EXPLOSION PROTECTION

A COMPREHENSIVE SOLUTION

WHITE PAPER

FIRESTOPPER®
Industrial - Commercial
Government

March 16, 2016

FireStopper Marketing Department

GLOBAL APPLICATION OF FireStopper® EXP FFC

FIRESTOPPER

Preface

FireStopper International Limited, a transnational Registered Company, is the developer of the most advanced and powerful firefighting and anti-explosion technology in the "World". It devoted the first 25-years of its existence to R&D and the recipient of subsequent stand alone testing results in ratings and certifications by the most recognized and respected third-party testing and listing facilities in the world.

Moreover, this unique Technology has rendered the only available all fire class effective and anti-explosive products, which are non-toxic, non-irritant, environmentally safe and non-hazardous per the most demanding environmental and life exposure testing over all other existing and available products in the explosion, fire and safety channel of business.

In the explosion amelioration technology channel, FireStopper® branded anti explosion systems exclusively deploy EXP FFC. This FireStopper® FFC (*Fire Fighting Catalyst*) is an environmentally safe liquid formula that has garnered the great distinction of being the only product in over 20-years of search for a product capable of suppressing hydrogen/methane explosive environment. This breakthrough discovery became apparent during its initial demonstrative testing at Gexcon, AS Norway.

Having proven the former statement through the outstanding results of the products testing, rating, and certifications thus received, FireStopper®, in tandem with its novel firefighting and anti-explosion products (the "software"), developed the most durable and reliable supporting hardware and detection systems available today, which also meet and exceed the relative standards used to certify said product lines.

With the advent of this technological breakthrough, FireStopper® can now provide Government, Industry, and by way of innovation, the consumer with a never before wider dimension of safety and protection.

Notwithstanding the above, the FireStopper® lines of products reach across the full spectrum of safety application including environmental remediation post spills both onshore and offshore.

In the International arena, the FireStopper® brand is the recipient of the highest certifications in all categories of Governmental requirements to market such as defined below:

Anti-Explosion:

Initial stage testing - Gexcon, AS (Norway)

Handheld Portable Extinguishers:

ANSI/UL711, ULC – Southwest Research Institute (San Antonio, TX)
Defense Logistics Agency (DLA) US Gov. NSN Approval #s'

EN3-7; EN3-8[1] – MPA, Dresden (Germany)
CE[2] – DNV

[1] This Standard refers to hardware durability, reliability and efficacy

Firefighting Foam Concentrates:

EN1568 – MPA Dresden
ICAO – CNPP (France)
IMO – MPA Dresden, Lloyds Registry, DNV, MED
CE

Environmental Testing:

NAMSA, USA
Associated Laboratories, CA USA
Environmental Medicine, Inc., USA
OPUS, Ltd., UK

Executive Summary

Every new technology has barriers to entry. Often times these barriers are based on myth or inaccurate facts that have been presented in the media. Some times the barriers are based on real world experience of customers using similar technologies. Other times a truly new technology comes along that addresses a problem in a different way. In all cases, it is incumbent upon the vendor to educate prospects, analysts, and the press about the technology or a new approach to solving the problem.

Oil refineries, petrochemical processing plants and even coalmines, among many industries operate in the presence of combustible gases and vapors the precursors of explosion. The objective of this document is to introduce and describe the now available, fully automated and redundant manually activated FireStopper® anti explosive and fire suppression systems. This document does not cover barriers placed in safe areas, and focuses only on devices placed in hazardous areas to diminish the devastating effects of explosion and fire.

Historical First Event:

In 2001 after completing 4-years of joint testing training with the UK MoD (Ministry of Defense) FireStopper® was invited to participate in a demonstration of its Technology/Product's efficacy as an anti-explosive. This invitation was to demonstrate FireStopper®'s drop-in Halon replacement capability in the explosion and fire suppression system operating in the Centurion Military Tank deployed by the South African Defense Forces.

Please note: in 1999 the FireStopper® technology was at its earliest developmental stage and at such time the only product it had developed was the primary version of a 6% concentrate named AB 40002 FFC.

Full MoD Report Below:

[2] This Mark assures manufacturing quality through yearly inspections

AUTOMATIC FIRE SUPPRESSION FOR ARMOURED FIGHTING VEHICLES

1. BACKGROUND INFORMATION

- OVER THE LAST 15 YEARS THERE HAS BEEN SIGNIFICANT DEMANDS MADE ON GOVERNMENT TO IMPROVE THE ENVIRONMENT.

- WHICH HAS BROUGHT ABOUT LEGISLATION THAT HAS HAD A MAJOR EFFECT ON THE FIRE FIGHTING INDUSTRY.

- PARTICULARLY ON FIRE FIGHTING MEDIAS SUCH AS FLUORINATED FOAMS AND HALON GASES.

2. BACKGROUND INFORMATION

- THIS HAS PROMPTED THE FIRE INDUSTRY TO RESEARCH AND DEVELOP
- ALTERNATIVE MEDIAS, WHICH ARE LESS HARMFUL TO THE ENVIRONMENT BUT CAN STILL SUCCESSFULLY, EXTINGUISH FIRES.

- COMPANIES HAVE MADE MANY CLAIMS DURING THIS TIME. UNFORTUNATELY NOT ALL OF THEM HAVE BEEN VALIDATED.

3. BACKGROUND INFORMATION

- WE BELIEVE THAT WE HAVE IDENTIFIED A PRODUCT THAT CANNOT ONLY REPLACE FLUORINATED FOAMS BUT CAN ALSO REPLACE SOME HALON APPLICATIONS.

- THIS HAS BECOME INCREASINGLY IMPORTANT DUE TO RAPIDLY APPROACHING MILESTONES, WHICH HAVE BEEN IMPOSED BY THE MONTREAL PROTOCOL.

4. THE MONTREAL PROTOCOL

- ALL MAJOR POWERS FORMALLY AGREED THE MONTREAL PROTOCOL IN 1987.

- WITH A PRIME OBJECTIVE TO REDUCE THE WORLDS OUTPUT OF OZONE DEPLETING SUBSTANCES.

- THIS RESULTED IN THE PRODUCTION BAN OF HALON 1211 AND 1301 IN 1995 WITH A TARGET TO BAN THE USE OF HALON 1211 AND 1301 BY 31 DEC 2002.

5. CRITICAL USE EXEMPTION

- BECAUSE HALON 1211 AND 1301 IS IN WIDE USE THROUGH OUT THE MOD TO PROTECT SPECIALIST EQUIPMENT.

- THE MOD SOUGHT AGREEMENT FOR CERTAIN APPLICATIONS TO BE LISTED AS CRITICAL USE.

- THIS WAS AGREED FOR SOME APPLICATIONS WHERE ALTERNATIVES COULD NOT BE FOUND.

6. CRITICAL USE

- HOWEVER, THE TIME FRAME WAS NOT INDEFINITE AND MANY AREAS THAT REQUIRED PROTECTION DID NOT WARRANT CRITICAL USE STATUS.

- THIS HAS RESULTED IN A LONG ROAD TO FIND A SUITABLE 'GREEN' HALON ALTERNATIVE.

- WITH THE ULTIMATE GOAL OF A DIRECT DROP-IN REPLACEMENT.

7. CRITICAL USE

- ONE AREA THAT IS LIKELY TO FALL OUTSIDE CRITICAL USE STATUS IS:

- UNMANNED ENGINE BAYS, AND

- POSSIBLY ARMOURED FIGHTING VEHICLE CREW COMPARTMENTS.

8. ARMOURED FIGHTING VEHICLE PROTECTION

- WITH THE SECOND PHASE OF CHALLENGER II NOW IN PRODUCTION THE NEED TO FIND A SUITABLE PRODUCT TO:

- PROTECT THE ENGINE BAYS, AND
- PROTECT MANNED CREW COMPARTMENTS FROM BOTH FIRE AND EXPLOSION IS CRITICAL.

9. ARMOURED FIGHTING VEHICLE PROTECTION

- WITH THESE TARGETS IN MIND TRIALS HAVE BEEN CARRIED OUT BY SMB SUPPLIES USING FIRESTOPPER.
- SMB SUPPLIES ARE A SOUTH AFRICAN COMPANY THAT SPECIALISE IN DEVELOPING AND MANUFACTURING FIRE AND EXPLOSION SUPPRESSION SYSTEMS FOR BOTH ARMOURED VEHICLES AND THE MINING INDUSTRY.

10. ARMOURED FIGHTING VEHICLE PROTECTION

- THE FIRST TARGET WAS TO FIND A MEDIA, WHICH COULD BE USED TO EXTINGUISH ENGINE BAYS WITHOUT CAUSING DAMAGE TO THE ENGINE.
- FIRESTOPPER WAS CONSIDERED A POSSIBILITY ALTHOUGH THERE APPEARED TO BE RESISTANCE FROM CERTAIN AREAS IN TAKING THIS FORWARD.

11. ENGINE BAYS

- THE INITIAL TRIALS WERE CARRIED OUT ON AN ENGINE BAY SIMULATOR.
- DIMENSIONS BEING 2 METRES BY 1.5 METRES BY 1.5 METRES. WITH A 1 CUBIC METRE CENTRAL CONTAINER REPRESENTING THE ENGINE.
- WITH 20 LITRES OF EXPOSED FUEL.

12. ENGINE BAY

- 2 SETS OF HIGH PRESSURE PIPES WITH NOZZLES WERE MOUNTED ON 2 OF THE SIDE WALLS.
- 1 TIMES 4.2 LITRE PRESSURE CYLINDER CONTAINING 3.6 LITRES OF FIRESTOPPER AT 6% (0.216-L OF CONCENTRATE) WAS PRESSURISED WITH NITROGEN TO 50 BAR.
- THE DETECTION WAS THROUGH THE USE OF ‘FIREWIRE’.

13. ENGINE BAY

- 6 TESTS WERE CARRIED OUT IN THE PRESENCE OF INDEPENDENT OBSERVERS.
- IN EACH CASE THE FIRE WAS EXTINGUISHED INSTANTLY FOLLOWING THE ACTIVATION OF THE PROTECTION SYSTEM.
- THIS CAN BE OBSERVED FROM THE FOLLOWING VIDEO CLIP.

14. CREW COMPARTMENT

- ALTHOUGH FIRESTOPPER PROVED SUCCESSFUL ON ENGINES, IT WAS FELT THAT FURTHER DEVELOPMENT WORK WAS REQUIRED FOR CREW COMPARTMENTS.
- THE TARGET WAS TO TRY AS FAR AS POSSIBLE TO EMULATE A GAS BY DELIVERING FIRESTOPPER AS MICRO PARTICLES SIMILAR TO WATER MIST.

15. CREW COMPARTMENT

- SMB CARRIED OUT A NUMBER OF TESTS INVOLVING DIFFERENT DELIVERY SYSTEMS.
- AFTER VARIOUS CHANGES THEY BELIEVED THEY WERE ON TO SOMETHING.
- THE FOLLOWING SLIDES WILL SHOW YOU THEIR PROGRESS.

16. CREW COMPARTMENT

- FOR THE CREW COMPARTMENT TEST AN OLIFANT MK I TANK WAS USED.
- ALL HATCHES WERE WELDED SHUT EXCEPT FOR THE LOADERS HATCH, WHICH WAS SECURED BY LATCHES.
- A 145 MM HOLLOW CHARGED ROUND WAS POSITIONED OUTSIDE THE TURRET ON A DIRECT LINE TO AN INTERNAL MOUNTED 20 LITRE DIESEL TANK.

17. CREW COMPARTMENT

- INSIDE THE TURRET WERE;

- 3 X 4.2 LITRE HIGH PRESSURE CYLINDERS FILLED WITH 3.6 LITRES OF 6% (0.216-L OF CONCENTRATE) FIRESTOPPER AND PRESSURISED WITH NITROGEN TO 50 BAR.

- 4 X DUAL SPECTRUM DETECTORS (IR/TEMP).

- A 4 TO 20 MILLIAMP PRESSURE SENSOR AND TEMPERATURE SENSOR.

18. CREW COMPARTMENT

- RESULTS:

- FLASH DETECTION OCCURRED 500 MICROSECONDS FROM FIRING HOLLOW CHARGE.

- CONTROLBOX PROCESSING TIME WAS 200 MICROSECONDS.

- BOTTLES FIRED AT 700 MICROSECONDS**.**

19. CREW COMPARTMENT

- BOTTLES RELEASED ALL CONTENTS WITHIN 70 MILLISECONDS.

- MAX PRESSURE RECORDED 6 BAR DURING 2 PERIODS - 1 FOR 5 MILLISECS AT 56 MILLISECS AFTER EXPLOSION AND 1 FOR 8 MILLISECS AFTER 161 MILLISECS FROM EXPLOSION. AVE PRESSURE 0.5 BAR.

- MAX TEMP REACHED WAS 49 DEGREES C.

20. CREW COMPARTMENT

- OBSERVED: SEE VIDEO CLIP

- HOLLOW ROUND MADE AN ENTRY HOLE OF 75 MM AND EXPLODED THE DIESEL.

- DIESEL WAS FORCED THROUGH SMALL OPENINGS IN CUPOLA AND CAUGHT FIRE. ALL EXTERNAL FLAMES WERE GONE WITHIN 4 SECS.

- NO SIGNIFICANT INTERNAL HEAT DAMAGE.

Videos available upon request and/or visit:
http://www.firestopperinternational.com/?context=commercial&tmpl=videos

Fig 1.

Fig 2.

Fig 3.

Fig 4.

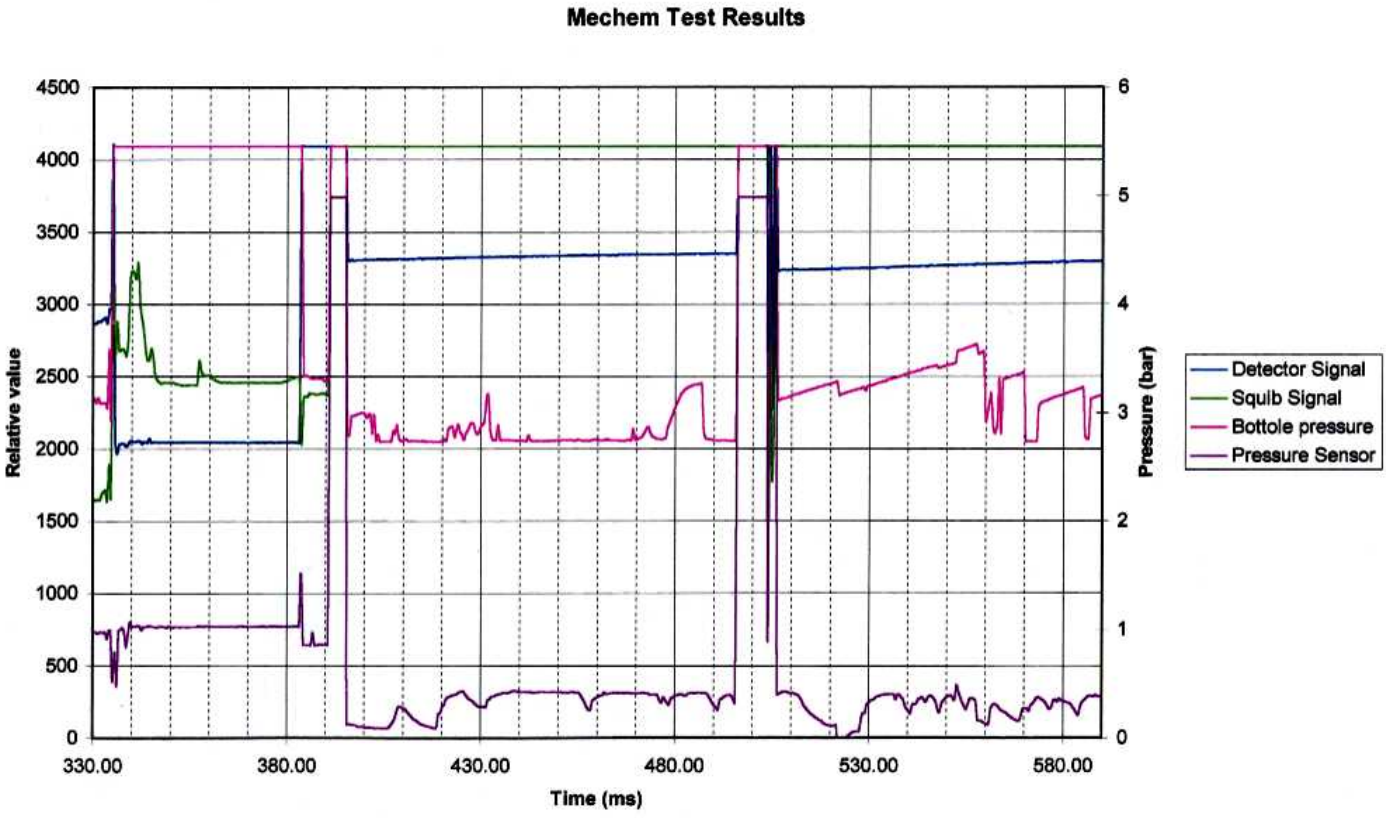
Figures 1-4 depict beginning and result of explosion test (please note these are 4 of 32-slides taken in sequence of the full explosion).

Below Figure 5 & 6 represent the round entry and exit points.

RESULTS OF DEMONSTRATION ENVIRONMENT MONITORING DEVISES

- *Pressure[3] readings were taken at entry of round and exit of round*
- *Temperature[4] readings were also taken at entry and exit or round*
- *Additional temperatures were recorded:*
  - *Ambient temperature*
  - *Event temperatures*

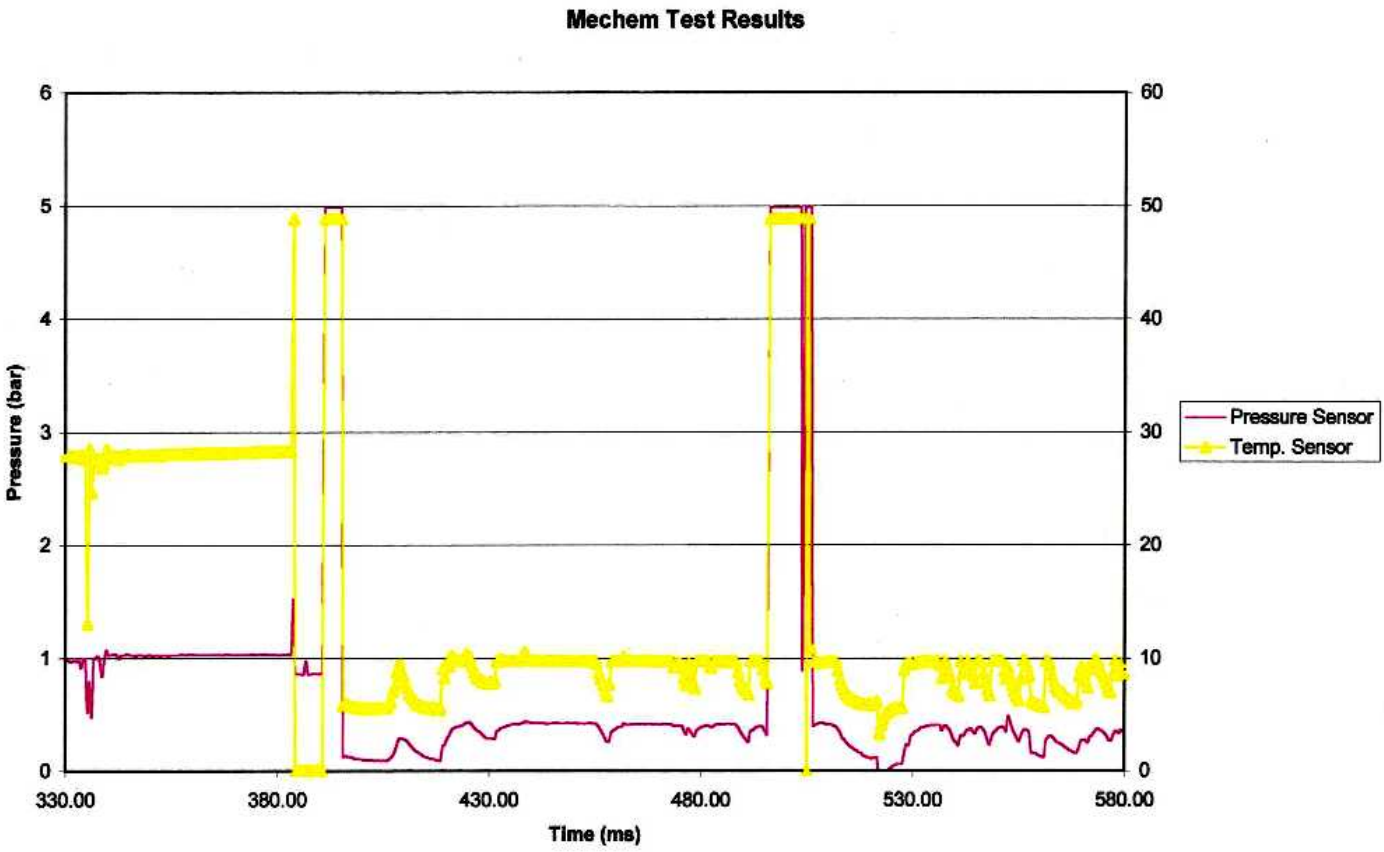
Fig. 7



[3] PLEASE SEE CHART BELOW

[4] PLEASE SEE CHART BELOW

Fig 8.



Pursuant to the above test report, FireStopper continued its improvement of deployment of the suppressant and based on the performance as stated above, the agent FireStopper® AB 40002 FFC refined its suppression capability of the explosion and fire as described in the MoD report in less than100 ms.

TODAY'S COMMERCIALLY AVAILABLE ANTI-EXPLOSION PRODUCT

(The below extract was generated as a direct result of recognition that FireStopper® EXP FFC is "the only viable comprehensive explosion and fire suppressant" capable of delivering the most reliable anti-explosive and fire protected environment for all applicable uses.)

MINUTES OF MEETING[5]:

Suppression of transformer explosions
Place: GexCon AS
Date: 15.03.2013
Participants: Per Olav Hetland, Statkraft
Geir Vårdal, SiraKvina
Ranjit Bedi, CEO Firestopper International Ltd.
Teis Kvilhaug, FireStop AS
Olaf R. Sigmundsson, FireStop AS
Several other participants from FireStop AS and FireStopper International Limited
From Iceland, Norway and USA
Gisle Enstad, GexCon AS
Kees van Wingerden, GexCon AS

Copy: Brian Wilkins, GexCon AS
Prepared by: Kees van Wingerden
Project: 44229
MM No.: 1

Background

The main aim of the meeting was to investigate whether there is an interest in the Norwegian power industry to support a project aiming at finding alternatives to Halon, which are still used to suppress fires and explosions in transformer rooms. Norwegian power companies still have dispensation for the use of Halon (which are forbidden in connection with these compounds causing depletion of the ozone layer). A project proposal has been sent to several power companies and one producer of transformers regarding the testing of a new suppressant called FireStopper®.

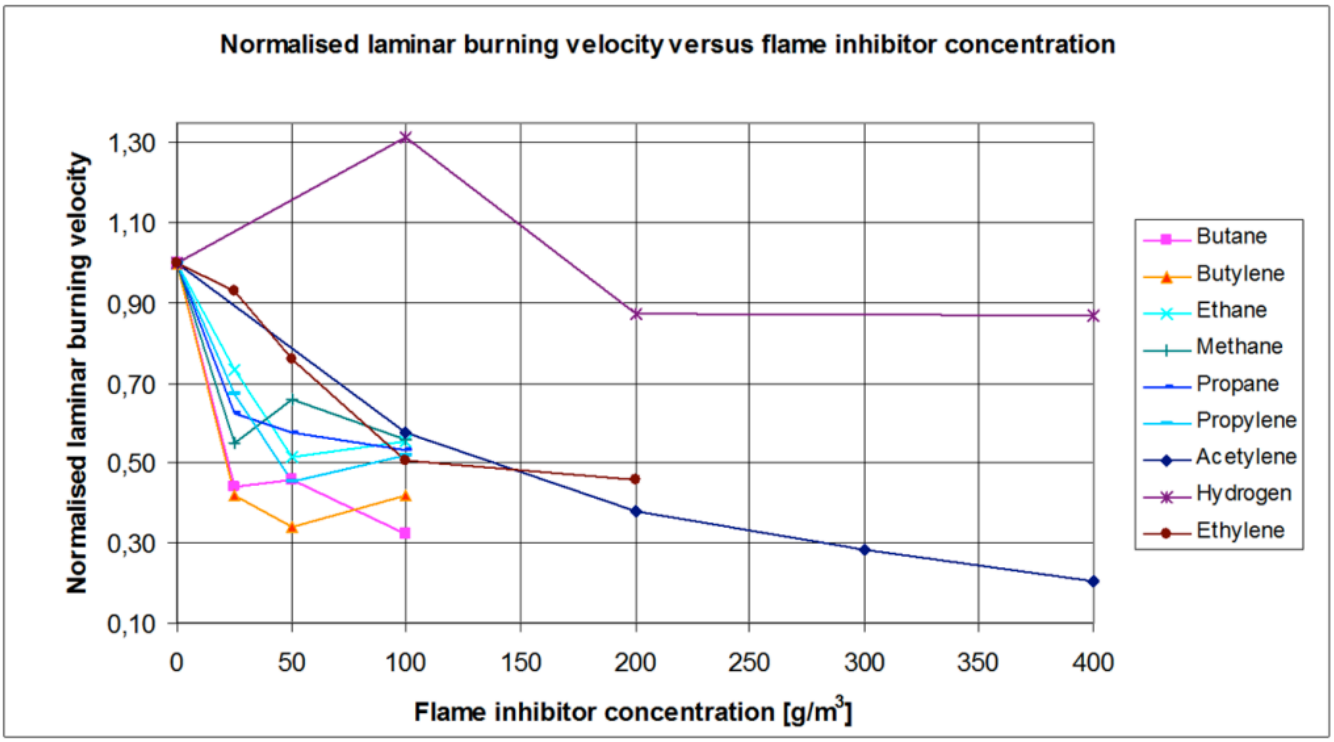
Experiments performed during a project performed in 2001 showed that several suppressants failed when the concentration of hydrogen (of oil mist-hydrogen mixtures) was increased (hydrogen is one of the flammable gases resulting from cracking in case of short circuit in mineral insulating oil in a transformer). The suppressants used were water mist, sodium bicarbonate and an aqueous solution with chemical additives (salts). The limited effect of salts such as sodium bicarbonate and potassium carbonate on hydrogen explosions was also demonstrated in tests in a 20 l sphere involving mixtures of hydrogen, potassium carbonate and air and various hydrocarbons mixed with air and potassium carbonate. A strong reduction of combustion rates was seen when relatively small amounts of potassium carbonate were added to hydrocarbon-air mixtures; for hydrogen this was not the case (see Figure below; from “Van Wingerden, K. and Hoorelbeke, P. (2011) On the potential of mitigating vapor cloud explosions using flame inhibitors, Proceedings of the 7th Global Congress on Process Safety, Chicago, Illinois, March 13-16”).

Although several companies who were invited to the meeting and could not attend a genuine interest was expressed among many of the invited companies (some did participate via telecommunication).

[5] Gexcon, AS’s proposal to Industry to uptake the cost of testing and certification based on the stand-alone efficacy of the FireStopper® technology producing said advancement. Industry has accepted their participation in the project.

Below is a chart expressing the expansion of different explosive media:

Fig 9. Suppression of transformer explosions MoM



MM No.: 2

Introduction of FireStopper International

At the start of the meeting, Ranjit Bedi, CEO and Kees van Wingerden, Technical Director introduced the companies. PowerPoint presentations[6] presenting the companies have been attached to this MoM. During the presentation also properties of FireStopper (the suppressant) were presented. FireStopper is water based, is PH-neutral, can be applied for a wide range of temperatures, can be applied for all types of fire: A, B, C, D and F (C = Electric) and will be effective against all hydrocarbons and hydrogen. A report showing it can be used against electric fires (according to UL 711; electrical conductivity test)[7] has been enclosed.

MM No.: 3

Presentation of Gexcon Proposal

Kees van Wingerden presented the instant proposal. It is proposed to test the properties of FireStopper in a 1.2 m3 vessel following the guidance given in the European standard EN 14373. The experiments would be performed with methane and methane-hydrogen mixtures. The first

[6] Available upon request

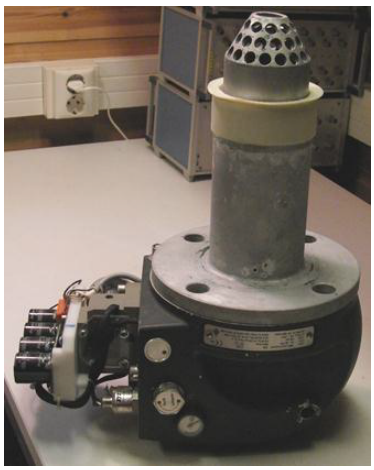
[7] Available upon request

would allow for comparison to experiments published for Halon (Bartknecht, W. “Explosionsschutz; Grundlagen and Anwendungen; Springer; Berlin; Heidelberg; 1993”) the second to represent oil mist-cracking products mixtures. The tests would involve variations of the following parameters:
· _Activation pressure (varied from 0.05 to 0.2 bar)
· _Amount of FireStopper® introduced to suppress explosion
· _Gas type (methane and hydrogen-methane)
· _Gas concentration

The specific FireStopper® that would be used in the proposed work is referred to as FireStopper® PFE-FR FFC.

The tests would be performed with a standard (powder based) suppression system (see pictures below): Suppression of transformer explosions MoM

Fig 10.



Nozzle Commercial Suppression System

Fig 11.

Valve Commercial Suppression System

Fig 12

Container For Suppressant Mounted on to Valve

PRODUCT AND APPLICATION

- **FireStopper® EXP FFC** (a premix exclusively available with for use in conjunction with FireStopper® trademarked systems)

Advantages:

- The only proven product effective on Hydrogen/Methane explosions (at Gexcon, Norway)
- Non-toxic, non hazardous and non-corrosive
- Biodegradable/Environmentally Safe
- Super anti-explosive properties
- No unpleasant odor

- Great temperature reduction i.e. (>1500°F in < 40 sec.)
- Freeze Resistant: -100°F (-73.33°C)
- pH Neutral
- Post blast all fire class effective agent (A-B-C-D- (F)-K) and all sub-classes of flammable materials

APPLICATIONS THROUGH SYSTEMS:

- Petrochemical Operations
- Government
- Mining
- Shipping
- Tanking
- Fueling
- Transportation
- Military
- Aerospace
- Aviation
- *And any other applications requiring explosion and fire protection*

FireStopper® provides full systems in the portable and fixed range with the full capability to supply specially designed systems to fit the purpose. It will also provide full service from design to installation and training should the need arise.

In concert with this great technological leap, FireStopper® will provide the most advanced and durable detection and activation systems, ***capable of detecting <4-microsecs and deploying in <40-msecs***, to complement the intended application results. All wet materials are supplied in the most durable stainless steel available to insure quality and reliability.

FireStopper® is the only manufacture to provide its customers with a 20-year limited warranty on all wearable parts.

In the economy of time, we will address one major application as an exemplar use that can be modified to any size or application of this category of FireStopper® products:

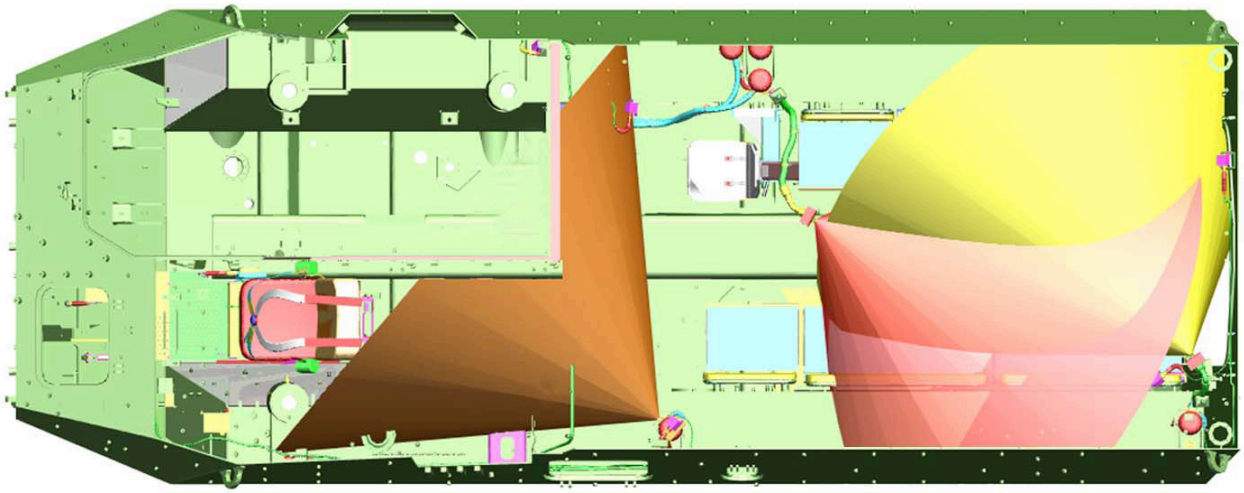
INTRODUCTION

Military armored vehicles have incorporated Automatic Fire Extinguishing Systems (AFES) to protect the crew from combat fuel explosions caused by penetrating munitions for more than 20-years (ref. 1). Before the Montreal Protocol went into effect, Halon 1301 (Bromotrifluoromethane) was the agent of choice in military vehicle crew-bay systems. Newer military vehicles have been protected using a Halon-alternate HFC agent. Unfortunately, HFC agents have significant Green-House Warming Potential (GWP). Therefore, a third generation of agents with acceptable GWP was explored thereafter. Water with freeze-point depressant additives, Novec 1230, and a host of Fluorinated streaming agents such as FM 200, FE 25, 36, & 13 were promising third generation agents. All Halon-alternate agents have significantly different physical properties than Halon. The

result is that no replacement agents applied in a military crew-bay AFES have been a drop-in replacement for Halon. But Halon-alternate agents have been successfully integrated in military vehicle AFES. In all cases significant re-engineering has been required before acceptable fire suppression and operational safety was achieved. The major steps required in order to apply Halon-alternate agents are described in this paper.

Environmental legislation, principally the US DoD direction to phase out ozone depleting materials such as Halon and other CFC's from military applications, led to a search for non-Halon, or "alternate" fire suppression agents. At about the same time, the US Army refined its safety requirements. TACOM conducted testing aimed at finding alternate agents that met the new medical and environmental requirements. Two agents were reported as acceptable: a blend of HFC-227ea (a type of heptafluoropropane) and 5% by weight dry chemical (based on sodium bicarbonate) and water with a freeze point depressant additive. The HFC-227ea and dry chemical blend is now listed as HFC227-BC under the EPA's Significant New Alternatives Policy (SNAP) Program. Alternate agents applied in crew-bay AFES were also studied in independent research done by others. The first qualification of a crew-bay AFES using HFC227-BC was for the USMC EFV, formerly known as the AAAV.

Fig 13. Exemplar of an amour personnel carrier's potential system



REVIEW OF REQUIREMENTS FOR AFES CREW BAY PROTECTION SYSTEMS

The crew-bay AFES used in legacy vehicles to protect the crew use high-speed extinguishers charged with Halon 1301 (bromotrifluoromethane). The performance requirements for these systems were that they quickly extinguish a fuel explosion, typically in less than 250 ms. The first systems were designed to achieve 6 to 7% Halon 1301 concentration by volume in air and to meet NFPA 12A (1970) exposure limits. Much later, the EPA invented the No Observed Adverse Effects Limit (NOAEL) and the US Army Surgeon General specified a 6% maximum.

The results of medical research of combat related issues in armored vehicles were published in the late 1980's. The Walter Reed Army Institute did extensive research into the health aspects of Halon systems and recommended limits on criteria other than fire out time. A result was the refinement of performance and safety requirements for crew-bay AFES.

Associated with the Army's push to develop a new crew-safe fire-suppression agent were new safety, test methodology, instrumentation, and approval issues. In addition to obtaining SNAP listing, the new agent needed to be approved by US Army Center for Health Promotion and Preventive Medicine (USACHPPM). Existing criteria for impulse force and discharge noise studies had to be revisited, and new areas of concern, such as soft tissue damage due to exposure to cryogenic fluid and dust bombardment had to be addressed. Medical criteria for the latter may need to be developed for military applications. Finally, high-speed concentration measurement instrumentation needed to be changed to accommodate agent property differences.

The new performance requirements were mainly based on reports to the US Army Surgeon General from the medical community. Maximum HFC227-BC fire suppression agent exposure concentrations were based on NFPA-2001 (2000). The acceptable acid gas levels can be based on exposure times or a peak recorded level.

The US Army develops the application-specific Fire Suppression requirement during the Performance Verification Tests.

Employing the vast advancements in the FireStopper®/Enviro-Safe® Technology today we can demonstrate improved explosion and fire suppression in less than 50 ms in addition to providing fire protection in all known class and subclass of rated potential fires by employing advanced detection, activation, and deployment of the fail safe suppression product, FireStopper® PFE-FR FFC and FireStopper® EXP FFC the latest development in the Technology.

These exclusive new Agents available only through FireStopper® Systems come with third-party Non-Toxic, Non-Irritant to skin and eyes certification and exceed recognized eco safety requirements as mandated by governmental decree in addition to rating and listing under NFPA 10, ANSI/UL711, and ULCS508 in addition to resisting conductivity to 100kv as required by all the above standards for "C" rating at 24 inches with a fog spray. Moreover, adjunct to the above litany of certifications, FireStopper® PFE-FR FFC is in the process of certification to EN3-7. This new candidate for use in AFES does not require premixing for ease of use and as an aqueous base product, it resists freezing to -100˚F (-73.3˚C) without employing dangerous and hazardous antifreeze compounds.

System Validation – Independent Evaluator

The final steps in system validation often involve tests designed and conducted by the end user, for example, the US Army. The end user independent evaluator tests can include agent concentration measurements and live-fire tests. The AFES vendor may or may not be present during these tests.

CONVERSION FROM HALON TO ANOTHER AGENT

Converting an armored vehicle crew-bay automatic fire protection system from a suppression agent to another is not trivial. In addition to the steps described earlier, Integration issues that must be addressed or re-addressed include:

1. Selection of an appropriate agent
2. Review of performance qualification criteria (e.g. fire suppression performance including toxic by-products)
3. Review of environmental qualification criteria (e.g. operational and storage temperature

limits)
4. Review of operational safety qualification criteria (e.g. discharge acceleration forces)
5. Size and placement of extinguisher components (e.g. a different quantity of agent and/or different nozzle design and/or placement may be required)
6. Material compatibility (e.g. are the seals used in the Halon extinguishers compatible with the replacement agent for the life of the product?)
7. Qualification test methods and plan (to verify design based on above)
8. Third party approvals (if required)
9. Post-deployment support issues to address:
    a. Is AFES warranty affected?
    b. Revised vehicle documentation including spares parts lists and operation and maintenance manuals and instructions will be required.

Conclusion

Medical and Environmental concerns necessitated changes in armored vehicles including changes to the crew-bay AFES. A major change in the AFES was the switch from Halon 1301 to a Halon-alternate suppression agent such as a blend of HFC-227ea and sodium bicarbonate based dry chemical. However, the experience gained from the recent use of alternate suppression agents to date beg for the search and implementation of an agent that would truly raise the bar on the survivability during an explosion or fire event to the AFES.

In addition, the new agent should be capable of delivering added protecting to the crew by maintaining a habitable environment in the aftermath of an ordnance intrusion event so that the crew could mount an escape or a counter attack. Moreover, the next generation agent after its deployment should not pose any added burden to perform their duties or add any danger to the health of the crew.

Notwithstanding the above, FireStopper®'s EXP FFC and PFE-FR agents are easy to handle during the required maintenance of the system therefore reducing the need for highly trained personnel in time of need. Also, their obvious advantage over the tired old technology products currently employed both in efficacy and environmental requirements, make these products the most desirable options going forward. FireStopper® is providing this advance line of products without limitation in quantity within acceptable standard delivery time.

The integration of the Halon-alternate suppression agents in crew-bay AFES presented unique challenges. The integration of FireStopper® EXP FFC and PFE-FR FFC will usher in a new and reliable system of protecting AFES in a level of safety and efficacy not contemplated to date by TACOM or any other DoD agency charged with the task of developing new requirements.

Responsibility to provide safety is owed to the public by both Government and Industry. In current profound social and economic conditions, Government, Industry and the consumer cannot afford the risk of loss both materially and always risk to life. FireStopper® offers the only real security against the always present danger of serious environmental degradation, catastrophic fire and or worst, explosion.