

**Committee of Experts on the Transport of Dangerous Goods
and on the Globally Harmonized System of Classification
and Labelling of Chemicals**

Sub-Committee of Experts on the Transport of Dangerous Goods

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**Global harmonization of transport of dangerous goods regulations
with the Model Regulations**

Stowage of water-reactive materials

Summary report of the Formal Safety Assessment

Transmitted by the expert from Germany

SUB-COMMITTEE ON DANGEROUS
GOODS, SOLID CARGOES AND
CONTAINERS
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STOWAGE OF WATER-REACTIVE MATERIALS
Summary report of the Formal Safety Assessment
Submitted by Germany

SUMMARY

Executive summary: This document contains a Summary Report of the Formal Safety Assessment (FSA) – The Safe Sea Transport of Dangerous Goods which react dangerously with water and/or carbon-dioxide

Strategic direction: 5.2

High-level action: 5.2.3

Planned output: 5.2.3.6

Action to be taken: Paragraph 5

Related documents: MSC 83/25/6, DSC 15/8, DSC 15/18, DSC 16/INF.2

Background

1 The Maritime Safety Committee, at its eighty-third session, having considered document MSC 83/25/6 (Germany) agreed to include in the Sub-Committee's work programme and the provisional agenda of DSC 13 a high-priority item on "Stowage of water-reactive materials", with a target completion date of 2009, in co-operation with the FP Sub-Committee, as necessary and when requested by the DSC Sub-Committee.

2 Document MSC 83/25/6 highlighted that there are some water-reactive substances that could even react with carbon-dioxide in hot atmospheres which would render the use of conventional fire-fighting mediums worthless and in some cases dangerous, and recalled that the risks connected to the stowage of such cargoes in cargo spaces protected by water-based fire-extinguishing systems were identified in 2000 but the issue was not resolved. The document therefore proposed a review of the cargo stowage, segregation and packing requirements for such substances with a view to developing specific requirements for the stowage of water-reactive materials.

3 Since no documents had been submitted to DSC 13 and DSC 14, MSC 87 extended the target completion date of the agenda item to 2010. In the meantime, Germany started a Formal Safety Assessment (FSA) on the cargo stowage, segregation and packing requirements for water-reactive substances and/or reacting with carbon dioxide in hot atmosphere and informed the Sub-Committee on the ongoing activities for the FSA study (DSC 15/8). Consequently, MSC 88 extended the target completion date once again to 2011.

4 The annex to this document contains a Summary Report of the Formal Safety Assessment (FSA) – The Safe Sea Transport of Dangerous Goods which react dangerously with Water and/or Carbon Dioxide. The complete version of the report is presented in document DSC 16/INF.2.

Action requested of the Sub-Committee

5 The Sub-Committee is invited to take note of the information provided, consider the results of the FSA and take action as appropriate

ANNEX

SUMMARY REPORT OF THE FORMAL SAFETY ASSESSMENT (FSA)



Summary Report for RD-Project of BMVBS (*Kurzfassung zu FE-Projekten des BMVBS*)

Topic (*Thema*):

Formal Safety Assessment FSA – The Safe Sea Transport of Dangerous Goods which react dangerously with Water and/or Carbon Dioxide

RD-No. (*FE-Nr.*):

96.0942/2009

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Scope of Work

There are substances that react dangerously with water and/or with carbon dioxide. For these reasons, the on board of ships available fire-fighting mediums: water on the weather deck and water and carbon dioxide in the cargo holds, are not only unfeasible, but dangerous. It is therefore necessary to develop specific requirements for the transport of such substances by sea.

The Emergency Schedules EmS (Emergency Response Procedures for Ships carrying Dangerous Goods) in the IMDG Code Supplement provide guidance for dealing with fires and spillage of dangerous goods onboard ships. The validity and practicability of the recommendations of the Emergency Schedule for Fire Golf (EmS F-G) are to be investigated within the research project.

The Maritime Safety Committee (MSC) of the International Maritime Organization (IMO) has assigned this responsibility to the Sub-Committee on Dangerous Goods, Solid Cargoes and Containers (DSC). During further development of the Emergency Schedule for Fire Golf (EmS F-G) in 2000, the commissioned correspondence group noticed that the contact of fire-fighting water to the water reactive substances imposes danger. The fire department of a large German chemical company has conducted fire tests with such substances, the results of which were submitted by Germany to the Sub-Committee (DSC 6/INF.4). In 2006, as shown in agenda item DSC 11 (DSC 11/18/1), the necessary investigations of the risks and modifications to the stowage, segregation and packing requirements of the IMDG Code for substances, dealt within the Emergency Schedule for Fire Golf (EmS F-G), were identified.

The aim of this research project is to develop organisational and technical measures that reduce the risks associated with dangerous goods transport. More specifically, the project focuses on the prevention of fire and protection against fires started from dangerous goods that can react dangerously with the ship's available fire extinguishing systems such as water and carbon dioxide. For these goods the EmS F-G will give guidance in the event of fire incidents. The research has been conducted in form of a formal safety assessment to be submitted to the IMO Sub-Committee DSC.

Research Method

To support the relevant committees of the IMO in the development of regulations, the research project is presented in the form of a "Formal Safety Assessment" (FSA) in accordance to MSC/Circ. 1023. Hence, it can be submitted by Germany to the relevant IMO Sub-Committees to support the rule making process. The amendments to MSC/Circ. 1023 at MSC 80 (MSC/Circ. 1180-MEPC/Circ. 474) and MSC 82 (MSC-MEPC.2/Circ.5) are consolidated in MSC 83/INF.2.

A FSA can be used by the IMO as a means of assessing new rules and regulations or comparing new and existing rules and regulations. This method ensures comprehensive consideration of technical and operational matters including safety, environmental impact and cost. During the decision making process within the IMO, a FSA can be applied with the benefit of highlighting regulation changes (e.g. ramifications for people or the environment). In the evaluation of recommendations, the advantages are compared against costs in order to assess the feasibility of their implementation.

The performed FSA consists of five steps, described in the following:

Step 1: Hazard Identification (HAZID):

For the FSA to be carried out, initially the main risks need to be qualitatively determined with a hazard identification. The hazard identification is carried out in form of a Failure Mode and Effect Analysis (FMEA, IEC 60812). In the FMEA the potential hazards are identified and rated by means of an established evaluation into main risks which will be qualitatively investigated through additional analyses in the following steps.

The following input parameters are taken into account in determining the main hazards:

- Historical data
 - o LMIU (Lloyds Maritime Information Unit) accident database;
 - o LRFP (Lloyds Register Fairplay) accident database;
 - o Publications of IMO (FSA Container Ships, MSC83/21/1, MSC83/INF.2; FSA Open Top Container Ships, MSC87/18/1, MSC87/INF.2).
- Existing regulations
 - o SOLAS II-2/19 „Construction – Fire protection, fire detection and fire extinction; Carriage of Dangerous Goods“;
 - o SOLAS VII „Carriage of Dangerous Goods“;
 - o IMDG Code (International Maritime Dangerous Goods Code);
 - o Emergency Schedule for Fire - Golf (EmS F-G) des IMDG Code Supplement.
- System description (System: dangerous substances linking to the EmS F-G)
- Limitation of analysis:
 - o Sea transport in container;
 - o Container ships incl. design acc. to SOLAS;
 - o Fire fighting equipment acc. to SOLAS.
- Transport volume (relevant for quantification)
 - o Estimations of the SAFEDOR project.
 - o Estimation by experts (in the context of the hazard identification).

From the results of the FMEA the main risks are selected based on the probability of occurrence (in a deductive part) and the severity of the consequence (in an inductive part), as listed below:

Deductive risk scenarios with the highest frequency of occurrence:

- D3.1 (for Class 5.1): Different external temperature at loading/transport (e.g. transport across climate zones) → condensation in the container → softening of packaging → substance reacts with organic packaging → fire
- D3.2: Cleaning of container before loading/ loading of container in rain (or snow, moisture) → wet container (high humidity) → reaction with released gas → corrosion/ fire conceivable
- D3.3: Sea water enters (through ventilation, flaws in the container) → corrosion/ fire conceivable

Inductive risk scenarios with most severe consequences:

- I2.3: Release of flammable gases, venting of flammable liquids and gases → reaction inside the container, ignition and destruction of container
- I2.4: Release of flammable gases, venting of flammable liquids and gases → reaction outside the container, ignition
- I4.3: Substance reacts with water with the release of corrosive gases (e.g. HCl-gas → hydrochloric acid) → toxic effect on people, extreme corrosion; on deck: possible structural damage; in hold: significant structural damage

- I5.1: EmS F-G substance reacts due to damaged packaging (e. g. due to fire/attempt at extinguishing the fire) with released gases/ liquids from other substances in fire → advances the fire; combination between substances which don't allow any fire-extinguishing methods (e.g. chlorine and oxidizing agents)

Step 2: Risk quantification:

In this section, the previously identified major risk scenarios will be evaluated.

In the deductive part of the analysis, the most common cause of the start of a fire with the involvement of dangerous goods, D3.1 to D3.3 are examined in more detail. All these scenarios lead to ignition of the dangerous goods or of their flammable packaging within the container. In most cases, the fire does not spread beyond the effected container and extinguishes after a short time so that the incident goes unnoticed and is not included in statistics. An ignition under fire favouring circumstances rarely leads to a spreading fire beyond the effected container. This is the reason that the frequency of considered ignitions with 3 cases per ship per year (according to expert estimates in the hazard identification) is approx. 3 times higher than the frequency of fire accidents statistically recorded.

In the inductive part of the analysis the risk for the listed scenarios in (I2.3, I2.4, I4.3, I5.1) are analysed with the help of event trees. Based on a fire with the involvement of dangerous goods, different scenarios are analysed as a consequence thereof. This is the case if the dangerous goods are on fire, or if a fire burns in the vicinity of dangerous goods, in that case the dangerous goods pose an additional risk.

Detailed statistics of the occurrence of each incident are required to quantify the risk. However, since there are no reliable databases the analysis is based on the qualitative assessments by experts.

Step 3: Identification of mitigation measures:

Risk mitigation measures have been identified during the HAZID. Each of these measures can have more than one sub-measure. Identified measures were documented and evaluated in the following step of the analysis.

Results

The following list summarises the overall evaluations of each risk reducing measure (Step 4 of FSA). This summary compares the overall effectiveness and the costs of each measure:

1. Sufficient equipment for fire-fighting in the vicinity of the fire, acc. to FSA Container Fire on deck (FP54/15, FP54/INF.2): effective at medium effort
2. Improved capacity of the CO₂-extinguishing system (increased capacity and feed rate): no or negligible effectiveness at low to medium effort
3. Improved packaging and loading of the container, limitations for certain goods within one container: effective at low effort
4. Improved stowage of containers with dangerous goods on the ship: effective at low to medium effort
5. Special equipment for containers with dangerous goods (ventilation, fire detection, water protection): effective with high efforts
6. Amendments and/or improvements of the EmS and EmS F-G: less effective with low effort
7. Training of the crew with regard to handling fires with involvement of dangerous goods: less effective at medium effort

The measures 1, 3, 4, 6 and 7 are recommended for implementation.

Recommendations (Step 5 of FSA)

Recommendation 1 Modifications to the IMDG Code regarding improved packaging and stowage. This recommendation includes the following requirements for the packaging and container loading of substances for which the EmS F-G applies:

- For certain dangerous goods, a limitation on the quantity of transported goods per packaging unit and/or per container should be introduced;
- Packing of containers only in dry conditions for all dangerous goods for which the EmS F-G applies;
- Use of moisture resistant packaging;
- Reducing condensation water with the use of moisture absorbents, for example Silica gel;
- Dangerous goods should be stowed separate from other flammable goods within the container. In particular substances, which when in combination make effective fire-fighting impossible, have to be identified and stowed separately from each other. Goods of class 5.1 should not be transported in containers with mixed goods.

Additionally, the following requirements should apply for the stowage of containers on ship:

- Certain dangerous goods should not be stowed below deck. Instead, these substances should be stowed on deck protected from sea water. This applies to substances of class 5.1, which release oxygen when in contact with water and/ or with heat and substances, which release dangerous corrosive gases when in contact with water and/or heat;
- Placement of the container with dangerous goods in such a way that sufficient accessibility and good fire control is guaranteed.
- Placement of the container with dangerous goods in such a way that allowing the container with dangerous goods to burn out would be possible in case of a fire (not in the vicinity of the bridge).

Recommendation 2 Adjustments to fire protection equipment. With reference to the FSA „Container fire on deck“ (FP54/15, FP54/INF.2), the following requirements for the fire protection equipment are recommended for vessels of 30,000 GT and higher with container on deck:

- Increase of the required pump capacity of 180 m³/h (SOLAS II-2/10.2.2.4.1.2) to 250 m³/h;
- Increase of the required pressure at hydrants from 0.27 N/mm² to 0.4 N/mm² (similar to the passenger ships from 4,000 GT);
- At least one hydrant between two neighbouring stacks of containers on each side of the ship;
- At least two mobile monitors, and for vessels with more than 30 m widths at least four mobile monitors with the corresponding pump capacity and pressure for reaching the full height of a container stack.

These indicated measures increase the success during fire-fighting and therefore reduce the probability of the spread of the fire and thus the expected consequences.

Since the effort for these measures vary depending on local conditions on board, this recommendation can only be granted, if the implementation is possible with reasonable effort. In other cases, these measures are to be classified as not cost effective.

Recommendation 3

Modification of the EmS and/or EmS F-G: The EmS and/or the instructions in the EmS F-G should be revised in regards to the following points:

- The EmS and/or the instructions in the EmS F-G should contain information to the fact that there are fires which cannot be extinguished with the equipment on board. In such cases, risks to persons are to be minimized by considering to forgo fire-fighting measures and initiate preparations to abandon ship;
- The EmS and/or the instructions in the EmS F-G should contain detailed instructions for fire-fighting with the involvement of dangerous goods in liquid form;
- The general part of the EmS should contain information on the spread of a fire by considering fires with involvement of dangerous goods.

Recommendation 4

Supplement of the training for fire-fighting as part of the IMO Model Courses: As risk reducing measure, part of the training for fire-fighting of fires with the involvement of dangerous goods, the following should be included:

- Assessment of the spread of a fire with the involvement of dangerous goods. With help of the training, the crew will be able to determine whether it is possible to let the fire on deck burn out or whether a fire-fighting measure should be initiated;
- Assessment, when fire-fighting with dangerous goods is too dangerous and therefore not appropriate; and when preparation should be initiated to abandon ship.

This content can be integrated into the general part of the EmS or into the IMO Model Course 1.20.

Generally, it can be stated that the existing safety measures are already at a high safety standard, even if higher consequences, including total loss of the ship, cannot be ruled out for any fire involving the considered dangerous goods.