Test Guideline

"General Basics of Ballistic Material, Design and Product Tests"

VPAM-APR

Edition 3

Version: 15 March 2021

Englische Übersetzung, es gilt immer die deutsche Originalfassung!

English translation, however the original German edition always prevails!

Issued by:

Association of Test Laboratories for Attack Resistant Materials and Constructions (VPAM)

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Change Record

(in the event of a edition change no change record will be kept; for previous editions see www.vpam.eu in the guideline archive)

Change of Date		Changes were implemented in the following paragraphs
No.	Date	

Introductory Remarks

This guideline was prepared by the Association of Test Laboratories for Attack Resistant Materials and Constructions (VPAM).

The latest edition of the binding guideline, the follow-on documents AND-SoM, AND-BaG and AND-ReB as well as follow-on decisions are available at: www.vpam.eu

Source of supply of VPAM-APR:

VPAM
Association of Test Laboratories for Attack Resistant Materials and Constructions

www.vpam.eu

Objectives and Self-Concept of VPAM

VPAM was founded in 1999 with the aim to promote experience exchange and mutual assistance in matters concerning the testing of attack resistant materials and designs.

The co-operation is supported by common statements regarding standards, guidelines and other regulations.

Publishing own test guidelines ensures reproducible results on the one hand and more market transparency for customers and users on the other hand by allowing an objective and reproducible evaluation and comparison of products from different suppliers.

Based on the test procedures and conditions described in this guideline products are tested for ballistic penetration resistance.

The test procedures described in the product-specific guidelines always constitute snapshots with a limited test scope. Attacks beyond this scope are not considered in these test procedures.

Demonstrating a protection of 100 % is thus not feasible. Moreover, there are non-reproducible individual results that can in part be ascribed to known patterns of behavior, while the other part cannot be explained in a comprehensible manner.

It must be noted, however, that a single test within the scope of the VPAM guideline has no significance for quality assurance in the ongoing production process.

The manner in which quality assurance is performed cannot be specified by VPAM and rests with the manufacturer/procuring agency.

VPAM pursues the aim to promote experience exchange, mutual assistance in technical matters and mutual information exchange with regard to round-robin tests for instance. This shall, among others, enable a joint opinion formation in central issues concerning the testing of attack resistant materials.

The members of VPAM are independent and committed to neutrality.

The test centers which are members of VPAM operate exclusively according to the pertinent quality standard EN ISO/IEC 17025 (General requirements for the competence of testing and calibration laboratories).

The address details and the lists of services provided by the VPAM test centers are listed online at www.vpam.eu.

Table of Contents

1 Scope of Application

This document describes the basics of ballistic tests and/or conformity assessments[1] of materials, designs and products which offer protection against projectiles fired from small arms and rifles. It thus applies to the product-specific VPAM guidelines ARG, BRV, BSB, BSR and PM where it is referred to. For the product-specific guidelines BSW and HVN applies – pending their revision – VPAM APR 2006 (as of: 12 May 2010) where reference is made to them.

The basics include:

- Terms
- Test conditions
- Test and measuring equipment
- Test procedures
- Test evaluation and documentation

This guideline is complemented with product-specific test guidelines of VPAM. It may include deviating test conditions, test and measuring equipment and test procedures.

In case there is leeway to act during the test and/or the results evaluation the respective guideline shall be interpreted in such a manner that the aims specified under “Objectives and Self-Concept of VPAM” are met in the best possible way. In case of doubt the inspector decides as experienced and independent expert.

2 Relevant documents

Specifications taken from the following documents are incorporated in these VPAM guidelines by reference.

The documents listed below shall always be applied as amended (combination of edition and date). If, in justified cases, the Customer is permitted to conduct a test pursuant to a previous edition and date, the applied edition and the associated date must be indicated in the test report and certificate.

[1] To simplify reading, the term "testing" is used in the following text to refer to ballistic testing and/or conformity assessment.

- VPAM decisions
- VPAM AND-SoM "Munitionsarten für Sonderprüfungen" (Ammunition Types for Special Tests)
- TDCC, dimension sheets of the Permanent International Commission for the proof of small arms (C.I.P.)

There are also foreign-language editions (translations) of other VPAM guidelines/documents available, the German edition, however, being the original and valid edition. The associated decisions form also part of the guidelines.

This VPAM guideline as well as all the other ones and the decisions may be accessed on the internet under www.vpam.eu or under www.cip-bobp.org/de.

3 Terms

For the use of this general guideline the following terms shall apply:

3.1 Impact Side

The side of the test specimen which is facing the impact/attack and which has to be identified/marked by the manufacturer/Customer.

3.2 Angle of Attack

The angle between the flight direction of the projectile's center of gravity and the axis of the projectile.

3.3 Impact Velocity

The projectile velocity in m/s at a max. distance of 2.5 m in front of the impact point.

3.4 Point of Impact

Predetermined point on the specimen where the projectile is expected to impact. It will be marked in the appropriate spot prior to firing.

3.5 Angle of Impact

The angle between the flight direction of the projectile's center of gravity and the surface of the specimen at the point of impact. The VPAM definition corresponds to the complementary angle (supplementary angle at 90°) IAW the NATO definition, i.e. vertical firing (angle of impact = 90 º) IAW VPAM corresponds to firing IAW NATO angle of 0 °.

3.6 Ballistic Penetration Resistance

Materials, designs and products thereof are bullet-resistant if they offer a defined resistance against attacks with specific types of arms and ammunitions.

3.7 Edition

Each fundamental change of a test guideline which may have an impact on the test result leads to a new edition.

3.8 Classification

Allocation to a particular class according to the tested bullet-resistant behavior under defined conditions in conjunction with a product-specific guideline.

3.9 Conformity Assessment

Conformity assessment is the determination of the conformity of a design, material etc. with the specifications (target / actual comparison).

3.10 Sample

One or more test specimens to be submitted at the same time that are necessary to perform the test.

3.11 Sample/Type Designation

The designation (name or code) which is used to identify the model, the type and the materials of a tested product unmistakably and comprehensibly.

3.12 Specimen

An item provided for testing implemented according to a product-specific test guideline.

Model, type and materials of the specimen shall be in compliance with the specifications provided by the manufacturer or the customer and shall be typical for the product.

3.13 Test Level

Designation of a resistance against a certain attack as per paragraph 4.1.

3.14 Firing Distance

The distance between the muzzle of a gun and the impact point of the projectile on the test specimen.

3.15 Version

The version on the guideline's cover sheet refers to the date of issue of a guideline. Editorial changes that do not have an impact on the test result will lead to a change of the guideline's version, but not to a change of edition. Usually, the guideline with the most current version shall be applied.

3.16 Hit Spacing

The distance between the centers of two hits on the test specimen.

3.17 Hit Distance to the Edge

The distance between the hit center and the nearest line which indicates the edge of the protection area.

3.18 Impact Location

Actual spot where the projectile hits the test specimen. This spot may be different from the marked point of impact.

4 Test Conditions

4.1 Test with Standardized Ammunition Types

Table 1: Classification of test levels

Test level	Ammunition and projectile				Test conditions	
	Caliber	**Type**	**Nominal mass** [g]	**Manufacturer/ type**	**Firing distance** [12] [m]	**Impact velocity** [m/s]
1	22 Long Rifle[4]	L/RN	2.6	RUAG HV Field Line	10 ± 0.5	360 ± 10
2	9 mm Luger [5) 7)]	FMJ/RN/SC	8.0	DAG, DM 41 [11)]	5 ±0.5	360 ± 10
3	9 mm Luger [5) 7)]	FMJ/RN/SC	8.0	DAG, DM 41 [11)]	5 ±0.5	415 ± 10
4[1)]	357 Magnum	FMJ/CB/SC	10.2	Geco	5 ±0.5	430 ± 10
	44 Rem. Mag. [6)]	JSP/FN/SC	15.6	Speer No. 4454	5 ±0.5	440 ± 10
5	357 Magnum	FMs/CB	7.1	Specification IAW VPAM [13)]	5 ±0.5	580 ± 10
6	7.62 x 39	FMJ/PB/FeC	7.9	PS[10)]	10 ±0.5	720 ± 10
7[1)]	223 Rem.[2) 8)]	FMJ/PB/SCP	4.0	MEN, SS 109	10 ± 0.5	950 ± 10
	308 Win. [9)]	FMJ/PB/SC	9.55	MEN, DM 111	10 ±0.5	830 ± 10
8	7.62 x 39	FMJ/PB/HCI	7.7	BZ[10)]	10 ±0.5	740 ± 10
9	308 Win.[3) 9)]	FMJ*/PB/HC	9.6	FNB, P 80	10 ±0.5	820 ± 10
10	7.62 x 54 R	FMJ/PB/HCI	10.4	B32[10)]	10 ± 0.5	860 ± 10
The twist rates can be gathered from the dimension sheets (TDCC) of the C.I.P. Deviating twist rates and dimensions are marked by exponents in the column “Caliber”.						

Table 1 abbreviations

CB	Coned Bullet	C.I.P.	Permanent International Commission for the Proof of Small Arms
FeC	Iron (Fe) Core	DAG	RUAG Ammotec, Germany
FMJ	Full Metal Jacket	FNB	FN Herstal, Belgium
FMJ*)	Full Metal Jacket, Copper Jacket	Geco	RUAG Ammotec, Germany
		MEN	Metallwerk Eisenhütte Nassau, Germany
FMs	Full Brass (Ms)	Speer	VISTA Outdoor, USA
FN	Flat Nose	TDCC	C.I.P. dimension sheets
HC	Hard Core		
HCI	Hard Core Incendiary		
JSP	Jacketed Soft Point	The model designations are:	
L	Lead		HV Field Line, DM 41, PS, SS 109, DM 111, BZ, P 80, B 32
PB	Pointed Bullet		
RN	Round Nose		
SC	Soft Core		
SCP	Soft Core Penetrator		

1)	At these levels always both calibers must be used.
2)	Twist rate 178 mm ± 5 %
3)	Twist rate 254 mm ± 5 %
4)	Test barrel with longer cartridge chamber, see Annex 2
5)	Test barrel with a transition of 7.5 mm, see Annex 2
6)	Test barrel with a short transition IAW carbine storage pursuant to C.I.P., see Annex 2
7)	or 9x19 mm NATO
8)	or 5.56 x 45 mm NATO
9)	or 7.62 x 51 mm NATO
10)	As per Russian standard GOST
11)	Tail cover with small plates
12)	As a rule, the firing distances have to be complied with in accordance with table 1. The firing distance may be adjusted if it is necessary regarding the required velocity, the angle of attack and impact location of the projectile or due to any other technical necessity.
13)	In a justified case of need the drawing may be requested at all VPAM test centers.

The test levels 1 to 10 are listed in the increasing order of their ballistic penetration resistance. Attack resistant materials and designs successfully tested in accordance with test level 1 offer the lowest resistance against penetration, while attack resistant materials and designs successfully tested in accordance with test level 10 offer the highest resistance. The sequential order of test level 1 to 10 is based on projectile effectiveness while taking energy density, the design of the projectile and target medium behavior into account. A claim to adherence to the sequential order of their ballistic penetration resistance does not exist in principle. This is due to different types of projectiles, material compositions and resulting lethal mechanisms.

4.2 Test with Non-Standardized Ammunition Types

In addition to the standardized ammunition types specified in paragraph 4.1 the follow-on document VPAM AND-SoM "Munitionsarten für Sonderprüfungen" (Ammunition Types for Special Tests) specifies ammunitions types (as required) which may also be tested in accordance with the product-specific guideline and, if applicable, a certificate may be issued. In this context, the restrictions specified in paragraph 7.3 shall apply.

5 Test and Measuring Equipment

5.1 Test Setup

The test setup is depicted in Annex 1. The firing distances are to be taken from paragraph 4.1 and/or the follow-on document VPAM AND-SoM "Munitionsarten für Sonderprüfungen" (Ammunition Types for Special Tests). Additional and deviating requirements are described in the product-specific test guidelines.

5.2 Weapon System

It must be ensured that the parameters defined in paragraph 4.1 and/or in VPAM AND-SoM "Munitionsarten für Sonderprüfungen" (Ammunition Types for Special Tests) are achieved with the used weapon system and the selected ammunition. Compliance with the defined requirements (e.g. impact point, impact velocities) may call for the use of special tools and barrels as well as specially assembled ammunition.

5.3 Accuracy of the Measuring Equipment

To determine the measureable quantities relevant to testing, the following accuracies are required:

- Measuring installation for velocity of projectiles: ≤ 1 % of value measured
- Thermometer ± 0.5°C
- Hygrometer: ± 3 % relative humidity
- Linear measurement device: ≤ 1 % of value measured
- Protractor: ± 0.5°
- Weighing scale: ≤ 1 ‰ of measured value

If the measuring equipment complies with these accuracies the defined tolerances apply to the indicated values, which means for example that the velocity displayed by the metering system is considered as the impact velocity.

6 Test Procedures

6.1 General

If the test procedures and parameters are not defined here, refer to the product-specific test guidelines.

The test will be carried out exclusively using the requested ammunition in accordance with paragraph 4.1 or ammunition pursuant to the follow-on document VPAM AND-SoM "Munitionsarten für Sonderprüfungen” (Ammunition Types for Special Tests).

Prior to the firing test suitable measures should be taken to ensure an “as low as practicable” angle of attack on the impact point.

In justified exceptional cases (e.g. during ongoing invitations to tender) and at the request of the applicant it will be possible to issue a certificate and a test report based on already replaced VPAM guidelines. In the certificate and in the test report it must be indicated that a new edition of the test guideline exists.

6.2 Test-relevant Parameters

- Projectile-velocity IAW paragraph 4.1 and/or VPAM AND-SoM
- Temperature tolerance at conditioning: ± 3 °C
- Tolerance of the relative humidity at conditioning: ± 5 %
- Tolerance of impact location and distances between impacts (hit spacing): ±10 mm

6.3 Repetition of the Test

If the results do not allow an unambiguous assessment, the test center may repeat the test at an analogous point. This spot must not have been influenced by the previous hit.

If in an individual case the impact velocity is outside the tolerance range, the shot shall be repeated in the following cases only:

- If, at an impact velocity below the lower limit, no penetration occurred.
- If, at an impact velocity above the upper limit, a penetration occurred.

If in an individual case the hit spacing is outside the tolerance range, the shot shall be repeated in the following cases only:

- If, at a shorter hit spacing, a penetration occurred.
- If, at a larger hit spacing, no penetration occurred.

7 Test Evaluation and Documentation

Certificates and test reports are considered as original and source documents. They must not be changed, supplemented or rewritten.

As regards additions/changes concerning an already certified specimen the specified requirements and test conditions of the respective product-specific guideline shall apply. For additions/changes of this kind only supplements (including a test report) can be issued with respect to an already granted certificate.

7.1 Evaluation of the Test

A test according to a product-specific guideline is considered as successful if the requirements of a test level in accordance with paragraph 4.1 or those specified in the follow-up document VPAM AND-SoM "Munitionsarten für Sonderprüfungen" (Ammunition Types for Special Tests) are complied with.

7.2 Test Report

The test and the test result must be documented in the test report. This report has to include the following details and statements:

General Information

- Name and address of the test institute
- Name and address of the customer
- Name and address of the manufacturer
- Number and date of the test report
- Name and signature of the person responsible for the test
- Date of the test
- Name, edition and date of the product-specific guideline
- Requested class IAW with the product-specific guideline and/or test conditions for tests with ammunition IAW VPAM AND-SoM "Munitionsarten für Sonderprüfungen" (Ammunition Types for Special Tests) and/or test conditions pursuant to the customer's test plan.
- Ambient temperature and relative humidity
- Storage temperature and relative humidity
- The individual test results
- Remarks on special observations and findings during the test
- Statement that the test results refer exclusively to the test specimen

- Remarks on certificate, if applicable
- Note that without approval of the test center the test report or extracts of it must not be duplicated
- Additional measurements, inspections, derived results, tables, diagrams, sketches and/or photos, if available

Details of Specimen

- Distinctive, verifiable marking of the specimen
- Construction, size and number of specimens as well as further relevant details
- Details of the material or a unique marking allowing conclusions on materials used as well as production and processing procedures.

7.3 Certificate

If the test provides a positive result in accordance with paragraph 4.1 or paragraph 4.2 a certificate will be issued. Only the members of the VPAM are entitled to issue a certificate according to this guideline. This is why test centers that are members of the VPAM must insert a reference to their membership on the certificates.

On the certificate, the classification must be documented in accordance with the product-specific guideline.

If the test is carried out with a type of ammunition specified in the follow-up document A VPAM AND-SoM a certificate will be issued without indicating the classification, unless otherwise provided for in the product-specific guideline. In this case the certificate shall also contain the caliber, ammunition type and projectile mass, type and manufacturer as well as the projectile velocity.

The test certificate shall explicitly state that it applies to the specimen tested only. It includes at least the following information:

- Name and address of the test center
- Name and address of the customer
- Name and address of the manufacturer
- Name, edition and date of the product-specific guideline
- Distinctive, verifiable marking of the specimen
- The classification shall be in accordance with the product-specific guideline and/or the indication of the test requirements of the product-specific guideline and/or details pursuant to VPAM AND-SoM "Munitionsarten für Sonderprüfungen" (Ammunition Types for Special Tests).

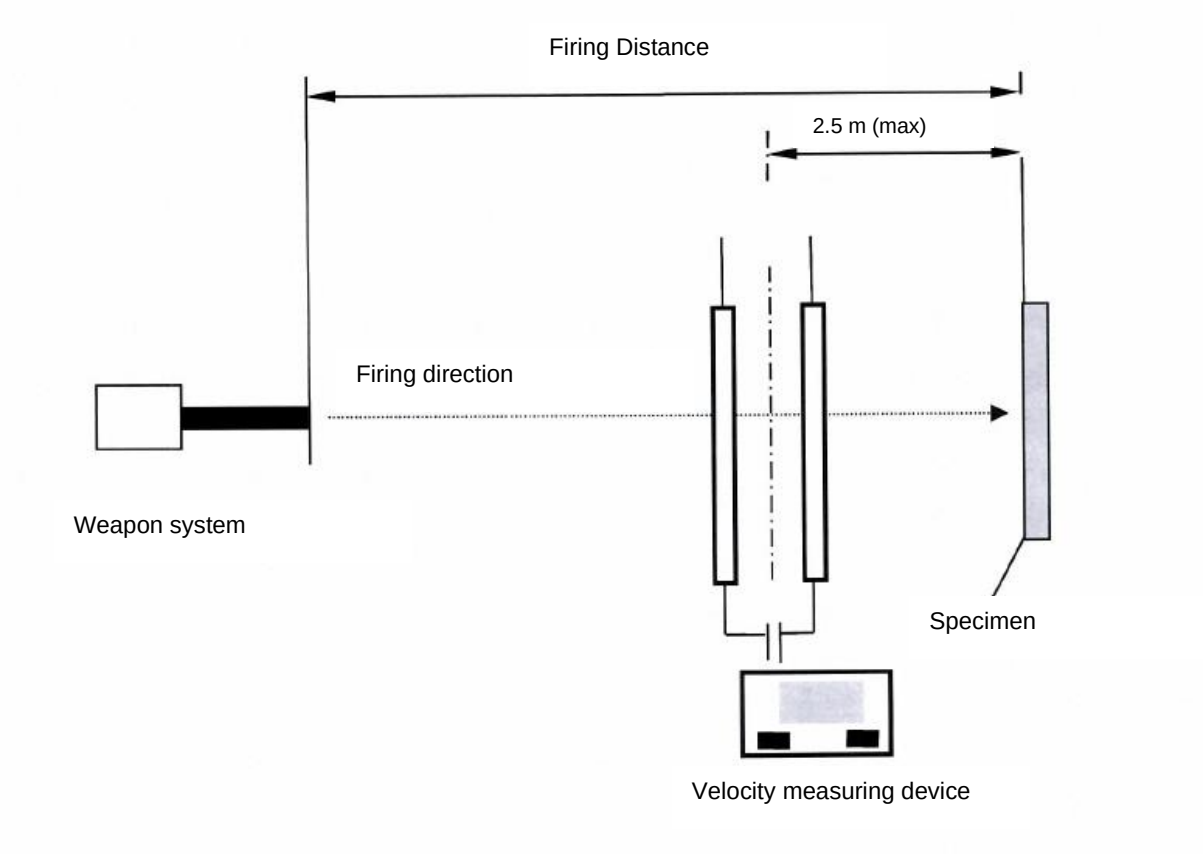
- Number of the certificate
- Date of the certificate
- Number of the associated test report
- Name and signature of person responsible for issuing the certificate
- Note that without approval of the test center the certificate or extracts of it must not be duplicated.

7.4 Traceability of Results

The manufacturer shall be responsible that the products manufactured subsequently are in conformity with the specimen. Changes or modifications in the materials' production process or to the quality management system could thus affect product conformity.

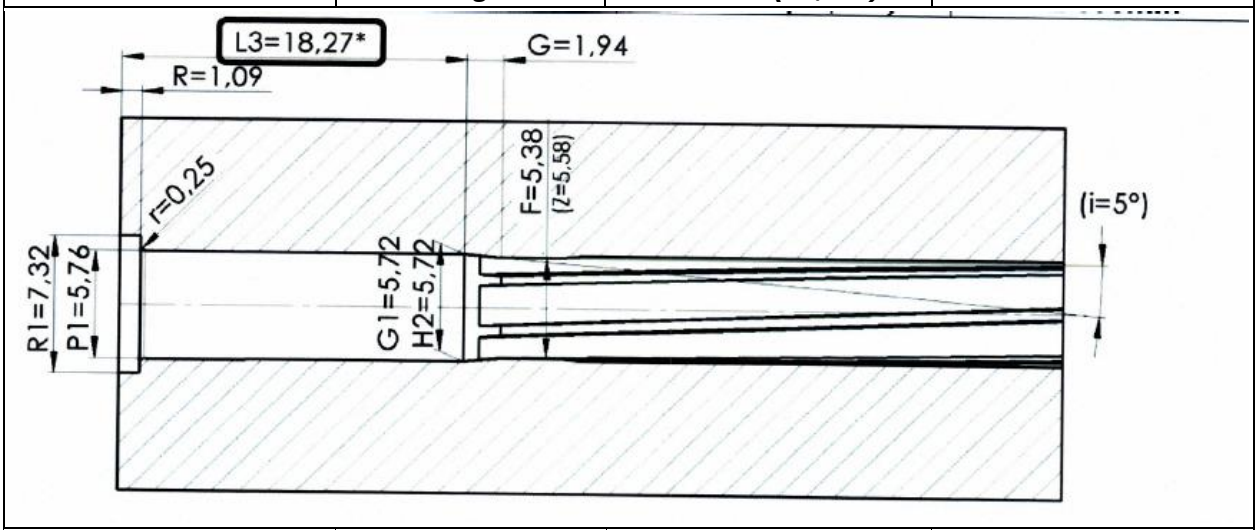
The customer has to ensure the traceability of the test results.

Annex 1: Test Set Up – Ballistic Test (Schematic)



Annex 2: Cartridge Chamber Dimensions Deviating from C.I.P. TDCC

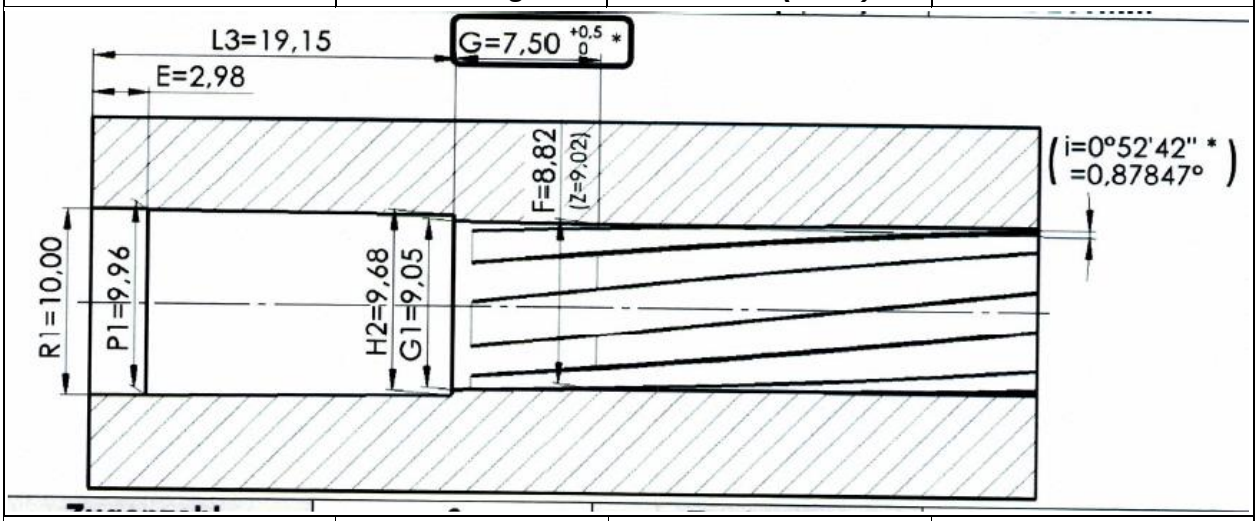
Test level	Caliber	Twist rate	Barrel length
1	*22 Long Rifle*	*406 mm (15,98")*	*≥ 600 mm*



Groove no.	*6*	Groove width	*2.16 mm*

Differences to C.I.P. standard barrels 22 Long Rifle are marked with*, if applicable.

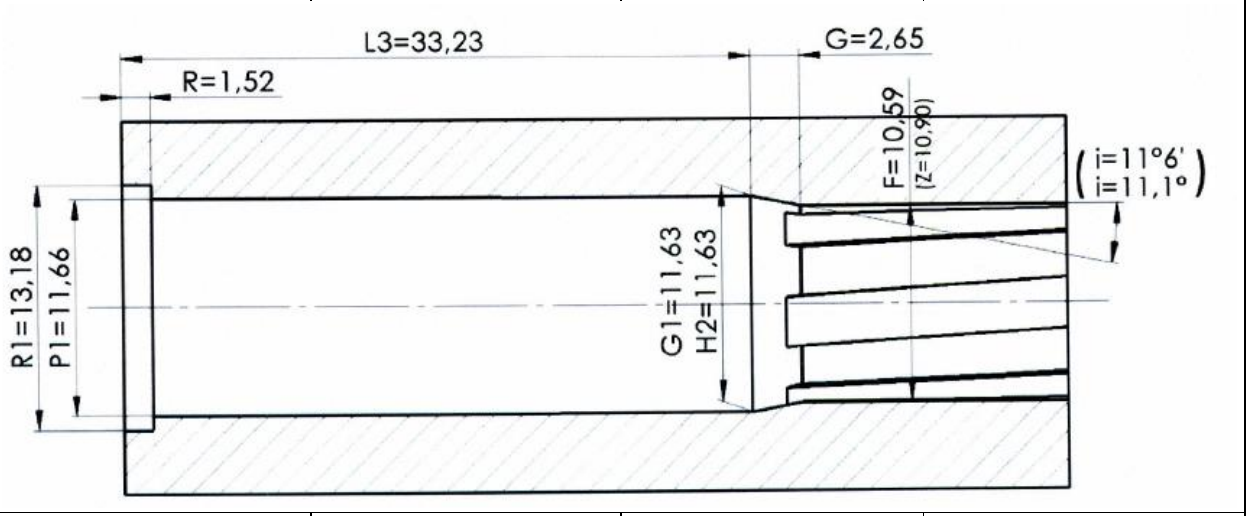
Test level	Caliber	Twist rate	Barrel length
2 & 3	*9 mm Luger*	*250 mm (9.84")*	*≥ 260 mm**



Groove no.	*6*	Groove width	*2.49 mm*

Differences to C.I.P. standard barrels 9 mm Luger are marked with*, if applicable.

Annex 2 (cont.)

Test level	Caliber	Twist rate	Barrel length
4	*44 Rem. Mag.*	*508 mm (20")*	*≥ 260 mm**
			
Groove no.	*6*	**Groove width**	*2.73 mm*
Differences to C.I.P. standard barrels 44 Rem. Mag. (carb.) are marked with *, if applicable.			