NORTH ATLANTIC TREATY ORGANIZATION
ORGANISATION DU TRAITE DE L'ATLANTIQUE NORD

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29 March 2000 MAS/0368-PPS/4506

See CNAD AC/310 STANAG distribution

STANAG 4506 PPS (EDITION 1) - EXPLOSIVE MATERIALS, PHYSICAL/ MECHANICAL PROPERTIES UNIAXIAL TENSILE TEST

Reference:
AC/310-D/137 dated 8 January 1998

1. The enclosed NATO Standardization Agreement which has been ratified by nations as reflected in page iii is promulgated herewith.

2. The reference listed above is to be destroyed in accordance with local document destruction procedures.

3. AAP-4 should be amended to reflect the latest status of the STANAG.

ACTION BY NATIONAL STAFFS

4. National staffs are requested to examine page iii of the STANAG and, if they have not already done so, advise the Defence Support Division, through their national delegation as appropriate of their intention regarding its ratification and implementation.

A. GRØNHEIM
Major General, NOAF
Chairman, MAS

Enclosure:
STANAG 4506 (Edition 1)

STANAG No. 4506
(Edition 1)

NORTH ATLANTIC TREATY ORGANIZATION
(NATO)

MILITARY AGENCY FOR STANDARDIZATION
(MAS)

STANDARDIZATION AGREEMENT
(STANAG)

SUBJECT: EXPLOSIVE MATERIALS, PHYSICAL/MECHANICAL PROPERTIES UNIAXIAL TENSILE TEST

Promulgated on 29 March 2000

A. GRØNHEIM
Major General, NOAF
Chairman, MAS

RECORD OF AMENDMENTS

No.	Reference/date of amendment	Date entered	Signature

EXPLANATORY NOTES

AGREEMENT

1. This NATO Standardization Agreement (STANAG) is promulgated by the Chairman MAS under the authority vested in him by the NATO Military Committee.

2. No departure may be made from the agreement without consultation with the tasking authority. Nations may propose changes at any time to the tasking authority where they will be processed in the same manner as the original agreement.

3. Ratifying nations have agreed that national orders, manuals and instructions implementing this STANAG will include a reference to the STANAG number for purposes of identification.

DEFINITIONS

4. Ratification is "In NATO Standardization, the fulfilment by which a member nation formally accepts, with or without reservation, the content of a Standardization Agreement" (AAP-6).

5. Implementation is "In NATO Standardization, the fulfilment by a member nation of its obligations as specified in a Standardization Agreement" (AAP-6).

6. Reservation is "In NATO Standardization, the stated qualification by a member nation that describes the part of a Standardization Agreement that it will not implement or will implement only with limitations" (AAP-6).

RATIFICATION, IMPLEMENTATION AND RESERVATIONS

7. Page (iii) gives the details of ratification and implementation of this agreement. If no details are shown it signifies that the nation has not yet notified the tasking authority of its intentions. Page (iv) (and subsequent) gives details of reservations and proprietary rights that have been stated.

FEEDBACK

8. Any comments concerning this publication should be directed to NATO/MAS - Bvd Leopold III - 1110 Brussels - BE

NAVY/ARMY/AIR

NATO STANDARIZATION AGREEMENT
(STANAG)

EXPLOSIVE MATERIALS, PHYSICAL/MECHANICAL PROPERTIES, UNIAXIAL TENSILE TEST

Annexes:

A - Test procedures

B - Data Exchange Format

Related Document: None

AIM

1. The aim of this agreement is to standardize the uniaxial tensile test for explosive materials. The test and the test report sheet described in Annexes A and B have been developed to give a every nation the means to determine tensile mechanical properties of explosive materials, and to know how the results were obtained.

AGREEMENT

2. The participating nations agree to use the test procedures described in Annex A and the test report sheet described in Annex B for assessing the mechanical behaviour when requested by the procuring nation.

IMPLEMENTATION OF THE AGREEMENT

3. This STANAG is implemented when a nation has issued the necessary orders/instructions putting the contents of this agreement into effect.

TEST PROCEDURE

1. SCOPE

1.1 This document defines a standard test technique for evaluating the uniaxial tensile properties of solid propellants and cast plastic bonded explosives (PBX) undergoing deformation at a constant strain rate. The procedure prescribes a standard specimen geometry and standard test conditions. To characterize a material, tests should be conducted at various temperatures and strain rates.

1.2 The standard defines requirements, recommendations, and/or "factors to consider" for each section of the test procedure. Every detail of the test that deviates from the requirements shall be reported. Recommendations and "factors to consider" are only provided for information purposes.

1.3 The standard units for measurement are SI units.

2. DEFINITIONS (Technical Terms)

2.1 Strain (γ)

The change in the gage length divided by the original gage length. This definition is sometimes referred to as engineering strain. Strain is normally expressed as a percentage.

The gage section is that portion of the standard specimen having a nominal width of 9.7 mm. The gage length may be the distance between any two points in the gage section.

If direct strain measurement methods are not used (e.g. extensometers), strain shall be defined as the cross-head displacement divided by the Effective Gage Length (EGL).

2.2 Effective Gage Length (EGL)

The length that divided into the displacement of the cross-head gives a number equal to the strain in the center of the specimen. Unless the actual effective gage length has been determined (e.g. using an extensometer) for the specimen geometry shown in figure 1, an effective gage length of 69 mm shall be assumed. For other specimen geometries the EGL must be determined.

2.3 Strain Rate

The change in strain level divided by the corresponding time interval. Units are inverse seconds.

2.4 Stress (Φ)

The load (F) divided by the original cross sectional area (A_o). This is sometimes referred to as nominal stress, engineering stress, or uncorrected stress. Units are MPa.

2.5 Initial Tangent Modulus (E_o)

The maximum slope of the progressive portion of the nominal stress-strain curve. Units are MPa.

2.6 Stress at Maximum Load (Φ_m)

The largest load on the load displacement curve divided by the original cross-sectional area of the test specimen.

2.7 Strain at Maximum Load (γ_m)

The highest strain for which the load is at the maximum value. If the range of strains at maximum load is large (e.g. plateau), then report both maximum and minimum strain at maximum load.

2.8 Rupture Strain (0_r)

The strain at which the specimen breaks.

2.9 Rupture Stress (Φ_r)

The nominal stress corresponding to the rupture strain.

2.10 Corrected Stress (Φ^c)

The nominal stress (load divided by the original cross sectional area) multiplied by the sum of one plus the corresponding strain on the nominal stress-strain curve (i.e., $\Phi^c = \Phi^* (1+0)$). This correction is used to compensate for the reduced cross-sectional area as the specimen is strained. This correction assumes that there is no volume change.

2.11 Maximum Corrected Stress (Φ^c_m)

The maximum stress value on the corrected stress-strain curve.

2.12 Strain at Maximum Corrected Stress (0^c_m)

The strain value for which the corrected stress is a maximum.

2.13 Machine Compliance

The difference between the total displacement measured and the actual specimen displacement per unit load that results from the application of load to the test specimen. If the machine distortion is a linear function of load, machine compliance should be expressed as displacement per unit force. If the machine compliance is not constant, then a more complex representation must be given. The inverse of machine compliance is machine stiffness.

2.14 Other definitions

If other data are reported, definitions and data reduction procedures should be provided.

3. TEST APPARATUS

3.1 Specimen Measurement Equipment

Requirement:

Accuracy: the equipment used to measure the width and thickness of the specimen shall measure to a minimum accuracy of 0.025 mm.

Recommendation:

Equipment that imposes no distortion in the process of measuring the specimen should be used. This is critical to accuracy of the stress calculation.

3.2 Environmental Conditioning

A - Preconditioning.

Applies to prepared specimens prior to insertion into the test conditioning chamber on the load frame.

Requirements:

Temperature: capable of maintaining selected temperature level ± 2°C.

Relative humidity: capable of maintaining the selected level ± 5% (if controlled) (selected levels may be between 10% to 90%).

B - Test Conditioning.

Requirements:

Temperature: capable of maintaining selected temperature level ± 1°C.

Relative humidity: capable of maintaining the selected level ± 5% (if controlled) (selected levels may be between 10% to 90%).

3.3 Test Frame

Requirements:

The basic device preferred for conducting uniaxial tensile tests is an electromechanical or servo-hydraulic tester. The machine shall be capable of providing a uniform rate of cross-head displacement. The measurement of the displacement of the cross-heads shall be accurate to 0.10 mm. Table 1 lists the requirements for rate accuracy and position repeatability.

Table 1: test frame requirements

Cross-head speed	Rate accuracy	Position repeatability
< 1 m/min	1%	0,05 mm
≥1 m/min	25%	not applicable
≥ 600 m/min	none	none

A load monitoring system, connected to movable or fixed cross-heads and capable of recording the load exerted upon a test specimen, shall be provided. The accuracy of the recording devices are discussed in a later section of this procedure. The testing machine shall be of such physical dimensions to permit a temperature conditioning chamber to enclose the specimen during testing.

3.4 Specimen holding grips:

Requirements:

The test machine (including grips) shall not deflect more than 0.4 mm at the maximum load for the test.

The grips shall maintain load through the virtual center of the specimen to within 1° and conform to the dimensional limits shown in figure 2.

Factors to consider:

Proper adjustment should be made on the load shoulder for those grips that are adjustable. The spacing of the load shoulders becomes more critical with decreasing specimen modulus.

3.5 Test load measurement equipment (load cell):

Requirement:

Accuracy: ± 0.5% of the maximum load cell capacity.

Factors to consider:

Response time for high rate test and/or high modulus materials must be considered.

3.6 Test data analog recorder:

Requirements:

* Rate from zero to full scale in less than 0.5 second.
* Positional accuracy of the pen: ± 0.5% for X and Y for X-Y recorder.
* Chart rate accuracy: timing for chart rate advance should be within ± 0.5%.

3.7 Test data digital equipment:

Requirements:

Sampling rate must be sufficient to detect peak and failure loads to within ± 0.5%. This is a function of the modulus and test rate.

Recommendation:

A minimum of 10 data points per percent of strain and a minimum of 200 points for each test event is desirable to describe the test.

Factors to consider:

Increases in the sampling rate provide finer resolution for automatic data reduction.

4. TEST SPECIMEN

4.1 Preparation from bulk quantities

The method of preparation of the test specimen from bulk quantities may vary depending on the material, availability of equipment, and existing procedures. Pages A-17 and A-18 provide information on this subject.

4.2 Specimen configuration

The specimen shall conform to the geometric shape and dimensions shown in figure 1. Deviations form the standard configuration must be reported.

4.3 Environmental conditions

Test specimens shall be carefully packed flat on plane surfaces to prevent distortion and damage. The samples provided must be representative of the manufactured material and stored in a similar manner. Exposure of explosives to atmospheric conditions (relative humidity and temperature) should be minimized.

Preferably, specimen preparation shall be carried out in an air-conditioned and humidity-controlled environment. Unless they are to be tested within eight hours, the specimens should be closely wrapped or similarly protected to prevent moisture contamination. Inclusion of a humidity indicator on the bulk sample is recommended.

5. TEST METHOD

5.1 Preconditioning procedures

Unless otherwise specified, the specimens shall be preconditioned in a suitable conditioning chamber at less than 30% RH for 48 hours at 23 ± 5°C.

5.2 Test conditioning procedure

Prior to testing, the specimens shall be conditioned at the test temperature for sufficient time to assure a uniform temperature distribution throughout the specimen within ± 1°C of the desired temperature. The time required to achieve a uniform temperature distribution will vary with factors such as material type, stacking of specimens in the test conditioning chamber, and environment; however, one hour is usually satisfactory for most conditions. For conditioning temperatures of 45°C and above, a half hour conditioning time is sufficient; it should not exceed 2 hours. For conditioning temperatures of 15°C and below, conditioning time should not exceed 24 hours. The conditioning chamber air temperatures shall be measured.

Recommendations

It is a recommended procedure to monitor the temperature of the test specimens by embedding a thermocouple in a dummy specimen with thermal properties and characteristic dimensions similar to the test specimens. The monitored specimen should be placed among the test specimens throughout the conditioning and testing period. No specimen should be tested when the monitored specimen temperature and the conditioning box temperature deviate from the specified test temperature or from one another by more than 1°C. This is more critical at cold temperatures.

5.3 Equipment calibration procedure

Load measurement system:

The load cell shall be calibrated with a traceable standard at least once per year. The calibration shall be carried out on the most sensitive scale and on the test scale to be used.

Verification shall be conducted at the temperature before the specimens are tested and shall be carried out and recorded as frequently as necessary to assure accurate data, but not less than once each day. Verification at the test temperature may be omitted if insensitivity to test temperature variation has been demonstrated within the last 120 days.

Displacement measurement system:

Displacement measurements should be corrected for machine compliance so that only the specimen deformation is reported. A typical procedure for measuring machine compliance involves testing a standard metallic sample under similar loading conditions.

5.4 Specimen dimensional measurement device

Requirements:

Accuracy calibrated with gage blocks, checked at least every three months.

5.5 Load frame

Requirements:

Cross head rate accuracy:

Calibrated at initial purchase. Checked annually thereafter. This calibration is very important if the cross-head displacement is not measured directly.

Axial alignment:

The centerline of the specimen and the loading axes of the test machine must coincide during measurement.

5.6 Testing

Requirements:

At least five trials will have to be performed for each test condition.

The specimen shall be examined for obvious defects.

At a minimum, specimen measurements should be taken as shown in figure 3. The average values shall be used.

Factors to consider:

The load applied by the gage can cause shifts in the measurement of the gage section of the specimen. Therefore, reading must be taken immediately, especially on spring-loaded system.

5.7 Load measurement

Requirement:

The appropriate load cell and range should be selected and verified to produce an accuracy within 1% of the maximum load during the test.

5.8 Specimen installation and positioning

Requirement:

The specimen shall be placed in the grips with a minimum amount of handling, especially within the gage portion of the specimen.

5.9 Strain measurement

For data exchange, direct strain measurements are expected. Strain measurements using an EGL may be used if the difference between direct and indirect methods has already been established.

A - Direct strain measurement.

Requirement:

The measurement of true strain on the specimen shall in no way impair the acquisition of the load data.

Factors to consider:

Cross-head data should also be reported.

B - Cross-head based data (indirect strain measurement)

Requirement:

An EGL of 69 mm shall be used for reporting purposes on the data exchange format in Annex B.

Factors to consider:

If a different EGL than 69 mm is used, then it must be reported.

5.10 Analog chart recording

The X-Y or X-t traces shall be checked to make sure they are within the time response capabilities of the recorder. If feasible, the maximum force should deflect the recording pen at least half the chart width. Ideally, the chart speed will be adjusted to give a modulus slope of approximately 45°.

5.11 Post-test specimen examination

All samples shall be examined for visible flaws. If samples exhibit flaws, said information should be documented. Flaws include voids, low-density areas, binder-rich areas, oversized particles, foreign matter, agglomerates, etc...

5.12 Data recording

Information shall be recorded as required to complete the NATO data exchange format. If corrected stress and strain values are used, then uncorrected values must also be reported.

6. DATA REDUCTION

6.1 A typical curve of load vs displacement for a uniaxial tensile test is shown in figure 4. AA is a line drawn tangent of the maximum slope point on the progressive portion of the curve; the slope of this line defines the initial tangent modulus (E_o).

6.2 "p" is the intercept of line AA with the load baseline (zero load line).

6.3 "d_o" is the distance from p to the intersection of the load baseline with a line drawn vertical from point F_o which is on line AA.

6.4 BB is a line drawn parallel to the load baseline and tangent to the maximum point of the load on the load record curve.

6.5 "m" is the point before the load record curve drops below line BB. This point is used to define the quantities d_m and F_m.

6.6 "r" is the point where the tangent CC, as defined in figure 4, meets the load record curve.

6.7 Computation of the desired quantities should be made using the following formulae:

6.7.1 Initial specimen cross-sectional area: mm^2 (A_o)

$A_o = W*T$

- Note: average gage section width = W
- Note: average gage section thickness: T

6.7.2 Initial tangent modulus: MPa (E_o)

E_o = $(GL*F_o) / (A_o*d_o)$

GL = gage length

6.7.3 Stress at maximum load: MPa ($^{\Phi}{}_m$)

$$\sigma_m = \frac{F_m}{A_o}$$

6.7.4 Strain at maximum load: (γ_m)

$$\varepsilon_m = \frac{d_m}{GL}$$

6.7.5 Stress at rupture: (Φ_r)

$$\sigma_r = \frac{F_r}{A_o}$$

6.7.6 Strain at rupture (γ_r)

$$\varepsilon_r = \frac{d_r}{GL}$$

6.8 Corrected data

The load displacement data may also be analyzed to account for the effects of decreasing test specimen cross-sectional area because of increasing axial strain while the specimen volume is assumed invariant. To do this, the load vs displacement record is converted to corrected stress (Φ^c) vs strain (0) using the following relationship:

$$\Phi^c{}_{i=} \Phi_{i*} (l + 0_i)$$

where:

Φ_i^c is the corrected stress at that instant;

Φ_i is the nominal stress at that instant;

$$- \sigma_i = \frac{F_i}{A_o}$$

- $\mathbf{F_i}$ is the load on the specimen at that instant

- $\mathbf{A_o}$ is the original cross sectional area

γ_i is the corresponding strain at that instant ($\mathbf{d_i}$/GL)

- $\mathbf{d_i}$ is the net change in length of the gage section at that instant.

An example of converted stress-strain record curve is given in figure 5. The lines AA, BB, and CC and the points m and r shall be determined using procedures parallel to those described for the uncorrected data. The values for maximum corrected stress (Φ_m^c), strain at maximum corrected stress (γ^c_m), corrected rupture stress (Φ^c_r) and strain at rupture (γ^c_r), can be read directly from the figure as shown.

NOTE: If anomalies exist in the load-displacement curve, they should be reported.

6.9 Multiple peaks

If more than one point of zero slope occurs on the load displacement curve as shown in figure 6, then the peaks will be numbered in sequence. The property values reported must indicate the number of the peak to which they refer.

7. CAUTIONS

7.1 Results using this test procedure above 50% strain may be questionable.

7.2 End effects and nonlinearities can strongly influence results.

7.3 For materials with low strain capability (< 5%), accurate strains determined using an EGL will be difficult.

7.4 It was demonstrated in round robin testing that significantly different results were obtained for strain values calculated from cross-head displacement versus direct strain measurements.

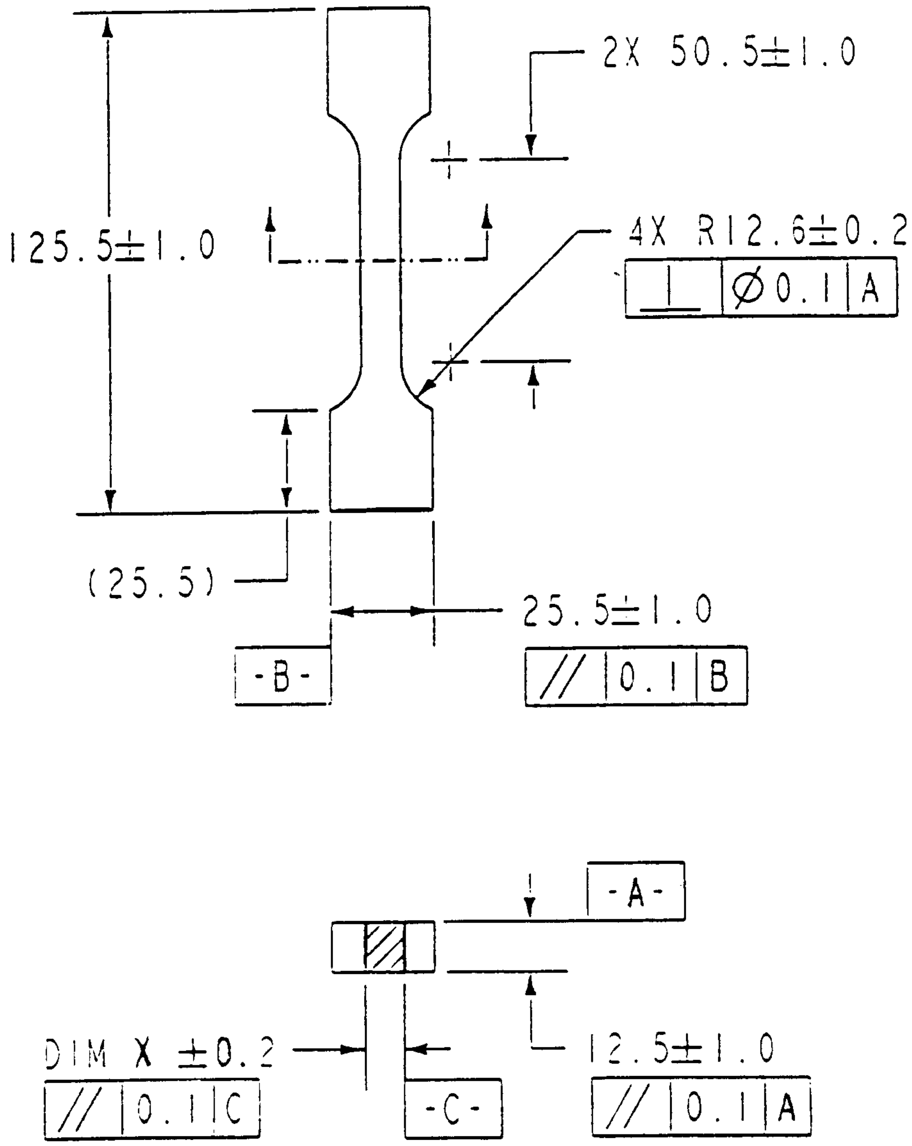

Figure 1 - SPECIMEN CONFIGURATION

NOTES:

1 - All dimensions are in millimeters.
2 - The transition from the gage section to the radius must be tangential.
3 - Parallelism and perpendicularity requirements apply to metal calibration sample only.
4 - Calibration sample is symmetric about all axes
5 - "Dim X" or sample width in the gage section must be in the range of 8.7 mm to 10.7 mm

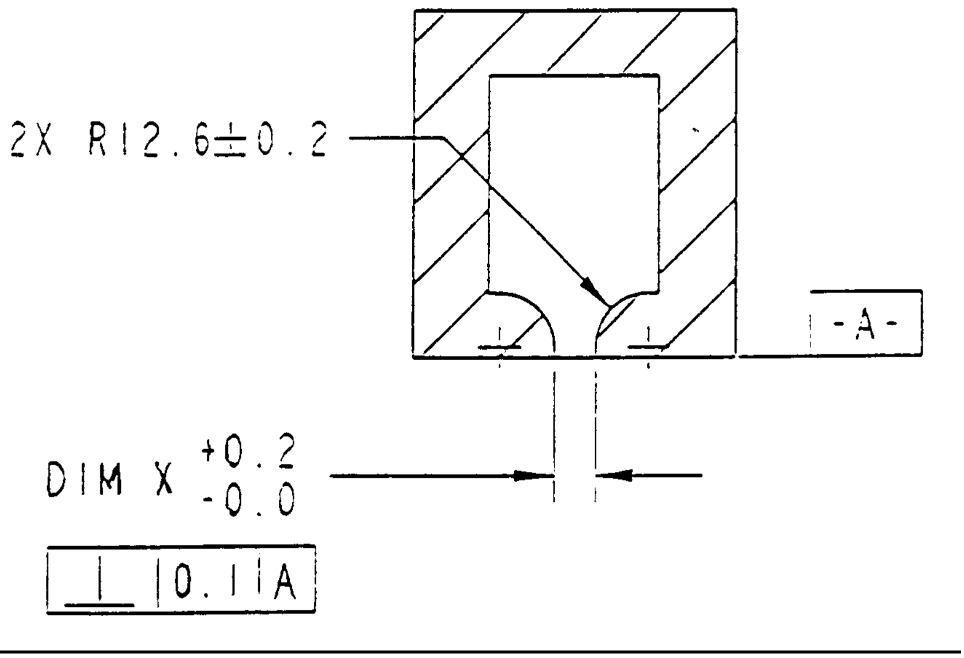

Figure 2 - CRITICAL DIMENSIONS FOR GRIPS

NOTE:

1 - Specimen should fit as tightly as possible in the grips.
2 - "Dim X" is the sample width in the gage section (see figure 1).

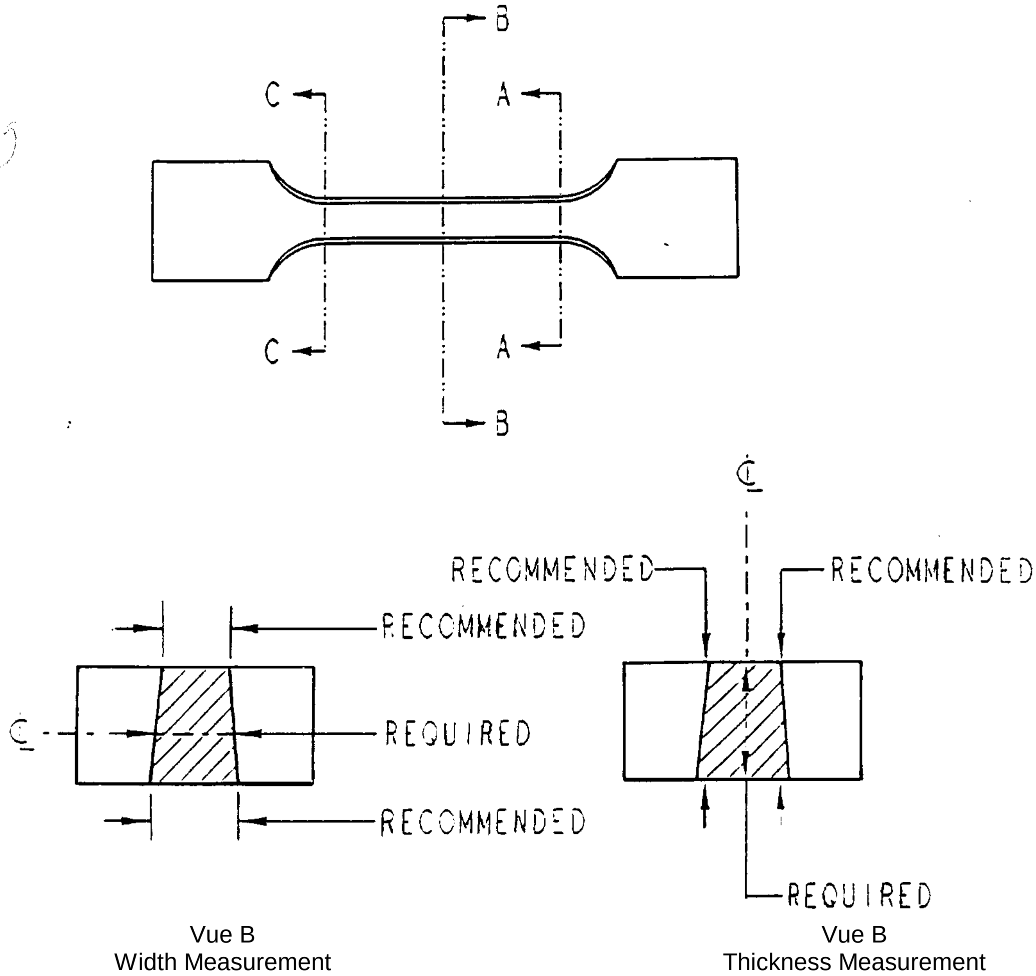

Figure 3 - REQUIRED AND RECOMMENDED MEASUREMENT LOCATIONS

NOTES:

1. Views A and C have the same measurement locations as View B except all measurements are recommended only.
2. Dimensions apply at 23 ± 5°C.
3. Die cut specimens typically have a taper as shown in the top view and view B.

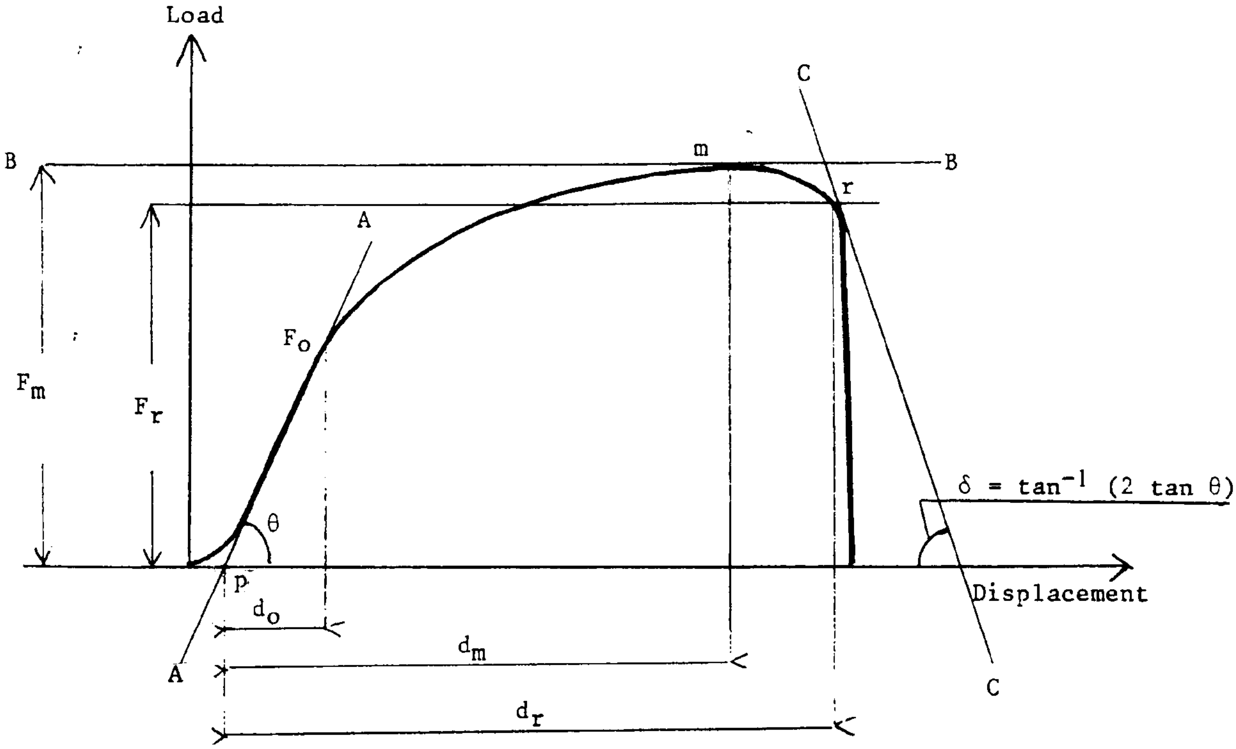

Figure 4 - TYPICAL LOAD DISPLACEMENT CURVE

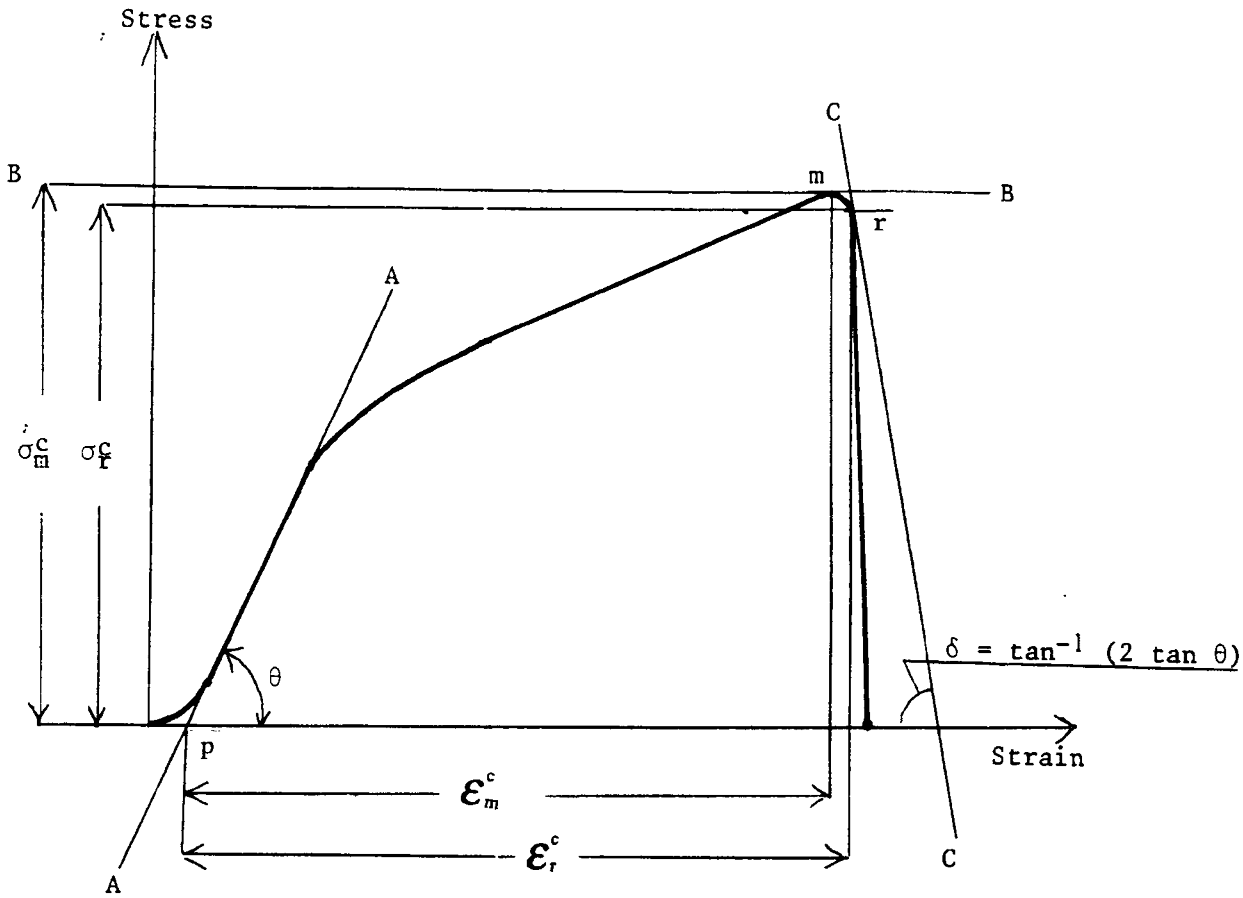

Figure 5 - TYPICAL CORRECTED STRESS VS STRAIN CURVE

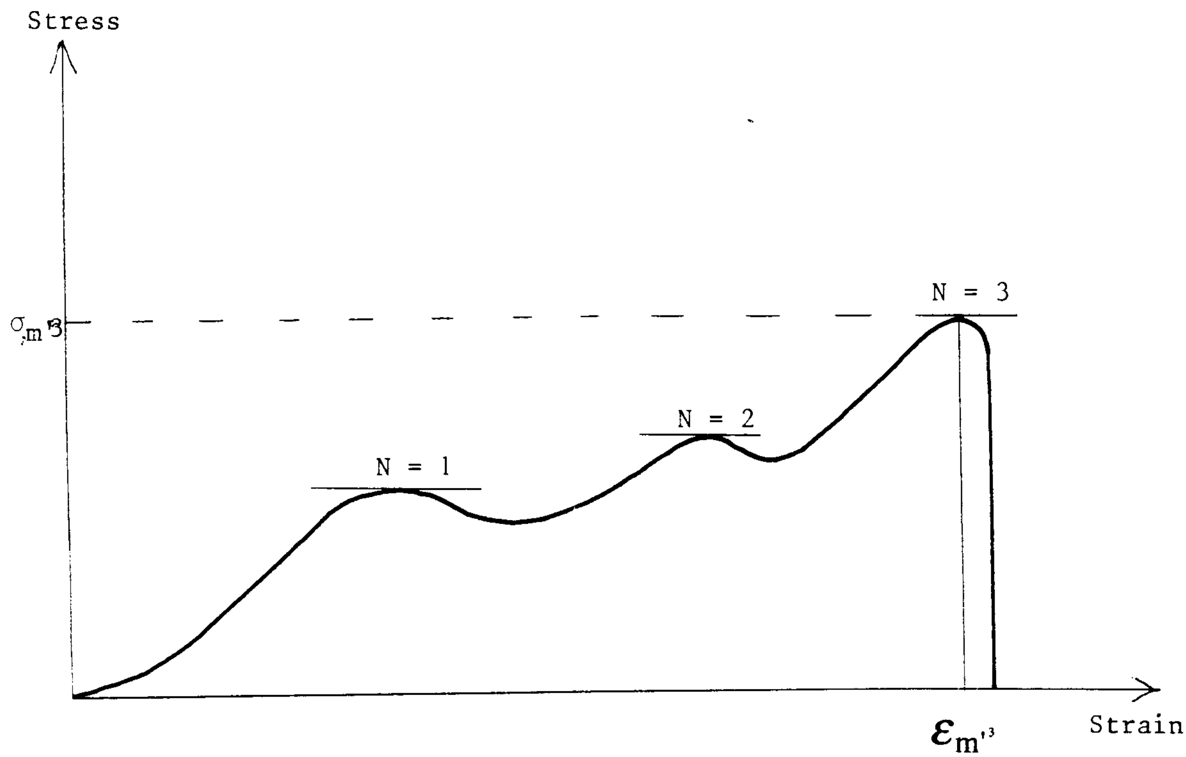

Figure 6 - MULTIPLE PEAKS

Preparing bulk material

Bulk quantities of explosives from charge sections, large blocks, or cartons may need to be reduced to a size suitable for laboratory use by one of the following methods: sawing, machining, slicing, guillotining, and/or wire cutting. To avoid binder diffusion affected, or damaged surfaces, cutting shall be conducted in such a manner that the "skin" on the surface of a block of explosive material shall be removed.

Recommendations:

- A minimum depth of 1.25 cm should be removed from all surfaces of the block or bulk sample.
- Temperature: 23 ± 5°C.
- Relative humidity: < 50% (< 20% for hygroscopic materials).
- Rate: as a function of geometry and modulus.

Factors to consider:

Storage conditions and orientation of specimens shall be carefully maintained. Inadequate control of the storage conditions can lead to wide variation in test results. In particular, many explosive materials are sensitive to variations in temperature and humidity.

Specimen preparation notes

I. UNTABBED SPECIMENS

Method 1: Machining

Recommendation:

- The specimen should conform to the geometric shape and dimensions as shown in figure 1.
- Temperature: as required for machinability and safety considerations, temperatures other than ambient should be reported.
- Tool speed: as a function of material modulus.
- Dimensional tolerances: as shown in figure 1.

Factors to consider:

Due to changes in the material, feed and cutting rates may have to be adjusted to maintain required average dimensions with changes in material. If the specimen preparation area has a relative humidity greater than 50%, exposure of the specimens to the environment shall be minimized.

Method 2: die cutting, slicing, and guillotining.

Recommendation:

- The specimen should conform to the geometric shape and dimensions shown in figure 1.
- Temperature: as required for machinability and safety considerations, temperatures other than ambient should be reported.

Rate: constant and continuous during cutting operation.

Factors to consider

If the specimen preparation area has a relative humidity greater than 50%, exposure of the specimens to the environment shall be minimized.

II. TAB BONDED SPECIMENS

A specimen with metal or wooden tabs bonded to the ends of the gage length section of the untabbed specimen is called a tab bonded specimen. Tab bonded specimens usually permit more accurate strain measurement if an EGL is used.

STANAG 4506- DATA EXCHANGE FORMAT

Uniaxial Tensile Test

Report Reference Number:

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TEST SITE INFORMATION

Laboratory:
Date:
Test Procedure:
NATO Test Procedure Number: STANAG 4506
Date Tested:
POC:

TEST CONDITIONS

Temperature (°C):
Relative Humidity (%):
X-Head Speed (mm/sec):
Machine Type:
Grip Type:
Machine Stiffness (kN/mm):

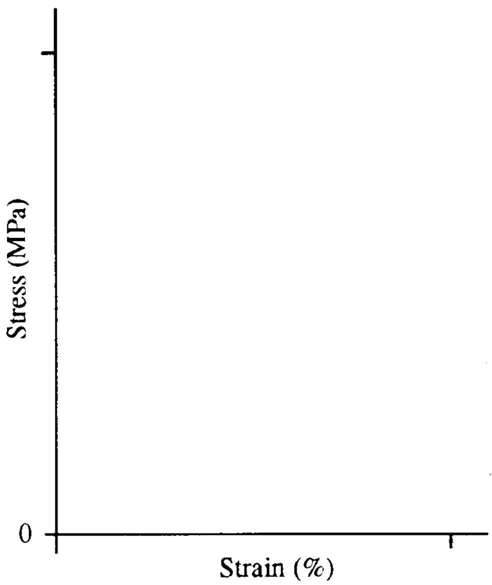
Extensometer
Yes ☐ No ☐

SPECIMEN INFORMATION

Dimensions: Length (Gage Length):
(mm) Width:
Thickness (Diameter):
X-Sectional Area (mm^2):
Form:
Preparation Method:
Manufacturing Method:
Source:
Lot or ID Number:
Conditioning Period:
Composition:

Component	Percent
____________	____________
____________	____________
____________	____________
____________	____________
____________	____________
____________	____________

TYPICAL RESULTS



Test	Specimen T (°C)	A_0 (mm^2)	ε (S^{-1})	σ_m (Mpa)	ε_m (%)	σ_r (Mpa)	ε_r (%)	E_0 (MPa)	ε_m (Direct) (%)	ε_r (Direct) (%)	E_0 (Direct) (%)
Average											
($\sigma_{(n-1)}$)											

Data Sent To:

Comments:

STANAG 4506 - DATA EXCHANGE FORMAT
Uniaxial Tensile Test

Report Reference Number:

Page…………of………Page(s)

Test	Specimen T (°C)	A$_0$ (mm^2)	ε (S^{-1})	σ_m (Mpa)	ε_m (%)	σ_r (Mpa)	ε_r (%)	E$_0$ (MPa)	ε_m (Direct) (%)	ε_r (Direct) (%)	E$_0$ (Direct) (%)
Average											
($\sigma_{(n-1)}$)											

Data Sent To:	Comments:

STANAG 4506 - DATA EXCHANGE FORMAT
Uniaxial Tensile Test

Report Reference Number:

Page………of………Page(s)

TEST SITE INFORMATION

Laboratory: Naval Ordnance Station
Date: 5 Nov 90
Test Procedure: Uniaxial Tensile Test
NATO Test Procedure Number: STANAG 4506
Date Tested: 31 Aug 89
POC:

TEST CONDITIONS

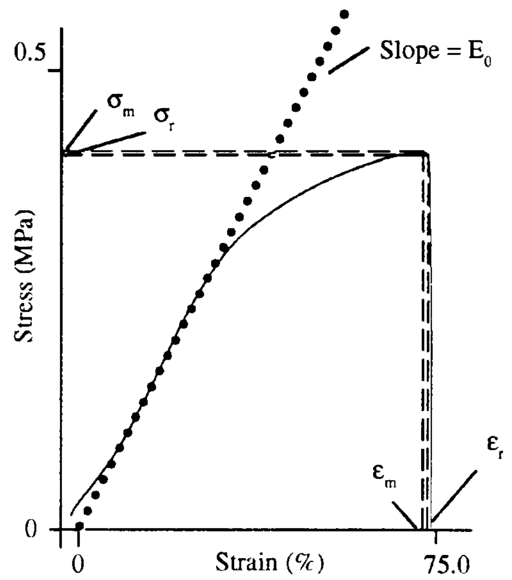
Temperature (°C): 23.9
Relative Humidity (%): 50
Extensometer Yes ☐ No ☒
X-Head Speed (mm/sec): 0.847
Machine Type: Instron AMT System v4.05a
Grip Type: JANNAF Dogbone
Machine Stiffness (kN/mm): 257

SPECIMEN INFORMATION

Dimensions: Length (Gage Length): 68.58
(mm) Width: 8.46
Thickness (Diameter): 12.57
X-Sectional Area (mm^2): 106.34
Form: JANNAF Class C Dogbone
Preparation Method: Stamped
Manufacturing Method: Cast
Source: NOSIH
Lot or ID Number: DVT-1
Conditioning Period: None
Composition: MK-6

Component	Percent
Not Available	

TYPICAL RESULTS



Test	Specimen T (°C)	A_0 (mm^2)	ε (S^{-1})	σ_m (Mpa)	ε_m (%)	σ_r (Mpa)	ε_r (%)	E_0 (MPa)	ε_m (Direct) (%)	ε_r (Direct) (%)	E_0 (Direct) (%)
1	24	104.5	0.012	0.394	65.2	0.392	66.8	1.08			
2	24	106.3	0.012	0.403	67.1	0.401	67.8	1.17			
3	24	107.4	0.012	0.437	63.6	0.429	65.4	1.32			
4	24	106.5	0.012	0.415	67.2	0.406	67.8	1.13			
5	24	105.8	0.012	0.403	69.7	0.397	71.2	1.10			
Average			0.012	0.410	66.5	0.405	67.8	1.16			
($\sigma_{(n-1)}$)				0.016	2.34	0.015	2.2	0.10			

Data Sent To:

Comments: