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

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Explosives and related matters: test series 8

Recommendation on miscellaneous changes to 18.5 Series 8 Type (b) Test prescription in the Ammonium Nitrate Emulsions, Suspensions and Gels: Series 8 Test (b

Transmitted by the Institute of Makers of Explosives

I. Introduction

1. The Institute of Makers of Explosives is proposing a number of changes to Section 18.5. of the United Nations Committee of Experts Recommendations on the Transport of Dangerous Goods Manual of Tests and Criteria 5th Revised Edition (ST/SG/AC.10/11/Rev.5 – referred to subsequently in this note as MTC5). These are detailed in separate notes and include recommendations on modifications to: (*i*) the PMMA spacer; (*ii*) the steel confinement tube specifications; and (*iii*) the use of 50/50 pentolite boosters.

2. In the course of the examination of TS8(b), suggestions for a range of miscellaneous changes have also become apparent, and the aim of this report is to recommend:

- Correction of two barrier pressure entries in the gap test calibration data;
- Amendments to the specification of the mild steel witness plate;
- Amendments to the use of a cardboard tube for assembly of the test; and

II. Discussion

3. The TS8(b) in MCT5 appears to have evolved almost directly[1] from MTC's TS7(b), which was developed with only minor modifications from the Naval Surface Warfare Center Expanded Large Scale Gap Test (NSWC ELSGT)[2], which in turn grew from the original standardised Naval Ordinance Laboratory Large Scale Gap Test (NOL LSGT). In all Gap Tests, the role of the donor is to generate a shock pressure that after partial attenuation by the gap material, delivers a specified shock pressure to the confined test material.

[1] Michael M. Swisdak, Jr., "Hazard Class/Division 1.6: Articles Containing Extremely Insensitive Detonating Substances (EIDS)", *NSWC TR 89-356*, Naval Surface Warfare Center, 1 December 1989.

[2] T.P. Liddiard and D. Price, "The Expanded Large Scale Gap Test", NSWC TR 86-32, Naval Surface Warfare Center, March 1987.

4. Gap test shock pressure has been measured in a number of studies. In the NSWC LSGT, Tasker and Baker[3] calibrated the shock pressure in the PMMA attenuator against distance using donors comprised of two half-length pressed 50/50 Pentolite pellets of density = 1.56 g/cm^3. Table 1 shows the measured variation in shock pressure with PPMA (attenuator) thickness. An associated NATO version of the Gap Test, the STANAG-4488 was subsequently developed with only minor changes from the NSWC ELSGT[4]. The published results from the defining testing program for STANAG-4488 provide experimental PMMA shock pressure versus distance data for RDX/Wax/Graphite donors, but also provide calibration data for a Pentolite donor, evidently copied from the original NSWC report[3]. However a series of transposition errors were introduced and are highlighted in Table 1. As will be shown, these copying errors have been perpetuated in subsequent related gap test procedures, but occurred only in the tabulated version of Table 3 of Annex C to STANAG-4488, with the plotted version of the same Table being correct. Hence it is possible to track the original source of these errors to the anonymous author of STANAG-4488.

5. In TS8(b) of MTC5, calibrations for pressures in the PMMA attenuator are provided at 5 mm intervals for both the 50/50 Pentolite and RDX/Wax/Graphite donors. It appears highly likely that these calibrations have been copied from the STANAG-4488 document[5] and not from the original NSWC source documents[3]. As can be seen in Table 1, the same errors from STANAG-4488 also appear in the Pentolite column of the calibration Table 18.5.1.1 in MTC5 for TS8(b). The plotted version of the Pentolite calibration in Figure 18.5.1.2 of MTC5 for TS8(b) is also in error. Furthermore, the alternative calibration provided for TS8(b) is for an RDX/Wax/graphite donor (as described in STANAG-4488), despite the TS8(b) procedure specifying only RDX/Wax without the graphite. Fortunately, these errors in MTC5 are of no consequence whatsoever, as no use is made of these erroneous calibrations in the test procedure or its criteria.

6. It should be noted that in contrast, the entry on TS7(b) in MTC5 makes no mention of the pressures in the PMMA attenuator.

[3] Douglas G. Tasker and Robert N. Baker, Jr., "Experimental Calibration of the NSWC Expanded Large Scale Gap Test", *NSWCDD/TR-92/54*, Naval Surface Warfare Center, January 1992.

[4] J. Isler, "Classification Tests For Assignment to Hazard Class/Division 1.6: SNPE Two Years Experience", *25th US Department of Defence Explosive Safety Board Seminar*, Anaheim CA, August 1992, pp. 419-441.

[5] J. H. Erikson, "Explosives, Shock Sensitivity Tests", *NATO Standardization Agency Agreement STANAG 4488*, Edition 1, 12 September 2002.

Table 1. Section of ELSGT calibration curve using 50/50 Pentolite donor showing transposition copying error in STANAG-4488 and its flow-on to UN TS 8(b).

Attenuator thickness (mm)	PMMA shock pressure (GPa)		
	Tasker and Baker[3]	STANAG-4488[5]	UN TS8(b) from MTC5
50	5.18	5.18	5.18
51	5.13	5.13	
52	5.08	5.08	
53	5.03	5.03	
54	4.98	4.98	
55	4.91	4.76	4.76
56	4.83	4.68	
57	4.76	4.60	
58	4.68	4.51	
59	4.60	4.41	
60	4.51	4.31	4.31
61	4.41	4.22	
62	4.31	4.31	
63	4.22	4.22	
64	4.13	4.13	
65	4.02	4.02	4.02
66	3.91	3.91	
67	3.80	3.80	
68	3.70	3.70	
69	3.61	3.61	
70	3.53	3.53	3.53

7. The TS8(b) also introduces a number of miscellaneous variations that appear to be inconsistent with the intent of that test, and also from the intent of predecessing and related gap tests in MTC5 and elsewhere. For example TS8(b) specifies the use of cardboard tube to align the donor, attenuator, steel tube, and test substance components of the test, and also provide good contact between adjacent sections. Practical experience gained by the authors while performing many tests has shown that it is not feasible to ensure the desired good contact between the various components when slid down inside an opaque cardboard tube. Superior contact can be ensured by starting with the filled steel tube standing on the witness plate, and then taping each successive component up the train securely to its predecessor. It should be noted that the assembly description in MTC5 for the TS1(a) and 2(a) gap tests do not require an alignment tube. Furthermore, the original predecessor tests, (NSWC ELSGT[2]) makes no mention of cardboard alignment tubes.

8. The predecessors for the TS8(b) gap test, namely the NOL LSGT, the NSWC ELSGT and the NATO ELSGT do not quote any specific mechanical properties for the witness plate in the test. Neither do the tests TS1(a) and TS2(a) in MTC5 define specific mechanical properties. The witness plates are required to be “mild steel”, and the width, length and depth dimensions defined. In the case of the NSWC ELSGT and NATO ELSGT, a negative “–” result is defined as:

9. "An undamaged plate, broken plate, or one with a poor quality hole is considered to indicate that detonation was not initiated in the sample, and the result is noted as "-"."

III. Recommendations for Test Changes

3.1. Recommendation on the gap test calibration data and correction of two barrier pressure entries in that calibration data

10. It is recommended preferably that Table 18.5.1.1 be removed entirely. No use is made of these (currently erroneous) calibrations in the test procedure or its criteria. This would bring the entry for TS8(b) into agreement with that of TS7(b) in MTC5, which in contrast, makes no mention of the pressures in the PMMA attenuator.

11. If Table 18.5.1.1 must remain, then it is recommended that two entries in Table 18.5.1.1 be corrected for the Pentolite 50/50 donor, and Figure 18.5.1.2, be redrawn.

12. According to the original NSWC ELSGT calibration performed by Tasker and Baker[3], the barrier pressure for the 55 mm gap should read 4.91 GPa, not 4.76 GPa. The barrier pressure for the 60 mm gap should read 4.51 GPa, not 4.31 GPa. Again it should be noted that this correction makes no material difference to the test method or results.

3.2. Recommendation regarding the specification of the mild steel witness plate.

13. It is recommended that Section 18.5.1.2.1 (f) is modified to read:

"Mild steel plate, 200 mm × 200 mm × 20 mm;"

14. This modification, dropping any reference to specific mechanical properties, would bring the steel used for the TS 8(b) gap test into alignment with the steel used for the TS1(a) and 2(a) gap tests, as well with the steel used during the development of their predecessors, namely the NOL LSGT, the NSWC ELSGT and the NATO ELSGT.

3.3. Recommendation regarding the use of a cardboard tube for assembly of the test.

15. It is recommended that Section 18.5.1.2.1 (g) be deleted completely. This recommendation arises from practical operational experience conducting numerous TS8(b) tests for ammonium nitrate emulsions, that have found the most effective way to satisfy the need for good contact between the various test components to be to stand the filled steel tube on the witness plate, and then tape each successive component up the train securely to its predecessor. This modification would bring the assembly of the TS8(b) gap test into alignment with the assembly for the TS1(a) and 2(a) gap tests (where no alignment tube is required), as well with the assembly of its direct predecessor, namely the NSWC ELSGT. It also brings the materials list into alignment with paragraph 18.5.1.3.1 and with Figure 18.5.1.1, neither of which mentions a cardboard tube at all.

16. In addition, it will subsequently be necessary to modify section heading 18.5.1.2.1 (h) to be 18.5.1.2.1 (g), accounting for the deletion of one paragraph.