Extract from FPX103C fire control panel user manual

14. Testing and Commissioning

14.1 Testing the Detection line

In a system where automatic detection is used:

1. Connect the End of Line (EOL) termination resistance (supplied with the FPX-103C panel) at the end of the Detection Zone/Loop 1 (*the detection loop can be comprised of a Linear Heat Detection cable or conventional Smoke or Heat Detectors or other conventional detectors, suitable for use in the specific application, connected in a Zone/Loop*).

2. Confirm that the panel detects the presence and the absence of the EOL resistance → the "**Detector Loop(s) Fault**" LED indicator will turn OFF and the buzzer will stop sounding, if the detection loop identifies the presence of the EOL resistance. Similarly, the "**Detector Loop Fault**" LED indicator will turn ON (Red AMBER) and the buzzer will start sounding if the detection loop identifies the absence of the EOL resistance.

3. Upon completion of the above (i.e. testing of Detection Zone/Loop 1), repeat steps 1 and 2 to test Detection Zone/Loop 2, if used.

14.2 Testing Detection line Alarm conditions

In order to test whether the panel correctly identifies Fire Alarm conditions:

1. Short circuit the LHD cable (or other detectors) installed on Zone/Loop 1, at the End of Line (EOL) * → If the "**Detector Loop(s) Fire Alarm**" LED indicator turns ON (Red) and the buzzer sounds, then the Fire Alarm conditions have been correctly confirmed.

2. Repeat step 1 above to test Detection Zone/Loop 2, if used, for Fire Alarm conditions in the same way.

3. Ensure that the (post-)Alarm Outputs are activated upon verification of Fire Alarm conditions (as per steps 1 and/or 2) → Shut Down Relay output has latched and the Alarm (Siren) output has been activated.

** The detection loop resistance drops below the 700 Ohm Alarm condition threshold when short circuited*

14.3 Commissioning and Testing of correct Aerosol unit(s) connection

In order to test whether the condensed Aerosol units have been correctly connected at the Fire Suppression loop make sure you have installed the Bidirectional Diodes of type 1.5KE15CA (1500W) in parallel to each Aerosol unit as per the below schematic diagram:

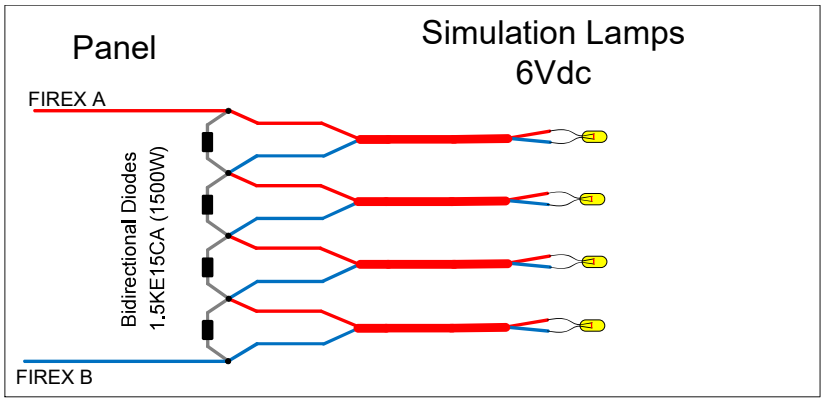

Figure 5: Typical connection of bidirectional diodes and aerosol units

For Testing and Simulation purposes, each Aerosol unit is disconnected and replaced by a simulation lamp as per the following guidelines, **after switching** the panel and the whole system **OFF**:

- If 4 Aerosol units are connected – replace with 4 lamps rated 6 Volts each
- If 2 Aerosol units are connected – replace with 2 lamps rated 12 Volts each
- If 1 Aerosol units are connected – replace with 1 lamp rated 24 Volts

NOTE: If 3 Aerosol units are connected, you can use either 6 Volt or 12V simulation lamps, which will illuminate either slightly brighter or dimmer respectively, when connected.

The above used simulation lamps should have a Resistance rating between 40 and 70 Ohms.

14.4 Testing Fault conditions

In order to test whether the panel correctly identifies Fault conditions on the Extinguishing line/loop, follow the steps below:

1. Upon correctly commissioning and testing the simulation lamps in place of the Aerosol units, as per section 14.3 above, disconnect 1 or more of the simulation lamps (one by one alternatively and/or more than one at the same time). This should initiate Fault conditions

2. The "**Fire Suppression Fault**" LED indicator should turn ON (Red AMBER) and the buzzer should sound → This means that the panel has correctly identified the Fault.

3. Upon completion of thorough testing as per steps 1 and 2 above, reconnect the simulation lamps.

14.5 Testing of Fire Suppression procedure

In order to test whether the panel correctly simulates fire suppression procedure:

1. According to the pre-programming of the panel – i.e. if it is set on Manual or Automatic mode – initiate Fire Alarm and Suppression conditions as follows:

    a. Manual mode: Press the Manual Release button ("Push & Hold for 1 sec") and observe whether the panel "**Fire Suppression Activation**" LED illuminates and the simulation lamps also turn on.

    b. Automatic mode: Initiate Fire Alarm conditions according to the detection used (see section 14.2) and observe whether the panel "**Fire Suppression Activation**" LED illuminates and the simulation lamps turn on (after the pre-programmed time delay, if any, as set by the dip switches – see section 9 above)

14.6 Return to operating conditions

After you perform the above testing/commissioning procedures and have verified the correct operation of the panel/system:

1. Reset the panel to normal operating conditions.

2. Power OFF the panel/system completely and remove the simulation lamps.

3. Before re-connecting the Aerosol units, ensure that the resistance at the electrical actuator terminals lies within the acceptable limits – i.e. between 1.6 and 3.6 Ohms – as demonstrated by the schematic below:

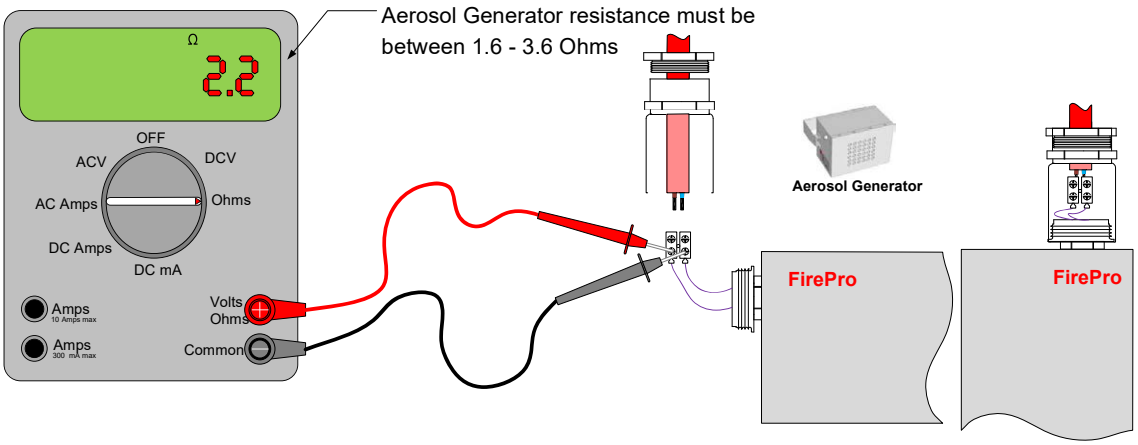

Figure 6: Measuring the Aerosol unit resistance

4. Re-connect the Aerosol units.
5. Power ON the panel/system.

15. Additional Technical information

15.1 FPX-103C Panel operating temperature range:

Designed and tested to meet temperature range -20 to +71C.

15.2 FPX-103C IP rating:

IP65 with back box, cable glands and tamper tag correctly fitted.
IP rating with direct panel mount depends primarily on seal achieved with panel surface (use a gasket to seal if required).

15.3 FPX-103C Shock and vibration rating:

We can only comment on the panel as a component, wiring and peripheral components will be more susceptible to mechanical agitation, good installation and wiring practice suitable for the application environment must be observed.

We have not issued any specific ratings for the panel and every application has a different characteristic frequency/amplitude spectrum which must be evaluated for each application.

The unit is configured to provide maximum reliability possible using the surface mount assembly technology. Good design practice and quality control of soldering and final assembly gives durability appropriate to envisaged application.

We once did a demonstration of throwing a panel out of an upstairs window on to concrete (=3.5Mtr drop test). Case was dented but unit was still fully functional.

We have not seen any vibration or shock induced field failures of the panel.

Note that all critical circuit paths are monitored for continuity with failure mode effects analysis carried down to PCB component level.

15.4 FPX-103C EMI/EMC standards met:

The susceptibility to electromagnetic interference is largely dependent on the specific installation – wire harness lengths and structure materials involved.

Any meaningful EMC qualification must be performed on an installed system. There are no specific level requirements in CE root documents Recreational Craft Directive.

There is extensive EMC protection on all inputs, outputs and power connections for 20V/m radiated emissions 500KHz – 5GHz.

Upset tests for specific threat frequencies have been performed on first article product - mobile phones/3G also VHF (160MHz marine band) and UHF (446MHz PMR and 462MHz FRS/GMRS).

Field experience over several years and thousands of units verifies environmental suitability unlike competitors panels that have proven susceptibility to marine VHF transmitter.

Conducted susceptibility is to MIL-STD-1275 "Characteristics of 28VDC electrical systems in military vehicles".

15.5 Dirty Electricity on Systems:

Dirty electricity is a form of electromagnetic pollution or radiation. It is also called electromagnetic interference (EMI) or electrical "noise".
Dirty Electricity is actually a Mid-high frequency (100Hz-100000KHz) electric noise that makes its way over the electric wires and that is created because of the way that electronics and non-linear electric devices operate and also from external sources (like RF sources and Electromagnetic Fields next to power lines).

This noise is carried over the electric wires all around the room/vessel and since the noise frequency is higher than 50Hz (relatively to 50 or 60 Hz mains frequency) the electric and magnetic fields that are created by these currents can spread all over the room/vessel.
The dirty earth circuit, is an electronic filter to stop feeding back to the system Radio Frequencies through the earthing point.

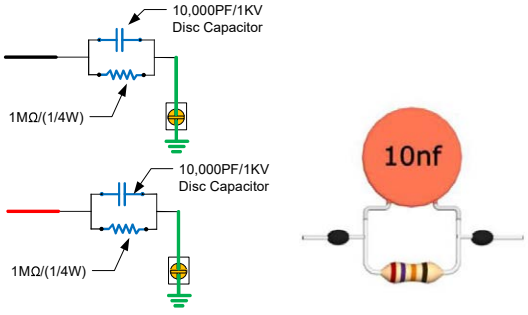

Figure 5: Dirty Electricity filter

For more information regarding EMI interference in systems and methods to reduce the effect of electromagnetic interference please refer to FirePro guideline "Technical guidelines for the prevention of EMI signals in Fixed Fire Fighting Systems".

15.6 Automatic changeover power sources

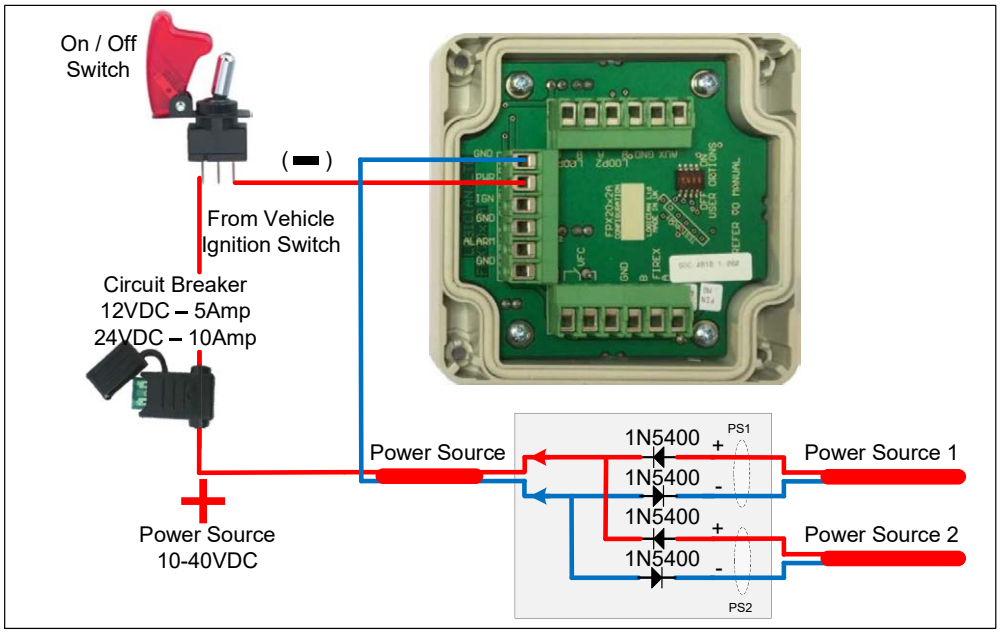

Figure 6: Automatic changeover power sources with diodes

15.7 Impact of non-isolation of the power supply network from shore to vessel

When a boat/vessel is connected to a shore supply of mains power, it is vulnerable to certain sources of corrosive damage not faced by boats/vessels that have no shore connection.

This is because safely wired boats/vessels will be connected to the mains Earth, and this can create a corrosion risk in one of the following ways:

All the boats/vessels in a marina that have a mains electricity connection will effectively share a physical connection with each other via the Earth wire of the supply cable.

They also share a physical connection through the water, and this can lead to a flow of electrons from the metal parts of one boat/vessel, (usually the sacrificial anodes) to the metal parts of another.

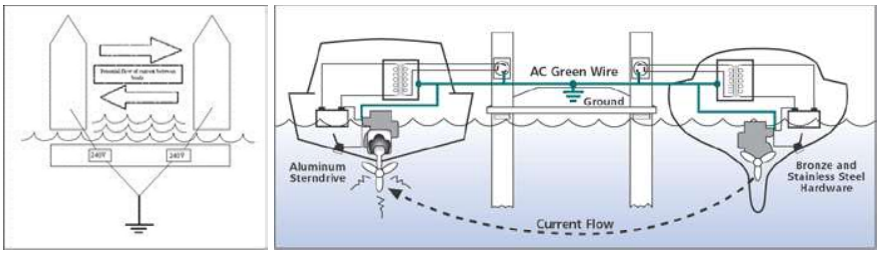

Figure 7: Potential flow of current between boats

A secondary corrosion risk exists in the difference between the Electrical Earth, which is the potential of Earth at the hook up point, and the True Earth, which is the potential of the water that the boat/vessel floats in.

The boat/vessel creates a circuit between the two potentials. At the electricity power station, the potential of Electrical Earth is the same as True Earth.

However, as the power cables make their way across the country/land, the Earth can pick up an electrical charge from stray currents in the cable.
This can lead to a difference at the mooring power point between the two Earths, causing current to flow from the boat/vessel, through the hull and into the water.

At the points where the current flows, there is a risk of corrosion.

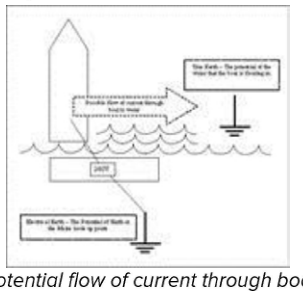

Figure 8: Potential flow of current through boat to water

To prevent such problems and avoid further electrical problems an Isolation Transformer should be used. This type of problem is not unique but appears worldwide and there are solutions to overcome this problem.

An Isolation Transformer has no physical connection between its Primary and Secondary coils. This means that it can sever connection between moored boats/vessels whilst they are still able to draw power and be safely connected to earth.

A simple wiring diagram showing an Isolation Transformer.

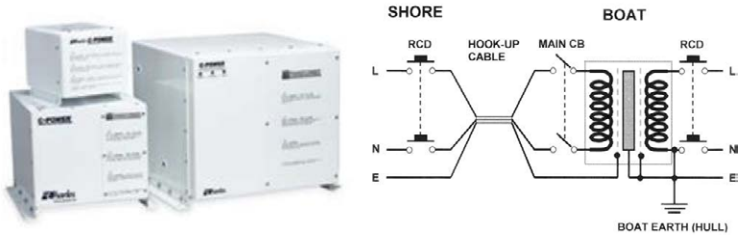

Figure 9: Isolation Transformer wiring diagram

To identify and confirm that this is the problem then check if the voltage difference between the neutral cable (on the boat/vessel) and ground (keel of the vessel), is not zero volts (0V).

When the boat/vessel mains power cables (Live, Neutral, and Earth) are connected to the shore mains power, there is a voltage difference between the neutral voltage and keel of the vessel.

When the boat/vessel mains power cables (Live, Neutral, Earth) are disconnected from the shore mains power, the voltage difference between the neutral voltage and the ground (keel of the vessel), disappears.

This proves that the voltage of the neutral cable on the boat/vessel, is not zero volts (0V).

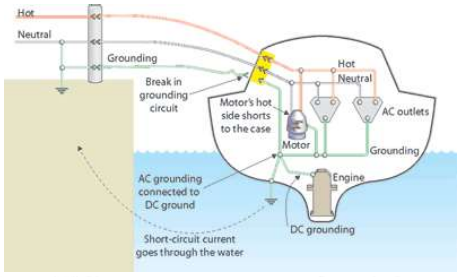

Figure 10: Short circuit current goes through the water

If the isolation transformer is not possible to be installed as a total solution for the boat/vessel, a second solution is also applicable.

An isolated DC-to-DC converter can be used to protect the fire fighting system.
Isolated dc-dc converters provide full dielectric isolation (no electric contact) between input and output circuits by means of a high frequency transformer.

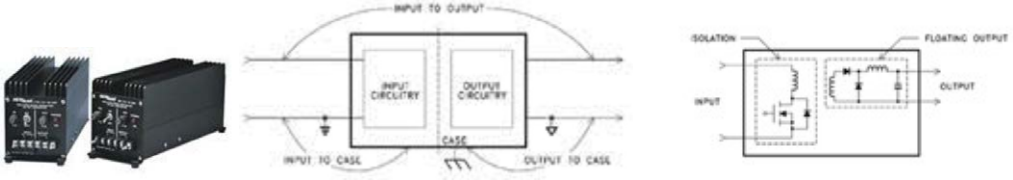

Figure 11: Isolated dc-dc converter

Problems or malfunctions that may arise in electrical / electronic systems (such as the firefighting system) maybe consequences of non-isolation of the power supply network from shore to boat/vessel.

FirePro Material Safety Data Sheet

FirePro Systems Ltd./ Celanova Ltd.

FirePro®

Issue date: 20.04.2012 MATERIAL SAFETY DATA SHEET - MSDS

1.	**Identification of the Substance/Company**	
1.1	Trade name	: FirePro®
1.2	Manufacturer/Supplier	: FirePro Systems Ltd./Celanova Limited 6, Koumandarias & Spyrou Araouzou Str., Tonia Court II, 6ht Floor Limassol - 3076 , Cyprus Phone : 00357-25-379999 Fax : 00357-25-354432 e-mail : mail@firepro.info website : www.firepro.info
1.3	Telephone number in case of emergency: + 357-25-379999	

2.	**Composition/Information on Ingredients**				
2.1	Component	Wt.%	CAS No.	EINECS	Class, R and S phrases
	Potassium Nitrate	77	7757-79-1	231-818-8	See section 15
	Potassium Carbonate	4	584-08-7	209-529-3	See section 15
	Magnesium	<1	7439-95-4	231-104-6	See section 15
	Epoxy Resin Polymer	18	25068-38-6	any "polimerizate, polycondensate, or polyadduct" is exempted by 81/437/EEG	See section 15

3.	**Hazards Identification**	
	- Hazards for humans related to the SBK solid compound has not been found. - Hazards for humans related to the aerosol released by the solid compound have not been established because TLV's are not applicable. - Signs and symptoms related to the aerosol phase are only referred to acute exposure and/or chronic overexposures, while in real life the exposure will be very short (i.e. in the event of an accidental discharge when people were not evacuated on time).	
3.1	For humans	
	Threshold Limit Values	: None established
	Signs and Symptoms by acute exposure	
	Eye Contact	: At normal contact no injury
	Inhalation	: Not a likely route of entry
	Skin Contact	: At normal contact no injury
	Ingestion	: At normal contact no injury
	Chronic Overexposure	: At normal contact no injury
	Medical Conditions Generally Aggravated by Exposure	: None known
	For Environment	: None established

4.	**First-Aid Measures** First-Aid measures are referred to acute exposure and/or chronic over exposure	
4.1	Inhalation	: Remove from exposure area to fresh air.
	Eye Contact	: If necessary wash eyes.
	Skin Contact	: Change clothing and shoes. Wash skin with soap.
	Ingestion	: Not likely.

[redacted]

5.	**Fire fighting Measures**	
5.1	Extinguishing Media	: This is an Extinguishing Agent
5.2	Unusual Fire and Explosion Hazards	: The material does not present an explosion danger. It can be ignited by means of a fire. Hot aerosol is present in the close up area of the outlets
5.3	Special Procedures	: In places where there is a fire always wear personal protecting equipment and clothing

6.	**Accidental Release Measures**	
6.1	Personal Precautions	
	Respiratory Protection	: at normal contact not needed
	Hand Protection	: at normal contact not needed
	Eye Protection	: at normal contact not needed
	Skin and Body Protection	: at normal contact not needed
6.2	Environmental Precautions	
	Waste Disposal Methods	: See section 13
6.3	Clean up Precautions	: Sweep up

7.	**Handling and storage**	
7.1	Handling Precautions	: Avoid contact with combustible materials.
7.2	Storage Precautions	: Should be stored in original container. Keep dry.
	Storage Class	: 9 miscellaneous , solid

8.	**Exposure Controls and Personal Protection**	
8.1	Exposure	: Before entering a room with the material in aerosol phase vent properly to avoid unnecessary exposure.
8.2	Personal protection	
	Respiratory Protection	: at normal contact not needed
	Hand Protection	: at normal contact not needed
	Eye Protection	: at normal contact not needed
	Skin and Body Protection	: at normal contact not needed

9.	**Physical and Chemical Characteristics**	
9.1	Appearance	: Solid
	Colour	: Off white
	Odour	: None
	Relative Density	: Not applicable
	Solubility in water	: Insoluble
	Ph (if in water, % Conc.)	: Not determined
	Boiling Point	: Not applicable
	Vapour Pressure (mm Hg)	: Not applicable
	Vapour Density	: Not applicable
	Flash Point	: Not applicable
	Flammability Limits in Air (% by volume)	: Not applicable
	Auto Flammability	: Not applicable
	Explosive Properties	: Not applicable
	Oxidizing Properties	: Not determined

[redacted]

FIREPRO SYSTEMS LIMITED

10.	**Stability and Reactivity**	
10.1	Stability Conditions to avoid	: Stable : None known
10.2	Hazardous Reactions Conditions to avoid	: Will not occur : None known
10.3	Materials to Avoid	: None known
10.4	Hazardous Decompositions Products	: None ascertained

11.	**Toxicological Information**		
	The TLV's (Treshold Limit Values) of the chemicals released in the aerosol phase are applicable only in case of long, as long as a complete professional life, exposure. This is not the case of a real life situation.		
11.1	Product		
	The potential damage is not caused by the product mixture composition, but by the fact that it is respirable. The TLV's apply in case of long exposure, sometimes exposure during a complete professional life, whilst in this case is once only and short (in case of accidental discharge when evacuation does not take place on time).		
	In case of fire the toxicity is caused by the fire itself and the products involved in the fire.		
11.2	Components		
	Potassium Nitrate	Toxicity Target Organs	: Oral LD_{50} (rat) 3750 mg/Kg : Blood, central nervous system
	Potassium Carbonate	Toxicity Target Organs	: Oral LD_{50} (rat) 1870 mg/Kg / Oral LD_{50} (mouse) 2570 mg/Kg : Respiratory system
	Magnesium	Toxicity Target Organs	: Oral LD_{50} (dog) 230 mg/Kg : Central nervous system, liver, kidneys
	Epoxy Resin Polymer	Toxicity Irritation Data	: Oral LD_{50} (rat) 11.4 g/Kg : Skin (guinea pig) 2750 mg/55 days Inert Eye (rabbit) 100 mg Mild

12.	**Ecological Information**	
12.1	Mobility Absorption/Desorption	: with present data no problems : with present data no problems
12.2	Degradability Biotic and Abiotic Degradation Aerobic and Anaerobic Degradation Persistence	: with present data no problems : with present data no problems : with present data no problems : with present data no problems
12.3	Accumulation Bioaccumulation Potential Biomagnification	: with present data no problems : with present data no problems : with present data no problems
12.3	Short and Long Term Effects on	
	Ecotoxicity Aquatic Organisms Soil Organisms Plants and Terrestrial animals	: with present data no problems : with present data no problems : with present data no problems : with present data no problems
12.4	Other Adverse Effects	
	Ozone Depleting Potential (ODP) Photochemical Ozone Creation Potential Global Warming Potentials (GWP) Effects on Waste Water Treatment Plants	: none : none : none : with present data no problems

13.	**Disposal Considerations**
13.1	Dispose of in Compliance with local, state and national regulations.

[redacted]

14.	Transportation Information	
14.1	Hazard Class or Division	: 9 miscellaneous, solid : For additional transport information contact FirePro Systems Ltd / Celanova Limited

15.	Regulatory Information			
	For 15.1 Components: The EU classification and R&S phrases, referred to the components of the SBK compound are related only to the single components considered as separate chemical entities. Once mixed in the production of the SBK compound, the risk sentences of the single components are not applicable being the SBK compound a separate chemical entity.			
15.1	Product			
	Potassium Nitrate	EU Classification R Phrases S Phrases 	Oxidizer 8 16 41	- Contact with combustible material may cause fire Keep away from sources of ignition – No smoking In case of fire and/or explosion, do not breathe fumes
	Potassium Carbonate	EU Classification R Phrases S Phrases 	Irritant 22 36/37/38 26 37/39	- Harmful if swallowed Irritating to eyes, respiratory system and skin In case of contact with eyes, rinse immediately with plenty of water and seek medical advice Wear suitable gloves and eye/face protection
	Magnesium	EU Classification R Phrases S Phrases 	Flammable 15 17 2 43 7/8	- Contact with water liberates highly flammable gases Spontaneously flammable in air Keep out of reach of children In case of fire never use water Keep container tightly closed and dry
	Epoxy Resin Polymer	EU Classification R Phrases S Phrases 	Irritant 36/38 43 53 28 37/39 61	- Irritating to eyes and skin May cause sensitisation by skin contact May cause long-term adverse effects in the aquatic environment In case of contact with skin, rinse with water Wear suitable gloves and eye/face protection Avoid release to the environment. Refer to special instructions/ Safety Data Sheets
	Limit Values for Exposure EINECS Status Restrictions on Marketing and Use	: None listed : All components are included in EINECS inventories : None (Refer to any other national measures that may be relevant)		

[redacted]

16.	Other Information
16.1	None Known

17.	Disclaimer
17.1	The data in the above material safety data sheet reflect the current state of knowledge of our product and shall be used only as a guideline. No binding statements as to the contractually agreed product characteristics may be inferred there from.

Maritime and Coastguard Agency Certificate of Inspection and Tests

Maritime & Coastguard Agency

CERTIFICATE OF INSPECTION AND TESTS

Issued under the authority of
the Government of the United Kingdom of Great Britain and Northern Ireland,
by the Maritime and Coastguard Agency,
an Executive Agency of the Department for Transport

The Secretary of State in exercise of statutory powers is satisfied that information relating to the product below has been reviewed. Information or Sample ☐

SECTION 1. PRODUCT DETAILS

Product Name / Model	Small Boat Machinery Space FirePro Fixed Aerosol Fire Suppression System
Manufacturer Details	FirePro Systems, 6 Koumandarias Street, PO Box 54080, CY-3720 Limassol. Cyprus
	UK Distirbutor - FirePro UK Ltd
	Leigh House, Weald Road, Brentwood
	Essex
	CM14 4SX
MCA File Reference	MS 22 / 3 / 0910 [redacted]

SECTION 2. Under powers conferred by

SI 1998 No. 1609 Reg 8(1), SI 1998 No. 2771 Reg 6, SI 2001 No. 0009 Reg 7(1), SI 2002 No. 2201 Reg 5(1)

Statutory Instrument No.		No.		Act year and ch.		

and has been found satisfactory for the purposes of:- Continued ☒ (continued overleaf)

1. MGN 280 - Small Vessels in Commercial Use for Sport or Pleasure, Workboats and Pilot Boats - Alternative Construction Standards;

provided that the conditions attached to the Schedule are fulfilled and the product remains satisfactory in service.

SECTION 3. SCHEDULE including conditions or terms, if any, on which the certificate is issued:

1.0 PERFORMANCE TESTING

1.1 The FirePro aerosol system has been accepted on the basis of its satisfactory performance during a series of trials devised to simulate typical fire scenarios that can occur in the machinery space of small craft. The trials were carried out on 14th July 2005 at the Fire Test Ground, Biggin Hill Airport, Kent. The results are contained in the document:- Fire Test Report: PC/9348 - dated 8th September 2005. Certificates can be renewed on the basis of Test reports that are less than 15 years old after which re-testing will be required.

This Certificate is valid until **10 May 2021** Continued ☒ (continued overleaf)

NOTE: This certificate does not apply to a product which has been varied or modified from the product assessed. The manufacturer must submit modified products for consideration by this Agency if they wish to obtain for them a valid Certificate of Inspection and Test.

Issued at **MCA HQ (UK)** Signed [redacted]
(Signature of Authorised Official issuing the certificate)

Date **06 July 2016** Name [redacted]

MCA Maritime & Coastguard Agency Survey and Inspection
Official Stamp

SECTION 2. (Continued from Page 1) | **Date of Issue** | **06 July 2016**

2. The Codes of Practice for the Safety of Small Commercial Motor or Sailing Vessels of up to 24 metres Load Line length;

3. The Codes of Practice for the Safety of Small Workboats and Pilot Boats;

4. MSN 1813 (F) -The Fishing Vessels Code of Practice for the Safety of Small Fishing Vessels;

5. MSN 1770 (F) - The Fishing Vessels Code of Safe Working Practice for the Construction and Use of 15 metre length overall (LOA) to less than 24 metre registered length (l) Fishing Vessels; and

6. The Codes of Practice for Police Boats.

Note: The FirePro Fixed Aerosol System is considered suitable for installation in normally unoccupied spaces containing fuel having a flash point of not less than 43 degrees C (closed cup test), of vessels of less than 24 metres load line length, where the space to be protected does not exceed a deck height of 4 metres, or an area of 64 square metres.

CERTIFIED TRUE COPY OF ORIGINAL

[redacted]

mca An executive agency of the Department for Transport Maritime and Coastguard Agency

SCHEDULE including conditions or terms, if any, on which the certificate is issued (Continued from Page 1)

1.2 A series of eight tests were requested, which were combined into four fire tests, as follows:-

1.2.1 Open pool fire - diesel fuel (Test 3);
1.2.2 Hidden spray fire- diesel fuel (Test 1);
1.2.3 Hidden pool fire - lube oil (Test 1);
1.2.4 Combined open pool/hidden spray - diesel fuel (Test 3);
1.2.5 Combined open pool/hidden spray - lube oil/diesel fuel (Test 2;
1.2.6 Combined hidden pool/hidden spray - lube oil/diesel fuel (Test 3);
1.2.7 Combined open pool/hidden pool/hidden spray - diesel fuel/lube oil/diesel fuel (Test 3);
1.2.8 Wood crib (Class A fire) (Test 4)

Note: Tests 1.2.1 - 1.2.7 are for Class B fires

1.3 The tests were carried out in a combined format agreed with the MCA as follows:-

1.3.1 Fire 1: Combined hidden pool and hidden spray fire (lube oil/ diesel fuel); this test 1 - was given a 2 minute pre-burn.

1.3.2 Fire 2: Combined open pool fire, hidden pool fire and hidden spray fire (lube oil/ diesel fuel); this test 2 - was given a 2 minute pre burn.

1.3.3 Fire 3: Combined open pool fire, hidden pool fire and hidden spray fire (diesel fuel/ lube oil/ diesel fuel); this test 3 - was given a 2 minute pre burn.

1.3.4 Fire 4: Wood crib (class A fire); this test 4 -was given a 4 minute pre burn.

☑ Click here to generation an additional page

SECTION 2. (Continued from Page 1) **Date of Issue** **06 July 2016**

SCHEDULE including conditions or terms, if any, on which the certificate is issued (Continued from Page 1)

1.3.5 Metholated spirits were used as the accelerant agent for pre-ignition.

1.4 The test enclosure comprised a compartment (7850 mm long x 2280 mm wide x 2300 mm high) of a steel container, with a viewing window on one side and double doors at one end. The diesel engine mock-up was constructed of sheet steel, together with a floor plate system surrounding the mock-up to represent a bilge mock-up. A fuel tray was placed underneath the engine mock-up. A diesel fuel spray nozzle was situated at the forward end of the engine mock-up, aiming across the engine and hidden under a plate cover. A further steel tray was placed in the open area beyond the engine. In all four corners of the enclosure, small lit can fires were placed to check the distribution of the extinguishing agent.

1.5 Four FirePro Aerosol extinguishers were installed in the container to provide the appropriate level of protection. The FirePro extinguishers used were 2 x FP1200c and 2 x FP500 and were mounted just below the ceiling of the container.

1.6 The container doors remained open prior to, and during,the 2 minute and 4 minute pre-burn period to ensure that the fires were well established. As the system was designed as a total flooding system, the doors were closed immediately prior to the system activation. The system was activated with a discharge time of less than 10 seconds, the time of extinguishment was recorded via data recorders. No re-ignition occurred. All fires were extinguished with a design concentration of 82 grams per cubic metre.

1.7 The hidden pool fire - the tray was 500 mm x 1020 mm x 90 mm deep and was filled with a mixture of 5 litres diesel fuel and 5 litres of engine oil on a water base. The tray was located under the engine mock-up.

1.8 The hidden pool spray fire -fed from an oil pump connected to a 6 mm bundy tube to a 1 mm nozzle mounted to the engine mock-up and covered from above by a steel plate. The pump provided approximately 1 litre of diesel fuel per minute at 3 bar.

SCHEDULE including conditions or terms, if any, on which the certificate is issued (Continued from Page 1)

1.9 The open pool fire - the tray was 800 mm x 1200mm x 90 mm deep and was filled with 10 litres of diesel fuel on a water base. The tray was located on the floor of the container in the open area beyond the engine and bilge mock-up.

1.10 The wood crib fire - the crib was constructed of 9 pieces of kiln dried wood measuring 34 mm x 34 mm x 190 mm and placed over a steel tray. Diesel fuel was poured over the wood crib with metholated spirits to aid ignition.

2.0 PRODUCT DESCRIPTION

FirePro is a fire extinguishing aerosol system consisting of a non-pyrotechnicaerosol forming solid compound together with the non-pyrotechnic natural mineral coolant and egress chambers which are contained within a non-pressurised canister with one or two discharge outlets.

The FirePro non-pyrotechnicaerosol forming solid compand is made up mainly of potassium nitrate 77%, potassium carbonate 4%, magnesium 1% and an epoxy resin polymer18%. Once activated the SBK solid compound is turned into a rapidly expanding aerosol gas comprising of nitrogen(N2),Carbon dioxide (CO2),water vapour (H2O)and solid particles of potassium salts (K2C03).

FirePro tackles fire on a molecular level, by inhibiting the chain chemical reaction present within combustion.

The FirePro aerosol generators are available in various sizes depending on the mass of aerosol forming solid compond contained in the canister. Operation of the generator is electrical, manual and thermal automatic. The aerosol gas-like medium is close in density to air and is non-toxic, non-corrosive and non-conductive.

The FirePro aerosol forming generators consist of eight main elements:-

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[redacted]

An executive agency of the Department for Transport
mca Maritime and Coastguard Agency

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SECTION 2. (Continued from Page 1) **Date of Issue** **06 July 2016**

SCHEDULE including conditions or terms, if any, on which the certificate is issued (Continued from Page 1)

1. Canister
2. Thermal activation port
3. Electrical activation port
4. Activator
5. Non-pyrotechnic solid compound
6. Non-pyrotechnic mineral coolant
7. Egress chamber
8. Delivery nozzle

3.0 FIREPROGENERATORS

Model	Activation	Dimensions (mm)	Capacity (grams)	Gross weight (grams)	Discharge time (secs)
FP8	TH	14 x 52 dia	8	14	3-6
FP20S	TH	165 x 32 dia	20	290	3-6
FP40S	E&TH	140 x 51 dia	40	590	5-10
FP80S	E&TH	185 x 51 dia	80	820	5-10
FP100S	E&TH	120 x 84 dia	100	1270	5-10
FP200M	M	150 x 84 dia	200	1630	10-15
FP200S	E&TH	150 x 84 dia	200	1630	5-10
FP500S	E&TH	260 x 84 dia	500	2850	5-10
FP1200	E&TH	216 x 300 x 167	1200	10050	10-15
FP2000	E&TH	300 x 300 x 185	2000	14100	10-15
FP3000	E&TH	300 x 300 x 185	3000	15000	15-20
FP5700	E&TH	300 x 300 x 300	5700	23700	15-20

Where:- E = Electrical TH = Thermocord M = Manual

SCHEDULE including conditions or terms, if any, on which the certificate is issued (Continued from Page 1)

4.0 DESIGN

The FirePro fire extinguishing aerosol system is to be installed in accordance with the manufacturer's design, operating and maintenance manual: FP/MarineInstall/0305

The design of a FirePro fire extinguishing aerosol system should involve the following as a minimum:-

4.1 Identify all possible fire hazards within the engine enclosure. Refer to the manufacturer's manual for installation requirements for use with specific hazards/fuel types that may require additional quantities of agent.

4.2 Identify possible points of agent loss within the engine enclosure and adjust the quantity of agent required to compensate for the calculated loss.

4.3 Determine the volume of the engine enclosure. Identify if the required coverage extends to the full deck-head void and raised deck, and determine the protected volume as required.

4.4 Calculate the quantity of agent required for the fuel type and hazards within the engine enclosure. The minimum system design quantity for Class B fires is 82 g/m3, and the minimum for surface Class A fires is 100g/m3. Factors such as non-closeable openings, forced ventilation,low altitude, low temperature and other conditions may effect the quantity of agent required, and need to be considered when calculating the minimum system design factor.

4.5 Select the model and quantity of generators required and the method of activation.

5.0 SYSTEM ISOLATION SWITCH

In some cases, it will be a requirement for the discharge of a FirePro aerosol generator to be prevented by means of an isolationswitch, or other means, that shall be manuallyoperated when personnel are present within the protected engine

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enclosure,or adjacent areas, which could be rendered hazardous by the discharge of the system.

The system isolation switch shall be situated outside the protected area close to the system control panel, or adjacent to the main entrance to the engine enclosure,and protected for accidental operation.

While the system isolation switch is active, and the discharge of the system is inhibited, the fire detection and alarm system shall continue to function and the system shall return to manual control when the switch is reactivated.

The operation of the system isolation switch shall electrically isolate and earth each conductor of the wiring to the extinguishant discharge device and initiate a visual fault indicator at the system control panel.

The system isolation switch shall be used when there is a possibilityof people entering the protected enclosure for whatever reason.

6.0 CONTROL PANELS

6.1 FPX103C control panel manufactured by Logician Ltd -Basic panel for use with automatic and manual activation of up to four FirePro aerosol generators within the engine or machinery enclosure. Installation and user manual, FPX103CIInstalV0305

6.2 FPX104C control panel manufactured by Logician Ltd -Panel providing fire detection and manual activation of up to four FirePro aerosol generators within the engine or machinery enclosure. Installation and user manual, FPX104CIInstall/0305

SCHEDULE including conditions or terms, if any, on which the certificate is issued (Continued from Page 1)

7.0 SYSTEM MAINTENANCE

The user should carry out monthly inspections of the FirePro aerosol generator system installed. This should include looking out for obstructions of the discharge nozzles,extension/alteration of the protected enclosure, openings left unclosed that were not catered for during the design, and that the position and orientation of the FirePro aerosol generators remain in their installed position.

8.0 SERVICE LIFE

The FirePro aerosol generators have a service life and should be renewed in accordance with the manufacturer's recommendations.

9.0 IN ADDITION TO THE GENERAL SYSTEM APPROVAL DESCRIBEDABOVE, THE FOLLOWING CONDITIONS ARE TO BE COMPLIED WITH:-

9.1 Plans for each intended system, together with details of components used and test certificates, are to be submitted to the Maritime and Coastguard Agency prior to installation and survey on the vessel.

9.2 The installation is to be to the satisfaction of the attending surveyor. Certificates of commissioning and acceptance testing are to be submitted on completion.

9.3 Clear and legible instructions for installation,maintenance, testing and operation, and applicable to the specific system fitted on the vessel, are to be provided onboard.

9.4 Clear and legible safety labels shall be placed at the entrance to the protected enclosure, inside the protected enclosure, at the system isolate switch and the manual release point. Also simple operating instructions are to be

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placed at the system operating position.

9.5 Means are to be provided to close all openings,which may admit air in to the protected enclosure.

9.6 A normally unoccupied area is an area that is not occupied by humans under normal circumstances but may be' entered occasionally for brief periods. Whenever the space is entered then the isolation method is to be used to de-activate the generators within the protected enclosure.

SCHEDULE including conditions or terms, if any, on which the certificate is issued (Continued from Page 1)

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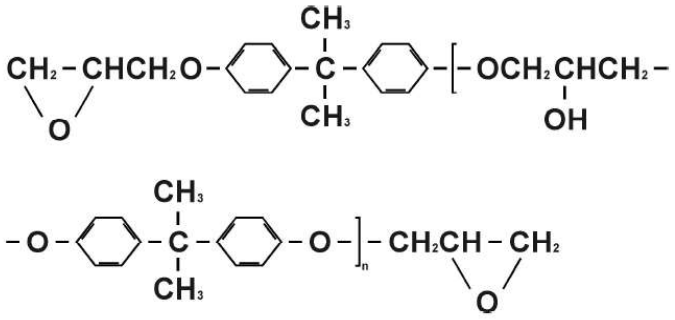
Annex D

Health and Safety Executive Incident Report Section 8 Appendix

8 APPENDIX: CHEMISTRY OF AEROSOL GENERATION

The structure of the epoxy resin used in the pyrotechnic composition is shown below. The elemental composition is dominated by the bracketed repeating unit $C_{18}H_{20}O_4$.



The stoichiometric reaction of this compound with potassium nitrate to form the products of full combustion CO_2, N_2, K_2CO_3 and water can be written

$$84\ KNO_3 + 5\ C_{18}H_{20}O_4 \longrightarrow 42\ K_2CO_3 + 48\ CO_2 + 50\ H_2O + 42\ N_2$$

The molecular masses of the nitrate and epoxy are 101 and 300 respectively, so full balanced combustion requires 84.2% potassium nitrate (by mass) and 15.8% epoxy.

The composition (percentage by mass) of the pyrotechnic used for FirePro is 77 % KNO_3, 18 % epoxy, 4% K_2CO_3 and up to 1% magnesium.

Potassium carbonate in the original mixture is simply expelled from the device without chemical reaction. The effective composition can be adjusted to eliminate this by multiplying mass fractions of the other components by a factor of 1/0.96. Magnesium is a fuel and will require input of nitrate but the KEMA results suggest levels may in fact be negligibly low. Adjusting the composition to neglect magnesium can be done by multiplying by a further factor of 1/0.99. Overall this gives an effective composition (by mass) of 81.0 % KNO_3 and 19.0% epoxy.

Comparing with the stoichiometry required for complete combustion shows that the composition is significantly fuel rich. The stoichiometric ratio is actual air to fuel ratio divided by that needed for full combustion. In this case the stoichiometric ratio is

$$\frac{81/19}{84.2/15.8} = 0.8$$

Some idea of the potential impact on combustion properties can be gained from the data in Figure 2 that shows the typical variation of CO production from gas boilers as the stoichiometric ratio falls below 1 and they become under-ventilated. Any significant reduction in the stoichiometric ratio below 1 risks very rapid increase in CO production.

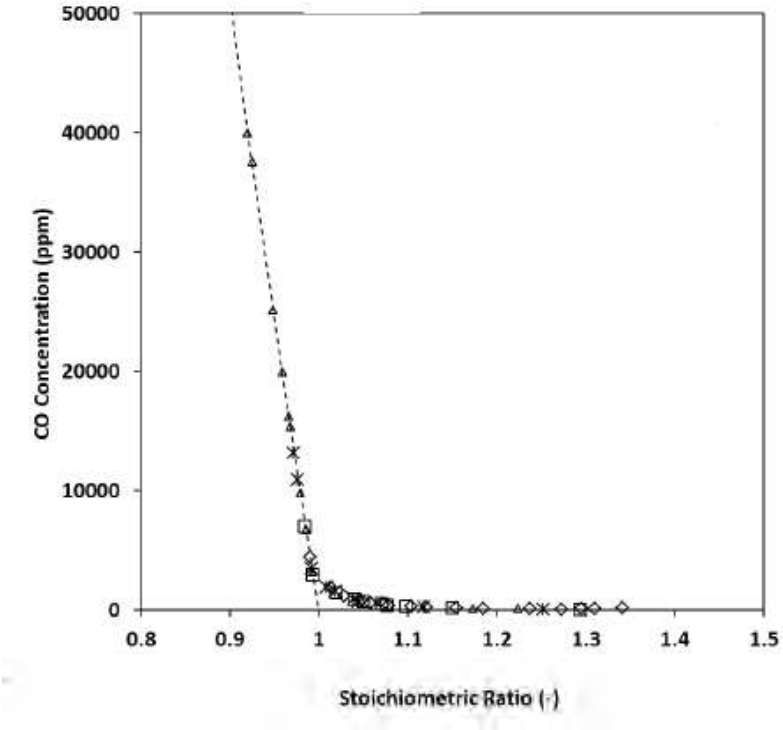


Figure 2: CO production from boiler combustion at stoichiometric ratios below 1.

8.1 COMBUSTION PRODUCT ESTIMATION

The actual reaction of the effective composition can be written (in molar terms) as

$$0.9268\ KNO_3 + 0.0732\ C_{18}H_{20}O_4 \longrightarrow 0.4634\ K_2CO_3 + 0.4634\ N_2 + a\ H_2O + b\ H_2 + c\ CO_2 + d\ CO$$

The molar fractions of the different product fractions a, b, c and d can be determined at a given final temperature from three equations of mass conservation (for hydrogen, carbon and oxygen) and the equilibrium constant for the water gas shift reaction at that temperature.

Carbon balance: $1.317 = 0.4634 + c + d$

Hydrogen balance: $1.464 = 2a + 2b$

Oxygen balance: $2.78 + 0.2928 = 1.390 + a + 2c + d$

Water gas shift equilibrium constant[7] : $\frac{bc}{ad} = 10^{(-2.4198+.0003855.T+2180.6/T)}$

Figures 3 to 6 show the solutions of these equations at a range of product temperatures.

[7] https://web.wpi.edu/Pubs/ETD/Available/etd-050406-023806/unrestricted/ccallaghan.pdf

[redacted]

Figure 3 shows the molar fractions and Figure 4 shows the mass yields of different products as a proportion of the amount of potassium nitrate in the device. Figure 5 shows the volume fraction of CO in the undiluted suppressant stream.

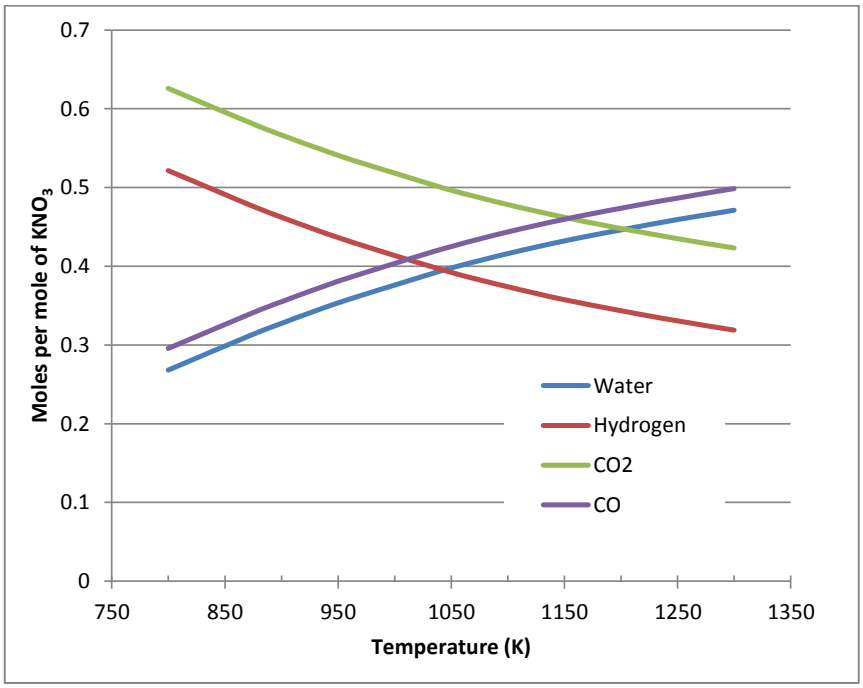


Figure 3: Mole fractions of products

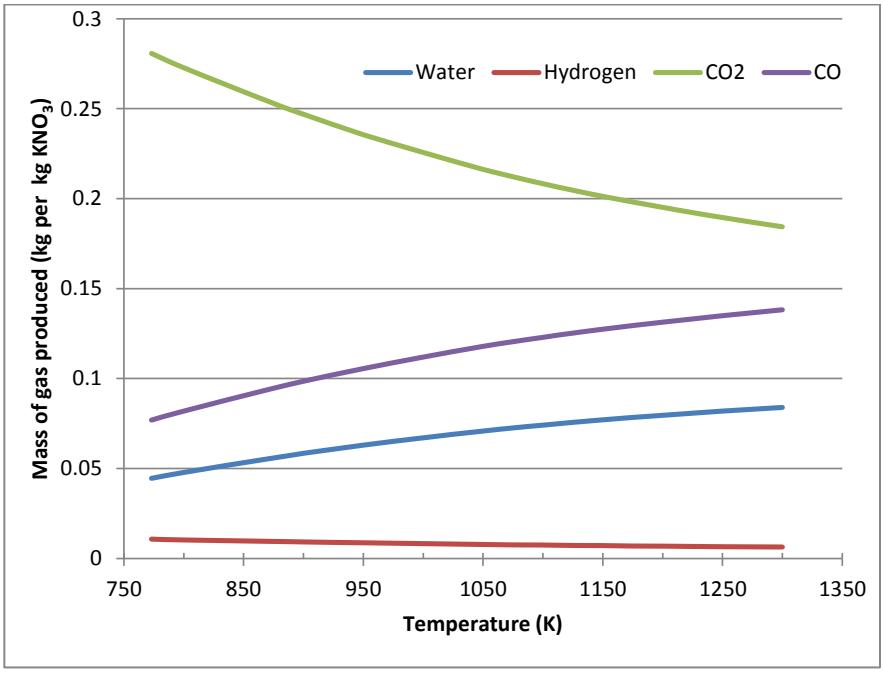


Figure 4: Mass fractions of products

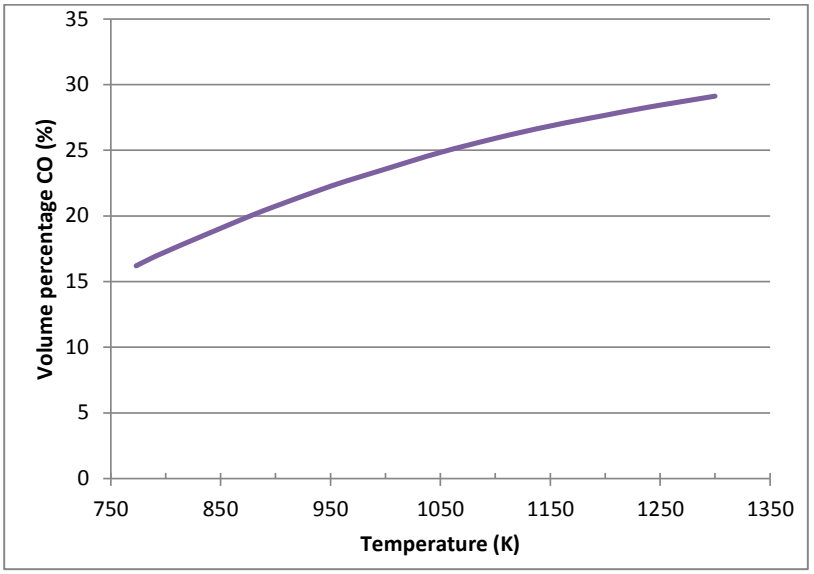


Figure 5: Volume fraction of CO in the undiluted stream. Note 20% = 200,000 ppm

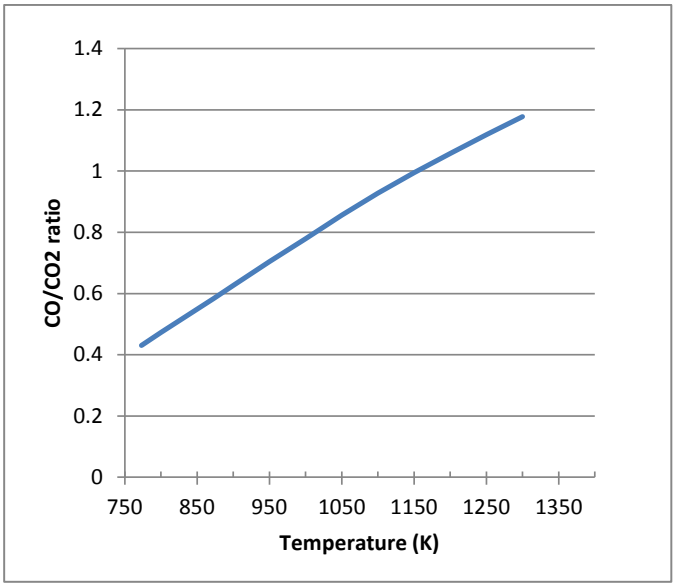


Figure 6: CO/CO2 molar ratio

The question of what product temperature is appropriate depends on the rate of cooling, because the reaction is severely kinetically limited at low temperature.

To illustrate this point, the water gas shift reaction CO + H_2O -> H_2 + CO_2 is increasingly thermodynamically favoured at low temperatures. But when carried out industrially, the reaction temperature has to be raised to about 500-550 °C to make it progress at a reasonable rate.

It is unlikely that significant CO conversion continues in the Fire Pro device after the temperature drops to 500°C (773K). In all probability CO conversion will freeze out higher temperatures.

[redacted]

Overall the analysis of combustion products suggests a yield of CO of between 0.08 and 0.13 kg per kg of potassium nitrate (Figure 4) or between 0.06 and 0.1 kg per kg of pyrotechnic mix .

The CO concentration in the undiluted suppressant stream close to the outlet would be 160,000 to 290,000 ppm (Figure 5).

For the quoted composition (effective epoxy mole fraction 7.32%) the CO/CO2 molar (or volume) ratio would be between 0.42 and 1.15.

All of these decomposition product yields are very sensitive to the composition of the pyrotechnic. For example Figure 7 illustrates how CO/CO2 ratios fall sharply as the epoxy fraction falls towards the stoichiometric ratio (4.8% Epoxy).

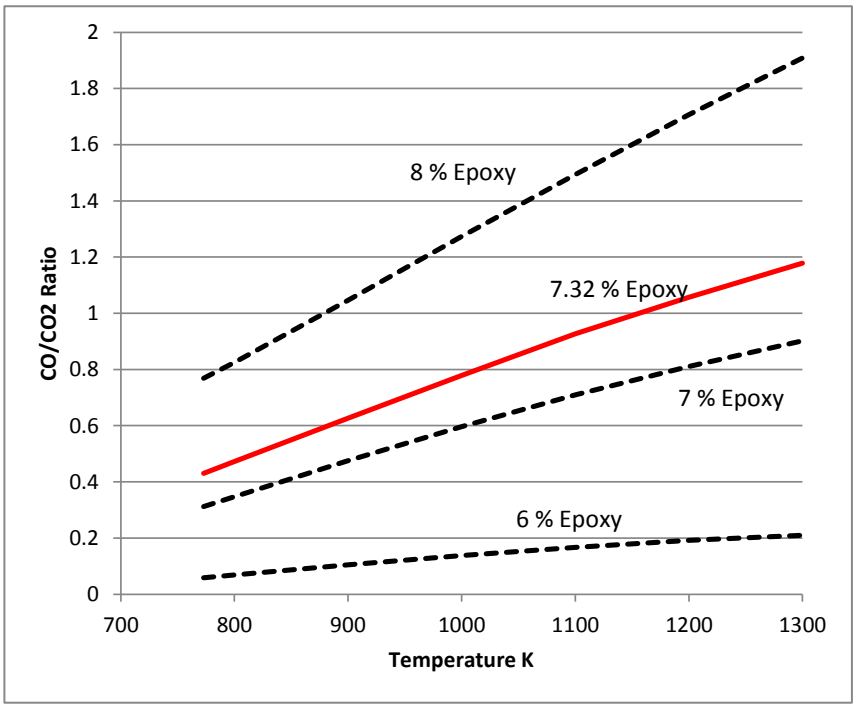


Figure 7: CO/CO2 ratios as a function of effective epoxy (mole) fraction.
The red line shows the composition quoted in the FirePro MSDS

If strict quality control is not maintained on the pyrotechnic composition in different batches then significant variations in CO yield are to be expected.

MAIB Safety Bulletin 1/2020

MAIB
MARINE ACCIDENT INVESTIGATION BRANCH

SAFETY BULLETIN

SB1/2020 MARCH 2020

Extracts from The United Kingdom Merchant Shipping (Accident Reporting and Investigation) Regulations 2012 Regulation 5:
"The sole objective of a safety investigation into an accident under these Regulations shall be the prevention of future accidents through the ascertainment of its causes and circumstances. It shall not be the purpose of such an investigation to determine liability nor, except so far as is necessary to achieve its objective, to apportion blame."

Regulation 16(1):
"The Chief Inspector may at any time make recommendations as to how future accidents may be prevented."

Press Enquiries:
01932 440015

Out of hours:
020 7944 4292

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0300 330 3000

NOTE
This bulletin is not written with litigation in mind and, pursuant to Regulation 14(14) of the Merchant Shipping (Accident Reporting and Investigation) Regulations 2012, shall be inadmissible in any judicial proceedings whose purpose, or one of whose purposes is to attribute or apportion liability or blame.

All bulletins can be found on our website:
https://www.gov.uk/maib

For all enquiries:
Email: maib@dft.gov.uk
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Inadvertent discharge of a FirePro condensed aerosol fire extinguishing system during its installation on board the fishing vessel *Resurgam* (PZ 1001) on 15 November 2019 resulting in one fatality

Image courtesy of www.marinetraffic.com

Resurgam

MAIB SAFETY BULLETIN 1/2020

This document, containing safety lessons, has been produced for marine safety purposes only, on the basis of information available to date.

The Merchant Shipping (Accident Reporting and Investigation) Regulations 2012 provides for the Chief Inspector of Marine Accidents to make recommendations or to issue safety lessons at any time during the course of an investigation if, in his opinion, it is necessary or desirable to do so.

The Marine Accident Investigation Branch is carrying out an investigation into the fatality of a shore-based engineering apprentice who was working in the engine room of the fishing vessel *Resurgam* in Newlyn on 15 November 2019.

The MAIB will publish a full report on completion of the investigation.

Andrew Moll
Chief Inspector of Marine Accidents

This bulletin is also available on our website: www.gov.uk/maib
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BACKGROUND

On 15 November 2019, the UK registered fishing vessel *Resurgam* was in Newlyn, England undergoing maintenance. An engineer and an apprentice from the owner's shore-based support team were working on the main engine in the engine room. Also working in the engine room were two contractors installing a new FirePro condensed aerosol fire extinguishing system.

During the installation and without warning, the fire extinguishing system partially and inadvertently discharged, filling the engine room with a dense cloud of aerosol fire suppressing particles **(Figure 1)**. Both installation contractors and the company's engineer managed to evacuate, but the apprentice collapsed in the engine room. He was later recovered by the local fire and rescue service but was found not breathing and could not be resuscitated.

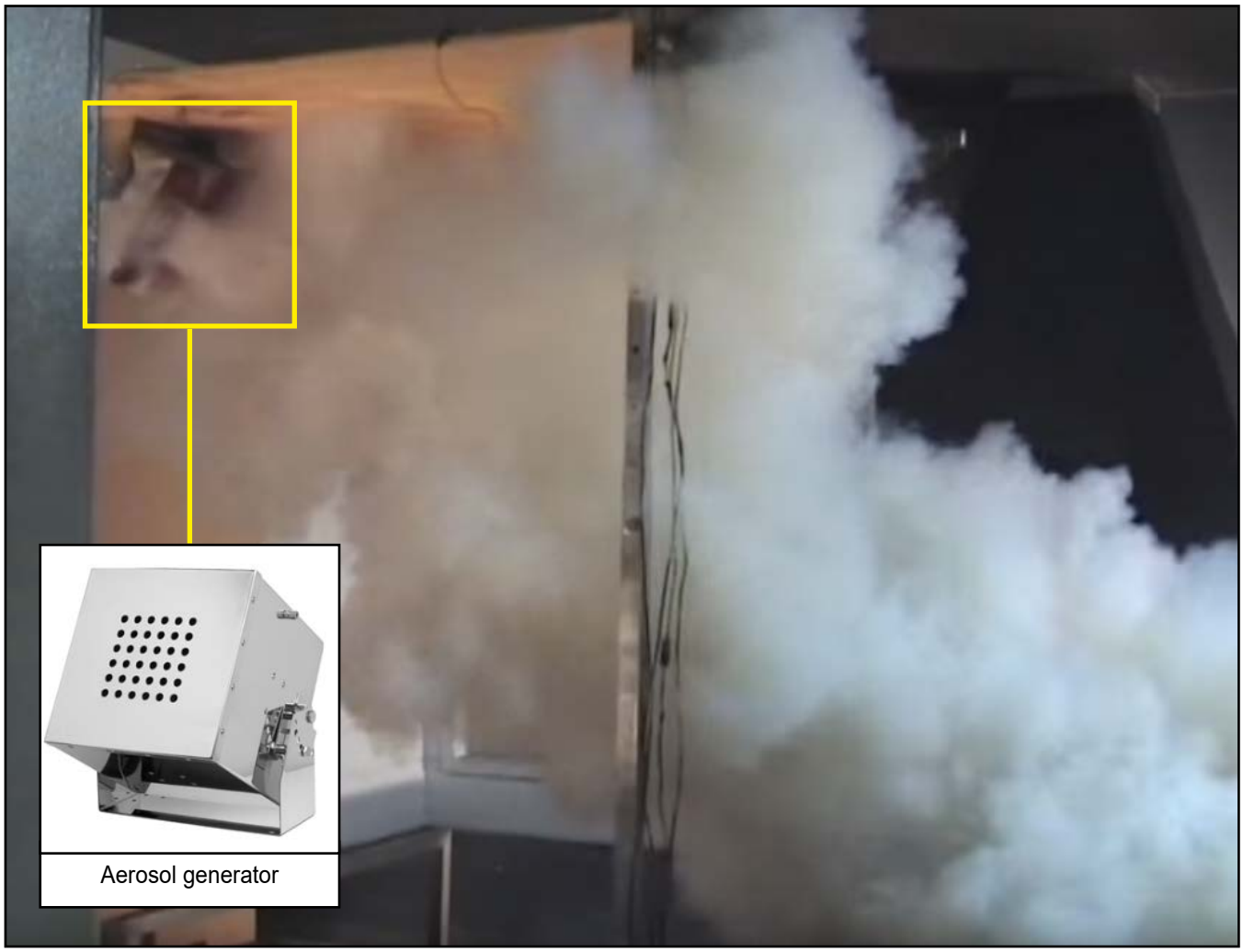


Figure 1: Typical discharge of a condensed aerosol fire suppressant
(not at time of accident)

INITIAL FINDING

The exact causes and circumstances of this accident are still being investigated and the findings will be published by the MAIB in a full investigation report. However, during the inadvertent discharge, it is evident that the apprentice inhaled a high concentration of the suppressant particles and this significantly contributed to the fatality.

FirePro's Installation and User Manual and its product's material safety data sheets had recognised the inadvertent discharge of the system, particularly during installation and maintenance, as a hazard. However, the loss of life was not identified as a potential outcome; therefore, the risk associated with inhaling or ingesting a large volume of the suppressant particles was not fully appreciated or protected against.

SAFETY LESSONS

Vessel owners, operators and those contracted to install FirePro and other similar condensed aerosol fire extinguishing systems should be fully aware of the potential risk to life from exposure to the aerosol particles.

Safety precautions should be put in place to ensure that personnel are not exposed to this hazard:

- Prior to intentional discharge of a condensed aerosol system, there should be visible and audible alarms to alert personnel. Checks should also be made to ensure the protected compartment has been evacuated before the system is activated.
- When condensed aerosol fire extinguishing systems are being installed or maintained the system should be fully isolated to guard against inadvertent activation, non-essential personnel should be clear of the area and an enclosed space rescue plan should be in place.

RECOMMENDATION

FirePro is recommended to:

S2020/114 Issue a safety alert to the owner/operators of vessels fitted with its systems and its network of marine installation/maintenance engineers highlighting the circumstances of this accident and advising them of appropriate measures to take to reduce the risk of exposure to fire suppressant particles.

MAIB safety flyer to the fishing industry

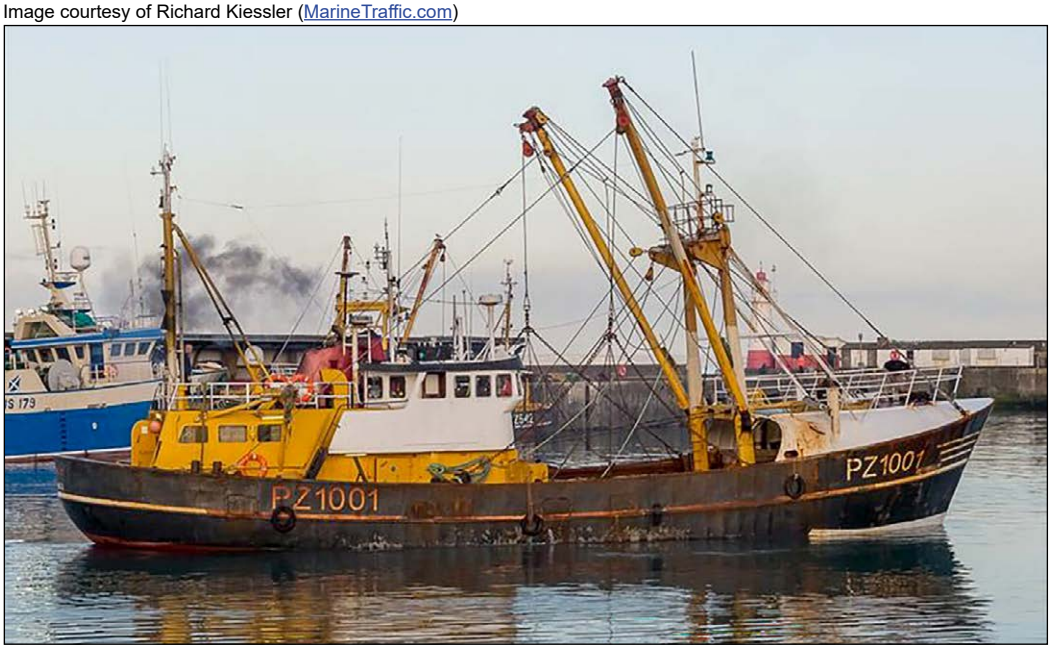
MAIB

MARINE ACCIDENT INVESTIGATION BRANCH

SAFETY FLYER TO THE FISHING INDUSTRY

Inadvertent discharge of a condensed aerosol fire-extinguishing system on board the fishing vessel *Resurgam* (PZ1001) on 15 November 2019

Image courtesy of Richard Kiessler (MarineTraffic.com)



Resurgam

Narrative

At 1609 on 15 November 2019, an apprentice engineer died when a FirePro condensed aerosol fire-extinguishing system was inadvertently activated in the engine room of the fishing vessel *Resurgam*. The apprentice engineer together with a shore engineer and two installation technicians were working in the engine room when the system activated, filling the engine room with the fire-extinguishing aerosol.

All four people attempted to escape the engine room's rapidly deteriorating atmosphere by climbing up an access ladder, which was the only exit. Three people escaped to the open deck but the apprentice engineer succumbed to the effect of condensed aerosol inhalation and collapsed at the foot of the ladder. The escape route for all four people passed in close proximity to a discharging fire-extinguishing generator. The apprentice engineer was later rescued by fire and rescue service personnel wearing breathing apparatus, but he could not be resuscitated and was pronounced dead at the scene.

At the time of the accident, *Resurgam* was undergoing a maintenance period and the skipper and crew were not on board. As the fishing vessel was non-operational and the work was being carried out by contractors, not under the control of the skipper or crew, the Health and Safety at Work etc. Act 1974 was applicable for all work activities on board.

Safety lessons

1. Any gaseous or particulate fire-extinguishing medium is hazardous to health when inhaled in significant quantities. The apprentice engineer died because he inhaled a concentrated mixture of hot particles and carbon monoxide and collapsed in a reduced oxygen atmosphere. Skippers of fishing vessels are to ensure that both they and their crew are aware of the hazards of exposure to fixed firefighting system media.

2. In the event that installation or maintenance of a fixed firefighting system is being undertaken, work in the area protected by the fixed firefighting system should be restricted to the people carrying out the work.

3. Fishing vessel crew do not usually consider an engine compartment an enclosed space. However, an engine space can become an enclosed space under the new regulations on enclosed spaces, *MGN 659 (M+F) Amendment 1 The Merchant Shipping and Fishing Vessels (Entry into Enclosed Spaces) Regulations 2022*[1], which came into force in May 2022 and applied to fishing vessels from May 2023.

4. The atmosphere in an engine space can rapidly change from a safe to a hazardous atmosphere for a number of reasons, including fumes emanating from hot work being carried out, leaking fluids and smoke emissions from overheating or smouldering machinery. In this case the inadvertent activation of a fire-extinguishing system adversely affected the breathable atmosphere and was harmful to anyone working in the engine room at the time. Make sure plans and procedures are in place so crew and contractors know how to react to such a situation.

5. The person in charge of the work in the engine space is responsible for ensuring that appropriate risk mitigation measures are taken before the work starts. This includes the completion of risk assessments and a detailed plan of the work, and identification of any conflicts with other tasks. As above, personnel working in the engine space need to know how to respond in an emergency.

[1] https://www.gov.uk/government/publications/mgn-659-mf-entry-into-enclosed-spaces

Attention is also drawn to the lessons published in MAIB's safety bulletin SB1/2020:

https://www.gov.uk/maib-reports/safety-warning-after-inadvertent-activation-of-condensed-aerosol-fire-extinguishing-system-leads-to-a-fatality

This flyer and the MAIB's investigation report are posted on our website: www.gov.uk/maib

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Published: December 2023

Extract from The United Kingdom Merchant Shipping (Accident Reporting and Investigation) Regulations 2012 – Regulation 5:

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NOTE

This safety flyer is not written with litigation in mind and, pursuant to Regulation 14(14) of the Merchant Shipping (Accident Reporting and Investigation) Regulations 2012, shall be inadmissible in any judicial proceedings whose purpose, or one of whose purposes is to attribute or apportion liability or blame.