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 the use of cold-drawn, seamless carbon steel tube for confinement in the Ammonium Nitrate Emulsions, Suspensions and Gels: Series 8 Test (b)

Transmitted by the Institute of Makers of Explosives

I. Introduction

1. Section 18.5.1.2.1 (c) 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), specifies “tubing, steel, cold drawn seamless” with the particular mechanical properties of tensile strength 420 ± 84 GPa, elongation of 22 ± 4.4 %, and Brinell hardness of 125 ± 25. The tube also has specified dimensions of 95 mm outer diameter, 11.1 mm wall thickness ± 10% variations, by 280 mm long.

2. Steel tube with these physical properties has proven difficult to source locally in Australia. For example, tubes can either be sourced with appropriate tensile strength and elongation, but slightly lower Brinell hardness (BH~80); or with acceptable elongation and surface hardness, but higher tensile strength (~750 MPa). Furthermore, the specified wall thickness limits exclude a logical wall thickness of 0.5 inches (12.70 mm) by 0.49 mm. The aim of this report is to recommend the alternative use of *cold-drawn, seamless, carbon steel tube* and to allow ± 15% variations in wall thickness. This material has been found to be more readily available.

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). For that transition, most test dimensions were doubled, with the major exception being the donor pellet diameter whose size increase was limited to a factor of only 1.875 due to

[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.

limitations in the size of available larger pressing moulds. The witness plate thickness was doubled, but its area was not "because of handling problems" associated with the greater mass to be manhandled. This doubling enabled the test to be applied to test materials with confined critical diameters up to 73 mm, which was deemed suitable for the vast majority of IHE of interest to military applications.

4. In the definition of the NOL LSGT[3], the confining steel tubes were described as being "cold drawn, mechanical steel (MT-1015) seamless tube" but were otherwise unspecified. The mechanical properties of the steel were never mentioned or specified. Price *et al*.[3] examined the effect of changing the tube confinement material in the NOL LSGT on the critical gap for 50% initiation of a cast donor (Composition B), where the critical gap measured the transition between a punctured ("+" result) and un-punctured ("-" result) witness plate in the test. In that study[3], two confinement types were tested by using tubes manufactured from lead and from mild steel. The results showed a critical gap length equivalent to 51.05 mm of PMMA spacer measured for mild steel confinement, compared with a gap of 51.82 mm of PMMA spacer for lead tube. Since the inherent scatter in the gap tests measurements was found to be ± 0.5 mm of PMMA spacer, this meant that there was *no functional difference between such extremes as steel tube or lead tube confinement*. Evidently the precise mechanical properties of the metals did not influence the outcome of the gap tests. Clearly, the developers of the NSWC ELSGT did not believe the mechanical properties of their steel tubes influenced the outcomes of their gap tests. Indeed, they had good reason for this belief, since the ultimate tensile strength of lead is about 0.012 GPa[4], roughly four orders of magnitude less than that of mild steel. It should also be noted that the hardness of lead is also orders of magnitude lower than that of steel, allowing lead to be scratched by a fingernail.

5. Table 1 shows a comparison of the mechanical properties of tubes used in the gap tests described above. For the NOL LSGT, the mechanical properties listed for the 1015-grade steel are shown in square brackets, and have sourced from current literature[5]. Defining specific mechanical properties of the mild steel referenced in the NSWC ELSGT and the carbon steels in MTC5's TS 1(a) and 2(a) gap tests is more difficult, however they would be expected to be similar to those of the NOL LSGT.

[3] D. Price, A.R. Clairmont, Jr., and J.O. Erkman, "The NOL Large Scale Gap Test. III. Compilation of Unclassified Data and Supplementary Information for Interpretation of Results", *NOLTR 74-40*, Naval Ordnance Laboratory, 8 March 1974.

[4] "Ultimate tensile strength", http://en.wikipedia.org/wiki/Ultimate_tensile_strength, accessed 17/11/2010.

Table 1: Mechanical properties of the steel tubes used in related gap tests.

Property	NOL LSGT	NSWC ELSGT	UN TS 1(a)/2(a)	UN TS 7(b)/8(b)
Description	Cold drawn, mechanical MT-1015.	Cold drawn, mild.	Cold drawn, seamless carbon steel.	Cold drawn seamless.
Ultimate tensile strength (GPa)	[386][5]	None specified or guaranteed.	None specified or required.	420 ± 84
Yield stress (GPa)	[284][5]	None specified or guaranteed.	None specified or required.	None specified.
Elongation (%)	[37.0][5]	None specified or guaranteed.	None specified or required.	22 ± 4.4
Brinell hardness	[111][5]	None specified or guaranteed.	None specified or required.	125 ± 25

III. Recommendations for Test Changes

6. It is recommended that all references to mechanical properties from section 18.5.1.2.1 (c) in MTC5 be deleted, and replaced with alternate test to read:

> "cold-drawn, seamless, carbon steel tube, 95 mm outer diameter, 11.1 mm wall thickness ± 15% variations, by 280 mm long;"

7. This modification would bring the steel used for the TS 8(b) gap test into alignment with the steel used for the TS 1(a) and TS2(a) gap tests, as well with the steel used during the development of their direct predecessors, namely the NOL LSGT and the NSWC ELSGT. Furthermore, the modification also allows for tube with a wall thickness of 0.5 inches, which currently could fall outside the current specifications by 0.49mm.

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[5] "AISI 1015 Carbon Steel", http://www.efunda.com/materials/alloys/carbon_steels/show_carbon.cfm?ID=AISI_1015&prop=all&Page_Title=AISI%201015, accessed 17/11/2010.