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TNO-report
PML 1992-69

Round Robin experiments on the Explosive Components Water Gap Test (ECWGT)

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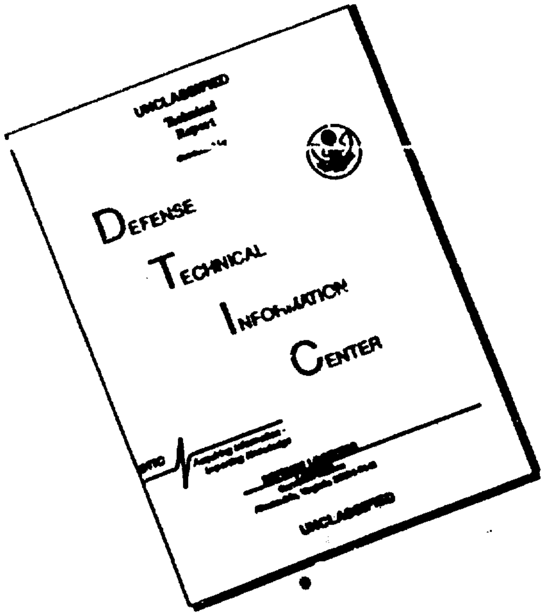

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Summary

Round Robin experiments have been carried out on the Explosive Components Water Gap Test (ECWGT). This test is proposed by the Experts Group on Explosive Components for Fuzing Systems of NATO AC310, Sub Group II. This report describes the experiments performed in the Netherlands on tetryl and PETN containing leads .

Samenvatting

Er zijn 'Round Robin' experimenten uitgevoerd met de 'Explosive Components Water Gap Test' (ECWGT). Deze test is voorgesteld door de Expert Group on Explosive Components for Fuzing Systems van NAVO panel AC310, sub groep II. Dit rapport beschrijft de in Nederland uitgevoerde experimenten met overdrachtsladingen gevuld met tetryl en pentriet.

CONTENTS

1 INTRODUCTION

The experts group on Explosive Components for Fuzing Systems of NATO AC310, Sub Group II has developed a test for the characterization of the sensitivity of explosive components: the Explosive Component Water Gap Test (ECWGT). A full description of this test is given in Allied Ordnance Publication - 21 (AOP-21) [1]. The agreement to use AOP-21 is recorded in Standardization Agreement 4363 (STANAG 4363).
To evaluate this test, a Round Robin programme has been proposed and accepted by the in the Experts Group participating countries (UK, France, USA, Germany, Denmark, Spain and the Netherlands). This report describes the work performed by the Netherlands at TNO - Prins Maurits Laboratory. The work described in this report is a part of the assignment A84/KL/147: Detonation trains of the Dutch Ministry of Defence.

2 TEST DESCRIPTION

The water gap test was originally developped by the German institute BICT and with their permission and support modified. A drawing of the test set-up is given in Figure 1.

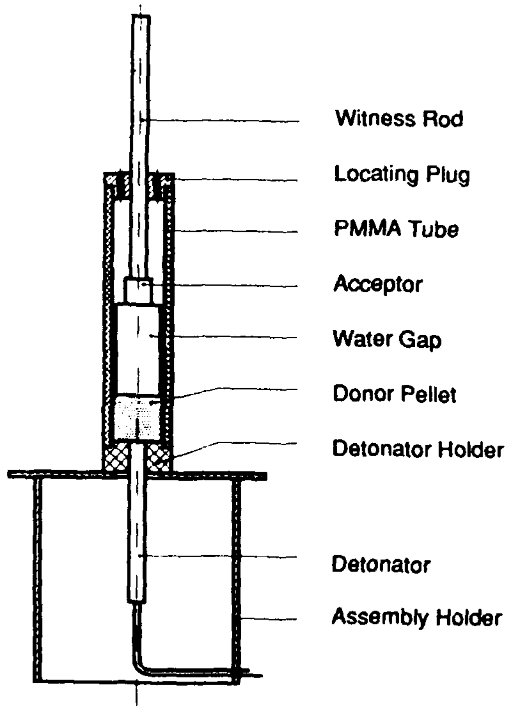


Figure 1 Set-up of the Explosive Component Water Gap Test

The test equipment consists of the following items:

- a 100 mm poly methyl methacrylate (PMMA) tube with an internal diameter of 21 mm and a wall thickness of 2 mm;
- a 21 mm diameter 10.0 g ± 0.05 g RDX/wax (95/5) donor charge pressed to a density of 1.6 g/cm^3;
- a flat base # 8 detonator (diameter ± 7.2 mm);
- a centralizing and locating detonator holder (diameter 25 mm);
- demineralized water as the gap medium;
- an aluminium alloy (BS 1474, length 100 mm, diameter 6 mm) witness rod;
- a centralizing and locating plug for the witness rod.

The explosive component (acceptor) is glued on the witness rod. The witness rod slides through the locating plug which has an extra hole of 2 mm diameter for water filling purposes. The donor charge is glued in the other end of the PMMA tube. To ensure a watertight closure, and to allow a secure fit for the detonator, another locating plug is glued under the donor charge and the PMMA tube. The distance between the top of the donor charge and the bottom of the explosive component is filled with demineralized water. The length of the water gap is inversely proportional to the pressure applied on the component. A number 8 detonator is placed just before firing, and the entire test set-up is placed on an assembly holder covered with a cardboard plate with a hole to allow a close fit on the detonator holder. Detailed drawings of the items are given in Appendix 1 to Annex B of AOP-21, which is added as Annex I to this report (SOURCE: BICT).
The damage inflicted upon the witness rod determines whether or not an explosion has taken place.

2.1 Adjustment of the gap length

Initially the gap length was obtained by using a digital marking gauge. The distance from the top of the PMMA tube to the top of the donor charge was measured. The desired gap length was subtracted from this length and the gauge was fixed at this value. The thus obtained length on the gauge was used to adjust the witness rod and the explosive component through the locating plug and to fix it with glue.
At a later stage, spacer blocks are used to obtain the gap between donor and acceptor.
After the witness rod and acceptor are glued in the locating plug, the space between donor and acceptor is filled with demineralized water. Most of the tests are performed with the water surface just touching the explosive component. Some experiments are carried out with the top of the explosive component immersed approximately 2 mm into the water while the distance between donor and component is at the desired gap length (see Figure 2).

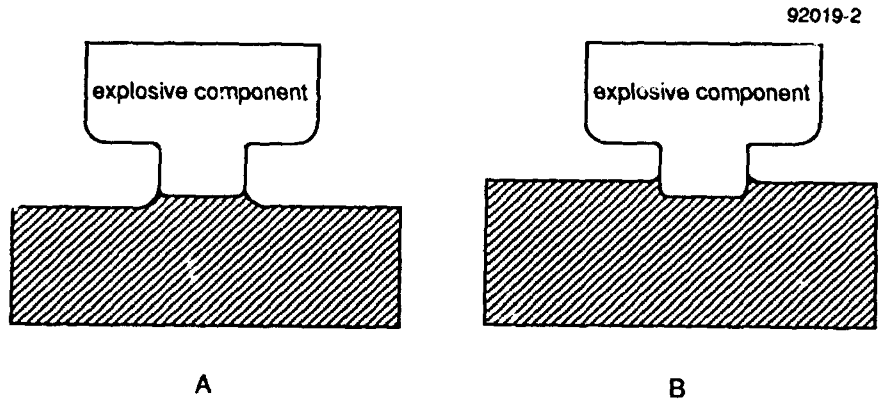


Figure 2 Two ways of adjusting the gap length. Figure 2(a) illustrates the method where the water surface just touches the bottom of the lead. In Figure 2(b) the lead is immersed approximately 2 mm in the water

3 TEST PROCEDURE

The sensitivity of the components is determined with the components in the most sensitive orientation according to the Bruceton test up and down staircase procedure. At first, tests are performed to establish the water gap levels at which positive and negative events occur. Once these levels are known the water gap length is increased or decreased by 1 mm until 20 tests are performed. (When the previous result was negative the gap is decreased, when it was positive the gap length is increased.) If necessary a safety test sequence is performed, i.e. when the number of negative results obtained at a gap length of 1 mm + the maximum gap where a positive event has taken place is less than 5. This safety test completes the number of 5 negative events and defines the "NO GO" level.

To determine the median gap length and the standard deviation, the minimum gap length (H_0) is indexed zero (index = i), the other gap lengths are indexed 1, 2, etc.. At each index the number of positive results (n^+) and the number of negative results (n^-) are counted. For further calculations, n^+ is used when the total number of positive results (ΣN^+) is less than or equal to the total number of negative results (ΣN^-).
For each indexed gap length, $i \cdot n^+$ and $i^2 \cdot n^+$ are calculated; the sum of these products is called A and B, respectively.

The median is calculated with the formula:

$$M_{50} = H_0 + \frac{A}{\Sigma N} \pm 0.5^* \qquad (1)$$

(* When using n^+ add 0.5, when using n^- subtract 0.5)

The standard deviation is calculated with the formula:

$$S = 0.05 + 1.6 \frac{(N \cdot B - A^2)}{N^2} \qquad (2)$$

An explosive component shall be considered suitably insensitive to shock to enable its uninterrupted use in explosive trains if its "NO GO" level is less than or equal to 28 mm of water.

4 RESULTS

Two types of lead have been tested: one containing tetryl and one containing PETN. The results are listed in Tables 1 and 2.

Data sheets in the layout as recommended in AOP-21 are given in Annex II.

Table 1 Results of the Explosive Component Water Gap Test obtained with the tetryl leads (X = explosion, - = no reaction)

	Characterization Test																				Safety test				
Water gap (mm)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
H_0 = 20		X		X				X				X				X		X		X					
H_1 = 21	-		-		X		-		X		-		X		-		-		-		-	-	-	-	-
H_2 = 22						-				-				-											
H_3 = 23																									
H_4 = 24																									
H_5 = 25																									
H_6 = 25																									

Table 2 Results of the Explosive Component Water Gap Test obtained with the PETN leads (X = explosion, - = no reaction)

	Characterization Test																				Safety test				
Water gap (mm)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
H_0 = 30	X		X		X		X		X		X		X		X		X								
H_1 = 31		-		-		-		-		-		-		-		-		X		-					
H_2 = 32																			-		-	-	-	-	-
H_3 =																									
H_4 =																									
H_5 =																									
H_6 =																									

Experiments numbers 5 to 14 from Table 1 were performed with the bottom of the lead immersed approximately 2 mm in the water. It appears that the "NO GO" level will be higher than when the water surface just touches the lead. In other experiments [2] we have found that the deviation in the results is larger too. A possible explanation is that the higher gap values are caused by the confinement due to the water, and that the larger deviation is caused by (relatively small) deviations in the water level alongside the lead.

For that reason it is assumed that the value obtained with the tip just touching the water surface is the correct one, and the safety test is performed on the 21 mm level.

4.1 Calculation

The calculation of the characteristic parameters is listed in Table 3 for the tetryl leads and in Table 4 for the PETN leads.

Table 3 Calculation of the characteristic parameters for the determination of the median and the standard deviation for tetryl leads. Since the number of positive events is equal to the number of negative events n^+ is used

H	i	n^+	n^-	$i.n^+$	$i2.n^+$
20	0	7	0	0	0
21	1	3	7	3	3
22	2	0	3	0	0
Σ		$N^+=10$	$N^-=10$	A = 3	B = 3

Calculation: $M_{50} = 20 + 3/10 + 0.5 = 20.8$ mm

$S = 0.05 + 1.6(3 \cdot 10 - 9)/100 = 0.39$ mm

Table 4 Calculation of the characteristic parameters for the determination of the median and the standard deviation for PETN leads. Since the number of positive events is equal to the number of negative events n^+ is used

H	i	n^+	n^-	$i.n^{\pm}$	$i2.n^{\pm}$
30	0	9	0	0	0
31	1	1	9	9	9
32	2	0	1	0	0
Σ		$N^+=10$	$N^-=10$	A = 9	B = 9

Calculation: $M_{50} = 30 + 9/10 + 0.5 = 31.4$ mm

$S = 0.05 + 1.6(9 \cdot 10 - 81)/100 = 0.19$ mm

5 CONCLUSIONS

1 The Explosive Component Water Gap Test (ECWGT) is an easy test to perform. It is a relatively accurate test to establish the sensitivity of explosive components and boosters meant for uninterrupted use in explosive trains. The results obtained here in the Netherlands agree with those obtained in the other countries.

2 We have found that the results obtained with the leads immersed approximately 2 mm in the water give a higher "NO GO" level than when the water surface just touches the bottom of the lead.

3 Further research is to be performed with leads that have been exposed to thermal shock or to the 12 meter drop test. The influence of confinement has to be investigated too.

6 AUTHENTICATION

The experiments were carried out by R. Oostdam and J.C. Makkus under the supervision of E.G. de Jong.

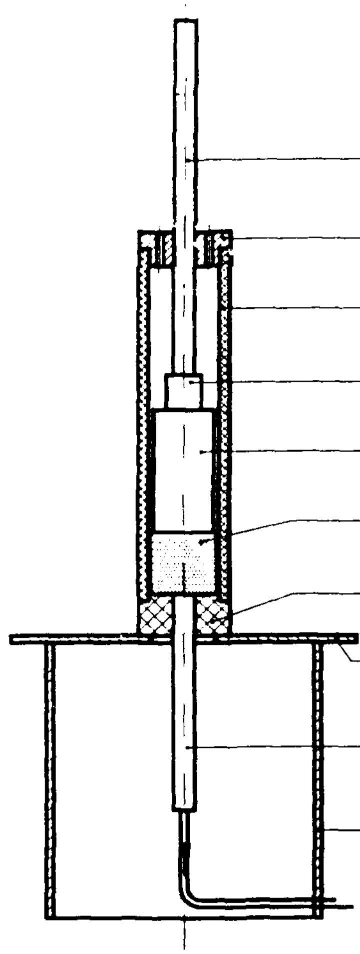
E.G. de Jong
(Project manager/Author)

7 REFERENCES

1 Fuzing systems. Manual of Development Characterization and Safety Test Methods for Lead and Booster Explosive Components. Allied Ordnance Publication - 21 (AOP-21); April 1991.

2 Unpublished data concerning the influence of confinement, thermal shock and 12 metre drop test on the sensitivity of explosive components with the ECWGT; June 1992.

ANNEX 1 DETAILED DRAWINGS OF THE ITEMS OF THE TEST EQUIPMENT



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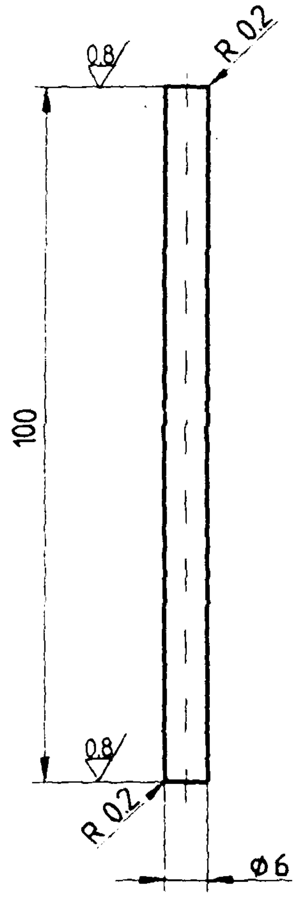
Bearb	25.01	Gulba				
Gepr						
Norm						
Maßstab 1 : 2		Werkstoff	Modell-Nr Gewicht	Ausgabe an	Anzahl der Fertigung	
Passmaß	Toleranz					
Explosive Component Water Gap Test			10-9101-4			



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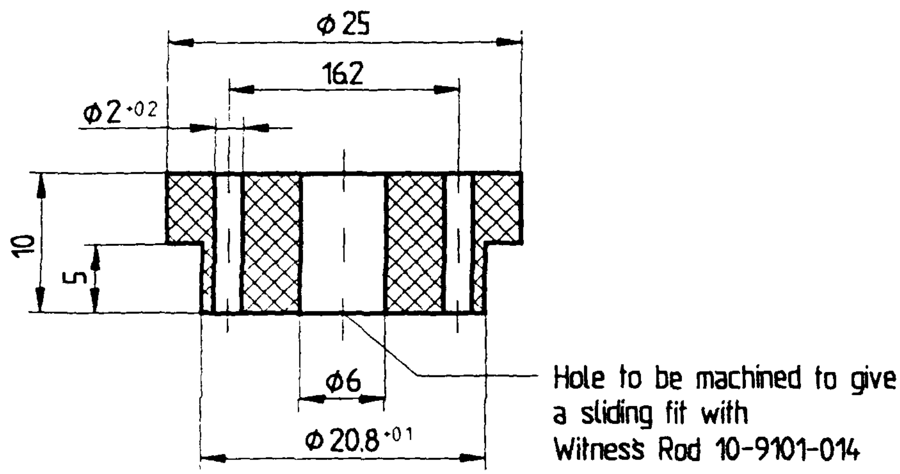
Gepr.			
Norm			

Passmaß	Toleranz	Maßstab 1 : 1	Werkstoff Aluminium Alloy BS 1474 6082 (HE 30) TF or Al Mg Si Pb DIN 1725	Modell-Nr Gewicht	Ausgabe an	Anzahl der Fertigung

Witness Rod	10-9101-014



1991	Tag	Name	Bundesinstitut für chemisch-technische Untersuchungen beim BWB (BICT)		
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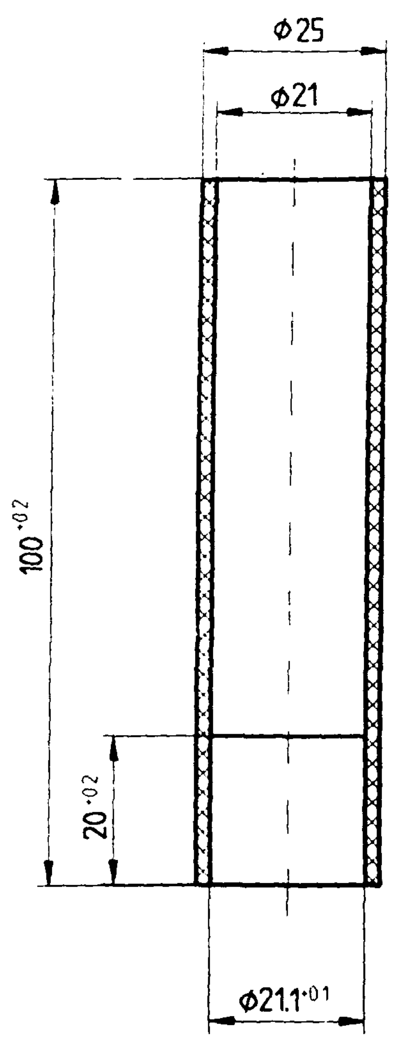
Gepr					
Norm					
Maßstab 2 : 1			Werkstoff Nylon 66	Modell-Nr. Gewicht	Ausgabe an	Anzahl der Fertigung
Passmaß	Toleranz				
		Locating Plug		10-9101-024	

5



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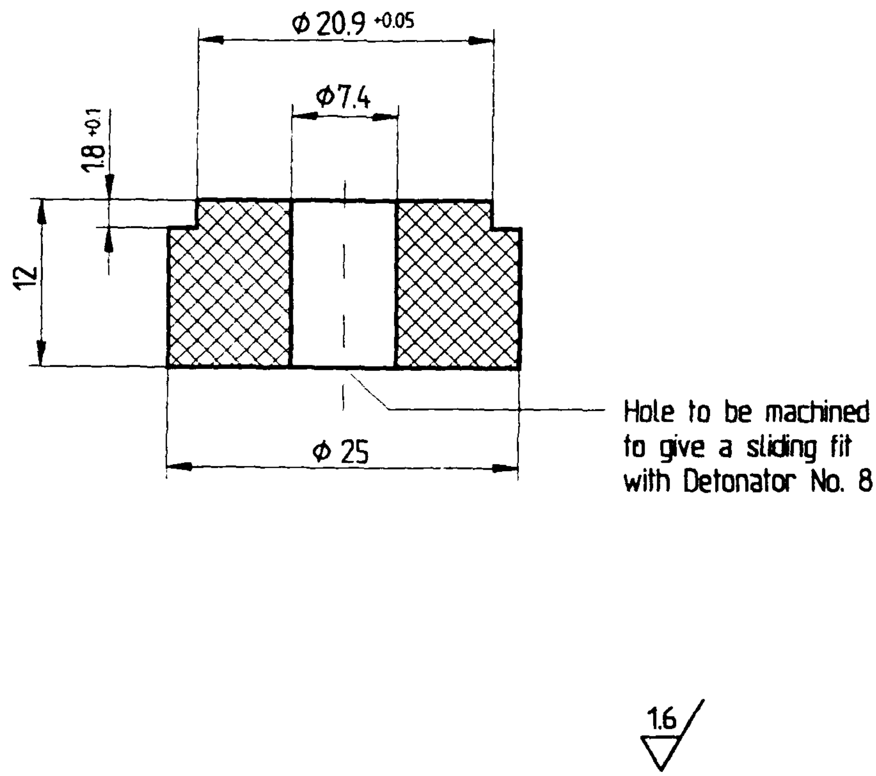
Gepr			
Norm.			

Passmaß	Toleranz	Maßstab 1 : 1		Werkstoff Acrylic Extruded Tube or Plexiglas XT, extruded	Modell-Nr Gewicht	Ausgabe an:	Anzahl der Fertigung

PMMA Tube — 10-9101-034



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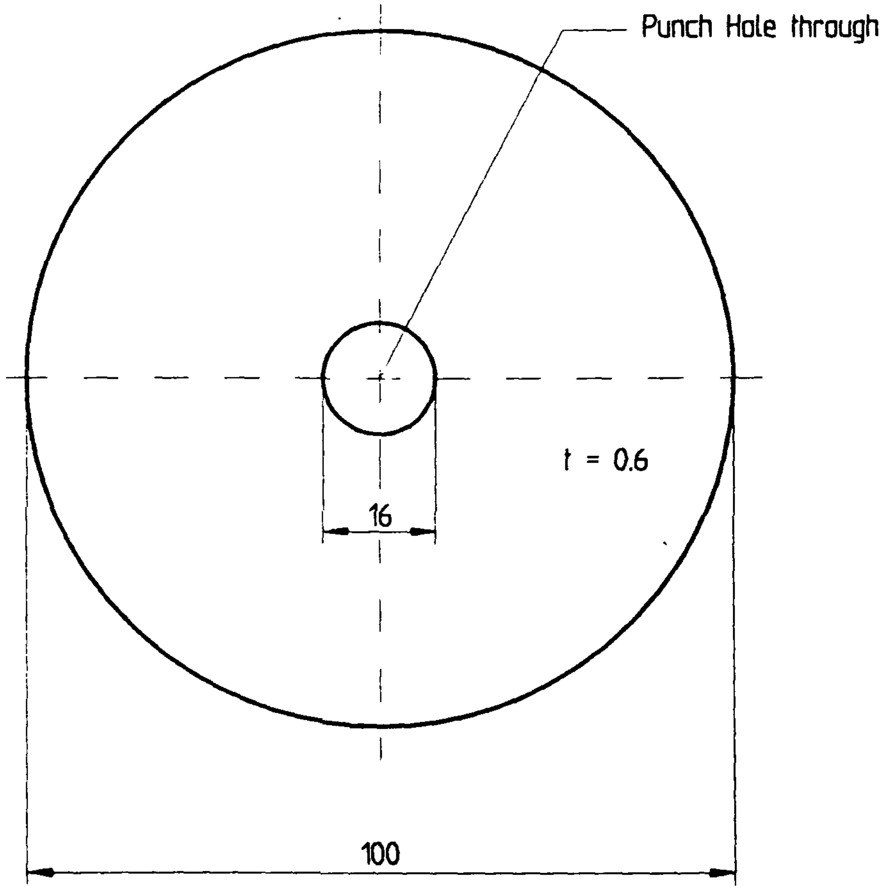
Bearb.	22.02	Gulba				
Gepr.						
Norm.						
Maßstab 2 : 1			Werkstoff Nylon 66	Modell-Nr Gewicht	Ausgabe an:	Anzahl der Fertigung
Passmaß	Toleranz					
			Detonator Holder	10-9101-044		



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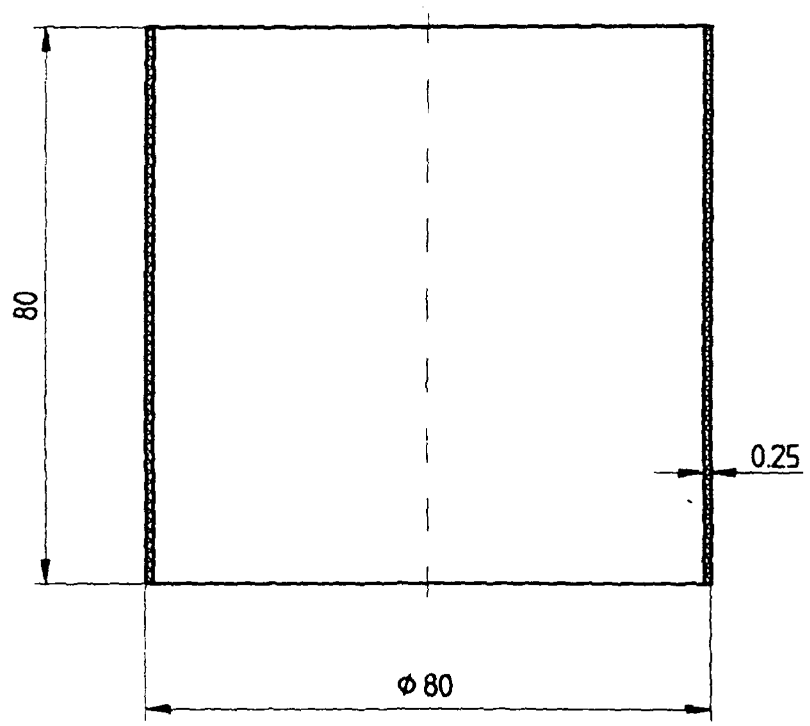
Bearb.	22.02	Gulba	
Gepr			
Norm			

Passmaß	Toleranz	Maßstab 1 : 1		Werkstoff Smooth Unbleached Kraft Paper e.g. DEF STAN 86 A Thickness ca. 0.6 mm	Modell-Nr Gewicht	Ausgabe an.	Anzahl der Fertigung

Support Disc

10-9101-054



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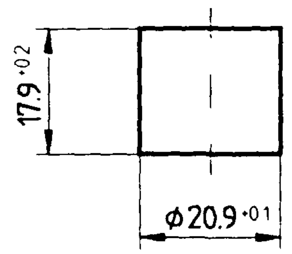
Norm.			

Maßstab		Werkstoff	Modell-Nr. Gewicht	Ausgabe an:	Anzahl der Fertigung
1 : 1		Smooth Unbleached Kraft Paper e.g. DEF STAN 86 A			

Passmaß	Toleranz

Support Tube	10-9101-064



Pressing Density 1.60 gcm^{-3}

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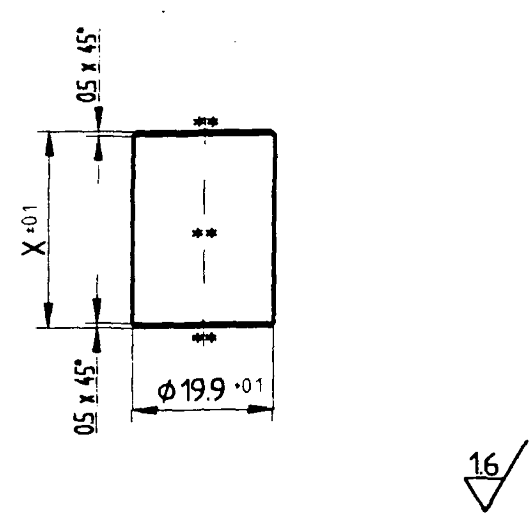
Maßstab 1 : 1			Werkstoff RDX/WAX 5 % - DEBRIX 2 or RDX/WAX/GRAPHITE 94.5/4.5/1	Modell-Nr. Gewicht 10.0 g	Ausgabe an:	Anzahl der Fertigung

Passmaß	Toleranz

Donor Pellet	10-9101-074



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(CHROMIC ACID PROCESS)

Length X	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Number of	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

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Gepr			
Norm.			

Maßstab		Werkstoff	Modell-Nr Gewicht	Ausgabe an:	Anzahl der Fertigung
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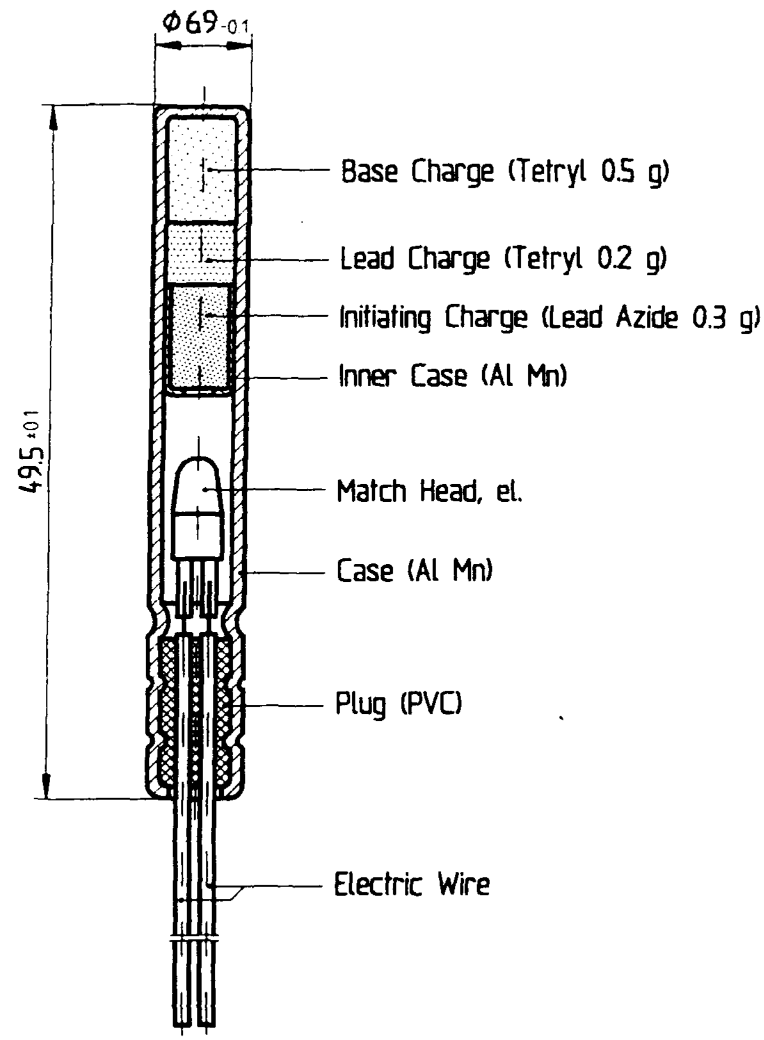
Passmaß	Toleranz

Spacers

10-9101-084



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Bearb	27.02	Gulba	
Gepr.			
Norm.			

Maßstab	Werkstoff	Modell-Nr Gewicht	Ausgabe an	Anzahl der Fertigung
2 : 1				

Passmaß	Toleranz

Detonator, el. No. 8

10-9101-104

ANNEX 2 DATA SHEETS OF THE ECWGT

Explosive Component: DM 1291
Lot No: 9 1933
Explosive Filling: Tetryl
Acceptor Orientation: most sensitive downward
Legend: X = explosion; - = no reaction

EC Data Sheet No:
Manufacturer: DNAG, Troisdorf
Filling Weight:
Loading Dimensions:

	Characterization Test																				Safety test				
Water gap (mm)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
H_0 = 20		X		X				X				X				X		X		X					
H_1 = 21	-		-		X		-		X		-		X		-		-		-		-	-	-	-	-
H_2 = 22						-				-				-											
H_3 = 23																									
H_4 = 24																									
H_5 = 25																									
H_6 = 26																									

CALCULATION

H	i	n^+	n^-	$i.n\pm$	$i^2.n\pm$
20	0	7	0	0	0
21	1	3	7	3	3
22	2	0	3	0	0
Σ		N^+=10	N^-=10	A = 3	B = 3

If $\Sigma n^+ \leq \Sigma n^-$, use n^+

If $\Sigma n^+ > \Sigma n^-$, use n^-

*: When using N^+ add 0.5
When using N^- subtract 0.5

Median: $M_{50} = H_0 + A/N \pm 0.5^*$ $\qquad$ $M_{50} = 20 + 3/10 + 0.5 = 20.8$ mm

Standard deviation: $S = 0.05 + 1.6 \dfrac{(N.B - A^2)}{N^2}$ $\qquad$ $S = 0.05 + 1.6 \dfrac{(30-9)}{100} = 0.39$ mm

Explosive Component: DM 1291
Lot No: 9 1934
Explosive Filling: PETN
Acceptor Orientation: most sensitive downward
Legend: X = explosion; - = no reaction

EC Data Sheet No:
Manufacturer: DNAG, Troisdorf
Filling Weight:
Loading Dimensions:

	Characterization Test																				Safety test				
Water gap (mm)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
H_0 = 30	X		X		X		X		X		X		X		X		X								
H_1 = 31		-		-		-		-		-		-		-		-		X		-					
H_2 = 32																			-		-	-	-	-	-
H_3 =																									
H_4 =																									
H_5 =																									
H_6 =																									

CALCULATION

H	i	n^+	n^-	$i.n\pm$	$i^2.n\pm$
30	0	9	0	0	0
31	1	1	9	9	9
32	2	0	1	0	0
Σ		N^+=10	N^-=10	A = 9	B = 9

If $\Sigma n^+ \leq \Sigma n^-$, use n^+
If $\Sigma n^+ > \Sigma n^-$, use n^-

*: When using N^+ add 0.5
When using N^- subtract 0.5

Median: $M_{50} = H_0 + {}^A/_N \pm 0.5^*$ $M_{50} = 30 + 9/10 + 0.5 = 31.4$ mm

Standard deviation: $S = 0.05 + 1.6 \dfrac{(N.B - A^2)}{N^2}$ $S = 0.05 + 1.6 \dfrac{(90-81)}{100} = 0.19$ mm

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11. AUTHOR(S)

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15. ABSTRACT (MAXIMUM 200 WORDS (1044 BYTE))

Round Robin experiments have been carried out on the Explosive Components Water Gap Test (ECWGT). This test is proposed by the Experts Group on Explosive Components for Fuzing Systems of NATO AC310, Sub Group II. This report describes the experiments performed in the Netherlands on tetryl and PETN containing leads .

16. DESCRIPTORS	IDENTIFIERS
Explosives Explosive Stability/Sensitivity Tests	Explosive Trains

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