Discrepancies between standards for marine and land based fixed gaseous fire extinguishing systems
1. **SCOPE** .......................................................................................................................... 3  
2. **CONTAINER CONTENTS VERIFICATION** ..................................................................... 3  
3. **CONTAINER PERIODIC TESTING** ................................................................................. 4  
4. **FLEXIBLE HOSES** ........................................................................................................ 6  
5. **BLEED VALVES** ............................................................................................................. 6  
6. **PIPELINE PRESSURE SWITCHES** .................................................................................. 6  
7. **ODORIZERS** .................................................................................................................... 7  
8. **SELECTOR/ISOLATION VALVE FUNCTIONAL TEST** .................................................. 7  
9. **ENCLOSURE INTEGRITY** ............................................................................................... 7  
10. **SERVICE PROVIDER COMPETENCY** .......................................................................... 8
1. SCOPE

The findings of MAIB report no 16/2018 highlighted that there were some significant differences between the use and servicing of Marine CO$_2$ fixed gaseous fire extinguishing systems and essentially similar land based systems.

There have also been changes in the safety requirements for land based CO$_2$ systems, and changes to the periodic testing of containers, which had not been replicated for Marine systems.

The purpose of this Guidance Document is to highlight where the requirements for Marine systems may have fallen behind those of land based systems, or where there may be scope for improvement, on the grounds of increasing safety.

2. CONTAINER CONTENTS VERIFICATION

Regular verification of the container contents is important to ensure that the required quantity of agent remains in the containers and confirm that they are free from any leakage.

For high pressure CO$_2$ systems, both MSIS 12 and MSC Circ. 1318 state that contents should be verified at least every 24 months or during each renewal survey.

Land based CO$_2$ standards such as NFPA 12 and BS 5306-4 both recommend that these containers should be verified for their contents at least every 6 months.

Verification of contents in other liquefied and inert gas clean agent containers are not covered under MSIS 12 and MSC Circ. 1318. It can be recommended that these follow land based clean agent system standards such as NFPA 2001, EN 15004 and ISO 14520 which recommend such containers to also be verified for their contents at least every 6 months.

Contents verification for CO$_2$ containers can be performed by:

- Weighing.
- Ultrasonic liquid level measurement.
- Heat sensitive strip liquid level indicator.

Whichever technology is used to verify the contents, the equipment must be used in accordance with the equipment manufacturers instructions, by staff trained and competent in the process.

Weighing of containers can be undertaken by the use of portable beam scales, if the CO$_2$ system was originally installed for this method of container contents verification. Otherwise, weighing of CO$_2$ containers involves dismantling the system to physically remove the containers and therefore should only be performed by trained servicing companies.

Using an ultrasonic liquid level indicator can be a quicker and more convenient method of container contents verification. Heat sensitive strips can be affected by ambient thermal conditions, which may limit their use.
Devices used to detect liquid level as a means of verifying container contents are not effective if the ambient temperature exceeds 31°C and requires adjustment to be made for the variation of liquid level with ambient temperature on interpreting the results.

The verification of CO₂ container contents and correct interpretation of the measurements could be beyond the abilities of a ship’s crew, requiring this to be undertaken by a specialist service company. Attendance of servicing companies is usually restricted to when the marine vessel is in port, which can vary and be infrequent depending on the vessel’s schedule. Therefore, it can be challenging to match the more frequent requirement of container contents verification of land based regulations.

For marine vessels to meet the more frequent container contents inspection specified by land based regulations, it is therefore recommended that ultrasonic liquid level indicators be considered.

Clean agent system containers are frequently fitted with pressure gauges and may also provide a remote low pressure alarm. For inert gas containers, the pressure indication is the means by which container contents is verified. For liquefied clean agent containers, any loss of nitrogen super-pressurisation, or liquid contents, would result in pressure loss being indicated on the gauge. Liquid level testing of liquefied clean agent containers can also be employed in combination with pressure measurement. CO₂ containers are not fitted with a pressure gauge, since the pressure will be the constant (at a given temperature) whilst there is any liquid CO₂ present within the container.

The clean agent standards for land based systems, NFPA 2001, EN 15004 and ISO 14520, specify that the pressure gauges are checked weekly. The developed pressure in the container varies with temperature; to be effective, the operator needs to know the ambient temperature and be able to interpret the results given by the pressure gauge. This may be addressed by information present on the container label.

The frequency of contents verification in the marine standards should at least match the land based standards requirement, or consideration be given to exceed it, to account for the conditions in a marine environment.

### 3. CONTAINER PERIODIC TESTING

The requirements for the periodic testing of compressed gas containers used in the UK and European Economic Area are defined by EN 1968:2002. This Standard states that 100% of containers are subject to periodic inspection within a specified time interval, or earlier if found to be defective beyond prescribed limits during a visual external examination. An extension of the interval between periodic inspections is permitted, but this is recommended to be no more than double the specified interval. However, it is also mandated that containers used for emergency purposes shall be tested within the specified interval, with no time extension permitted.

For liquefied CO₂ and other liquefied (fire extinguishant) gases super-pressurized with nitrogen gas, EN 1968:2002 specifies the interval between periodic inspections is within 10 years.
It should be noted that the information contained in MSIS 12/CH 7/REV 1012 clause 7.3.7.3 ii) is based on the incorrect interpretation of EN 1968 (the error occurring in clause 7.1.2 of MSIS 12) and the stated allowance of 20 years between periodic inspections is incorrect. The restriction in section 3 of EN 1968 applicable to containers used for emergency purposes has been overlooked in MSIS 12; it cannot be argued that a fixed gaseous fire extinguishing system is not an emergency purpose.

Furthermore, in the UK and Europe, containers which are found to have exceeded their periodic inspection date must be subject to periodic testing before they can be refilled.

The requirements for containers complying with North American standards are different to UK/EEA and is more complex. The containers used on NFPA compliant systems will generally be to US DOT standard, but the periodic test requirements of NFPA 12 and 2001 are also different to DOT requirements.

For CO$_2$ systems, NFPA 12 specifies that containers to be subject to periodic inspection (defined as a hydrostatic test) every 12 years, but once a container has passed 5 years since last test, it must be retested before being refilled, despite not reaching 12 years since the last test. NFPA 12 does not state any requirements for damaged containers.

It could be expected that the containers used on NFPA 12 compliant CO$_2$ systems would be to (US) DOT specification. The periodic inspection interval for DOT 3A and DOT 3AA containers is every 5 years, however, some DOT 3AA containers are also marked with a star, indicating the inspection interval is every 10 years.

The requirements for NFPA 2001 clean agent system containers are different to NFPA 12 CO$_2$ containers; there is no requirement for clean agent containers to be removed from service for periodic inspection once the containers have passed their periodic inspection date. Clean agent containers therefore can remain in use without a retest until such time that they are discharged. The only stipulation is that containers are visually inspected at least every 5 years and are subject to periodic testing before refilling, once they are more than 5 years since their last test date.

The requirements for DOT containers which may be used on NFPA 2001 systems is similar in that these do not require removing from service for retesting once they have passed their periodic inspection date. The periodic inspection dates for DOT containers varies depending on exact specification, some being up to 12 years. In such cases, the NFPA 2001 retest at 5 years prevails.

Whilst NFPA 12 and NFPA 2001 have no requirements for retesting of damaged containers, DOT regulations do and are similar to EN 1968 in that any damaged container shall be removed from service and subject to periodic inspection, or be replaced, regardless of age.

There are three methods of periodic inspection referenced in EN 1968:

1. Hydrostatic pressure strength test
2. Hydrostatic volumetric expansion test
3. Ultrasonic wall thickness test
However, MSC.1/circ. 1318 specifies a ‘hydrostatic test’ and refers to *ISO 6406 periodic inspection and testing of seamless steel gas cylinders*, but ISO 6406 itself specifies the same three test methods as EN 1968. In practice, the hydrostatic pressure strength test is probably the most common and easiest method, as multiple containers can be tested simultaneously by this method, which is not possible or as easy with the other methods.

To minimise downtime when fixed gaseous fixed extinguishing system containers fall due for periodic inspection, it is now commonplace in the UK that the service provider will arrange to have the required number of containers tested, fitted with new valves and the containers filled before the changeover is required. In this way, the recertified containers can arrive on site when required, all the installed containers are removed and replaced with the pre-prepared containers in a single action. The removed containers are returned to the container re-conditioner to replenish their old stock as a part of this service exchange process. This process minimises the downtime and potentially the cost for the end user. This may not be as straightforward for Marine as containers may arrive from any part of the world and the availability of service exchange product are likely to be more limited.

Compared to the Marine process of removing 10% of the containers, transporting these to a re-conditioner for test, then re-valving, refilling and transporting back to the dockyard, the service exchange process commonly used for land based systems is much quicker. This is especially so if one or more of the batch of containers sent for testing is found defective, requiring more containers to be removed from the ship for inspection. The complete pre-planned exchange of all the fixed extinguishing system containers in one go reduces the time required for the ship to be in dock for this process to take place.

The complete service exchange of the container has other safety benefits; current Marine practices could see the same 10% of containers tested every ten years, the remaining 90% never being tested. This process could therefore result in defective and potentially dangerous containers going undetected.

The service exchange process does require pre-preparation – the ship’s crew/owners would need to know the details of the fixed extinguishing system and age of containers and the type of valve fitted, so the service exchange could be pre-prepared and coordinated during a future port visit. A competent fixed extinguishing service provider should verify the age of the containers as part of the inspection and would advise when the containers are getting near to periodic inspection date.

Furthermore, the FIA recommend that valves with taper threads, as found on CO₂ and inert gas containers, be replaced once removed from containers, due to normal distortion of the valve thread, rendering it beyond the specified tolerance for re-use. There have been instances of subsequent leakage, or the complete catastrophic failure, where valves with taper threads have been re-used.
4. FLEXIBLE HOSES

Current practice for UK and EU land based fixed gaseous fire extinguishing systems is that the flexible hoses are generally replaced ‘on condition’ – i.e. if they appear defective they are replaced.

However, since as part of the periodic inspection of containers, at least one connection of the flexible discharge hose has to be removed, and depending on the valve make, potentially also both pilot hoses, it is considered good practice to replace the flexible discharge and pilot hoses, regardless of condition.

The practice of changing all flexible hoses every 10 years enhances safety, purely from the fact that flexible hoses are installed bent into an arc by varying degrees, the hoses can lose flexibility and take on a ‘set’ with age. Also, in a Marine environment, the hoses and fittings could be subjected to more extreme environmental conditions and temperature fluctuations than seen in land based applications.

The requirement for flexible hoses on NFPA compliant systems is that they are removed from the installation and pressure tested at a frequency of every 5 years; any hose failing the pressure test is replaced. However, in practice, in developed countries this process is probably not economic compared with simply replacing with new flexible hoses and retesting the existing hoses would take longer, possibly delaying the vessel in port.

5. BLEED VALVES

Bleed valves are fitted to pilot circuits where used with pilot containers, and are used to ensure that if there is a leak from a pilot container, pressure cannot build up in the pilot circuit which could eventually cause the accidental release of the system.

Where pilot circuits are connected to discharge pipework, such that the pressure from the extinguishant is used as the pilot gas source, and if the connections are made to a closed section of pipe – i.e. upstream of any isolation or selector valves, bleed valves must also be fitted to these pilot circuits, for the same reason as for pilot container systems.

6. PIPELINE PRESSURE SWITCHES

These devices provide a signal upon operation of the systems. The output signals are used to control the cause and effect of other functions.

The correct functioning of these devices is therefore essential to ensure the fixed gaseous extinguishing system remains fully operational. The pressure switches must be functionally checked as part of servicing, however, where pressure switches do not feature a self-test function, it relies on the service engineer detaching the pressure connection to apply mechanical force to the pressure switch internal plunger to trip the electrical switch. Faced with such, service engineers may omit such actions either through ignorance or laziness.

The guaranteed correct functioning of the system is therefore only proven by, and heavily dependent on, using trained and competent persons to service fixed extinguishing systems.
7. ODORIZERS

Odorizers are now mandatory on land based $CO_2$ fixed gaseous fire extinguishing systems in the UK; as $CO_2$ is odourless, these devices provide a warning of the presence of $CO_2$.

Odorizers are fitted to the distribution pipework such that the discharging extinguishant is dosed with an odorant; commonly either citreous, pine or mint odour. The fitment of these devices is an effective safety measure, particularly as with $CO_2$ being denser then air, it can migrate from the protected area when being ventilated and collect in other low-lying areas.

It is therefore recommended that Odorizers are fitted to all new $CO_2$ fixed gaseous fire extinguishing systems, that the correct fitment of an Odorizer is checked as part of the service routine and it is essential that following a discharge, the used Odorizer is replaced with a new item.

Where Odorizers are fitted to $CO_2$ systems complying with NFPA 12, all entrance doors into the protected space shall be fitted with the fitment of warning sign specified by NFPA 12. The fitment of such (and all) warning signs on NFPA 12 systems is retrospective.

8. SELECTOR/ISOLATION VALVE FUNCTIONAL TEST

The 2 year function test of the Pressure Operated Distribution (POD) valves as stated within IMO Circ.1/1318 may be insufficient. In order to address this an additional task of manually opening and closing the valve could be performed by the crew at 6 monthly intervals to ensure free movement of the internal parts of the valve.

A documented working practice may be required to ensure the valves are only opened by defined crew members, with a post check test by another crew member to ensure all valves have been closed after test. Crew members involved in such testing should be fully conversant with the functioning of the equipment.

9. ENCLOSURE INTEGRITY

The sound integrity of the protected enclosure is essential for the retention of the extinguishing agent, to ensure any fire will be extinguished and that a minimum concentration of agent is retained for a specified hold time.

The requirements for land based and Marine fixed extinguishing systems are similar in this respect. An integrity test should be carried out during system commissioning and a visual inspection of the enclosure is required every 12 months to assess for new penetrations, or changes which could affect the integrity of the protected enclosure. Use of alternative technologies to complement visual inspection, such as ultrasound, may be considered.

The difference however is that for land based systems, the same service engineer may be assigned to visit the site, thereby they could build a rapport with the end user and become familiar with the protected area, such that they may be more likely to notice any changes which may affect the integrity. Furthermore, when the service contract for a land based system changes companies, the new incumbent may often specify that a new integrity test be carried out to verify the integrity (as they will not know what its state is), resulting in the protected area being tested more frequently.
For Marine systems where the fixed extinguishing system may be serviced when the ship is in port when the service falls due, the system may rarely be serviced by the same company/engineers. The assessment of there being no changes to the protected enclosure which could affect its integrity is therefore much harder for the engineer to ascertain. Since the integrity of the enclosure is vital to ensure the fixed extinguishing system will extinguish the fire and there is equipment available to easily facilitate this, the annual retesting of the protected enclosure could be recommended for Marine fixed gaseous fire extinguishing systems.

10. SERVICE PROVIDER COMPETENCY

Service providers must be conversant with applicable standards, particularly as these are updated with best practices, to ensure that the level of servicing provided meets the requirements of the standards.

Service providers must be conversant with the product they are servicing, or in combination with adequate product literature, have the required skill and experience to able to apply and adhere to the specified system/product procedures.

Section 1 (General) of MSC.1/Circ.1318 states that “Certain maintenance procedures and inspections may be performed by competent crewmembers, while others should be performed by persons specially trained in the maintenance of such systems”; this could be amended slightly to include the wording “……persons specially trained and certified…….”

This may encourage persons responsible for organizing and planning the maintenance to then ask for copies of engineers’ certification, which in turn would encourage maintenance companies to approach Associations, manufacturers or other authorities to provide the necessary training and issue certificates to trained staff.
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