TITLE: Should Hazard Classification Assignments Be Revisited Over Time?

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ABSTRACT: Should hazard classification assignments be revisited over time? Currently munitions classifications are assigned early in their lifecycle and last for their entire life. Data to support or refute this approach is limited. This paper reviews the many aspects of harmonization between hazard classification and Insensitive Munitions (IM) that have occurred in the past ten years. Recently the IM community has started investigating the effects of aging on IM characteristics. With the similarities between the two disciplines, hazard classification should be participating to determine whether the aging data produced would have an impact of the classification assigned.

Should hazard classification assignments be revisited over time? Historically the Department of Defense (DoD) assigns hazard classification early in a munition's lifecycle using test data from assets which have been recently produced. Once assigned, this classification lasts the life of the munition and is typically not revisited. For the past few years, the Insensitive Munitions (IM) community has been investigating the effects of aging on the IM characteristics of a munition. With the similarities between IM and hazard classification, should the hazard classification community be considering this question as well with respect to the hazard classification assignment?

A DoD hazard classification identifies the damage potential of a munition during transportation and storage. It is an important element within the overall DoD explosive safety program. From a broader perspective, hazard classification includes all types of hazardous materials (e.g. flammable solids, poisons, oxidizers); however, the subset we are concerned with is munitions. DoD has been assigning hazard classifications for decades. The earliest tri-service (Army, Navy, and Air Force) instruction for hazard classification that can be identified is dated 31 July 1962; however, test reports for assigning classifications date back to the 1950s. Through the years, various classification systems have been utilized. In the 1960s a munition would be assigned numerous hazard classifications for different applications; including an Interstate Commerce Classification, a Coast Guard Classification, an Army and a Navy classification. As time passed and regulations changed, these different types of classifications have been consolidated into one classification system. The system now utilized is that of the United Nations (UN) as detailed in their "Recommendations on the Transport of Dangerous Goods."[1] It includes nine classes of hazardous materials and a not regulated category. Many of these classes are divided into divisions to further differentiate the damage potential. Within the United States, these UN recommendations have been adopted by the Department of Transportation (DOT) as delineated in Title 49, Code of Federal Regulations (CFR). Title 49 CFR regulates the transportation portion of hazardous materials, but as stated previously, a DoD hazard classification addresses both transportation and storage. The additional storage aspects are detailed in the Allied Ammunition Storage and

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14. ABSTRACT
Should hazard classification assignments be revisited over time? Currently munitions classifications are assigned early in their lifecycle and last for their entire life. Data to support or refute this approach is limited. This paper reviews the many aspects of harmonization between hazard classification and Insensitive Munitions (IM) that have occurred in the past ten years. Recently the IM community has started investigating the effects of aging on IM characteristics. With the similarities between the two disciplines, hazard classification should be participating to determine whether the aging data produced would have an impact of the classification assigned.

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Transportation Publication AASTP-3 "Manual of NATO Safety Principles for the Hazard Classification of Military Ammunition and Explosives"[2] and the North Atlantic Treaty Organization (NATO) Standardization Agreement (STANAG) No. 4123 "Determination of the Classification of Military Ammunition and Explosives."[3] DoD incorporates all of these regulations into a single document for use in the assignment of classifications. This document is the "DoD Ammunition and Explosives Hazard Classification Procedures."[4]

A DoD hazard classification is assigned by evaluating the munition's behavior to a variety of stimuli. This is achieved through a testing program consisting of a few full scale hazard classification tests. The test results are used to answer two questions: (1) is the munition too dangerous to transport, and (2) which division within Class 1 does the munition belong. The first question is answered through stability and sensitivity testing. Typically UN Test Series 4 is conducted at the munition level which includes thermal stability (UN 4(a)) and 12 meter drop (UN test 4(b)) testing. In certain situations, UN Test Series 3 may be used instead of Series 4. Series 3 is conducted at the substance level and includes thermal stability (UN Test 3(c)), impact (UN Test 3(a), friction (UN Test 3(b)), and small scale burn (UN Test 3(d)) tests. The second question is typically more complicated to answer and utilizes a combination of the following tests: single package (UN Test 6(a)), sympathetic reaction (UN Test 6(b)/7(k)), liquid fuel/external fire (UN Test 6(c)/7(g)), slow heating (UN test 7(h), bullet impact (UN Test 7(j) , and the extremely insensitive detonating substance (EIDS) tests (UN Test 7(a) through UN Test 7(f)) . To determine which of these tests are appropriate depends on the technical details of the specific munition as well as the classification being pursued. The table below provides the tests required to support the specific hazard division.

Hazard Division/Subdivision	Required Tests
1.1, 1.2.1, 1.2.2, 1.3, and 1.4	Single package or sympathetic reaction and liquid fuel/external fire
1.2.3	Sympathetic reaction, liquid fuel/external fire, slow heating, and bullet impact
1.6	Sympathetic reaction, liquid fuel/external fire, slow heating, bullet impact, and EIDS tests

Historically, the sympathetic reaction and liquid fuel/external fire tests have been the standard for the determination of the hazard division. Although still required for every division, they are only part of the suite of tests required for hazard divisions 1.2.3 and 1.6. Bullet impact and slow heating are also required tests for these divisions. In addition, for hazard division 1.6, EIDS testing is needed. Both divisions have stringent assessment criteria. They were created for munitions that would have otherwise been assigned hazard division 1.2.1 or 1.2.2, but have shown their insensitivity to the tested stimuli. For those munitions that qualify, the benefits are in the storage quantity distances.

Hazard divisions 1.2.3 and 1.6 illuminate the similarities between hazard classification and IM. The sympathetic reaction, liquid fuel/external fire, slow heating, and bullet impact tests required for these divisions are also required for IM. The procedures for these four tests have been harmonized between these two disciplines to allow a munition program to conduct one series of tests and use those results for both IM and hazard classification. With the very large cost of munitions and testing, this harmonized approach makes perfect sense. Harmonization has caused some minor variations in these tests as compared to the UN recommendations. These variations include the actual test names. The UN stack test (UN test 6(b)) is the harmonized sympathetic reaction test; the UN external fire (bonfire) test (UN test 6(c)) is the harmonized liquid fuel/external fire test. Although the names have been changed along with some other details, the variations do not prevent the appropriate data from being collected to assign a hazard classification or an IM signature. The harmonized procedures have been incorporated into the each of the specific test STANAGs (STANAG 4240 Liquid fuel/external fire, STANAG 4396 sympathetic reaction, STANAG 4241 bullet impact, and STANAG 4382 slow heating) and will be included in the next revision of the DoD hazard classification instruction. These harmonized procedures apply for all the divisions within Class 1, but hazard division 1.2.3 and, to some extent, hazard division 1.6 takes harmonization one step farther. For these divisions, the assessment criteria are harmonized as well. To qualify for hazard division 1.2.3, the munition must exhibit an explosion reaction (Type III) or better in sympathetic reaction and a burning reaction (Type V) or better in liquid fuel/external fire, bullet impact, and slow heating. Hazard division 1.6 is similar with the exception of bullet impact where a type III explosive reaction or better is acceptable. With this harmonization of procedures, and, in some cases, assessment criteria, the similarities between hazard classification and IM are clear.

For the past few years, there has been an interest in the IM community in the consequences of aging. The question raised was whether a munition would maintain its IM characteristics over time. Like hazard classification, IM testing is typically conducted on assets which have been recently produced. So after a munition has been in the military stock pile for 10, 15, 20 years, will the properties exhibited in those tests remain the same? It was recognized that both the Qualification and Ordnance Assessment programs do address aging through the munition’s lifecycle. Qualification conducts accelerated aging tests on the energetic materials to evaluate certain properties over time while Ordnance Assessment examines and predicts the effects of age and environmental exposure to the munition to determine whether to retain, replace, or destroy. IM has questioned whether the appropriate properties are being evaluated to address this issue, but to do so these properties would need to be identified. What are the critical aging mechanisms that contribute to the IM properties or aging of those IM properties? To begin to investigate these questions, a workshop on the effects of aging on IM was conducted by MSIAC and the Finnish Defence Forces in 2005. This workshop pulled together experts in the fields of IM, energetic materials, and munitions to share data and determine the current status of knowledge with respect to the effects of aging on IM. These experts provided status of their current understanding of age-induced changes to IM and participated in working group sessions investigating the fundamental areas of required knowledge regarding IM aging. The generally held "feeling" of the workshop participants was that aging was unlikely to have an effect upon the IM signature, but this "feeling" was based on guess work and very limited and fragmented studies. It was also recognized that with all countries having limited budgets enhanced international cooperation could allow for improved knowledge and understanding of this field.[5]

Since this workshop, a few test programs have been undertaken to help answer some of these IM aging questions. The United States conducted a study to determine the effects of aging on shock reaction for the explosive PBXN-109. PBXN-109 with different RDX fills (Type I, Type II, and Insensitive RDX) from different producers was evaluated. A series of gap tests were conducted on baseline and aged samples (accelerated aging at 70°C for 13 months). Results showed two of the six RDX fills had an increased sensitivity from aging. One of the fills that demonstrated this increased sensitivity is the standard RDX fill used in the specification for this explosive.[6] The question now is whether the change in the results from this small scale test will correlate to a change in the results from full scale testing used to determine the IM signature. To help answer this question, the United States has proposed a program to conduct full scale IM testing of aged PBXN-109 filled assets. Other countries are also contributing to the overall effort. The effect of aging on IM is a Key Technology Area (KTA) within the Technical Cooperation Program (TTCP) where efforts from several countries have been presented and discussed. To date the results are minimal due to the duration of accelerated aging programs, but programs are underway.

As data is generated to answer the IM aging question, it is important to keep in mind the connection between IM and hazard classification. Changes in the response levels to the IM tests could modify the hazard classification. This is especially true for those munitions hazard classified as hazard divisions 1.2.3 and 1.6. It may be unlikely that the effects of aging could change a test result from a burn to a mass detonation, but perhaps it could cause a change from a burn to a deflagration, which would affect the assignment of these divisions. Throughout the years, the IM program has become more and more successful in reducing munitions sensitivities. New energetics, advanced munition casings, and packaging have all been utilized to achieve these results, and these efforts have had an effect on hazard classification. In 2003, DoD had no munitions hazard classified as hazard division 1.2.3 or 1.6. Today we have 31 (all 1.2.3). So, should hazard classifications be revisited over time? Like IM, sufficient data does not exist to answer this question. We may have the same feeling as IM that the answer is no, but having data to support that feeling is always preferable. Luckily, IM has already started investigating this aging question. We in hazard classification should take advantage of this and become involved in, or at least stay abreast of, the data collected and the progress made. By doing this we will have more than a feeling to answer this question in the future.

References

1 United Nations, "Recommendations on the Transport of Dangerous Goods-Model Regulations, " ST/SG/AC.10/1/Rev 16, 2009 and " –Manual of Tests and Criteria," ST/SG/AC.10/11/Rev. 4, 2004

2 Allied Ammunition Storage and Transportation Publication, AASTP-3, "Manual of NATO Safety Principles for the Hazard Classification of Military Ammunition and Explosives, " Edition 1

3 NATO STANAG 4123, "Determination of the Classification of Military Ammunition and Explosives," Edition 3

4 NAVSEAINST 8020.8B, "Department of Defense Ammunition and Explosives Hazard Classification Procedures," (TB 700-2, TO 11A-1-47, DLAR 8220.1) 5 January 1998

5 MSIAC O-104, "Review of the May 2005 MSIAC/FInnish Defence Forces Sponsored Workshop on the Effects of Ageing on Insensitive Munitions," November 2005

6 Clark, K, 2009, "Effects of Aging on PBXN-109 with Variant RDX Fills", *PARARI Conference,* Adelaide, Australia

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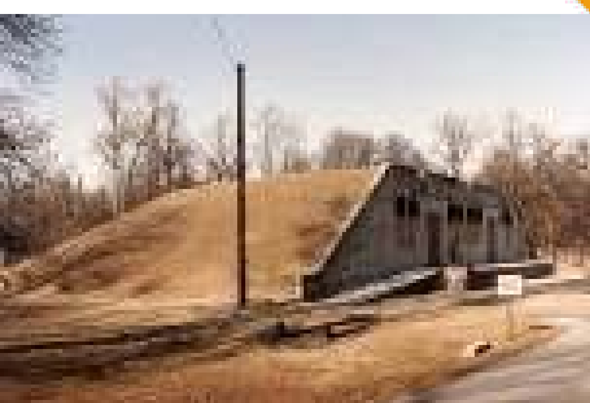

Ed Walseman
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15 July 2010

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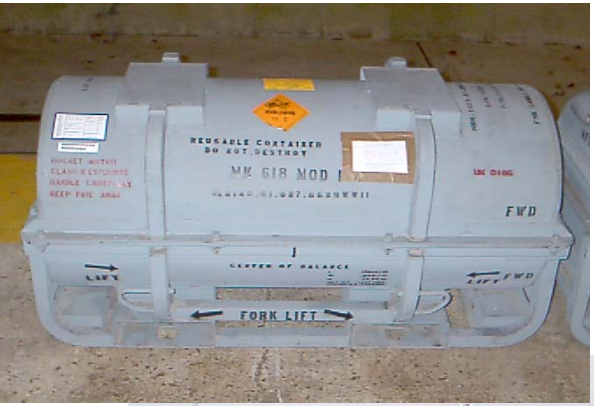
Hazard Classification



Identifies damage potential during transportation and storage

Evaluating munitions' behavior to a variety of stimuli

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Hazard Classification

Hazard Division/ Subdivision	Required Tests
1.1, 1.2.1, 1.2.2 1.3, and 1.4	Single Package or Sympathetic Reaction and Liquid Fuel/External Fire
1.2.3	Sympathetic Reaction, Liquid Fuel/External Fire, Slow Heating, and Bullet Impact
1.6	Sympathetic Reaction, Liquid Fuel/External Fire, Slow Heating, Bullet Impact, and EIDS tests

Harmonization

- Insensitive Munitions and Hazard Classification
- Test Procedures
  - Sympathetic Reaction
  - Liquid Fuel/External Fire
  - Slow Heating
  - Bullet Impact
- Assessment Criteria
  - Hazard Division 1.2.3
  - Hazard Division 1.6

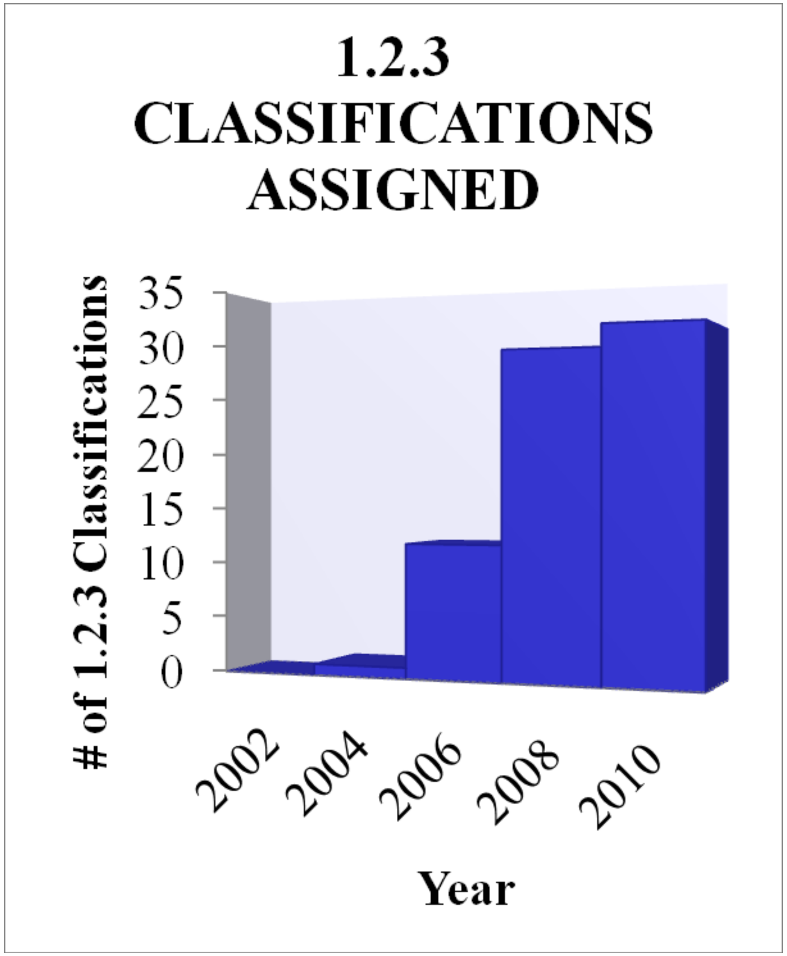
Harmonization

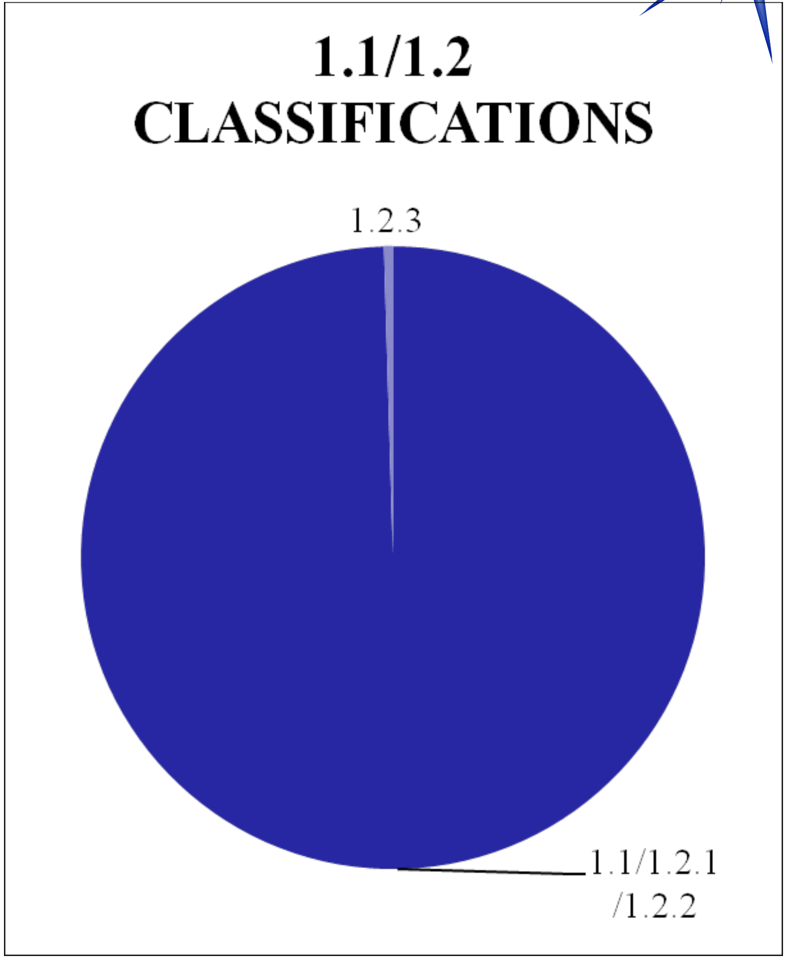
Test	Passing Criteria
Sympathetic Reaction	Explosion (Type III or better)
Liquid Fuel/External Fire	Burn (Type V or better)
Slow Heating	Burn (Type V or better)
Bullet Impact	Burn (Type V or better)

Harmonization

- Impact of Insensitive Munitions
  - Decreased munitions sensitivity through the use of:
    - Energetics
    - Casings
    - Packaging
  - Increased the number of these reduced sensitivity classifications

Hazard Division 1.2.3





IM and Aging

- Workshop on the Effects of Aging on Insensitive Munitions, 2005
  - General feeling was unlikely
    - Qualification Program
    - Ordnance Assessment Program
  - Data limited and fragmented

- TTCP KTA Effects of Aging on Insensitive Munitions

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IM and Aging

- PBXN-109 Aging Study
  - PBX made with various RDX fills
  - Gap sensitivity increased with age for certain samples
  - Does this correlate to changes in full scale IM tests?

IM and Aging

- Plans
  - Testing on aged PBXN-109 filled assets
    - Materials characterization
    - IM testing

Conclusions

- Should Hazard Classification Assignments Be Revisited Over Time?
  - Same situation as IM
    - Limited data
  - Hazard Divisions 1.2.3 & 1.6 may be the greatest risk
- Partner with IM