THE CATALYST

Q4 2022

JOIFF

The International Organisation For Industrial Emergency Services Management

JOIFF Welcomes New Members

The Board of Directors were pleased to welcome new Members during Q4 2022.

JOIFF Role of Honour

A list of JOIFF qualifications that have been awarded to specific persons during July, August and September 2022.

News from Accredited Training Providers

Highlighting successful audits that took place during Q4 2022.

IN THIS ISSUE:

RelyOn Nutec

Fire Academy

Fomtec Enviro ARK and Enviro USP

FM approved and UL listed Fluorine Free Foams

with sprinklers for hydrocarbon and polar solvent fuel fires.

Fomtec Enviro is a comprehensive range of Fluorine Free Foams for Emergency Response and System applications. Tested and approved high performance alternatives to PFAS based foam agents.

enviro by fomtec

fomtec Fire Fighting Foams & Equipment

ABOUT JOIFF

JOIFF, the International Organisation for Industrial Emergency Services Management is a not-for-profit organisation dedicated to developing the knowledge, skills and understanding of personnel who work in and/or who are required to provide emergency response to incidents In Industry, primarily High Hazard Industry, with the aim of ensuring That risks in Industry are mitigated and managed safely.

The 4 pillars of JOIFF aiming to support its Membership in preventing and/or mitigating hazardous incidents in Industry are: Shared Learning – improving risk awareness amongst JOIFF Members; Accredited Training – enhancing operational preparedness in emergency response and crisis management; Technical Advisory Group – raising the quality of safety standards in the working environment of High Hazard Industry and Professional Affiliation - networking and access to professionals who have similar challenges in their work through Conferences and other events and the prestige of being a member of a globally recognised organisation of emergency response.

Full Members of JOIFF are organisations which are high hazard industries and/or have nominated personnel as emergency responders/hazard management team members who provide cover to such organisations. Commercial Members of JOIFF are organisations that provide goods and services to organisations in the High Hazard Industry.

JOIFF welcomes enquiries for Membership - please contact the JOIFF
Secretariat for more information.

JOIFF CLG is registered in Ireland. Registration number 362542.
Address as secretariat.

JOIFF is the registered Business Name of JOIFF CLG.

ABOUT THE CATALYST

The Catalyst is the Official magazine of JOIFF, The International Organisation for Industrial Emergency Services Management. The Catalyst is published Quarterly – in January, April, July & October each year. The JOIFF Catalyst magazine is distributed to all JOIFF members and member organisations worldwide. The Catalyst magazine is published by ENM Media on Behalf of JOIFF.

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Message from the **Chairman**

Dear JOIFF Members and Catalyst readers,

Thanks to all our Readers for your support during the past few difficult years of COVID and lockdowns. I would like to update you on our activities since COVID first hit and the current status of JOIFF.

Within a few months of Worldwide lockdown in February 2020, the Directors, in association with our Commercial Managers, ENM, embarked on a series of online webinars. To date, these events covered a vast variety of the subjects including Training, Foam technology – the changing environment, Firefighter's Health and Well-being, Crisis Management, Inspection, Testing, Maintenance and Cost Benefit Analysis, CAFS Fixed Pipe Systems, Non-technical skills in an Emergency, Fighting Fires with Turbine Engines, Updates from LastFire, NFPA 11 Revisions and European Chemicals Agency with regard to PFASs in firefighting foams.

During the years since COVID hit, JOIFF's Subject Matter Expert Working Groups completed 2 very important Guidelines – "Emergency Response to incidents involving vehicles powered by Alternative Fuels (including Hybrid vehicles)" and "Emergency Services Management of Airports". Both of these Guidelines have been very well received and the Guideline on Emergency Response to incidents involving vehicles powered by Alternative Fuels has been translated into the Croatian language by one of our members in Croatia and published by the Croatian Firefighters' Association.

During 2021 and 2022 work proceeded on a major upgrade of the JOIFF website which greatly improved the level of service provided. With their own special password, our members can access the Members Area to find the JOIFF Membership Directory, the JOIFF Shared Learning archive, JOIFF Guidelines and a number of recorded presentations made at JOIFF's past conferences, webinars and seminars.

During the past few years with the excellent support of ENM Media, there have been major improvements in the print quality and content of our quarterly e-Learning magazine The Catalyst. Articles cover a wide and growing range of subjects related to Emergency Services Management and we extend our thanks to the authors and advertisers who support us in each quarterly magazine.

We are currently establishing Technical Advisory Groups drawn from Subject Matter Experts in our membership. We want these Groups to provide knowledge and opinions that can be discussed by members of JOIFF, with a view to building JOIFF codes of practice and standard operating procedures to assist its members in hazard management within their own sites and to provide specialist input to regulatory authorities and other policy making organisations at local, national, and international level.

Our planning is well advance for our first face-to-face events since COVID with the JOIFF Conference South Africa on 14th and 15th November 2022 at Emperors Palace Hotel, Johannesburg and the JOIFF Conference in association with RelyOnNutec which will take place in Rotterdam on 6th and 7th March 2023 These events will provide a great opportunity for networking, direct contact with suppliers and industry specialists, live demonstrations etc.

May I wish you health, safety and prosperity and to those engaged in any aspect of Industrial Emergency Services Management who are not yet members of JOIFF, I urge you to consider joining us to participate in our most important activity of Shared Learning to learn from and educate others from members' experiences aimed at improving standards of safety in the working environment in which JOIFF members operate.

Enjoy this edition of the Catalyst and I hope to see some of you soon at the JOIFF Conferences coming up!

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www.joiff.com

Please visit www.joiff.com for more information.

The Catalyst

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ROLL OF HONOUR

During July, August and September 2022, the following persons were awarded JOIFF qualifications:

JOIFF TECHNICIAN

Left to right:
Mat Rooney Tech JOIFF,
Owen Jones Tech.JOIFF,
Robert Birtles Tech.JOIFF

Greater Manchester Fire and Rescue Service United Kingdom

On successfully completing and being awarded the JOIFF Technician Mat, Owen and Robert agreed the following:

"Completing the JOIFF Technician programme has been enjoyable and educational. It has given me the necessary knowledge and skills to support an effective operational response in the event of an incident as well as helping me to give proactive advice and support as part of my role as a Fire Safety Enforcement Officer and Fire Engineer. This in turn helps all of us to reduce and manage the inherent risks, improving safety for the public, site operators and emergency responders while minimising the possible impacts to the environment".

"I have just recently received my JOIFF Technicians Certificate and completed the practical element at the H2K course in Vernon, France. I have really enjoyed my Petro-chemical journey so far. I am now looking to push my learning further by visiting a local oil refinery to embed the learning from Unit 6 of the Technician programme. My colleagues and I are organising four COMAH exercises, at a risk site in the Greater Manchester footprint, which will cover all four watches in order for the Foam Unit Stations and Petro-chemical officers to practice the skills we have learned in a real world environment. The skills I have acquired through the JOIFF program have bolstered the learning from the theoretical and practical elements in Essex and Vernon which we can now confidently pass on to our officer cadre and operational teams. Thank you for all your help and support."

The Catalyst and the Directors of JOIFF extend congratulations to all those mentioned.

John Trew MJOIFF
Technical Director
Falck Fire Services UK Ltd.
United Kingdom

John Trew MJOIFF began his career in Aviation Fire and Rescue in 1974. He joined British Airports Authority in 1979, and held the job roles Leading Fireman, Sub-Officer Fire Safety Officer, Operational Fire Station Manager and in 2001 was appointed Airport Fire Manager of BAA Fire Service (Heathrow).

As Airport Fire Manager, he was a key member of the Heathrow Management Team with responsibility for ensuring that the Airport Fire service was integrated into the airport business. Amongst his responsibilities in this role, he maintained a fully effective emergency fire & rescue service in order to save life and protect property in line with company standards and licensing requirements; he managed a Category 10 airfield rescue firefighting cover, leading a large team of 10 direct reports and 95 indirect reports; he provided technical advice to the fire service team, external emergency services and the crisis team in order to minimise business disruption and assist the business to return to normal operations, following an incident; he motivated and challenged the team to aspire to demanding goals and build confidence and a passion to achieve maximum potential and he encouraged and facilitated the development of a constructive culture, working closely with trade union representatives and chairing forums

On leaving Heathrow in 2009, he took on the role of Aerodrome Inspector with the UK Civil Aviation Authority. As a member of the Aerodrome Standards Team in the Safety Regulatory Group based at Gatwick Airport he had responsibility for overseeing a number of licensed aerodromes up to Category 10 in the areas of rescue and firefighting service and emergency planning

John is currently Technical Director of JOIFF member organisation Falck Fire Services UK Ltd.

John has been a supporter of JOIFF for many years and was advisor to the Working Group who developed the recently produced JOIFF Guideline on Emergency Services Management of Airports and a member of JOIFF's newly formed Subject Matter Expert Working Group on Aviation.

During Q2 2022 John Trew MJOIFF was recognised by ARFF Working Group for his excellent work in the Aviation Sector.

John Trew, receiving the ARFF WG Legend Award from Rob Relyea.
Rob Relyea is a founding member of the ARFF Working Group, an ARFF WG Legend, Chair of the Legend Committee and designer and creator of the Snozzle (HRET – High reach extendable Turret) widely used in Aviation firefighting today.

The presentation took place in Orlando, Florida at the ARFF Working Group seminar.

John Trew was chosen as the ARFF Working Group 2022 Legend Award recipient.

This prestigious honour is given to those who have made significant contributions to the advancement of aviation fire safety. The recipient must have
• been actively involved in the industry for a minimum of 20 years;
• played a significant role in the shaping and direction of the ARFF community;
• demonstrated a commitment over many years to foster progress within the ARFF industry;
• provided the catalyst for major change or improvement in the ARFF industry;
• developed a level of respect within the ARFF community that contributed to their effectiveness and
• made substantial sacrifices to continue to be engaged in the ARFF community.

At the presentation, John was told that the Aviation fire safety community is a better place largely due to his hard-fought efforts to recognise the need to improve the levels of service, technology, and involvement of the ARFF industry. Hs tenacity and "NEVER GIVE UP" attitude have not only benefited the Aviation fire safety industry but the safety of all those who take to the airways throughout the world.

JOIFF

RelyOn Nutec
Fire Academy

JOIFF

INDUSTRIAL EMERGENCY SERVICES MANAGEMENT CONFERENCE 2023

6 & 7 MARCH 2023

JOIFF In association with RelyOn Nutec are pleased to announce The JOIFF Industrial Emergency Service Management Conference 2023 will take place on March 6th & 7th 2023 at the Hilton Hotel - Rotterdam - The Netherlands.

World Class Presentations, Unique Face To Face Networking, Direct Contact With Suppliers & Industry Specialists, Live Fire Demonstrations

As part of the ongoing Shared Learning commitment to the high hazard industry JOIFF are pleased to announce that we will be hosting the JOIFF Industrial Emergency Management Conference 2023 in Rotterdam, The Netherlands 6th & 7th March 2023.

This will be both a live in person event and also a hybrid/virtual event with global subject matter experts from around the world presenting on the subjects that matter most to the Industrial Emergency Services Management Specialist.

Plus live demonstrations at the RelyOn Nutec Fire Academy.

To ensure that this unique Shared Learning is available to everyone JOIFF will not be charging delegates a registration fee to attend this Conference.
(Does not apply to travel, accommodation or refreshments outside of the Scheduled Conference)

World class presentations, unique face to face networking, direct contact with suppliers and industry specialists.

International speakers covering the full range of Industrial Emergency Management topics over the 2 day Conference, latest technical advances, case studies, technical presentations, live demonstrations, suppliers presentations & supplier exhibition.

Who Should attend:

Fire Engineers - Fire Safety Consultants - Fire Risk Consultants - Occupational Safety Managers
Process Safety Managers - Safety & HSE Managers - Emergency Services Personnel - HSEQ Managers
Risk Managers - Emergency Response Personnel - Security Managers - Operations Managers
Industrial Safety Managers - Inspection & Training Managers

FOR DELEGATE REGISTRATION PLEASE GO TO WWW.JOIFFCONFERENCES.COM

If you would like further information on how you can promote your company at this unique event please contact the Event Director - Paul Budgen
Tel: +44 (0) 1 305 831 768 or email: pbudgen@edicogroup.net

If you would like to submit a presentation for consideration please contact Conference Coordinator Lora Lammiman email:
lora.lammiman@edicogroup.net

JOIFF NEWS

Aviation

The JOIFF Guideline on Emergency Services Management of Airports was published in July 2021. It was very well received and instigated widespread discussion. As a result, the JOIFF Directors have established a Working Group of JOIFF members with the aim of reviewing the 2021 Guideline and to consider other Aviation matters as they arise.

Members of the JOIFF Aviation Working Group are Chairman, John Trew MJOIFF, Falck; Daryl Bean MJOIFF, Curriculum Manager, International Fire Training Centre, Darlington; Dave Cook, Aviation Consultant; Gerry Johnson FJOIFF, JOIFF Director, Ian Redfern MJOIFF, Group Manager, Greater Manchester Fire and Rescue Service; Chris Thain, Business Development Manager – Fire & Rescue Services G3 Systems Limited and Gary Wright, Fire Service Manager, Newcastle International Training Academy.

JOIFF Business Team

In August, the JOIFF Business Team met for their first "face-to-face" meeting since the COVID lockdown in 2020. The years since the lockdown was a busy one for the Business Team as outlined in the Chairman's message in this edition of The Catalyst.

The Team discussed the programme for 2023 and will be working to increase the content and extent of the JOIFF Shared Learning network and working to increase the membership of JOIFF and the network of JOIFF Accredited Training Providers.

NEW MEMBERS

During July, August and September 2022, the JOIFF Board of Directors were pleased to welcome the following new Members.

Corporate members
Shandong International Ocean Engineering Training Center (SIOETC) Weifang City, Shandong Province, China, represented by Wu Yue. SIOETC, established in 2018, is an International standardized safety training center. It is located on the coast of Bohai Sea and Laizhou Bay, adjacent to the national first-class open port-Weifang Sime Darby Port.

SIOETC combines international advanced training experience, training courses and management experience, meets international multi-organization standard certification, and trains in China to meet global marine engineering industry customers i.e. offshore oil, wind power, minerals etc. SIOETC also supports engineering systems i.e. military, marine, aviation, public security, firefighting, emergency rescue organizations, medical security departments and other related maritime personnel and management personnel, engaged in certification, certification & skills training, and the promotion of marine resources practitioners.

The principal of SIOETC training is to improve the safety, environmental protection, and survival skills of personnel at sea, and improve the survival rate of accidents and the success rate of rescue.

Thanks to the unity and tenacity of SIOETC's team there has been good progress in the system of internationalization in China and in the past two years and eight months, the Team in SIOETC is happy to report that they have passed the certification of a number of domestic and foreign industry organizations.

The World of Safety and Health Asia Awards recognise excellence within the safety industry based on new and innovative solutions that improve workplace safety and health. SIOETC was awarded the WSHAsia Award 2022 in the category of Best Product(s) Service(s).

The Safe Direction Company, Basra, Iraq, represented by Karrar Mohammed Makki, Managing Director. The Safe Direction Company is engaged in the supply of oil and gas fire fighting services, Emergency Management and Response training, fire protection design, supply and installation and PPE manufacturing and supply. The Company provides fire engineering risk assessment and design consultation and studies and provides environmental remediation and oil spill response equipment and services.

We look forward to the involvement of our new and existing Members in the continuing development of JOIFF.

The JOIFF Directors and the JOIFF Business Team met in Dublin in August.

Left to right: Mohanned Awad, Mark Feldman, Gerry Johnson, Kevin Deveson, Pine Pienaar, Alec Feldman, Paul Budgen

CONNECT WITH JOIFF ON THE WEB.

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Accredited Training Providers

During Q4 2022, the following accreditation audits were carried out

NATIONAL CHEMICAL EMERGENCY CENTRE
United Kingdom
National Chemical Emergency Centre (NCEC) Team being presented with their JOIFF certificate of accreditation

Josh Allaway, Gerry Johnson JOIFF Auditor, Ed Sullivan

NEWCASTLE INTERNATIONAL AIRPORT TRAINING ACADEMY
United Kingdom

Newcastle International Airport Training Academy Team being presented with their JOIFF certificate of accreditation

Carla Barry, Instructor, Gerry Johnson JOIFF Auditor, Gary Wright, Fire Manager, Victoria Woodhouse, Commercial Training Executive, Craig Kelsall JOIFF auditor

SASOL SECUNDA EMERGENCY MANAGEMENT TRAINING ACADEMY
South Africa

SASOL Secunda Team being presented with their JOIFF certificate of accreditation

Leon Cassel, SASOL, Pine Pienaar, JOIFF Auditor, Sakkie Joubert, SASOL

NEWS FROM JOIFF
Accredited Training Courses

Newcastle International Training Academy
United Kingdom

14 firefighters from the Federal Airports Authority of Nigeria were recently welcomed to newly JOIFF accredited Newcastle International Training Academy and took part in a bespoke Fire Instructor course with the Training Team in Newcastle over two weeks.

The feedback from the firefighters on the course was that the course is one of the best courses they have ever attended. The instructors were very experienced and facilities excellent and the accommodation was also outstanding.

Well done to the team at the Training Academy.

H2K
The Netherlands

JOIFF Accredited Training Provider H2K, The Netherlands recently held their first open enrollment 5-day Advanced Industrial Firefighting course. All international participants successfully completed the training and are now the proud owners of JOIFF certificates.

H2K said "It has been a great week!"

TRAINING INDUSTRIAL EMERGENCY RESPONDERS.

Introduction:
Training for emergency response personnel who provide cover to high hazard industries should be robust, challenging and relevant and based on the risk that they are exposed to, not based on standards. The goal should be to produce a well trained and properly organised emergency response team comprising members who are thoroughly familiar with their own site and its particular problems and are able to respond effectively to incidents on or off site according to the Area Emergency Response Plan.

JOIFF aims to achieve this goal through JOIFF Accreditation, a system of quality control of the policies, procedures and protocols operated by an organisation that provides training for emergency response personnel.

To obtain JOIFF accreditation, a Training Provider must meet the criteria set down for the three pillars that make up effective provision of training:

•Establishment/organisation including facilities, Safety Management Systems and procedures;

• Instruction

• Courses/programmes.

All aspects together must be to a required standard for JOIFF accreditation to be awarded and the applicant organisation must demonstrate proprietary ownership of all 3 pillars. The applicant organisation must be able to demonstrate that the required standard is part of the regular operation of the organisation and that they have in place on an on-going basis, effective systems and procedures that will ensure continual provision of all these outcomes.

Type and frequency of Training:
In developing a training programme, five distinct phases should be considered.

1.Initial training: "Acquisition" - to gain the attitude, knowledge, competency skills and understanding identified for a particular role, before being permitted to engage in emergency operations;

2.Continuous training: "Application" - to consolidate, practice and apply the knowledge, skills and understanding developed during initial training, to the Workplace;

3.Refresher training: "Maintenance" - a revision of fundamental knowledge and skills;

4.Conversion training: "Acquisition" - designed to familiarise whenever changes in procedures and/or technology are introduced, and/or new hazards are identified in the work environment;

5.Revalidation training: "Confirmation" - to up-date and develop new techniques and/or to enhance the skills learnt in earlier training.

Whether full time or part time, members of Emergency Response Teams (ERTs) expected to carry out the same duties and to have the potential to be exposed to the same risks, should receive the same amount and type of Continuous Personal Development (CPD) and be issued with and trained in the use of the same type of Personal Protective Equipment (PPE). Training should be as frequent as necessary to ensure competency and that members of ERTs can perform their duties in a safe and competent manner that does not pose a hazard to themselves or to other persons.

For the on-going safety and efficiency of emergency response personnel whose responsibility includes firefighting, it is considered essential that competence in practical firefighting and in the correct use of breathing apparatus (B.A.) is maintained. In order to maintain such competence, it is considered that practical firefighting on approved fire scenarios and B.A. wearing should take place and be assessed for all emergency responders at least once in every 12 months.

Certification:
It is usual that on completion of a training course, students receive a course completion certificate. Training certification presented to students after a course differs depending on the Training Provider - some Training Providers present Certificates of Attendance and some present Certificates of Qualification.

All JOIFF Accredited Training Providers are required to present Certificates of Competence to students who have successfully completed a JOIFF Accredited course. What is the difference between each certification ?

A certificate of attendance may be pretty to hang on a wall and list in a curriculum vitae/ personal resume but it is meaningless and does not certify that the student has any particular skills, knowledge, ability or understanding, nor that s/he is competent.

A certificate of qualification does have value as it indicates that a person has achieved a special skill, knowledge, or ability for a particular job or activity, but a certificate of qualification does not always verify demonstration of competence. A universal example of this is that all drivers on the road should have a driving qualification, but how many of them are competent ?

A certificate of competence indicates that the student where, having regard to the task that the student is required to perform and taking account of the size and/or hazards of the undertaking or establishment in which the student undertakes work, the student possesses sufficient training, experience and knowledge appropriate to the nature of the work to be undertaken.

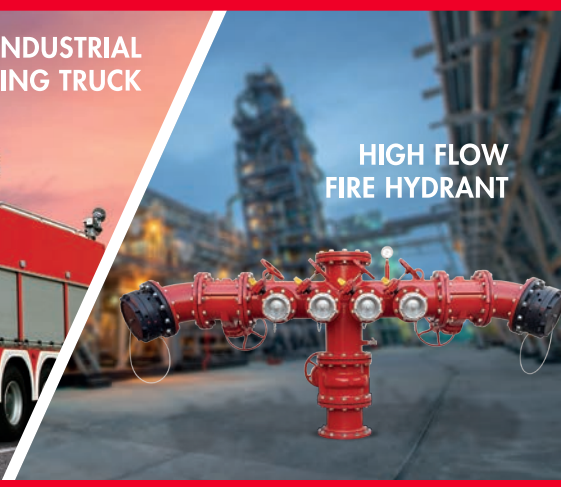
Maintenance of Competence:

JOIFF accredited training aims to bring students to the level at which they can demonstrate competence. As competence needs to be continually demonstrated, qualification from each JOIFF accredited course has a limited validity. Maintenance of competence is the responsibility of both employers and employees and to maintain competence, Continuous Personal Development (CPD) including refresher training for students should be in place.

CPD assists in demonstrating that existing knowledge and skills are being regularly refreshed and provides acquisition of new knowledge and development of more skills necessary to keep up with developments in firefighting underpinning knowledge and skills that may be necessary for career development.

BRISTOL

INNOVATIVE FIREFIGHTING
SOLUTIONS SINCE 1974



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INTERSCHUTZ

INDUSTRIAL DISASTERS
Can They Be Prevented?

Image Source: NPR

The primary aim of JOIFF is Shared Learning to drive inherent safety, continuous risk reduction and safe management of residual risk. JOIFF's Shared Learning provides information on incidents in high hazard industry that we hope will allow Members to benefit from the misfortunes of some to educate against the same mistakes being repeated by themselves. Supporting this aspect, The Catalyst researches and provides reports on some of the major industrial incidents that have taken place in each quarter of past years in the hope that this may stir people to action so that future incidents and subsequent unnecessary losses can be prevented.

Incidents that occurred during the 3rd quarter of a year past.

6th July 2013 LAC MÉGANTIC RAIL DISASTER

Background:

A freight train carrying 7.7 million litres of petroleum crude oil in 72 tank cars was making its way east across Canada travelling from North Dakota, USA to an oil refinery in New Brunswick, Canada. It was parked for the night nearby a town called Lac Mégantic, a busy town and a significant rail hub, with several factories and many tourists who came primarily to enjoy the vast and beautiful Lake Mégantic. In keeping with the railway's practice at the time, the lone engineer (driver) on board parked the train on a descending grade on the main track so that it could be picked up by another driver to continue the trip east in the morning. The engineer applied hand brakes on all five locomotives and two other cars and shut down all but the lead locomotive.

Shortly after the engineer left, the Nantes Fire Department responded to a 911 call reporting a fire in the smokestack of one of the locomotives. When the fire was extinguished, the firefighters and the track foreman were satisfied that the train was safe and they departed soon afterward. The train was held in place by 2 types of brake, a handbrake which physically secured a brake shoe against the wheels, and an air brake which used pressure to do the same thing. With all the locomotives shut down, the air compressor no longer supplied air to the air brake system and as air leaked from the brake system and was not being replaced, the main air reservoirs were slowly depleted, gradually reducing the effectiveness of the locomotive air brakes.

The Incident:

Just before 1 a.m. on 6th July 2013, the air pressure had dropped to a point at which the combination of locomotive air brakes and hand brakes could no longer hold the train, and it began to roll downhill toward Lac-Mégantic. As it moved down the grade with nobody at the controls, the train picked up speed, reaching a top speed of 65 mph, far too fast for the section of track which passed through the town and it derailed near the centre of the town at about 1:15 a.m. Tanker cars smashed into one another spilling the volatile fuel which formed a burning river which swept through the downtown area at a speed that persons trying to escape could not outrun. Buildings were swamped, streets were engulfed in flame and sewers and basements were flooded with burning oil.

The Emergency Response:

Local firefighters who initially responded, had no easy access to their fire station as the burning fuel surrounded it and when they eventually got to the station, they had to break in to get access to the pumps and other equipment.

More than 150 local responders and others from neighbouring towns attended the scene. A huge amount of volatile flammable liquid flowed into drains, basements and cellars of the town and ignited. The firefighters worked to block off drains to create firebreaks, used foam to tackle the flames and doused with water the tanker cars that were still intact. Heavy loading equipment from local factories was used to remove away from the fire, the few tankers and locomotives that were still on the rails. Despite the challenges of a large emergency, the response was well coordinated, and the fire departments effectively protected the site and ensured public safety after the derailment. The fires continued for 2 days.

The Casualties:

47 people perished, 2,000 people were evacuated from their homes, 30 buildings were destroyed and huge parts of the town Lac Mégantic were levelled. The local hospital was put on alert but few of the injuries caused by the disaster had been in any way survivable.

Almost all of the 63 derailed tank cars were damaged, and many had large breaches. About six million litres of petroleum crude oil was quickly released.

The tragedy marks one of the worst rail disasters in Canadian history.

The Environmental damage:

The disaster site was so heavily contaminated with benzene that firefighters and investigators in the first month worked in 15-minute shifts due to heat and toxic conditions. The waterfront and the town marina were contaminated by hydrocarbons which were contained by a series of booms. This rendered vessels and docks inaccessible until they could be removed from the water and decontaminated, a process which was to take until late August 2013 to complete.

The Chaudière River was contaminated by an estimated 100,000 litres (22,000 imp. gals; 26,000 US gals) of oil. The spill travelled down the river and reached the town of Saint-Georges 80 kilometres (50 mi) to the northeast, forcing local authorities to draw water from a nearby lake and install floating barriers to prevent contamination.

The Blame:

Many factors had contributed to the disaster - train left unattended on a hill, insufficient handbrakes, independent air brakes leaked off, mechanical problems of train and locomotive not remedied, the Company owning the train had provided minimal training, had ignored complaints about the safety of its tracks, had used outdated tanker, had cut corners on repair and in general had demonstrated an extremely relaxed attitude towards safety over many years.

Three men, including the driver of the train, were put on trial charged with 47 counts of criminal negligence causing deaths but given the factors identified about the Company, all men were eventually acquitted.

The Lessons Learnt:
The Transportation Safety Board of Canada communicated critical safety information on the securement of unattended trains, the classification of petroleum crude oil, rail conditions at Lac-Mégantic, and the employee training programs of short line railways. The operators of the train, Montreal, Maine & Atlantic Railway, eliminated single-person train operations, stopped moving unit trains of petroleum crude oil, and increased operating-rules testing and enforcement. Transport Canada introduced numerous initiatives, including an emergency directive prohibiting trains transporting dangerous goods from operating with single-person crews. Sections of the Canadian Rail Operating Rules were also rewritten, and new tank car standards were proposed.

Considerable action was also undertaken in the United States as a result of the incident. The National Transportation Safety Board issued recommendations aimed at route planning for hazardous materials trains, petroleum products response plans for worst-case spills, and the classification of hazardous materials. The U.S. Department of Transportation issued an emergency order strengthening train securement rules, and a notice of proposed rulemaking targeting, among other items, improved tank car standards.

21st September 2001 AZF FERTILISERS, TOULOUSE, FRANCE

The Background:

AZF fertiliser factory was a wholly owned subsidiary of Total Fina Elf. The plant had two main activities - the fabrication of nitrogen fertilizer and industrial nitrates, and the synthesis of chlorine-containing compounds. The plant synthesised ammonia that it transformed into ammonium nitrate, a part of which was then used to manufacture fertilizer, the rest being marketed directly in the form of industrial nitrates.

The Incident:

On Friday, September 21 2001 at 10:18 a.m. Toulouse was rocked by a devastating chemical explosion when between 20 and 120 tons of ammonium nitrate residue (equivalent to 20 to 40 tons of TNT and corresponding to a magnitude of 3.4 on the Richter scale.) detonated. A large cloud of dust and smoke drifted to the north-west. Before rapidly dissipating, the cloud containing ammonia and nitrogen oxides sickened witnesses who complained of eye and throat irritations.

The Emergency Response:

The local authorities and several governmental departments immediately activated emergency centres, and a support centre for the population and a crisis centre were established. The PPI (special administrative accident response plan) and the plant's emergency plan were put into action; reinforcements were requested to assist the departmental firefighters and the Civil Protection mobilised a chemical hazard evaluation cell and technological catastrophe specialists.

During the first 6 days,1,430 people were mobilised, including 460 firemen from the region, 620 firemen from other districts and 350 military personnel of the UIISC (civil security units). Roughly fifty doctors, 32 nurses/health care practitioners and more than 80 ambulance drivers were mobilised. Crisis management operations also mobilised 350 police officers plus 80 belonging to a mobile squad, primarily for traffic control, reinforcement and sanitary convoys. The population was ordered to remain confined as a precautionary measure and masks were distributed around the site.

Image Source: 20 minutes

The cause:

The disaster was due to several failures in risk assessment, management, governance, control and regulation. There were ambiguities on the chemical behaviour of some ammonium nitrate related compounds, and uncertainties on its explosive property in some conditions – it was classified as an "occasional explosive". There was also a long history of accidents that warned the industrial community about its inherent risks and its sensitivity in some conditions.

The Casualties:

There were 30 fatalities to workers and nearby residents, with an estimated 10,000 people receiving injuries and 14,000 suffering post-traumatic acute stress. Approximately 27,000 houses and flats in the city were damaged and all that remained from the two halls at the centre of the explosion was a crater 10 metres deep and 50 metres wide. The pressure from the explosion sent automobiles flying into the air, caused a nearby shopping centre to collapse and severely damaged all buildings in the surrounding area. Windows were shattered over a radius of 5 kilometres and many students at a secondary school in the neighbourhood suffered injuries. The city motorway towards the south was transformed into a field of rubble by a rain of dust and bricks, which damaged numerous cars and injured their drivers.

The telephone network collapsed as a huge orange coloured cloud of gas, smelling of ammonia, moved towards the city centre. The airport at Toulouse-Blagnac and the main railway station were closed and 90 schools in the area evacuated.

The Environmental damage:

During the drainage of a liquefied ammonia storage tank, an uncontrolled release of approximately 9 tons of ammoniated solution resulted in pollution of the Garonne and fish mortality. The remediation of the site led by the operator aimed essentially at reducing the concentrations of hydrocarbons, lead, arsenic and mercury in soil. In July 2006, after two years of work, more than 750,000 cubic meters of earth had been excavated, nearly 90% of the contaminated earth and concrete had been de-polluted through on-site washing and heat treatment at 850 ° C. De-pollution work is completed in early 2008. The operator estimated the cost of clean up measures at 100 million Euros.

The Blame:

At a judicial investigation in September 20, 2006, the plant manager was prosecuted for "involuntary homicide and injuries". A civil trial took place in 2009 and gave a large fine to the AZF group plus a three year suspended imprisonment order against the manager. In its judgment of 24 January 2013, the Administrative Court of Appeal of Bordeaux acknowledged partial responsibility of the State. Numerous investigations and court cases followed and 16 years after the incident, the Total subsidiary was found liable for the deadly AZF plant blast.

The lessons learnt:

The Toulouse accident provided the "window of opportunity" to trigger some organisational and regulation changes against political and economic constraints. However, some other root causes in risk management and regulation were likely missed due to the lack of depth of investigations on human, organisational and societal factors, which was a common investigation limit at that time

In 2002, an inquiry by a Parliamentary Commission formulated 90 proposals along six major themes:

- Reducing the risk at source;
- The human factor, notably with the employees playing a role in the prevention of accidents;
- Implementation of greater openness and expertise with regard to disasters;
- Urban planning questions;
- The adaptation of judicial procedures and
- The compensation of the victims of industrial catastrophes.

WHEN WILL THEY EVER LEARN ?

Could any these disasters have been prevented ? What do you think ?

"Organisations have no memory, only people have memory and once they leave the plant, the accident that occurred there is forgotten about."
Trevor Kletz, a prolific author on the topic of chemical engineering safety.

"Those who fail to learn from history are condemned to repeat it."
Winston Churchill paraphrased the statement by George Santayana, Spanish philosopher

"You are allowed to make mistakes – but not the same mistake again."
Pine Piennar, JOIFF Chairman.

Serious incidents in High Hazard Industry covered in previous editions of The Catalyst

Incident	Date of Incident	Edition of Catalyst
AZF Fertilizers, Toulouse, France	September 21st 2013	Q4 2022
Bhopal Disaster, India	December 3rd 1984	Q1 2022
Chenggang Chemical Industry, China	March 21st 2019	Q2 2021
Chernobyl Nuclear Plant, Ukraine	April 26th 1986	Q2 2016; Q2 2021
Currenta Waste Disposal, Germany	July 27th2021	Q4 2021
Deepwater Horizon Gulf of Mexico	April 20th 2010	Q2 2022
DuPont, Bell, West Virginia, USA	January 17th 2010	Q2 2022
Enschede Fireworks Disaster, The Netherlands	May 13th 2000	Q2 2022
Esso Longford explosion, Australia	September 25th 1998	Q4 2021
Kleen Energy Natural Gas Connecticut, USA	February 7th 2010	Q2 2022
Lac Mégantic Rail Disaster, Canada	July 6th 2013	Q4 2022
Norco Oil Refinery, Louisiana, USA	May 5th 1988	Q3 2021
Nypro site, Flixborough, North Yorkshire, England,	June 1st 1974	Q2 2022
Philadelphia Energy Solutions, Pennsylvania USA	June 21st 2019	Q3 2021
Piper Alpha Disaster, North Sea, UK	July 6th 1988	Q3 2013
SEVESO disaster, Italy	July 10th 1976	Q4 2021
Texas City Refinery Explosion, USA	March 23rd 2005	Q2 2021; Q2 2022
Tianjin Port Disaster, China	August 12th, 2015	Q4 2021
West Fertilizer Company, West Texas, USA	April 17th 2013	Q3 2021
Whiddy Island Disaster, Ireland	January 8th 2012	Q2 2021
Windscale Fire, Cumbria, UK	October 10th 1957	Q1 2022

Full Surface Storage Tank Fires

Getting the Right Number of Bubbles Into the Tank

By André Tomlinson - POG and Special Risks Advisor to Bristol Fire Engineering

Application rates may need to be increased to reach the tank centre or clear the lip of the tank. Image by Williams Fire & Hazard Control. Source: Williams Fire & Hazard Control

The question is posed if there is a case for incident commanders to deviate from established application rates when planning a master stream attack on a full surface storage tank fire.

One of the steps when planning a response to a full surface fire in a storage tank is to select an application rate. Today there are multiple choices for Type III firefighting operations. At first glance this appears to be a simple activity: Pick a standard and apply its recommended rate to the surface area of the tank in question. The reality is unfortunately not that cut-and-dried. There are a number of real-world factors that can impact the quantity and quality of bubbles that eventually arrive on the fuel surface. And that is assuming that they arrive at all. Is blindly applying application rates as determined by standard-setting entities adequate or is there a case to adjust the established rates in the interest of increasing the confidence that the fire can successfully brought under control?

Here are a number of conditions that may have impact on the decision to stick to the number in the code or adjust upwardly:

Wind Corruption

At the top of our list of flow disruptors is wind. Wind from any direction perpendicular to the stream will erode the application rate, the size and density of the impact area footprint as well as the reach of the stream. The higher the wind speed, the worse the impact on stream integrity which translates simply that less bubbles reach the tank. The application rate may need to be increased to compensate for wind losses or to increase for the shortened or flattened stream trajectory.

Making Reach

The effective reach of all master streams is influenced by flow. Simply put, the higher the flow at a specific pressure, the further the reach. The application rate, indicated by the product and tank surface area, may not satisfy the reach requirements of the monitor's position where it is located outside the tank bund (dike) in the upwind position. This dilemma may further be compounded by the height of the tank in that the monitor may have the horizontal reach but, at the given angle, may not clear the lip of the tank. In both instances the flow may need to be increased to simply make it into the tank. Not to be lost sight of is that flowing foam wipes up to 20% off the design reach off of composite stream master streams.

Foam Run

All environmental issues being equal, each monitor will produce a signature footprint where the bulk of the stream lands on a fuel at a specific flow. The dimensions and density of this zone has a strong influence on the forward foam run of the foam mass on the fuel surface. Flow increase may be required to firstly centre the footprint in the middle of the tank and, secondly, increase the size or number of the footprints in order to accommodate the forward and lateral foam run.

Precipitation

All streams will precipitate foam along its trajectory, some nozzles will produce more than others, that is from brand to brand and semi-aspirated versus low-expansion nozzles. As these losses can be substantial, flow rate adjustment may need to be considered based on the fallout rate of a specific nozzle.

The largest known tank to be successfully extinguished was a 83m gasoline tank in Norco, Louisiana that could only be was achieved by exceeding NFPA 11's recommended rate for Type III applications. There are tanks now dozens of tanks across the globe that exceed the 120 meter mark. Where would application rates need to be overcome the yet unknown burn characteristics of these monster tanks? Source: David White, Industrial Fire World

Thermal Losses

During fire conditions losses due to thermal attack occurs well before the bubble reaches the fuel surface. Radiant heat will start by drying out the foam, i.e. flashing water to steam, as the stream trajectory approaches the thermal column. Further evaporation occurs once the stream enters the fire column where the bubble is not only subject to direct flame contact but is also subject to the thermal updraft. This period of bubble vulnerability is compounded by the diameter of the tank. In the 100+ meter tank diameter range a bubble may have to travel well over fifty meters in the fire mass before it makes surface contact. The final flash off of water occurs when bubble meets the superheated fuel.

Bad Chemistry

Chemical compatibility plays a role in bubble quality and longevity. Foams as a rule perform poorer when produced from salt water rather than fresh water. There are also numerous fuels, like polar solvents and MTBE, as examples, that place a higher demand on a foam's performance or destroys foam at a greater rate. There is also the efficiency of the fuel shedding package in the foam composition as some foams perform better than others in their efficiency to shed fuel.

Time is Money

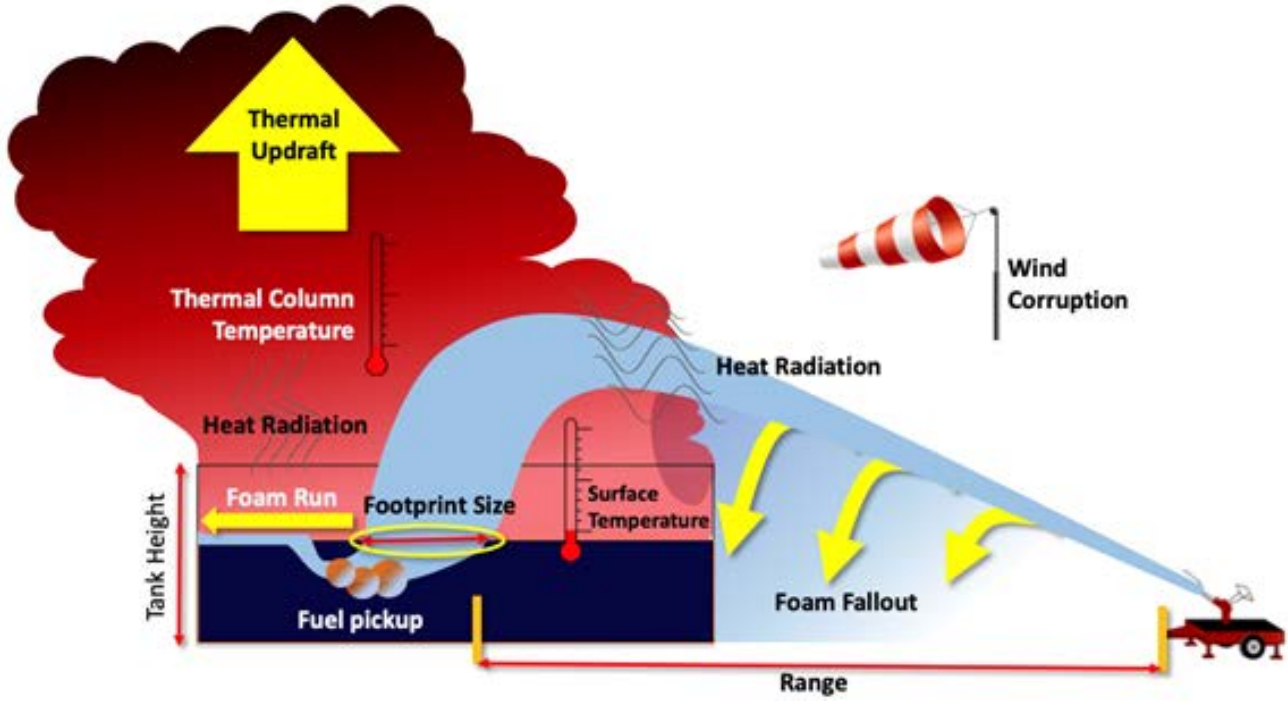
Every minute of a fire translates to a quotient of loss in product value, that is the cost or loss of revenue earnings from the product that is burning, as well as damage to assets including the subject storage tank and surrounding exposures. Losses may be compounded if the ire event has an impact on the larger facility's production through either reduced production capacity or total shut-down. There may be merit in achieving extinguishment faster just to limit these losses.

Risk Reduction

Burning crude oil and products like heavy fuel oil can present phenomena like Boilover that could have catastrophic life and property loss consequences with the potential of exponentially increasing the scale and scope of the incident. There may be merit to achieve extinguishment quicker, especially in instances where the attack on the fire was delayed due to the protracted deployment of resources, to minimise the risk of Boilover or other dramatic escalations like tank failure or exposed pipeline services rupture from occurring. There is also the issue of crew safety where every minute spent in proximity to the fire is a minute too long.

Strategic Asset Value

Some storage facilities have national or regional strategic value. Losses at facilities that house national reserves, primary fuel supplies



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to electrical or water generation plants or strategic export facilities could have an impact with broader consequences than just the value of the lost product or damaged assets. In these instances the responding services will want the highest degree of certainty that they will have extinguishment success. There are strategic installations where the incident scenario around which large-volume flow operations is planned is not just around the largest tank at a higher application rate than minimum, but actually two tanks being managed concurrently. With all the listed factors taken into account incident managers and event planners alike can create a case to add a safety buffer on top of the prescribed minimum application rates.

Not all the adjustments needs to be done at the application rate side of our calculations. Adjustments like reach, lip clearance, footprint size and footprint quantities can be done by adjusting the resulting flow, e.g.: A flow of 12000 l/min may meet the desired application rate but won't make reach whereas a 18 000 l/min flow will achieve reach.

In closing: Commentaries have been made over time concerning the issue that above a certain application rate the fire will not be extinguished any faster. Unfortunately no one has yet ventured to peg down the magic number.

Firefighter common sense dictates to err on the side of caution, especially when the risks moves into foreign territory like fires involving tanks exceeding the 83 meter in diameter mark.

Andre Tomlinson is POG and Special Risks Advisor to Bristol Fire Engineering.

Left: An example of wind corruption of a stream. Right: An example of the flow losses due to stream precipitation. Source: Bas Disberg, DNM Netherlands

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Gamification in the Fire Service

Gamification in the Fire Service

A few years ago, when working at a University, I had learnt to fly a drone. We were building prototype drones for search and rescue operations, and we needed pilots to get as many potential hours in the air as we could to test the efficiency of the tactics. Rather than letting me loose on a pretty expensive, unique and fragile prototype, I was given access to a software simulator, a log-in and told to rack up 250 hours of crash free flying before being allowed anywhere near the real thing. To cut a long story short, I spent about 150 hours crashing the drone into a variety of virtual obstacles, and the virtual ground, before we all decided that my talents probably lay in other aspects of the project.

The point of this anecdote though is to highlight a trend, existing in many industries, of gamification – the concept of building training for real work, often safety critical skills, through a gaming environment. The advantages of gamification in the fire service are immediately apparent; we can give our staff and recruits experience of dangerous scenarios without them having to physically be in danger.

This concept of gamification is not necessarily a new one. The use of games, or rhymes to learn key tactical procedures is well documented. For example, the British Library has a collection of recordings from the early 20th Century of soldiers and sailors singing ditties to accompany bugle or pipe calls to remember their meanings .

The use of a recreational activity to drive a functional activity is often believed to be routed in "green stamp" rewards schemes associated with petrol stations from the early 20th Century. From the 1920s to the 1970s the stamps were collected and sought after in their own right, driving sales to individual companies. Many iterations of this "collection" marketing strategy have existed, some of which becoming crazes in their own rights, and so pervasive into society that the original aim (to buy someone's product) is virtually forgotten.

Game Theory

The two main branches of game theory are cooperative and non-cooperative. Within non-cooperative game theory, which deals largely with how intelligent individuals interact with one another in an effort to achieve their own goals, there are sub categories such as, economic theory which has three further main branches: decision theory, general equilibrium theory and mechanism design theory. Decision and mechanism design theory are the interesting ones for the development of belief systems and as such link to the method of how augmented reality can involve the user in a systems that appears and feels as reel as actual reality. Theory can be understood has having knowledge of an issue however "knowing", or experience, can be understood as having applied that knowledge to a practical situation to experience the feelings which in turn begin to form beliefs based on the reactions of applying your knowledge .

Understanding how these theories link to the technology of AR and how that can then be used to form belief systems for future application of your knowledge in a command decision making environment is where we see the application of AR as a significant bridge between what is realistic training and reality.

Clearly, modern Game theory in all its complexity requires and generates a great deal of data. But, if we start to incorporate the wearable computing technologies covered in previous articles it's clear that we will be generating huge amounts of usable data through simply participating in virtual training.

Sensors recoding participants' affect (how their stance, movement and posture display emotion) and biometric data will be recorded constantly, as a standard. This data can be combined with more prosaic information such as times of events, decisions made and so on to feed the game theory algorithms.

What this allows the possibility for is a comparison between the reactions to, and decisions within, real and virtual training scenarios. For example, we could create the same training set-up, say a 3 pump house fire, with the subject being an officer in charge, but create one in virtual and one on a physical training rig. By recording the physical; and emotional responses to both, we can start to understand the differences between virtual and physical training – we can start to uncover how real virtual training feels.

But we can take that one step further, and really start to investigate how people operate in a training environment. If we take it as read that firefighters are all wearing an array of sensors, woven into fabrics, worn on., or in, helmets and theses sensors are recording physiological data, decisions, video, thermal and locations and that

this is now the norm on operations, we can see that we are creating a vast data set of real operational data – i.e., we have a dataset that underlies how real humans operate, react and behave in real conditions.

Where this can be undertaken as a standard form of data collection in the operational environment we will start to see the differences in reactions and decision making due to the wearers "knowing" they are in an exercise and the theory is this is safe and "knowing they are in an operational scenario and there is no "pause button", in other words uncertain outcomes which may result in a less than favourable outcome.

If we then use that data to create our virtual training worlds, figure 1, we can carry out a three-way comparison. We can compare how a subject reacts (and how their body reacts) in the same scenario, but on three test beds – virtual, live training and real life. Within these comparisons lie the answers to how we get the most out of personnel, how to make training most effective and challenging and how we protect our personnel from threats such as PTSD and how we avoid overloading spheres of decision traps with the command decision making processes in operations in high stress situations.

Like the use of rhymes or ditties to learn duties, the idea of employing games to aid in firefighting training is in itself not new. Holmatro have a game for understanding the principles of a phased approach to extrication in RTC . Nearly ten years ago, gaming artist Karlen Tam developed a game whilst at NYU-Poly, to train New York firefighters the principles of a ventilating fan . There have a number of "simulation" games on the market over the last 15-20 years based on varying levels of realism in firefighting tactics.

Even the diagrammatic cartoons explaining drills in recruits' manuals contain some of the elements commonly found in games. Imagine if the recruit could have spent months before before even arriving at training school virtually moving to the right position, responding to the correct commands and becoming familiar with the terminology associated with equipment.

Recent advances in "hand presence" allow for a much more realistic interaction with a virtual world and would allow for a more immersive training experience, especially with something like pump operation, or the use of small tools. For example, candidates learning to operate a manual winch would learn the fact that a button must be pressed in order to free the locking handle – but more critically learn the muscle memory associated with that act. Imagine the efficiencies to be gained with whole cohorts of recruits arriving at raining school already "knowing" how to operate the equipment, and how to move through all the drills. Furthermore, the nature of the gaming environment means that the candidate's interaction with the training game is recorded, so fire services would only need to accept trainees who have already demonstrated sustained levels of success in performing drills and operating equipment. Simply having recruits train in a gaming environment to learn the layouts of training vehicles – i.e. where to find the dividing breech – and demonstrate hour of competence in that, would save training and recruiting departments hundreds of hours of training time.

Figure 1: Still from experimental FDNY training game, by Karlen Tam, NYU-Poly.

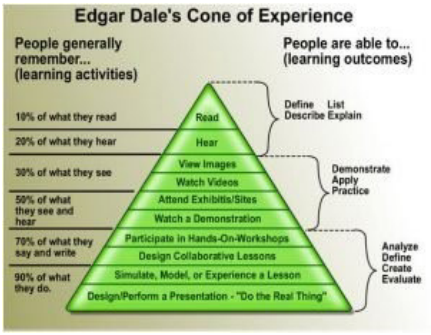
The growth and advances in gaming sophistication mean that virtual training that is as good as live training, or even operations is within our grasp.

The cognitive development of skills through the application of knowledge is as one of the most effective methods of creating and retaining information. Experiential learning and the continual practice of these skills as part of a pathway of progression within any organisation is critical to growing the organisational competence and as a result organisational safety. Edgar Dale's cone of experience indicates AR would have a 90% link to the retention knowledge initially experienced through this process.

Virtuous circles

The holy grail in integrating virtual and real-world training is create a positive feedback where each iteration of either training or operational activity contributes to the next occurrence of either. So, to put it simply, we gather data from real operational incidents about how individuals react and act – biometric data, movement and the operation of machinery or devices. This data is then used by our virtual training systems to create realistic scenarios, but also to take advantage of elements of game theory to create realistic virtual colleagues and "opponents" within the game. Similarly, we can take the physiological and deterministic

Figure 2: Lone Echo's Virtual Hands, allowing a more nuanced interaction with a virtual world.



reactions to a game-based simulation and use them to determine how we might better write policies, or create safety mechanisms for operations – effectively using the virtual world as a test bed for operations.

Conscious to Sub-conscious learning

Learning a new skill is all about memory and how you use it to develop beliefs through experience. Initially your short-term memory (located in the prefrontal cortex) stores your activities, experiences and the reactions your body and mind encounter. The mind is really busy figuring out how it's done and helping to direct to body to create the muscle memory required to be developed to become proficient. This is the part of your brain involved with conscious decision-making and planning. Once you develop proficiency it is freed up by as much as 90% and you can now perform that skill automatically, leaving your conscious mind to use the new capacity on other information. Importantly this spare capacity provides the mind with capacity assess the current performance through the ability to be self-aware, or be reflexive, to identify where there are opportunities to avoid poor performance or improve it.

Achieving and maintaining this automatic transference within the mind comes through overtraining by continuously practicing something you've already learned inside and out. Once you've over-learned a skill, you no longer need conscious thought to perform or even teach those skills. The key is to understand that the trained mind is not necessarily working much faster than an untrained mind—it is simply working more effectively, which means that the conscious mind has less to deal with.

Any example within the fire service is the repetition of basic drills until they could be achieved without direction and conscious communication between the members of the crew.

One thing we have to be very careful of, is tripping into the Dunning-Kruger effect, figure 4. It is (relatively) easy to create these virtual worlds, and as such easy to give people rich and realistic experiences of scenarios in which they may perform well. Without care, we could find ourselves falling foul of the "little knowledge is a dangerous thing" syndrome, in which we create a number of high confidence, low competence individuals – something 'tickbox training' (where training is received passively and the trainee not truly challenged) has produced. The creation of "virtual knowing" and it subsequent development of beliefs base on the experiences within the system could develop false risk perceptions and bias that reality would challenge with potentially significant effects for decision making, incident management and safety.

So why is all of this important? MarketsandMarkets estimates the global gamification market to be around $11.10 Billion by 2020. It would seem clear that the application is likely to be effective in the fire sector, leading to safer operations, and a move away from "tick box" training online. Bringing elements of the real world into a virtual world that we can manipulate will truly challenge our personnel, but allow better and more detailed training worlds to be created based on actual data and outcomes. The effectiveness and efficiencies that could be created through reduced reliance on physical training locations that are expensive to build and maintain that could also create flexibility and the ability to access training with limited impacts on operational availability. Ultimately AR is one of the keys to providing improved realistic training that meets an array of organisational needs on many fronts and keeps fire services in line with the changing legislative environment, but most importantly protects our staff and the public safe.

Figure 3: Recruits Manual, showing positions for a ladder drill.

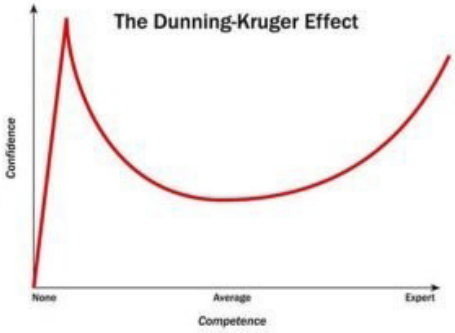


Figure 4: The Dunning-Kruger Effect

About the Authors

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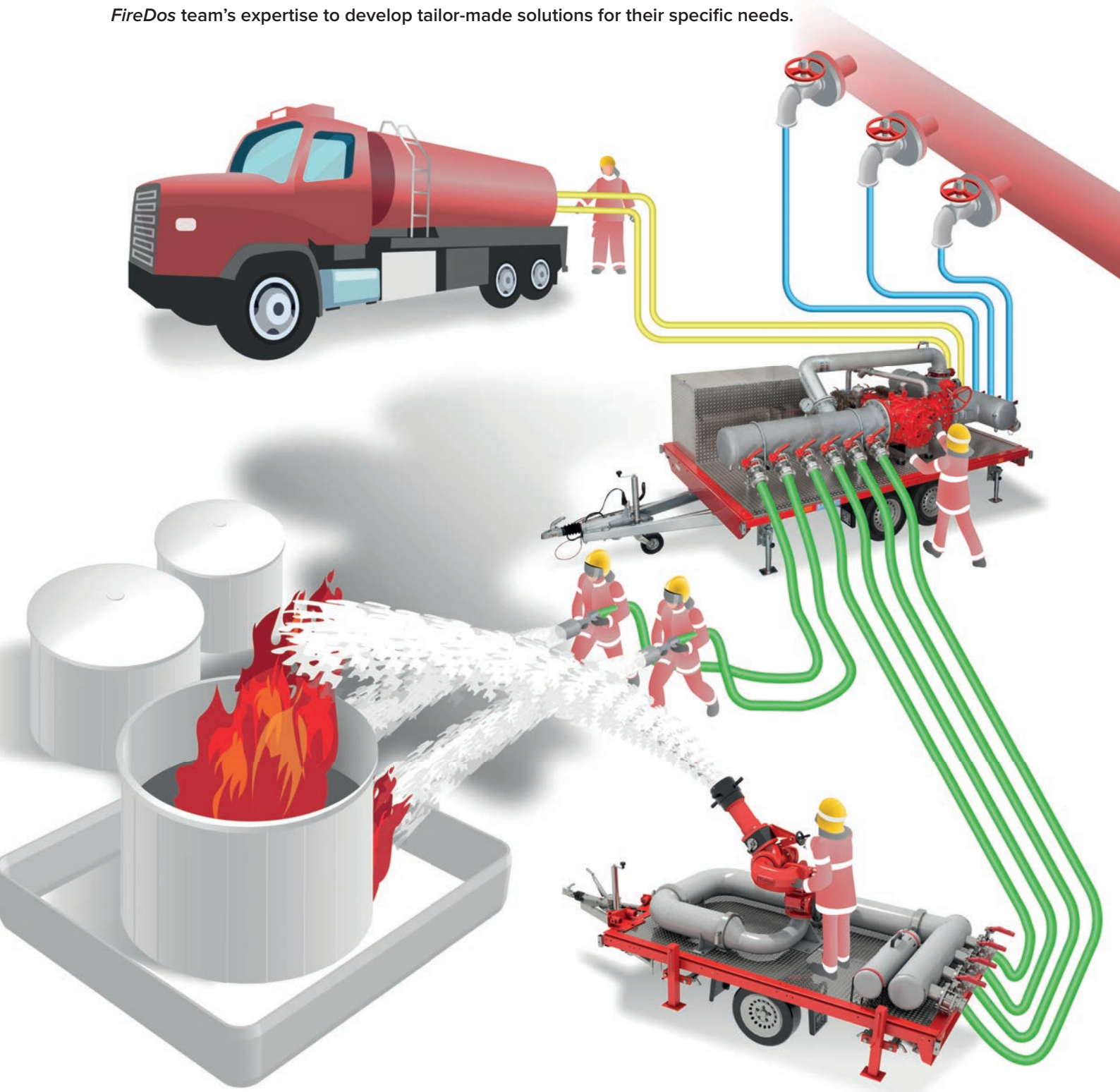

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Use of Foam for Fire Fighting in Tank Farms of the Oil and Petrochemical Industry

Fig. 1 Tank farm fire at Deer Park, Texas, USA

Abstract

Tank farm fires in the oil and petrochemical industry do not occur often. When they do occur, it is with devastating consequences and negative publicity. This article will focus on the correct and accurate proportioning of foam as the most suitable extinguishing agent by example of commonly used proportioning technology.

Introduction

Sadly, only news of fires that have caused massive damage to tank farms, oil refineries and loading terminals make its way into the news, unlike near-miss accidents where improved fire protection technology has prevented worse outcomes. This means that both fire protection and extinguishing methods must be improved to minimize the effects of future fires.

Laws and regulations

Diverse regional and national laws exist worldwide concerning fire protection. This article will be addressing the basics of the globally applied NFPA11 issued by the National Fire Protection Association, the standard for firefighting with foam.

In place of various national and international certifying bodies, the following should be mentioned: the VdS approval in Germany (Verband der Sachversicherer translated to Association of Property Insurers) and the FM approval (Factory Mutual) for the international market. Specifically, VdS and FM have prepared particular testing procedures for firefighting systems and have the necessary facilities and specialist personnel for testing. Multiple companies rely on these certifications.

Typical incidents

Fire incidents in tank farms of the oil and petrochemical industry occur in different scenarios, with consequences ranging from minor to disastrous. The most typical scenarios are listed as the following:

Rim Seal Fire - Rim seal fires occur on tanks with a floating cover. They can be extinguished quickly by the use of stationary systems as long as they are detected early enough. A longer fire, however, may damage the seal and, hence, cause an excess release of oil. This may develop into an extensive fire.

Full-surface tank fire - If oil or petrochemical liquids escape, they gather on the floating roof. In the worst case, even a sinking of the floating roof can occur. If this surface catches fire, a full-surface tank fire develops rapidly. Fires on tanks with a floating roof can be extinguished either by stationary extinguishing systems from inside or by mobile extinguishing systems from outside the dyke area. In the case of fixed-roof tanks, only the internal stationary extinguishing systems can be used until the roof collapses.

Boilover - A boilover may happen in case of a long-lasting oil tank fire where water has gathered at the bottom of the tanks. Due to the oil heating up to several hundred degrees Centigrade, the water may evaporate abruptly. The water steam rises to the surface in bubbles which burst at the surface and spread the oil above the tank. The enlarged surface area causes an abrupt fireball.

Vapor ignition - When storing petrochemical fluids, vapors may leak and be ignited by external sources, such as a lightning strike.

Dyke area fires - Tank farms are normally safeguarded by a dyke or located inside a basin to contain any escaping liquids. If oil or petrochemical fluids leak from a tank unintendedly, they may catch fire. If the fire is detected early enough, such fires can normally be extinguished easily and quickly by the use of fixed or mobile extinguishing equipment. If this is not the case, it can lead to a large surface fire which can also spread on the tank.

Foam as an extinguishing agent

Foam has proven to be the best medium to extinguish fluid fires. Foam consists of the components; water, foam concentrate and air.

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Foam as an extinguishing agent

Foam has proven to be the best medium to extinguish fluid fires. Foam consists of the components; water, foam concentrate and air. The foam concentrate is mixed with the extinguishing water at a precisely defined rate. Air is then added to this premix to generate the foam. Depending on the foam concentrate and the quantity of air, different types of foam are produced to extinguish different types of fire. Foam forms a homogenous layer of air bubbles, increasing the extinguishing agent's volume and, hence, reducing its density. The foam floats on top of the flammable liquid and spreads across its surface. Due to this and its chemical properties, the foam blanket suppresses the release of flammable vapors, cuts off the supply of air and cools down the substance on fire. Consequent application of foam until fully covering the entire surface of the burning liquid will finally smother the fire.

Foam concentrates are developed for extinguishing individual products or media at specific proportioning rates. The most common proportioning rates ones are 1% and 3%. As a general rule, a foam concentrate can form a stable and functioning foam only if it is mixed to the extinguishing water at no less than the correct proportioning rate. An increased proportioning rate may still form a stable and functioning foam;

Fig. 2 Devastation after explosion and fire in a petrochemical plant

however, the foam concentrate stored will be used up faster. A too thick proportioning rate may result in a foam that will loose some of its properties. A proportioning rate falling short will produce a foam which is unable to develop its full extinguishing power. There are various different types of foam concentrates, that are not discussed in greater detail here.

Extinguishing systems

Depending on the tank type and the size of the tank farm, the extinguishing systems must be designed differently. A fixed-roof tank must have a fixed extinguishing system which allows discharging foam under the roof. An application from mobile systems outside is possible only if the roof has been damaged or removed by a fire or an explosion. In case of a floating-roof tank, the foam can be applied by use of fixed or mobile systems.

Fixed extinguishing systems typically consist of one or more stationary fire pumps, a proportioning system and tank for the foam concentrate, discharge devices such as foam nozzles, sprinklers, foam pipes or fire monitors and the corresponding piping.

Mobile systems generally consist of the same components (fire pump, proportioner, supply tank); these must, however, be available in mobile form on vehicles or trailers. In addition, only fire monitors or hoses are usually used as discharge devices. The piping/lines consist of hoses and suction pipes.

Beside the tactical positioning of the foam discharge points, including mobile units, the foam concentrate and its proportioning into the extinguishing water are the most important factors for successful extinguishing. This will be looked at more closely referring to NFPA 11.

Foam concentrate

When storing the foam concentrate the quantity must be sufficient to allow extinguishing of the largest protected object, or of the objects to be protected simultaneously as a minimum. The proportioning rate (1% or 3%) will dictate the quantity of the foam concentrate required. Generally, it is important not to mix different foam concentrates as this can lead to unstable foam formation or the loss of extinguishing properties. Below is an example calculation for the foam demand according to NFPA 11.

Tank surface x specific extinguishing water quantity x proportioning rate of foam concentrate x requested minimum extinguishing time x safety factors

In case of a crude oil tank with 60m diameter, NFPA 11 requires an application of 6.5l per min per m2 for an extinguishing time of 65 min. When using a 3% foam concentrate, this results in a minimum amount of approx. 36 000 liters of foam concentrate and a required extinguishing water flow rate of approx. 18 000 l/min. NFPA 11 recommends stocking additional foam concentrate for the dyke area of about the same amount. In addition, a safety factor of 2 is recommended to compensate foam losses during extinguishing caused by, e.g., wind and other factors. This results in a stock of 144 000 l of 3% foam concentrate. If alternatively a 1% foam concentrate is used the total storage quantity would amount to only 48 000 l requiring smaller storage tanks and set up space. The choice of foam concentrate and proportioning rate is dictated by the fluid to be extinguished.

Fig. 3 Fire monitor in a test run at a tank farm

Foam concentrate proportioning

NFPA 11 describes various types of foam concentrate proportioning equipment. In the following, three systems are looked at which are most common. Tight limits for the proportioning of foam concentrate apply to all of them.

- The proportioning rate must not be less than the permitted values – i.e. 3% for a 3% foam concentrate or 6% for a 6% foam concentrate.
- The proportioning rate must not exceed 30% above the permitted value i.e.3,9% for a 3% foam concentrate or 7,8% for a 6% foam concentrate; respectively, the proportioning rate is allowed to be an absolute maximum of 1% above the permitted value – i.e. 4% for a 3% foam concentrate or 7% for a 6% foam concentrate (the smaller value must be used respectively).
- To guarantee correct proportioning, the proportioner, including the proportioning rate must be tested at least once per year and its correct functioning must be checked.
- It is very important to design the proportioning system to allow correct proportioning over the complete water flow range and anticipated pressures specified in the firefighting concept.

Bladder tank with proportioner

The bladder tank with a proportioner is a proven and cost-effective technology. The bladder tank is a pressurized vessel with a bladder inside which is filled with foam concentrate. The tank is pressurized with water from the fire extinguishing line and discharges the foam concentrate from the bladder when pressurized. The bladder is connected to a proportioner which operates using the venturi principle. When the fire pumps are activated, pressure is generated by the pump, causing delivery of foam concentrate to the proportioner. The extinguishing water flows through the venturi proportioner. The resulting vacuum induces the foam concentrate into the extinguishing water flow. This process will in return result in a high pressure loss within the fire extinguishing system. The advantages of this system are its simple design without moving parts and its easy operation. No external energy is required and the system is relatively inexpensive.

A disadvantage is that the system is a pressurized vessel subject to corresponding regulations such as ASME Boiler & Pressure Vessel Codes. In order to refill foam concentrate once the supply has been used, the system must be shut down and drained. The rubber bladder is sensitive; when damaged, water will contaminate the foam concentrate. At a given proportioning rate, the system is only designed for low variations in the extinguishing water flow pressure and volume. Adding or changing individual foam discharge devices is possible only to a very limited extent. The system is generally only designed for one specific foam concentrate.

To conduct any mandatory required annual testing, the system must be activated and premix generated at the venturi proportioner within in the extinguishing water line. The correct proportioning rate must be measured in the premix or the created foam by laboratory analysis. The generated premix or foam must be disposed of. The consumed foam concentrate in the bladder tank needs to be replaced.

Driven proportioning pump with flow meter

The system consists of an atmospheric tank for the foam concentrate, an electric or diesel-powered foam concentrate pump with an electronically controlled valve and a flow meter in the extinguishing water flow line. When the fire pumps are activated, the foam concentrate pump drive and electronic control system must be activated. The extinguishing water flow rate is measured by the flow meter and the control system adjusts the correct foam concentrate quantity via the control valve. The foam concentrate is injected into the extinguishing water flow by the foam concentrate pump. If there is a change in the flow rate, the amount of injected foam concentrate is regulated by the control valve. The system's advantage lies in the precise proportioning of the foam concentrate, independent of the extinguishing water pressure or flow rate. Foam concentrate can be topped up during the extinguishing operation. The system is capable of proportioning highly viscous foam concentrates. For the purpose of annual testing, the system must be activated; however, the delivered foam concentrate can be measured via a return line, if available. The proportioning rate is calculated from the extinguishing water and foam concentrate flow rate. No premix is produced; and as the foam concentrate is passed back into the tank, no foam concentrate needs to be refilled. Disadvantages are the requirement for an external interruption-free energy supply for the foam concentrate pump and the control system, as well as the need for a sophisticated control system and the comparatively higher purchasing costs, compared to a bladder tank system. Furthermore, it must be accepted that a delay occurs between the change of the extinguishing water flow rate and the newly adjusted foam concentrate amount. The foam quality may be compromised when constantly changing operating conditions as foam discharge devices are turned on or off or changed.

Most commonly gear pumps are used as foam concentrate pumps They are capable of proportioning highly viscous foam concentrates.

Water motor with proportioning pump

The system consists of an atmospheric tank for the foam concentrate, a water motor installed in the extinguishing water flow line and a foam concentrate pump which is connected directly to the water motor. Water motor and pump form one compact unit. Upon activation of the fire pumps, rotation in the water motor starts. The direct coupling to the foam concentrate pump affects immediate foam concentrate injection into the extinguishing water. If the flow rate changes, the amount of foam concentrate is adapted immediately.

The advantage of the system is its independence from external energy sources as well as a precise and immediate foam concentrate proportioning regardless of the extinguishing water pressure or flow rate. If a piston or plunger pump is used adjustment or calibration after installation is not

necessary since the water motor and the pump are volumetric devices firmly connected to each other. Foam concentrate refilling during operation is possible. The system must be activated for annual testing; however, the delivered foam concentrate can be measured via a return line. The proportioning rate is calculated from the extinguishing water and foam concentrate flow rate. No premix is generated; and if the foam concentrate is passed back into the tank, no foam concentrate needs to be topped up. The system is classified as a variable viscosity proportioner and capable of proportioning low and highly viscous foam concentrates.
The larger design and the comparatively higher purchasing costs are a disadvantage of the system. The costs are though quickly compensated through high savings achieved through the return process of foam concentrate during testing.

With any system, consideration should be taken into account for the annual testing costs, which can be considerable in terms of replacement foam concentrate, disposal of premix or foam and manpower.

Conclusions

When it comes to the decision on what type of proportioning system to use various aspects have to be considered.

- What are the properties of the foam concentrate

Bladder Tank with Proportioner

Fig. 4 Water motor with proportioning pump

- What is the anticipated minimum and maximum water flow

- How much do I initially want to invest

- What will the cost of my annual testing of the proportioning rate be

- What size of bladder tank or foam concentrate tank to I need to comply with NFPA 11 recommendations

All of the introduced technologies have individual advantages and downsides and a general recommendation cannot be given. Beside the proportioning system the following points should be considered when planning a fire protection system and concept.

- Have a suitable fire protection concept including alternative scenarios that adapt to varying situations

- Consider mobile extinguishing systems as a backup to fixed extinguishing systems

- Stock suitable foam concentrates

- Ensure sufficient foam concentrate supply

- Ensure sufficient water supply

- Keep well-maintained, quickly and well-accessible, strategically correctly placed and functioning extinguishing equipment available in a sufficient number

- Have trained personnel available in a sufficient number

- Train and maintain to ensure a quick implementation of a suitable plan of action

References

[1] National Fire Protection Association, NFPA 11 Standard for Low, Medium, and HighExpansion Foam 2005 Edition.

Pictures

Fig. 1 Tank farm fire at Deer Park, Texas, USA
Fig. 2 Devastation after explosion and fire in a petrochemical plant
Fig. 3 Fire monitor M9 in a test run at a tank farm
Fig. 4 Water motor with proportioning pump

About the Author

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ABOUT US

Based in Ireland, Sigteq are solution leaders in the emergency response sector. We use our 20 years of hardware and software design experience to create systems that respond to multiple emergency scenarios and customise them meet your specific needs.

By integrating with existing fire alarms and other on-site emergency systems our AlertNet line of equipment captures data in real time and pushes notifications to key personnel while also triggering tasks for critical response operations.

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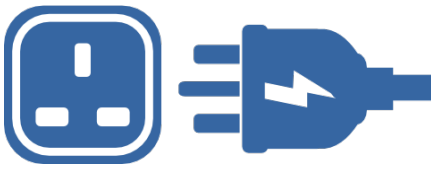
5 things to consider

When gauging how robust your response is

We are producers of the AlertNet emergency management systems which amalgamate multi-alarm monitoring, multi-channel alerting and also facilitate localised response controls. With decades of experience specialising in the Emergency Response sector, we're going to share with you 5 of the most common Emergency Response oversights we encounter.

1. Is there continuity during a power or network outage?

It's common to have vital processes supported by back-up power but a common consideration often overlooked is whether your ERT comms are also immune to a network or power failure. We recommend implementing backup battery or UPS systems for key radio/paging infrastructure and any other key components of your emergency response process.



Network based emergency alerting systems are becoming more and more common, however so are cyber attacks. From experience, we design our systems to operate on both (or either) local network and LTE 3G/4G/5G connectivity to assure continued functionality during a potential network interruption.

2. How quickly are faults identified and responded to?

If there's one thing we can guarantee based on our experience in this industry is that if it can go wrong, it will go wrong – and it will always happen at the worst time. However, root cause analysis more often than not reveals that the issue was present prior to the event, and it just took an emergency scenario like that to bring it to light. That's why we build all of our systems with the ability to analyse alarm data for potential faults and notify key stakeholders. Notice of these faults could be the difference between your fire system going down during a planned maintenance period and going down during a fire.

We also understand that call-outs to investigate systems can take time to schedule and complete. We are strong advocates of Remote Managed Support (RMS) and have designed our systems so that our engineers can log in remotely to investigate live issues, provide support and apply configurations and fixes without the need to schedule (or charge for) a callout to site.

3. Log and track the progression of your emergency response

There are a variety of benefits to having access to a time-stamped catalogue of each individual action of your emergency response e.g. time of sensor activation, ERT call out, staff notification, fire pump activation, alarm clearance to name a few. Primarily it makes it easier to identify weak links or processes in the chain and to track the impact of changes to this process. We've also found that having a timestamped log of each action is often vital to root causing an event and was a popular request from our clients which led to us introducing a secure database to automatically log key actions. It's also proven useful for compliance and system-test logging.

4. What else should you be monitoring and alerting on?

We have learned that the "extras" can be as useful as the main system being monitored. If as many items are automated as possible, human error is reduced. For example, additional critical alarms such as Gas, BGU, temperature or chemical measures could all be monitored in one system, where automated alerting could then save vital time. It's also worth considering if you have non-critical tasks which could be automated to streamline your response such as a button which calls out the cleaning team after a spill, or the nurse or maintenance technician if there is need for first aid or a repair.

5. Are there tasks that can be automated to streamline your response procedure?

Response-speed and efficiency are crucial elements in ensuring staff safety as well as reducing process down-time and associated financial losses during an event. Consider your evacuation flow - would it be easy enough for a new staff member to know what to do under pressure?

Simple but effective solutions that significantly improve evac flow could be: automated signage that informs staff of evac directions, or custom public announcements depending on the location on site. Perhaps you operate a busy site, and automating traffic diversions and gate opening could facilitate emergency vehicles' easy passage to where they're needed, saving time. Preparation is key here and saving vital seconds can amount to huge savings saved in damage, wasted product, injury or worse.

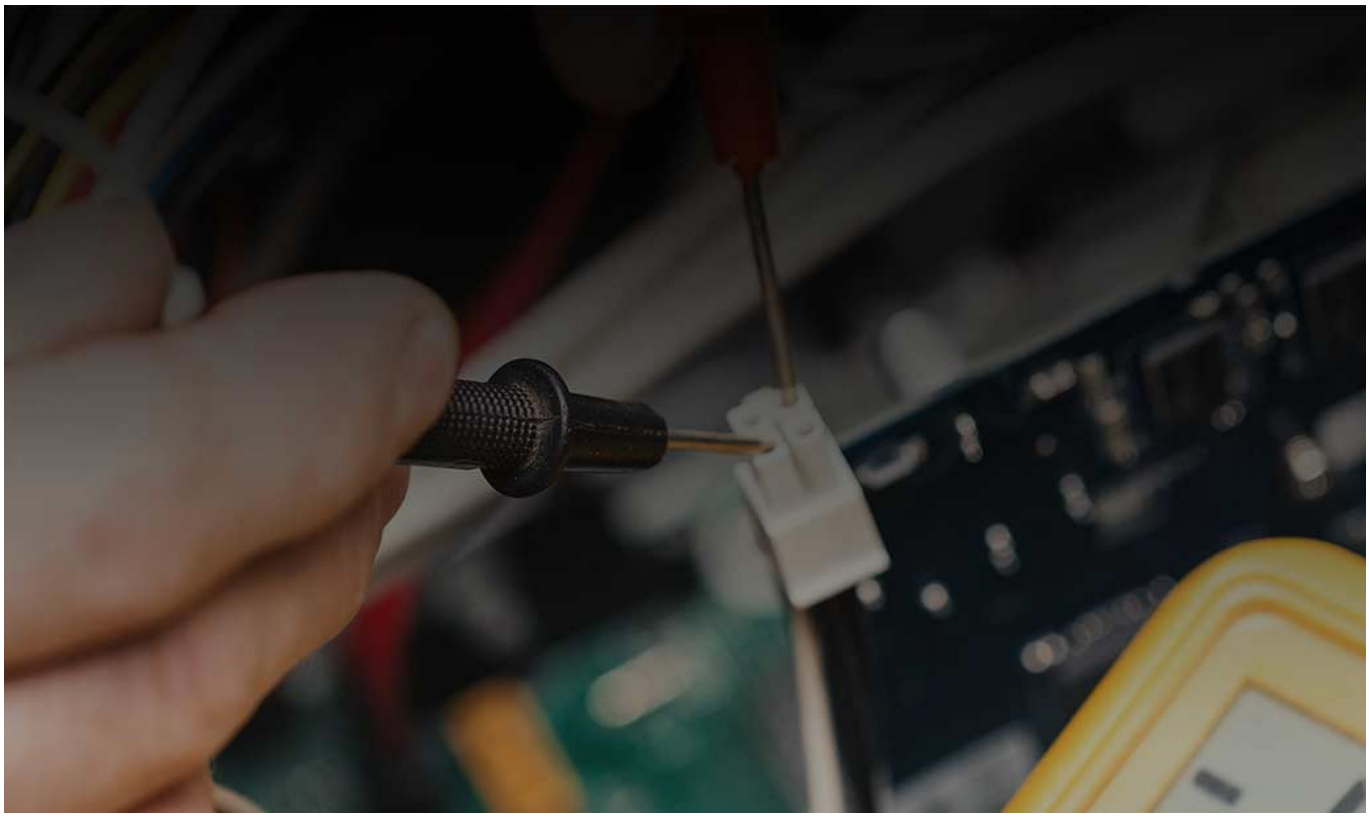
Interested in learning more? Have a chat with our experts

We really view ourselves as 'nerds' for Emergency Response technology and innovation; it's our passion. We're always more than happy to chat about emergency response, so if you'd like to chat with us, feel free to drop us a message or check us out online!

A little about us:

At Sigteq, we have proudly designed and built intelligent automated solutions for use in a large variety of industries including Oil & Gas, Tunnels & Ports, Hospitals, Universities, Manufacturing, the Armed Forces and more for over 20 years. We are passionate about what we do, and we really view ourselves as 'nerds' for technology and innovation. We're looking forward to sharing more of these key tips with you in the next edition, but if you want to learn a little more about us in the meantime feel free to drop us a message or check us out online!

https://www.sigteq.com/contact/



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AGENDA

Day 1 - Classroom – Hotel Rouen
- Introduction to foam
- Risk based Fire Hazard Management approach overview
- Foam system design outline

Day 2 - Classroom – Hotel Rouen
- Foam fire performance specification and assurance
- Ongoing foam assurance
- Foam performance standards
- Current levels of fire performance research

Day 3 - Classroom and Laboratory – Vernon
- How to use foam
- Preplanning for foam applications
- Case histories / Group Classroom Exercise
- Laboratory demonstration

Day 4 - Testing and Training Site – Vernon
- Fuel characteristics demonstrations
- Demonstration of foam types and application equipment
- Collecting and measuring foam properties
- Training exercises

Day 5 - Classroom – Hotel Rouen
- Transition issues – the pragmatic approach

SPEAKERS

Dr Eleanor Lister – Environmental Engineer
Mark Plastow – Process Safety Specialist
Dr Niall Ramsden – Oil industry Fire Hazard Management and Foam Systems Specialist
Isabelle Deguerry – Foam Testing Specialist
David Audouin – Industrial Safety and Crisis Management Expert
Nicolas Vacle – Senior Instructor Gesip

Date
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Managing Emergency Response
for Space Launch Operations

Safety has to be a key consideration for space launch services, which is why historically, launch operations have always been conducted in locations well away from spectators and operational staff. However, in the UK, where a number of new spaceports are currently seeking regulatory approval, the issue of Emergency Response and fire safety, is now the focus of increased attention. In this article, Chris Thain reviews the regulatory framework and legislation for the basics of fire safety and Emergency Response, which apply as much to Space Ports as to airports and similar facilities. The effective provision and management of on-site Emergency Response plans and resources, fire safety, fire prevention and asset protection are among the core responsibilities of UK Spaceport Launch Site Operators (LSO).

The UK is currently investing significant time and money in the development of its onshore space launch industry, with new laws and regulations enacted to enable a variety of commercial organisations to enter into this exciting new market. A critical part of the licensing requirement for LSO's is the preparation and approval of the Safety Case.

Regulated and licensed by the UK Space Agency, through the Safety Case, LSO licensees must satisfy the regulator that they have conducted a thorough assessment of risks to the health and safety of prescribed persons taking part in spaceflight activities and to have taken all reasonable steps to mitigate risks from spaceflight activities to the health, safety and property of other persons to 'as low as reasonably practicable' (ALARP) - (section 10(a) of the Space Industries Act and regulation 36(5). Thus, being able to demonstrate that operations are conducted at an ALARP level acceptable to the regulator is crucial to obtaining a launch site licence.

While the current space industry regulatory framework does not prescribe what the Emergency Response capabilities for each launch site must comprise, from a health and safety perspective, any risk identified through the risk assessment process must be mitigated in a manner that is both appropriate and proportionate.
In addition, the residual risks, even if the operator has met the ALARP test, must also be acceptable to the regulator, or the license will not be granted.

Primary and Secondary Space Legislation

Under the UK Space Industry Regulations enacted on 29th July 2021 as part of the Space Industry Act 2018 (SIA), LSO in the UK are required as a condition of the terms of their license to have an approved Emergency Response plan in place. Further guidance on duties for all licensees under the Space Industry Act 2018 are contained in the UK CAA's document CAP 2212 and CAP 2214.

While safety is always the paramount consideration, under Section 11 of the SIA, LSO are equally required to consider the environmental impacts of the spaceflight activities in an Assessment of Environmental Effects (AEE).

In turn, this assessment informs the level and type of Emergency Response (including the firefighting media (foam, dry powder, water etc.) to be employed) that the LSO will need on-site to satisfy the requirements of the regulator. LSO must also be aware of the requirements of the Civil Contingencies Act 2004 and be prepared to work with the Emergency Services and other multi-agency responders. This includes risk assessment, planning, and exercising for emergency incidents.

Horizontal v. Vertical Launch Sites

While each LSO is required to prepare an Emergency Response Plan (Regulation 165), the UK Space Agency is currently not being prescriptive about the Emergency Response services that will need to be in place for spaceflight activities to be conducted safely. The Emergency Response Plan for each LSO application will differ depending upon the mode of spaceflight activity that the launch site expects to undertake.

For Horizontal Launch Site Operators (HLSO), whose rockets and their payloads are propelled into sub-orbital or low earth orbits from carrier aircraft, such operations normally occur from existing aerodromes or airports.

These sites, comprising one or more runways, hanger buildings, air traffic control centres etc. operate under the regulatory authority of the UK Civil Aviation Authority (CAA) and are subject to established international safety and operational regulations and procedures, including the provision of on-site Aircraft Rescue and Fire Fighting (ARFF) services based upon the Category of the aerodrome and the size of and type of aircraft that utilise the facility.

ARFF services operate under International Civil Aviation Organisation (ICAO) regulations and standards which, under the UK CAA comprise CAP168 – Licensing of Aerodromes and CAP699 – Standards for the competence of rescue and firefighting services. The new CAP 2212 and CAP 2214, introduced as part of the Space Industry Regulations 2021 contains additional guidance pertinent to all LSO's

For Vertical Launch Site Operators (VLSO) however, no internationally recognised Emergency Response standards currently exist, although CAP 2212 section 5 does provide general guidance on the scope and purpose of the safety case. The UK Space Agency is leading on the development of operational requirements for vertical.

launch sites and is working closely with the CAA, LSO and industry specialists to define the Emergency Response services that may be required for such sites.

VLSO may also need to consider the installation of fire detection and alarm systems and fixed deluge firefighting systems around the launch platform and fuel storage areas, along with appropriate resources, assets and equipment for their mobile Emergency Response and firefighting crews.

It is important for both HLSO and VLSO to recognise that as commercial spaceflight operators, they cannot rely upon local authority fire and rescue services to provide stand-by Emergency Response cover for their spaceflight activities. They will need to risk assess their own activities and provide and maintain appropriate Emergency Response cover to suit their own circumstances and locations.

An area that may require more detailed consideration by each LSO involves the unusual risks associated with different types of rocket propellant fuels and hazardous chemicals that may be used in space flight activities. The storage, transfer and fuelling of rockets with highly reactive or explosive fuels coupled with the potential release of highly toxic gases and poisonous products of combustion from these fuels in the event of a launch site fire will require specialist knowledge and training for emergency responders.

Other diverse risks specific to spaceport LSO include the potential numbers and proximity of any tourists that wish to witness the launch site activities and the potential for environmental harm from fire if the launch site is situated in or around peat moorland.

On-site Emergency Response Provision

Under the Space Industry Regulations 2021 (Pt 9, c.8 – 154.1), a spaceport licensee must ensure that rescue and firefighting personnel, facilities and equipment are provided at the spaceport in a timely manner.

The cost of maintaining and operating an on-site Rescue and Fire Fighting Service (RFFS) or for airports, an Aircraft Rescue and Fire Fighting (ARFF) service, in order to fully meet the compliance and operational license requirements for commercial spaceflight activities will need to be carefully considered by the LSO within its planning and budgeting process.

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Failure to fully comply with and maintain Emergency Response services to defined standards or agreed levels will prevent the LSO from gaining or keeping its license to operate and, in the event of an incident, potentially expose the LSO to serious financial liability and significant reputational risk. Insurers will of course demand that any identified risk is minimised and mitigated before they provide insurance cover for the site and its operations.
Notwithstanding the availability of local or municipal resources to react in the event of an emergency or serious incident, the on-site RFFS, which will provide the vital 'First Response' to any incident, is generally a choice between two main options; an 'employed' service or an 'outsourced' service.

While some VLSO may elect to invest in their own Fire and Rescue Services, or for HLSO contract with the existing Airport ARFF service, which normally includes the provision of a dedicated Fire Station(s), skilled personnel, response vehicles and life-saving equipment, others will need to consider outsourced or sub-contracted service providers, to enable them to meet their operational needs in a more cost effective and compliant manner.

So, what are the factors that will influence the decision to outsource the Emergency Response function and how should LSO choose between these options?

Managing Risk and Maintaining Compliance

The requirement and resources for an on-site fire and rescue service will be determined chiefly by the type of activity that the LSO is involved in at each site or facility, the

assessment of the risks associated with the processes or activities that occur on-site and the impact that any emergency incident may have on the business, its employees and on the surrounding communities.

The decision to outsource may be driven by purely financial or economic motives as LSO seek to reduce costs and enhance their commercial competitiveness or by other strategic and tactical factors.

Ultimately, the motivation for investment in an on-site fire and rescue resource is like an insurance policy which is rooted in the avoidance of loss, which can be organisational, financial, reputational and/or personal in nature and in a need to ensure the on-going stability, security, and resilience of the launch facility.

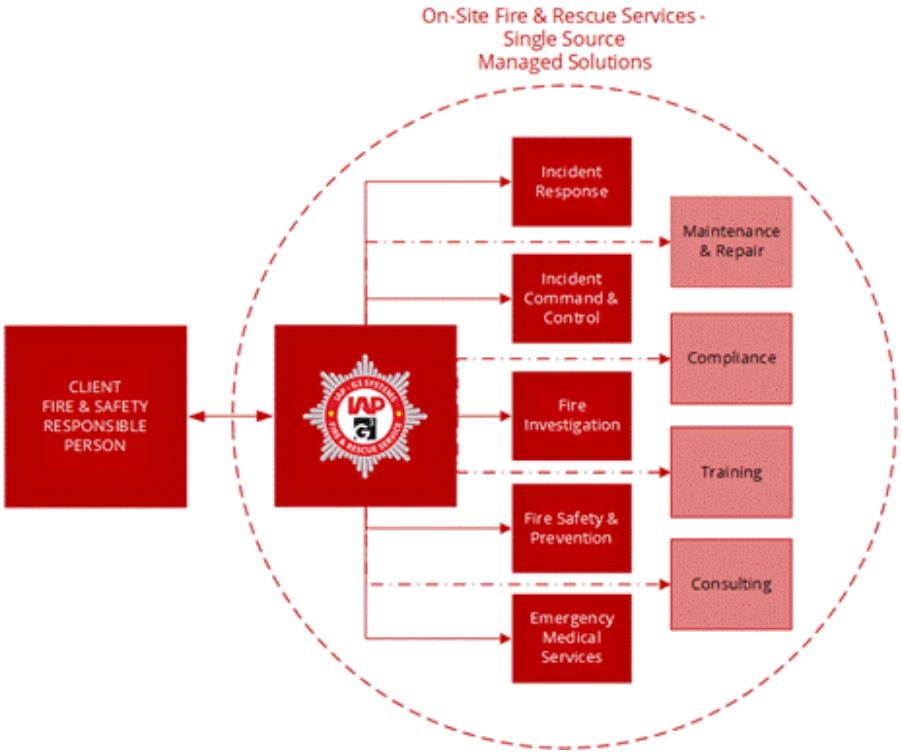
Regulatory compliance, business continuity reassurance and client 'peace of mind' are the benefits of such an investment, but as with any insurance policy, it is sincerely hoped that the Fire and Rescue Service will never need to be called upon in a real-life emergency situation.

not actually a core function of the organisation itself.

Fire crews must be skilled, qualified, and experienced and must train continually to maintain their competence. Skills fade is a very real and recognised phenomenon, and a lack of training is not something you wish to suddenly become aware of when responding to an emergency situation.

Outsourcing the firefighting and rescue service provision enables each LSO to focus on their core business while delegating essential but non-core elements to external specialist providers. This releases internal resources that can be put to more effective use for other purposes, leading to greater overall efficiency and competitiveness.

Certainly, during the initial stages of UK spaceport development, relatively infrequent space launches mean that the cost of an emergency service provision may seem quite high. This cost will of course be amortised as the increasing frequency of launches makes the overall provision more cost effective.



Recruiting, training, resourcing, and supporting an employed on-site fire and rescue service can be a relatively expensive operational cost for the LSO.

The day-to-day management of an employed Fire, Rescue and Safety service can sap the LSO managers of time and energy that, while imperative to the safe, legal and ultimately the profitable operation of the facility, is

One way to offset the early costs of the Emergency Response service is for LSO's to collaborate to share these costs. Collaborative working is a hallmark of the UK space industry and given that UK space launches will need to be deconflicted from a timing and location perspective, there is little reason why two or more LSO's could not contract to share an Emergency Response provision, thus saving money and mitigating their insurance liability

while also maintaining their regulatory compliance.

The question to be asked is, could an outsourced service provider deliver the required functions, tasks, and regulatory responsibilities, maintain and improve launch site safety, respond effectively to any emergency incident and add value to the organisation, at a more cost-effective rate than directly employing and maintaining an on-site team?

When properly executed, outsourcing the on-site Fire and Rescue Service can have a defining impact on the company's revenue recognition and can deliver improved business continuity and resilience as well as significant savings through lower operational and labour costs.

Specialist Knowledge, Skills, and Expertise

Realistically, launch site licensees cannot be experts in every business function, process, or discipline; it is simply uneconomic to cover all of the required specialist and technical roles in-house. By utilising an outsourced service provider for its Emergency Response requirements, the LSO can leverage a global knowledge base and resource, accessing world class capabilities, expertise, technical skills, and experience, at an economic level.

Managed FRS service providers often have access to a wider, more highly skilled, and diverse talent pool than the client themselves and will already have in place the requisite interview and selection processes designed to select only the strongest, most appropriately qualified and experienced staff.

Training and competence management will reflect global best practice, with space industry and launch site-specific risks recognised, evaluated, and reflected in the ongoing training provided to the FRS staff members.

Shared experiences coupled with specialist skills, learning and best working practices also enable the outsourced service provider to add value and resilience to and further reduce risk within the client's operation.

Shared Responsibilities and Liabilities

Although the LSO must retain its duty of care to operate in a safe and environmentally responsible manner, delegating Fire and Rescue Service responsibilities to external providers can release companies of day-to-day management functions that are difficult to administer and control, while still realizing the inherent benefit the FRS provides and crucially maintaining operational compliance and certification.

As specialists in their field, outsourced FRS service providers generally are much better at deciding how to cost effectively avoid risk in their areas of expertise without compromising safety and response than perhaps a fully employed on-site team might be. This is because their incentive to deliver a high level of service and to maintain their professional reputation and credibility while remaining profitable is potentially stronger for the outsourced provider. If, unfortunately, something does go wrong, a further consideration may be that the responsibility and possible consequential contractual liability could well be shared in whole or in part with the Service Provider, rather than being wholly carried by the contracting client themselves.

Making the Right Choice

The decision to resource the Fire and Rescue Service for a Space Port launch site cannot be made lightly. A thorough and detailed examination of the associated risks, costs and benefits must be investigated during preparation for the licensing process and as part of the site's comprehensive safety case construction.

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Author
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Chris Thain manages Fire & Rescue Service business development for G3 Systems Ltd, a UK based company that provides fully managed and compliant on-site Fire and Rescue Services for industrial, aviation and military clients around the world, specialising in operations in austere and hostile working environments. He sits on the UK CAA Space Port Launch Operators Working Group as well as the JOIFF Airports Working Group.

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Chris previously worked with Devon and Somerset Fire and Rescue Service, where he successfully managed the commercial trading business of the Fire Authority.

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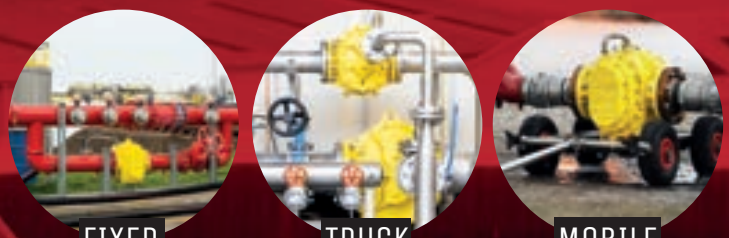

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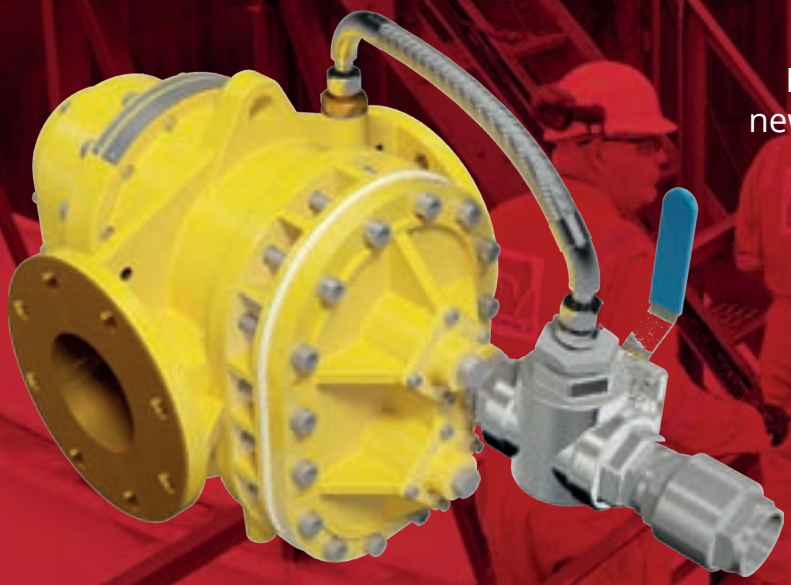

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London Fire Brigade Drone Capability

From Inception to The Future

By Lee Newman Station Officer & Drone Team Manager at London Fire Brigade

From Dec 2017 to Sept 2018 the London fire brigade investigated and implemented a drone capability mainly from recommendations after the tragic events of the Grenfell Tower fire in June 2017, in this time the team and capability was built based on research looking into what other services were currently operating at the time and also how the various assets were deployed, whether it by dedicated vehicles or by firefighters on fire engines.

From the go live date of Sept 2018 the drone team quickly grew to be a busy and integral part of fire service operations providing situational awareness to incident commanders and giving information not previously available to help bring fires to a safer quicker conclusion.

During this time, we investigated what other roles the drone could carry out based on incidents where they hadn't been present and thinking outside the box on how to use them to help in those incidents if they were to happen again.

One of these roles, which was taken from sharing ideas on what was feasibly achievable and a gap in where a drone could provide a service was the dropping of smoke hoods. Smoke hoods had been pushed into service mainly after the Grenfell recommendations were made and are usually deployed by fire crews in BA sets, however a scenario that had been envisaged was people stuck on balconies or roof tops in thick smoke out of the immediate reach of aerial ladder appliances or fire crews that had a long commute to reach them.

We took the idea to fix a smoke hood onto a drone with a dropping mechanism and fly it into a balcony to drop it to the person in distress, this was successfully carried out in various training exercises using a second drone to use the speaker function to relay the donning instructions to the person needing the smoke hood. This capability then lead onto the idea of dropping buoyancy aides to people in water related incidents which again was tested successfully at the Lea Valley white water rafting centre on rescue swimmers, the main benefits that the buoyancy aide kept the casualties above water and the drone could then help track their path down the river to help direct the water rescue technicians to the location.

Other capabilities we looked into was 3D/4D mapping software options, the main one being the digital mapping of high-risk buildings and using these to build models for firefighters to train with at station or via the ever popular VR delivery system. The option to make 3D/4D computer models with images captured after a fire was another option, these could be used by fire investigation for reports and investigations or for crews or recruits at training school to train with. Other uses of data capture software vary from Haz Mat mapping or USAR incidents where using the sophisticated tools within the software means you could for example measure building walls then provide the USAR technicians with dimensions to build shores without having to get close to it, thus keeping them safe out of the hazard zone until the shores are put in place.

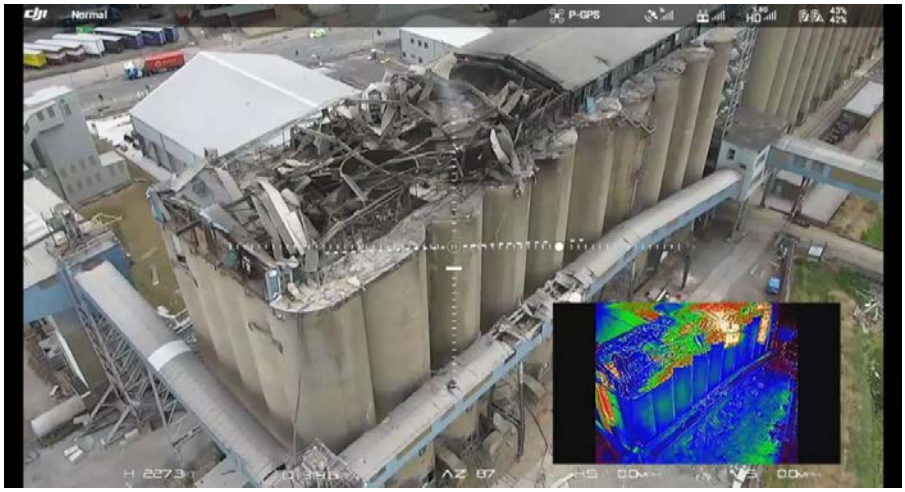
In the past year post the covid years we have wanted to expand what we could do as a team and what roles the drone could carry out within the fire service world. Whilst on a USAR (Urban Search and Rescue) exercise a team were tasked with entering a confined space to undertake a Haz Mat sweep using a gas detector,

this took a team of two and a whole host of safe systems of work to implement it which is standard practice but made us think could a drone do it instead. I spoke to a few scientific advisors and Haz Mat officers to determine if this was a feasible option.

It was asked how we would deploy a gas monitor using a drone to undertake this function, we came up with the idea of strapping a gas monitor to a Mavic 2E and used the camera to read the display, for additional protection we added the cage to the drone to protect encase of a strike whilst flying indoors.

The result was that we could use this for internal or external incidents and that after again consulting the experts was determined that the prop wash wouldn't alter the read out for the gasses. This is still a work in progress and are still closely working with the advisors to work through all possible scenarios. We recently investigated what was on the market for industrial and commercial companies for the Haz-mat role and discovered a device called the Alpha Geo Sniffer 4D.I held the first of what will be a yearly Haz Mat drone working group in Essex this spring and brought fire and police services together for a demonstration on its uses and applications, we also showcased the smaller drone that we had designed for smaller incidents which was received very well by all in attendance.

Another project we looked into this year was the tethered drone option. This had never really been on our wish list solely due to the way we operate and the limitations of tethered solutions, however the end user for this would be the fire boat and fits the bill to be able to give aerial thermal and optical coverage without waiting for the land-based drone team to attend.



A couple of years ago we demonstrated the use of drones on the boat showing night-time footage of exercises we had undertaken which was received with good feedback and a possible case for a drone on a boat was raised. Fast forward to present day and we have a solution to be able to do this which will require training a few operators on each watch up then undertake a trial to provide outcomes for a possible full-time capability. The other two areas we aim to cover this year and into next is using drones in a USAR environment, at various exercise at the Fire Service College last year we used the drone for initial size up and exploration purposes, the main aim being around firefighter safety and the option to recce incidents without putting people in danger first. In August this year we utilised a drone on a live USAR incident where we had to check for casualties and building damage at a explosion in a house, the top floor was too high from eyesight to see inside and no aerial was in attendance at that stage so the IC asked for the drone to be flown and have a look inside and help build an assessment of what they had to deal with. I have set up a national working group for USAR/Indoor flying and a host of fire service leads attended recently at the inaugural event to give internal flying a go and better understand how they can explore this capability within their own drone programmes.

The team never stops evolving we try and stay ahead of the curve of what we can be called upon to be used for, the recent grass fires in London have pushed the use of the drone to a new level and now the incident commanders are actively using it for their decision making and using it to confirm plans implemented are working or that they can plot fire movements easier with the footage they receive via the drone.

The future will bring more autonomous drones and even drones that will help extinguish fires but right now we are slowly building the foundations for that future one year at a time within the London fire brigade.

About the Author:

"Joined in 1997 and trained as a fire rescue technician in 2004 then undertook the USAR role later that year, I am also a part of the UK ISAR team and have done that for 10 years, I worked my way up to station officer where I then moved into HQ to join the operational policy and assurance team in 2017. After the tragic Grenfell tower fire of June that year I was tasked with developing the LFB's drone capability which I have done so ever since, we went live as a team within 9 months of starting the project and to date have flown over 350 incidents as a team. We pride ourselves on pushing the capability to higher levels and innovation of new capabilities."

Skin temperature measurements

and subjective responses during flue gas cooling experiment

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Introduction

In the Netherlands, the so-called 3D pulse method is used as a flue gas cooling technique. It is perceived by instructors that teaching this method is difficult, that it requires a lot of practice and training and that it is only performed correctly by few firefighters. This was expected to lead to dangerous situations for the deployment crew and victims. Therefore, in a study by Fire Service Academy (2021), two methods of flue gas cooling were compared – the 3D pulse method used in the Netherlands and the so called 'arc method' used in the United States of America. These methods were compared for both high and low pressure systems. The central question of the above mentioned study was to evaluate to what extent flue gases are cooled, and how the fire source and safety of firefighters and victims are affected by these methods when progressing to a fire source. The outcome of the comparison of the method effectiveness is in detail described in the study report (Fire Service Academy 2021).

This paper covers a limited number of physiological test results that were carried out in order to support eventual differences in danger level to the deployment crew while using either 3D pulse or arc method for flue gas cooling. These limited data were not included in the main report (Fire Service Academy 2021) as neither all tested methods nor all test persons were covered. However these data contain important information for the health and safety of the firefighters.

Methods
Test location and fire simulation

To best approach the practice of firefighting, the study was conducted in a stone building, specially built for these experiments. This building had an L shape, the long part of which consisted of a 2 meters wide and 20 meters long corridor. The fire place was situated in the short part of the L-shape. This shape was chosen to prevent direct contact with the fire source during the flue gas cooling methods testing.

One basic scenario was assumed during the experiments: a significant living room fire (total load of 6 8 MW) with the home door to the hallway open, with smoke flowing into the adjacent hallway, and with the home front door open. All experimental sessions were performed in duplicate, as well as the baseline measurement (the basic scenario) and with experienced professional firefighters.

During the experiments, various parameters were measured at different places and/or heights inside and outside the building. This concerns the temperature, radiation, gas concentrations and the visual image inside and outside.

By always using the same fire load and a fixed experimental protocol, the variation in starting conditions was minimized as much as possible. The measurements showed that in general the spread was limited (about 10 %), which indicates that the conditions were well reproducible (Fire Service Academy 2021).

Physiological measurements

The experiment, including skin temperatures of the test persons and their subjective responses, was intended to support the selection and recommendation of the most efficient, less strenuous and most safe extinguishing method. The skin temperature and subjective responses were collected during 3 days. Two persons did participate in the exercise simultaneously with one being nozzle operator and the other one assisting. The first measurements (test person 1, S1) were done during the pre-tests on a firefighter instructor who was familiar with the different smoke cooling techniques in May 2019. Subjective responses from both performing persons were collected after each individual exercise sessions.

The regular smoke cooling tests were scheduled for October 2019. Due to the delay of the arrival of the ordered instrument the test week was not possible to be utilized fully. Therefore, the instrument and its carrying and protective system was evaluated on test person 2 (S2, Figure 1a), who was only assisting and followed into the building (Figure 2) with the exercise team. At the same time subjective responses from the main actors (A1 and A2) were collected after each exposure. The system had to be modified, and only test persons 3 (S3) and 4 (S4) could be measured as originally intended (Figure 1b). Depending on the measurement system used and the sizing of the PPE the weight of the whole system could differ, but the estimated weight of all equipment carried was around 22 kg.

Procedure

In the beginning of the day the test persons were given the information about the tests. The tests were a part of a training program. The test persons signed a written consent related to the physiological measurements (skin temperature) and subjective responses.

Figure 1. S2 (a), and S3 and S4 (b) with protected instrument attached to the air bottle.

After the instructions four sensors were taped to the test persons' skin at the following locations: chest, upper arm, thigh and calf, and additional four at the same locations on the outer side of the clothing layer under the outer layer (either on the inner or on the middle layer depending on the used clothing combination of the test persons). The sensor positions were selected to allow mean skin temperature calculation according to Ramanathan (1964). The preparation took up to 30 minutes. The sensors stayed on the body for all experimental sessions.

The test persons followed the procedures as planned for the smoke cooling exercise (Fire Service Academy 2021). The posture of the firefighters during the exercise was commonly low, i.e. squatting or on knees. Subjective responses such as thermal, pain and humidity sensations, and perceived exertion were collected at the end of each exposure session. Between the exposures the test persons were allowed to remove the PPE for quick recovery. After the last session, the temperature sensors were removed from the skin and clothing, which took about 10-15 minutes.

Instruments

The skin and clothing layer temperatures were measured with either a MSR145WD data loggers (S1) or T-type thermocouples connected to Grant SQ2040-2F16 WiFi logger (S2-S4). In the first case also the humidity was measured at one spot on the skin and at one spot in the clothing (both at right chest). However, in order to allow removal of the clothing outer layer for better recovery of the test persons between the passes, then the sensors of the Grant logger had to be disconnected after each exposure and were reconnected before the next trial when the test persons were again equipped with the respiratory protective device (RPD, Figure 1).

The following subjective responses were collected (ISO 10551:2019):

Figure 2. Test building with the safety team members.

thermal sensation (9-point towards heat skewed scale, from -3 = cold to +5 = unbearably hot, 0 = neutral), pain sensation (5-point scale, from 0 = no pain to 4 = very, very painful, skin wetness sensation (7-point scale, 0 to 3 with a step of 0.5, 0 = normal) and perceived exertion (Borg's scale from 6 to 20; Borg 1982).

The test persons

All test persons were experienced professional firefighters. On the first day (pre-study) a male firefighter (47 years, 92 kg, 1.78 m) acted as the test person (S1). He participated in all sessions of the day. In two of them he was acting as the nozzle operator and in two of them he assisted. The second time another male firefighter (52 years, 100 kg, 1.93 m) acted as the test person. He was following the two main actors (A1 and A2) during all exposures and simulated some relevant exercises during the exposure. At the same time the subjective responses were collected from all exposed persons after each session. During the third measurement day 2 firefighters acted as the test persons. One of them was male (27 years, 82 kg, 1.78 m) and the other one was female (46 years, 67 kg, 1.65 m).

Results

Reference temperatures in the room

The temperatures in the room differed depending on the height and the distance from the seat of the fire (Fire Service Academy 2021). At 1.8 m height they ranged on average from 160 °C at 2 m from the entrance to 393 °C at 17 m into the room. At 1.5, 0.9 and 0.3 m height these values were 105 vs. 259, 42 vs. 53 and 23 vs. 46 °C at the start of each experiment, respectively. The firefighters stayed as much as possible in low position during the experiments. The average temperature reduction during the flue gas experiments depended on the specific method and ranged by method, for example, at 1.5 m height from 35 to 106 °C.

Physiological measurements

The exposure times for each measured subject are given in Table 1. The maximum recorded skin temperatures and the location of that measured maximum temperature (Tmax) are given in table 2. The maximum temperatures between clothing layers are shown in Table 3 together with the body location where this highest value was recorded. removed before lunch (~12:46, Figure 3) while relatively high changes in the temperature of upper arm was observed already between the first and the second exposure session (around 11:30) while examining the data for analysis.

During this first measuring day the thermal sensation of the test persons after the exposure ranged from slightly warm (+1) to hot (+3) (between warm and hot (+2.5) to hot (+3) when closest to the fire) for different cooling methods. Pain sensation was not reported (0) for any exposure. Wetness was reported with the highest values reaching between slightly wet and wet (1.5), and specifically mentioning knees. The perceived exertion was rated to lay between light and hard. It was commonly rated somewhat hard, and only once hard by one person (exposure 2).

The examples of the complete recorded skin and clothing temperature curves are shown for S1 in Figures 3 and 4, respectively. Figure 3 shows also the periods between entering and leaving the building. The first exposure was smoke cooling by pulsation (3D pulse method), the second one by surface spraying (arc method) and the third one was the continuation of the previous task, and under the fourth exposure smoke cooling by long pulsation method was performed. When taking off the sensors it was observed that at a certain timepoint upper arm sensor on skin had become loose and skin humidity sensor had glided under the tape. It might have happened sometimes after the third exposure when the equipment and clothing was

Figure 5 shows the relative humidity mea sured at the skin and between clothing layers for S1.

rated the perceived exertion between light – somewhat hard (12) and hard (15) (average somewhat hard (13), hard (15) was rated only once). This result is very comparable with pre-test results by the instructors. Similarly, no pain was reported and thermal sensations varied from slightly warm (+1) to hot (+3; average for A1 and A2 and for all test persons together was similar and close to warm (+2)) with a comment that the hottest happened when being closest to the fire. Also, in relation to wetness the test persons brought up especially knees and legs, while the skin wetness rating stayed around slightly wet (1.0; range 0-1.5). The only comment by the test persons was that the whole day was a very good training.

Also, during the last day of skin temperature recordings (S3 and S4) no pain was reported, skin wetness was rated around slightly wet (1.0, with recorded values between 0.5 and 1.5) and again specifically pointing out the knees. This time it was also mentioned that the (wet) knee that came closest to the fire felt as the hottest part of the body. The person who mentioned this could have been especially sensitive with this – during discussion this test person brought up that during an earlier incident he had got blistering on knee under the work exposure.

Thermal responses were varying from slightly warm (+1) to hot – very hot (+3.5) with the highest ratings for the first exposure (average warm – hot (+2.5) vs. slightly warm – warm (+1.5) for the second one). The perceived exertion was also rated similarly as earlier (average between light – somewhat hard (12), range from very light – light to somewhat hard, 10-13). The persons reported that they did not notice any disturbance from the instruments during the exposure.

In the second exposure logger 2 (S4) showed strange values (temperature drop instead of raise. At the end of the experiments it was observed that logger 2 was moist, i.e. the strange behaviour could be related to the effect of moisture on the instrument readings. The maximum recorded skin and clothing temperatures during the exposures (Table 1) stayed in the same range compared to the previous testing days (Tables 2 and 3).

Table 1. Exposure times for the measured subjects.

Subject	Exposure 1	Exposure 2	Exposure 3	Exposure 4
S1	8' 50''	6'	4' 10''	2' 15''
S2	2'	5' 40''	3' 9''	4' 42''
S3	6' 40''	1' 58''		
S4	6' 40''	1' 58''		

Table 2. Maximum skin temperature (°C) and the measured location for each exposure.

	Exposure 1		Exposure 2		Exposure 3		Exposure 4	
Subject	Tmax	Location	Tmax	Location	Tmax	Location	Tmax	Location
S1	39.2	Upper arm	36.4	Upper arm	37.0	Upper arm	41.1	Upper arm
S2	35.0	Upper arm	39.9	Upper arm	36.2	Upper arm	35.9	Thigh*
S3	36.1	Chest & Upper arm	36.4	Upper arm				
S4	37.7	Upper arm	-	Data lost				

* Upper arm sensor had lost contact with skin.

Table 3. Maximum temperatures (°C) between clothing layers and the measured location for each exposure.

	Exposure 1		Exposure 2		Exposure 3		Exposure 4	
Subject	Tmax	Location	Tmax	Location	Tmax	Location	Tmax	Location
S1	50.4	Upper arm	38.9	Upper arm	39.0	Upper arm	49.4	Upper arm
S2	36.9	Upper arm	46.6	Upper arm	41.4	Upper arm	44.8	Upper arm
S3	36.7	Chest	39.8	Chest				
S4	42.6	Chest	41.7	Chest				

Air pressure during this day stayed around 995 mbar.

During S2 exposures (Table 2) the tasks according to the schedule did cover smoke cooling techniques of 3D pulse method with flow rate of 450 l/min, arc method, arc method and 3D pulse method with flow rate of LD 450 l/min, respectively.

As S2 did not carry out the real exercise himself but only tried to simulate the activities, then his reported perceived exertion stayed commonly between very light (9) and light (11) for all exposures (average was 10), while the persons involved in smoke cooling training

Discussion and conclusions

We have noticed during the study all temperatures stayed below critical values for skin burns, i.e. 43 °C (S1, Figure 4). The same was the picture also for all other measured subjects and for different cooling methods (Table 2). The clothing temperatures between the layers gave commonly no indication for a dangerous situation.
However, in some cases the temperatures in the clothing layers raised close to 50 °C (S1, Table 3). This may indicate that in combination of positive contributory

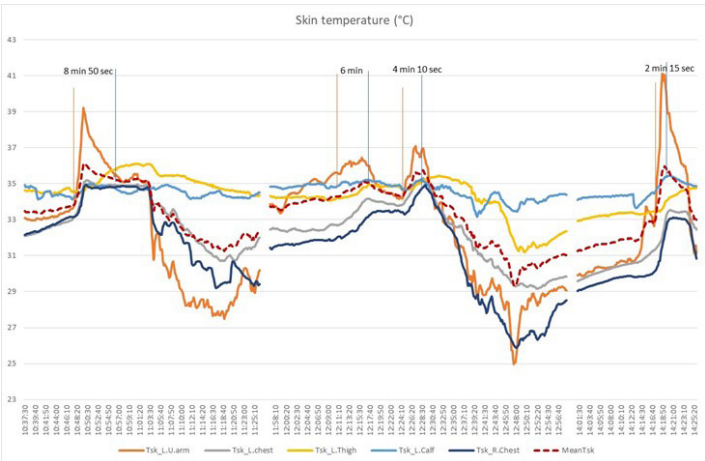

Figure 3. Local and mean skin temperatures of S1 during the exposures of the test day.

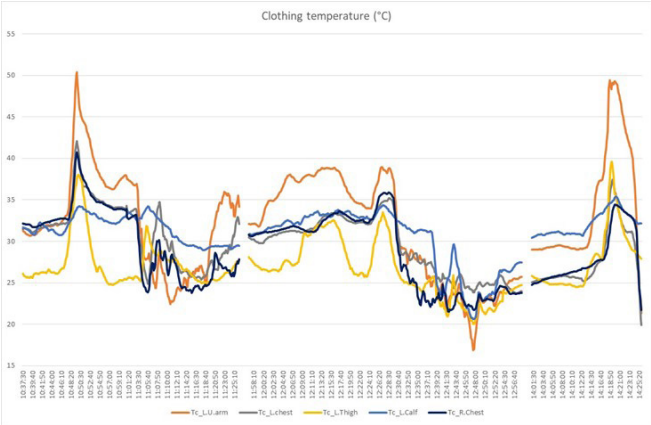

Figure 4. Local clothing layers' temperatures of S1 during the exposures.

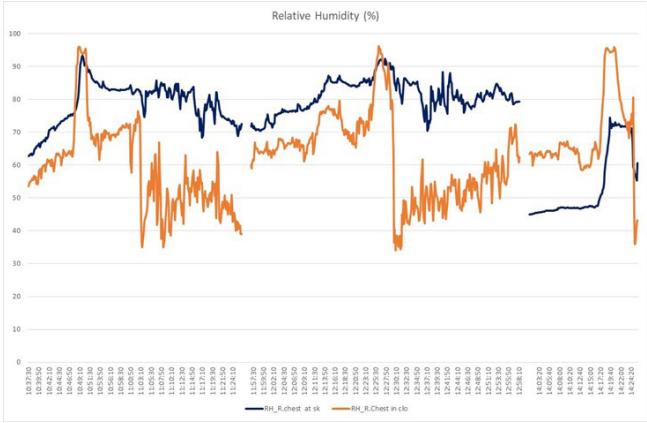

Figure 5. Relative humidity at the skin and between the clothing layers of S1.

factors such as sweating and other moisture leading to reduced insulation; compression leading to reduced insulation; exposed area towards fire leading to additional energy transfer from heat radiation, the outcome may lead to higher risk of local skin burn, especially, during repeated and extended (more than 4-5 minutes) exposures (S1, S2, Table 2). Also, the subjective responses on heat sensation at knee (temperature was not measured there) point to the same direction. Similar risks may be present in connection with any smoke cooling method and the safest method from this viewpoint can't be determined – exposure time and frequency, and tightness of the clothing fit seem to be the most relevant factors. However, the latter would, of course, allow to say that the method that allows to shorten the exposure would also be the one that most effectively reduces the skin burn injury risk.

Both methods provided cooling of the flue gases. Thus, performing flue gas cooling is therefore always better than making no effort. The arc method gave a more favourable result than the 3D pulse method in terms of cooling over the height and length of the corridor, as well as forward cooling and backward cooling. The results of the arc method were also more consistent, which seems to indicate that this method is easier to perform (Fire Service Academy 2021).

No unsafe situations for firefighters arose during the experiments. The limit value for safe operation was not exceeded with any of the investigated flue gas cooling methods (Fire Service Academy 2021). This was also reflected by the all collected subjective responses (Fire Service Academy 2021), and subjective responses and physiological measurements described in detail in this paper.

Also the intensity of the activities (based on perceived exertion ratings) stayed relatively low, so that besides the low risk on skin burns heat exertion is also not expected during these exposure times. Generally, the needed exertion to fulfil the set tasks were rated to be between light and somewhat hard. Skin temperatures in all exposures stayed below 43 °C meaning no risk for burn injuries under all tested conditions. This was confirmed by nobody reporting pain in any body parts - pain threshold is considered to lay at 43-45 °C – and that marks also safe exposure criteria with no risk for burn injury (Ye & De, 2017). The risks seemed not to increase with repeated exposures, i.e. with moisture accumulation in the clothing, as the temperatures could be higher or lower irrespective to the beginning or the end of the trials. At the same time the exposure lengths got commonly shorter later in the day compared to the morning.

Some adverse effects from moist clothing layers and their compression may be expected during coincident contributions of these factors, but these were not observed in the studied conditions. Such unwanted effects may be reduced with sufficient recovery time between the exposures and allowing moisture to evaporate from the turnout gear, but also by using garments with sufficiently loose fit.

In each of the studied cases the previous exposure could have been different. Exposure outcomes were dependent both on the accumulation of the moisture during the previous trial and to the exposure lengths – all exposures differed and were from about 2 minutes to above 10 minutes (combined exposure if entrances 2 and 3 of S1 are counted together). Additional variation was probably present due to potential effect of dry versus wet walls and ceiling of the building in the beginning versus at the end of the day. However, none of these influences raised the measured skin temperatures over the critical values for skin burns. It has to be pointed out that commonly the highest skin temperature values were recorded on the upper body (upper arm).

It reflects the importance of staying low during the exposure.

Simultaneously, nothing in the recorded values would refer to the risk for steam burns within the tested conditions – all measured temperatures stayed enough low for that and neither pain nor extreme thermal sensation was recorded .

Due to the aspects discussed above and due to that different persons (individual variation) carried out different tasks, and only few persons repeated the same activity (but never in exactly the same manner or within the same exposure length) it will be impossible to make a comparison of the tested smoke cooling methods from physiological stress viewpoint. At the same time the effectiveness of the methods might be compared from the viewpoint of the technical measurements, e.g. time to lower the temperature to an acceptable level, time to put off the fire, the rate of the temperature decrease and similar (Fire Service Academy 2021). From the physiological stress viewpoint the conclusions are that

•in the tested conditions there was no risk for skin burns;

•the physical load of all the tasks was acceptable (light – somewhat hard, with the highest reported value for various tasks being hard (15 in Borg scale))

•the skin wetness did not reach to extreme values in any case staying commonly below 2 (=wet)

•thermal load according to the subjective responses did not reach to extreme values in any case – it got maximally +3.5 once (between hot and very hot), and stayed commonly below 3 (hot).

It must be added that in the case of real incidents where repeated exposures do not allow the garments to dry, and the exposures follow in shorter intervals, the situation and the risks may be very different. For example, in the used settings there was no direct exposure to main source of heat radiation. The latter could have influenced the experienced and measured temperatures.

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First realistic exercise
By the LNG Assistance Service in the Netherlands

Exercise conducted on the RelyOn Nutec LNG training facility

Monday 26 October last, the RelyOn Nutec Rotterdam training location was all about LNG. The national LNG Expert group and the fire service specialists from the National Knowledge Centre for Incidents involving Hazardous Substances (LIOGS) were our guests. They held its regular meeting in the morning where all existing and new knowledge/insights in the field of LNG and Bio LNG were shared. In the afternoon, there was a realistic exercise for the LNG Emergency Assistance Service in which an accident situation was staged involving a damaged LNG tank.

The LNG Expert Group and LNG Assistance Scheme

The group consists of LNG experts and experts from both companies, research universities, fire brigades and legislators involved in LNG and Bio-LNG production, storage, transfer, transport and making of laws and regulations. The group was set up about 10 years ago to enable the safe use and transport of LNG in the Netherlands. Today, the group functions mainly to share new knowledge and insights in particular on Bio-LNG.

Incidents involving LNG require specialist advice and equipment beyond the existing knowledge of the emergency services. In response to this necessity the Dutch Fire brigade decide to set up a LNG Assistance Scheme together with commercial partners to provide Incident Management. The LNG Assistance Scheme forms the organisational interpretation of how specialist knowledge and resources can be used in response to LNG incidents. The exercise today was the first training event to evaluate the scheme using actual LNG.

Lessons learned from LNG expert group morning meeting

Filling an LNG storage tank at an LNG filling station, certain screw coupling were used in the Netherlands as a cryogenic connection between an LNG tank truck and an LNG tank. Experience has shown that almost always extra tightening of the connection is required leak due to shrinkage after cooling the filling line with cold LNG. Tightening of a leaking flange is an unsafe situation you want to avoid and there has been one case where the coupling broke off due to over tightening and caused a LNG release. As a consequence operators changed to a dry cryogenic connector but this threw up a new issue. These connectors are prone to freezing preventing the release after the transfer is complete. Experiments were made using dry compressed air to remove moister on both the male and female couplings, but this exacerbated the situation by blowing moister into the coupling. As a result the new preferred method is to use dry cloths to wipe away moister before connecting.

The carrier also advised that freezing due to rainwater can be prevented by pre-emptively wrapping household foil around them. Note; that the foil is not wrapped around the break-way connector as used in shore to ship bunkering!

Another discussion point was regarding blending LNG with Bio LNG. In the Netherlands, Bio-LNG is now made from waste materials but the production capacity of Bio-LNG is not yet sufficient to replace all LNG for the transport sector. Therefore fossil LNG and Bio-LNG are sometimes blended. Bio-LNG is extremely pure but has a slightly different composition to fossil LNG. This causes problems in a number of LNG applications. This has been made known within the Expert Group and the parties involved are consulting each other to develop a solution or standardisation for this.

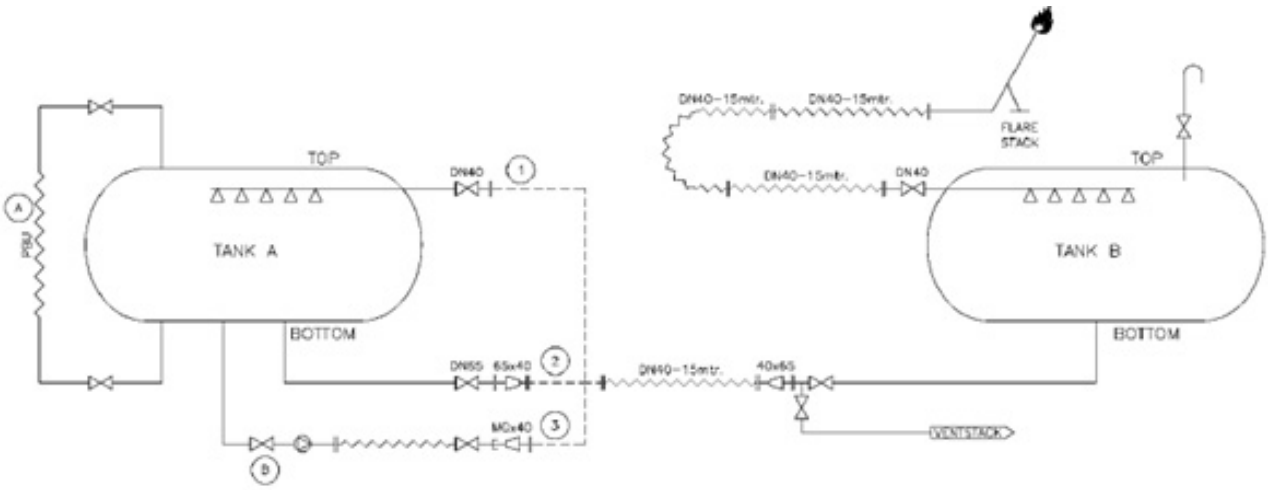

Figure 4 - Connections for pressure decanting with flaring

Lessons learned from the live exercise

The exercise simulated an incident where the thermal insulation on the tank truck following a collision was damaged, making it impossible to transport it further and therefore requiring the LNG to be siphoned off to another empty LNG tanker. Both LNG tankers were set up at our LNG Training facility where we are permitted to release LNG. The objective was to allow LNG assistance team to transfer the LNG firstly without and then with the use of an LNG pump in accordance with the procedure outline in the LNG assistance scheme.

According to the procedure the Assistance Team had to independently locate the right connections and valves, then assemble the LNG hoses and install the mobile flare to burn the boil-off gases to neutralise the pressure differentials. Once connected they then purge hoses, perform leak tests, cold cooling and finally siphon the LNG at the correct pressures whilst maintaining the flare fire.

Although the formal evaluation has yet to take place, learning points have already been identified that we can share:

- Reading a flow diagram of an LNG tanker truck requires additional technical insight and training;
- Gaskets between flange connections must be fitted dry. A leaking wet LNG gasket can no longer be sealed by increasing the tightening torque of the bolts;
- LNG flange assembly instruction with proper tightening torques and tools seems useful;
- The LNG flame on the mobile flare was blown out in certain conditions and revision of the design is necessary.

Should you require any further information regarding LNG training, please contact the Fire Academy of RelyOn Nutec: +31 181 376 666 or fireacademy@nl.relyonnutec.com

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Evaluation of the fire protection effectiveness of fluorine free firefighting foams

FINAL REPORT BY:

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Washington, DC, USA

January 2020

NFPA RF Report 2020

165 UL Fire tests show Fluorine-Free Foams need higher rates:

- 2 – 4 times AR-AFFF rates for IPA Fires (Gentle Application)
- 3 – 4 times AR-AFFF rates for Mil Spec Gasoline (Forceful Application)
- 6 – 7 times AR-AFFF rates for E10 Gasoline (Forceful Application)

NFPA RF Final Report

FAA Part 139 Cert Alert No 21-05 2021

Safety concerns of Fluorine-Free Foams identified:

- Notable increase in extinguishment time;
- Issues with fire reigniting (failure to maintain fire suppression); and
- Possible incompatibility with other firefighting agents, existing firefighting equipment, and aircraft rescue training and firefighting strategy that exist today at Part 139 air carrier airports.

FAA Cert Alert

US FAA Part 139 Cert Alert No 21-05 issued October 4, 2021

"While FAA and DoD testing continues, interim research has already identified safety concerns with candidate fluorine-free products that must be fully evaluated, mitigated, and/or improved before FAA can adopt an alternative foam that adequately protects the flying public."

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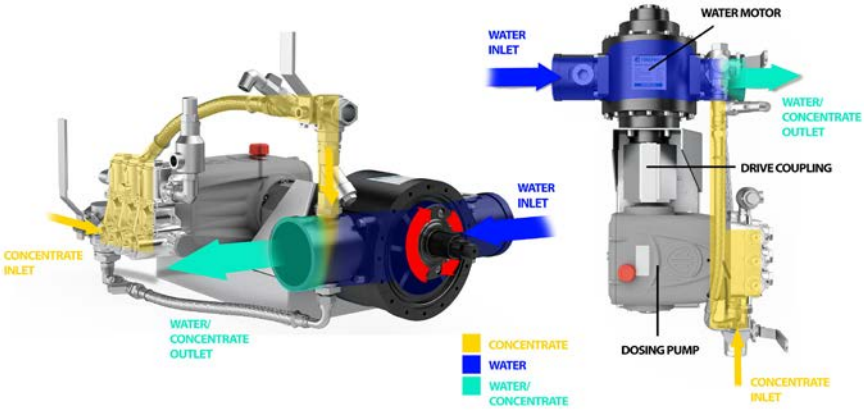
Verifying dosing rate

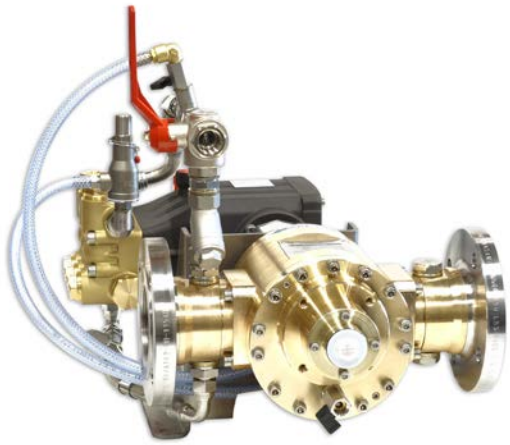
According to EN 13565-1, NFPA 11 and FM 5130 on water driven volumetric proportioners.

To measure and verify the dosing rate on a proportioning system according to regulations and standards at the commissioning and regular yearly maintenance is an important task for the persons in charge. The aim is to ensure that the installed firefighting system proportion the correct amount of the concentrate into the firefighting water flow, as intended and designed.

FIREMIKS is a water driven volumetric proportioner for firefighting – for fixed installations connected to a concentrate tank with gravity feed to the dosing pump. Extinguishing water drives the volumetric water motor, which in its turn drives the positive displacement pump that doses the correct amount of concentrate in the extinguishing water exiting the water motor.



FIREMIKS Basic function principle



FIREMIKS 1200-3-PP-F-BRZ-DRV, equipped with optional Dosing return valve (DRV) and Pressure relief valve (PRV)

To measure and verify the dosing rate on a proportioning system according to regulations and standards at the commissioning and regular yearly maintenance is an important task for the persons in charge. The aim is to ensure that the installed firefighting system proportion the correct amount of the concentrate into the firefighting water flow, as intended and designed.

FIREMIKS is a water driven volumetric proportioner for firefighting – for fixed installations connected to a concentrate tank with gravity feed to the dosing pump. Extinguishing water drives the volumetric water motor, which in its turn drives the positive displacement pump that doses the correct amount of concentrate in the extinguishing water exiting the water motor.

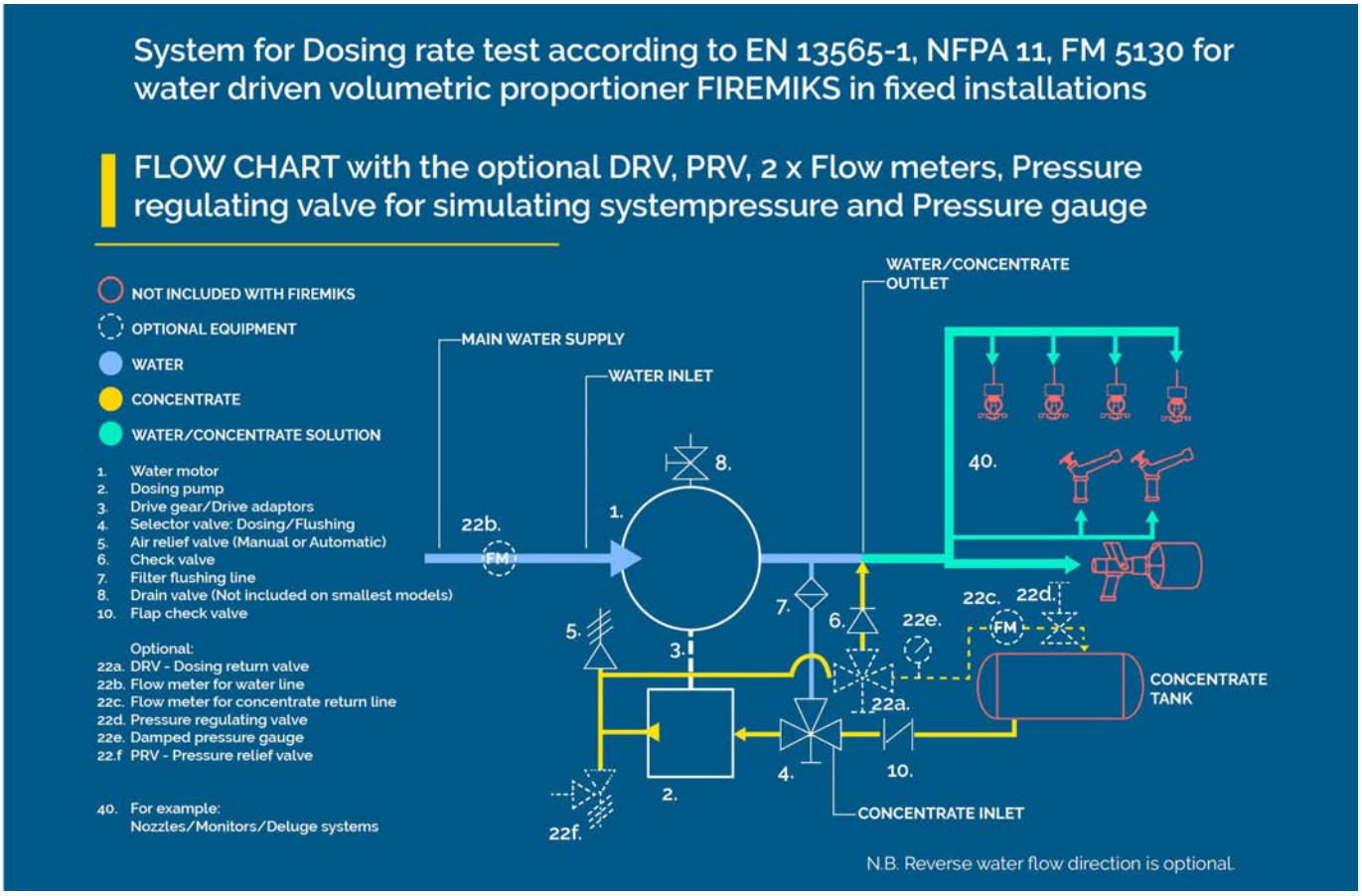
To be able to easily test and verify the correct proportioning the FIREMIKS unit needs to be equipped with an optional Dosing return valve (DRV) (no 22a.) that directs the concentrate back to tank instead of being induced into the water flow. This allows for testing the system without mixing the concentrate.

A Pressure relief valve (PRV), (no 22f.) is included with the DRV to eliminate the risk for over-pressure if return line to tank is closed/ blocked by mistake.

Furthermore, one needs to install two calibrated Flow meters; one for main water line (22b.) and one electromagnetic flow meter for concentrate return line (22c.), combined with a Pressure regulating valve (or a regular valve which can be partly closed to regulate the backpressure, e.g.., globe valve) (22d.) to simulate system pressure, displayed by a Pressure gauge (22e.).
See Flow chart for correct set-up of the above optional equipment's which all can be supplied together with the FIREMIKS unit.

Environmentally and economically beneficial testing system

This described dosing test system ensures that it is possible to practise and test dosing rate without consuming the concentrate. It gives also substantial savings over the years with no cost for cleaning or destruction of dispersed solution after the test. With the growing strict environmental regulations, this advantage has become even more important today.



The accurate way of verifying dosing rate
Verifying dosing rate equals to verifying the correct volumetric function of both the water motor and dosing pump with two independent calibrated flow meters and calculate to this formula, in accordance with EN 13565-1, NFPA 11, FM 5130:

$$\frac{\text{Concentrate flow}}{\text{Water flow + Concentrate flow}} \times 100 = \text{Dosing rate \%}$$

Revolution counter method – the limits

The revolution counter method which is also presented on the market assumes the correct working of the water motor, this means it gives only an estimate of water flow and therefore this estimated water flow cannot be used to correctly verify the dosing rate, as the dosing rate is directly dependent on the performance of the water motor.

The revolution counter method is not an approved method to verify dosing rate as described by
EN 13565-1, NFPA 11 and FM 5130, who each require the use of a separate flow meter to measure water flow. Quote from FM Approval guide ref. rpm method: "...may be used to provide a general estimate of the extinguish water flow...."

Revolution counting with handheld tachometer
The estimated water flow can be measured with handheld tachometer (contact or non-contact) to ensure that the unit is not over-speeding, i.e. working within the upper rpm = flow limit specified in the Data sheets of each FIREMIKS model.

Measuring concentrate flow

An alternative method to measure the pumped concentrate that does not require a flow meter, is to pass it into a separate container after the pressure regulating valve (22d) and weight the amount used from the tank during a defined time and then converting it to the corresponding flow rate.

This is akin to the Nordtest NT Fire 042 method, and this is actually the prescribed method for EN 13565-1 5.3. The flow meter method for the concentrate described above must be shown to correlate to this Nordtest method.

Similarly to Nordtest, FM 5130 requires the concentrate flow measurement with a flow meter to be correlated with the weight method.

In our experience, Magnetic flow meters work well for measuring concentrate flows. Even so, it is even better to be able to establish a known weight or volume of concentrate used in a known time interval, because even approved magnetic flow meters are not tested on all concentrates available.

Handling and monitoring on site or remote

The flow meters, valves and pressure gauge described above can either be handled, monitored and read on site, or connected to remote handling, monitoring and readings. Independently of this - the most important factor is to ensure that data is measured in an accurate way according to the standards, to ensure that the installed firefighting system proportion the correct amount of the concentrate into the firefighting water flow, as intended and designed.

Author information:

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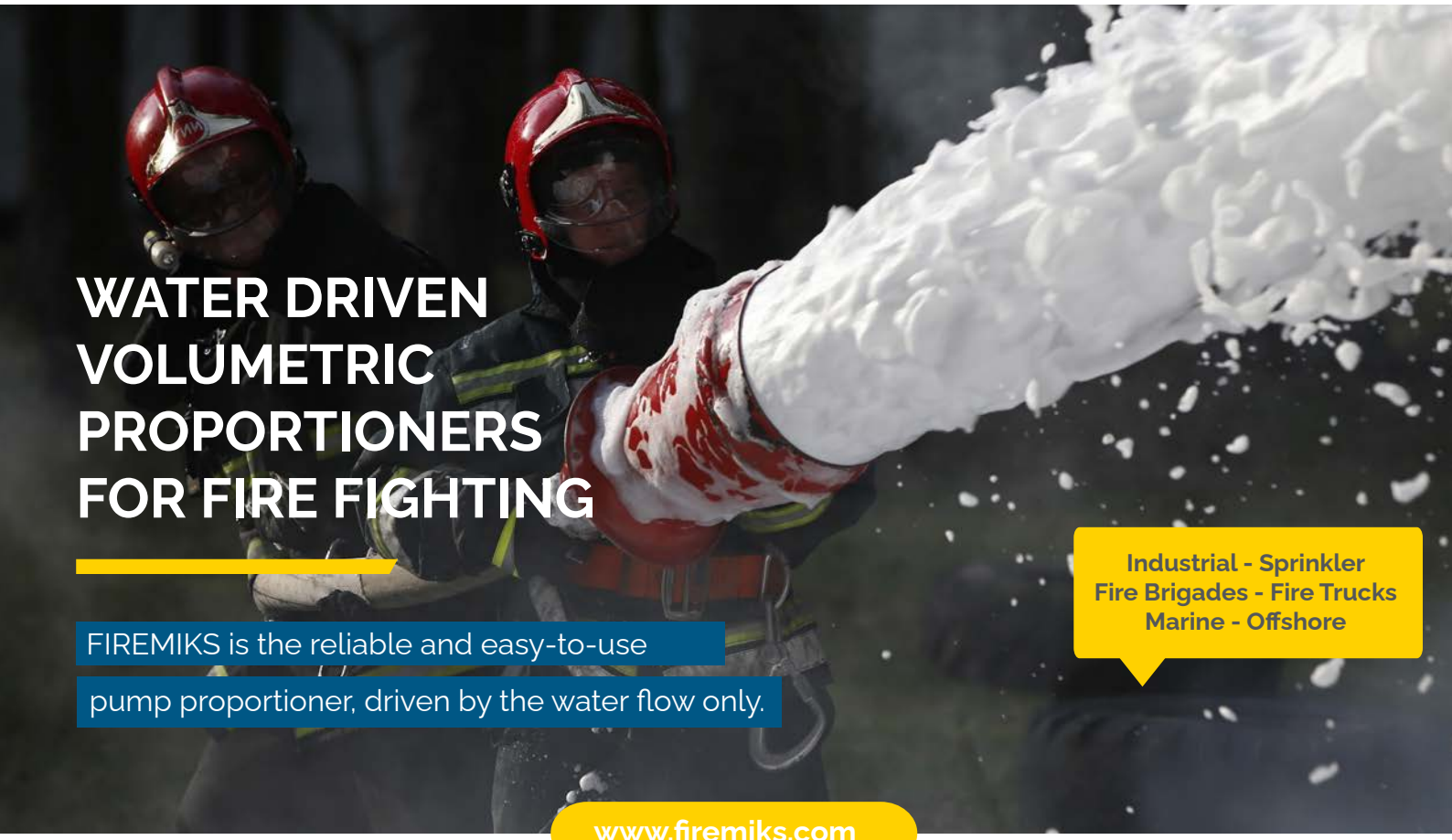

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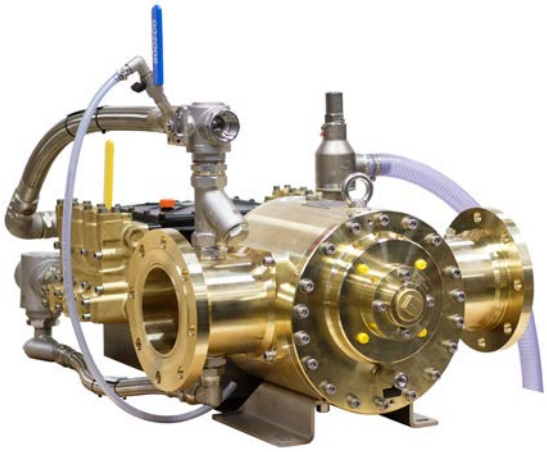

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