

COMPARISON OF FIRE SUPPRESSION SYSTEMS

Grouping	Types	Method of Fire Suppression	Approvals
Inerts	IG01	Depletion of oxygen	All inerts generally have 3rd party approvals, such as UL
	IG55		
	IG100		
	IG541		
Halocarbon	FM200	Mainly heat absorption and some chemical reaction	All FM200/HFC227ea generally have 3rd party approvals, such as UL
	HFC227ea		
Fluorinated Ketones	Novec1230	Mainly heat absorption and some chemical reaction	All Novec1230 have UL listing
Watermist	Low Pressure	Heat absorption and depletion of oxygen	Only some watermist systems have product approvals and in most cases limited and specific application approvals only
	High Pressure		
Condensed Aerosol	FirePro	Chemical reaction	Have UL listing amongst other approvals

Environmental	In event of fire : Toxicity / Harm to people	In event of false discharge : Toxicity / Harm to people
No GWP or ODP	May cause asphyxiation	May cause asphyxiation
Has a GWP = 3220	When in contact with fire will form toxic and acidic by-products such as HF	Design concentrate is 7% but LOAEL is very close at 10.5%
Has a GWP = 1	When in contact with fire will form toxic and acidic by-products such as HF and COX ₂	Design concentration is 4.7% but LC ₅₀ /ALC is very close at 10%
No GWP or ODP	When in contact with fire will form high temperature steam	Safe
No GWP or ODP	No toxic or harmful by-products are produced	Tested non-toxic or harmful to people

Complexity of Equipment (operation)	Effects on Sensitive Equipment	Enclosure Integrity
The initiating fire signal typically only actuates one cylinder valve and other follow-on means are needed to discharge all the cylinders	High frequencies caused by discharge are documented to have caused sensitive equipment to fail	Design very dependent on enclosure integrity - significant leakage will cause system to fail
The initiating fire signal typically operates the single cylinder to discharge	Sudden temperature drop caused by discharge may cause thermal shock to sensitive equipment	Design very dependent on enclosure integrity - significant leakage will cause system to fail
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The set up is complicated as the initiating signal requires the pump to start and other valves to open	High humidity and condensation after discharge may affect sensitive equipment	Not significantly affected by leakage
The set up is complicated as the initiating signal requires the pump to start and other valves to open. Systems using high pressure cylinders require the		
The initiating signal directly operates all the aerosol generators to discharge	Tested to have no effective on sensitive equipment	Not significantly affected by leakage

Enclosure Pressure Venting	Equipment Space Requirements	Safety of Installed Equipment
Pressure vents must be provided as peak pressure of around 1750 Pa may be created within the enclosure	Large storage space required for the multitude of very high pressure cylinders	Very high pressure cylinders pose a hazard to operating or maintenance personnel
Pressure vents must be provided as negative peak pressure of -800 Pa may be created within the enclosure	Storage space required near or within protected enclosure for the high pressure cylinder	High pressure cylinders pose a hazard to operating or maintenance personnel
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No need for pressure vents	Storage space required for the water tanks and pumps, or high pressure cylinders	Leakage of water may pose a hazard to nearby electrical equipment
		High water pressure and leakage hazards
No need for pressure vents	No storage space required	System is static and pose no hazard when installed

Provision of electrical power sources	Maintenance	Complexity of equipment (maintenance)	Equipment Warranty
Does not require power supply (other than from fire alarm system)	Valves, mechanical devices require regular maintenance	Very high pressure seamless cylinders and discharge hoses must be hydrostatically tested periodically	Typically 1 year on equipment
Does not require power supply (other than from fire alarm system)	Valves, mechanical devices require regular maintenance	High pressure welded tanks and discharge hoses must be hydrostatically tested periodically	Typically 1 year on equipment
Does not require power supply (other than from fire alarm system)	Valves, mechanical devices require regular maintenance	High pressure welded tanks and discharge hoses must be hydrostatically tested periodically	Typically 1 year on equipment
Require 3 phase power supply source for the pumps	Pumps, motors, valves, mechanical devices require regular maintenance	Pumps and motor controllers require specialist maintenance	Typically 1 year on equipment
Require 3 phase power supply source for the pumps		High pressure pumps and motor controllers require specialist maintenance	
Does not require power supply (other than from fire alarm system)	Only visual inspections required	Almost maintenance free - visual inspection and checking of resistance of generators	Warranty lifespan 15 years on the generators

Ease of Installation	Relative equipment cost (based on protection of 3 room: 81m ³ , 232m ³ , 587m ³) 1=highest;6=lowest	
Require installation of high pressure pipework from cylinder storage area to protected enclosure	Based on a Central Bank System with cylinder qty based on largest room (*If based on individual room, Inerts are the most expensive)	2 (*1)
Require installation of high pressure pipework from cylinder storage area to protected enclosure	Individual Room Protection	5
Require installation of high pressure pipework from cylinder storage area to protected enclosure	Individual Room Protection	4
Require installation of high pressure pipework from cylinder storage area to protected enclosure	Including water tank, pumps, nozzles and accessories	3
Require installation of high pressure pipework from cylinder storage area to protected enclosure	Including water tank, pumps, nozzles and accessories	1
Installation similar to devices such as smoke detectors or fire alarm bells	Individual Room Protection	6

Grouping	Inerts			
Types	IG01	IG55	IG100	IG541
Method of Fire Suppression	Depletion of oxygen			
Approvals	All inerts generally have 3rd party approvals, such as UL			
Environmental	No GWP or ODP			
In event of fire : Toxicity / Harm to people	May cause asphyxiation			
In event of false discharge : Toxicity / Harm to people	May cause asphyxiation			

Complexity of Equipment (operation)	The initiating fire signal typically only actuates one cylinder valve and other follow-on means are needed to discharge all other cylinders
Effects on Sensitive Equipment	High frequencies caused by discharge are documented to have caused sensitive equipment to fail
Enclosure Integrity	Design very dependent on enclosure integrity - significant leakage will cause system to fail
Enclosure Pressure Venting	Pressure vents must be provided as peak pressure of around 1750 Pa may be created within the enclosure
Equipment Space Requirements	Large storage space required for the multitude of very high pressure cylinders.
Safety of Installed Equipment	Very high pressure cylinders pose a hazard to operating or maintenance personnel

Provision of electrical power sources	Does not require power supply (other than from fire alarm system)
Maintenance	Valves, mechanical devices require regular maintenance for proper functioning at the time of fire.
Reinstatement after a discharge	Cylinders need to be dismantled and transported to a gas refiller for refilling.
System integrity and approval after discharge	Inert gases refilled at non-UL listed fill stations lose their original UL listing. The gas refiller also needs to follow exactly the individual gas constituent purity and tolerance during filling, including the control of moisture PPM.
Complexity of equipment (maintenance)	Very high pressure seamless cylinders and discharge hoses must be hydrostatically tested periodically.
Equipment Warranty	Typically 1 year on equipment.
Ease of Installation	Require installation of high pressure pipework from cylinder storage area to protected enclosure.
Simplicity of Design	Require UL listed software to carry out hydraulic and design density calculations, and vary depending on fire class and hazard type.

CO ²	Condensed Aerosol
	FirePro
Depletion of Oxygen (Cutting the Oxygen level From 25% to 12.5%)CO2 provides a heavy blanket of gas that reduces the oxygen level to a point where combustion cannot occur.	Chemical reaction
UL, FM approved.	Have UL listing amongst other approvals
having ODP	No GWP or ODP
100% causes asphyxiation- CO2 is 1.5 times heavier than air and therefore tends to settle in lower levels of the room etc.This can be life threatening due to oxygendisplacement.	No toxic or harmful by-products are produced
100% Causes asphyxiation. It is common belief that the only risk to people from CO2 is that of asphyxiation. However, CO2 is not a truly inert gas, is toxic, and causes injuries and death by interfering with the functions of the central nervous system. Discharge of CO2 in concentrations used in Reclamation units causes serious hazards to personnel, including suffocation and reduced visibility during and after the discharge period.There is also some risk of frostbite.	Tested non-toxic or harmful to people

The initiating fire signal typically only actuates one cylinder valve and other follow-on means are needed to discharge all other cylinders	The initiating signal directly operates all the aerosol generators to discharge
	Tested to have no effective on sensitive equipment
Design very dependent on enclosure integrity - significant leakage will cause system to fail	Not significantly affected by leakage as it is a solid SBK compound which turns into aerosol in case of fire.
Pressure vents must be provided as peak pressure of around 1750 Pa may be created within the enclosure	No need for pressure vents
Large storage space required for the multitude of very high pressure cylinders.	No storage space required
Very high pressure cylinders pose a hazard to operating or maintenance personnel	System is static and pose no hazard when installed

Does not require power supply (other than from fire alarm system)	Does not require power supply (other than from fire alarm system)
Valves, mechanical devices require regular maintenance for proper functioning at the time of fire.	Only visual inspections required
Cylinders need to be dismantled and transported to a gas refiller for refilling	FirePro aerosol units are not refillable. Discharged units are replaced with new ones.
Inert gases refilled at non-UL listed fill stations lose their original UL listing. The gas refiller also needs to follow exactly the individual gas constituent purity and tolerance during filling, including the control of moisture PPM.	Replacement with new units mean the UL listing of the fire suppression system is maintained as when new.
Very high pressure seamless cylinders and discharge hoses must be hydrostatically tested periodically.	Almost maintenance free - visual inspection and checking of resistance of generators
Typically 1 year on equipment.	Certified lifespan 15 years on the generators with 5 years functionality warranty.
Require installation of high pressure pipework from cylinder storage area to protected enclosure.	Installation similar to devices such as smoke detectors or fire alarm bells.
Require UL listed software to carry out hydraulic and design density calculations, and vary depending on fire class and hazard type.	Based on UL tested standard design density applicable for all classes of fires.

Notes
Inert gases due to its high pressure discharge is very susceptible to room leakages.
The FirePro aerosol currently has the most number of approvals and listings on a single system.
Whilst the fire suppressant agents both have no GWP, the manufacturing processes of the system components do contribute to GWP. A simple observation of the large quantity and mass of steel required for inert gas systems will give an indication of the relative amount of GWP caused compared to the simple FirePro aerosol units.
The potential to cause asphyxiation (suffocation) is highlighted by the NFPA especially by the LOAEL warning (52%). There is no LOAEL warnings in the NFPA for aerosol systems as there is no proven toxicity or harmful effects on people.

To understand the complexity of inert systems, trace the actions required to achieve the extinguishing effect in the protected room. **INERT** : fire alarm signal > energize the solenoid coil > magnetic core moves > pushes cylinder strainer valve downwards > pressure holding cylinder valve core close is vented allowing valve core to open > pressurized inert gases travels through manifold > travels down the next discharge hose to the next cylinder valve > gas pressure pushes next cylinder strainer valve downwards (repeats as above) > gases discharges through nozzles to distribute gas evenly. If there are selector valves, the process is even more complex. Compare with **FirePro Aerosol** : fire alarm signal > heater coil heats up all the aerosol units directly > solid aerosol compounds dissociates into gaseous aerosol > discharge from the aerosol units into the protected room.

The fire suppressant inert gases by themselves are "clean" ie contains no foreign solid particles. However unless due care is taken with cleaning the cylinders, manifolds and piping, a lot of particles, such as rust, oil, dirt and even water (from hydrostatic pressure testing) can be discharged into the protected room. These foreign particles can and will cause effects on electrical/electronic equipment. FirePro aerosol units discharge known solid particles and inert gases into the protected rooms. There are no unknown foreign particles as a result of a discharge. These known solid particles have no effects on electrical/electronic equipment. And 3rd party tests have been carried out to prove this. Aerosol discharges leaves very fine residue if not exhausted from the protected room after a few hours. These have no impact on equipment and can be cleared easily by dusting or by vaccuming the room with a normal vacuum cleaner.

Room integrity tests must be done to ensure that the design concentrate can be achieved. At the same time room structural integrity must be verified as a tight room will result in over-pressurization and possible failure of enclosure components (such as glass observation windows or doors). Room pressure during an inert discharge may rise to 1700Pa. Aerosol system discharge gives rise to only 200Pa pressure.

Space saved can be used for better operational or revenue generating purposes.

There are numerous reports of incidents involving high pressure inert gas fire suppression systems either during installation, maintenance or a discharge.

To avoid foreign particles entering the protected room during a discharge, manifolds and distribution piping needs to be blown out regularly. After a discharge high pressure cylinder valves cannot be refilled without servicing. This is due to the possible presence of contaminants inside the cylinder valve. Selector valves must be blown to remove any foreign particles from the valve seats before resetting. FirePro aerosol units need only be inspected for wiring disconnections or physical damage.

The reinstatement of inert gas system may take days to weeks - unless 100% spares are installed or kept on site. This is due to scheduling at the industrial gas fillers. FirePro aerosol units can be replaced immediately ensuring the fire protection of the protected room.

Loss of UL listing of the fire suppression system has serious implications both regulatory and with liabilities. The installation may be no longer compliant with Singapore fire regulations if the system is no longer UL listed. There may also be commercial liability issues with the owner insurer if the system is non-compliant.

CP12 defines the mandatory requirements for high pressure cylinders. NFPA defines the mandatory pressure testing of both cylinders and all discharge hoses (every 5 years).

Despite the complexity and many components inert gas system offer only 1 year warranty on all parts and components. The user stands the risk that some components may become obsolete affecting the usability of the entire system. FirePro aerosol generators are standalone units so each unit can be replaced with an entirely new one with affecting the rest and the system as a whole.

Any alterations to inert gas systems will require messy pipe work re-routing and changes. Cylinder storage rooms may be affected if more cylinders are required and the manifolds need to be changed. Generally a totally new system is required. FirePro aerosol units can be installed without significantly affecting protected room operations as only wiring works need to be done. Additional units can be added (or reduced) easily purely based on room volume increment (or reduction).

Inert gas system design must be carried out using proprietary UL listed software that the user cannot verify. The design must also be re-done after installation as as-built pipe work routings affect the pipe and nozzle sizing. FirePro aerosol design is simply based on UL determined density directly proportional to hazard room volume. The user can verify if the design is correct.