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

28 June 2023

Sub-Committee of Experts on the Transport of Dangerous Goods

Sixty-second session
Geneva, 3-7 July 2023
Item 2(a) of the provisional agenda
Review of Test Series 6

Information related to document ST/SG/AC.10/C.3/2023/26: Exit from class 1, relating to electrostatic discharge and electromagnetic interference / radio frequency interference

Transmitted by the Council on the Safe Transportation of Hazardous Articles (COSTHA)

Introduction

1. COSTHA's and SAAMI's document ST/SG/AC.10/C.3/2023/26 was submitted to allow for test reports of ongoing research on this topic. While the research focused on gathering packaging-independence data and exclusion test data, information was found relating to the probability of ignition from electrostatic discharge (ESD) and electromagnetic interference (EMI) / radio frequency interference (RFI)[1].

2. COSTHA poses questions about the potential usefulness of further research related to the probability of accidental ignition of articles of the type being considered. Available test standards and threshold values are discussed.

Discussion

3. The ability of truck radios to initiate electric detonators is known, at least in the past. While electric detonators may have long lead wires which function as antennae to concentrate electromagnetic energy, microgas generators (MGG's) have very short leads, for example 4 millimeters. Additionally, the thickness of metal in the devices is a factor, as thinness of metallic components can reduce the potential effect of EMI, for example, the bridge wire and leads. It is the opinion of industry experts that accidental ignition via ESD or EMI is not credible for various modern explosives. Per other discussions in the explosives working group, no transport incident data exists to corroborate accidental electrical activation of the explosive articles under discussion.

4. The criticality of operations within the automotive and aerospace industries, coupled with harsh conditions in uncontrolled circumstances, require high standards to protect against accidental functioning. The lack of incidents indicates that the standards are effective for the prevention of unplanned events.

5. Electrical testing information has been provided by a manufacturer of non-lethal policing tools. Such tools are critical to provide law enforcement with alternatives that do not rely on pain for compliance or inflict lethal force. Such tools have been exempted from

[1] The terms RFI and EMI are often used interchangeably. In practice, EMI may refer to short range interference caused by high frequency emissions within the device itself, but also includes ESD. RFI refers to longer wavelength interference from sources external to the device. Applicable test standards use the term "electromagnetic" to cover EMI, RFI and ESD.

explosives requirements for security and safety purposes. They are exempted for transport when carried by government representatives. However, difficulties arise in global distribution when classified as explosives, which falsely indicates an ability to explode[2], resulting in national controls to prevent explosions, loss of life and damage to infrastructure.

Testing approach

6. Guidelines for EMI testing are provided in military and civil standards, which were used in the attached test report:

- The U.S. Department of Defense has standard MIL-STD-461G, Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment. This standard includes both RFI and ESD tests.
- The International Electrotechnical Commission (IEC) has standard IEC 61000-4-2, Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test.

7. Automotive standards were not used in the attached test report, but include USCAR28, Initiator Technical Requirements and Validation and AK-LV 16 Electric Igniters for Pyrotechnical Systems.

RFI discussion and test results

8. RFI is measured in volts/meter. Typical values* are:

Source	V/m at source
Battleship radar	400
Radio station	95
Police and fire radio	5-30
Amateur Radio	5-100
Aircraft Radio	118-137
Truck radio (“CB radio”)	5-50
Normal maximum exposure	25-30
Normal high maximum exposure	50

* Estimated

9. RFI test results are attached in Annex 1 for a device containing a sub-assembly (“cassette”) containing two MGG’s each containing 96 mg NEM. The energetic components of the MGG include zirconium potassium perchlorate and smokeless powder:

- The MIL-STD-461G RS103 TEST was performed at a strength of 50 V/m and frequency of 500 – 1,000 MHz of a the device including MGG’s. There was no malfunction of the device and no reaction of the MGG’s.
- The MIL-STD-461G RS103 TEST was performed at a strength of 100 V/m and frequency of 500 – 1,000 MHz of a the device including MGG’s. There was no malfunction of the device and no reaction of the MGG’s.

[2] See Model Regulations, Appendix B, Glossary of Terms: “Explode. The verb used to indicate those explosive effects capable of endangering life and property through blast, heat and projection of missiles. It encompasses both deflagration and detonation.”

10. ESD test results are attached in Annex 2 for a sub-assembly ("cassette") containing two MGG's each containing 96 mg NEM. The energetic components of the MGG include zirconium potassium perchlorate and smokeless powder:

Contact Point	Direct/Indirect	Level (kV)	Contact Type	Observation
P1, P2, P3, P6, P7	Direct	6, 8	Normal Use	None
P1, P2, P3, P6, P7	Direct	4, 8	During Service	None
P1, P2, P3, P6, P7	Direct	2, 4, 8	Installation	None
P1, P2, P3, P6, P7	Indirect	11, 13, 15	Normal Use	None
P1, P2, P3, P6, P7	Indirect	9, 15	During Service	None
P1, P2, P3, P6, P7	Indirect	5, 9, 15	Installation	None

Note: "Px" in the table above refers to the cassette interface board pin numbers / layout.

Summary

11. The results show that the tested MGG's are not susceptible to ignition from energies exceeding credible amounts of ESD. While probability may be assumed to be 1.0 (100% certainty of an accidental activation), this is not always credible. Perhaps industry should be incentivized to provide a higher level of safety, and prove it with testing as part of the classification process.

Proposal

12. COSTHA requests that the explosives working group consider this data with respect to the probability of initiation and discuss the potential benefit of these and similar tests.

Annex 1 to 2 attached below

BAM
Bundesanstalt für
Materialforschung
und -prüfung

12200 Berlin, Germany
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Test Report

on testing "CHEMLOK QDO GROUND" according to the UN-Test 6 (c)

and

Expert Opinion

to classification according to the UN Recommendations on the Transport of Dangerous Goods

BAM reference	20043557
Copy	1st copy of 2
Customer	Lord Germany GmbH Itterpark 8 40724 Hilden Germany
Order date	04.09.2020
Receipt of order	04.09.2020
Test samples (BAM Code)	„CHEMLOK QDO GROUND" (2.23/291019/01), Batch 0011962172, 118 kg
Receipt of samples	29.10.2019
Test date	September 2020
Test location	Bundesanstalt für Materialforschung und -prüfung (BAM) Unter den Eichen 87 12205 Berlin, Germany and BAM Test Site Technical Safety An der Düne 44 15837 Baruth/Mark, Germany
Test procedure according to	UN Recommendations on the Transport of Dangerous Goods, 21st revised edition 2019, Manual of Tests and Criteria, 7th revised edition, 2019.

This Test Report consists of page 1 to 4.

1 Introduction

At the request of the company Lord Germany GmbH the Bundesanstalt für Materialforschung und -prüfung (BAM) carried out an external fire test to classify „CHEMLOK QDO GROUND" according to the UN Recommendations on the Transport of Dangerous.

The BAM carried out the external fire test at the BAM Test Site Technical Safety.

2 Composition

According to the information of the customer, the sample „CHEMLOK QDO GROUND" contains about 95 % by mass of benzochinone dioxime.

3 Test methods

The used test method is described at the Manual of Tests and Criteria, seventh revised edition, 2019.

4 External fire test

This test is performed on packages of the explosive substance to determine whether there is a mass explosion or a hazard from dangerous projection, radiant heat and/or violent burning when involved in a fire.

Since the sample „CHEMLOK QDO GROUND" (2.23/291019/01) has already been evaluated in larger packages in accordance with test series 6 and classified in Division 1.4 (see BAM-reference 19019049), the UN-test 6 (c) should be used to examine whether the test substance in smaller packaging may be excluded from the Class "Explosives".

The sample „CHEMLOK QDO GROUND" (2.23/291019/01) was packed in plastic jerricans (3H1) with removable head and a volume of 20 l/5 gallone (inner packaging). Each plastic jerrican was inserted in a fibreboard box (4G) (outer packaging)

At the UN-test 6 (c) observations are made on the following:

(a) Evidence of explosion;
(b) Potentially hazardous projections and
(c) Thermal effects.

For the external fire test 14 packages each with 8 kg of the sample „CHEMLOK QDO GROUND" were placed on the metal grid.
The wood crib was ignited using a mixture of liquid fuels and an igniter.
The heat flux was measured using infrared sensors (bolometer).

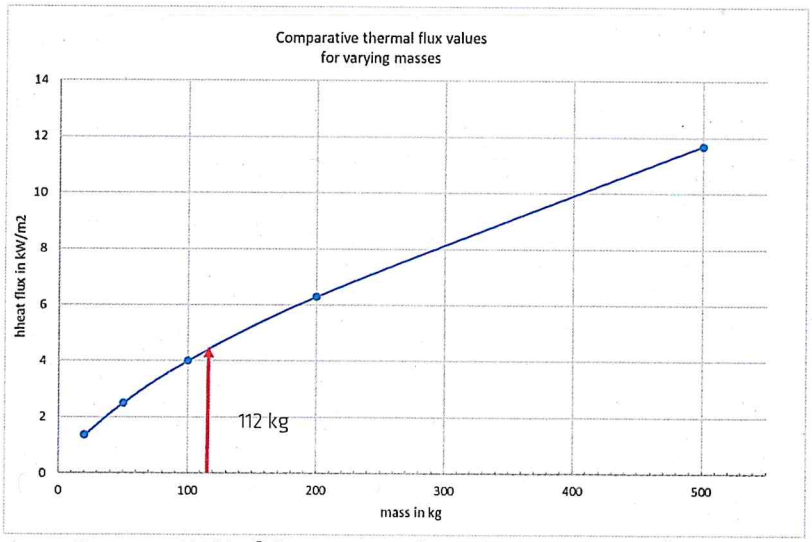
The burning time was about 100 s for a net mass of 112 kg with a maximum height of the flame of about 15 m.

5 Evaluation of the test results

The criteria for thermal effects are the burning time and the heat flux in 15 m and 5 m distances. The heat flux is measured 5 s during the period of maximum heat generation.

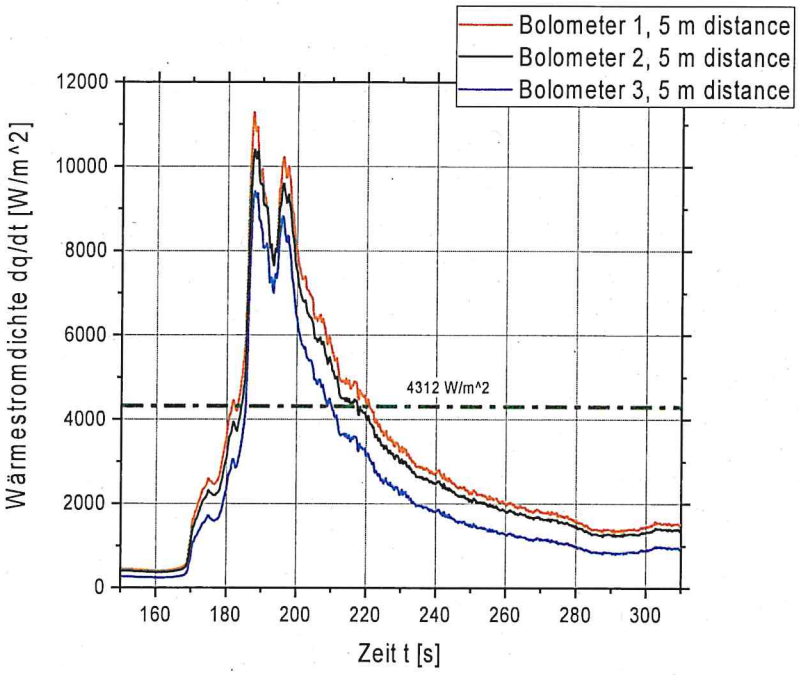
For an exemption from Class 1 "Explosives" of the UN Recommendations of the Transport of Dangerous Goods or the Hazard Class "Explosives" of the GHS the heat flux shall be determined at the distance of 5 m.

The heat flux criteria for different masses are listed at table 16.2 of the UN Manual (distance 5 m).



The comparable heat flux to 4 kW/m² for a mass of 100 kg is 4,3 kW/m² for a mass of 112 kg.

Heat flux of 14 packages each with 8 kg „CHEMLOK QDO GROUND" (2.23/291019/01)



The substance „CHEMLOK QDO GROUND" (2.23/291019/01) showed no evidence of explosion and no potentially hazardous projections but the measured burning time was less than 330 seconds for 100 kg net mass and the heat flux in 5 m for 100 kg was higher than 4,0 kW/m² (comparable heat flux for 112 kg is 4,3 kW/m²).

Based on the test results the sample „CHEMLOK QDO GROUND" (2.23/291019/01) as packed shall be classified as Division 1.4 Compatibility Group C.

Bundesanstalt für Materialforschung und -prüfung (BAM)
12200 Berlin

Berlin, 07.12.2020

Division 2.2 „Reactive Substances and Systems"

by order

(Official seal)

Dr. Heike Michael-Schulz
Regierungsdirektorin

Distribution list: 1st copy: Customer
2nd copy: BAM

BAM

Federal Institute for Materials Research and Testing

Report
and
Expert Assessment

on classification of the substance "CHEMLOK QDO GROUND" in accordance with the regulations concerning hazardous materials/hazardous substances and the Explosives Act

Reference	19019049
Copy	1. Copy of 2
Applicant	Lord Germany GmbH Itterpark 8 40724 Hilden
Application date	4/12/19
Logo Received	
on	4/18/19
Test item/Test material	"CHEMLOK QDO GROUND" (2.23/150419/01), batch 0011784596, 3 x 1.1 kg "CHEMLOK QDO GROUND" (2.23/150419/02), batch 0011746732, 20 X 250 g "CHEMLOK QDO GROUND" (2.23/291019/01), batch 0011962172, 540 kg
Received on	4/15/19 and 10/29/2019 .
Test period Test	June to November 2019
Location	Bundesanstalt für Materialforschung und -prüfung (BAM) (Federal Institute for Materials research and Testing (BAM)) Unter den Eichen 87 12205 Berlin BAM Testgelände Technische Sicherheit (BAM Technical Safety Test Site) An der Düne 44 15837 Baruth/Mark
Testing according to	UN Recommendations on the Transport of Dangerous Goods, twentieth revised edition 2017, Manual of Tests and Criteria, 7th revised edition, 2019 and Method A.14 of Regulation (EC) No. 440/2008.

This document consists of pages 1 to 14.

1 Context

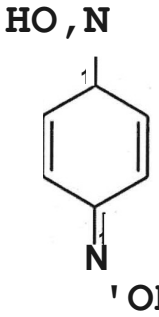
With a letter dated 4/12/19 the company Lord Germany GmbH submitted the substance "CHEMLOK QDO GROUND" to the Federal Institute for Materials Research and Testing (BAM) in accordance with § 2 Part 1 of the Explosives Act (SprengG) and provided the following test reports

[1] Cranfield University Ordnance Test and Evaluation Centre, Report Number COTEC/TL/1900/18, February 2017;
[2] DEKRA Insight, Report J4028001445R1V1/2018, UN Transportation Testing on Quinone Dioxime, March 23, 2018;
[3] DEKRA Insight: Report)4028001445R2V1/2018, Heat Accumulation Storage Test (UN H.4), March 23, 2018

.
For the necessary experimental investigations, different batches of the test substance were received by BAM on 4/15/19 and on 10/29/19.

2 Composition

According to the information applicant, the test substance "CHEMLOK QDO GROUND" (2.23/150419/01) is benzoquinone dioxime with a maximum 5% 4-Nitrosophenol.



benzoquinone dioxime

3 Test Results

3.1 Differential-Scanning-Calorimetry (DSC):

Determination of the Decomposition temperature at heating rate of 5 K/min yielded the following results:

"CHEMLOK QDO GROUND" (2.23/150419/01), batch 0011784596

Test No.	Sample weight (mg)	Extrapolated ONSET temperature [°C]	Decomposition temperature [J/g]
1	3.49	229	1892
2	2.18	237	2041

"CHEMLOK QDO GROUND" (2.23/150419/02), batch 0011746732

Test No.	Sample weight (mg)	Extrapolated ONSET temperature [°C]	Decomposition temperature [J/g]
1	3.49	229	1892
2	2.36	232	1942

"CHEMLOK QDO GROUND" (2.23/291019/01), batch 0011952172

Test No.	Sample weight (mg)	Extrapolated ONSET temperature [°C]	Decomposition temperature [J/g]
1	3.15	233	1879
2	2.70	237	2153

3.2 Steel tube test (Method A.14 or UN Test 2 (b)):

"CHEMLOK QDO GROUND" (2.23/150419/ 02), batch 0011745732

Test No.	1	2	3	4
Empty tube mass (g)	25.1	25.9	25.3	25.0
Sample weight (g)	19.4	19.4	19.4	19.4
Nozzle diameter (mm)	2.0	5.0	5.0	5.0
t,/t, + t2/t2 (s)	9/21/12	10/32/22	10/35/25	8/25/17
Fragmentation view (number)	F(3)	0(0)	0(0)	0(0)
Assessment	Explosion	No explosion		

Assessment in accordance with Method A.14: In accordance with Method A.14, the test substance was found to be thermally sensitive with partially defined inclusion (nozzle diameter 2.0 mm).

Assessment in accordance with UN Tests 1 (b)/2 (b): "positive"

3.3 BAM drop hammer (Method A.14)

Preparation of the test substance "CHEMLOK QDO GROUND" (2.23/150419/02), batch 0011745732: none, testing in condition delivered

Drop weight 10 kg, Drop height 40 cm (40 J impact energy)

Test No.	Observations	Result
1	Odour, discoloration of substance, full implementation	Explosion
2	Odour, discoloration of substance, full implementation	Explosion
3	Odour, discoloration of substance, full implementation	Explosion
4	Odour, discoloration of substance, full implementation	Explosion
5	Odour, discolouration of substance, full implementation	Explosion
5	Odour, discolouration of substance, signs of reaction in some places	No explosion

Drop weight 5 kg, Drop height 15 cm (7.5 J impact energy)

Test No.	Observations	Result
1 .	No discernible reaction	No explosion
2	No discernible reaction	No explosion
3	No discernible reaction	No explosion
4	No discernible reaction	No explosion
5	No discernible reaction	No explosion
6	No discernible reaction	No explosion

The test substance showed an explosion in five out of six tests at an impact energy of 40 J. The test substance showed no explosion in six tests at an impact energy of 7.5 J.

Assessment in accordance with Method A.14: The test substance was shown to be sensitive to impact at an impact energy of 40 J and not sensitive to impact at 7.5 J.

3.4 BAM friction apparatus (Method A.14)

Preparation of the test substance "CHEMLOK QDO GROUND" (2.23/150419/02), batch 0011746732: none, testing in condition delivered

Friction pin load: 360 N

Test No.	Observations	Result
1	No discernible reaction	No explosion
2	No discernible reaction	No explosion
3	No discernible reaction	No explosion
4	No discernible reaction	No explosion
5	No discernible reaction	No explosion
6	No discernible reaction	No explosion

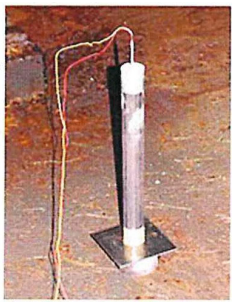
The test substance showed no explosion in six tests at a friction load of 360 N

Assessment in accordance with Method A.14: The test substance was shown to be non-sensitive to impact at a friction pin load of 360 N.

3.5 Analysis of detonation capability in UN GAP Test 1 (a)

This test is used to determine the ability of a substance to transmit a detonation when the substance is exposed to a detonating booster charge in a steel tube.

General test set-up



The test substance is placed in a steel tube (outer diameter 48.0 mm± 2.0 mm, wall thickness 4.0 mm± 0.1 mm, · length 400.0 mm± 5.0 mm). The booster charge consisting of 150 g of RDX/wax (95/5), diameter 50.0 mm, length 50.0 mm. A non-alloy steel test plate (150.0 mm ±10.0 mm square, 3.2 mm ±0.2 mm thick).
The test substance used for the tests was "CHEMLOK QDO GROUND" (2.23/291019/01), batch 0011952172.

1. Test:

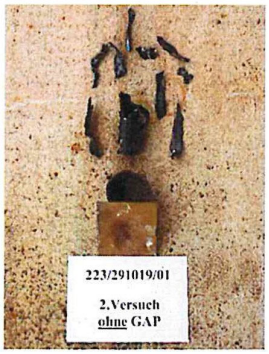
mass of test substance:	**254 g**
tube length obtained:	70 cm
tube length torn apart:	30 cm

No substance residue

Result:

The steel tube was torn apart over a length of 30 cm and the test plate was buckled.

2. Test:



mass of test substance:	255 g
tube length obtained:	9 cm
tube length torn apart:	31 cm

No substance residue

Result:

The steel tube was torn apart over a length of 31 cm and the test plate was buckled.

Assessment in accordance with UN tests 1 (a)/2 (a):

"-" (negative), the test substance is not capable of transmitting detonation.

1.5 Time/pressure testing (UN Test 1 (c) (i)/2 *(c)* (i))

Under confinement in a time-pressure bomb, the test substance "CHEMLOK QDO GROUND" (2.23/150419/02), batch 0011745732 showed a pressure increase, after 43 ms, 32 ms and 34 ms, of 590 kPa to 2070 kPa.

Assessment in accordance with UN test 1 (c) (i):	"+" (positive), the test substance is capable of deflagration
Assessment in accordance with UN test 2 (c) (i):	"-" (negative), the test substance is not capable of rapid deflagration.

3.7 Deflagration test (UN test C.2)

In the first test, the test substance "CHEMLOK QDO GROUND" (2.23/150419/02), batch 0011745732 deflagrated so fast that the speed could not be determined. In the second test, a rate of deflagration of 4.35 mm/s was measured, a deflagration occurred at the end of the test.

Assessment in accordance with UN test C.2: "yes, fast" (worst case).

3.8 Dutch pressure vessel (UN test E.2)

Preparation of the test substance "CHEMLOK QDO GROUND" (2.23/150419/02), batch 0011745732: none, testing in condition delivered

Test No.	Sample weight [g]	Nozzle diameter [mm]	Reaction time t, [s]	Reaction time t2, [s]	Result
1	10.00	1.0	43	43	Explosion
2	10.00	2.0	45	49	Explosion
3	10.03	3.0	44	58	No explosion
4	10.02	2.5	50	55	Explosion
5	10.00	3.0	48	80	No explosion
5	10.04	3.0	55	102	No explosion
7	10.05	3.0	55	81	No explosion

Assessment in accordance with UN test E.2: "Low"

3.9 BAM Trauzl test_e.SJ (UN test F.3)

In the lead block, the test substance "CHEMLOK QDO GROUND" (2.23/150419/02), batch 0011745732, showed a bulge of 24 ml for 10 g of the substance. Due to the clear result, there was no need for further testing.

Assessment in accordance with UN test F.3: "Low"

3.10 Test series 6

The results of the test procedures in test series 5 are used to determine which of the subclasses 1.1, 1.2, 1.3 or 1.4 most closely corresponds to a representation of the behaviour of the test substance in the event of a fire/explosion. The results are also required for the purpose of determining whether a test substance can be exempted from inclusion in class 1 of the Hazardous Goods Regulations or the Hazard Class of "Explosive substances/mixtures and products containing explosive substance" according to the

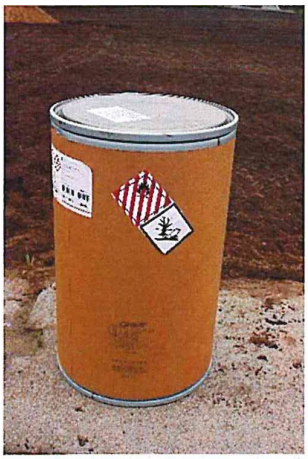
GHS or CLP regulations.

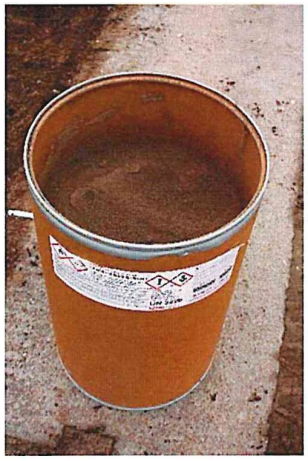
For substances, Test Series 5 consists of three test procedures 6 (a), 6 (b) and 6 (c), with these test procedures carried out in alphabetical order.

Test procedure 6 (b) can be dispensed with if the outer part of the package is not damaged by internal detonation and/or ignition or if the test substance inside the package explodes so weakly that it is possible to exclude the risk of transfer to another package.

Test procedure 6 (c) is a test with packages containing an explosive substance, used to determine whether there is a mass explosion or danger from hazardous projectile material, heat radiation and/or intense combustion or other hazardous effects when exposed to external fire.

The test substance "CHEMLOK QDO GROUND" (2.23/ 291019/01), batch 0011962172 was packaged as follows:





45.4 kg of test substance is packed into a cardboard container (1 G).

The container is closed using a clamping ring.

3.10.1 *Test procedure 6 (a)*

In test procedure 6 (a), a test with a single package is carried out to determine whether a mass explosion takes place under confinement.

Testing with a detonator was not necessary, since the test substance "CHEMLOK QDO GROUND" in test procedure 1 (a) showed a negative result and is not capable of transmitting a detonation.
The ignition test was not omitted, since the test substance "CHEMLOK QDO GROUND" in test procedure 2 (c) (i) showed a negative result in terms of the test procedure (32 ms) but the measured value in the limit range was positive (time for pressure increase from 590 kPa to 2070 kPa (overpressure) less than 30 ms).

For confinement a single package was placed in a hole in the ground on a steel test plate on the ground and a detonator was inserted into the test substance. The lid was closed and the hole was filled in with sand.

After the ignition was triggered, the test substance burned quickly with heavy flames and smoke.

After combustion, the packaging showed that the clamping ring on the cardboard container had opened and the test substance had burned completely.
The cardboard container was not destroyed, but it was burnt in some places.
The test plate was not damaged.

Test procedure 6 (b) was able to be dispensed with, due to the clear result from test 6 (a).

3.10.2 *Test procedure 6 (c)*

3.10.2.1 *External fire test*

For this test, 3 packages of the test substance "CHEMLOK QDO GROUND" (2.23/ 291019/ 01) were used, to determine whether the test substance packaged as shipped would produce a mass explosion or a hazard from hazardous heat radiation and/or intense combustion or other dangerous effects. Substances that are not produced for the purpose of generating explosive or pyrotechnic effects, may also be exempt, on the basis of the results from test procedure 6 (c), from inclusion in Class 1 of the Hazardous Goods Regulations or from the Hazard Class "Explosive substances/mixtures and products containing explosive substances".

Due to the packaging, it was not possible for any metal fragments/projectile material or similar to be produced, and therefore no test screens were used.

In order to assess the thermal effects, heat radiation was measures using 4 heat radiation sensors (range 2 kW/ m_2 or 10 kW/ m_2 of which were located at measured distances of 20 m and 25 m from the front edge of the metal tub.

On a metal grating (height 1.0 m), standing in a metal tub, 3 shipping packages containing 45.4 kg of the test substance (total mass 136.2 kg) were placed with wood stacked underneath.

Wood shavings were inserted between the wooden slats and soaked with a gasoline/diesel mixture.

Test set-up for external fire test, full fire phase (maximum flame) after ignition.

The fire took place quickly, with a high level of soot generation. During the burning, several substances were emitted. The burning time was approximately 130 s for 136.2 kg of test substance.

3.10.2.2. Heat radiation analysis

Assessment criteria for thermal effects are the burning time and the heat radiaiton at distances of 15 m and 5 m. Heat radiation is measured for a period of 5 s during the period of maximum heat development. Heat radiation assessment criteria for different masses, in accordance with the UN Manual of Tests and Criteria, seventh revised edition, 2019, Table 16.2, are presented in Diagram 1.

Heat flow in kW/m²

Mass in kg

Diagram 1.: *Heat flow comparisons for different masses*

The graph of heat flow comparison values for different masses results in a heat radiation criterion of 4.9 kW/m² for a mass of 136 kg.

Intensity I, Distance 15 m, in W/m²

Time t, in s

Diagram 2.: *Total heat radiation is calculated at a distance of 15 m, smoothing was applied to the graphs.*

The graph of heat flow comparison values for different masses results in a heat radiation criterion of 4.9 kW/m² for a mass of 136 kg.

Intensity I, Distance 5 m, in W/m²

Time t, in s

Diagram 3.: *Total heat radiation is calculated at a distance of 5* m, *smoothing was applied to the graphs.*

Intensity I, Distance 5 m, in W/m²

Time t, in s

Diagram 4: *Detailed view of total heat radiation values calculated at a distance of 5* m, *smoothing was applied to the graphs.*

In order to better assess the contribution of the support fire (stacked wood) to the total heat radiation, a separate stack of wood (support fire) , identical in structure, but without any packages, was burned and its heat radiation was measured at distances of 5 m, producing 2.0 kW/m^2 and 15 m producing
0.5 kW/m^2 .

Based on the proportion of the contribution of the wood fire and the heat flow comparison values for different masses (Diagram 1) a total heat radiation of 5.4 kW/m^2 is obtained for 136 kg of test substance at a distance of 15 m, and at a distance of 5 m a total heat radiation of 6.9 kW/ m^2; this corresponds to 4.9 kW/m^2 for 136 kg of test substance (without the wood fire proportion) at a distance of 15 m and 5 m. Diagram 2 shows that, at a distance of 15 m, the total heat radiation is less than 5.4 kW/ m^2 .

The limit value of 6.9 kW/m^2 (total heat radiation) at a distance of 5 m is shown in Diagrams 3 and 4, labelled (a).

On the basis of Diagrams 3 and 4 it can be seen that at a distance of 5 m, the value for total heat radiation of 6.9 kW/m^2 is significantly exceeded.

6 Assessment of test results

The DSC measurements identify the test substance "CHEMLOK QDO GROUND" as high in energy.

The test substance "CHEMLOK QDO GROUND" proved not to be sensitive to friction with friction pin load of 360 N, but is sensitive to impact at an impact energy of 40 J.

The test substance "CHEMLOK QDO GROUND" proved to be thermally sensitive when heated under confinement with a nozzle diameter of 2.0 mm.

The substance "CHEMLOK QDO GROUND" has therefore proven to be explosive in accordance with test procedure A.14 of the regulations (EC) No. 440/2008 and the Explosives Act.

The test substance "CHEMLOK QDO GROUND" was not detonated in the UN GAP test 1(a) when initiated with a booster.

In the time-pressure bomb, the substance "CHEMLOK QDO GROUND" in accordance with UN test 1 (c) (i) shows a positive result, i.e. the substance is capable of deflagration in principle. The time for the pressure increase
is however more than 30 ms and the test substance is not capable of rapid deflagration, according to UN test 2 (c) (i).

The test substance "CHEMLOK QDO GROUND" showed a deflagration rate representing "yes, fast" (worst case) according to UN test C.2.

The test substance "CHEMLOK QDO GROUND" showed a "low" result according to UN test E.2.

The test substance "CHEMLOK QDO GROUND" showed a "low" result according to UN test F.3; the explosive force is low.

Test procedure 6 (a) showed no evidence of a mass explosion for the test substance "CHEMLOK QDO GROUND".

Test procedure 6 (c) showed no signs of explosion and no potentially hazardous projectile material for the test substance "CHEMLOK QDO GROUND".
The risks arising from thermal effects must therefore be assessed with regard to the classification in a subclass/category or exemption from that class.

Thermal effects are assessed on the basis of heat radiation at distances of 15 m and 5 m or by burning time.

The following criteria are to be applied for classification under subclasses 1.3 or 1.4:

1.3 the burning time measured for 100 kg net mass of the test substance is less than 35 s or for low-energy substances: heat radiation at a distance of 15 m exceeds that of the fire by more than 4 kW/m² (4.9 kW/ m_2 for a net mass of 135 kg) .

1.4 the burning time measured for 100 kg net mass of a substance is less than 330 s or the heat radiation at a distance of 5 m exceeds that of the fire by more than 4 kW/ m² (4.9 kW/ m_2 for net mass of 135 kg).

At a distance of 15 m, heat radiation for 135 kg of the test substance "CHEMLOK QDO GROUND" was less than 4.9 kW/ m².

At a distance of 5 m, however, heat radiation for 135 kg of the test substance "CHEMLOK QDO GROUND" clearly exceeded 4.9 kW/m².

The burning time for 135.2 kg of the packaged test substance "CHEMLOK QDO GROUND" was 130 s and is therefore less than 355 s but greater than 39 s (burning time criteria corrected to 135 kg in accordance with the UN Manual of Tests and Criteria, 7th revised edition, 2019, Table 15.2).

The test substance "CHEMLOK QDO GROUND" in tested packaging, is assigned to Class 1, subclass 1.4, compatibility Group C of the Hazardous Goods Regulations or Hazard Class "Explosive substances/mixtures and products containing explosive substances", subclass 1.4 of the CLP regulations or GHS.

7 Expert Assessment

The DSC measurements identify the test substance "CHEMLOK QDO GROUND" as high in energy.

Exothermic decomposition starts at about 230°C, so the substance is sufficiently thermally stable to not be assigned to subclass 4.1 "Self-reactive substances" of the Hazardous Goods Regulations or Hazard Class "Self-reactive substances and mixtures" of the CLP regulations or GHS. Test substance "CHEMLOK QDO GROUND" is also thermally stable in accordance with UN test 3 (c) at 75°C .

The substance "CHEMLOK QDO GROUND" contains chemical groups that indicate possible explosive properties and its exothermic decomposition energy is about 2000 J/g so significantly higher than 500 J/g.

According to Appendix 6 of the UN test manual, the acceptance procedure for explosive substances should therefore be carried out, since the substance "CHEMLOK QDO GROUND" may potentially be classified in Class 1 of the Hazard Goods Regulations or Hazard Class "Explosive substances/mixtures and products containing explosive substances" of the CLP regulations or GHS.

The acceptance procedure for explosive substances comprises test series 1 and 2; to decide whether a substance is not sensitive enough to need to be assigned to Class 1 of the Hazardous Goods Regulations or to Hazard Class
"Explosive substances/mixtures and products containing explosive substances" in the regulations (EC) no. 1272/2008 (CLP regulations) or GHS, test series 2 is used.

Test series 1 and 2 include the following properties to be tested:

(a) capacity to transmit detonation
(b) effect when heated under defined inclusion
(c) capacity for deflagration.

The substance "CHEMLOK QDO GROUND" gave the following results:

(a) "-" (negative), not able to transmit detonation (UN test 1 (a));
(b) "+" (positive), effect when heated under defined inclusion (UN test 2 (b));
(c) "-" (negative), no ability for rapid deflagration (UN test 2 (c) (i)).

Based on its effect when heating under defined inclusion, "CHEMLOK QDO GROUND", in accordance with test series 2, is not too insensitive for possible classification in Class 1 of the Hazardous Goods Regulations or Hazard Class "Explosive substances/mixtures and products containing substances" of the CLP regulations or GHS.

The substance "CHEMLOK QDO GROUND" therefore had to be subject to the procedure for classification in a subclass/category in accordance with Figure 10.2 of the UN Test Manual.

As the substance, in accordance with the test series 3, is thermally stable and sufficiently mechanically insensitive at 75°C, in accordance with test series 6 it is classified in Class 1 of the Hazardous Goods Regulations or the Hazard Class "Explosive substances/mixtures and products containing substances" (CLP regulations/GHS).

Based on the results of test series 6 the substance "CHEMLOK QDO GROUND", packaged as described in 3.10, impedes fire-fighting in the immediate vicinity, due to heat radiation/rapid burning; it is classified in subclass 1.4, compatibility group C.

According to Directive 2014/28/EU from the European Parliament and Council of 26 February 2014 on harmonisation of Member State laws concerning marketing and control of explosives for civil use, explosive substances and items considered as explosive substances under the "United Nations recommendations on transport of Hazardous Goods" are classified in Class 1 according to these recommendations.

Based on this directive, the substance "CHEMLOK QDO GROUND" in the packaging described is therefore an explosive in accordance with directive 2014/28/EU and also in accordance with Section 3 (1), no.2 of the German Explosives Act.

It is necessary to comply with the provisions of the German Explosives Act applicable to explosives and the European rules on provision of explosives on the EU market.

Federal Institute for Materials Research and Testing (BAM)
12200 Berlin

Berlin, 07.05.2020

Section 2.2 "Reactive substances and substance systems"

on behalf

(Dienstsiegel)

Dr. Heike Michael-Schulz
Government

Dr. Marcus Malow
Oberregierungsrat

Distributor: 1. Copy: Applicant
2. Copy: BAM

* We confirm that this expert assessment has been prepared to the best of our knowledge and understanding, and is impartial and free of any instruction results. BAM reserves the right to make subsequent changes, additions and, if necessary, to revoke the expert assessment as necessary (e.g. because of significant new information).

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Section 2.2
"Reactive substances and substance systems"

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marcus.malow@bam.de

Your reference: -
Your message dated: 12.04.2019

Our reference: 19019049 Our message dated: -

Date: 07.05.2020

"CHEMLOK QDO"

Dear Mrs. Aumann,

we are sending you the classification of the substance "CHEMLOK QDO GROUND" as requested by letter dated 12.04.2019 in accordance with the Hazardous Goods Regulations.

Notification of the cost will be sent in a separate communication.

Best regards,

on behalf of

[signature]
Dr. Marcus Malow

Appendix