Motivations for North Atlantic Treaty Organization (NATO) Standardization of Hazard Classification (HC) Procedures

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INTRODUCTION

This paper explains why, within NATO nations, I believe the standardization of HC procedures, specifically as those pertain to classing explosive substances, mixtures and articles bound for military applications, a.k.a., military munitions, is so important and necessary. The HC procedures I am primarily referring to are those included in or derived from the United Nations (UN) Transport of Dangerous Goods Model Regulations, and Manual of Tests and Criteria, which I will refer to hereafter as the Orange Books (OBs). The HC assignments resulting from applying those procedures are appropriately applicable throughout an explosive's life cycle, including during storage in magazines and in other situations, so long as the explosives remain in their as-packaged-for-transport configuration. Therein seems to lie the most fundamental connection between HC assignment and explosives safety management (ESM). The very first question always seeming to need answering in every explosives safety siting approval situation is, "What is the germane HC of the explosives configuration at the site?"

If the explosives at the site needing approval are unpackaged in any way, then applying an additional set of "in-process" analyses and procedures is necessary to determine the appropriate Class 1 Division to use for explosives safety siting purposes. I believe such analyses and procedures could also benefit from standardization across NATO nations.

BACKGROUND

My involvement in HC spans the period from when I began working for the DDESB in 1995 to today. I began my DDESB career with over a decade of Army and Navy engineering tenure in explosives development programs, including fuzing systems, and weapons systems safety, including insensitive munitions (IM); but HC assignment and ESM, including the application of quantity-distance (QD) criteria, were not specifically within my skill set yet. It has been over my past twenty-plus years of working at the DDESB that I have come to learn – and sometimes question – DoD's application of HC procedures to its military munitions. Many of my DDESB work experiences have also precipitated the development of my ESM skills over the years.

Immediately upon joining the DDESB Secretariat (as we were known back then), I began routinely attending biannual NATO AC/310 "Safety and Suitability for Service of Munitions and Explosives (S3)" meetings and participating in their standardization activities, some of which I was familiar with from my prior Navy weapons systems safety work. In the summer of 1997, I became involved with the U.S. DoD Insensitive Munitions (IM) Integrated Product Team (DoD IM IPT), as it began its meetings and activities that continue today, as does my DoD IM IPT and

Joint Service IM Technical Panel (JSIMTP) involvement. By 1999 I became heavily involved, along with Dr. Jerry Ward and Messrs. Herb Egbert and Jim Elliott, in what I consider to be the first international HC/IM harmonization effort.

Our tasking was to harmonize the HC, IM, and safety test methods to minimize the number of tests and associated costs necessary to determine HC assignments, and to demonstrate compliance with safety and IM goals. Our deliverables were the draft second editions of each of the following NATO Standardization Agreements (STANAGs), which then proceeded into NATO ratification and promulgation:

- STANAG 4240 Edition 2 - Liquid Fuel / External Fire (LF/EF), Munition Test Procedures;
- STANAG 4396 Edition 2 - Sympathetic Reaction (SR), Munition Test Procedures;
- STANAG 4382 Edition 2 - Slow Heating (SH), Munition Test Procedures;
- STANAG 4241 Edition 2 - Bullet Impact (BI), Munition Test Procedures; and
- STANAG 4375 Edition 2 - Safety Drop (SD), Munition Test Procedures.

Other than for SD testing, those STANAGs specifically included in that first international harmonization effort were the four with direct HC and IM relevance. At that time, hazard classifiers could only assign Storage Sub-Division (SsD) 1.2.3 to transport configurations of high explosive (HE) military munitions that did not exhibit any sympathetic detonation response in the SR test, nor any reaction more severe than burning in the LF/EF test, BI test, and SH test. Those SsD 1.2.3 HC criteria matched what I had already come to know as the requirement goals for IM compliance. So, the connection that achieving four-sevenths of the way towards IM compliance, at least in the logistical configuration, equated to a munition receiving an HC assignment providing more favorable (i.e., lesser radii) QD arcs for explosives safety siting purposes became one of my foundational understandings. (I note that four-sevenths, rather than four-sixths, is cited above because Edition 1 of STANAG 4439[1] in effect at the time included the spall threat, which was subsequently removed in STANAG 4439 Edition 2[2].) I believe the HC criteria for Hazard Division (HD) 1.6 assignment at that time were alike in terms of article testing, i.e., the UN Test Series (TS) 7 article tests that had to be passed were the same set of four cited above for SsD 1.2.3. However, additionally, each explosive substance within a military munition had to also pass a set of substance tests within UN TS 7 for the munition to qualify as HD 1.6. When achieved, HD 1.6 was intended to provide an additional explosives safety siting benefit, i.e., further QD arc radii reductions.

During the domestic deliberations regarding the updating and review of STANAG 4439 Edition 2 I learned another very fundamental principle. I rather distinctly recall a specific conversation I had with Mr. Tony Melita. At the time, he was the Director of the DoD Office of Munitions and also the US Key Delegate to NATO AC/326, the "Conference of National Armament Directors (CNAD) Ammunition Safety Group." AC/326 had stood up in 2003 due to the merger of AC/310 and AC/258, the "NATO Group of Experts on the Safety Aspects of Transportation and Storage of Military Ammunition and Explosives." In response to the notion being inserted into draft STANAG 4439 Edition 2 that some NATO nations wanted to begin

[1] STANAG 4439 Edition 1 – "Policy for Introduction, Assessment, and Testing for IM (MURAT)"
[2] STANAG 4439 Edition 2 – "Policy for Introduction and Assessment for IM (MURAT)"

marking munitions with additional labeling (e.g., one, two, or three stars) indicating the level of IM compliance the munitions had achieved, Mr. Melita countered that the IM label should be the HC assigned. An additional IM label would be duplicative of the HC assignment. His perspective solidly reinforced the foundational connection between IM compliance and HC assignment I had previously come to understand.

Through my years as a member of the DDESB Staff (as we are now known), my HC and ESM skill set continued to develop as I:

- remained involved in the activities of NATO AC/326;
- participated in numerous DDESB endeavors and meetings often aimed at updating the DoD explosives safety standards;
- participated in the triannual meetings of the DoD Joint Hazard Classifiers (JHC), which I now chair;
- updated Joint Technical Bulletin (TB) 700-2, the DoD Ammunition and Explosives HC Procedures;
- became a US Competent Authority (CA) for approving DoD explosives HCs for transport in accordance with the authority delegated to the DDESB Chairman within the US Code of Federal Regulations (CFR), i.e., within 49 CFR §173.56; and
- participated in multiple biannual UN TDG and the Globally Harmonized System (GHS) of Classification and Labelling of Chemicals meetings, including the TDG's Working Group on Explosives, which focus on maintaining the efficacy of their publications.

It is only with my accumulation of knowledge, skills and experiences cited above that I now feel capable of offering my perspectives on why NATO's standardization of HC procedures is important and necessary.

THE NEED FOR NATO HC PROCEDURE STANDARDIZATION

Probably the number one reason I began championing NATO HC procedure standardization is the significant ambiguity associated with the HC assignment criteria in the UN OBs. For example, the establishment of exactly what explosives behavior constitutes a HD 1.1 "mass explosion" hazard, which would seem to need to be perfectly clear since the other explosives HDs' criteria build off of not posing such a hazard, is in fact quite flawed within the UN OBs. The OBs define a "mass explosion" as one that affects almost an entire load virtually instantaneously. However, the OBs also state test results indicative of a "mass explosion" following UN TS 6 Type 6 (a) Single Package testing are a crater or damage to the witness plate beneath the package, blast measurement, or disruption and scattering of the confining material. In Single Package testing a donor munition, within its transportation packaging and under an additional confinement burden, is purposefully functioned in its design mode. That act of intentionally detonating any typically sized HE military munition will unquestionably create all those indicative effects; but as I have witnessed time and again those effects are not at all relevant to whether almost an entire load of those packaged military munitions will explode virtually instantaneously. This is especially true during the ongoing IM era, where through technological insertions military munitions are incrementally becoming less vulnerable to the SR threat. It is clear, at least to me, that assessing for "mass explosions" should only be focusing on prompt package-to-package propagation to

acceptor munitions, while completely disregarding all ancillary effects produced by the donor. This UN OB example is a prime reason why I have come to believe that the architecture of UN TS 6 probably performs quite well for the many smaller articles typical of the worldwide commercial explosives enterprise, but simultaneously it frequently just does not appropriately accommodate the larger HE IMs now commonly entering NATO's military inventories.

A second example of UN TS 6's architectural flaw in dealing with today's military IMs is as follows. In contrast to the above situation where a transport CA could per OB criteria legitimately assign HD 1.1 due to, for example, seeing a crater following Type 6 (a) testing, another CA, again without doing any wrong, might interpret the OB criteria completely differently and consequently assign that same larger HE military munition to HD 1.3. This is plausible if the second transport CA deems that Type 6 (b) Stack testing results do not justify HD 1.1 assignment, and also Type 6 (c) External Fire (bonfire) testing just results in a burning reaction without producing projections, as is often the case with today's state-of-the-art IM. However, such a HD 1.3 assignment would grossly conflict with that internal NATO HC framework I pointed out earlier as being my initial foundational understanding. Logically, there would be absolutely no incentive to pursue further IM compliance via successful additional SH and BI testing and subsequent SsD 1.2.3 assignment if a larger HE military munition could be assigned HD 1.3 by simply executing the UN TS 6 protocols, which exclude SH and BI testing. Assignments of HD 1.3 provide even more favorable (i.e., lesser radii) QD arcs than SsD 1.2.3 assignments do. Additionally, there would also not have been any reason to ever create UN TS 7 for HD 1.6 assignment if a shortcut to explosives safety QD arc benefits similar to those afforded to such extremely insensitive explosive articles was achievable by conducting UN TS 6.

A third ambiguity example leading to variable HC assignments by transport CAs is the OBs' current portrayal of criteria on how articles intentionally containing explosives can escape from assignment within Class 1. Some CAs seem to interpret that the current OB criteria require such articles to be assigned within Class 1 unless specific exclusion from Class 1 criteria is met. Conversely, other CAs seem to rather routinely assign such articles outside of Class 1. I believe this happens because of their interpretations the OB phrase "producing a practical explosive or pyrotechnic effect," which is completely undefined, or because the UN OB's exclusion from Class 1 protocol does not account for the possibility of other hazardous materials besides explosives being present within the article too. It is often easy to logically understand how the presence of those other hazardous materials leads CAs to conclusions that the explosives are not the predominant hazard posed by the article.

The UN OBs also contain a clause that permits explosives to not go through the normal HC assignment procedure when the explosive has been declared from the outset to be in HD 1.1. It is unclear, however, who can actually make such a declaration. Is it, for example, the applicant who is going to a transport CA to get their new commodity classed? Or, is it the transport CA's prerogative to decide, if formally requested to do so by such an applicant prior to the execution of the HC assignment procedures? Either way, if that HD 1.1 assignment is not accurately reflective of how an entire load of those explosives will behave in terms of producing a mass explosion or not, then all QD applications downstream of that decision become deleteriously effected in terms of their accuracy too. You might now be thinking that such downstream effects are benefiting explosives safety because the radii of the QD arcs applied will be larger than needed. If anything

though, my time at the DDESB has taught me that the costs of burdening real property within a QD arc when that is unnecessary must be avoided. ESM is all about appropriately managing risks, where any ultra-conservatism has absolutely no role.

While I'm on the subject of explosives safety risk management, I'll raise another point about the current state of affairs between UN HC assignment procedures and the QD NATO and other nations apply. My understanding is the projection (or fragment) hazard component of established NATO QD criteria intends to afford appropriate protectiveness to people from 58 foot-pound (~79 Joule (J)) impacts. However, within the past decade or so the UN HC metal projection criterion for assigning HD 1.2 became 20 J. Since that occurred, a significant mismatch has existed where munitions in HC LF/EF testing generate, for example, a 21J projection, can consequently be sited for QD purposes as if they actually encumber real property commensurate with 79J projection production. So, there has been a significant unintended consequence caused by that UN HC projection energy criterion adjustment that should benefit from being revisited.

My final motivation supporting a strong proponency for NATO HC procedure standardization is the abundancy of leeway afforded to CAs while they execute their HC assignment responsibilities. Multiple sources provide such leeway, including the UN OBs, each individual nation's domestic hazardous materials transportation regulations, and even NATO's promulgated STANAG 4123 Edition 3[3] covering promulgated NATO AASTP-03 Edition 1 Version 4[4], which currently allows a variety of HC testing protocols to coexist. In accordance with STANAG 4123 Edition 3, national CAs may decide to conduct HC testing based on the UN OBs, or alternatively to conduct HC/IM harmonized testing in accordance with pertinent NATO testing Allied Publications (APs). To my knowledge, the US is the only NATO nation that for at least the past decade has consistently utilized the results of harmonized HC/IM testing per NATO APs for both IM assessment and HC assignment. All other NATO nations seem to independently test for IM compliance per the NATO APs, and for HC assignment per the UN OBs.

What the US has been doing over that period of time is in essence routinely applying the article test portion of UN TS 7, and the UN Response Descriptors, for DoD HC assignment purposes. By doing so, the US has assigned many military munitions to SsD 1.2.3, while other nations have not; however, the US has yet to make a single HD 1.6 assignment. One aspect of the methodology the DoD has been following that I have found frustrating is when SsD 1.2.3 or HD 1.6 is not achieved, then, for example, the SH and BI test data providing valuable safety information about the potential hazards posed by the munition are completely disregarded. It seems hazard classifiers could gain additional clarity or reinforcing insight if they instead utilized that currently ignored information during all their military HC assignment determinations. After all, military HC assignments remain applicable in situations and circumstances far beyond those typically of concern during global transportation, which is the UN OB's sole focus. Routinely accounting for potential adverse threats commonly posed to military munitions outside of such transportation environments, e.g., in potentially more hostile forward operating locations where

[3] STANAG 4123 Edition 3 – "Determination of the Classification of Military Ammunition and Explosives"
[4] AASTP-03 Edition 1 Version 4 – "Manual of NATO Safety Principles for the HC of Military Ammunition and Explosives"

bullets and fragments can be flying, during the military HC assignment process might be a more comprehensive and therefore a better way ahead.

Now, I will get back to the subject of broad HC assignment leeway afforded to CAs, before I digressed. Frequently CAs seem to find themselves in positions where the HC guidance they are following very reasonably allows them to zig or zag while making their HC decisions. To inject consistency into US DoD HC assignment decision-making, TB 700-2 prescribes how the JHC have collaboratively agreed to handle numerous HC situations that have arisen over time and continue to arise, sometimes often, and others, not so much. Also, nary a JHC meeting seems to go by without us collectively deliberating to resolve a new specific HC situation that has come to our attention, or revisiting a past resolution to see that we remain in agreement with it given the current environment. The broad HC leeway afforded to CAs, if not controlled through standardization, manifests itself similarly to how the aforementioned UN OB ambiguities typically do, i.e., you will notice that varying HCs having been independently assigned by different CAs to the same explosive article[5] in the same transport packaging.

THE IMPORTANCE OF NATO HC ASSIGNMENT CONSISTENCY

The variability in the processes in which NATO and Partner nations execute their HC assignments, which do sometimes lead to national CAs assigning different HCs to the same explosive article in the same transport packaging, can be a significant concern. I hypothesize that such HC assignment variability may especially come to a head during multi-national training exercises or warfighting operations, though the fact that it has come into play might actually remain unobserved. During such multi-national events, governance for ESM, if normally executed in accordance with national criteria during domestic military munitions scenarios, switches to a stance where NATO ESM criteria is required to be followed by all participating NATO and Partner nations. Explosives Safety and Munitions Risk Management (ESMRM) is integrally included within that NATO ESM governance, to deal with risk acceptability decision-making in specific circumstances where required military operations can compel a need to consider taking explosives safety risks higher than those permitted by, for example, QD standards. Only appropriate NATO leadership, informed by risk or potential consequence assessments conducted to specifically evaluate the high-risk scenario being faced, are authorized to make such risk acceptability decisions. However, I believe those assessments are exclusively reliant on the HCs each participating nation's transport CA has assigned to their packaged munitions involved in the scenario. (If unpackaged, then those "in-process" analyses and procedures I mentioned above in my introduction apply.) Therefore, those assessments intended to inform NATO risk acceptability decision-makers during ESMRM situations can be unknowingly skewed by any underlying transport CA HC assignment variability included within those aggregations. For example, consider that two nations' militaries might have brought a common larger HE military munition in the same packaging to the fight. If that munition was assigned HD 1.1 by one participating

[5] By the UN OB definitions, an "explosive article" is an article containing one or more explosive substances. An "explosive substance" is a solid or liquid substance (or a mixture of substances) which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such a speed as to cause damage to the surroundings. Pyrotechnic substances are included within "explosive substances" even when they do not evolve gases.

nation's CA, and HD 1.3 by the other, as I stated earlier was completely plausible, then conceivably the aggregated data set on which the risk or potential consequence assessment will be based can actually end up somewhat misinforming the NATO risk acceptability decision-maker. Any potential for misinformed risk management while dealing with explosives is not something that should be taken lightly.

Summary

I hope that I have made myself clear and provided sufficient examples showing why NATO HC procedure standardization is important and necessary. In closing, however, there are two additional specific points I want and need to make clear. One is that all HC procedure adjustments agreed to during NATO's standardization activities are not intended to mandatorily apply retroactively to military munitions that have already been classed using current or prior HC procedures. This is because experience has shown that any required remarking of munition assets stored in magazines scattered across the globe is untenable in terms of both costs and physical execution. My second point pertains predominantly to the US HC and IM communities because of the harmonized HC/IM system DoD has directed them to collectively operate under. It seems there is currently no necessity nor reason for that to undergo change. My point is NATO HC procedure standardization cannot be executed without IM criteria consequences, just as IM criteria adjustments cannot occur without HC procedure criteria consequences. For success, the bottom line is both the NATO IM community and NATO experts on the bases of QD plus QD's specific usage during explosives safety siting must become members of the NATO working group currently pursuing HC procedure standardization.