SANDIA REPORT

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Printed January 2017

Final Hazard Classification Request for Not More Than 5 Percent Explosives in Solution

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Prepared by
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Final Hazard Classification Request for Not More Than 5 Percent Explosives in Solvent Mixtures

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Abstract

This report requests a non-explosive hazard classification of trace explosives in solution. UN Series 1 and 2 explosive hazard classification tests were performed on a simulated worst-case waste stream of five (5) percent by weight of explosive (CL-20) dissolved in a solvent solution (acetone) for transport and storage. The explosive hazard classification test results reported the sample to be non-explosive and the report provides the necessary data for the Department of Transportation to determine and assign the appropriate hazard class for five (5) percent or less of trace explosive in solvent solutions when being shipped and/or stored. Based on the test results, this report requests that the Department of Transportation assign a hazard class of 3, Desensitized explosive liquid, n.o.s. for this type of substance.

CONTENTS

TABLES

NOMENCLATURE

CL-20	2,4,6,8,10,12-hexanitrohexaazaisowurtzitane (HNIW)(CL-20)
DOE	Department of Energy
DOT	Department of Transportation
g	grams
PI	Packaging Instructions
SNL	Sandia National Laboratories

1. INTRODUCTION

1.1. Purpose

Sandia National Laboratories (SNL), on behalf of the Department of Energy (DOE), is requesting that the Department of Transportation (DOT) issue a non-explosive hazard classification for not more than five (5) percent of any explosive mixture in any solvent mixture or solution. These trace explosive mixtures meet the definition of new explosives under Title 49, Code of Federal Regulation (CFR) Section 173.56, however, five percent or less of explosives by weight present in solvent solutions do not exhibit explosive hazards or explosive chemical properties at these concentrations.

1.2 Scope

Sandia National Laboratories is a research and development facility that performs analytical studies on many explosives substances. Hundreds of samples comprising dozens of explosive in solvents in all possible combinations could be created. Most of these solutions are not more than 5 percent by weight explosive substance and are handled as non-explosive substances throughout their processing due to the explosives present not exhibiting any explosive hazards or chemical properties. Once the solutions are created, they are assigned an explosive hazard classification for storage, transportation in public domain, and disposal. SNL is requesting a non-explosive hazard classification for solutions containing not more than five (5) percent by weight of any explosive. Per 49 CFR 173.56(b)(3), the explosive solvent mixture was tested per the *Department of Defense Ammunition and Explosive Hazard Classification Procedures*, 5 January 1998 (TB 700-2) which is incorporated by reference in 49 CFR 171.7(o)(i). The more recent version of TB 700-2, dated 30 July 2012, was also used for reference.

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2. REQUIREMENTS

2.1 Substance Description

The trace explosive solution hazard classification request is for not more than five (5) percent by weight of any explosive in any single solvent or solvent mixture.

2.2 Test Substance Description

Hexanitrohexaazaisowurtzitane, also known as CL-20, due to being a fairly sensitive molecule (slightly more sensitive than PETN) and also having the highest detonation energy of any commonly available explosive, was used to simulate the worst case of an explosive substance. Acetone was selected as the simulated solvent due to it being the most likely to be used and the most flammable of solvent substance. The worst-case explosive-solvent solution used to test whether such substances would have explosive properties contained five percent by weight CL-20 in acetone.

2.3 Explosive Testing Laboratory

49 CFR 173.56(b)(1) provides that new explosives must be examined and assigned a recommended shipping description, classification, and compatibility group by a person who has been approved by the Associated Administrator.

Explosive Examiners, LLC, met that qualification and was selected as the testing agency.

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3. HAZARD CLASSIFICATION TEST DATA

Explosives classification tests were performed by Explosive Examiners, LLC at UTEC Test Site NW110 Street and Center Star Road, Hallowell, KS, 66725 on August 24, 2016. Details of the tests are provided in Appendices A through F.

3.1 UN Series 1 Tests

The following UN Series 1 tests described in Chapter 5 of TB 700-2 were conducted to provide the answer to "Is a solution with not more than five (5) percent by weight of an explosive an explosive substance?"

A solution of five (5) percent by weight CL-20 in acetone was created for testing.

Table 1. UN Series 1 Tests

Tests to Determine if Substance is an Explosive			
UN Test No.	**Test Types**	**Name of Test**	**Results**
1(a)	Shock	UN Gap Test	Negative
1(b)	Heating under confinement	Koenen Test	Negative
1(c)(ii)	Ignition under confinement	Internal Ignition Test	Negative

Conclusions: The negative results for these three tests indicated the solution is excluded from classification as a Class 1 explosive, using the criteria in TB 700-2.

3.2 UN Series 2 Tests

The following UN Series 2 tests described in the 2012 version of TB 700-2 were conducted to provide the answer to "Is a solution with not more than five (5) percent by weight of an explosive too insensitive for inclusion in Class 1?"

A solution of five (5) percent by weight CL-20 in acetone was created for testing.

Table 2. UN Series 2 Tests

Tests to Determine if Substance is an Explosive			
UN Test No.	**Test Types**	**Name of Test**	**Results**
2(a)	Shock	UN Gap Test	Negative
2(b)	Heating under confinement	Koenen Test	Negative
2(c)(ii)	Ignition under confinement	Internal Ignition Test	Negative

Solutions excluded from Class 1 could require assignment to another class based on the other substance hazards, hazard class 3, Flammable liquid for most solvents.

Conclusions: The negative results for these three tests indicated the solution is excluded from classification as a Class 1 explosive, using the criteria in the 2012 version of TB 700-2.

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4. CONCLUSIONS

4.1 Explosive Hazard Classification

Based on the results of the explosive hazard classification tests summarized in Section 3, SNL requests that the DOT classify the various solutions with not more than five (5) percent by weight of any explosive materials as described below in Table 3.

Table 3. Explosive Hazard Classification

Proper Shipping Name:	Desensitized explosive, liquid, n.o.s.
Hazard Class and Division:	3
Identification Number:	UN3379
Packing Group	I
Packing Instruction Per 49 CFR 172-101	Column 8B (non-bulk) 173.201
Packaging Description:	Packaging shall be in a plastic drum (1H1), plastic jerrican (3B1) or internal packaging of glass of plastic contained in combustible outer packagings (wood, plywood, plastic, or fiberboard). Metal containers shall not be used.

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4. REFERENCES

1. Department of Transportation (DOT), Code of Federal Regulation (CRF) Title 49, Parts 100-177, November 1 2015.
2. TB 700-2, *Department of Defense Ammunition and Explosives Hazard Classification Procedures*, 5 January 1998.
3. TB 700-2 *Department of Defense Ammunition and Explosives Hazard Classification Procedures*, 30 July 2012.
4. Safety Data Sheet for Acetone
5. Material Safety Data Sheet for CL-20

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APPENDIX

APPENDIX A: Explosive Examiners, LLC, Explosive Examination Report: SANDIA-001 Revision B, December 14, 2016.

APPENDIX B: UTEC Procedure for the UN Test 1(a) Gap Test for Liquids in Accordance with TN 700-2 (1998).

APPENDIX C: UTEC procedure for UN Test 1(b), 2(b) Koenen Test in accordance with TB 700-2 (2012).

APPENDIX D: UTEC Procedure for UN Test 1(b)(ii) Internal Ignition Test in Accordance with TB 700-2 (1998).

APPENDIX E: UTEC Procedure for UN Test 2(a) Gap Test for Liquids in Accordance with TB 700-2 (2012).

APPENDIX F: UTEC Procedure for the UN Test 2(c)(ii) Internal Ignition Test in Accordance with TB 700-2 (2012).

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APPENDIX A

Explosives Examiners, LLC
3714 Crescent Drive, Pearland, Texas 77584-9455
Phone: +1-281-692-0178
e-mail: explosivesexaminers@gmail.com

Explosives Examination Report:

SANDIA-001 Revision B

Prepared for: Sandia National Laboratories
Regulated Waste & Pollution Prevention Department
P.O. Box 5800
Albuquerque, NM 87185-1117

Purchase Order No.: 1704960

December 13, 2016

Revision Notes:

08/29/16 Revision A.
12/13/16 Revision B. Changed SAND-001 to SANDIA-001 at the request of the client.

EXECUTIVE SUMMARY.

Item Tested: 5% CL20 dissolved in acetone
Manufacturer: Sandia National Laboratories
Manufacturer's Location: 1515 Eubank SE, Albuquerque, NM 87123

Test	Result
UN 1(a) UN Gap Test	Negative
UN 1(b) Koenen Test	Negative
UN 1(c)(ii) Internal Ignition Test	Negative
UN 2(a) UN Gap Test	Negative
UN 2(b) Koenen Test	Negative
UN 2(c)(ii) Internal Ignition Test	Negative

Recommendations: Proper Shipping Name: **Desensitized explosive, liquid, n.o.s.**
Hazard Class and Division: **3**
Identification Number: **UN3379**
Packing Group: **PGI**

This hazard classification recommendation is packaging dependent.

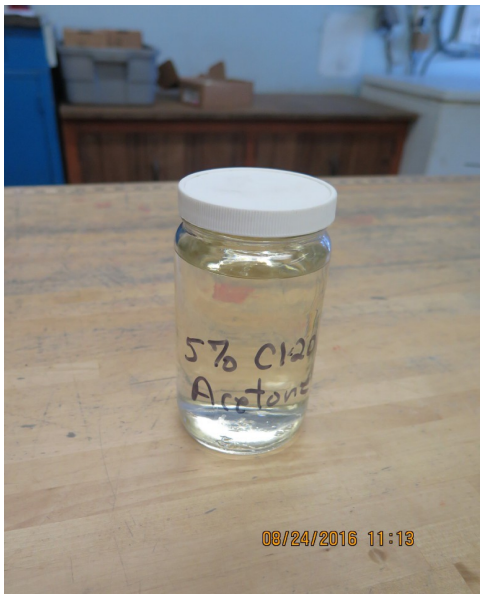
Packaging shall be in plastic drums (1H1), plastic jerrican (3B1) or internal packagings of glass or plastic contained in combustible outer packagings (wood, plywood, plastic, or fiberboard). Metal containers shall not be used because in a fire the desensitizing solvent may evaporate or burn away leaving a detonable residue in the container.

This recommendation applies to all explosive materials with the following restrictions. Any suitable liquid may be used as the desensitizing agent. The explosive must be completely dissolved in the solvent. The explosive content of the solution shall not exceed five (5) percent by weight. The desensitizing liquid shall not freeze and the dissolved explosive shall not precipitate at the anticipated shipping temperatures.

DESCRIPTION.

The customer desires a hazard classification to allow shipment of many different laboratory wastes for disposal. Since their list of wastes is literally composed of hundreds of samples comprising dozens of explosives and solvents in all possible combinations, it is simply not feasible to test every waste. We decided to test a single representative simulated waste. The substance tested was a five (5) percent by weight solution of hexanitrohexaazaisowurtzitane (HNIW, or CL20) in acetone. CL20 is thought to

represent the worst case in that it is a fairly sensitive molecule (slightly more sensitive than PETN) and it also has the highest detonation energy of any commonly available explosive.



A photograph of the sample material.

A tentative approval was prepared for the test sample, CA2012011461-TA0047. The sample was shipped using a Department of Energy issued interim hazard classification.

TEST SELECTION LOGIC.

The intent is to desensitize the explosive and remove the solution from class 1. The appropriate tests are from UN Series 1 and 2.

UN Series 1 tests are designed to answer the question, "Is it an explosive substance?" The 1(a) UN gap test (no gap), 1(b) Koenen test (1 mm hole), and 1(c)(ii) internal ignition test (20 g BP igniter charge) are all required tests. Usually a negative indication of all Series 1 tests would be sufficient to remove a substance from class 1, however, the Department of Energy's competent authority also desired to see the Series 2 tests completed as well.

UN series 2 tests are applied to answer the question, "Is the substance is too insensitive for inclusion in Class 1?" The 2(a) UN gap test (50 mm PMMA gap), 2(b) Koenen test (2 mm hole), and 2(c)(ii) Internal ignition test (10 g BP igniter charge) are required tests.

The Department of Energy's competent authority also requested that the Series 1 tests be conducted in accordance with TB 700-2 (1998) and Series 2 tests in accordance with TB 700-2 (2012). Test procedures conforming to TB 700-2 were specially written for this effort and were submitted to Sandia and DOE for approval. The procedures were approved and were followed for all tests.

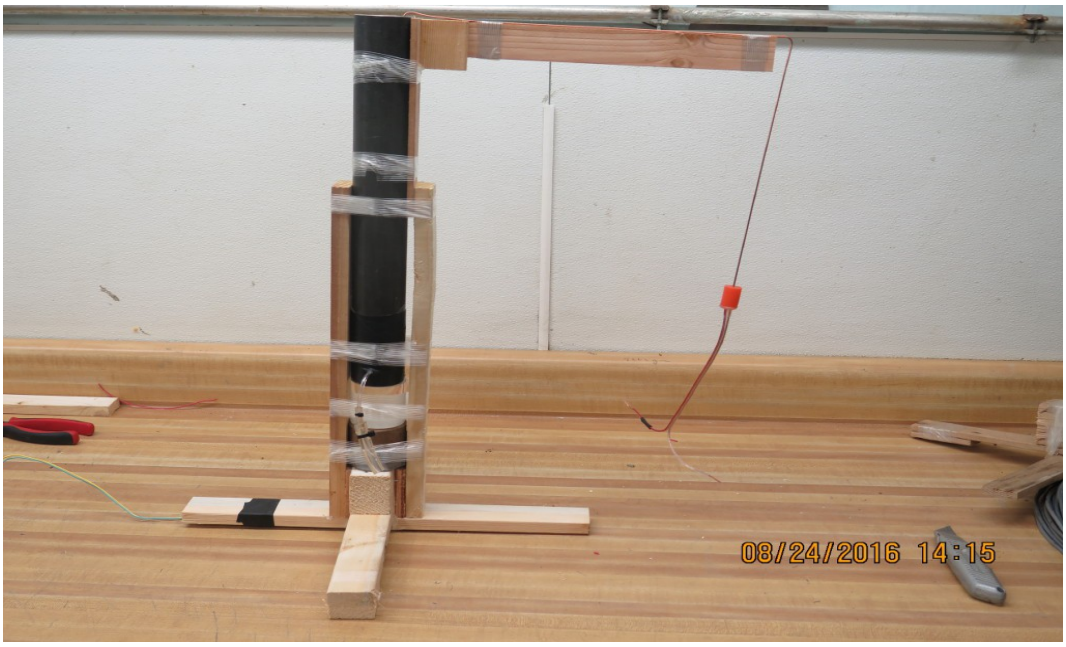
TEST RESULTS.

2(a) UN Gap Test. Result: Negative

Test Location: UTEC Test Site, NW 110 Street & Center Star Road, Hallowell, KS, 66725

Test Date and Witness: 24 August 2016, witnessed by Philip Kneisl

Two trials were conducted in full compliance with Section 12.4 of the *UN Manual of Tests and Criteria* and TB 700-2 (2012). The two trial results were identical. The gap test tube was undamaged. The PMMA gap was shoved into the bottom of the gap test tube by the detonating booster. The witness plate was not holed. No steady shock velocity was measured. The test result is negative.



2(a) Setup showing bubbler tube, PMMA gap, and detonation velocity probe.

2(a) Trial 1 post-test.

2(a) Trial 2 post-test.

2(b) Koenen Test. Result: Negative

Test Location: UTEC Test Site, NW 110 Street & Center Star Road, Hallowell, KS, 66725

Test Date and Witness: 24 August 2016, witnessed by Philip Kneisl

Three trials were conducted in full compliance with Section 12.5 of the *UN Manual of Tests and Criteria* and TB 700-2 (2012). The sample tube was loaded to within 15 mm of the tube top with sample and the 2 mm hole disk installed. The three trial results were identical. The sample vented and burned for 10 to 15 seconds. There was no detonation or deflagration and consequently no damage to the sample tubes. All trials were video taped.

The test result is negative.

2(b) Trial 1, 2, and 3 post-test.

2(c)(ii) Internal Ignition Test. Result: Negative

Test Location: UTEC Test Site, NW 110 Street & Center Star Road, Hallowell, KS, 66725

Test Date and Witness: 25 August 2016, witnessed by Philip Kneisl

Three trials were conducted in full compliance with Section 12.6.2 of the *UN Manual of Tests and Criteria* and TB 700-2 (2012). The three trial results were identical. No sound was heard when the sample was initiated. The pipe nipples were recovered intact with their end caps on. Neither the tube or end caps were fragmented.

The test result is negative.

2(c)(ii) Trials 1 and 2 post-test.

2(c)(ii) Trial 3 post-test.

1(a) UN Gap Test. Result: Negative

Test Location: UTEC Test Site, NW 110 Street & Center Star Road, Hallowell, KS, 66725

Test Date and Witness: 24 August 2016, witnessed by Philip Kneisl

Three trials were conducted in full compliance with Section 11.4 of the *UN Manual of Tests and Criteria* and TB 700-2 (1998). The three trial results were identical. The bottom 5-6 inches of the gap test tube was split from the effect of the Pentolite booster but the remainder of the tube was intact. The witness plate was not holed. No steady shock velocity was measured. The test result is negative.

1(a) Setup showing no PMMA gap, detonation velocity probe, the bubbler tube is on the far side.

1(a) Air supply for bubbler (also used for the UN 2(a) tests).

1(a) Trial 1 post-test.

1(a) Trial 2 post-test.

1(a) Trial 3 post-test.

1(b) Koenen Test. Result: Negative

Test Location: UTEC Test Site, NW 110 Street & Center Star Road, Hallowell, KS, 66725

Test Date and Witness: 24 August 2016, witnessed by Philip Kneisl

Three trials were conducted in full compliance with Section 11.5 of the *UN Manual of Tests and Criteria* and TB 700-2 (2012). The sample tube was loaded to within 15 mm of the tube top with sample and the 1 mm hole disk installed. The three trial results were identical. The sample vented and burned for 10 to 15 seconds. There was no detonation or deflagration and consequently no damage to the sample tubes. All trials were video taped.

The test result is negative.

1(b) Trial 1, 2, and 3 post-test.

1(c)(ii) Internal Ignition Test. Result: Negative

Test Location: UTEC Test Site, NW 110 Street & Center Star Road, Hallowell, KS, 66725

Test Date and Witness: 25 August 2016, witnessed by Philip Kneisl

Three trials were conducted in full compliance with Section 11.6.2 of the *UN Manual of Tests and Criteria* and TB 700-2 (1998). The three trial results were identical. No sound was heard when the sample was initiated. The pipe nipples were recovered intact with their end caps on. Neither the tube or end caps were fragmented.

The test result is negative.

1(c)(ii) Trial 1 post-test.

1(c)(ii) Trials 2 and 3 post-test.

Recommended DOT Classification.

Based on the observations contained in this report, a review of the *UN Manual of Tests and Criteria*, and in accordance with 49 CFR Parts 172, 173.50, 173.52 it is recommended that up to 5 percent by weight explosive dissolved in solvent, should be described as:

Recommendations: Proper Shipping Name: **Desensitized explosive, liquid, n.o.s.**
Hazard Class and Division: **3**
Identification Number: **UN3379**
Packing Group: **PGI**

This hazard classification recommendation is packaging dependent.

Packaging shall be in plastic drums (1H1), plastic jerrican (3B1) or internal packagings of glass or plastic contained in combustible outer packagings (wood, plywood, plastic, or fiberboard). Metal containers shall not be used because in a fire the desensitizing solvent may evaporate or burn away leaving a detonable residue in the container.

This recommendation applies to all explosive materials with the following restrictions. Any suitable liquid may be used as the desensitizing agent. The explosive must be completely dissolved in the solvent. The explosive content of the solution shall not exceed five (5) percent by weight. The desensitizing liquid shall not freeze and the dissolved explosive shall not precipitate at the anticipated shipping temperatures.

The required non-bulk surface transportation packaging instructions can be found in:
49 CFR Part Part 173.201.

The required non-bulk surface transportation marking instructions can be found in:
49 CFR Part 172.301.

The required non-bulk surface transportation labeling instructions can be found in:
49 CFR Parts 172.420.

Please note that this test report does not authorize you to ship the examined material. You must submit this test report to a recognized US competent authority and apply for approval before any material may be offered for shipment.

I hereby certify that this classification recommendation report, and all evaluation, examination, and testing carried out by Explosives Examiners LLC in preparation of this report are in full compliance with the applicable requirements of the HMR and CA2012010042 **.**

Philip Kneisl
President
Explosives Examiners LLC

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Before beginning this test, a review of any applicable Material Safety Data Sheets must be conducted. Furthermore, personnel must wear/use all necessary PPE when conducting this test.
At the completion of testing, clean up should be done in a timely manner and using lab approved methods.

UTEC Procedure for the UN Test 1(a) Gap Test for Liquids In Accordance With TB 700-2 (1998)

A. OUTLINE OF METHOD:

The purpose of this test is to determine if the substance is too insensitive to shock for inclusion in Class 1. A full test regiment consists of three trials.

B. INTERFERENCES:

There are no known interferences for this method.

C. SAFETY:

Follow all IME recommendation on the handling of blasting caps (see IME SLP No. 4, 17, 20). Make sure all cell phones, CB radios or any item using an RF signal are turned off. Handle all explosives with extreme care.

D. MATERIALS:

The following materials are required.

a) Steel tubing, ASTM 1026 or drawn over mandrel (DOM)
1.875 in (4.76 cm) OD
1.440 in (3.65 cm) ID
16 in (40,6 cm) long

b) Booster Pellet, 50/50 Pentolite
Density = 1.60 ± 0.05 g/cc
2.00 in (5.08 cm) dia. x 2 in (5.08) height
Weight = 165 g

c) Blasting cap, No. 8

d) Wooden stand and detonator holder.

e) Spacer, 0.063 in (0.16 cm)

f) Witness plate, ASTM 1020 - 1025
6 in x 6 in x 0.125 in (15.24 cm x 15.24 cm x 0.32 cm)

g) Continuous detonation velocity probe

h) Tygon tubing, 4 mm OD with holes on one end (for air bubbles)

i) Air flow meter

j) Air regulator with flow control valve

k) Air cylinder

l) Polyethylene film and PVC electricians tape

E. PROCEDURE:

At the Main Building.

1. A 4 mm hole is drilled in the side wall of the steel tube about 12 mm from its bottom end, and the 4 mm o.d. Tygon bubbler tubing is passed through the steel tube's sidewall. The Tygon tube's bubbler section (0.5 mm diameter holes punched in tube) is seated in the bottom of the tube. Sealant is applied to the area where the Tygon tubing passes through the steel tube's sidewall to prevent leaking. A small notch is cut in the top end of the steel tube to allow for the passing of the continuous VOD probe.

2. The bottom of the steel tube is sealed with a piece of polyethylene sheeting and PVC electrical tape. The integrity of the seal is checked. The detonation velocity probe is positioned inside the steel tube along its sidewall, and a small amount of sealant is applied to the notched area of the steel tube to prevent leaking.

3. Fill the steel tube with the test liquid (load to within 1.6 mm of the top of the tube) and partially seal the top of the tube with a piece of polyethylene sheeting and PVC electrical tape (enough of an opening must be maintained to allow for the escape of the air bubbles).

4. Assemble the steel tube with the booster pellet, wooden stand and detonator.

5. The firing technician shall remove the firing key from the firing box and keep it in his possession.

On the Firing Line.

1. Position the air cylinder and regulator at a safe location from the test.

2. Attach the air supply line (which includes the air flow meter, air regulator and air cylinder) to the air bubbler tubing coming out of the steel pipe fixture, and adjust the air flow to 1200 ± 100 cc/min (this setting for the air flow should be determined before hand).

3. Add the spacer and witness plate to the top of the steel tubing and connect the velocity measurement leads to the data lines. When all is ready connect the detonator to the firing leads.

4. Double check that the air supply is on, the witness plate is in place and the firing leads are connected to the detonator.

5. Evacuate the firing range and return to the main building/firing location.

At the Main Building.

1. Verify that the continuous detonation velocity instrumentation is turned on and is operational.

2. The firing technician shall account for everyone at the test site and ensure each person is at a safe location before firing the test.

3. When all personnel are accounted for, the firing technician shall install the firing key in the firing box.

4. The firing technician shall sound the warning siren for 15 seconds while arming the firing box (turn the firing key to the arm position), after checking the surveillance cameras, the firing button shall be pressed and the shot fired.

5. The firing key shall be turned to the safe position and a suitable safety wait observed.

On the Firing Line.

1. Turn off the air supply.

2. Locate the steel tube and witness plate.

3. Police the test site and prepare it for the next trial.

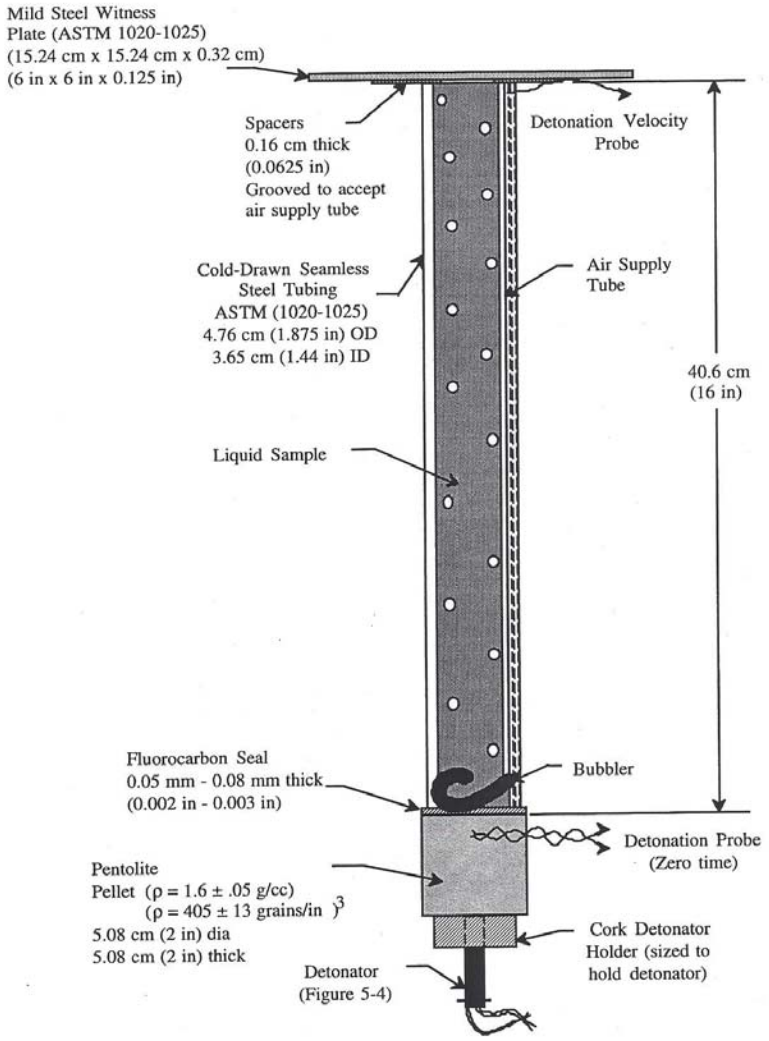
F. ASSESSING THE RESULTS:

1. The results are positive (+) and the substance is considered to be a potential candidate for Class 1 if any two of the following three criteria occurs:
   a. A hole is punched through the witness plate.
   b. The sample tube is fragmented along its entire length.
   c. A stable detonation velocity greater than the velocity of sound in the test substance.
2. If the results are negative (-), the test is repeated two more times or until a positive result is obtained.

G. REFERENCES:

1. Department of Defense Ammunition and Explosives Hazard Classification Procedures, TB 700-2, published 5 January 1998.

2. UN's "Recommendations on the Transport of Dangerous Goods Manual of Test and Criteria", Sixth Revised Edition.



NOT TO SCALE

See Paragraph 5-2.*a*.

Figure 5-3. Gap test configuration for liquid substances—UN Test 1(a) (iii)

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EMAIL: gary@utec-corp.com

Before beginning this test, a review of any applicable Material Safety Data Sheets must be conducted. Furthermore, personnel must wear/use all necessary PPE when conducting this test.
At the completion of testing, clean up should be done in a timely manner and using lab approved methods.

UTEC Procedure for the UN Test 1(b), 2(b) Koenen Test In Accordance With TB 700-2 (2012)

A. OUTLINE OF METHOD:

This test is used to measure the sensitiveness of a substance to an intense heat source with high confinement and to determine if the substance is too dangerous to transport in the form tested. It is applicable to solid, liquid, and powdered substances.

B. INTERFERENCES:

None.

C. APPARATUS:

a) The test apparatus is designed so that a sample can be encased in a steel tube with an orifice plate attached and subjected to high heat by 4 propane burners. The tube and burners are encased in a steel structure designed to limit the exit of steel fragments, and to keep the fragments from destroying the burner support structure and gas manifolds.

b) Steel tubes, 24 mm. inside diameter by 75 mm. long with a wall thickness of 0.5 ± 0.05 mm. The mass of the tubes shall be 26.5 ±1.5 grams. These tubes carry a BAM certification.

c) Steel enclosures and orifice plates. Orifice plates are sized at 1.0 mm, 1.5 mm, 2.0 mm, 2.5 mm, 3.0 mm, 5.0 mm, 8.0 mm, 12 mm, and 20 mm. The threaded collar and nut are made from heat resistant chrome steel.

d) 4 replaceable propane burners. These burners provide the intense heat to sample tubes.

e) The steel structure which supports the burners and gas manifolds. This structure keeps the steel fragments from destroying the gas manifold structures and incoming gas lines. It also supports the tube assembly as it is being heated.

D. CALIBRATION OF THE BURNERS:

1) Assemble the burners and gas manifold to the steel support structure. Attach gas line to gas manifold. Secure and test all connections.

2) Light pilot light and adjust all burners for equal gas feed. Make sure all burners light when remote valve is activated.

3) Fill 1 tube with 27 cm^3 (28.16 grams) of dibutyl phthalate. Slide nut up the tube and place the 3.0 mm orifice on tube and screw on threaded collar. Tighten. Set tube into steel support structure and place barrel enclosure over test apparatus. Insert thermocouple into orifice plate to a depth of 43 mm.

4) Return to UWE building and activate remote valve. Record time between temperatures of 135 to 285°C. Calculate heating rate as degrees K per second.

5) Adjust burners to give a heating rate of 3.3 ± 0.3 K/s

E. <u>PROCEDURE:</u>

1) Place new tube on balance. Zero balance.

2) Load test substance into tube until within 15 mm of the top. Record weight.

3) Slip bottom threaded collar on tube, place appropriate orifice plate on tube, and apply anti-seize lubricant to threads. The nut is screwed on threads and hand tightened. The assembled tube is weighed and recorded.

4) The assembled tube is placed in a vice and tightened with a spanner.

5) The assembled tube is placed in the steel support structure. The area surrounding the tank enclosure is cleared, and the video camera started.

6) Return to UWE building and activate remote valve. Start the timer at the same time. Heating is continued for five minutes, unless a rupture occurs. The time of the rupture event is recorded, along with any information on venting events.

7) After the heating period is complete, the video camera is turned off, and the assembled tube removed and weighed. If the tube has ruptured, the pieces are recovered, and weighed.

8) The tube is evaluated as to the effects of the heating.
The following effects are differentiated as:
"O" Tube undamaged
"A" Bottom of tube bulged out
"B" Bottom and wall of tube bulged out
"C" Bottom of tube split
"D" Wall of tube split
"E" Tube split into two fragments

"F" Tube fragmented into three or more mainly large pieces which in some cases may be connected with each other by a narrow strip

"G" Tube fragmented into many mainly small pieces, closing device undamaged

"H" Tube fragmented into many very small pieces, closing device bulged out or fragmented

9) The effects "O" through "E" are considered as no explosion or negative (-) results at that orifice diameter. Effects "F", "G", and "H" are considered to be explosion or positive (+) results at that orifice diameter.

10) The limiting diameter is considered the largest diameter in which the result explosion is obtained. Since this is a pass/fail test at 2.0 mm (2(b) test), or 1.0mm (1(b) test), 3 negative results must be obtain at this orifice size.

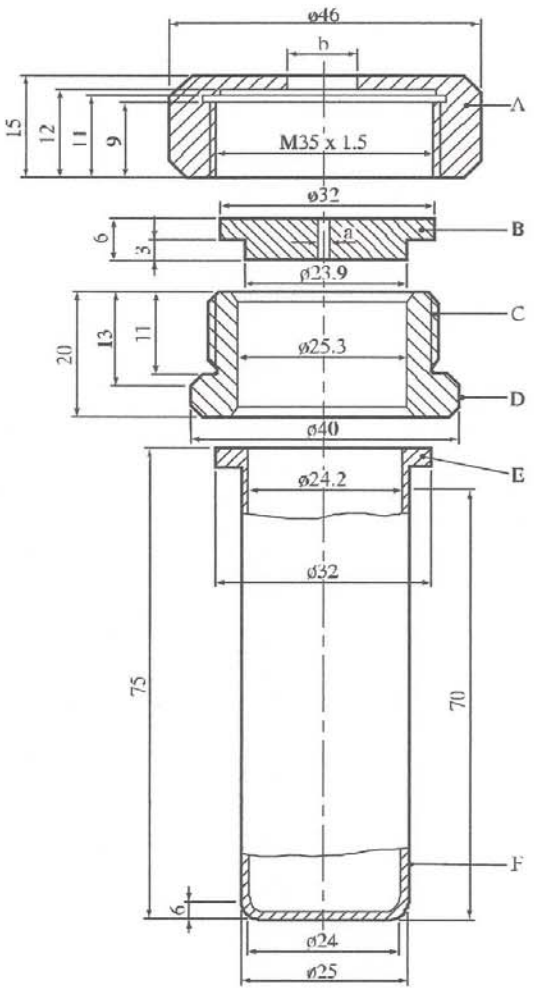
F. ASSESSING THE RESULTS:

The test results are assessed on the basis of whether the substance shows some effect on heating under confinement if the limiting diameter is 1.0 mm or more in the 1(b) test---negative(-) result---or 2.0 mm or more in the 2(b) test---negative(-) result---per UN manual direction.

G. REFERENCES:

1. Department of Defense Ammunition and Explosives Hazard Classification Procedures, TB 700-2, published 30 July 2012.

2. UN's "Recommendations on the Transport of Dangerous Goods Manual of Test and Criteria", Sixth Revised Edition.



(A)	Nut (b = 10.0 or 20.0 mm) with flats for size 41 spanner	(B)	Orifice plate (a = 1.0 → 20.0 mm diameter)
(C)	Threaded collar	(D)	Flats for size 36 spanner
(E)	Flange	(F)	Tube

Figure 11.5.1.1: TEST TUBE ASSEMBLY

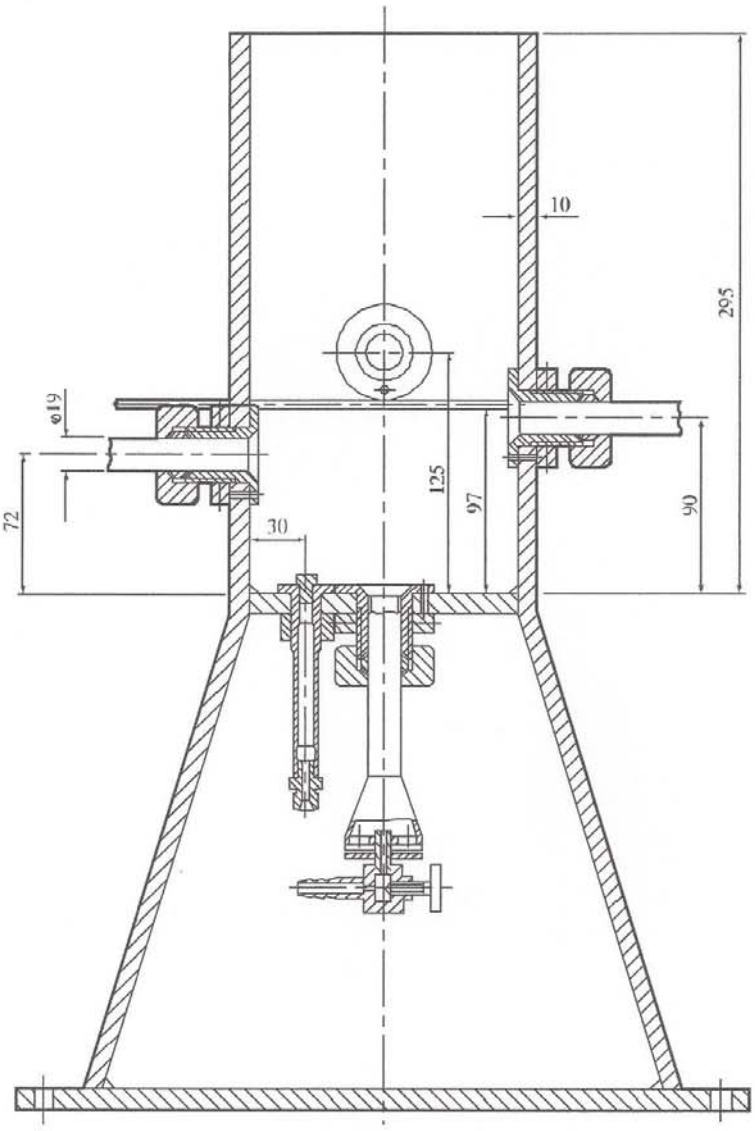


Figure 11.5.1.2: HEATING AND PROTECTIVE DEVICE

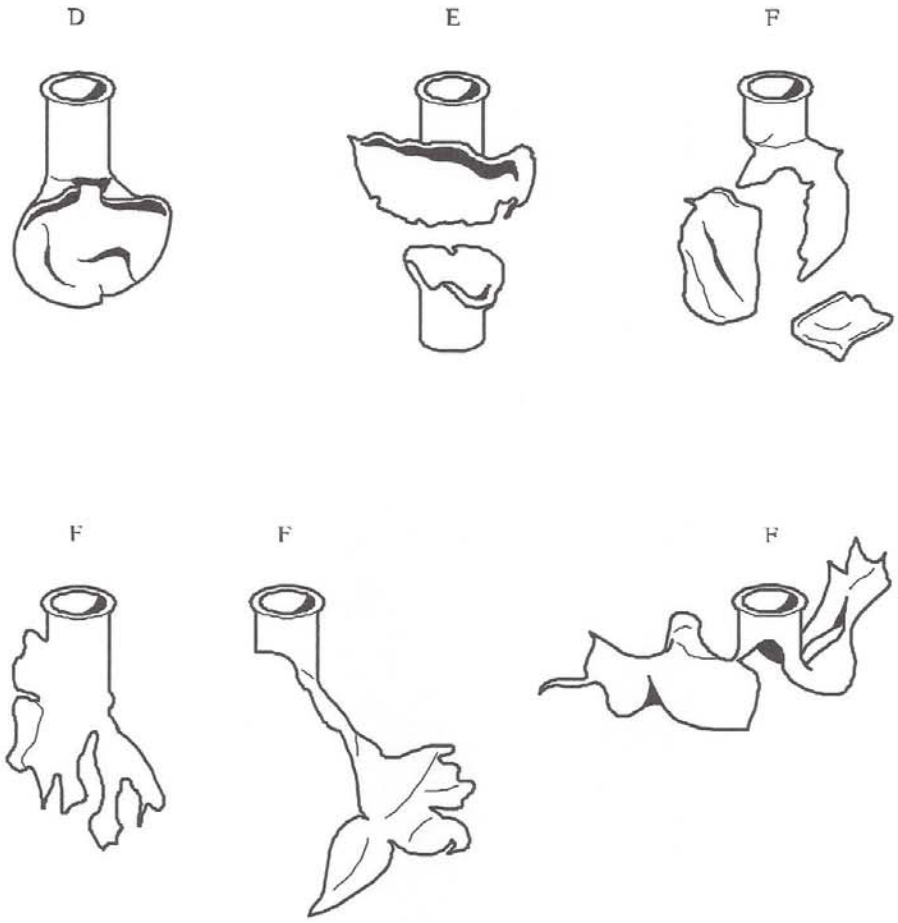


Figure 11.5.1.3: EXAMPLES OF EFFECT TYPES D, E AND F

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Before beginning this test, a review of any applicable Material Safety Data Sheets must be conducted. Furthermore, personnel must wear/use all necessary PPE when conducting this test.
At the completion of testing, clean up should be done in a timely manner and using lab approved methods.

UTEC Procedure for the UN Test 1(b)(ii) Internal Ignition Test In Accordance With TB 700-2 (1998)

A. OUTLINE OF METHOD:

The internal ignition test is designed to determine the response of substances to rapidly rising temperatures and pressures. A full test regiment consists of three trials.

B. INTERFERENCES:

There are no known interferences for this method.

C. SAFETY:

Follow all IME recommendation on the handling of blasting caps (see IME SLP No. 4, 17, 20). Make sure all cell phones, CB radios or any item using an RF signal are turned off. Handle all explosives with extreme care.

D. MATERIALS:

The following materials are required.

a) 3,000 lb forged steel end cap (2 required)
ASME B16.1 1-1991

b) 3.0-inch (76.2 cm) Sch 80 Steel pipe nipple (A53 Grade B)
0.3 in (0.76 cm) wall thickness
2.90 in (73.77 cm) ID
18 in (45.7 cm) long

c) Initiator assembly, composed of:
20 grams sieved black powder (100% thru No. 20, 100% retained No. 50)
Nickel-Chromium alloy wire, 0.012 in dia. x 1.0 in long
Plastic liquid tight container.

d) Two conductor wire

e) Epoxy for sealing

f) Power supply and firing line

E. PROCEDURE:

At the Main Building.

1. Assemble the pipe nipple with the igniter assembly, connector wire and epoxy sealant, and allow the epoxy to cure for a suitable period of time. The igniter assembly should be liquid tight to prevent ingress of the test sample.

2. Install the lower end cap using Teflon tape or pipe dope to achieve a liquid tight seal.

3. Holding the pipe nipple vertically, fill the nipple completely with test sample.

4. Install the upper end cap using Teflon tape or pipe dope to achieve a liquid tight seal.

5. The firing technician shall remove the firing line from the power supply and make sure the line is shunted.

On the Firing Line.

1. Position the pipe nipple inside the covered firing area.

2. Connect the firing leads to the connector wires.

3. Evacuate the firing range and return to the main building/firing location.

At the Main Building.

1. The firing technician shall account for everyone at the Hallowell test site and ensure each person is at a safe location before firing the test.

2. When all personnel are accounted for, the firing technician shall install the firing line to the power supply.

3. The firing technician shall sound the warning siren for 15 seconds before arming the firing line and after checking the surveillance cameras, the power supply will be turned on and brought to the correct current flow.

4. After the current flow has been interrupted, the power supply turned off, the firing line shall be removed from the power supply and shunted, a suitable safety wait time shall be observed.

On the Firing Line.

1. Locate and recover all pieces of the pipe nipple and both end caps.

2. Police the test site and prepare it for the next trial.

F. ASSESSING THE RESULTS:

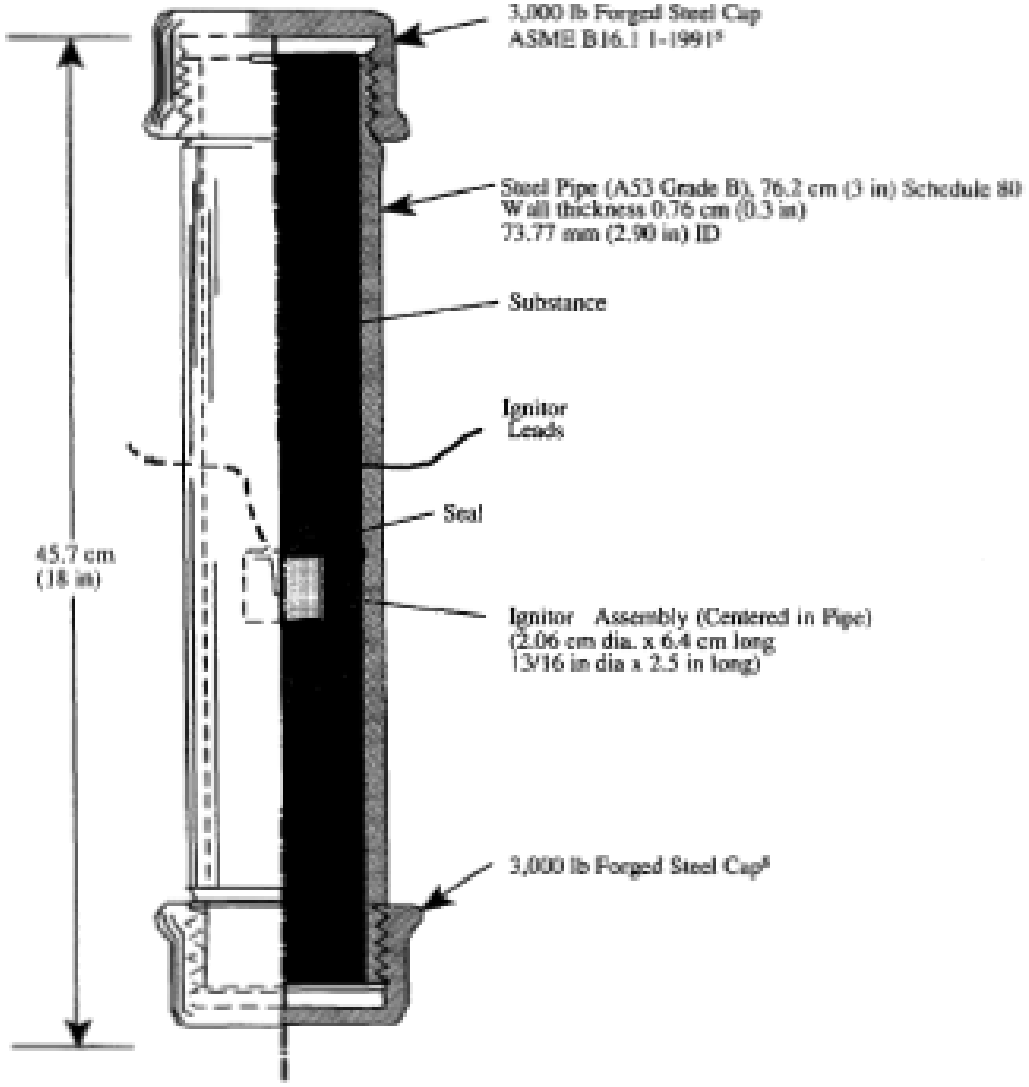
1. The result is positive (+) and the substance is a potential candidate for Class 1, if either the pipe nipple or one of the end caps is fragmented into at least two distinct pieces separated from the pipe.

2. The result is negative (-) if the reaction is no more violent than the pipe is either just split open or the end cap is only distorted.
3. If the results are negative(-), the test is repeated two more times or until a positive(+) result is attained.

G. REFERENCES:

1. Department of Defense Ammunition and Explosives Hazard Classification Procedures, TB 700-2, published 5 January 1998.

2. UN's "Recommendations on the Transport of Dangerous Goods Manual of Test and Criteria", Sixth Revised Edition.



NOT TO SCALE

[5]ASME B16.11-1991, "Forged Fittings, Socket-Welding and Threaded," American Society of Mechanical Engineers, New York, NY (latest revision).

See Paragraph 5-2.6.

Figure 5-5. Internal ignition test—UN Tests 1(b) (ii) and 2(b) (ii)

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Before beginning this test, a review of any applicable Material Safety Data Sheets must be conducted. Furthermore, personnel must wear/use all necessary PPE when conducting this test.
At the completion of testing, clean up should be done in a timely manner and using lab approved methods.

UTEC Procedure for the UN Test 2(a) Gap Test for Liquids In Accordance With TB 700-2 (2012)

A. OUTLINE OF METHOD:

The purpose of this test is to determine if the liquid substance will propagate a detonation through a polymethyl methacrylate (PMMA) gap. A full test regiment consists of two trials. It should be noted that the VOD measurement component of this test is optional, according to the test method, and is not include in the test criteria for assessing the test results.

B. INTERFERENCES:

There are no known interferences for this method.

C. SAFETY:

Follow all IME recommendation on the handling of blasting caps (see IME SLP No. 4, 17, 20). Make sure all cell phones, CB radios or any item using an RF signal are turned off. Handle all explosives with extreme care.

D. MATERIALS:

The following materials are required.

a) Steel tubing, ASTM 1026 or drawn over mandrel (DOM)
1.875 in (4.76 cm) OD
1.440 in (3.65 cm) ID
16 in (40,6 cm) long

b) Booster Pellet, 50/50 Pentolite
Density = 1.60 ± 0.05 g/cc
2.00 in (5.08 cm) dia. x 2 in (5.08) height
Weight = 165 g

c) PMMA pellet, (Plexiglass), 2.00 in (5.08 cm) dia. x 2 in (5.08) height

d) Blasting cap, No. 8

e) Wooden stand and detonator holder.

f) Spacer, 0.063 in (0.16 cm)

g) Witness plate, ASTM 1020 - 1025
6 in x 6 in x 0.125 in (15.24 cm x 15.24 cm x 0.32 cm)

h) Continuous detonation velocity probe

i) Tygon tubing, 4 mm OD with holes on one end(for air bubbles)

j) Air flow meter

k) Air regulator with flow control valve

l) Air cylinder

m) Polyethylene film and PVC electricians tape

E. PROCEDURE:

At the Main Building.

1. A 4 mm hole is drilled in the side wall of the steel tube about 12 mm from it bottom end, and the 4 mm o.d. Tygon bubbler tubing is passed through the steel tube's sidewall. The Tygon tube's bubbler section (0.5 mm diameter holes punched in tube) is seated in the bottom of the steel tube. Sealant is applied to the area where the Tygon tubing passes through the steel tube's sidewall to prevent leaking. A small notch is cut in the top end of the steel tube's sidewall to allow for the passing of the continuous VOD probe.

2. The bottom of the steel tube is sealed with a piece of polyethylene sheeting and PVC electrical tape. The integrity of the seal is checked. The detonation velocity probe is positioned inside the steel tube along its sidewall, and a small amount of sealant is applied to the notched area of the steel tube to prevent leaking.

3. Fill the steel tube with the test liquid (load to within 1.6 mm of the top of the tube) and partially seal the top of the tube with a piece of polyethylene sheeting and PVC electrical tape (enough of an opening must be maintained to allow for the escape of the air bubbles).

4. Assemble the steel tube with the PMMA pellet, booster pellet, wooden stand and detonator.

5. The firing technician shall remove the firing key from the firing box and keep it in his possession.

On the Firing Line.

1. Position the air cylinder and regulator at a safe location from the test.
2. Attach the air supply line (which includes the air flow meter, air regulator and air cylinder) to the air bubbler tubing coming out of the steel tube fixture, and adjust the air flow to 1200 ± 100 cc/min. (this setting for the air flow should be determined before hand).

3. Add the spacer and witness plate to the top of the steel tube and connect the velocity measurement leads to the data lines. When all is ready, connect the detonator to the firing leads.

4. Double check that the air supply is on, the witness plate is in place and the firing leads are connected to the detonator.

5. Evacuate the firing range and return to the main building/firing location.

At the Main Building.

1. Verify that the continuous detonation velocity instrumentation is turned on and is operational.

2. The firing technician shall account for everyone at the test site and ensure each person is at a safe location before firing the test.

3. When all personnel are accounted for, the firing technician shall install the firing key in the firing box.

4. The firing technician shall sound the warning siren for 15 seconds while arming the firing box (turn the firing key to the arm position), after checking the surveillance cameras, the firing button shall be pressed and the shot fired.

5. The firing key shall be turned to the safe position and a suitable safety wait observed.

On the Firing Line.

1. Turn off the air supply.

2. Locate the steel tube and witness plate.

3. Police the test site and prepare it for the next trial.

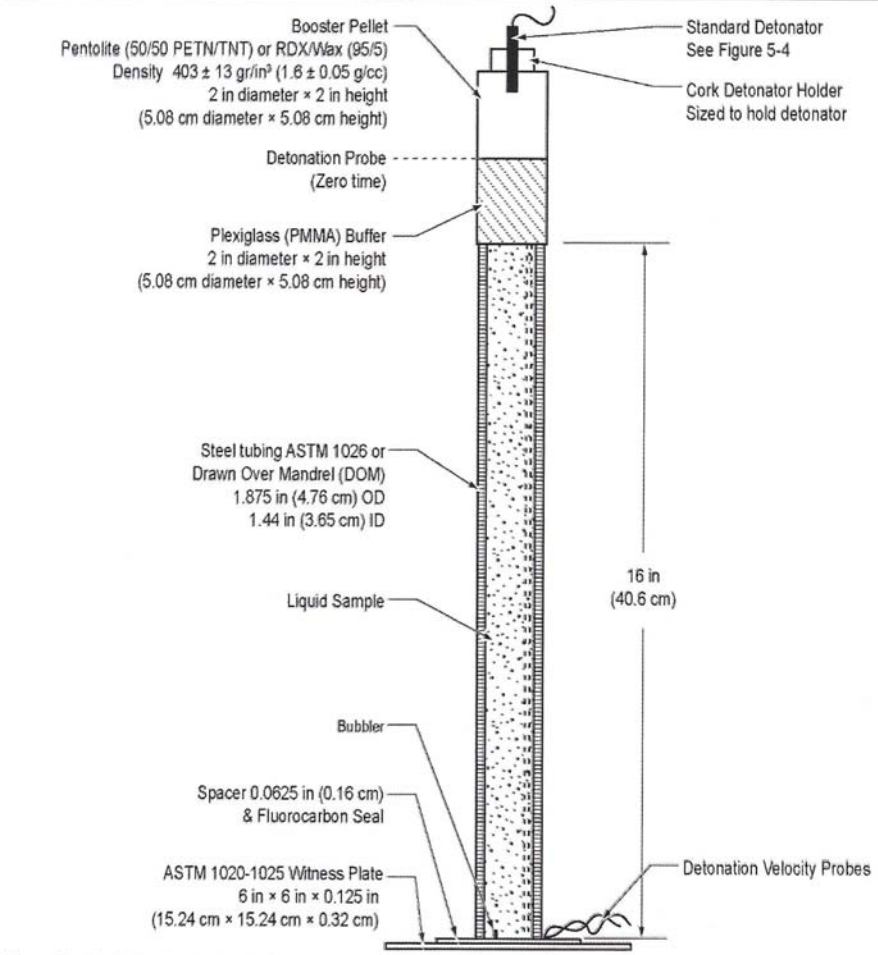
F. ASSESSING THE RESULTS:

1. The result is positive (+) and the substance is a candidate for Class 1 if either of the following criteria occurs:
   a. A hole is punched through the witness plate.
   b. The sample tube is fragmented along its entire length.
2. If the results are negative(-), the test is repeated one more time. If the results are positive (+), the testing is suspended.

G. REFERENCES:

1. Department of Defense Ammunition and Explosives Hazard Classification Procedures, TB 700-2, published 30 July 2012.

2. UN's "Recommendations on the Transport of Dangerous Goods Manual of Test and Criteria", Sixth Revised Edition.



(shown with optional detonation velocity probes)

NOTE: An air gap of at least 2 in (5.08 cm) is required between the witness plate and any solid surface to which the witness plate might be abutted.

Figure 5-7 Gap Test Configuration for Liquid Substances (UN Test 2(a))

c. UN Test 2(a)(ii) – Internal Ignition test

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Before beginning this test, a review of any applicable Material Safety Data Sheets must be conducted. Furthermore, personnel must wear/use all necessary PPE when conducting this test.
At the completion of testing, clean up should be done in a timely manner and using lab approved methods.

UTEC Procedure for the UN Test 2(c)(ii) Internal Ignition Test In Accordance With TB 700-2 (2012)

A. OUTLINE OF METHOD:

The test is used to determine the tendency of the substance to undergo transition from deflagration to detonation. A full test regiment consists of three trials.

B. INTERFERENCES:

There are no known interferences for this method.

C. SAFETY:

Follow all IME recommendation on the handling of blasting caps (see IME SLP No. 4, 17, 20). Make sure all cell phones, CB radios or any item using an RF signal are turned off. Handle all explosives with extreme care.

D. MATERIALS:

The following materials are required.

a) 3,000 lb forged steel end cap (2 required)
ASME B16.1 1-1991

b) 3.0-inch (76.2 cm) Sch 80 Steel pipe nipple (A53 Grade B)
0.3 in (0.76 cm) wall thickness
2.90 in (73.77 cm) ID
18 in (45.7 cm) long

c) Initiator assembly, composed of:
10 grams sieved black powder (100% thru No. 20, 100% retained No. 50)
Nickel-Chromium alloy wire, 0.012 in dia. x 1.0 in long
Plastic liquid tight container.

d) Two conductor wire

e) Epoxy for sealing

f) Power supply and firing line

E. PROCEDURE:

At the Main Building.

1. Assemble the pipe nipple with the igniter assembly, connecting wire and epoxy sealant and allow the epoxy to cure for a suitable period of time. The igniter assembly should be liquid tight to prevent ingress of the test sample.

2. Install the lower end cap using Teflon tape or pipe dope to achieve a liquid tight seal.

3. Holding the pipe nipple vertically, fill the nipple completely with test sample.

4. Install the upper end cap using Teflon tape or pipe dope to achieve a liquid tight seal.

5. The firing technician shall remove the firing line from the power supply and make sure the line is shunted.

On the Firing Line.

1. Position the pipe nipple inside the covered firing area.

2. Connect the firing leads to the connector wires.

3. Evacuate the firing range and return to the main building/firing location.

At the Main Building.

1. The firing technician shall account for everyone at the Hallowell test site and ensure each person is at a safe location before firing the test.

2. When all personnel are accounted for, the firing technician shall install the firing line to the power supply.

3. The firing technician shall sound the warning siren for 15 seconds before arming the firing line and after checking the surveillance cameras, the power supply will be turned on and brought to the correct current flow.

4. After the current flow has been interrupted, the power supply turned off, the firing line shall be removed from the power supply and shunted, a suitable safety wait time shall be observed.

On the Firing Line.

1. Locate and recover all pieces of the pipe nipple and both end caps.

2. Police the test site and prepare it for the next trial.

F. ASSESSING THE RESULTS:

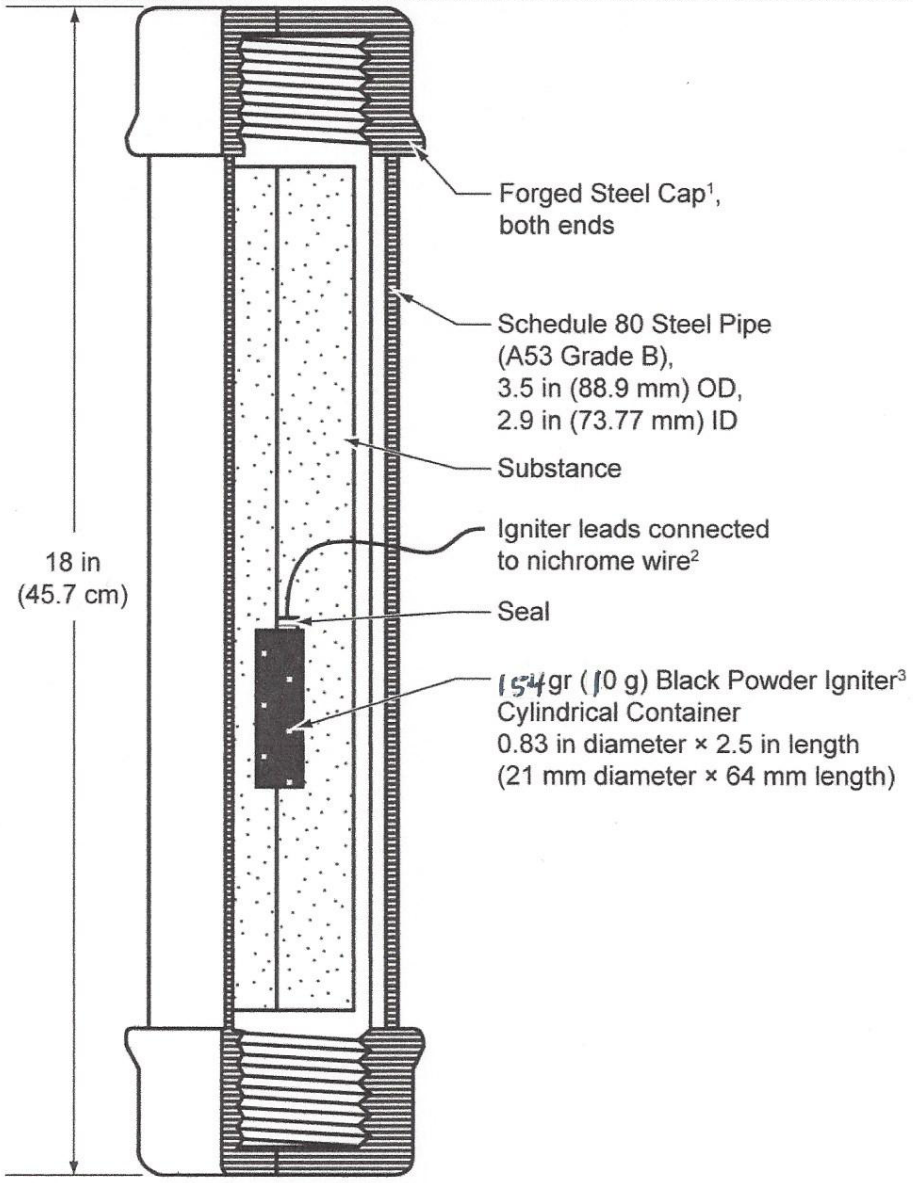
1. The result is positive (+) and the substance is a candidate for Class 1 if either the pipe nipple or one of the end caps is fragmented into at least two distinct pieces.

2. The result is negative (-) if the pipe is intact or split (laid open, not fragmented) or the end caps are only distorted.

G. REFERENCES:

1. Department of Defense Ammunition and Explosives Hazard Classification Procedures, TB 700-2, published 30 July 2012.

2. UN's "Recommendations on the Transport of Dangerous Goods Manual of Test and Criteria", Sixth Revised Edition.



NOTES: 1. ASME B16.11, "Forged Fittings, Socket-Welding and Threaded," American Society of Mechanical Engineers, New York, NY (latest version).

2. Nichrome wire – 25.4 mm long (1.0 in), 0.3 mm diameter (0.12 in), 0.35 ohm. Leads – tinned copper 0.66 mm diameter (0.026 in) with 1.3 mm diameter (0.051 in) outside diameter insulation.

3. Black Powder – 100% passed through a No. 20 sieve, 0.84 mm (0.033 in) and 100% retained by a No. 50 sieve, 0.297 mm (0.0117 in).

Figure 5-5 Internal Ignition Test Configuration (UN Test 2(c) (ii))