

European industry involved in logistic gains assessments

by IMEMG Q/D Expert Working Group (see § 9)

Introduction: Quantity/Distances Expert Working Group

In October 2003 IMEMG Board approved the establishment of an Expert Working Group (EWG) designated "Insensitive Munitions (IM) Quantity/Distances (Q/D's) and benefits for the Armed Forces".

This EWG has been tasked to participate in the work being undertaken internationally to agree a common Hazard Division (HD) Classification for Insensitive Munitions as opposed to non-IM solutions.

Additionally, the EWG has also been tasked to analyse and compare existing national and international rules detailing the "Quantity of munitions or energetic materials / isolation distances" ratios, more commonly known as Q/D's, in relation to IM/Murat characteristics and to act as a think-tank in the definition of specific Q/D ratios for IM.

The intrinsic advantages of Insensitive Munitions appear obvious in terms of environmental risks, survivability of platforms, and operational use, but, as ever, the users must take the final decision, as they are the final beneficiaries of the technical progress achieved.

The objective of the Q/D's EWG is therefore to highlight and publicise the benefits to the Armed Forces and Customers resulting from the use of Insensitive Munitions, including logistics, safety and security aspects and to focus on direct advantages of a Hazard Division classification that is specific to insensitive weapons transport and storage.

Since its inception, the Group has met several times and its work has resulted in the completion of a number of studies including a review of existing National and International processes for assessing munitions for Hazard Division Classification and the relationship of these to IM.

The Group's principal activity to date has centred on reviewing the work ongoing internationally to agree the applicability to IM of the existing HD 1.6 or the potential for expanding the current HD 1.2 criteria and the proposed introduction of a new HD 1.2.3 for IM, based on the Unit Risk principle.

1. Hazard division assessment

The result of the Group's review of National and International processes for assessing munitions and for defining Hazard Divisions Classifications and their relationship to Insensitive Munitions is summarised in Table 1.

Country / Organisation	Authority	Reference documentation
U.N.	U.N. Economic Commission for Europe (UNECE) - Transport Division	UN Recommendations on the Transport of Dangerous Goods, Model Regulations "Orange Book" (13 th revised edition)
NATO	Ammunition Safety Group (AC/326)	Manual of NATO Safety Principles for the Storage of Military Ammunition and Explosives AASTP-1 Ed. 1 of 08/1997
France	DGA / IPE: <i>Délégation Générale pour l'Armement / Inspection de l'armement pour les Poudres et Explosifs</i>	Order of September 26, 1980 "Règles de détermination des distances d'isolement relatives aux installations pyrotechniques" ¹ and letter of 08/05/1981
Germany	WIWEB: <i>Wehrwissenschaftliches Institut für Werk-, Explosiv- und Betriebsstoffe</i>	"Zentrale Dienstvorschrift ZDV, Reihe 34" ²
United Kingdom	Defence Ordnance Safety Group (DOSG)	JSP 482 "MoD Explosive Regulations Volume 1"
U.S.	DoD: Department of Defense	DoD ammunition and explosives safety standards 6055.9-STD of 05/10/2004, § 9

Table 1: Hazard division assessment

Up to date many countries or organisations have implemented a formalized HD Classification system but few have formalised a specific HD Classification for IM and provided the associated Q/D tables. As IM cannot detonate by sympathetic reaction, existing regulations tend to classify IM in HD 1.2. However this path does not appear credible, as this does not differentiate between conventional HD 1.2 munitions and Insensitive Munitions. The latter exhibiting a better response when subjected to accidental standardized aggressions than HD 1.2 munitions.

¹ Order of September 26, 1980 determining the rules for setting the isolation ranges relative to pyrotechnical installations

² Central service regulation No. 34

2. Implementation of IM policy

The beneficial contribution of IM ordnance to the general drive to limit loss of human life and operational platforms vulnerability in the event of an accident is now well recognised by a number of Nations and these are implementing policies to support the full scale development of IM and their introduction into service. These policies are based mainly on the Unit Risk principle and expansion of the HD 1.2 criteria, resulting for instance in formal adoption of Sub-Divisions of the HD 1.2 Classification, currently 1.2.1, 1.2.2 and 1.2.3, by NATO, the US, UK and partly by France with MURAT labels. These Sub-Divisions are not recognized yet by the UN as transportation classes and are only used for storage purposes. Details of the HD policies for IM for the involved Nations and Organisations are summarised in Table 2.

Country / Organization	Policy	Reference documentation
U.N.	Hazard Division 1.6	UN Recommendations on the Transport of Dangerous Goods, Model Regulations "Orange Book" (13th revised edition)
NATO	NATO Storage Sub-Divisions (SSD) 1.2.1 / 1.2.2 / 1.2.3	AC/258(ST)WP/208 of 06/10/1999 AC/258(ST)WP/218 of 04/09/2002 Change 3 to AASTP-1 (expected early 2006)
France	MURAT Labels ☆, ☆☆ or ☆☆☆ (Note 1358 DGA/IPE of 23/09/97: 1.2 Unit Risk)	Instruction 0260 DGA/IPE of 04/08/1993 " <i>Doctrine nationale française en matière de munitions à risques atténués</i> " ³
Germany	Draft IM policy implementation concept	Draft " <i>Implementierungskonzept Insensitive Munition in der Bundeswehr (IKIMBw)</i> " ⁴
U.K.	HD 1.6 and SSD 1.2.3 draft implementation concept	JSP 520 - UK MoD's Ordnance, Munitions and Explosives Safety Management System, Part 1 - Policy of 06/2005
U.S.	Storage Sub-Divisions (SSD) 1.2.1 / 1.2.2 / 1.2.3	DoD Ammunition and Explosives Safety Standards 6055.9-STD of 05/10/2004

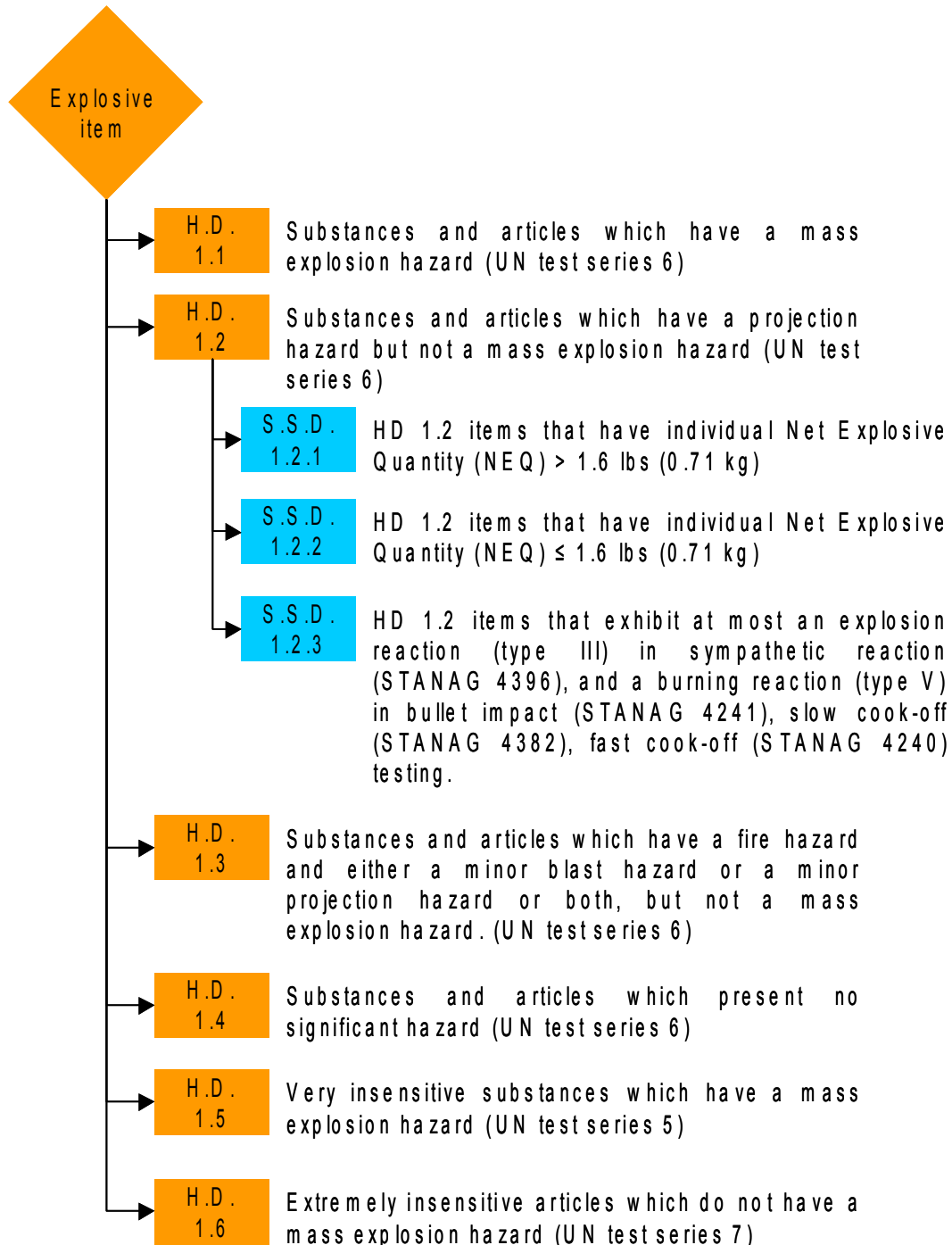
Table 2: Implementation of IM policy

³ French doctrine for IM/Murat

⁴ Implementation concept for IM in the German Army

3. Hazard Division description

Class 1, comprising explosive substances and articles, is divided into six UN Hazard Divisions. With the introduction of the Storage Sub-Divisions (SSD) the revised designation of Class 1 Hazard Divisions now appears as shown in the following Table:



- UN hazard division: applicable for transportation and storage
- U.S. / NATO Storage Sub-Divisions (SSD): applicable for storage only in specific, national circumstances and not applicable for transportation.

4. Classification of IM: a complex issue

The new SSD 1.2.3 for IM based on the Unit Risk principle is welcome.

Not surprisingly the Group has found this to be a complex and highly controversial topic still being hotly debated in some quarters. To reinforce an understanding of the crucial factors influencing this debate and to focus on the benefits to the User from the adoption of IM, the Group has built up an effective relationship with stakeholders including National and International Hazard Division Classification Authorities and NATO especially MSIAC. The Group is collaborating with these authorities with the objective of contributing to the definition of those standards that will formalise the HD Classification of IM and the associated Quantity Distance Tables. The inference drawn so far from these associations is that, under the present Classification System, a move to a subset of HD 1.2 is the most favoured. This hypothesis is supported by the formal adoption of this Classification by the USA (SSD 1.2.3) and France (HD 1.2 Unit Risk) while implementation by the UK is currently ongoing. NATO AC 326 has incorporated this new SSD in AASTP-1.

Nevertheless this new SSD devoted to IM should not be easy to implement.

IM-ness assessment remains currently a national approach. Ultimate goals under several stimuli are defined in Stanag 4439 but Threat Hazard Analysis are authorized to ban some stimuli according to life cycle. ALARP⁵ spirit approaches in addition to national waivers systems lead currently only to domestic IM compliance.

Obviously lot of guided weapons equipped with a rocket motor are not currently able to meet easily requirement such as a type V reaction under slow cook-off (STANAG 4382). Either thermal aggression is adapted after Threat Hazard Analysis or the threat is not considered as relevant. Such approach accepted by a National Authority will not be possible when Hazard division assignment.

Hazard division assignment is based on the following protocol:

- Mandatory Tests are to be performed: Fast Cook-Off / Slow Cook-Off / Bullet Impact / Sympathetic Reaction.
- Response descriptors are to be compared to criteria as defined in AOP 39.
- Then a dossier with description of tests program and munitions responses is to be sent to Competent Authority.
- Then Official certificate can be issued.

No test can be banished such as SCO and full signature is to be established.

This new SSD 1.2.3 is welcome to make IM visible for users even if not applicable for transport and even if munitions packaging remain marked HD 1.2.

This situation should not preclude the potential logistic gains that induce reduced Q/Ds in peacetime or deployed depots, as the most important is to reduce the number of transport operations. Nevertheless as Transport regulations will not soon take into account a new HD 1.2.3, ammunition packaging will remain identified as HD 1.2 and IM will remain not visible for users.

When implementing IM policy France decided to adopt a new marking for its MURATs and awarded them one to three stars: MURAT ☆ / MURAT ☆☆ / MURAT ☆☆☆.

⁵ "As Low As Reasonably Practicable"

So a fully IM compliant ammunition assigned SSD 1.2.3 could be identified and marked MURAT ☆☆.

Shall IMEMG EWG invite NATO Group AC 326 to adopt a visible label for SSD 1.2.3 ammunitions such as: "NATO IM" and shall this marking to be displayed on shipping and storage packaging for the future.

5. QD assessment using actual Quantity Distance criteria

After presenting Q/D's safety criteria of several countries, this assessment evaluates the process of moving from HD 1.1 and 1.2 to HD 1.2.3 and how IM/MURAT can influence the safety distances. Moreover, it shows that throughout the munitions community safety criteria are not so far different to each other.

Definition of safety criteria for USA and NATO

Safety Q/D's criteria are based on the calculation of two characteristic distances, guarantying the absence of risk outer these perimeters:

- IBD: Inhabited Building Distance, this criterion defines the minimal distance between the ammunition storage and surrounding external buildings.
- PTRD: Public Traffic Routes Distance, this criterion defines the minimal distance between the storage and a route, with classification in low/medium/high traffic densities.

The explosives safety criteria standards of NATO and US are comparable, but calculation methods and results are slightly different. In Q/D assessments of Table 5 and Table 6, only IBD criterion is calculated, and is taken from [Ref. 1].

Definition of safety criteria for France

Five theoretical zones are defined, with a decreasing level of effects and severity: see Table 3.

The definition of safety criteria for France and the definition of acceptable risk were already presented by National Authority during IMEMTS 2003 (see [Ref. 2]).

For the Q/D assessment tables, only the Z4 perimeter is calculated because this criterion is approximately comparable to the above-defined IBD.

	Z1	Z2	Z3	Z4	Z5
Pressure threshold	≥ 0,6 bar	≥ 0,3 bar	≥ 0,1 bar	≥ 0,05 bar	< 0,05 bar
Energy of projected fragment	≥ 50 J	≥ 20 J	≥ 8 J	< 8 J	-
Density of heat flow	≥ 1,5 W/cm ²	≥ 0,6 W/cm ²	< 0,6 W/cm ²	-	-
Personal injury	Lethal injury in more than 50 % of cases	Serious injuries which may be lethal	Injuries	Possible injuries	Very low probability of slight injuries
Property damage	Very serious damage	Serious damage	Medium and slight damage	Slight damage	Very slight damage

Table 3: Criteria for definition of French danger zones

Definition of safety criteria for Germany

Safety Q/D criteria are based on the calculation of the same two characteristic distances as the U.S. and NATO: that is IBD and PTRD.

Nevertheless, calculations are quite different and use formulae like:

$$\text{Safety Distance} = k \cdot G^{1/3}$$

With:

k: coefficient issued from tables (Donor, Acceptor) listed in reference documents indicated in paragraph *Hazard division assessment*

G: Net Explosive Quantity (NEQ) of High Explosive in TNT equivalent.

Typical limiting scaled distances (k coefficient) for injuries are given in Table 4.

Limit value for coefficient k		Damage
9	↔	Threshold Eardrum Rupture
5	↔	50 % Eardrum Ruptures
4	↔	Threshold Lung Haemorrhage
2	↔	50 % Lethal Lung Haemorrhage
1,8	↔	99 % Lethal Lung Haemorrhage

Table 4: Criteria for definition of German safety Q/D

Definition of safety criteria for United Kingdom

The UK follows NATO practices and subdivides HD 1.2 into storage subdivisions 1.2.1, 1.2.2, and 1.2.3. The rules are somewhat different than the US in determining QD's, and follow the document "*MoD Explosive Regulations JSP 482*" Volume 1, Chapter 10.

Open storage of 500 M107-equivalent HE artillery projectile

Individual Net Explosive Quantity (NEQ – in TNT equivalent) of 10 kg – total of 5000 kg of explosive for all projectiles.

Safety criteria	Hazard Division		
	1.1	1.2	Insensitive Munitions
NATO: IBD	400 m	337 m	122 m
France: Z4	376 m	400 m	267 m
Germany: IBD	380 m	320 m	No specific criteria for IM
U.K.: IBD	400 m	337 m	Not implemented
U.S.: IBD	381 m	337 m	122 m

Table 5: Q/D's assessment for 500 M107-equivalent HE artillery projectiles

Open storage of 83 Mk82-equivalent bombs

Individual NEQ of 120 kg – total of 9960 kg of explosive for all bombs

Safety criteria	Hazard Division		
	1.1	1.2	Insensitive Munitions
NATO: IBD	480 m	370 m	214 m
France: Z4	473 m	400 m	400 m
Germany: IBD	465 m	355 m	No specific criteria for IM
U.K.: IBD	480 m	370 m	Not implemented
U.S.: IBD	381 m	370 m	214 m

Table 6: Q/D's assessment for 83 Mk82-equivalent bombs

6. Benefits

It can be seen from these assessments that many benefits can be gained by using IM. Some examples of these are as follow:

- Gains from the additional quantity of IM that may be stored within the same safety distances. For example, using NATO criteria, it is possible to store more than the double number of IM projectiles instead of 500 projectiles from HD 1.2, in the same open range depot.
- Gains from the requirement to utilize reduced storage areas and reduced number of shelters or warehouses for storage of the same quantity of ammunitions
- Gains from the use of reduced numbers of security personnel to guard the same quantity of ammunition. In the earlier example of the storage of the 83 MK82 bombs, by using IM versions of the same bomb instead of HD 1.2, it is possible to reduce the storage perimeter by up to 57 %. This can reduce the time to patrol around the depot by the same scale. Knowing that the average cost to maintain a European soldier in Kabul is about 20 000 €/month, one of the benefits of using IM can be quickly estimated.

7. Conclusion

This general overview on Q/D reduction thanks to IM is focusing that logistic benefits and safety constraints reductions can obviously be assessed and rated.

But such as IM compliance is still a domestic assessment, methodologies to determine gains with IM do need efforts among NATO Nations for a more common approach.

8. References

[Ref. 1]: "*QD Assessment Using US and NATO Quantity Distance (QD) Criteria*", Eric Deschambault, MSIAC - NATO Headquarters, July 2005

[Ref. 2]: "*French Unit Risk Assignment for IM offers Visible Logistical Gain*" by Jean-Paul HUFSCMITT, DGA (France) and Henri MIERMONT, MBDA-F - 2003 IMEMTS - Orlando (Florida) - USA - 10-13 March 2003

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