AEROSOL FIRE SUPPRESSION FOR HIGH RISE STRUCTURAL APPLICATIONS VIA AIRCRAFT DISTRIBUTION USING METALSTORM TECHNOLOGIES

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ABSTRACT

Aerosol Fire Extinguishment Agents have been under development for the last ten years. PyroGen aerosol is a widely accepted HALON 1301 alternative. In high rise buildings above the reach of ladder or aerial apparatus the fire departments are reduced to relying on stairwells to reach fires above the thirty ninth floor. Sprinklers have historically provided suppression in these structures. If PyroGen flooding systems are not installed in these higher floors, Metal Storm technology may provide a method to deliver enough aerosol agent into burning buildings to suppress the fire until fire fighters can gain access and extinguish the fire. Pyrogen grenades, hand deployed throw-in units, have proven to be effective in structural fires in rooms less than 25 cubic meters. The agent is effective at suppression and extinguishment, the problem has been the ability to get enough aerosol forming compound into the space in a very short period of time to reach extinguishing concentrations before commencement of the aerosol discharge.

Metal Storm with its high firing rates and Pyrogen with its exceptional fire suppression and agent distribution properties are a solution to fighting high rise building fires in the future.

PyroGen Generators and Metal Storm launchers mounted on a military or law enforcement helicopter can provide advanced suppression and buy time for the fire fighters to confront a fire in upper floors preventing a reoccurrence of the World Trade Center structural collapse. Prior to metal storm technology the ability to get enough Pyrogen into a structural fire limited the use of aerosols to total flooding applications. Suppression or extinguishment of large structural fires was just too hard. Metal Storm now allows the ability to introduce up to one thousand kilos of aerosol forming compound into a building floor in less than 10 seconds from hovering aircraft.

INTRODUCTION

PyroGen Aerosol is a solid propellant based gas-like chemical extinguishing agent that is proven to be more effective for flooding than Halon 1031. With established extinguishment concentrations at 100 grams per Cubic Meter (100g/M^3) Pyrogen is an effective and efficient chemical agent. Metal Storm originally designed as an electronic controlled gun system, has a firing rate in excess of one million rounds per minute (1,000,000 RPM). With no moving parts and electronic control a Metal Storm 40MM-launch tube is perfect to deploy large amounts of PyroGen Aerosol Agent. A 40MM PyroGen Generator containing 250g of aerosol forming compound (AFC) is fitted into the Metal Storm Launcher Box. The 40MM Grenade is launched into the fire in large enough quantities to extinguish or suppress high rise structural fires. Large quantities of fire fighting agent can be rapidly deployed up to rates of 20,000 per minute.

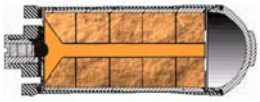

Fig 1. 40 MM PyroGen Generator

MAIN SECTION

Historically fixed sprinkler systems have been used to suppress or control high rise structural fires. Recent events have shown that under high fuel loads or when the sprinklers fail, structural failure can lead to building collapse. Structural failure has always been a main concern for fire fighters, especially in buildings where access is restricted or flame fronts are too high limiting hose team access.

PyroGen Aerosol

Pyrogen is a patented, US EPA SNAP listed chemical Aerosol Fire Fighting Agent. Starting in a solid pellet the aerosol forming compound is combusted thermally decomposed into an extinguishing aerosol in a canister or generator upon the activation of the system.. Before being discharged the aerosol is passed through a solid cooling medium based on magnesium carbonates.

The discharged aerosol out gas components are mainly solid micron-sized potassium carbonates and gaseous nitrogen, water vapor and carbon dioxide. a carbon potassium compound the actual fire fighting. PyroGen is a chemical agent. The prime extinguishing action of Pyrogen aerosol is a removal of free radicals O, H and OH, which propagate the actual fire reaction. This removal is effected either via direct reaction of the above radicals with K radicals supplied by potassium carbonates or via their recombination of the extensive surface of the micron aerosol particles. This carbon/potassium crystal prevents the combination of free radicals of Oxygen O and Hydrogen H in the flame reaction. Pyrogen Aerosol Forming Compound (PAFC) is a Polymer composition highly impregnated with endothermic ingredients into a solid pellet.

$$KNO_{3(s)} + C_nH_mN_pO_{q(s)} + C_{(s)}$$

The size and shape of this pellet determines the discharge time and internal pressure of the aerosol generator. Out gas components consist of solid potassium carbonates, carbon dioxide gas, nitrogen gas and water vapor.

$$KHCO_{3(s)} + K2CO_{3(s)} + CO_{2(g)} + N_{2(g)} + H_2O_{(g)}$$

The out gases from the thermal decomposition process of the PAFC is passed through a cooling medium of magnesium-oxide The AFC and coolant are enclosed in a metal cylinder.

PYROGEN GENERATOR

Pyrogens aerosol-forming compound, solid cooling medium and activation devices are enclosed in a metal cylinder. This assembly is referred to as a PyroGen Aerosol Generator. The generators are manufactured in various sizes from 20g to 20Kg. For discussion this paper will focus on a newly designed 250g generator capable of being launched from a 40mm Metal Storm firing tube. This design has a discharge time of 8-10 seconds creating a 0.75 cubic meter aerosol cloud that will reliably protect 2.5 m3 risk enclosure at the standard design concentration of 100g/M^3.

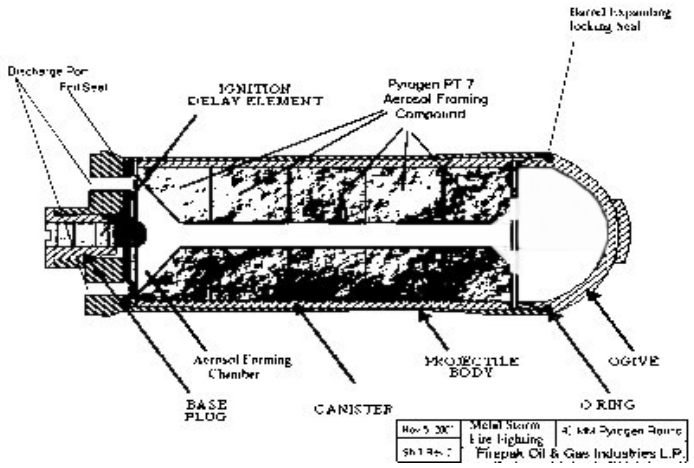

Fig 2. 250g Air Launch PyroGen Generator

The PyroGen generators produce a gas cloud of inert gases and chemical fire fighting agent. The chemical agent, a micron sized solid, acts like a gas and will follow the natural convection currents created by the fire. As air is drawn into the flame front, PyroGen aerosol is also drawn in. Even at concentrations below 100g/M3 it is effective at reducing flame intensity and absorbing thermal energy.

Metal Storm Launcher

The Metal Storm launching system is a multi barreled computer controlled system. A case-less propellant is used to propel and arm the PyroGen generator. Operating like an ink jet printer it can direct a firing voltage to any barrel and can fire from one to ninety six generators at a time. In addition to fire fighting aerosol generators, the same launcher can also launch warning

devices or alarm sirens This can allow for evacuation of offices prior to discharging the aerosol generators. The lacks of moving components, propellant cases or shells make the deliverable agent to pod weight ratio of the launchers one of the highest ever designed.

The air-launched system is designed to be mounted externally to any military or civil law enforcement helicopter. The box launcher contains ninety-six (96) barrels each containing 20 air launched PyroGen generators. One thousand nine hundred twenty (1920) generators per launcher. Two box launchers are placed on each side of the helicopter. A quick attach system is used to allow for rapid loading and re-arming of the delivery aircraft. Launcher systems can be pre positioned at refueling heliports or transported to landing sights for rapid deployment of this novel fire fighting system. A simple self-contained / self-powered box launcher can quickly be added to any helicopter.

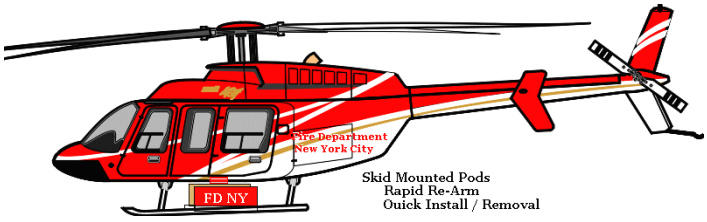

Fig.3 Skid Mounted Launcher

The Metal Storm Launcher is fitted to the skid / side door with a firing control imbecile cable provided to the copilot or crewman. Discharge and fire rates are computer controlled and determined by building / floor volumes and are independently configurable based on the emergency. Copilot/observer can rely on pre fire plans to predict the number of generators and the delivery timing to produce the best results. The flexibility of the MetalStorm launching system allows on scene adjustments of delivery rates and the amount of aerosol forming compound introduced into the fire. This allows for adjusting from a single office fire to a full conflagration like the World Trade Center inferno. Weather conditions, winds and thermal convection currents can be fed into the computer to insure the best aerosol distribution.

Rapid Deployable, Self Contained System

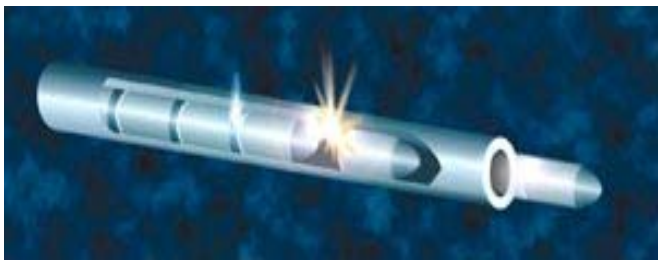

Fig 4. Launch Tube Configuration

Metal Storm/PyroGen fire fighting method combines two new technologies providing a new and novel fire fighting system. A highly efficient fire extinguishing agent with a rapid variable delivery system, PyroGen, as a flooding agent is three times more efficient than Halon 1301. Its ability to be used as a streaming agent is yet to be fully proven.

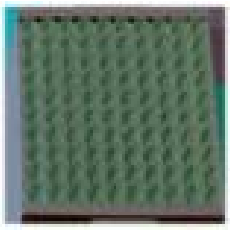

Fig 5 Airborne Launcher

The potential of Pyrogen's ability to achieve adequate agent levels as a streaming agent have never been tested, the main limitation having been the ability to get the required amount of the aerosol forming compound into the flame front. This delivery problem has been over come with the Metal Storm launcher system.

A generator departure velocity of 65 meters per second and convergence laser aiming system mounted to each launcher allow for aiming and delivery without a great deal of training. The pilot simply flies the aircraft and points the laser spots on the agent entry point. This is done up wind allowing good visibility for the crew and introduction of the fire fighting agent into the fire the same way the oxygen is being introduced. When the laser spots from the launchers collate the observer or copilot fires the system.

Pre loading the launcher firing rates in the pod computer or controller can be done prior to launch or on scene depending on the system design. This flexibility allows for an initial knockdown and follow up depending on the on scene commanders requirements.

In the past if the PyroGen Aerosol System was not pre engineered and installed as a total flooding suppression system, it was not practical to deploy the system after the fire was discovered. The adaptation of the MetalStorm Technology now allows us to look at the aerosol agents as a new method of suppression or extinguishment. When fired from a helicopter into a burning structure, the superior knockdown capabilities of PyroGen can be exploited. Metal storm launcher boxes have the capability of introducing far in excess of the $100g/M^3$ extinguishing concentrations required. Four launchers can carry over 1800 Kg (4000 lbs.) of aerosol forming compound. Enough to flood over 1900 cubic meters (1900 M^3) or 31,000 cubic feet. Load factors for individual helicopter airframes also dictate the number of pods and delivery rates. Distribution times can be varied based on the volume to prevent overpressure caused by the volume of the fire fighting agent. The out gas of the 40mm air delivered generator is approximately 3 liters of gas per gram of aerosol forming compound. Delivery rates and entry points will need to be determined on scene by the pilot/observer.

The launcher box is attached to the helicopter skid via a quick clamping system. The complete fire fighting system is self-contained with multi launch tubes containing the aerosol generators, laser aiming system and power. Total weight and carrying capacity of each helicopter will need to be reviewed and a United States Department of Transportation, Federal Aviation Administration, Supplemental Type Certificate (STC) will need to be approved by the administrator for each type and model aircraft used to deploy the system. The same self-contained launcher can also be configured and fired from land vehicles in future applications.

Replacement or reloading of the helicopter launcher can be done in the field, new fresh launchers can be carried close to the emergency, and quickly replaced by ground crew. The quick disconnect skid mounting attachment system is designed to be rapidly re loaded allowing

re-attack of the fire if required. Prepositioned systems can be located on roof top helopads in large cities. The system is designed to fit on commercial or military helicopter. local news or traffic helicopters can be used to ferry launchers into the scene of the emergency.

Other aiming or control technologies may be added in the future as they mature. Electro-optical and computer controlled systems in the future may assist in computing and determining delivery rates. Thermal imaging, analyzing heat flux density or flame propagation / spread in the structure can improve the effectiveness of the system. Location of the air entry point feeding the flame front through this medium would enhance the efficiencies of the aerosol fire fighting system. Introduction of the chemical aerosol agent with the natural thermal circulation of the fire will enhance the gas-like distribution of the fire fighting agent.

Pyrogen Aerosol works in two ways to extinguish fire

Primary:

Chemical - Removal of chain carriers

Secondary:

Physical - Heat absorption

1. **Chemical** - removal of free radical chain carriers OH, H and O in the flame chain

   in gaseous phase:

   $K + OH = KOH$

   $K + O = KO$

   $KOH + H = K + H_2O$

   on particles surface:

   $O + H = OH$

   $H + OH = H_2O$

2. **Physical** - heat absorption Lowering the fire temperature to a level below which the fire reaction cannot continue

   $KHCO_3 = K_2CO_3 + CO_2 + H_2O$

   $K_2CO_3(s) = K_2CO_3(g)$

Heat absorption via endothermic phase changes

$K_2CO_{3(s)} = K_2CO_{3(l)} = K_2CO_{3(g)}$

Heat absorption via endothermic decomposition changes

$2KHCO_{3(s)} = K_2CO_{3(S)} + CO_{2(G)} + H_2O_{(g)}$

These two properties combine to make this one of the most efficient extinguishing agent systems developed to date.

Metal Storm Technology

The metal storm launcher overcomes several obstacles that have limited the delivery rates of launchers in the past. This innovative approach has revolutionized the science of rapid controllable ballistic delivery systems. Prior systems were limited by:

1. Cycle time of mechanical components used to expel empty propellant cases

2. Heating of launch tubes or barrels

3. Volume of magazines and ammunition feed systems

4. Weight of conventional launchers and these mechanical systems

With no moving parts the cycle time of each launch barrel is controlled only by the time delay of the computer firing pulse. Storing the projectile in the launch tube removes the magazines and feed system. The majority of the metal storm system weight is fire fighting aerosol generators. Components made from advanced composite materials also reduce the system weight. Electronic control allows selection of individual rounds, from individual barrels, one at a time. These can be programmed in cycles or volleys to maximize the effectiveness of the fire fighting system.

Lifting or payload weight is critical for helicopter operations. Weight and balance of external loads have a severe impact on performance and station keeping of rotary winged aircraft. Metal Storm through its unique computer controlled delivery system can insure the aircraft remains inside its operation limitations. By selecting launch tubes automatically the side load and weight of each launched pod can be monitored. Recoil thrust can be counteracted by small counter charges fired from the aft end of the launcher. This system ensured that in the heat of the battle a pilot/observer does not get the helicopter out of it design limits.

Metal storm and PyroGen are a novel blend of two evolving technologies. With most major cities of the world constructing larger and taller buildings innovative methods of fire suppression are required.

CONCLUSION

Combating fires in high rise buildings has always presented serious risk to fire and rescue departments. Fires resulting from explosions are the most challenging as they can disrupt a fixed total flooding fire suppression system resulting in its failure to operate. In such cases a deployable highly efficient and rapidly delivered fire fighting system could be a solution in preventing spreading of the fire and possible collapse of the building.

Incorporation of Pyrogen Aerosol Generators with Metal Storm Technology has created a new and novel method of fire fighting, which combines a superior knockdown capabilities of Pyrogen extinguishing aerosol with a unique method of its delivery by Metal Storm launchers. Combating high fuel loading fires in high rise buildings will continue to create challenges to fire departments in the future. A rapid deployable highly efficient fire fighting system is needed. The three dimensional properties and efficiencies of aerosols agents are a sound method of combating this problem.

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DEFINITIONS, ACRONYMS, ABBREVIATIONS

PAFC	PyroGen Aerosol Forming Compound
ADFP	Air Delivery fire fighting Pod
NFPA	National Fire Protection Association
FAA	Federal Aviation Administration
AUVSI	Association of Unmanned Vehicles and Systems International.

Late authors note:

> *In March 2002, DSTO successfully tested the 60mm launcher tube with fire rated in excess on 20,000 rounds per minute. This allows for increasing the weight of the aerosol forming compound to 500g in each grenade. The number of launch tubes pre box increased to 144.*