

**STATUS OF DEVELOPMENT AND PROPERTIES OF NAF
AS AN ALTERNATIVE TO HALON**

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Since the introduction of the Montreal Protocol, the fire industry has been seeking suitable alternatives for Halons. North American Fire Guardian Technology (Vancouver B.C., Canada) and its associate company, Safety Hi-Tech S.r.l. (Rome Italy) set about to develop replacements which would closely resemble Halon 1301 and 1211.

The task was to produce products which could utilise existing Halon equipment, preferably without modification, that were safe and clean in use. That would also be cost effective in order that users could replace their existing systems without major expense and in developing nations would not place an unfair economic burden for countries wishing to move speedily away from the use of ozone depleting substances, finally they had to be environmentally friendly.

The Montreal Protocol sought to address the control of substances, which depleted the Ozone Layer it did not address any other environmental consideration. During the development of the NAF range of products, it was considered, that to have a future sustainable life it would be necessary to identify other effects which these products may have on the environment.

During the developments, consideration was given to the Global Warming Potential and the Atmospheric Lifetime of the resulting products. Like most things in life, it was found that in order to achieve the goals which had been set, that the resultant "Blend" was the best compromise to satisfy the market needs.

Environmental Considerations					
	Halon 1301	NAF S III	HFC 227ea	PFC 410	HFC 23
ODP (CFC 11= 1)	12	0.036	0	0	<0.0004
GWP (CO2 100 years)	5600	1444	3300	5500	12100
ALT (years)	65	12	41	3000	250

The products are blends of HCFC's and a special detoxifying additive which helps reduce the formation of toxic decomposition products which may be produced during a fire scenario. The NAF product type S III is listed in International standards as "HCFC Blend A", NAF P IV which is a new streaming agent has now been accepted by the US EPA and is referred to as "HCFC Blend E".

Whilst NAF S III satisfies the need to reduce the levels of Ozone Depletion, particularly in the case of Halon 1301, which is the most damaging ODS, NAF S III is not a totally zero ODP product. However, the ODP is very small, up to 400 times lower than Halon 1301.

It has been suggested that NAF is not suitable to replace Halon since any replacement must be ZERO ODP and it is considered by many that only Halocarbon products which satisfy this aspect should be allowed.

Only now, some 10 years after the signing of the Protocol has the need to consider the other environmental aspects been recognised, indeed this was reflected at the last meeting of the Parties held in Costa Rica during November 1996, when the use for HCFC's in fire fighting was officially recognised, following a request from the European Union.

NAF S III offers the most balanced package of environmental performance of any of the currently available Halon replacements for use in "occupied" areas.

Specific reference has been made to the use of the products in areas which are "occupied", particular attention had to be paid to this point, since Halons had been largely chosen because of their ability to be used in a safe manner for these types of applications, thus any substitute that stood any chance of acceptance would clearly have to satisfy this requirement.

The use of HCFC's presented less of a challenge to satisfy this very important need, since despite the low level use, they had in fact been produced and used for about 50 years and thus a large amount of toxicological data was already available. However the need to be "sure" was paramount and the manufacturers of HCFC products participated in many voluntary International research projects in order to collect additional data and assurances that the products were safe for use.

The Environmental Protection Agency in the USA introduced a listing procedure for products which met the necessary criteria which would allow their use as replacements for current Ozone Depleting Substances. Included in this screening process was an evaluation of available toxicological data.

The NAF products are recognised and accepted for use in the USA.

Since in fire protection applications there may be exposure to the products by humans, an additional screening test was introduced by the EPA. This identified a measure of the cardiotoxic effect, and thus has now been established, what has become to be known as the NOAEL and LOAEL levels. This protocol is now used to screen suitable candidate gases and it is included in most important International standards to determine the acceptance of gases as replacements for Halons, for use in "occupied " areas.

The design concentration of systems employing these new products, must not exceed the established NOAEL level, if they are to be used in normally occupied areas .

NAF S III can be used safely for applications when this condition arises.

	Toxicity	
	NAF S III	Halon 1301
NOAEL (%)	12	5
LOAEL (%)	14	7.5
Design concentration	8.6-12	5

One of the development goals for NAF S III as suitable replacement for Halon 1301 also recognised the need for the product to be suitable for retrofitting into existing Halon systems with the minimum of modification and thus the minimum of disruption and associated costs.

NAF S III was developed in order that it could be used with existing proven Halon system engineering and technology, this ideally had to mean little or no modification to the valve and hardware. In addition it was considered important, that where possible, the existing pipework could be used without the need for costly replacement.

Carefully tuning the physical properties of the NAF S III formulation allowed these requirements to be satisfied. The developed product, having exceptional flow characteristics and an extinguishing performance which would allow the existing Halon pipework to be used and require only a simple change of nozzles to meet the required discharge time.

NAF S III systems can now be designed to give the same degree of protection to that found with Halon 1301 systems by using only 10% more gas by weight, thus in about 80% of cases where NAF has been chosen to retrofit Halon 1301 the existing storage capacity for the gas can be used.

Many of the current Halon valves can be used without any modification for NAF, some however do require the manufacturer to change elastomer or rubber compound used for the seals.

To assist in system design a unique software programme was developed by North American Fire Guardian Technology Inc. for use by the system design engineers, the suitability of this programme has been proven both by extended laboratory development and by many approvals bodies world-wide and more importantly by the testimony of the number of systems installations, now in excess of 15,000 around the world.

Further proof of the suitability of NAF systems resulted from the exhaustive series of comparative testing which took place during 1996. Manufacturers had long been producing data for their products, but little work had been undertaken to make direct comparisons between all the commercially available Halon Replacements.

During 1995/1996 a programme of work was undertaken at the Loss Prevention Council in the UK, all the available contenders of both Halocarbon and Inert gases were evaluated during an exhaustive test programme. This was the first time that the products had been independently evaluated under very carefully controlled conditions with exactly the same fire loads being used for each gas. During this series of tests NAF S III performed satisfactorily in a system which was designed at 12% concentration, giving a 20% safety level above heptane cup burner value. The results indicated a performance comparable to other Halocarbon products which were evaluated in systems, some of which had been designed at up to a 65% safety level above cup burner.

Loss Prevention Council - Extinction Time		
	NAF S III	Halon 1301
Small wood crib	8.0 (12%)	8.0 (5%)
Large wood crib	6.0 (12%)	5.0 (5%)
Large wood crib	22.0 (8.6%)	-
PVC ribbon	2.0 (12%)	3.0 (5%)
PVC cable crib	10.0 (12%)	9.0 (5%)

A separate test programme was commissioned by North American Fire Guardian Tech. Inc. using the same test rig, but utilising a design concentration of only 8.6%. Satisfactory results were obtained with both Class A and B fuels, thus confirming the suitability of NAF systems which could be designed with only a 10% increase of gas to that used in existing Halon systems.

Also during 1996 test series was carried out by the US Coast Guard to determine a suitable test protocol for selection of replacement products for use in marine applications.

US Coast Guard - Scenario #4a - Results			
	NAF S III	PFC 410	HFC 227ea
Design concentration	12	8.2	8.7
Design concentration vs. cup burner (%)	+ 20	+ 60	+ 30 ^A /+ 50 ^B
Agent weight (kg)	264	444	349
# of nozzles	2	4	4
Discharge time (s)	10.5	10	10
Extinguishment time heptane pan fire (s)	11	8	12
Extinguishment time heptane spray fire (s)	2	1	2
Extinguishment time diesel spray fire (s)	11	9	14
HF concentration (ppm)	1900	4500	3700

^A Based on NRL cup burner for n-heptane (6.6)

^B Based on Fenwal cup burner for n-heptane (.5.8%) used for UL/FM listing

During this test programme NAF produced the closest results to Halon 1301 both in terms of extinguishing performance and also the low levels of decomposition products which were produced. It should perhaps be noted that the most significant result of this test programme was the suitability of the NAF system to use the existing 2 nozzle pipework layout which was also designed and installed for the Halon system. The other gases evaluated required both larger pipes and 4 nozzles in order to maintain the short discharge time and also to maintain suitable uniform distribution and concentration levels.

This demonstrated a clear advantage when NAF would be used for retrofitting existing systems, the advantage being minimal disruption to use of the facility, little downtime of the fire protection system and finally low cost.

Confirmation of this point was also obtained in tests conducted by the US Air Force at their Tyndall base in the USA. NAF S III once again performed closest to Halon 1301 with the shortest extinguishing time and low levels of toxicity.

Tyndall Air Force Base - Test Results

New Mexico Engineering Research Institute Report #96/10/32310

	Halon 1301	NAF S III	PFC 410	HFC 227ea
Agent concentration (vol. %)	6.3	12.2	7.7	7.1
Weight (lbs)	85.3	132	201	137
Extinguishing time (sec)	5.4	6.8	16.0	37.4
HF average production (ppm)	425	1150	1150	2450

This aspect confirming the performance figures and vindicated the concept of including our patented detoxifying additive into North American product range.

NAF S III and the NAF P IV streaming agent which has been developed to replace Halon 1211 are now clearly confirmed as the most cost effective and environmentally balanced contenders for the early replacement of Halons.

These products give the fire protection industry the opportunity to engage in a speedy phase out of the use of Halons with minimal economic disadvantages and make a considerable contribution to protect the Environment.