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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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Item 2 (e) of the provisional agenda
Explosives and related matters: miscellaneous

Determination of impact sensitiveness using the Modified Bureau of Mines (MBOM) Impact Machine

Transmitted by the expert from the United States of America[1]

Introduction

1. Sensitiveness of a substance to impact stimuli must be determined to ensure the safety of people and protection of property during shipment.

2. The modified Bureau of Mines (MBOM) impact machine is a device that determines the impact sensitivity of a solid, semisolid, liquid, or powder substance using a sample of approximately 30 mg. The name has been derived from the fact that the machine has been modified from the original test to eliminate the use of sample cups, reduce the weight of the drop mass, lower the maximum drop height, and include a catch mechanism to prevent the sample from receiving a second strike during impact. The modified machine consists of an anvil upon which the sample is placed, an intermediate hammer of known contact area that rests on the top of the sample, and a falling drop mass that strikes the intermediate hammer. Impact energy is imparted to the intermediate hammer by a constant mass dropped from a variable height. The amount of energy imparted to the sample is controlled by the drop height. Initiation is observed by an audible report or production of smoke, fire, charring or visible light.

Discussion

3. Including the MBOM impact machine within the Manual of Tests and Criteria to determine the impact sensitivity of a substance would be advantageous for the following reasons:

[1] In accordance with the programme of work of the Sub-Committee for 2013-2014 approved by the Committee at its sixth session (refer to ST/SG/AC.10/C.3/84, para. 86 and ST/SG/AC.10/40, para. 14).

(a) The MBOM impact machine has a well-documented design that has been refined and standardized over 40 years. The current design implements features to improve the quality and repeatability of the sensitivity data.

(b) The MBOM impact machine has been used extensively by many United States of America and international laboratories to characterize impact sensitivity of substances. These laboratories include the following:

(i) Dugway Proving Grounds

(ii) Naval Air Warfare Center - China Lake (United States of America Navy)

(iii) U.S. Naval Research Laboratory

(iv) Air Force Research Laboratory-Tyndall Air Force Base (United States of America Air Force)

(v) Federal Bureau of Investigation/Rocky Mountain Scientific Laboratory

(vi) Radford Army Ammunition Plant (United States of America Army)

(vii) Lake City Army Ammunition Plant (United States of America Army)

(viii) United States of America Naval Sea Systems Command (NAVSEA) - Allegany Ballistics Laboratory

(ix) Alliant Techsystems (ATK) – Bacchus, Promontory, Elkton

(x) Australian Department of Defence / Thales Group

(c) The MBOM impact machine can produce data at a rate similar to other tests currently used to determine impact sensitivity. Only six trials are required to determine whether a substance is too dangerous for transport (screening test) similar to the other Series 3 (a) test methods. The machine design can also facilitate operational automation.

(d) The MBOM impact machine simulates a true impact scenario that is free from confinement. This configuration eliminates thermal variables that may be introduced when a confined sample is tested.

(e) The contact surfaces between the anvil and intermediate hammer insert are required to have a specific surface finish or surface roughness. Additionally the contact area is of constant size that must be verified prior to testing. These two factors ensure consistency between trials. The contact surfaces are designed to be refurbished and reused, in accordance with a standardized procedure. This configuration yields a controlled and repeatable impact stimulus.

(f) The critical aspects of the MBOM impact machine have been standardized via the Explosives Testing Users' Group (ETUG) including machine operation, calibration, and sample preparation procedures, along with defined reaction types. The ETUG is an international group of explosives testing experts with a charter to systematically minimize the variability associated with energetic materials testing to enable consistent/repeatable test data and interpretation of test results.

(g) The MBOM impact machine allows for broader use of the data to determine the safety of people and protection of property during all stages of transport, handling and use of the material. The MBOM impact machine has been used by multiple engineering firms and national laboratories to express the impact results in calibrated engineering units based on empirical data (J/m^2 for solids, J/s for liquids)

that take into account the impact area and any energy losses. Data expressed in these calibrated engineering units are compared to the in-process values for a given process to determine risk.

Proposal

4. It is proposed to include the MBOM impact machine in the Test Series 3 (a) impact sensitivity options titled Test Series 3 (a) (vii), as follows:

"13.4.7 Test 3 (a) (vii): Modified Bureau of Mines impact machine test

13.4.7.1 *Introduction*

This test is used to measure the sensitiveness of the substance to drop-mass impact and to determine if the substance is too dangerous to transport in the form tested. The test substance is subjected to a vertical impact force through an intermediate hammer via a drop mass. It is applicable to solid, semisolid, liquid, and powder substances.

13.4.7.2 *Apparatus and materials*

13.4.7.2.1 The general design of the MBOM impact test apparatus is given in Figure 13.4.7.1. The following components are required:

A mechanism containing a drop mass of 2.0 kg (4.4 lbs.), two drop mass guide rails, a drop mass holding, lifting, and dropping mechanism, and a 1.02 kg (2.25 lbs.) intermediate hammer containing a 1.27 cm (0.5 in) diameter steel insert with a surface roughness of 1.27 – 1.78 µm (50 – 70 µin) that is resting on a sample placed on an steel anvil (impact surface 3.81 cm (1.5 in) diameter) with a surface roughness of 1.27 – 1.78 µm (50-70 µin). Details of the target area are given in Figure 13.4.7.2.

13.4.7.3 *Procedure*

13.4.7.3.1 Solid sample placement

As a rule substances are tested in the form in which they are received. Wetted substances should be tested with the minimum quantity of wetting agent required for transport. Depending on the physical form, the substances should then be subjected to the following procedures:

(a) Powders are to be tested on the anvil in a monolayer; i.e., the thickness of the granular material. Place enough granules on the anvil to cover an area in excess of the 1.29 cm^2 (0.2 in^2) area of the insert.

(b) Solid propellants are tested in the form of thin, uniform slices. The slices are usually square, having a minimum edge length of 1.587 cm (0.625 in) and a thickness of 0.084 ± 0.01 cm (0.033 ± 0.004 in). This thickness is easily obtainable with the use of a microtome cutting tool.

The intermediate hammer is raised. The test substance is placed centrally on the anvil. The intermediate hammer is then carefully lowered onto the substance on the anvil.

13.4.7.3.2 Liquids and semisolids sample placement

Depending on the physical form, the substances should then be subjected to the following procedures:

(a) Liquids are tested with a controlled thickness and a fixed gap of 0.05 cm (0.02 in) above the liquid level using a spring between the hammer collar and the guide collar (adjustable tension). The thickness of the liquid sample is controlled by putting a piece of 0.015 cm (0.006 in) thick tape (compatible with the substance) with a 1.587 cm (0.625 in) diameter hole in it on the anvil. The intermediate hammer is raised. The hole in the tape is centrally positioned on the anvil such that the intermediate hammer insert does not touch the tape. A 0.05 cm (0.02 in) feeler gauge is used to set the proper gap above the liquid. The tape hole is filled with the liquid substance and levelled-off using a straight-edge ensuring that no air gaps are present in the sample. The intermediate hammer is then carefully lowered to 0.05 cm (0.02 in) above the substance on the anvil.

(b) Semisolids (slurries, gels, etc.) are prepared and tested in much the same way as liquid samples; however, the sample thickness is governed by the largest particle size. If the largest particle size is greater than the 0.015 cm (0.006 in) thickness then a monolayer sample is spread on the anvil in a monolayer; i.e., the thickness of the granular material. If the cohesive properties of the semisolid are not practical for a 0.015 cm (0.006 in) thickness, then the minimum attainable thickness is used. Place enough granules on the anvil to cover an area in excess of the 1.29 cm^2 (0.2 in^2) area of the intermediate hammer insert.

13.4.7.3.3 Machine operation

The drop mass is raised to the desired height (17 cm (6.7 in) for solids and semisolids and 11 cm (4.3 in) for liquids) and released to drop onto the intermediate hammer. Observations are made on whether a "reaction" occurs as evidenced by audible report or production of smoke, fire, charring or visible light as observed by human senses. The type of reaction that occurs is documented. The surfaces are cleaned with a cloth or light abrasive pad to remove any residual material from the anvil or intermediate hammer insert. The anvil and intermediate hammer insert are inspected for scratches, scoring, divots, or other damage which may affect the surface roughness. If damaged these items should be replaced before use on the next trial. Six trials are performed for each test sample.

13.4.7.4 *Maintenance and calibration*

Moving parts should be inspected to ensure that they are freely moving and that friction between them is minimal. The distance between the drop mass and the intermediate hammer that is resting on the anvil should be verified. The contact area between the intermediate hammer insert and anvil should be uniform. The test machine should be periodically cleaned and calibrated according to a schedule based on the amount of usage. At a minimum, the machine should be calibrated on an annual basis.

13.4.7.5 *Test criteria and method of assessing results*

13.4.7.5.1 Solids

The test result is considered "+" if a reaction (see 13.4.7.3.3) is observed in at least 1 out of 6 trials at a drop height of 17 cm and the substance is considered too dangerous for transport in the form in which it was tested. Otherwise,

the result is considered "–". Borderline cases may be resolved using the Bruceton method (see Appendix 2).

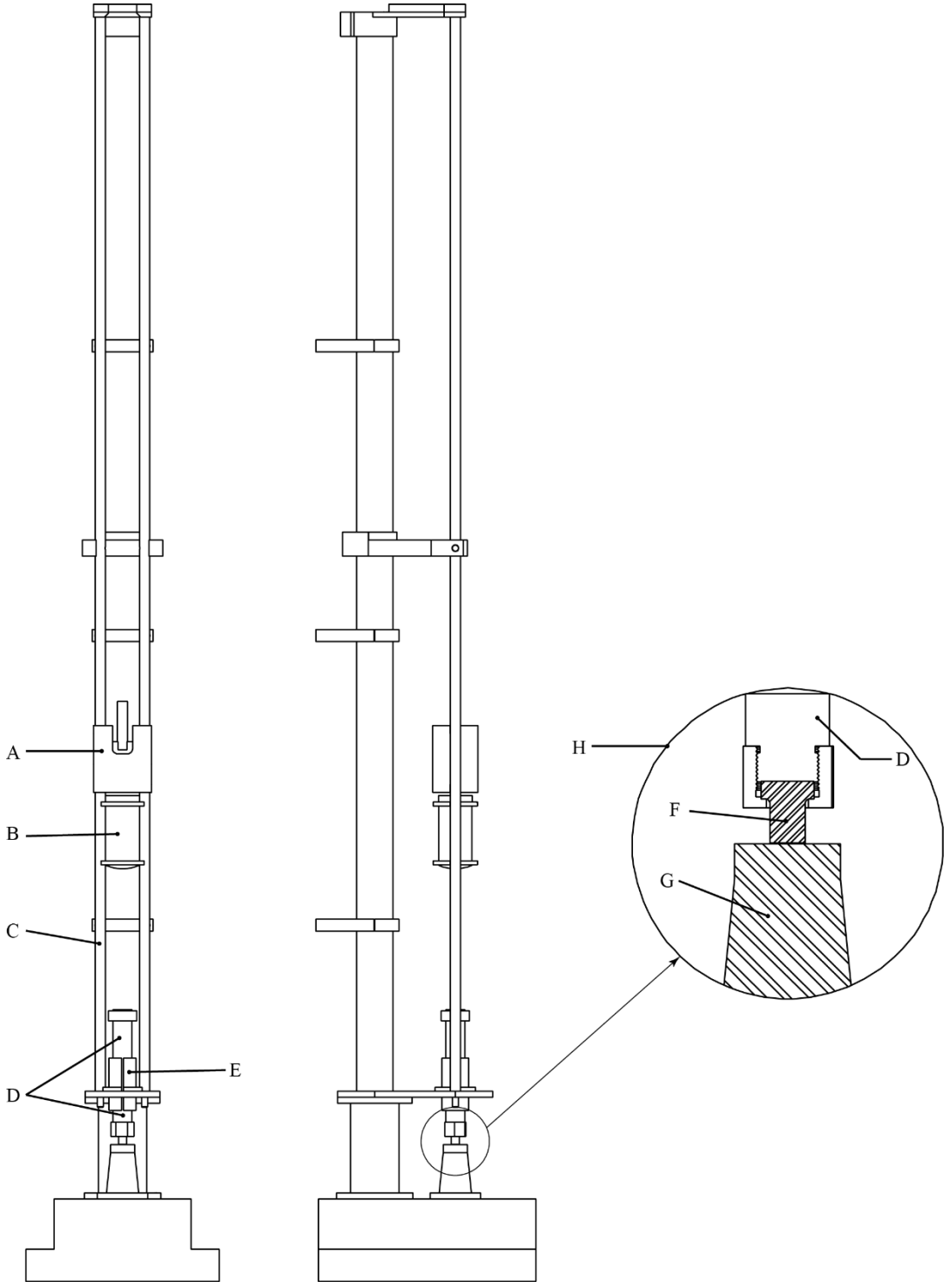
13.4.7.5.2 Liquids

The test result is considered "+" if a reaction (see 13.4.7.3.3) is observed in at least 1 out of 6 trials at a drop height of 11 cm and the substance is considered too dangerous for transport in the form in which it was tested. Otherwise, the result is considered "–". Borderline cases may be resolved using the Bruceton method (see Appendix 2).

13.4.7.6 *Examples of results*

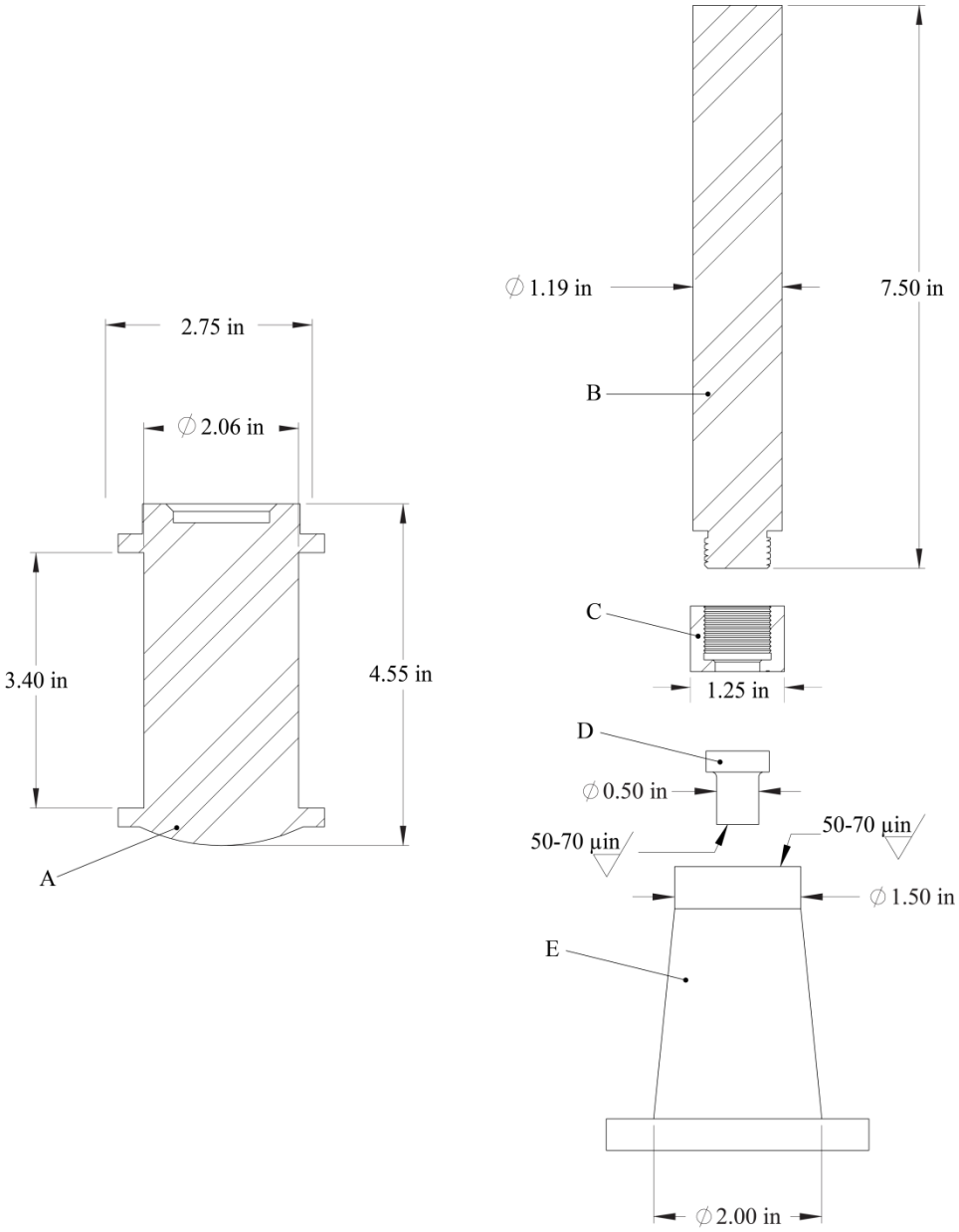
Substances[1]	**Result**
RDX (dry)	+
PBXN-8	–
Nitrocellulose/DNT (90/10)	–
PETN (dry)	+
Nitroglycerin	+

[1]Data acquired at relative humidity of 10-30% and temperature of 60-75 °F



(A)	Drop mass lifting, holding, and dropping device	(B)	Drop mass
(C)	Drop mass guild rails	(D)	Intermediate hammer
(E)	Intermediate hammer guide	(F)	Intermediate hammer insert
(G)	Anvil	(H)	Magnified view of target area

Figure 13.4.7.1: MBOM Impact machine



(A)	Drop mass
(B)	Intermediate hammer
(C)	Intermediate hammer insert retaining nut
(D)	Intermediate hammer insert
(E)	Anvil

Figure 13.4.7.2: MBOM Impact machine drop mass and target area detail"