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THE ANALYSIS OF APPLICATION AND REQUIREMENTS SMALL CALIBER REFERENCE AMMUNITION AND POLISH ACHIEVEMENT IN THE FIELD OF WORKING OUT NATIONAL REFERENCE AMMUNITION

In this paper there is presented the main application of small calibre reference ammunition, according to NATO requirements and the latest Polish achievement in working out the family of small calibre reference cartridges.

1. Introduction

According to NATO documents the main purpose of reference ammunition is to allow for correction of the result obtained during testing of ammunition in different day climatic conditions, through barrels of various states of wear, back to a known datum. The known datum is 6 barrels of low life which are held as master barrels by the Regional Test Centre (RTC) which have been used in accordance with the procedures contained in Manual of Proof and Inspection Procedures (MOPI), to establish a set of assessed values.

The main application of reference ammunition:

- to establish the ballistic and equipment corrections;
- for weapon testing in the event of stoppages during the function;
- as a comparator for the smoke and flash test;
- for investigating or checking the performance of equipment when doubts arises over the equipment performance;
- for testing the suitability of a proposed new or upgraded Nominated Weapon.

The reference ammunition shall be used to establish the ballistic and equipment correction for:

- qualification approval tests;
- production tests;
- surveillance tests.

The reference lot should meet all the requirements MOPI and STANAG the concrete calibre ammunition.

According to NATO procedures the Regional Test Centre (RTC) is responsible for maintain and supply cartridges, reference NATO. The RTC will fire an assessment and publish the following values for the reference cartridge (for example 5,56mm):

- Ballistic Data (EPVAT):
 1. Average velocity results at 24 meters and:
 - extreme variation,
 - standard deviation.
 2. Average case mouth pressure results and:
 - extreme variation,
 - standard deviation.
 3. Average port pressure results and:
 - extreme variation,
 - standard deviation.
 4. Average action time results and:
 - extreme variation,
 - standard deviation.
- Ballistic Data (Precision):
 1. Average velocity results at 24 meters and:
 - extreme variation,
 - standard deviation.
 2. Precision at 550 metres and:
 - horizontal standard deviation,
 - vertical standard deviation.
- Assessment values:
 - velocity at 550 metres,
 - case mouth pressure,
 - port pressure,
 - action time at 21° C,
 - precision statistics.

The Superintendent of the RTC will monitor the assessed values of the reference lot in the following manner:

- a) The data from all firings of the reference cartridges conducted at the RTC during a calendar year will be maintained.
- b) Charts will be prepared showing the average values obtained at each of the RTC and the combined averages. These will be plotted against the assessed values and the difference obtained. Significant differences will be statistically determined by using an “f” or “t” tests.
- c) The results will be reported by the Superintendents to SG/1 NATO Group each year.

In table 1 there are presented assessed values of small caliber reference ammunitions in NATO type barrels.

2. Method of conducting the assessment tests (as an example 5,56mm reference cartridges)

Before testing the reference cartridges shall be conditioned at a constant temperature of approximately 21° C for a minimum of 24 hours prior to being placed in the constant temperature-controlled box for 2 hours at $21 \pm 2^\circ$ C. The three EPVAT barrels used for the official assessment of the reference lot shall be defined as the “master assessment” barrels and shall be retained for use in assessing a new reference lot or re-assessing the original lot if its values are significantly changing.

The manner and sequences for conducting the assessment shall be the same as described in the EPVAT and Precision Test, using barrels previously fired approximately 500 times. Twenty cartridges shall be fired in each of three EPVAT barrels. The average velocity at 24 metres, case mouth and peak pressures, and action time with the three EPVAT barrels for the first day shall be obtained. If the average velocity of any barrel assembly deviates from the average of the three barrels by more than 6 metres per second or if the standard deviation for any individual barrel exceeds 10 metres per second, that barrel shall be replaced with another barrel and the firing for that barrel shall be repeated and new averages calculated. An additional 20 cartridges shall be fired in the same manner in the same three EPVAT test barrels and with the same pressure gauges on each of the two succeeding days. The velocity difference between the highest and lowest daily averages should not exceed 4 metre per second.

The assessed value for precision will be obtained by repeating the Precision Test three times and averaging the results.

3. Use of reference cartridges to establish the ballistic and equipment correction for qualification approval, production and surveillance tests (as an example 5,56mm ammunition EPVAT tests)

Minimum 20 of reference cartridges shall be fired in the weapon to be used for the test. The observed mean case and port pressure and observed mean velocity of reference cartridges shall be compared with the assessed values. If the assessed value is higher, the difference is a plus correction and shall be added to the case mouth pressure, port pressure or mean velocity of the test cartridges. If the assessed value is lower, the difference is a minus correction and shall be subtracted from the mean case mouth, port pressure or mean velocity of test cartridges. If both values are identical, no correction is applied. Charts shall be maintained of the results obtained with each barrel using the reference cartridges.

The EPVAT barrel assembly shall be withdrawn from service when any of the following performance variations from the assessed value of the reference cartridges is exceeded:

- mean peak case mouth pressure - ± 25 MPa;
- mean peak port pressure - ± 14 MPa;
- mean velocity - ± 12 m/s.

Table 1 Assessed values of NATO reference ammunitions in NATO type barrels

	6215 Transducer			6203 Transducer			Expected	Expected Precision Details			
	Chamber	Port	Velocity	Chamber	Port	Velocity	Action	s hor	s ver	Velocity	
	MPa	MPa	m/s	MPa	MPa	m/s	Time	ms	mm	mm	m/s
5.56mm Lot No. FNB83 F002R001	345	116	912	321	100	904	0,848	90	90		
Average sd	6,0	1,2	5,0								
7.62mm Lot No. NATO LC-Y-505	358	72	825	340	63	820	1,070	85	85		
Average sd	9,6	0,7	5,2								
7.62mm Lot No. FA-Y-498	361	78	830	332	71	820					
9mm Lot No. 304 IVI 79	224	-----	408	192	-----	400	0,777				
Average sd	9.5		8.1								
12.7mm Lot No FNB00D000R001	296	-----	888	-----	-----	-----	2,532	142	144	887	
Average sd	10.1		5.3								

NOTE: Only Chamber Pressures, Port Pressures and EPVAT Velocity values are to be corrected with the above figures.

The Action Time and Precision statistics are shown for information purposes to enable Test Ranges to check their equipment performance.

4. The Polish achievement in the field of working out national reference ammunition.



Fot. 1 The family of Polish small calibre reference ammunition

The NATO reference ammunition of course is not used for everyday as a production control. Individual ammunition producers should normally produce their own reference ammunition for this purpose and only use the NATO reference to monitor the performance of their own reference ammunition or as a final check prior to submitting for NATO Qualification Approval Testing.

According to previous Polish documents (technical requirements) reference cartridges were used to determine the size ballistic correction of ballistic equipment during all of ballistic tests as well to certify ballistic weapon, as to qualify their usefulness in ballistic tests.

We can see, that application of reference ammunition in tests according to NATO standards is significantly wider than according to previous Polish documents. The most important problem is to supply reference cartridges to our national laboratories.

The Polish Armed Forces as a new members of NATO are in continuous reorganisation and transformation.

We are during the withdrawing process of former Warsaw Treaty Organisation armament to substitute it for armament compatible with other members of NATO. But we still have on armament small calibre ammunition according to Soviet standard. That's why in our national laboratories we need as well NATO, as Soviet calibres small calibre reference ammunition.

To satisfying our national needs, in 2005 Military Institute of Armament Technology and "MESKO" Metal Works Industry started working out the family of Polish reference small calibre ammunition (fot.1). This project is realizing thanks to subsidy Ministry of Education and Science.

The family of our national small calibre reference ammunition consist of:

According to NATO calibres:

- 5,56 x 45 mm;
- 7,62 x 51 mm;
- 9 x 19 mm;
- 12,7 x 99 mm;

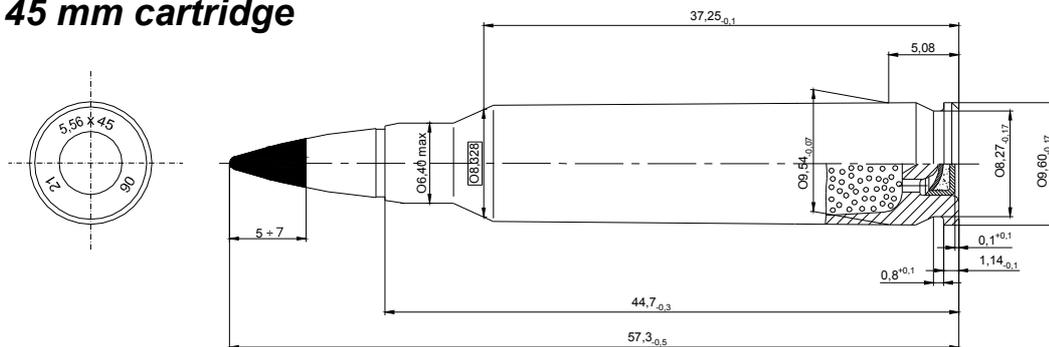
According to Soviet calibres:

- 7,62 x 39 mm;
- 7,62 x 54 mm;
- 9 x 19 mm.

The reference ammunition is characterized by narrow tolerance of ballistic and tactics-technical parameters. Below there are presented the most important requirements of national reference ammunition.

4.1 Requirements of ballistic and tactical-technical parameters national reference ammunition

5,56 x 45 mm cartridge



Ballistic requirements

1. The average velocity of bullet at 24 m from the muzzle of the barrel [V_{24ave}] for fifteen 20-round series, cartridges conditioned at $21 \pm 2^\circ\text{C}$ shall be

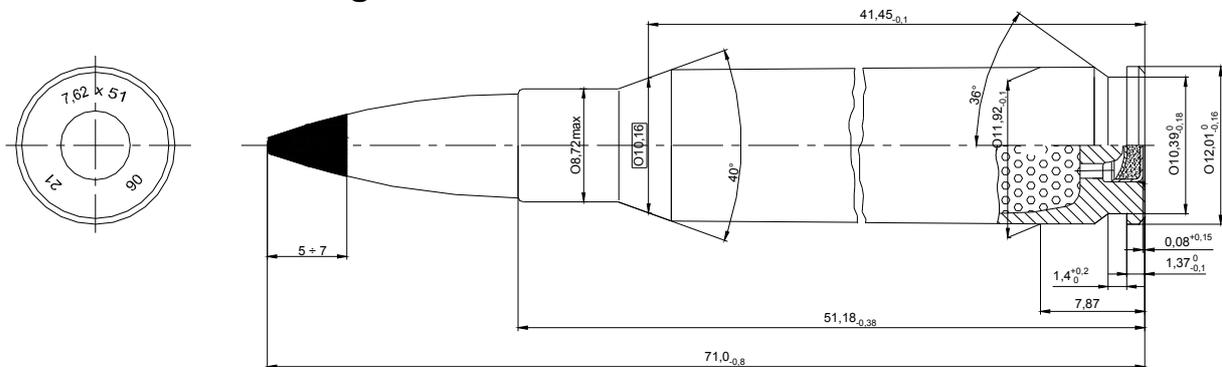
$V_{24\text{ ave}} = 912 \pm 6$ m/s, and the average of the standard deviation of the velocities for fifteen 20-round series shall not exceed 8 m/s.

2. The average chamber pressure for fifteen 20-round series cartridges [p_{maxave}], conditioned at $21 \pm 2^\circ\text{C}$ shall not exceed 380 MPa, and the average of the standard deviation of chamber pressure for fifteen 20-round series shall not exceed 13,8 MPa.
3. The average cartridge action time plus five standard deviations shall not exceed 3 ms when fired at -54°C .

Tactical requirements (precision)

When fired from a standard proof barrel at a range of 600m, all shoots shall be in a group whose mean radius not exceed 22,5 cm.

7,62 x 51 mm cartridge



Ballistic requirements

1. The average velocity of bullet at 24 m from the muzzle of the barrel [$V_{24\text{ave}}$] for fifteen 20-round series, cartridges conditioned at $21 \pm 2^\circ\text{C}$ shall be $V_{24\text{ave}} = 830 \pm 6$ m/s, and the average of the standard deviation of the velocities for fifteen 20-round series shall not exceed 8 m/s.
2. The average chamber pressure for fifteen 20-round series cartridges [p_{maxave}], conditioned at $21 \pm 2^\circ\text{C}$ shall not exceed 365 MPa, and the average of the standard deviation of chamber pressure for fifteen 20-round series shall not exceed 13,8 MPa.
3. The average cartridge action time plus five standard deviations shall not exceed 4 ms when fired at -54°C .

Tactical requirements (precision)

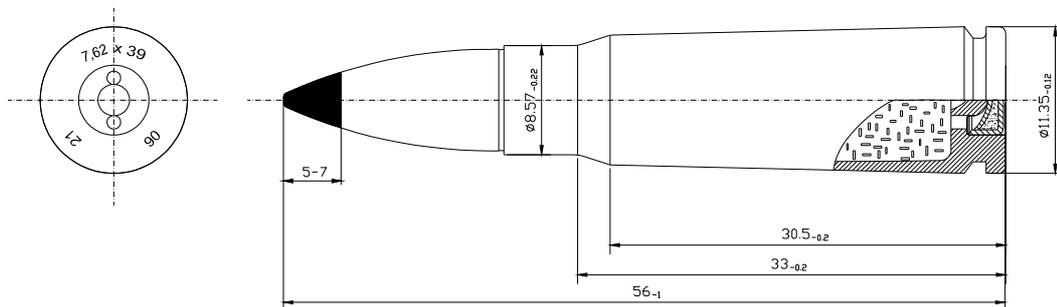
When fired from a standard proof barrel at a range of 550 m, all shoots shall be in a group whose mean radius not exceed 25 cm.

- The average chamber pressure for fifteen 20-round series cartridges [$p_{\max\text{ave}}$] , conditioned at $21 \pm 2^\circ\text{C}$ shall not exceed 448 MPa, and the average of the standard deviation of chamber pressure for fifteen 20-round series shall not exceed 13,8 MPa.
- The average cartridge action time plus five standard deviations shall not exceed 4 ms when fired at -54°C .

Tactical requirements (precision)

When fired from a standard proof barrel at a range of 550 m, all shoots shall be in a group whose mean radius not exceed 30 cm.

7,62 x 39 mm cartridge



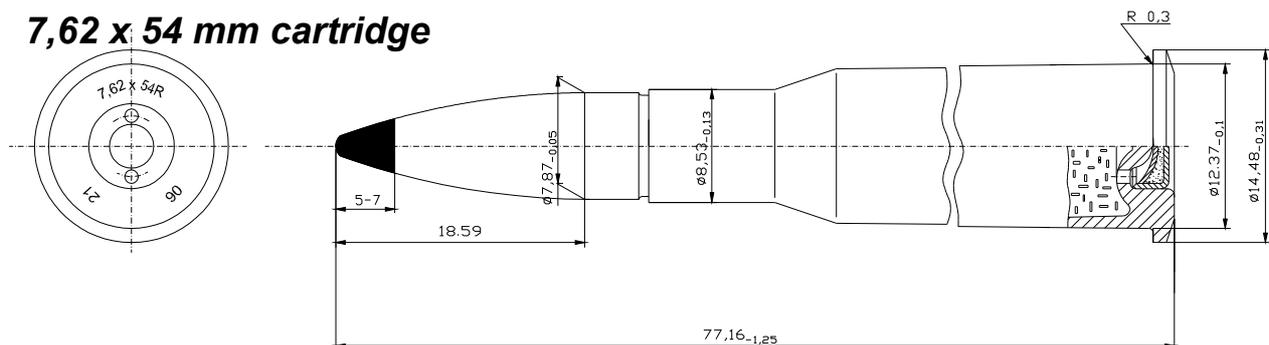
Ballistic requirements

- The average velocity of bullet at 25 m from the muzzle of the barrel [$V_{25\text{ave}}$] for fifteen 20-round series, cartridges conditioned at $21 \pm 2^\circ\text{C}$ shall be $V_{24\text{ave}} = 718 \pm 6$ m/s, and the average of the standard deviation of the velocities for fifteen 20-round series shall not exceed 6 m/s.
- The average chamber pressure for fifteen 20-round series cartridges [$p_{\max\text{ave}}$] , conditioned at $21 \pm 2^\circ\text{C}$ shall not exceed 275 MPa, and the average of the standard deviation of chamber pressure for fifteen 20-round series shall not exceed 13,8 MPa.
- The average cartridge action time plus five standard deviations shall not exceed 4 ms when fired at -54°C .

Tactical requirements (precision)

When fired from a standard proof barrel at a range of 600 m, all shoots shall be in a group whose mean radius not exceed 25 cm.

7,62 x 54 mm cartridge



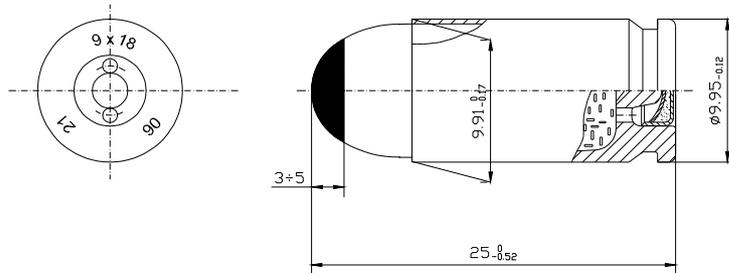
Ballistic requirements

7. The average velocity of bullet at 25 m from the muzzle of the barrel [V_{25ave}] for fifteen 20-round series, cartridges conditioned at $21 \pm 2^\circ\text{C}$ shall be $V_{24ave} = 826 \pm 6$ m/s, and the average of the standard deviation of the velocities for fifteen 20-round series shall not exceed 6 m/s.
8. The average chamber pressure for fifteen 20-round series cartridges [p_{maxave}], conditioned at $21 \pm 2^\circ\text{C}$ shall not exceed 285 MPa, and the average of the standard deviation of chamber pressure for fifteen 20-round series shall not exceed 13,8 MPa.
9. The average cartridge action time plus five standard deviations shall not exceed 4 ms when fired at -54°C .

Tactical requirements (precision)

When fired from a standard proof barrel at a range of 600 m, all shoots shall be in a group whose mean radius not exceed 25 cm.

9 x 18 mm cartridge



Ballistic requirements

4. The average velocity of bullet at 10 m from the muzzle of the barrel [V_{10ave}] for fifteen 20-round series, cartridges conditioned at $21 \pm 2^\circ\text{C}$ shall be $V_{10ave} = 300 \pm 10$ m/s, and the average of the standard deviation of the velocities for fifteen 20-round series shall not exceed 5 m/s.
5. The average chamber pressure for fifteen 20-round series cartridges [p_{maxave}], conditioned at $21 \pm 2^\circ\text{C}$ shall not exceed 118 MPa, and the average of the standard deviation of chamber pressure for fifteen 20-round series shall not exceed 10 MPa.
6. The average cartridge action time plus five standard deviations shall not exceed 3 ms when fired at -54°C .

Tactical requirements (precision)

When fired from a standard proof barrel at a range of 46 m, all shoots shall be in a group whose mean radius not exceed 5,8 cm.

4.2 Results tests of model lots reference ammunition

In table 2 there are presented some results of tests reference ammunition from model lots, in relation to requirements. In every calibres achieved required ballistic and tactical parameters.

Table 2

Parameter	Requirements / Results	Calibre of reference ammunition						
		5,56 x 45	7,62 x 51	12,7x99	9 x 19	7,62 x 39	7,62 x 54	9 x18
Average velocity [m/s]	Requirements	V _{24 ave} 912 ± 6	V _{24 ave} 830 ± 6	V _{24 ave} 887 ± 6	V _{16 ave} 350 ± 10	V _{25 ave} 718 ± 6	V _{25 ave} 826 ± 6	V _{10 ave} 300 ± 10
	Results	915,7	830,7	885	352,7	714,6	825,1	304,5
Average velocity standard deviation [m/s]	Requirements	≤ 8	≤ 8	≤ 6	≤ 5	≤ 6	≤ 6	≤ 5
	Results	4,19	3,92	4,44	2,82	4,61	2,93	4,4
Average chamber Pressure [MPa]	Requirements	≤ 380	≤ 365	≤ 448	≤ 215	≤ 275	≤ 285	≤ 118
	Results	328	330	328	213	261	255,1	106,2
Average chamber pressure standard deviation [MPa]	Requirements	≤ 13,8	≤ 13,8	≤ 13,8	≤ 10	≤ 13,8	≤ 13,8	≤ 10
	Results	7,50	6,9	7,3	3,7	5,2	2,73	2,84
Precision /mean radius/ [cm]	Requirements	/600 m/ ≤ 22,5	/550 m/ ≤ 25	/550 m/ ≤ 30	/46 m/ ≤ 7,6	/600 m/ ≤ 25	/600 m/ ≤ 25	/46 m/ ≤ 5,8
	Results	14,4	12,2	10,8	2,0	23,5	16,8	4,0

4. Conclusions

Presented in this article the pragmatic of application reference ammunition undoubtedly show essentiality this type of ammunition in every stages of ballistics tests as well ammunition (in qualification, production and surveillance tests) as weapon and ballistic equipment. The initial achievement "MESKO" Metal Works Industry and Military Institute of Armament Technology in working out the family of small calibre national reference ammunition are good prognosis, the possibility of implementation this kind of ammunition in Polish accredited ballistic laboratories. Because of the unique ballistic and tactical-technical parameters of reference ammunition, there are possibility of international cooperation in this matter too.

5. References

- [1] "The methodology of ballistic tests small calibre ammunition" , WITU study TUMO nr A 04320/68B;
- [2] Polish Standard NO-13-A503 "The reference ammunition certification";
- [3] Technical requirements "7,62mm carbine ammunition";
- [4] Manual of Proof and Inspection Procedures for NATO 5,56 mm ammunition.

Streszczenie

W artykule przedstawiono zasadnicze zastosowanie strzeleckiej amunicji wzorcowej w odniesieniu do wymagań NATO i bieżące polskie osiągnięcia w dziedzinie opracowania, rodziny krajowych naboju wzorcowych.