PERMANENT INTERNATIONAL COMMISSION (C.I.P.)
FOR FIREARMS TESTING

Permanent Bureau
Av. de la Renaissance, 30
B-1000 BRUSSELS
Belgium

Decision XXXIII – 32

Decision made pursuant to paragraph 1 of Article 5 of the Regulation.

"Decision XXXII-48 and all other previous Decisions concerning pressure measurement using electromechanical sensors are hereby rescinded."

MEASUREMENT METHODS

PRESSURE MEASUREMENT USING ELECTROMECHANICAL SENSORS

MEASUREMENT OF VELOCITY AND KINETIC ENERGY

1. Definitions

1.1. The physical unit used to express the value of gas pressure is the Pascal [Pa] or bar (1 MPa = 10 bar).

1.2. The physical unit used to express the value of the velocity of a projectile is metre per second (m/s).

1.3. The physical unit used to express the value of the kinetic energy of a projectile is the Joule (J).

1.4. Unification of pressure symbols:

- Pi = individual pressure of the cartridge = the maximum pressure at the site of the measurement.
- PT = gas pressure by pressure sensor
- PTmax = maximum mean pressure in accordance with C.I.P. specifications
- PK = maximum statistical individual pressure
- PE = mean minimum test pressure
- M = site of pressure measurement (mm)

1.5. Basic method for gas pressure measurement

The basic method for measuring gas pressure is defined as follows:

- using a recessed piezoelectric sensor sealed in the front (see Fig. 1.)
- in the loading space, the casings are drilled or milled (rimfire cartridges), with the exception of calibres from Table VI of the TDCC.

For cartridges for industrial purposes, in accordance with Table VI of the TDCC, the gas pressure is measured at the mouth of the casing without drilling or milling the casing.

The values of PTmax stated in the TDCC apply to the basic method.

The other methods (i.e. tangential or conformal sensor without drilling of the casing) are allowed, so long as the correlation with the basic method is known and mastered. The Proof Houses are responsible for the definition of mastery of this correlation. In case of conflict, only the basic method shall prevail.

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2. Pressure Sensor and Accessories

2.1. Pressure Sensor

All types of recessed piezoelectric pressure sensors sealed in the front are allowable if they meet the following conditions:

Minimum sensitivity: 1.0 pC/bar

- Measurement domain: 0…1.2x the range of the expected pressure
- Calibration domain: 100 bar…1.2x the range of the maximum expected gas pressure
- Natural frequency: ≥ 100 kHz
- Linearity deviation in measurement domain: ≤ 1% of the final value

The sensitivity value should be chosen as a function of the expected range of maximum pressure.

2.2. Protection of the surface of pressure transmission.

To avoid or reduce heat transmission to the membrane and to the surface of the sensor's pressure transmission, thermal protection corresponding to the sensor manufacturer's instructions should be used, and mechanical protection according to the manufacturer's instructions is mandatory.

The measurement channel remains free of grease.

2.3. Load amplifier

The following conditions must be met:

- Cut-off frequency (-3 dB): ≥ 80 kHz.
- Linearity deviation: ≤ 0.1 % of the final value.
- Deviation: ≤ 0.05 pC/s at T = 25 ± 1°C and < 60% RH

2.4. Electric filter

Second order low pass filter (-12 db/octave), Bessel or Butterworth, with a cut-off frequency of 20/22 kHz (-3dB), which can be incorporated into the load amplifier, the appropriate indicator, or the software.

2.5. Appropriate indicator

Numerical transient recorder with digital indication of the maximum individual pressure (Pi) and graphical representation of the pressure profile:

- Cut-off frequency (-3 dB): ≥ 100 kHz
- Sampling frequency: ≥ 200 kHz
- Resolution: ≥ 12 bit
- Recording time: > 4 ms.

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3. Manometric Barrels

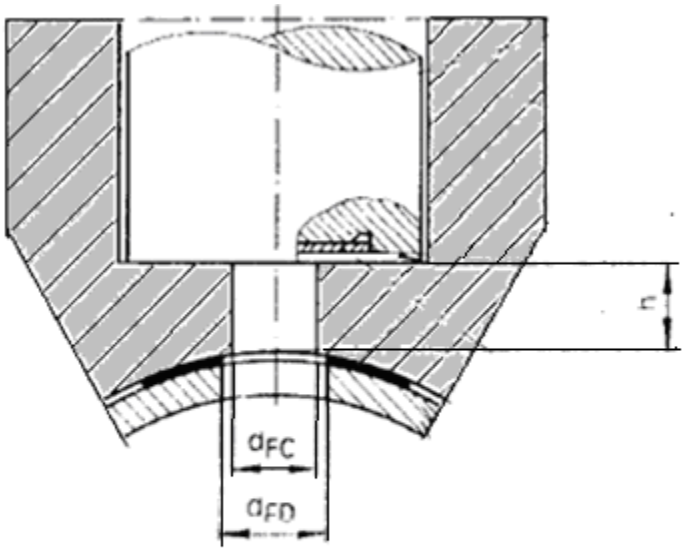
The dimensions of the manometric barrels and the location of the pressure measurement must comply with the instructions of the C.I.P. currently in effect.

The dimensional inspection of the manometric barrels must be carried out by any means of measurement to ensure compliance.

The bore for the pressure sensor must be set at the measurement location determined by the C.I.P. for the given calibre. The dimensions of this bore and their tolerances shall be those specified by the manufacturer of the pressure sensor.
In order to obtain the maximum precision and reproducibility of measurement results, the greatest care must be taken in producing this bore.

The basic blueprint for installing the pressure sensor is presented in Fig. 1, the dimensions and tolerances of the measurement channels for the various types of munitions will be defined in the respective sections.

Fig. 1



d_{FC} = diameter of the measurement channel of the manometric barrel

h = length of the measurement channel of the manometric barrel

d_{FD} = diameter of the bore or the casing milling

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3.1. Centrefire cartridges for smoothbore firearms

- d_{FC} = 2.5 + 0.1 mm
- h = 2.5 + 0.25 mm
- d_{FD} (drilling) = 3.0 + 0.1 mm

The interior dimensions of the barrel and chamber must conform to the minimum dimensions established by the C.I.P.

The following tolerances are allowed:

- Diameter of the core of the barrel B: + 0.10 mm
- Diameter of the dredger G: + 0.05 mm
- Diameters of the chamber D and H: + 0.05 mm
- Depth of the dredger T: + 0.05 mm
- Length of the chamber L: + 2.00 mm
- Angle of the coupling cone α1=10°30': -30'.

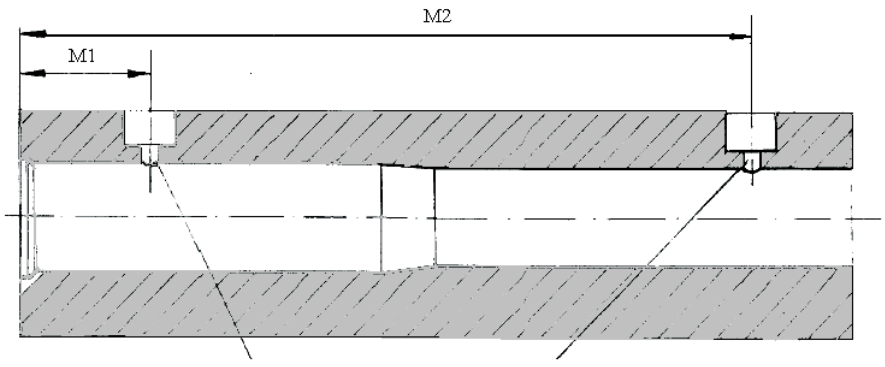
The groove should not exceed 0.10 mm.

Length of the manometric barrel: Lc = 700 ± 10 mm (cylindrical barrel without choke)

Distance between the measurement bore axes and the cylinder head breech (see Fig. 2):

- 25 mm ≤ M1 ≤ 30 mm for calibres 24 gauge and larger.
- M1 = 17 mm + 1 mm for calibres smaller than 24
- M1 = 12.5 mm – 0.5 mm for calibres 32/50.7, 410/50.7, 8 mm and 9 mm

Fig. 2



measurement bores

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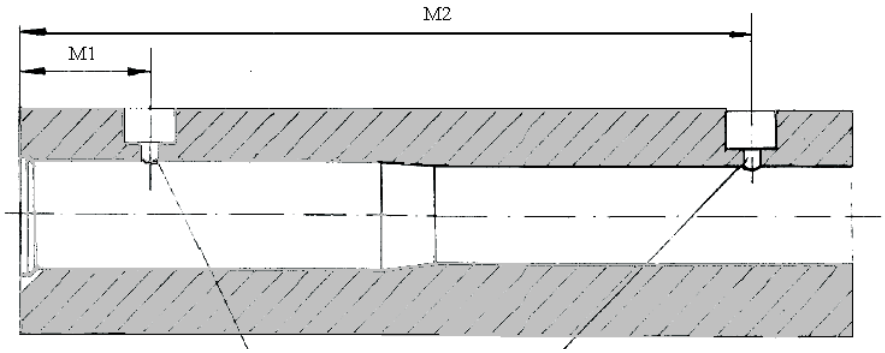
Indirect pressure measurement at the distance M2 from the cylinder head breech

When required, pressure measurement at the distance M2 from the cylinder head breech is performed indirectly.
To do so, one records the transit time from the rear of the wadding through the section located at the distance M2 from the cylinder head breech and one measures the pressure that exists at that time at the distance M1 from the cylinder head breech.
Recording the transit from the rear of the wadding can be performed with either a mechanoelectric transducer or with any other suitable sensor, such as, for example, a photodiode placed behind a quartz window.

M2 = 162 mm ± 0.5 mm.

Fig. 3



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3.2. Centrefire cartridges for rifled barrel firearms

- d_{FC} = 2.5 + 0.1 mm
- h = 2.5 + 0.25 mm
- d_{FD} (drilling) = 2.0 + 0.1 mm

The measurement locations M stipulated in the TDCC are determined on the following basis:

> M will be located 25 mm from the breech of the cylinder head when the length of the casing is greater than 40 mm, at 17.5 mm from the breech of the cylinder head when the length of the casing is between 30 and 40 mm, the limit values included.
> When the length of the casing is less than 30 mm, the pressure measurement will be taken between 7.5 mm and 3/4 of the length of the casing. In this case, the measurement location M will be individually determined for each calibre (see TDCC).

The following tolerances are allowed:

- Diameter of rifled area F: +0.02 mm
- Diameter at base of rifling Z: +0.03 mm
- Diameters P1 and G1: +0.03 mm
- Diameters P2 and H2: + 0.02 mm
- Length of the chamber L3: +0.1 mm
- Inclination i: -5/60 i (for i ≥12'), -1' (for i <12').
- Location of measurement M: ± 0.1 mm

The groove should not exceed 0.10 mm.

Length of manometric barrels:

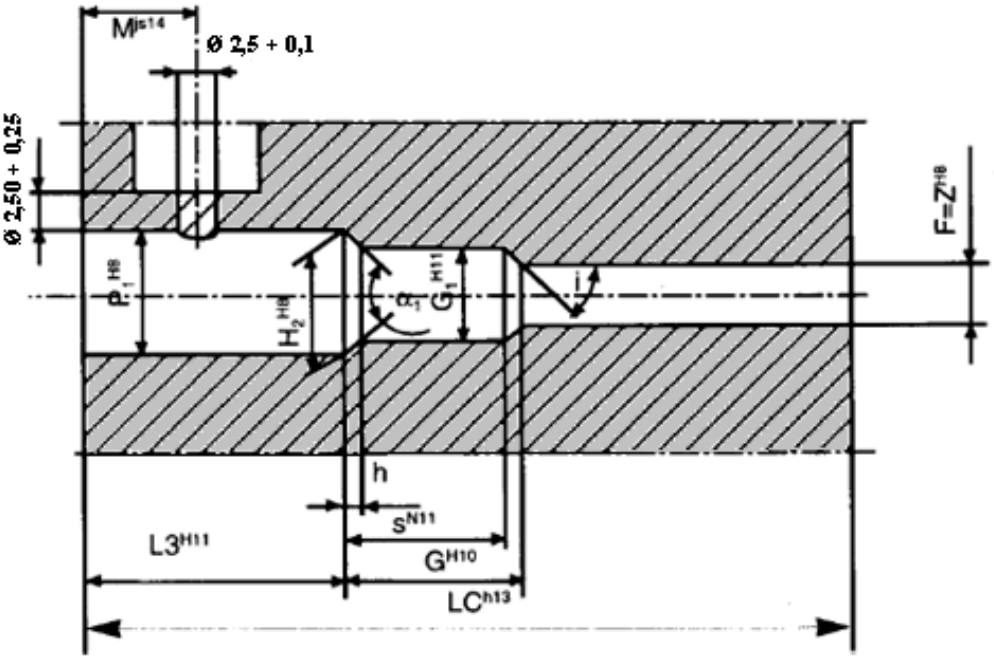
- for cartridges at the throat: LC = 600 ± 10 mm
- for rimmed cartridges: LC = 600 ± 10 mm
- for magnum base cartridges: LC = 650 ± 10 mm
- for cartridges for pistols and revolvers: LC = 150 ± 10 mm.

3.3. Shot cartridges

- d_{FC} = 2.5 + 0.1 mm
- h = 2.5 + 0.25 mm
- d_{FD} (drilling) = 2.0 + 0.1 mm

The other fixed values are indicated in Fig. 4

Fig. 4



No.	Calibres	M/Tol.		Lc/Tol.	
1	35 GR	8.50		62	
2	35 R GR	8.50		62	
3	8 mm GR	7.00		62	
4	380 GR/9 mm R GR	8.50	js 14	62	h 13
5	44 Mag. GR	8.50		62	
6	45 L GR	8.50		62	
7	6.3/16 N.C. GR	7.00		62	

M = location of the pressure measurement
L_C = total length of the manometric barrel.

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3.4. Cartridges for industrial purposes

- d_{FC} = 3.0 + 0.1 mm
- h = 2.75 + 0.25 mm

The gas pressure is measured in a manometric barrel with a weight at the end of the casing without drilling or milling of the casing.

Calibre: 16 mm (F7)
Length: 200 ± 1 mm (from the end of the chamber)
Location of the gas measurement: 1.5 mm (from the end of the chamber)

Weight:

- Diameter: 16 mm (h7)
- Mass: Mp = 80 ± 1 g
- Material: brass (58 at 70% Cu) or semi-hard steel (R = 55 to 65 decanewton/mm²)
- Additional volume: Va = 0.04 cm^3 to 0.80 cm^3
- Length: proportional to the mass

Chamber of the manometric barrel
Dimensions: According to Tab. VI of the TDCC

The following tolerances are allowed:

- Diameters P1 and H2: + 0.03 mm
- Diameter R1: + 0.05 mm
- Depth of dredger R: + 0.05 mm
- Length of the chamber L3: + 0.10 mm

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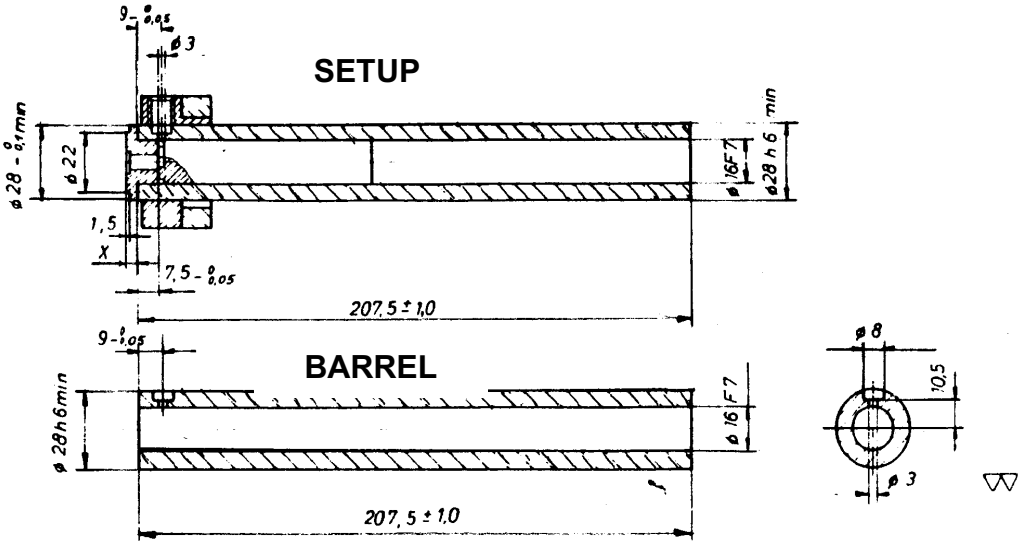
Fig. 5

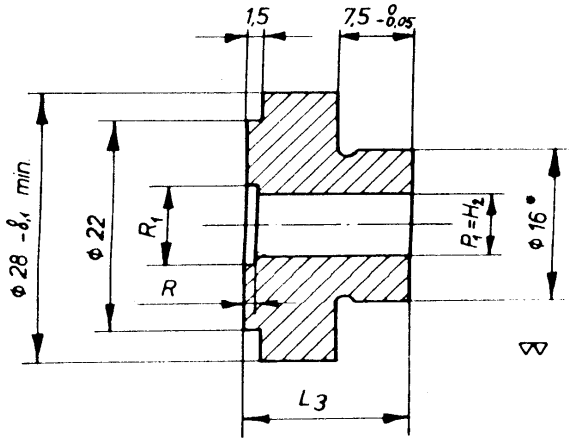
TEST BARREL WITH WEIGHT



Material no. 1.7225 (42 Cr Mo 4)
or equivalent (R = 1000 MPa)

TEST BARREL WITH WEIGHT
Cartridge Holder

Material no. 1.7707 (30 Cr Mo V9)
or no. 1.6580 (30 Cr Ni Mo 8)
or equivalent (R = 1300 MPa)



* diameter to adjust for placement within barrel

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Cal	5.6/16	6.3/10	6.3/12	6.3/14	6.3/16	6.8/11	6.8/18	9 x 17	10 x 18
L_3	16.33	11.0	13.0	15.0	17.0	12.0	19.0	18.5	19.0
$P_1=H_2$	Ø5.76	Ø6.35	Ø6.35	Ø6.35	Ø6.35	Ø6.90	Ø6.90	Ø9.60	Ø10.05
R_1	Ø7.30	Ø7.70	Ø7.70	Ø7.70	Ø7.70	Ø8.55	Ø8.55	Ø11.20	Ø10.95
R	1.10	1.25	1.25	1.25	1.25	1.45	1.45	1.30	1.15

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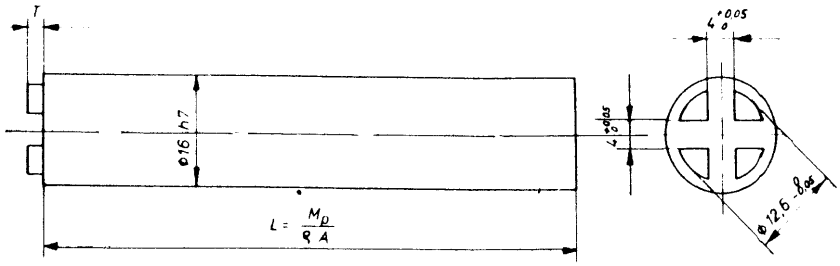
Fig. 6

TEST BARREL WITH WEIGHT

Weight



M_p = 80 ± 1.0 g

V_a cm^3	T Mm
0.04	0.25 + 0.01
0.08	0.50 + 0.01
0.16	1.00 + 0.02
0.25	1.56 + 0.02
0.40	2.50 + 0.05
0.60	3.70 + 0.05
0.80	5.00 + 0.05
1.10	*6.88* + **0.05**

Fig. 7

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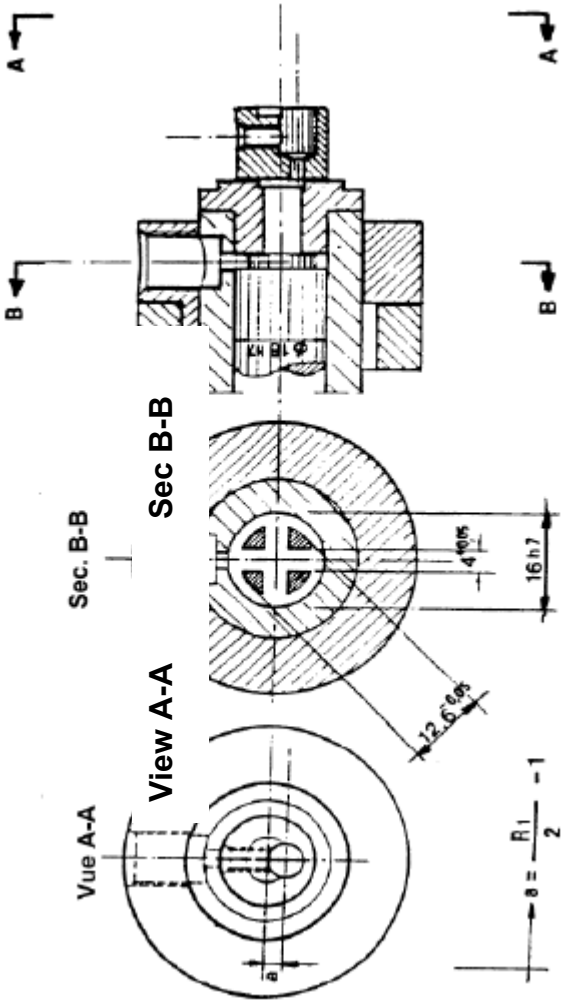
SEALING CARTRIDGES

Manometric Barrel

Position of the cross slot (Sec. B-B)
and
Position of the firing pin (below) (View A-A)



The cross slot of the weight must be in the axis of the channel of the transducer.

For rimfire cartridges, the strike should be at the base of the cartridge.

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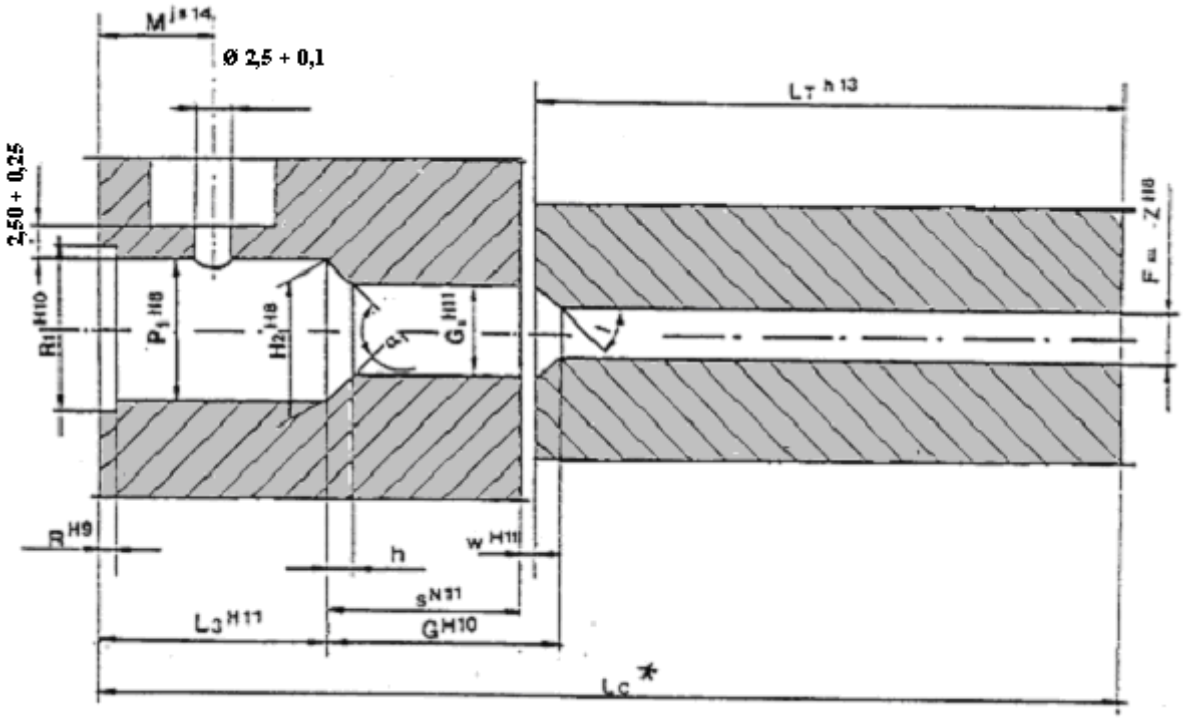
3.5. Blank cartridges

- d_{FC} = 2.5 + 0.1 mm
- h = 2.50 + 0.25 mm
- d_{FD} (drilling) = 2.0 + 0.1 mm

3.5.1. Blank cartridges for revolver

The specific values are indicated in Fig. 8

Fig. 8



M = Location of the pressure measurement
Lc = Total length of the manometric barrel (* = for informational purposes)
L_T = Length of the barrel at the core diameter F = Z

No.	Calibres	M/Tol.		L_T/Tol.		L_C*	W	
1	320 Court Blanc	7.5		50		80.5	1.5	
2	380 R Blanc / 9 mm R Blanc	7.5	js 14	50	h13	86.5	1,5	H11
3	45 K Blanc	7.5		63		99.4	1.1	

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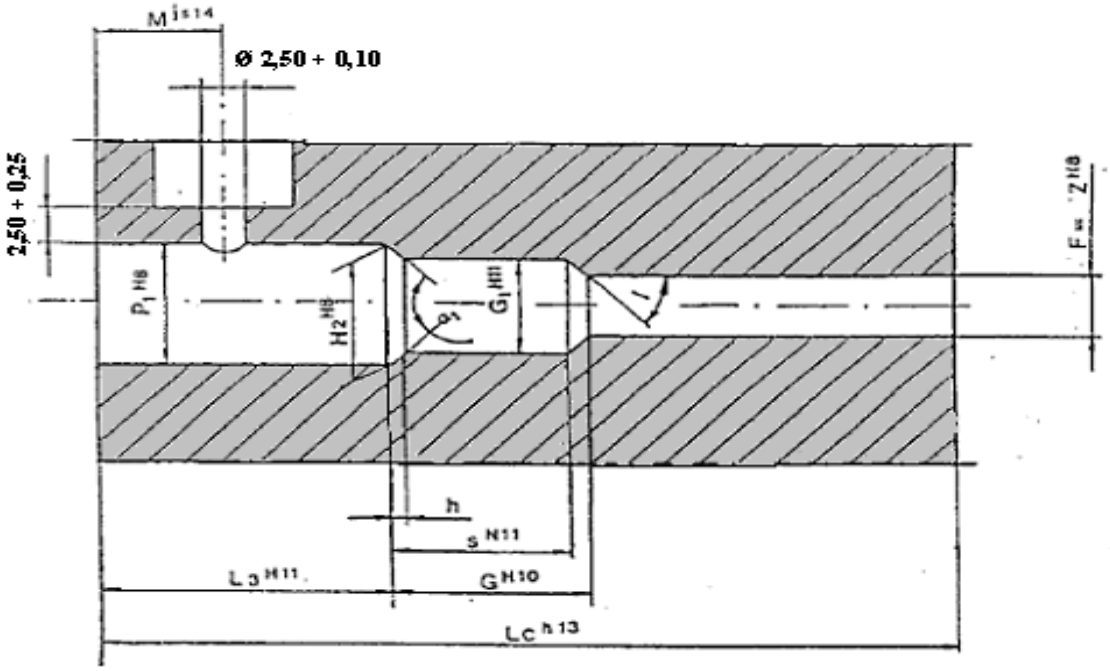
3.5.2. Blank cartridges for pistols – XXXIV-17 -

The specific values are indicated in Fig. 9

Fig. 9



No.	Calibres	M/Tol.	L_C/Tol.
1	10TK	8,50	62
2	10 x 31	10,50	150
3	22 Long Blanc	7,00	60
4	315 blanc	7,00	60
5	8 mm blanc	7,00 > js14	60 > h13
6	35 blanc	8,50	62
7	35 R blanc	8,50	62
8	9 mm PA blanc	8,50	62
9	57TK	25,00	150

M = Location of the pressure measurement
Lc = Total length of the manometric barrel

3.6. Rimfire cartridges

Gas pressure measurement by piezoelectric sensor is applicable only to calibres for which there is a C.I.P. decision in this sense.

- d_{FC} = 2.0 + 0.1 mm
- h = 2.0 ± 0.1 mm
- d_{FD} (milling) = 2.0 + 0.1 mm
- Depth of milling: 0.15 mm

The interior dimensions of the manometric barrel must conform to the minimum dimensions established by the C.I.P.

The following tolerances are allowed:

Rimfire cartridges for smoothbore firearms:

F=Z	L3	P1	P2	H2	G1	i
+0.03	+0.10	+0.05	+0.05	+0.05	+0.03	-5/60 i (max =1°)

Rimfire cartridges for rifled barrel firearms:

F	Z	L3	P1	H2	R	R1	i
+0.02	+0.02	+0.10	+0.03	+0.02	+0.03	+0.05	±0°20’.

The groove should not exceed 0.10 mm.

Length of the manometric barrel: Lc = 600 ± 10 mm

The location of the pressure measurement M is established individually for each calibre (see TDCC).

4. Manometric Unit and Firing Mechanism

4.1. Manometric Unit

The manometric unit will include manometric barrels whose chambers can hold the cartridge in its entirety. This applies to new manometric units and manometric barrels. Existing manometric units and manometric barrels can continue to be used.

4.2. Firing Mechanism

The hardness of the firing pin point should be at least 50 HRC with a projection between 0.9 and 1.5 mm.

The firing pin provides sufficient energy if the hemispherical tip of a diameter between 1.8 mm and 2.2 mm penetrates a copper crusher cylinder with dimensions 5 x 7 mm with an HV hardness of 5 to 50 to a depth of at least 0.50 mm.

For this test, the copper crusher cylinder should be introduced into an empty steel casing, which will in turn be introduced into the corresponding chamber of the manometric barrel.

The firing mechanism must guarantee effective, regular, and efficient firing.

5. Preparation of Pressure Sensor and Cartridges

5.1. Preparation of the pressure sensor

The pressure sensors will comply with the C.I.P. decisions in effect and will be installed in compliance with C.I.P. instructions, following the manufacturer's instructions. In particular, one will ensure the proper use of the sealing joint (i.e. sealing collar) if it is prescribed.

Each user must calibrate his pressure sensors. For this purpose, it is possible to check the pressure sensors using other means of calibration by an accredited test facility. This also applies to all elements of the chain.

One will also check:

- the application of the torque specified by the manufacturer
- that the connector between the pressure sensor and the connecting cable is clean, free of any grease, and dry (insulation resistance).
- that the sensitivity (pC/bar) chosen be the closest possible to the expected pressure.

5.2. Preparation of cartridges

In the case where this is prescribed, all cartridges of a given series must be drilled or milled according to the requirements, prior to shooting.

With the help of an appropriate device, one will ensure that the borehole or the milling in the casing be of the specified distance and concentric to the pressure measurement channel of the manometric barrel.

One will check the borehole of the casing afterwards to ensure it is not deformed and that there are no metallic shavings in the hole drilled, to avoid gas leaks.

The closure of the borehole in the casing should be made using a special heat-resistant adhesive (such as Intertape 4118) or using grease (such as P8 silicone) to avoid the loss of powder or gas leaks.

In the case where drilling of casings is prescribed, the following procedure will be applied:

- The velocity must be measured without drilling the casing with the manometric barrel to be used for the pressure measurements.
- The closure of the borehole should be carried out such that the difference between the mean velocities measured in a series for an identical size with the drilled and non-drilled casings is less than or equal to 1.5% for the velocities up to 500 m/s and less than or equal to 1% for higher velocities.

The attainment of these values is presently a desired goal, and is not a formal requirement.

In case of conflict, the basic method shall prevail. However, other methods to optimise the closure of the borehole in the casing are admissible once the correlation with the method described is known and mastered.

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6. Gas Pressure Measurement

The measurement will be carried out with a manometric barrel placed horizontally.

The cartridges to be tested should be placed vertically on an unloading platform, with the base of the cartridge directed downward.

The cartridge will be sampled from the unloading platform in such a way that the powder is on the side of the primer, it will be placed in the chamber of the manometric barrel by slowly tilting it into the desired position such that the powder remains on the side of the primer. One will ensure that the hole bored into the casing is concentric and coaxial to the pressure transmission channel of the manometric barrel.

After each new installation of the pressure sensor and before each series of pressure measurements, at least a buckling shot should be fired. In the case of comparative tests, the measurement report should include, in the observation rubric, the value of the pressure recorded for the buckling shot.

After each series of measurements, the pressure sensor must be removed and its status verified. Before commencing to take measurements, all possible safety precautions (for example, protective washer, thermal protection) must be verified.

7. Velocity Measurement

Simultaneously alongside the gas pressure measurement, the velocity must be measured at a distance 2.5 m ± 5 cm from the mouth of the barrel.

For luminous barriers, the length of the base must be at least 0.5 m and the measurement point is the centre of the base.

The total uncertainty/total error for the velocity measurement must be ≤ 0.5%.

The values will be used to calculate the kinetic energy (proof cartridges and ammunition for which kinetic energy must be measured instead of gas pressure) and momentum (lead-free cartridges for smoothbore firearms).

To measure the velocity of cartridges for smoothbore firearms, it is recommended to use a filter of 2.5 or 5.0 kHz to process start and stop signals.

No restriction exists regarding the means of measurement (visible light, IR, Laser, etc.).

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8. Kinetic Energy Measurement

The measurement of kinetic energy instead of the measurement of gas pressure is justified in the following cases:

- the volume of the combustion chamber is small enough that the installation of a manometer could alter the normal development of pressure;
- the primer load also constitutes the propulsive load: the amount of pressure is, in this case, fast enough that the measurement of the pressure obtained by classic procedures is not significant;
- the measurement of pressure of the cartridge with an unmounted projectile;
- an appropriate manometer to measure pressure is not available (new cartridge or cartridge that is rarely used).

In the "Tables of Dimensions of Cartridges and Chambers", these types of cartridges are recognisable by the indication of their energy at the muzzle, expressed in Joules instead of the indication of maximum pressure.

Measurement Procedure

The kinetic energy of the projectile is obtained by the formula:

$$E = \frac{mV^2}{2}$$

The velocity V of the projectile is obtained by measuring the time elapsed between the transit of the projectile through two points on its trajectory. See § 7

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8.1. Cartridges with projectile

1. Dimensions of measurement barrels

The interior dimensions of measurement barrels are identical to those of manometric barrels. The length and the tread of the rifling of these barrels must meet the values set by the C.I.P.

For the measurement of kinetic energy of rimfire cartridges, the standard test barrel dimensions are:

- LC: 200 ± 2 mm: length of barrel
- F: ± 0.02 mm
- Z: ± 0.03 mm
- u: 450 mm: rifling tread
- b: 1.25 ± 0.10 mm: length of rifling
- N: 6: number of rifling

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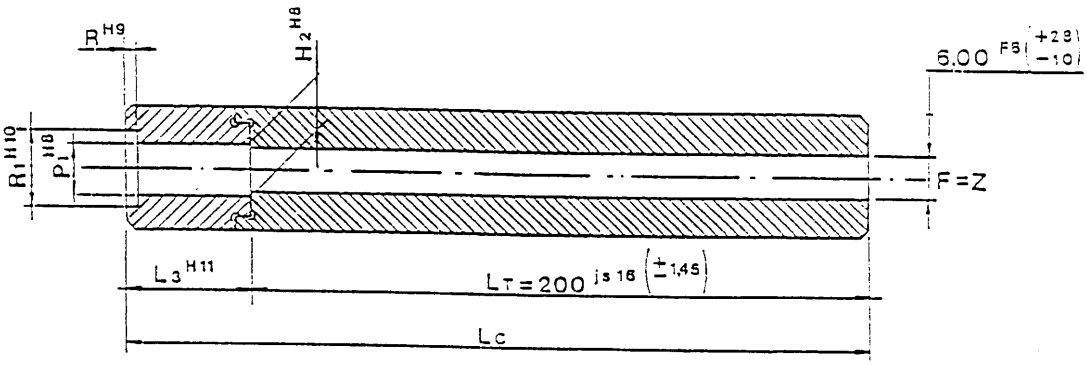
8.2. Cartridges without projectile

Barrel for the measurement of kinetic energy for blank cartridges

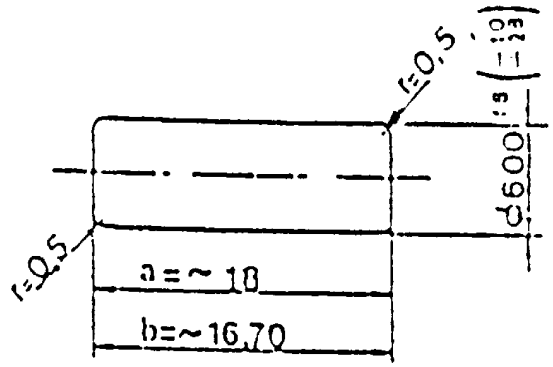


L3 = Length of the chamber at H2
LT = Length of the barrel at the core diameter F = Z
Lc = length of the barrel (L3 + LT)

Projectiles to be used during the measurement of kinetic energy

Materials:

a) steel (R = 550 to 650 MPa)
b) brass (58 to 70 % Cu)
c) mass = 4.0 +/- 0.04 g



Note: The length of the projectile is given as a guideline. It is defined relative to the mass of the projectile.

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9. Evaluation of results

9.1. Statistical rules

The analysis of measurement results will be carried out applying the statistical rules

- $\bar{P}n$: arithmetic mean pressure of n measurements
- Ki.n: coefficient of tolerance for n measurements (see § 9.2.)
- Sn: standard deviation of the pressure of n measurements

9.1.1. For lead centrefire cartridges, smoothbore firearms

The mean pressure of the commercial cartridge must be less than or equal to the allowable PTmax value. Furthermore, the requirement for a commercial cartridge to not have any pressure value 15% greater than the PTmax value is met if in 95% of cases the upper value of the limit of tolerance does not exceed 1.15 PTmax, with a statistical certainty of 95%, that is, if the following inequality is met:

$$\bar{P}n + K2.n \times Sn \leq 1.15\ PTmax$$

The mean pressure of the test cartridge must be at least 25% higher than the maximum pressure allowed for the commercial cartridges. Furthermore, so that in 90% of cases the lower value of the limit of tolerance is not less than 1.15 PTmax, with a certainty of 95%, the following inequality must be met:

$$\bar{P}n - K3.n \times Sn \geq 1.15\ PTmax$$

In order not to over-stress the weapon subject to test, the test cartridge must not exceed a certain pressure value set by the following inequality:

$$\bar{P}n + K3.n \times Sn \leq 1.60\ PTmax$$

Influence of barrel dimensions on pressure measurements - Recommendations (Minutes XVI) (see Appendix A.2.2.)

9.1.2. For centrefire cartridges, rifled firearms

The mean pressure of the commercial cartridge must be less than or equal to the allowable PTmax value. Furthermore, the requirement for a commercial cartridge to not have any pressure value 15% greater than the PTmax value is met if in 99% of cases the upper value of the limit of tolerance does not exceed 1.15 PTmax, with a statistical certainty of 95%, that is, if the following inequality is met:

$$Pn + K1.n \times Sn \leq 1.15\ PTmax$$

The mean pressure of the test cartridge for pistols and revolvers must be at least 30% higher than the maximum pressure allowed for the commercial cartridges.
The mean pressure of the test cartridge for long rifled firearm cartridges must be at least 25% higher than the maximum pressure allowed for the commercial cartridges.
Furthermore, the test kinetic energy of the projectile of the test cartridge for long rifled firearms must be equal to or greater than the values for kinetic energy mentioned in the TDCC.

Furthermore, so that in 90% of cases the lower value of the limit of tolerance is not less than 1.15 PTmax, with a statistical certainty of 95%, the following inequality must be met:

$$Pn - K3.n \times Sn \geq 1.15\ PTmax$$

In order not to over-stress the weapon subject to test, the test cartridge must not exceed a certain pressure value set by the following inequality:

- pistols and revolvers: $Pn + K3.n \times Sn \leq 1.50\ PTmax$
- long rifled firearms: $Pn + K3.n \times Sn \leq 1.40\ PTmax$

9.1.3. For rimfire cartridges

The mean pressure of the commercial cartridge must be less than or equal to the allowable PTmax value. Furthermore, the requirement for a commercial cartridge to not have any pressure value 15% greater than the PTmax value is met if in 95% of cases the upper value of the limit of tolerance does not exceed 1.15 PTmax, with a statistical certainty of 95%, that is, if the following inequality is met:

$$\bar{P}n + K2.n \times Sn \leq 1.15\ PTmax$$

The mean pressure of the test cartridge must be at least 30% higher than the maximum pressure allowed for the commercial cartridges. Furthermore, so that in 90% of cases the lower value of the limit of tolerance is not less than 1.15 PTmax, with a certainty of 95%, the following inequality must be met:

$$\bar{P}n - K3.n \times Sn \geq 1.15\ PTmax$$

In order not to over-stress the weapon subject to test, the test cartridge must not exceed a certain pressure value set by the following inequality:

$$\bar{P}n + K3.n \times Sn \leq 1.50\ PTmax$$

9.1.4. For blank cartridges and shot cartridges

The mean pressure of the commercial cartridge must be less than or equal to the allowable PTmax value. Furthermore, the requirement for a commercial cartridge to not have any pressure value 15% greater than the PTmax value is met if in 90% of cases the upper value of the limit of tolerance does not exceed 1.15 PTmax, with a statistical certainty of 95%, that is, if the following inequality is met:

$$\bar{P}n + K3.n \times Sn \leq 1.15\ PTmax$$

The mean pressure of the test cartridge must be at least 30% higher than the maximum pressure allowed for the commercial cartridges. Furthermore, so that in 90% of cases the lower value of the limit of tolerance is not less than 1.15 PTmax, with a certainty of 95%, the following inequality must be met:

$$\bar{P}n - K3.n \times Sn \geq 1.15\ PTmax$$

In order not to over-stress the weapon subject to test, the test cartridge must not exceed a certain pressure value set by the following inequality:

$$\bar{P}n + K3.n \times Sn \leq 1.50\ PTmax$$

9.1.5. For cartridges for which the measurement of kinetic energy is required instead of the measurement of gas pressure

The analysis of measurement results will be carried out applying the statistical rules:

- Emax: maximum value of kinetic energy for the projectile allowed by the C.I.P.
- En: arithmetic mean kinetic energy of the projectile obtained for n measurements
- Sn: standard deviation of the kinetic energy of the projectile over n measurements.
- K3.n: coefficient of tolerance for n measurements in order to obtain a statistical certainty of 95% in 90% of cases

The mean kinetic energy of the commercial cartridge must be less than or equal to the allowable Emax value. Furthermore, the requirement for a commercial cartridge to not have any individual kinetic energy value greater than 1.07 Emax, with the certainty mentioned above, is met if the following inequality is met:

$$En + \overline{K3.n} \times Sn \leq 1.07\ Emax$$

The mean kinetic energy of the test cartridge must be at least 10% higher than the maximum mean kinetic energy allowed for the commercial cartridges. Furthermore, no individual kinetic energy value may be less than 1.07 Emax with the certainty mentioned above. This requirement is met when the following inequality is met:

$$En - \overline{K3.n} \times Sn \geq 1.07\ Emax$$

In order for the kinetic energy not to exceed a certain value with the certainty mentioned above, the following inequality must be met:

$$En + \overline{K3.n} \times Sn \leq 1.25\ Emax$$

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9.2. Coefficients of tolerance

Coefficients of tolerance for n measurements in order to obtain a statistical certainty of 95% in

- K1.n 99% of cases
- K2.n 95% of cases
- K3.n 90% of cases

n	K1.n	K2.n	K3.n
5	5.75	4.21	3.41
6	5.07	3.71	3.01
7	4.64	3.40	2.76
8	4.36	3.19	2.58
9	4.14	3.03	2.45
10	3.98	2.91	2.36
11	3.85	2.82	2.28
12	3.75	2.74	2.21
13	3.66	2.67	2.16
14	3.59	2.61	2.11
15	3.52	2.57	2.07
16	3.46	2.52	2.03
17	3.41	2.49	2.00
18	3.37	2.45	1.97
19	3.33	2.42	1.95
20	3.30	2.40	1.93
25	3.15	2.29	1.83
30	3.06	2.22	1.78
35	2.99	2.17	1.73
40	2.94	2.13	1.70
45	2.90	2.09	1.67
50	2.86	2.07	1.65
60	2.81	2.02	1.61
70	2.77	1.99	1.58
80	2.73	1.97	1.56
90	2.71	1.94	1.54
100	2.68	1.93	1.53

For intermediate values: interpolate linearly.

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10. Measurement Report

The measurement report should include, at a minimum, the following items:

a. name and address of test laboratory

b. client name

c. measurement report order number

d. measurement date

e. operator name

f. name and signature of person responsible

g. technical characteristics of the ammunition (calibre, type and mass of projectile, batch, manufacturer)

h. meteorological conditions: temperature, humidity

i. technical characteristics of the measurement system (number of manometric barrel and sensor, sensitivity of pressure sensor at the expected pressure, indications regarding the velocity measurement system)

j. individual pressures and velocities

k. averages and deviations of gas pressures and velocities

l. statistical analysis of measurements

m. observations concerning possible anomalies in conditions or measurement results.