standard power source that provides at least 2 Amp current and 6 to 24 Volts voltage shall be used.

The power source shall have a backup power supply of the same voltage. Where the backup power is shared with other devices, sufficient capacity for a minimum of 24 hour's standby condition, 1-hour alarm condition and thereafter, sufficient capacity remaining to discharge the generators shall be provided for.
- **Wiring procedure**

1) Install electrical wiring;

2) Install and connect such devices as audible and visual alarm devices, manual release points or automatic activation fire panel, heat or flame detectors, timer, etc;

3) Connect miniature filament lamps with 12-24 Volts voltage and current up to 50mA *in place of MAG generators*;

4) Ensure the manual release point or the automatic activation fire panel has been protected from the accidental discharge. Placing of a sign “Do not press. Device is under service” is recommended.

5) Connect the circuit to a power supply;

6) Activate the system. All devices shall operate and all lamps shall glow. Should the system fail to operate properly, disconnect the power supply, check connections between devices, reconnect the power supply and try again.

7) Reset the system. All lamps shall be switched off;

   **WARNING! Prior to connecting MAG generators ensure the wires leading to the generators are not carrying voltage. Connection of MAG generators should always be the last function in electrical wiring procedure.**

8) Disconnect all of the lamps and connect the MAG generators in its place. Install MAG generators in accordance with installation recommendations;

9) Remove the sign on the manual release point or the automatic activation fire panel.
6.6 Connection of the Thermal Initiating Device

Should a thermal initiating device be incorporated into Pyrogen MAG generators (refer to Section 6.2) complete the provision of automatic thermal operation by carrying out the following steps:

**Prior to connection of Pyrogen generators to the electrical circuit:**

- Run the fire conducting cord through the most hazardous locations. Avoid close proximity of the cord to the heat sources, such as exhaust pipes, hot surfaces etc.

- Clamp the fire conducting cord at appropriate points of its length to secure its fixed position. Use plastic ties or any other appropriate means. Do not squeeze the cord. Avoid extreme tightening or sagging of the cord.

- Should several MAG generators be installed, knot extending fire conducting cords together so that all generators are connected to each other with the cord.

**After connection of Pyrogen generators to the electrical circuit:**

- Screw the holder (3, Fig. 6-1) with the fire conducting cord into a socket (1) of the MAG generator in place of a removed end cap (2).
Diagram 6 - 4 -- 2RMDT Connector Assembly and Wiring for Pyrogen Connectors

From control panel

Rubber

Tightened with screws

Soldered

Note: Only pins 1 & 2 are utilized for connection

To Pyrogen
SECTION 7:

SYSTEM MARKINGS
SECTION 7. SYSTEM MARKINGS

7.1 Pyrogen Installation and Expiry Date Label

The following label is “filled in” and affixed to every generator used in the system by the installation contractor.

<table>
<thead>
<tr>
<th>PYROGEN GENERATOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>INSTALLED DATE:</td>
</tr>
<tr>
<td>EXPIRY DATE:</td>
</tr>
</tbody>
</table>

For systems with electrical operation only (no thermal automatic operation) the installed date is the current date and the expiry date is normally 10 years later, except when installed in an aggressive environment where the service life is likely to be less, in which case please refer to an Approved Representative for an assessment of the expected service life.

For systems with thermal automatic operation (use of fire conducting cord) the installed date is the current date and the expiry date is normally 5 years later.

After filling out these details the installer places the clear protective self-adhesive film over the front of the label and attaches the label onto the generator adjacent to the body label.

7.2 Pyrogen Warning & Instruction Signs

The following Warning and Instruction Signs shall be firmly attached to specified locations by the installer on completion of Pyrogen installation in normally unoccupied areas, where people may enter the enclosure for brief periods:

a) Label to be displayed at entrance to enclosure:

<table>
<thead>
<tr>
<th>THIS AREA IS FITTED WITH A PYROGEN FIRE EXTINGUISHING AEROSOL SYSTEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO NOT ENTER</td>
</tr>
<tr>
<td>UNLESS THE FIRE SUPRESSION SYSTEM IS ISOLATED</td>
</tr>
<tr>
<td>AFTER AEROSOL DISCHARGE DO NOT ENTER</td>
</tr>
<tr>
<td>UNTIL AREA HAS BEEN THOROUGHLY VENTILATED</td>
</tr>
</tbody>
</table>
b) Label to be displayed inside enclosure

<table>
<thead>
<tr>
<th>THIS AREA IS FITTED WITH A PYROGEN FIRE EXTINGUISHING AEROSOL SYSTEM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EVACUATE AREA ON SOUND OF ALARM</strong></td>
</tr>
<tr>
<td>AFTER AEROSOL DISCHARGE DO NOT ENTER UNTIL AREA HAS BEEN THOROUGHLY VENTILATED</td>
</tr>
</tbody>
</table>

c) Label to be displayed at System Isolate Switch

<table>
<thead>
<tr>
<th>PYROGEN SYSTEM ISOLATE SWITCH</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WARNING</strong></td>
</tr>
<tr>
<td>CHECK THAT THE AREA IS CLEAR OF PERSONNEL BEFORE RE-ACTIVATING THE SYSTEM</td>
</tr>
</tbody>
</table>

d) Label to be displayed at Manual Release Point

<table>
<thead>
<tr>
<th>PYROGEN FIRE EXTINGUISHING AEROSOL SYSTEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>MANUAL RELEASE POINT</td>
</tr>
<tr>
<td><strong>ENSURE AREA IS EVACUATED BEFORE RELEASE OF PYROGEN AEROSOL</strong></td>
</tr>
</tbody>
</table>

e) Tag to be attached to the Fire Conducting Cord

<table>
<thead>
<tr>
<th>BRAIDED FIRE CONDUCTING CORD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AVOID NAKED FLAME</strong></td>
</tr>
</tbody>
</table>
SECTION 8:

SYSTEM COMMISSIONING
SECTION 8. SYSTEM COMMISSIONING

A Pyrogen Warranty Card is required to be completed by a contractor upon Pyrogen installation and sent to your Pyrogen Key Representative/Distributor.

The completed Pyrogen installation shall be commissioned in accordance with Commissioning Checklist attached in Appendix A (Form 2).

On completion and acceptance of the commissioning procedure, the installation contractor shall issue a Notice of Completion in Appendix A (Form 3).

Commissioning should be carried out by trained and authorised personnel only.
SECTION 9:

SYSTEM MAINTENANCE
SECTION 9. SYSTEM MAINTENANCE

The user of the installation should ensure that the system is in good working order at all times. The user should carry out monthly inspections of the fire suppression equipment. This should include looking out for obstruction of the discharge nozzle, extension/alteration of the protected enclosure, openings left uncleaved that were not catered for during design, and that the position and orientation of the Pyrogen generators remain in the designed position.

The installation should be inspected at least twice a year by an authorised inspector. The inspection plan should include all components of the system and parts of the premises necessary for the effective operation of the system.

A system maintenance log should be kept and status of every maintenance visit is recorded. For a typical system maintenance report refer to the attached Maintenance Checklist in Appendix A (Form 4).

Periodic check-up is required for electrical circuitry of Pyrogen system. The following steps shall be undertaken:

If the control system is designed to transmit alarm signals to a remote manned centre, always ensure that the link is disabled, or in the event that disabling the link is not an option, it would be essential to notify the centre before undertaking the test. Occupant of the premises should also be notified that the system test might result in the sounders being activated.

WARNING! Prior to the start of ANY maintenance work, always ensure as the first step, that wiring to all Pyrogen generators have been electrically isolated. Should thermal automatic operation be used unscrew holders with the fire conducting cord from all Pyrogen generators and replace them with attached end caps. Failure to do so may result in unwanted spurious discharge.

1) Disconnect the wiring at EVERY single MAG generator. This is extremely important to ensure that there are no generators inadvertently left connected.

2) Connect miniature filament lamps with 12-24 Volts voltage and current up to 50 mA in place of MAG generators.

3) Connect the circuit to a power supply.

4) Activate the system. All devices shall operate and all lamps shall glow. Should the system fail to operate properly, disconnect the power supply, check connections between devices, reconnect the power supply and try again.

5) Reset the system. All lamps shall be switched off.
**WARNING!** Prior to connecting MAG generators, ensure the wires leading to the generators are not carrying voltage. Connection of MAG generators should always be the last function in electrical wiring procedure.

6) Disconnect all of the lamps and connect the MAG generators in its place. Install MAG generators in accordance with installation recommendations.

7) Screw holders with the fire conducting cord into a socket of MAG generator in place of the removed end caps.

8) Remove the sign on the manual release point or the automatic activation fire panel.

*For installations where the fire conducting cord is used, a regular check on its mechanical integrity is recommended.* The following steps shall be undertaken prior to step 7 of the above check-up procedure for electrical circuitry:

1) Ensure the fire conducting cord is protected by braiding.

2) Ensure the fire conducting cord is intact. There shall be no cracks or fractures of the cord. The cord shall have uniform thickness all along its length.

3) Ensure all grommets/bushes securing the position of the cord are in place.

4) Ensure that at least one warning/instruction tag is attached to the fire conducting cord and clearly visible.
SECTION 10:

SAFETY MEASURES
SECTION 10. SAFETY MEASURES

10.1 Personnel safety

The uses of Pyrogen automatic total flooding systems are limited to unoccupied and normally unoccupied areas only. In any proposed use of Pyrogen where there is a possibility that people may enter the protected enclosure or be close to the protected risk, the following safety aspects shall apply:

- a thermal automatic operation shall not be used;

- a system isolate switch at the entrance to the protected area, to prevent actuation during abnormal periods of occupation, such as maintenance and repair.

- a location drawing at any manual actuation points.

- exit routes kept clear at all times, emergency lighting and adequate direction signs to minimise travel distances.

- consideration should be given to canister location in the event of spurious activation. Unless absolutely unavoidable, canisters should not be placed at head height or in close proximity to egress doors nor emergency exits.

- outward-swinging doors shall be self-latching and incorporate a self-closing mechanism to prevent possibility of doors opening inadvertently due to increase of pressure within the protected enclosure during discharge. Doors should be able to be opened from the inside including when locked from the outside.

- continuous visual and audible alarms at entrances and designated exits, until the protected area has been made safe.

- warning and instruction signs in accordance with Section 7.2.

- pre-discharge alarms operated immediately upon detection of the fire.

- a time delay incorporated within the manual release point and commencing upon Pyrogen system operation.

- means for ventilation after discharge; forced draft ventilation will often be necessary. Care should be taken to completely dissipate hazardous atmospheres and not just to be moved to other locations.
- written instructions appropriate to the risk, instructions and drills of all personnel within or in the vicinity of protected area, including maintenance or construction personnel who may be brought into the area, to ensure their correct actions when the system operates.

- A hold off switch should be provided within any protected area if there is a risk of personnel taking longer to egress than any pre-discharge alarm may allow. This may apply to persons who are physically or mentally impaired, involved in maintenance or are unfamiliar or untrained in the company fire procedures.

10.2 Potential hazards

The discharge of Pyrogen in fire extinguishing concentrations represents potential hazards to personnel in protected area. The hazards include the following:

- **high obscuration caused by the aerosol during and after discharge.**

- **potential toxicity due to some by-products of the aerosol-generating combustion reaction**.

- **thermal hazard due to a high temperature at the end plate nozzle. See Section 2.9 Design Limitations for minimum clearances.**

Please refer to Section 1.8 for a detailed information on the above hazards.

10.3 Re-entry

Following the use of Pyrogen, personnel should not enter the protected area until it has been thoroughly ventilated. The minimum holding times should be observed prior to ventilation of the protected area (please refer to Section 2.10 for minimum holding times). Unless stated otherwise the minimum holding time permitted before re-entry is 3 minutes.

**Avoid exposure to the fire by-products and extinguishant mixture.**

The wearing of suitable RPE & other available means of protection may be required should it be necessary to enter the area before it is fully ventilated.
10.4 Clean-up

Following a system discharge the aerosol particles that have settled should be vacuumed, using HEPA filter fitted equipment, brushed or, if appropriate, washed away.

Protective gloves and goggles should be worn. A suitable RPE or mask may be required.

Be aware, that any residue that is allowed to build up in large quantities and to absorb moisture may become electrically conductive.

When replacing MAG generators, be aware that immediately after discharge the canisters outer surface may exceed 200°C. Therefore, protective gloves should be worn before handling generators until at least 15 minutes after discharge.

10.5 Handling Fire Conducting Cord

The following safety measures shall apply during installation, maintenance and any other activity involving Pyrogen fire conducting cord:

- Do not smoke or use any heat source with a surface temperature exceeding 100°C.

- Avoid accumulation of static electricity. Cotton work clothing is recommended. Prior to any operation with fire conducting cord relieve any possible charge of static electricity by touching an earth point or an earthed metal object.

- Avoid rough handling of the fire conducting cord.

Fire conducting cord may be used in unoccupied areas only.

10.6 Hot Work

As naked flame or prolonged exposure to temperatures above 400°C may cause activation of the generators, hot work must not be carried out within the vicinity of any generator. If so they shall be removed prior to any hot work being carried out.

10.7 Storage and Transportation

Storage and transportation shall be in accordance with Class 4.1 Dangerous Goods Classification.
APPENDIX A -- APPROVAL DOCUMENTATION

PYROGEN INDUSTRIAL FIRE SUPPRESSION SYSTEM

FORM 1 -- SYSTEM DESIGN APPROVAL CERTIFICATE

To be completed by the contractor to seek the approval of the appropriate authority prior to installation (where required for a specified risk area)

Forms an integral part of Pyrogen Warranty Card to be completed upon Pyrogen installation and sent to a local Pyrogen Key Representative/Distributor.

1. CLIENT INFORMATION:

Address:........................................................................................................................................

Telephone:.............................................Fax:............................................................................

Contact:......................................................................................................................................

Name:.........................................................................................................................................

2. CONTRACTOR:

Name:...........................................................................................................................................

Address:......................................................................................................................................

Telephone:.............................................Fax:............................................................................

Contact:......................................................................................................................................

3. FIRE HAZARD CLASSIFICATION (Type of Fire: Class A, B, C, E or F) (Please refer to Section 2.3 of the Design, Operation and Maintenance Manual):

......................................................................................................................................................

......................................................................................................................................................
4. **PROTECTED SPACE IDENTIFICATION:**

Name of Space........................................................................................................................................

Occupancy:  
- unoccupied
- normally unoccupied
- intermittently occupied

5. **ELECTRIC POWER SUPPLY AVAILABLE:**

Main.......................................................................................................................................................... 

Emergency.............................................................................................................................................. 

6. **NUMBER AND ELECTRICAL CHARACTERISTICS OF EQUIPMENT TO BE SHUTDOWN**

............................................................................................................................................................... 

7. **DESIGN CALCULATIONS:**

Protected space dimensions:

Height.........................................................................................................................................................m 

Length....................................................................................................................................................m 

Width.....................................................................................................................................................m 

Area.......................................................................................................................................................m² 

Total area of unclosable openings to the total area of the enclosure......................% 

Protected space volume:

Maximum Gross volume .........................................................................................................................m³ 

Add for exhaust and inlet ducts.......................................................... m³ 

Deduct non-removable equipment, e.g. tanks, etc..........................m³ 

Design Net volume.................................................................................................................................m³
Quantity of agent required:

**Design Factor:** (Typ. 100 g/m³) .................................................................

Minimum Design Quantity: Minimum Design Factor x Design Net vol.......................g

Actual Design Quantity (should compensate for aerosol losses via unclosable openings, due to forced ventilation and other special conditions be required) ..........g

**Pyrogen generators selected:**

<table>
<thead>
<tr>
<th>Type</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAG-</td>
<td>..........</td>
</tr>
<tr>
<td>MAG-</td>
<td>..........</td>
</tr>
<tr>
<td>MAG-</td>
<td>..........</td>
</tr>
<tr>
<td>MAG-</td>
<td>..........</td>
</tr>
<tr>
<td>MAG-</td>
<td>..........</td>
</tr>
</tbody>
</table>

Installed quantity of agent as determined by sizes of Pyrogen generators available:.........g

*This quantity shall never be less than the minimum design quantity.*

*This form must be completed by the contractor to seek the approval of the appropriate authority, which may require that approved installers are to submit details to the authority before installation.*

*This form shall form part of the Pyrogen Warranty Card to be completed by the contractor upon Pyrogen installation and sent to a local Pyrogen Key Representative/Distributor.*

**8. METHOD OF ACTUATION**

a) **Automatic Electrical** .................................................................
(i.e. Control Panel & detection system required – please provide for further data)

Automatic Thermal (Pyrotechnic Fuse) ..........................................................
(Typically Engine, Marine & Machinery Applications)

Automatic Electrical/Thermal ..........................................

b) **Manual Electrical** .................................................................
(Typically Engine, Marine & Machinery Applications)
Criteria for Acceptance

The completed Pyrogen system shall be commissioned in accordance with this Commissioning Checklist. On completion and acceptance of the commissioning, the installation contractor shall issue a commissioning report.

## COMMISSIONING CHECK LIST

<table>
<thead>
<tr>
<th>No</th>
<th>Inspection</th>
<th>Compliance verified</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Obtain a copy of the System Design approval Certificate (Form 1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Isolate Pyrogen generators by disconnecting generators power supply or system power supply. Should thermal automatic operation be used, unscrew holders with fire conducting cord and replace them with attached end caps</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td><strong>Risk area classification</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(a) Is it the same as the System Design Approval Certificate (Item 3 Form 1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(b) Is the occupation the same as the System Design Approval Certificate (Item 4 Form 1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(c) Are air handling shutdown relays and fire dampers provided</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(e) Are there any uncloseable openings</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4 | **Design Calculations**
---
(a) Are volumes the same as System Design Approval Certificate (Item 7 Form 1)
(b) Are the dimensions of the enclosure the same as System Design Approval Certificate (Item 7 Form 1)
(c) What is minimum design factor? Does this correspond to the type of hazardous materials involved? (Item 8 Form 1)
(d) Check minimum design quantity. Is it correct?
(e) If unclosable openings are present, have calculations of maximum design quantity been effected as required? Are they correct?
(f) Are design limitations in terms of enclosure height, length and width not exceeded for the type of MAG generators selected?
(g) Check number of MAG generators can supply the design quantity required

5 | **Power source**
---
Check there are not less than two (2) separate sources of power, one being emergency source remote from the protected area

6 | **Manual release system** (where appropriate)
---
(a) Is manual release system installed outside the protected space?
(b) Check the connection of manual release system to Pyrogen generators
(c) Is 30 seconds time delay incorporated within the release mechanism?
<table>
<thead>
<tr>
<th>7</th>
<th><strong>Electrical circuitry</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>Disconnect the wiring circuit(s) to the generators at the manual release point</td>
</tr>
<tr>
<td>(b)</td>
<td>Check integrity of the electrical circuit of the whole system. Use digital multi-meter only (supervisory current not to exceed 0.05 A for the period of 5 min)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>8</th>
<th><strong>Thermal initiating device</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>Is thermal initiating device incorporated in MAG generators?</td>
</tr>
<tr>
<td>(b)</td>
<td>Is fire conducting cord protected by braiding?</td>
</tr>
<tr>
<td>(c)</td>
<td>Is fire conducting cord intact? Are there any cracks, fractures, uneven thickness or other visible defects?</td>
</tr>
<tr>
<td>(d)</td>
<td>Are grommets/bushes securing the cord in place?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>9</th>
<th><strong>Instruction and warning signs</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>Is the warning sign fitted inside the space?</td>
</tr>
<tr>
<td>(b)</td>
<td>Is the warning sign fitted next to the entrance outside the space?</td>
</tr>
<tr>
<td>(c)</td>
<td>Is operation sign for the manual release point fitted?</td>
</tr>
<tr>
<td>(d)</td>
<td>Is warning/instruction sign attached to the fire conducting cord?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>10</th>
<th><strong>Alarm test</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Perform a functional alarm system check. Ensure evacuation/visible/audible alarms operate.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>11</th>
<th><strong>Timer &amp; Release test</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Check the operation of the 30s time delay by operating the manual release mechanism at the manual release point. Alarms should sound and after 30 s sufficient power should be available to the disconnected generator circuit(s).</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td><strong>Post fire ventilation</strong></td>
</tr>
<tr>
<td>----</td>
<td>--------------------------</td>
</tr>
<tr>
<td>(a)</td>
<td>Do the ventilation systems work satisfactory?</td>
</tr>
<tr>
<td>(b)</td>
<td>Check operational conditions of air handling shutdown relays and fire dampers if provided. Do they open and close satisfactorily?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>13</th>
<th><strong>Reconnection of the system</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reconnect generators by reconnecting the power supply and ensure the system is left in operable condition. Screw holders with fire conducting cord into MAG generators in place of the removed end caps. This should always be the last commissioning function.</td>
</tr>
</tbody>
</table>
PYROGEN INDUSTRIAL FIRE PROTECTION SYSTEM

FORM 3 -- NOTICE OF COMPLETION

TO BE COMPLETED BY INSTALLER FOLLOWING THE COMMISSIONING CHECK

I (name of installer)...........................................................................................................................................................................

of (company)........................................................................................................................................................................................

hereby certify that we have completed on (date).....................................................................................................................................

to the (name/address/identification of protected area).....................................................................................................................

a PYROGEN Fire Suppression System installation in accordance with the requirements detailed in the System Design Approval Certificate.

Commissioning test(s) were conducted by..........................................................................................................................Date..................

Commissioning test(s) were witnessed by..........................................................................................................................Date..................

This notice of completion shall have the following attached:

a) System Design Approval Certificate
b) Commissioning Check List

Signature of installer..............................................Date...........................................................................................................
# PYROGEN INDUSTRIAL FIRE PROTECTION SYSTEM

## FORM 4 -- MAINTENANCE CHECK LIST

<table>
<thead>
<tr>
<th>No</th>
<th>ITEM</th>
<th>MONTHLY, BY OWNER</th>
<th>ANNUALLY, BY AUTHORISED INSPECTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Electrically isolate Pyrogen generators. Unscrew holders with fire conducting cord from MAG generators and replace them with attached end caps.</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>2</td>
<td>Confirm the generators are secure, undamaged and free from corrosion</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>3</td>
<td>Check that generators’ nozzles are unobstructed within the specified in Sec. 2.9 minimum clearances</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>4</td>
<td>Confirm all electrical wiring and connections are intact</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>5</td>
<td>Confirm fire conducting cord is braided and intact</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>6</td>
<td>Open the manual release point enclosure</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>7</td>
<td>Confirm that 30 sec time delay, evacuation and/or audible, visual and fire alarms operate</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>8</td>
<td>Check that instruction and warning signs are legible</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>9</td>
<td>Inspect power source condition</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>10</td>
<td>Inspect emergency power source (back-up battery) condition</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>11</td>
<td>Confirm that all previously requested rectification’s or modifications have been completed</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>12</td>
<td>Inspect the area to confirm there are no unclosable openings</td>
<td>-</td>
<td>✓</td>
</tr>
<tr>
<td>13</td>
<td>Inspect controls for closing area vents where applicable. Inspect for damage, corrosion, accessibility and test correct operation.</td>
<td>-</td>
<td>✓</td>
</tr>
<tr>
<td>14</td>
<td>Check the post fire ventilation facilities are functional.</td>
<td>-</td>
<td>✓</td>
</tr>
<tr>
<td>15</td>
<td>Check that the expiry date of all generators will not occur within the next 12 months and report to the owner.</td>
<td>-</td>
<td>✓</td>
</tr>
<tr>
<td>16</td>
<td>Check the generator’s electric activation circuit. Follow steps 1-8 of Section 9.</td>
<td>-</td>
<td>✓</td>
</tr>
<tr>
<td>17</td>
<td>Check that all system controls are returned to normal and system is “on line”</td>
<td>-</td>
<td>✓</td>
</tr>
<tr>
<td>18</td>
<td>Reconnect Pyrogen generators. Screw holders with fire conducting cord into the generators.</td>
<td>-</td>
<td>✓</td>
</tr>
<tr>
<td>19</td>
<td>Record all inspections and necessary rectification’s</td>
<td>-</td>
<td>✓</td>
</tr>
<tr>
<td>20</td>
<td>Inform owner</td>
<td>-</td>
<td>✓</td>
</tr>
</tbody>
</table>

Signed:............................................ Date:.....................................
PYROGEN INDUSTRIAL FIRE SUPPRESSION SYSTEM

FORM 5 -- ANNUAL MAINTENANCE CERTIFICATE

TO BE COMPLETED BY THE MAINTENANCE CONTRACTOR AFTER EACH ANNUAL MAINTENANCE SERVICE

I .................................................................................................................................
(name of Service Person)

of ............................................................................................................................
(company)

hereby certify that we have completed the Annual Maintenance on

........................................................................................................................................
(protected area)

on ........................................
(date)

at ..................................................................................................................................
(location)

in accordance with the attached Maintenance Checklist.

Signature of Service Person.................................................................

Date ........................................