CLASSIFICATION AND IN-PROCESS CLASSIFICATION TESTING - WHERE DO WE GO FROM HERE?

by

F. L. McINTYRE
COMPUTER SCIENCES CORPORATION
NASA NATIONAL SPACE TECHNOLOGY LABORATORIES
NSTL STATION, MS 39529

ABSTRACT

In 1974, an agreement was reached between DoD and NATO to standardize Hazards Classification Procedures and adopt the UN Classification System. Implementation by DoD was scheduled for 1976. Actual adoption occurred in 1978; however, TB700-2 was not released until March 1982.

Basically this procedure does not change the existing Bulk Interim Qualification Tests which still include: Card Gap; Detonation; Ignition and Unconfined Burning; Impact and Thermal Stability Tests. End-item classification testing changed significantly and includes: Single Package, Stack Test and External Fire Stack Test. Additional constraints on End-item Munition Testing Require Heat Flux and Firebrand Data for 1.3 and 1.4 materials and TNT Equivalency and Fragmentation Assessment for 1.1 and 1.2 class munitions.

This new procedure was instantly open to criticism. Card Gap and Impact Sensitivity tests are too severe for most materials, particularly small arms propellants and pyrotechnics. The Ignition and Unconfined Burning Test is not applicable to pyrotechnics. End-item tests are more costly in terms of the amount of munitions required as well as instrumentation requirements (Heat Flux and TNT Equivalency). Finally in-process classification was excluded.

I hope to briefly discuss the new Hazards Classification Procedures, the need for In-process Classification, and Pyrotechnic Test Procedures proposed by the Pyrotechnic Committee at the Second International Conference on Standardization of Safety and Performance Tests for Energetic Materials. It is impossible to cover all in great detail - rather, my intention is to provoke thought and, possibly, some action.

limited to the selected tests such as Card Gap, Detonation, Ignition and Unconfined Burning, Impact Sensitivity, and Thermal Stability Tests. The initiating influences for end-items were limited to Detonation Test "A", Detonation Test "B", and External Heat Test "C".

In 1974, an agreement was reached between DoD Components and NATO. A new document was to be written and published as early as 1976 that would incorporate the United Nations Classification System and incorporate similar tests as outlined in the Transport of Dangerous Goods NATO IN1EREG ST/SG/AC.10/1/[3]. The final version of this document, *The DoD Explosives Hazard Classification Procedures*, was published March 1982[1].

During this period, a significant amount of research and testing was devoted to developing In-process Hazards Classification Procedures. A NATO Committee was established to standardize test procedures. ARRADCOM, under the auspices of Single Service Management for the Manufacture of Munitions, proposed in-process classification to reduce the number of incident/accidents associated with manufacturing. In 1980, a safety committee also established the need for In-process Hazards Classification and Identification. These concepts and studies have met considerable resistance and basically have remained ignored since their inception.

DISCUSSION

Changes in the new DoD Explosives Hazard Classification Procedures deal with terminology, adaptation of the UN Classification System and new End-item Classification requirements. There is a distinction between bulk and end-item classification; bulk material testing is referred to as interim qualification and end-item testing as classification. Figure 2 shows the interpretation for interim qualification. Other significant changes deal primarily with end-item testing.

End-item testing has changed significantly. Three types of tests are conducted: Single Package Test; Stack Test; and External Fire Stack Test. The number of tests per configuration have been reduced from five to three

for the Single Package and Stack Test versus five each tests for the Detonation Tests "A" and "B" configurations. However, the Stack Test now requires five items versus two for the Detonation "B" test. Five items are also required for the External Fire Stack Test versus two to six for the External Heat Test "C". Another major change for pyrotechnic end-items now requires confinement ranging from a minimum of 0.5 m (1.64 ft) to a maximum of 1 m (3.28 ft) dependent upon the size of the external packages.

Other changes require that radiant flux, firebrand, and fragment density be reported for division 1.3 and 1.4 materials. TNT equivalency and fragmentation assessments are required for divisions 1.1 and 1.2 materials. Interpretation of the end-item results is shown in Figure 3.

Criticisms came from several areas. End-item tests were costly, as instrumentation for heat flux and TNT equivalency is expensive. Fragmentation assessment was costly and time-consuming. Confinement (up to 1 m (3.28 ft)) was too severe. Bulk Interim Qualification tests remained unchanged. These tests were either too severe for small arms propellants and pyrotechnics, or they did not apply. Other participants were concerned that their proposed tests had not been included. As a result In-process Classification was still excluded.

Such criticisms are unwarranted, as the critics fail to grasp the intent of the classification procedures. TB700-2 is used to determine the effects of accidental initiation and to set parameters to protect property and personnel. This is accomplished by conducting a limited number of tests representing "worst case" situations; then reporting the results, at the same time providing for an acceptable safety margin. It is not intended that these tests replace parametric, stability, sensitivity and performance (output) tests which are obtained separately, or in conjunction with, and included in component data safety statements. The component data safety statements and hazards classification results can ultimately be conbined to represent the hazards associated with handling, transporting, storage and use of a particular item. The existing classification procedure meets this objective. Based upon a survey of incident/accidents[4], there is no known incident/accident attributed to

the item's being categorized in the wrong division. The opposite is true when classification is assigned by analogy without testing to support the assigned hazards division.

The same incident/accident analysis also indicated that the majority of all incidents were associated with manufacturing. This is understandable because the manufacturing process is in a constant state of change and the amount of data available concerning in-process hazards are not readily available. The next logical step in the classification process would then be to screen or classify the materials during various stages of manufacturing. Potential problems would be identified and prevented. An initial attempt at in-process classification was developed by Pape and Napadensky[5] whose efforts concentrated on propellants and explosives. The study was based upon several factors including: Historical Accident Survey; Engineering Analysis; Survey of Existing Test Methods; Definition of the Classification Procedure Structure; Selection of Candidate Tests; and Validation and Finalization of the Proposed Tests Procedures. Their scheme is illustrated in Figure 4. The potential of the study represents a quantum step forward in reducing potential mishaps during the manufacturing process.

In 1977 and 1979, the International Conference on the Standardization of Safety and Performance Tests for Energetic Materials [6,7], through several international agreements, strove to develop a document on the principles and methodology for the acceptability of energetic materials for military use. This manual makes possible the international and interservice acceptance of qualification data obtained by individual services and industrial laboratories. The Pyrotechnics Subcommittee established at the second conference [7] recommended a series of tests applicable to pyrotechnic (Table 1) including mandatory and prescribed tests. The submissions were accepted without prejudice with the only stipulation being that sufficient information to understand and duplicate the test results be submitted. It was also noted that additional changes could be submitted when better procedures were developed. The mandatory test methods submitted included: Hygroscopicity, Heat of Combustion, TNT Equivalency, Dust Explosion, Linear Burn Rate and Pressure Time, all of which have standard procedures. Additional mandatory tests

which do not have a standard developed procedure include: Ignitibility Burning Rate (Flares), Candle Power, Efficiency, IR Calibration, Chromaticity, High Pressure, Heat Flux and Chemiluminescence. In the case of an illuminant output measurement it was felt that no standard test could be developed until the instrumentation could be standardized. None of these proposed tests were considered for incorporation to the TB 700-2 or ST/SG/AC.10/1/Rev 1 NATO Transport of Dangerous Goods [3].

The cursory synopsis of changes in test methods during the past decade will have a significant impact on the pyrotechnic community. Generally pyrotechnics are grouped under the broad term of "explosives." Classification tests are now more rigorous due to confinement and the slightest change in the formulation of a given mixture would require reclassification. The accomplishments of Pape and Napadinsky's study on in-process classification and the efforts of the pyrotechnic subcommittee at the Second International Conference of the Standardization of Safety and Performance Tests for Energetic Materials are basically unknown. Probably the most serious result of this is the fact that the formation of the International Pyrotechnic Society is still a well kept secret.

It is imperative that we in pyrotechnics adopt some positive action to bring our plight to the forefront. Such steps are beginning to surface. McDonald, Robinson and Johnson [8] have proposed in-process classification for pyrotechnics. They have also proposed an in-process hazards identification scheme. The identification scheme has considerable merit. Logically, it follows that we should consider in-process classification as a means of reducing incidents during manufacturing. This can only be accomplished when a united group clamor for changes. In discussing in-process classification with various DoD safety components, all indicate a need for it, but each is waiting for someone else to take the initiative. In-process classification would be welcomed when and if such techniques were validated. The initiative is ours.

If we are to have any input into the Allied Ordinance Publication [9] concerning pyrotechnic performance testing, we should take advantage of the test methods proposed by the subcommittee at the Second Standardization Conference [7] or substitute updated more germane test methods. A possible

update could indicate friction testing using the Rotary Friction Device Standardized by Naval Weapons Support Center. Another area would be to validate the 20 liter and 1 m^3 dust chambers and substitute these procedures for the Hartmann Test. Possibilities are limitless.

CONCLUSIONS

1. We have a new updated DoD Explosives Hazard Classification Procedure that we must take the time to understand and use as it was intended. It will stand the test of time.
2. In-process classification is feasible and some form of in-process classification should be validated.
3. In-process classification techniques demonstrate the potential to reduce manufacturing incidents.
4. Through international agreements it is possible to use, validate, or submit standardized test methods applicalbe to the pyrotechnic community that allow for international and interservice acceptance.
5. Cognizant DoD safety representatives understand the need for in-process classification but they are waiting for others to take the initiative.
6. The initiative is ours.

REFERENCES

1. Department of Defense Explosive Hazard Classification Procedures, Army Technical Bulletin TB700-2, NAVSEAINST 8020,3, TO 11A-1-47, DLAR 8220.1 March 1981

2. Department of the Army Technical Bulletin TB700-2, NAVORDINST 8020.3, TO 11-A-47 DSAR 8220.1, 19 May 1967

3. Transport of Dangerous Goods NATO INTEREG ST/SG/AC.10/1/, December 1980 Addendum 3 Annex 4

4. McIntyre, F. L. Edgewood Arsenal Contractor Report EM-CR-76001-EA-5711 Incident/Accident Survey (1950-1974), December 1975

5. Napadensky, Hyla; Pape, Ronald; Recommended Hazard Classification Procedures for In-process Propellant and Explosive Material. U.S. Army ARRADCOM Large Caliber Weapons System Laboratory, Dover, New Jersey September 1980

6. L. Avrami, H. J. Matsuguma, R. F. Walker (Editors), "Proceedings of the Conference on the Standardization of the Safety and Performance Tests for Energetic Materials - Volume 1" ARRADCOM Special Publication ARLCD-SP-77004, U.S. Army, Army Armament Research and Development Command, Dover, NJ, September 1977 (AD-E400-004)

7. R. F. Walker, H. S. Matsuguma, L. Avrami (Editors), Minutes of the Second International Conference on the Standardization of Safety and Performance Tests for Energetic Materials, January 1980, Held at ARRADCOM, Dover, New Jersey, 15-19 October 1979

8. McDonald, J. P.; Johnson, D. M.; and Robinson, C. O., A System For In-process Hazards Classification and Identification for Pyrotechnic Materials, Presented at ADPA Pyrotechnics and Explosives Meeting at Livermore National Laboratories, CA. November 4-5, 1981.

9. Allied Ordnance Publication Number 7.

Table 1. Proposed Pyrotechnic Standardized Test Methods

Test Requirement	Status	Typical Test Method
Hygroscopicity	Mandatory All Mixtures	U.K. MOAD Method 303 US EA4D01 Final Report
Heat of Combustion	Mandatory All Mixtures	MIL-STD-268-B UK/Performance/Pyrotechnics-2
TNT Equivalency	Mandatory All Mixtures	TB700-2 UK To Be Written Up
Ignitability	Mandatory All Mixtures	Radiation Pulse Test UK Bickford Fuze Test
Dust Explosion	Mandatory Mixtures and Constituents	Harmann, 1 m^3 Dr Passman, Holland 20 liter Dr Passman, Holland
Linear Burn Rate	Mandatory, Delays Only	UK/Pyrotechnic Performance/1 ARRADCOM Procedure, NSWC US Navy Procedure
Burning Rate	Mandatory, Lined Candle & Bare Grain	No Standard Test Method Submitted
Candle Power (CANDELA)	Mandatory, Photoflash and Illuminants	UK Performance/Pyrotechnic/4
Efficiency (Candle/Sec-kg)	Mandatory, Photoflash and Illuminants	UK Performance/Pyrotechnic/4
Chromaticity	Mandatory, Colored Flares	No Standard Test Method Submitted
Chemiluminescence	Mandatory Illuminants	No Standard Test Method Submitted
IR Calibration	Mandatory IR Items	UK Performance/Pyrotechnics/5
KTA-8	Mandatory for Smoke	
Pressure/Time	Mandatory for Explosion Charges	D. Dillehay 5th IPS
Spin	Mandatory (TRACER)	Valcartier, Canada Test Method Frankford Arsenal Spin Test USA
High Pressure Vessel	Mandatory (TRACER)	Gun Breech Simulator UK Valcartier, Canada Test Method
Heat Flux	Desirable for Incendiaries	TB700-2
Bullet Impact	Desirable	Method 107 US EA4D01 Final Report

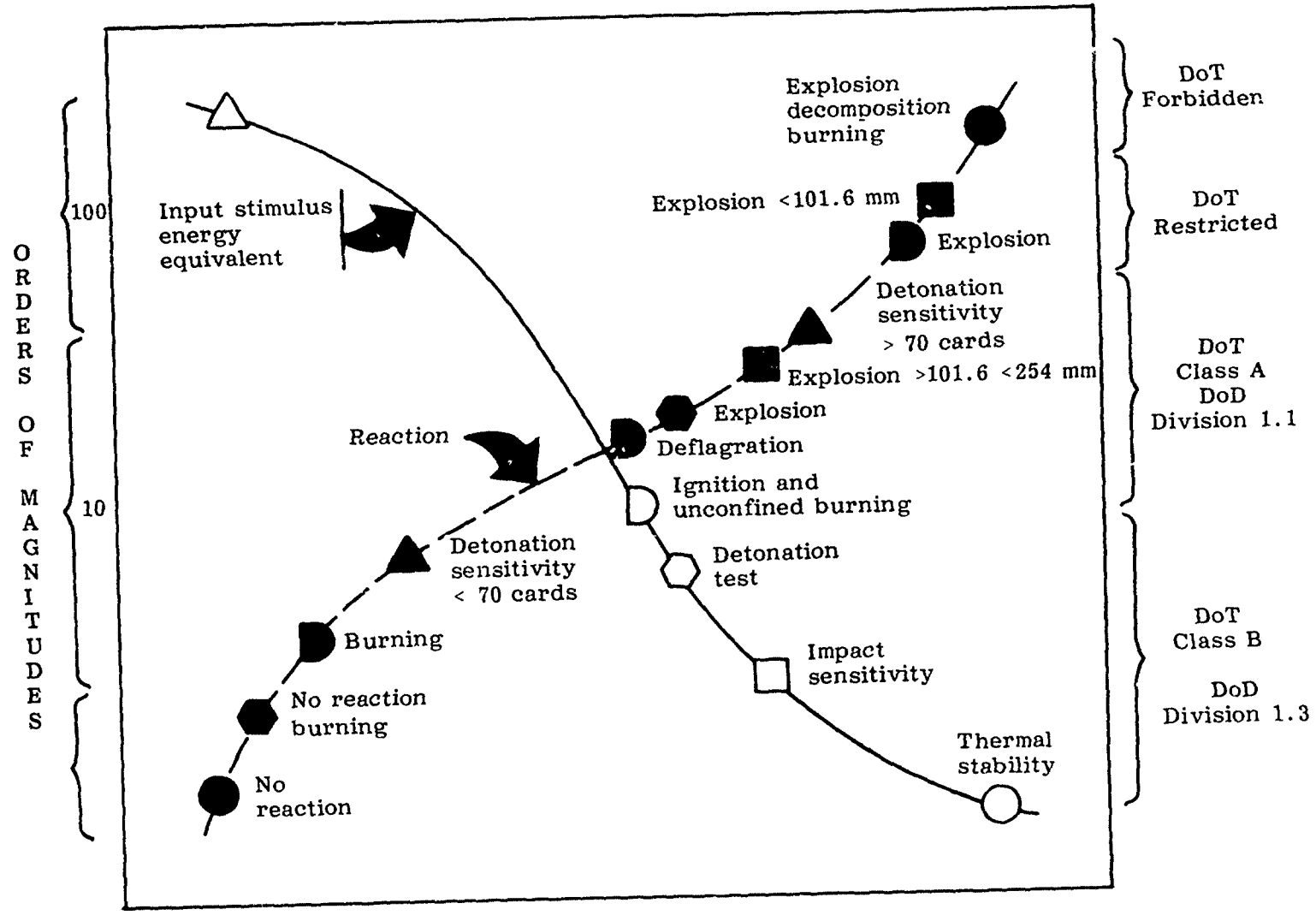

Figure 1. Interim qualification for bulk materials per DoD explosives classification procedures initiation susceptibility versus output reaction

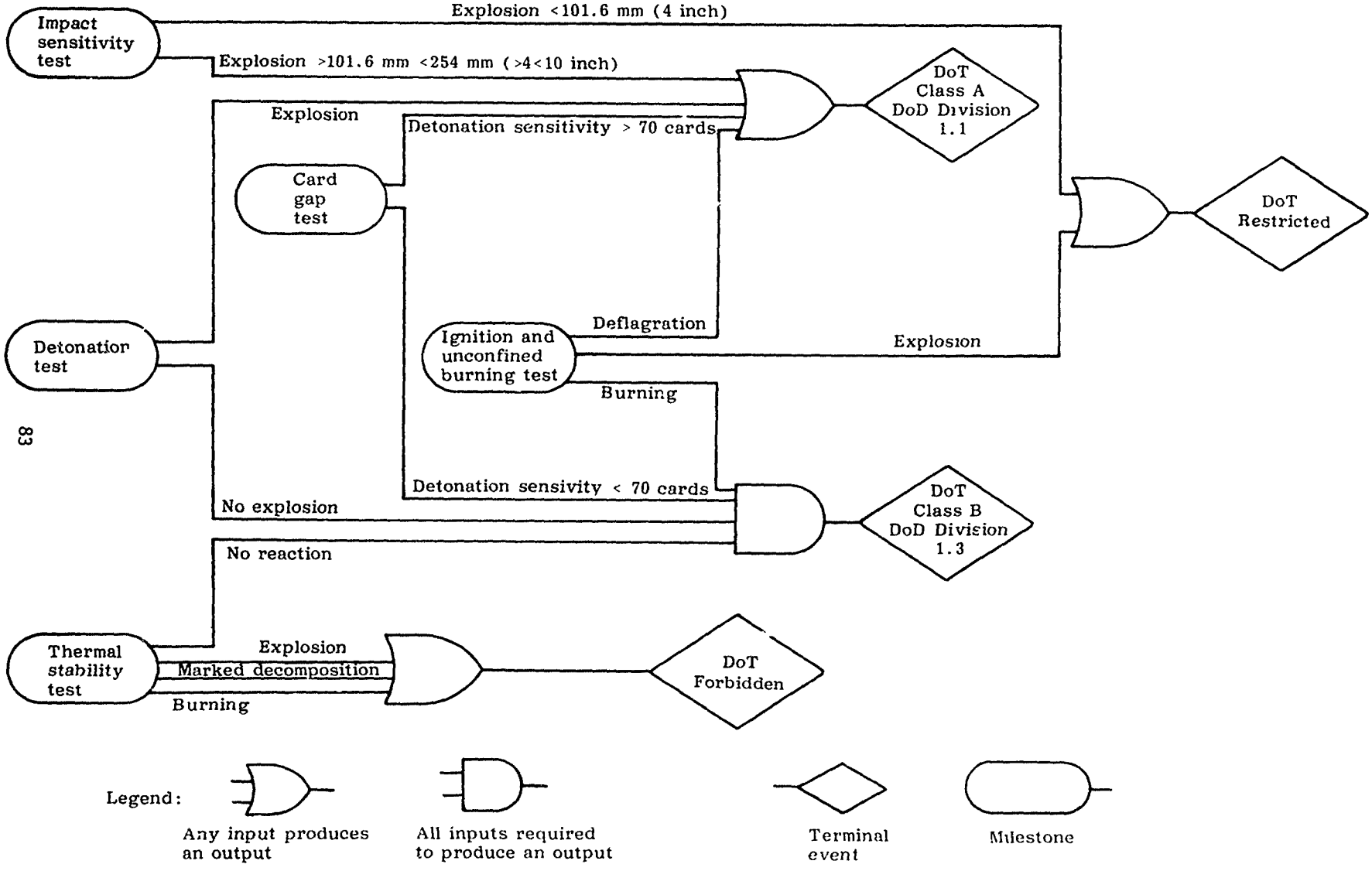

Figure 2. Interpretation of interim qualification tests paragraph 5.4 DoD explosives hazards classification procedures TB 700-2

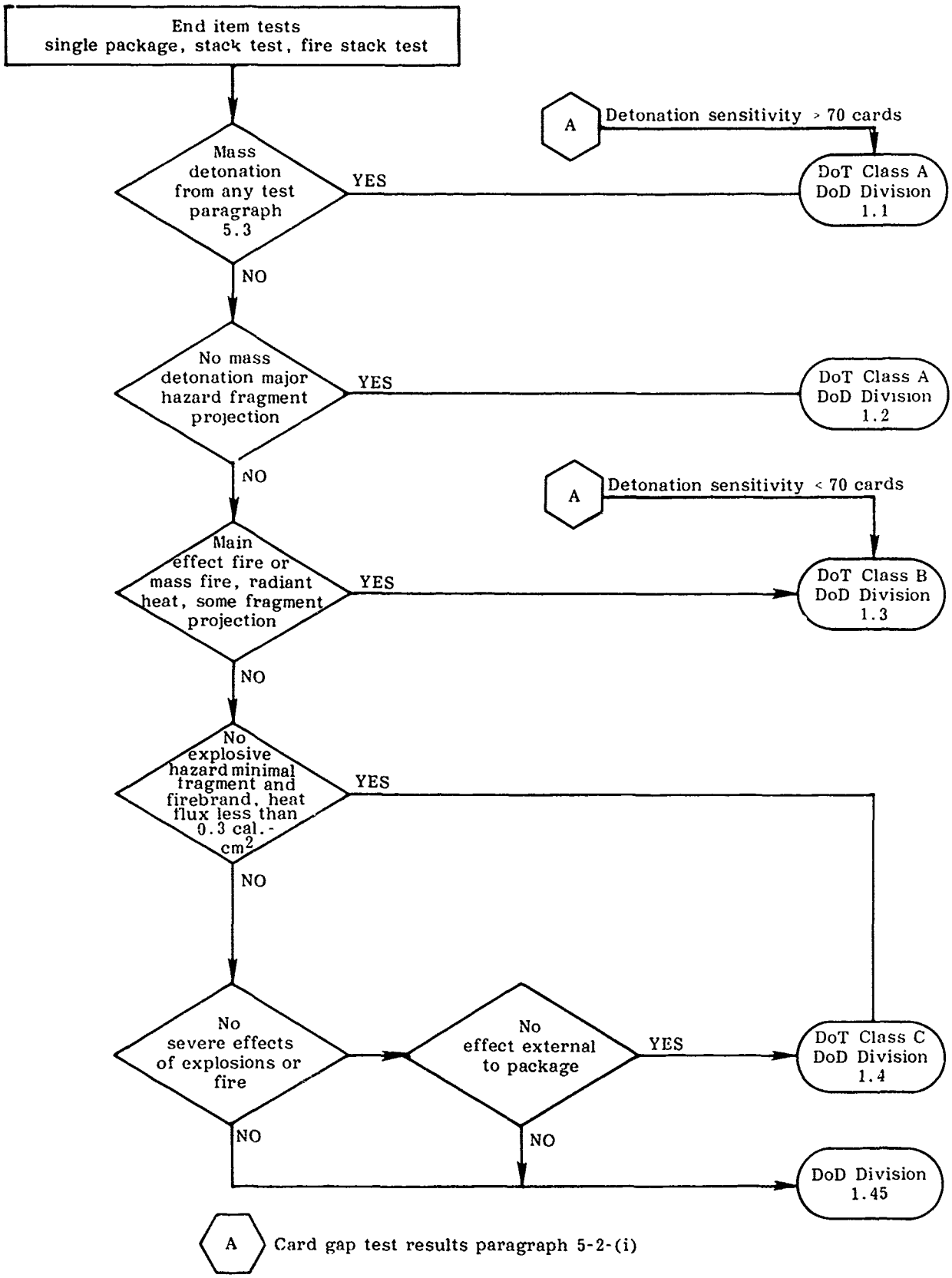

Figure 3. Interpretation of results for end item classification tests

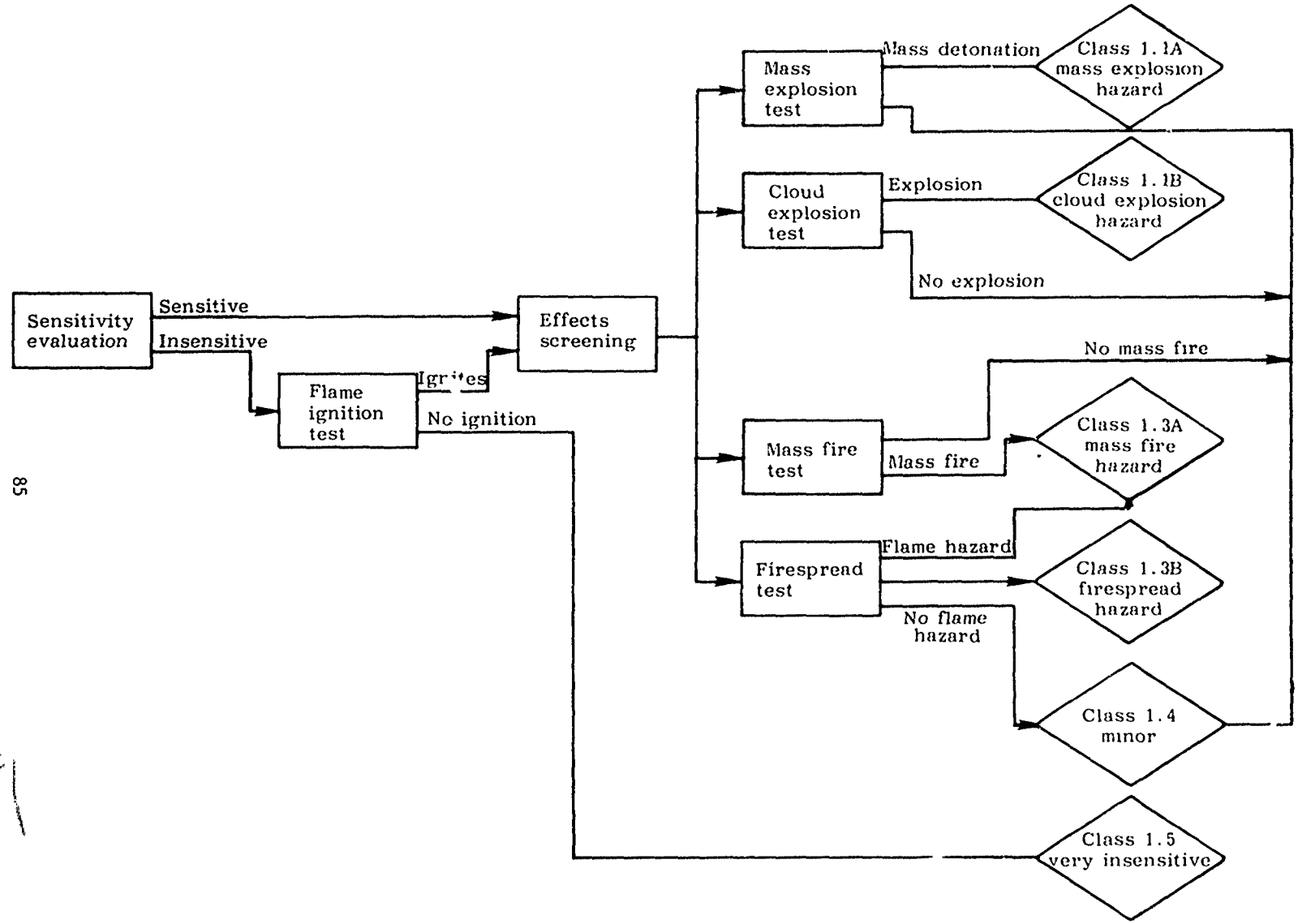

Figure 4. Proposed in-process hazards classification procedure