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ENVIRONMENTAL VIBRATION TESTING of shipboard equipment

Applicable Standard – Reference **MIL-STD-167-1A** Mechanical Vibrations of Shipboard Equipment (Type 1 – Environmental). Tests conducted Sep 2021.

Exploratory vibration test	
Frequencies Range (Hz)	4 - 33
Amplitude (mm)	0,254 ±0,051
Frequency intervals (Hz)	1
Time of each frequency (s)	15
Variable frequency test	
Frequencies Range (Hz)	4 - 33
Amplitude (mm) for frequencies between 4 - 15 Hz	0,762 ±0,152
Amplitude (mm) for frequencies between 16 - 25 Hz	0,508 ±0,101
Amplitude (mm) for frequencies between 26 - 33 Hz	0,254 ±0,051
Frequency intervals (Hz)	1
Time of each frequency (s)	5
Endurance test	
Amplitude (mm) for selected test frequencies between 4 and 15 Hz	0,762 ±0,152
Amplitude (mm) for selected test frequencies between 16 and 25 Hz	0,508 ±0,101
Amplitude (mm) for selected test frequencies between 26 and 33 Hz	0,254 ±0,051
Frequency time (hours) if only one test frequency is selected	2
Time at each frequency (hours) in the case of the selection of two test frequencies	1
Time at each frequency (mins) in the case of the selection of three test frequencies	40

The above tests were performed in the vertical, transversal and longitudinal axes.

SHOCK TEST– UNDEX Underwater Explosion

The UNDEX test aims to assess the Aerosol Generator's ability to withstand a shock resulting from a submarine explosion without contact with the ship, when installed on board the engine room.

Applicable Standard

STANAG 4370 AECTP 400, method 403 – Environmental Testing - Classical waveform Shock

MIL-STD-810G, method 516.6 Department of Defense Test method Standard

BR 3021, Shock Manual

MIL-S-901D, Military Specification shock Tests - High Impact for shipboard equipment.

Shock test parameters						
Vertical (up)		Transversal (both directions)		Longitudinal (both directions)		No. Pulses for each direction
a (g)	Δt (ms)	a (g)	Δt (ms)	a (g)	Δt (ms)	
76	7	38	7	38	7	3

"a" is the maximum dynamic acceleration of the pulse (g)

Δt is the pulse duration time (ms)

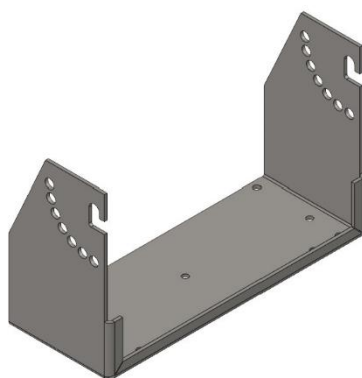
Approval parameters:

1. Visual Inspection - cracks, breakages, etc.
2. Functional test - Discharge of the Aerosol Generator by manual activation.

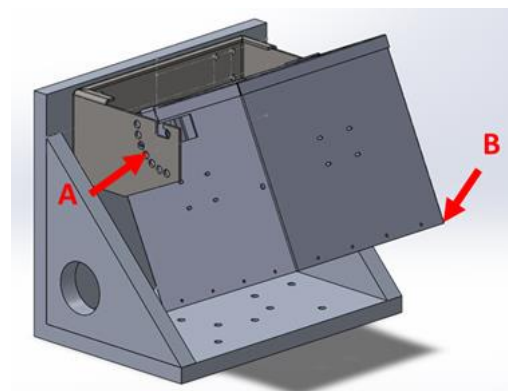
Tested unit characteristics:

- FP-5700S
- Reinforced bracket
- Nylon locknuts for the bracket screws
- Screws "A" locked with LOCTITE 241

Heavy Duty Bracket



HD Bracket was used for these tests



Results:

The tested set (FP-5700S + bracket) passed all vibration and shock tests without suffering any structural damage.

The set did not present resonance in the tested frequency ranges (from 4 to 33 Hz).

There were no structural failures in the shock test (76g).

The maximum dynamic acceleration at point "B" reached 293g.

At the end of all tests, we activated the FP-5700S, without any anomaly.

CERTIFICATION – Safety Integrity Level (TUV)

FirePro Condensed Aerosol Fire Extinguishing Units have been assessed and was found to meet the standards defined requirements of details in the table T-2006-SIL-156 according to IEC EN 61508:2010 Part 1 and 2.

CERTIFICATION - UL (Underwriters Laboratory)

FirePro Condensed Aerosol Fire Extinguishing Units have been certified under UL2775 which is the Joint Canadian and United States Standard. This requires a number of tests to be performed to achieve certification.

Clause 23	General
Clause 21	Discharge Test
Clause 22	Temperature Measurement Test
Clause 23	Mounting Device Test
Clause 24	Rough Usage Test
Clause 25	Vibration Test
Clause 26	Pyrotechnic Reaction Containment Test
Clause 27	Fire Exposure Test
Clause 28	High Humidity Test
Clause 29	Moist Hydrogen Sulfide Air Mixture Corrosion Test
Clause 30	Moist Carbon Dioxide-Sulfur Dioxide Air Mixture Corrosion Test
Clause 31	Salt Spray Corrosion Test
Clause 32	Thirty-Day Elevated Temperature Test
Clause 33	Temperature Cycling Test
Clause 34	One-Year Time Leakage Test



This is an extract from the standard for the **Rough Usage** and the **Vibration test** requirements.

24 **Rough Usage Test**

- 24.1 After being weighed and dropped onto a concrete surface, aerosol generator samples representative of each size and design of extinguishing system unit and automatic extinguisher unit shall:
- Operate as intended;
 - Have a discharge time within ± 20 percent or within ± 5 s (whichever is greater) of the average discharge time determined at $21 \pm 4^\circ\text{C}$ in the Discharge Test, Section 21; and
 - Have an agent discharge quantity at least 90 percent of the average agent discharge quantity determined at $21 \pm 4^\circ\text{C}$ in the Discharge Test, Section 21.
- 24.2 Each sample shall be weighed and dropped from a height of 915 ± 15 mm as measured from the concrete surface to the bottommost part of the unit. Each sample is to be positioned to impact on the weakest point with the orientation of the unit dependent on its design. For the first test, each sample is to be held in the vertical position and dropped. For the second test, each sample is to be held in the horizontal position and dropped. After dropping, each aerosol generator sample shall be conditioned to $21 \pm 4^\circ\text{C}$ and discharged as described in 21.3

25 **Vibration Test**

- 25.1 After vibration, each generator samples representative of each size and design of extinguishing system unit shall:
- Operate as intended;
 - Not cause a risk of injury to persons;
 - Not experience physical deterioration or malfunction of components to the extent that requires replacement;

- d) Have a discharge time within ± 20 percent or within ± 5 s (whichever is greater) of the average discharge time determined at $21 \pm 4^\circ\text{C}$ in the Discharge Test, Section 21; and
- e) Have an agent discharge quantity of at least 90 percent of the average discharge quantity determined at $21 \pm 4^\circ\text{C}$ in the Discharge Test, Section 21

Aerosol generators of automatic extinguisher units shall be evaluated with the intended thermal actuating mechanism. After vibration, each aerosol generator sample shall be conditioned to $21 \pm 4^\circ\text{C}$ ($70 \pm 7^\circ\text{F}$) and discharged as described in 21.

- 25.2 Physical deterioration of components that requires repair or replacement of the aerosol generator or attached components before they are able to be returned to service does not comply with this requirement.
- 25.3 Each sample is to be mounted in its bracket or a test fixture and secured to the vibration-test apparatus in an orientation simulating intended installation.
- 25.4 Following securement, each sample is to be subjected to variable frequency and endurance vibration tests in each of the three rectilinear orientation axes: horizontal, lateral, and vertical. Both variable frequency and endurance are to be completed in one plane of vibration before the sample is tested in another plane. For variable frequency, each sample is to be vibrated at the table displacement indicated in Table 25.1 with frequencies from 10 to 60 hertz in discrete intervals of 2 hertz and maintained at each frequency for 5 min. For endurance each sample is to be vibrated for 2 h at the frequency and corresponding table displacement that produced maximum resonance as determined during variable frequency or, when no resonance is observed during variable frequency, at a frequency of 60 hertz and table displacement of 0.51 ± 0.05 mm.

Table 25.1 Vibration -test apparatus settings		
Frequency of vibration, Hertz	Table displacement - mm	Amplitude - mm
10-19	1.52 ± 0.15	0.76 ± 0.08
20-39	1.0 ± 0.1	0.51 ± 0.05
40-60	0.51 ± 0.05	0.25 ± 0.03

- 25.5 For these tests, amplitude is the maximum displacement of sinusoidal motion from position of rest or one-half of the total table displacement. Resonance is the maximum magnification of the applied vibration

UL Certification does not disclose results of each of the performance tests. The certification requires that all tests all passed.

Case Study – SPENO RAIL



Location: Australia Application: Track Maintenance Industry: Mining



SPENO INTERNATIONAL SA

SPENO RAIL MAINTENANCE AUSTRALIA Pty. Ltd specialising in rail maintenance, technology, diagnostics and rectification.

These machines are designed and built in Western Australia. This company is accredited by BVQI, complying with ISO9001. In addition, we have 'Rail Access Agreements' with each client. These agreements require us to maintain and operate according to strict Railway Regulations and Rail Safety Acts.



Risks Involved & Consequences

A fire from a hydraulic drive and/or a high pressure hose or electrical source can rapidly destroy all equipment. On heavy equipment which must cope with difficult working conditions, these risks become exaggerated. Fire systems are required to protect and reduce collateral damage across all equipment.

The Task

Design and install a fire suppression system that will protect the engine bay and hydraulic compartments of the track maintenance machines. The enclosures have diverse fire risks and therefore, the technology needed to be effective against multiple classes of fire. It should also require as little maintenance as possible and be in line with Australian Standards, Health & Safety and protection of the Environment (HSE) strategy. Also, the systems needed to monitor and protect the enclosures from various fire scenarios.



Why FirePro ?

Firstly, the FPC Compound found inside the FirePro generators is effective against various classes of fire (A, B, E). Secondly, the compactness and modularity of the system allows fire engineers to customise the design and efficiency according to project mission and space requirements. The size of the FirePro units allows for the units to fit within the tight space requirements of the machine. Furthermore, the FPC poses no active threat to operators and will remain environmentally friendly even after activation which is in line with environmental policy. As a final point, the generators have a 15-year lifetime cycle and no re-filling requirements thus lower maintenance.

Results & Implementation

Detection and extinguishing systems were installed to engine bay and hydraulic compartment of the machine. Looming fires are detected and extinguished while alarms notify the operator and other personnel of the fire hazard. The systems can be easily reached providing a convenient maintenance process. More importantly, there are no Health and Safety issues of concern in regards to the units. Additionally, **FirePro's** FPC compound 15-year life span and low system maintenance maximises ownership benefits and value for the company.



Case Study – SEOUL METRO TRACK MAINTENANCE



Location: Asia Representative: FirePro Korea Application: Rolling Stock Industry: Transportation



서울교통공사
Seoul Metro

The **Seoul Metro Subway** is a railway system located in northwest South Korea. It serves Seoul, Incheon and Suwon plus satellite cities and provinces that lie fairly far from the capital. Seoul Metro is one of the largest and most efficient urban railway systems in the world with over 300 km of track with 3,550 of trains and premium services such as wireless internet and platform screen doors on most stations.

The Task

Design, supply, install and maintain a highly reliable fire suppression system for the high-pressure watercart locomotive engine bay. Since this is a high dependency asset the fire protection specialists needed to endorse that the system works as intended. A series of tests demonstrated that the system remains consistently reliable under stress and supplementary challenges. Engine room monitoring cams recorded and attested to (remove to) the activation, efficiency and robustness of the system employed on this unique vehicle.

FirePro Systems Used
FP-5700

Why FirePro?

FirePro fire protection systems can be integrated with existing control systems, enabling real-time system status feedback. The overall system arrangement has minimal space and maintenance requirements as well as an unmatched 15-year certified product life. These attributes are quite important since everyday operations can damage or even destroy many system components during its useful lifetime. What's more, the extinguishing compound is environmental friendly – a fact that experts around globe are saluting. Consequently, the engineers tested, approved and recommended FirePro as an applicable fire suppression system.

Risks Involved & Consequences

Slippery rail occurs when leaves or fine dust on the rail cause trains to experience low adhesion. The subsequent low wheel grip renders the track provisionally inoperable. Seoul Metro remedies this condition with a special cart that jet blasts impurities away with water. The high-pressure watercart needs to be fully operable at all times in order to keep Seoul Metro safe. This entails that its engine and vital systems must be protected from fire that might render the vehicle utterly inoperable.



FirePro.

Results & Implementation

FirePro Korea supplied and installed the proprietary technology for the fire suppression system as per project specifications. FirePro Korea designed the system and carried out the installation within a set period of time. The system currently protects the engine when activated by the driver. In fact it was able to extinguish a fire that occurred within the engine compartment soon after the installation; consequently reducing engine damage and down-time.

