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MILITARY STANDARD

BALLISTIC ACCEPTANCE TEST REQUIREMENTS FOR SOLID PROPELLANT FOR CANNON

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DEPARTMENT OF DEFENSE
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Ballistic Acceptance Test Requirements for Solid Propellant for Cannon.

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1. SCOPE

1.1 This standard covers methods of ballistic acceptance testing. Testing involves:

a. The determination of the recommended charge weight (RCW) of propellant required for filling the ammunition.

b. Ensuring that ammunition lot performance satisfies ballistic requirements.

c. Confirming that the RCW of propellant is loadable in the ammunition.

1.2 This standard implements QSTAG 560, Propellant Proof, in which the Armies of the United States, United Kingdom, Australia and the Canadian Forces have agreed to standardize ballistic acceptance tests for gun ammunition (excluding 40mm and smaller).

1.3 Purpose. The purpose of this standard is to provide a single publication as a Military Standard containing the requirements of ballistic acceptance tests and to implement QSTAG 560.

2. REFERENCE DOCUMENTS

2.1 Standards.

MIL-STD-652 - Propellants, Solid, for Cannons Requirements and Packing.

2.2 Other government documents.

TOP-4-2-606
SB-742-1
TM 9-3305

2.3 Other publications.

Quadripartite standardization Agreement 560 Propellant Proof

2.4 Order of precedence. In the event of a conflict between the text of this standard and the references cited herein, the text of this standard shall take precedence.

3. DEFINITIONS

3.1 Definition of terms used in this standard.

3.1.1 Gun. A projectile throwing device consisting essentially of a projectile-guiding tube, with an incorporated or connected reaction chamber in which the chemical energy of a propellant is rapidly converted into heat and the hot gases produced expand to expel the projectile at a high velocity.

3.1.2 Cannon. A complete assembly, consisting of a tube and a breech mechanism, firing mechanism or base cap, which is a component of a gun, howitzer, or mortar. The term is generally limited to calibers greater than 30mm.

3.1.3 Gun tube. Hollow cylindrical structure in which the projectile receives its motion and initial direction.

3.1.4 Proof ammunition. Ammunition incorporating solid, blunt-nosed, steel or cast iron shot of inexpensive manufacture; used in proof firing of guns; used to simulate the weight of projectile designed for the gun in adjusting the charge weight of propellant.

3.1.5 Lagrange interpolation. The construction of a function which is not defined for all points in a interval by using a Lagrange multiplier.

3.1.6 Master calibration lot. A yardstick for measuring the interior, and in some cases exterior and terminal, ballistics performance for a specified ammunition-weapon system. The master calibration round is assembled from one set of components which is considered to represent the average or typical ammunition lot being used in a service application. The master lot performance is established to give absolute ballistics by an extensive, statistically designed test, as specified in TECOM Test Operation Procedure 4-2-606. This provides sufficient information on the master lot to avoid or minimize errors such as gun to gun differences, occasion differences, first round interference, temperature variations, etc. A master lot will be used to establish reference calibration lots and to provide correction in the same manner as a reference calibration lot.

3.1.7 Reference calibration lot. A lot made up from one set of components which provides the necessary calibration factors while conserving the master lot. Reference lots are established by comparison against the master lot in accordance with TECOM Test

Operation Procedure 4-2-606. Reference rounds will be used for any acceptance, surveillance, or product improvement tests where uncontrollable variations would prevent other means of correction to standard (or absolute) conditions for the purpose of evaluating ballistic performance.

3.1.8 Warming rounds. Rounds used to heat the gun tube. These rounds are frequently not the same charge weight or zone as the item being tested.

3.1.9 Conditioning rounds. Rounds fired after warmers which are similar in ballistic performance to the rounds being tested. These rounds are used to check the test equipment and alleviate conditions such as lay by and tube memory.

3.2 Definition of acronyms used in this standard. The following acronyms listed in this Military Standard are defined as follows:

RCW - Recommended Charge Weight
FCW - Fixed Charge Weight
MV - Muzzle Velocity
CV - Charge Verification
QAA - Quality Assurance Analyst
PIMP - Permissible Individual Maximum Pressure

4. GENERAL REQUIREMENTS

4.1 General. Ballistic acceptance is the ultimate form of testing in the production and inspection sequence. It is carried out in addition to the Quality Control measures taken during manufacture. All lots of propellant, except for those which are loaded to a fixed charge weight (FCW), are subjected to this testing. In particular, ballistic acceptance is conducted to:

a. Determine the RCW required for the filling of each type ammunition.

b. Confirm that the RCW is loadable.

c. Ensure that weapon system safety and reliability are not compromised by propellant performance.

4.2 Item specification. A prerequisite of propellant manufacture and testing is a specification for the propellant. The specification will normally make reference to:

a. Materials and formulas to be used during manufacture.

b. Quality assurance measures to be taken during and after the completion of manufacture.

c. Weapon equipment with which the propellant is to be used.

d. Ammunition with which the propellant is to be fired.

e. Performance requirements during ballistic testing.

f. Loading criteria.

g. Environmental conditioning of ammunition to be fired (when applicable).

h. Defined standard weapon conditions and corrections to be applied based on reference round performance.

4.3 Materials. The quality of materials to be used in the manufacture of propellants will be specified and the specifications will include details of or make reference to the procedures to be used in testing.

4.4 Manufacturing procedures. The specification for the manufacture of a propellant will require the use of an approved method. The Quality Plan will provide checks that the manufacturing processes are carried out in accordance with an approved method. Following ballistic acceptance tests, during the loading of propellant, note will be taken of the results of these Quality Assurance Checks.

4.5 Testing after manufacture. Quality Assurance measures will provide for visual, physical, chemical and performance testing of the propellant before ballistic acceptance tests are performed. Testing is to include as required by the individual specification:

a. Visual checks, straightness, grain size and perforations.

b. Physical testing; Bulk density, absolute density and compressibility.

c. Chemical testing; Composition and chemical stability.

d. Closed bomb testing; Force, vivacity/quickness testing may also be used to provide an initial estimate of the RCW.

4.6 Equipment and components used during ballistic testing.

4.6.1 General considerations. It is desirable that ballistic acceptance testing be performed with gun tubes, projectiles, cartridge cases and primers, etc. representative of those which will be used in service. However, in instances where production sources change from year to year due to competitive procurement practices, and where duplication of truly representative service conditions are not possible, alternate courses to maximize the validity of the test must be pursued. The specifications will detail the equipment and ammunition components with which the propellant is to be tested.

4.6.2 Gun tubes.

4.6.2.1 General. It is known that gun tubes vary from one maker to another and that gun tubes from any one maker do not necessarily give the same new gun characteristics, and that over a short period of manufacture they will have a bias towards a certain ballistic level.

4.6.2.2 Selection of gun tubes for standardization/ calibration. Gun tubes are selected by one of the procedures described below:

a. When minimizing ballistic differences between production end items is of primary concern and when the service mix or identity of gun tube manufacturers cannot be predicted due to competitive procurement policies, 3 or more representative new gun tubes will be selected from the manufacturer(s) of gun tubes used during ammunition R & D and engineering trials. These gun tubes will be used to establish a master calibration lot of propellant. The best tube with respect to wear, velocity level and uniformity as determined from calibration data is designated as the "master gun tube" and the next best will be designated the "check tube". The master tube will be preserved as long as possible by only using it to confirm the performance of the master calibration lot of propellant. The check tube is used at regular or specific intervals to ensure that no significant physical or chemical trends or changes have occurred which would alter the ballistic performance of the master calibration lot or its associated reference calibration lot. A reference calibration lot is a lot of propellant used for the purpose of providing calibration factors while conserving the master lot. A reference lot is established by comparison testing with the master lot IAW TOP-4-2-606.

b. When minimizing ballistic differences between test conditions and service conditions is of primary concern and when the service mix and identity of tube manufactures can be predicted it is considered particularly important that tubes used for standardization firings should be truly representative of tubes in which the propellant lots undergoing testing will be fired in service. In order that this may be achieved tubes should be selected, where possible, from two or more makers and from different dates of manufacture from any one maker.

4.6.2.3 Tube wear. Ideally a gun tube will be kept for each type of propellant to be tested and used only for that purpose throughout its life. Usually only gun tubes in the first 50% of their wear life will be used for ballistic acceptance tests. Exceptions to this rule exist for equipment in which a longer wear life can be tolerated without compromising the integrity of the test or in high velocity rounds where 50% wear is unacceptable and tubes with 75% remaining life must be used.

4.6.3 Projectiles.

4.6.3.1 General. Service projectiles, inert filled, with inert fuze and tracer, adjusted to ballistic tolerance for weight, $\pm$ 0.5%, are generally used for both standardization and ballistic acceptance tests. Proof ammunition may, however, be used when service projectiles are not available or are economically unfeasible. An allowance will be made for the ballistic difference between the service projectile and the proof ammunition.

4.6.3.2 Projectiles for standardization firings. Projectiles for standardization firings will be selected in accordance with the procedure described below:

When the identity of the projectile manufacturer cannot be predicted and minimizing variations due to projectile differences is of primary concern, a large single lot of projectiles suitable for inert filling will be selected for use in standardization firing, i.e. for the establishment of master and reference calibration lots. It is preferable that these inert filled projectiles should come from the manufacturer used during the R&D stage. Additional single lots of projectiles will be selected, preferably from the same maker, to establish 2nd and 3rd etc. calibration projectile lots. It is required at a 95% confidence level that there be no significant difference in pressure or velocity between lots at comparison firings with the original and subsequent lots of projectiles. Also, the uniformity of performance must be in accordance with the specified ballistic acceptance test requirements. Projectiles which have not satisfied the specification requirements will not be used for standardization purposes.

4.6.3.3 Projectiles for ballistic acceptance tests. In order to avoid round-to-round variations due to lot effects, projectiles all from one maker and from one lot will be used for ballistic acceptance tests. When projectiles have been standardized by the procedure described in 4.6.3.2 the calibrated or standardized lot will also be used for ballistic testing.

4.6.4 Cartridge cases.

4.6.4.1 General. The configuration of cartridge cases has a direct relationship on effective chamber capacity and, therefore on the ballistics obtained. In order to avoid round-to-round variations the variations in configuration of cases used on any one occasion for standardization firings should be kept to a minimum.

4.6.4.2 Selection of cases for testing. The conditions of 4.6.2.1 and 4.6.3.3 also apply for cartridge cases used in ballistic acceptance testing.

4.6.4.3 Combustible cartridge cases. A standard at present consists of a lot of propellant and a lot of combustible cases which have been standardized as a pair. Case monitoring of each lot of combustible cases is based on the result of physical and chemical laboratory tests. It has been found however, that the energy provided by the combustible cartridge case must be accounted for in the total energy produced by the charge.

4.6.5 Ignition.

4.6.5.1 General. Difference in ballistic levels can be caused by the use of primers from different manufacturers or from different lots from the same maker.

4.6.5.2 Ignition for standardization firings. The procedures described in 4.6.3.2 for projectiles will also be used for the selection of primers.

4.6.5.3 Ignition for ballistic acceptance testing. In order to avoid round-to-round variations due to lot effects, primers all from one maker and from one lot will be used for ballistic acceptance testing. When primers for the standardization lot are selected in accordance with a procedure as described in 4.3.6.2, the ballistic acceptance testing lot and standardized lot will be one and the same lot.

4.7 Performance requirements. Details of the ballistic test requirements contained in the item specification will show:

a. The uniformity requirement, which should be in terms of a recognized statistical parameter and related to the level of QA required and the sample size employed.

b. The assessed muzzle velocity or assessed pressure for any equipment combination and the conditions to which it applies i.e., details of charge design, components, whether shell or proof ammunition, number and type of gage for pressure measurement, temperature etc.

c. An upper limit for mean pressure when the charge is adjusted to a prescribed velocity.

d. The PIMP (Permissible Individual Maximum Pressure) for a round, either under standard conditions or at extreme conditions or both.

e. A lower limit for muzzle velocity when the charge is adjusted to a prescribed pressure.

f. Maximum weight for RCW for any propelling charge to ensure loadability.

Depending on the specification, the following may also be specified:

g. Maximum permissible firings intervals, i.e., time between initiation of the primer and the projectile leaving the gun tube, or some pressure threshold in the chamber.

h. Pressure differential limits between forward, middle, and breech section of the chamber.

i. A lower limit for mean pressure in the case of an assessed velocity.

4.8 Selection of samples for ballistic tests. Propellant for acceptance tests is to be chosen in accordance with a specified sampling procedure which should state whether or not it should be blended before assembly into charges. Boxes are to be selected at random from all parts of the propellant lot using a statistical procedure and propellant is to be taken randomly from each box. Propellant is to be taken from at least 10 boxes. When this is impracticable samples from less than 10 boxes may be taken if the homogeneity of the blend can be demonstrated. For single-base propellants, the sample should not be taken until moisture equilibration has been reached (particularly if water was added) and the minimum time between packing and sampling specified. Some propellants are required to be aged for a specified length of time between pack out and charge establishment. Attention should be paid to the requirements for each individual type of propellant.

5. BALLISTIC TEST METHODS

5.1 General. There are two methods of ballistic acceptance tests currently used. The preferred, and by far the most widely used, is a comparative test in which the RCW is determined as a result of comparing the ballistic performance of the test propellant with that of a standard lot. An alternate less satisfactory method is an absolute test in which the RCW is determined by firing for absolute ballistics; this method would be used when a standard lot is not available.

5.2 Comparative tests.

5.2.1 General. This type of test consists of firing the lot sample to be tested, round for round against a standard in a gun tube using standard components (primers, fuzes, projectiles) when available. A standard lot is specially selected lot of propellant whose performance under standard ballistic conditions in the average/typical new gun at a given charge weight and using standard components is known.

5.2.2 Testing. A comparative test is based on the assumption that, if the conditions are carefully controlled, the difference between the as-fired ballistics of the standard lot and its approved ballistics is due to gun tube wear and firing conditions, and can equally be applied to the as-fired ballistics of the lot being tested to obtain its new gun ballistics. Thus, if the lot being tested gives a velocity 2 m/sec above the standard lot it can be assumed that it would give 2 m/sec above the approved ballistics of the standard lot if fired in a new gun tube. An adjustment can then be made to the as-fired charge weight to obtain the weight necessary to give the assessed muzzle velocity or the assessed pressure thus obtaining the recommended charge weight (RCW).

5.3 Absolute test (Research and development control rounds). During the development of a new gun or round before a control or standard lot can be made or where, for some other reason, no standard is available an RCW can be determined by firing for absolute ballistics in at least two new gun tubes. The mean MV and pressure are corrected for the difference between the as-fired cartridge case weight, and the mean case weight before adjusting the charge weight to give the RCW. Absolute testing is less satisfactory than comparative testing because it is not possible to reduce the round-to-round variation to a minimum (by reducing component effects etc.) without the risk of introducing a bias due to unrepresentative conditions.

5.4 Uniformity. Irrespective of the test method employed it is necessary to produce uniform conditions for the firing of each round of the test and reduce occasion to occasion differences to a minimum. Considerations will be given to a greater or lesser extent the following aspects.

5.4.1 Selection of gun tubes. Ideally a gun tube will be kept for each type of propellant to be tested and used for that purpose only. If possible a gun tube is to be new when taken into use for ballistic acceptance testing and will be used for that purpose until it is no longer suitable.

5.4.1.1 Tube life. A gun tube will be considered to be finished for ballistic acceptance test purposes when any of the following conditions have been met.

a. A 3% drop in the velocity from the velocity calibration level at 21°C.

b. At 21°C, a drop in pressure of 41.4MPa, or 15% whichever occurs first. It should be noted that a pressure drop of 15% could occur with low pressure charges from shoot to shoot or between hot and cold gun conditions.

c. Velocities or pressures have become abnormally irregular, using a criteria that the standard deviation expected of the standard lot should not be exceeded on two successive occasions.

d. When the gun tube is condemned for wear or any other reasons.

5.4.2 Order of fire.

5.4.2.1 General. Lots will be fired round for round with the standard. Ideally three lots will be tested on one occasion as this economizes on standard rounds but does not involve too large a firing from the point of view of gun tube wear, firing time etc. The firings will be preceded by one (or more) warmer or conditioning rounds to bring the gun to a reasonably stable ballistic level. The final conditioning round where several are fired should always be the same size etc. as the standard. The order of fire is therefore W + C+ N (T A B C)

where:
W = warmer round(s)
C = Conditioning rounds
T = standard round
A B C = round of lots A, B, C, under proof
N = number of rounds in a series.

5.4.2.2 Multiple Charges. Multiple charges and composite charges are to be fired in descending order of charge for standardization to get hot gun tube conditions but for ballistic acceptance testing this will not be possible because the RCW for the lower charges must be known before the higher charges can be fired. This type of test should therefore be carried out charge by charge on different occasions. The method of applying a lagrange interpolation is an acceptable alternative.

5.4.2.3 Low zone charge. In the lower charges of multiple charge equipment, consistent results can only be obtained under hot gun conditions, therefore several warmers (of the highest charge) are fired before the charges being assessed are fired. If hot gun tube conditions are not met, the propellant lot may fail to meet the specification for uniformity through no fault of its own.

5.4.3 Ballistic hump.

5.4.3.1 General. Ballistic hump is characterized by a rise in velocity and pressure in the early life of the gun tube. It normally occurs with ammunition which gives a low rate of wear and is most marked in small caliber guns. It occurs more frequently with cool picrite (nitroguanidine) propellants but it can occur with hot double base propellants. It appears that the underlying cause of hump is common to all gun tubes but in fast wearing gun tubes the wear effect masks the hump effect. When wear reducing techniques are used, hump tends to appear.

5.4.3.2 Magnitude. Ballistic hump is considered to be due to an increase in shot-start resistance caused by the onset of craze crackings of the bore surface. This causes an increase in the burning rate of the propellant which leads to an increase in the maximum pressure. The magnitude of the hump can be varied by alternating the burning rate of the propellant. Rotating bands probably contribute to the magnitude of the effect. Only small humps (13.8MPa) have been detected with non-metallic bands where increases of 41.4MPa have been obtained with copper bands. The duration of the hump depends on the rate of wear. With a very slow wearing round it may take 1000 rounds to get back to new gun ballistics. The increase in pressure is great compared with the increase in velocity that would be expected from their normal relationship. This may be due to an increase in the rate of burning or friction down the bore or a combination of both. The pressure and velocity peaks do not always coincide. Ballistic hump has little effect on ballistic acceptance testing since conditions are alike for both the standard and test lots. It may occasionally cause high MV and pressure particularly when the position of all-burnt is well forward. Calibration tests should not be conducted during the most active changes occuring in a ballistic hump. It may be necessary to conduct these tests after the peak of a ballistic has elapsed.

5.4.4 Crash.

5.4.4.1 General. Crash is a pronounced downward trend in velocity during the firing of a series of rounds. Velocities return to normal between series.

5.4.4.2 Effect on ballistics. Crash may cause difficulties during ballistic acceptance testing because the effect increases the standard deviation in MV of a series. It could happen that the standard deviation in MV will exceed that permitted by the propellant specification resulting in the rejection, for non-uniformity of a lot which is intrinsically homogeneous. This should be guarded against by keeping the number of rounds fired to a minimum and, if necessary, analyzing the test results statistically.

5.4.5 Creep.

5.4.5.1 General. Creep is defined as a slow upward trend in velocity during a series. If enough rounds are fired the velocity eventually levels off. It would appear to be a bore heating effect, since it is essentially associated with low velocity rounds with copper bands. One of the factors could be the reduction in cooling of the propellant gases as the bore warms up. Creep generally occurs in the bottom charges of multi-charge guns.

5.4.5.2 Magnitude. The order of magnitude of the effect is approximately 10 m/sec in 50 rounds before the velocity stabilizes. Limited evidence suggests that the use of non-metallic bands considerably reduces the creep effect. Its only effect on ballistic acceptance testing will be to increase the standard deviation in MV. This can be avoided by firing several rounds of a high charge to warm the gun tube thoroughly.

5.4.6 Round effects.

5.4.6.1 Projectiles.

5.4.6.1.1 Comparative testing. For comparative testing, projectiles all from one maker and lot are to be used in any one test firing. This procedure will avoid round-to-round variations due to lot effects. Projectiles are to be weighed and adjusted to the design weight ± 0.5%.

5.4.6.1.2 Absolute testing. For absolute testing and standardization, projectiles are selected from different lots and makers so as to average out the ballistic differences between makers and lots.

5.4.6.2 Cartridge cases. As variations in cartridge case configurations cause variations in velocity and pressure it is necessary to keep the variation to a minimum for any one shoot. The RCW derived for each lot will only give the correct velocity in service if it is filled into cases whose configuration are at or near the mean case weight.

5.4.6.2.1 Correction for weight variations. For absolute testing and standardization firings knowledge of the mean cartridge case weight is important. If possible the mean weight should be the new case weight at the midpoint of the design limits. When the mean level and the mean case weight differ a correction must be applied to the as fired ballistics and will be based on the theoretical effect on ballistics of a small change in effective chamber capacity.

5.4.6.2.2 Combustible charge containers. The present situation of assessing charge weight is described in 4.6.4.3.

5.4.6.3 Ignition.

5.4.6.3.1 Comparative test. During comparative testing primers all from one maker and one lot should be used in order to avoid round-to-round variations due to lot effects.

5.4.6.3.2 Absolute Test. For absolute testing and standardization firings primers from several different lots and makers should be chosen so as to average out ballistic differences between different lots and makers.

5.4.7 Lay by effect.

5.4.7.1 General. This effect appears as abnormal ballistics (drop in MV) for the first few rounds fired in a gun tube that has not been fired for a period of months or years. This effect is thought to be due to imperfect cleaning or preservation of the bore resulting in some corrosive or chemical change in the nature of the bore surface.

5.4.7.2 Conditioning. Gun tubes which have been laid by for more than three months will normally fire a conditioning series of three (3) rounds at least 24 hours prior to the firing of test rounds. The rounds in the conditioning series should be similar to those in the test series.

5.4.7.3 Tube memory. This effect is similar in nature to lay by. It is a "memory" of previous rounds of ammunition of a different configuration fired in the gun tube. It is corrected by firing a series conditioning rounds of the same configuration as the rounds being tested prior to testing.

5.4.8 Coppering.

5.4.8.1 General. When copper banded projectiles are fired at velocities above 366 m/sec a little of the copper melts and a film of copper is left on the bore. Repeated firings can lead to the development of a copper choke.

5.4.8.2 Effect on ballistics. If copper is deposited in the early part of the bore there will probably be an increase in ballistics due to an increase in shot-start resistance. If copper is deposited well down the bore the tendency is to reduce the velocity of the projectile. The inclusion in the design of tin or lead salts in the propellant or of tin or lead foils in the round removes the copper deposits.

5.4.9 Loading of charge. In many bag-charge guns and in guns where a loose (granular) charge is employed, particularly when loading density is low, variation in the position of the charge in the chamber has a significant ballistic effect. Ballistics are higher when the charge is in contact with the mushroom head or breech block and lower when charge is in contact with the projectile. Extensive trials have shown that the effect increases with wear of the gun tube and varies with charge temperature and the type of propellant. This may be an ignition effect, as the length of the flash is shorter when the charge is in contact with the block. It is therefore essential to have a fixed position of loading for ballistic acceptance tests. This will usually be the normal chamber position of the charge in service use. Care should be taken therefore to assure that the loading procedure employed, particularly the placement of the charge is consistent.

5.4.10 Ramming of projectile.

5.4.10.1 General. Ideal ramming in separate loading guns is achieved when the rotating band is firmly jammed into the forcing cone and band engraving has just started. Short ramming reduces chamber capacity and allows gas to escape past the band before the projectile seats. The ballistic effect is unpredictable.

5.4.10.2 Ramming during testing. Many modern guns use power ramming and there may be a ballistic difference between power and hand rammings. Theoretically power ramming should give higher ballistics as it should lead to higher shot-start pressure. It is desirable that absolute ballistic firing should be carried out with the service ramming when possible.

5.4.11 Bullet pull.

5.4.11.1 General. Bullet pull is the effort which must be exerted to extract the projectile from the cartridge case and is similar in effect to short-start pressure. Increased bullet pull increases the rate of burning of the propellant and its ballistics. The effect tends to decrease with fast burning propellants and increase in worn gun tubes and high performance rounds. It is greater in small caliber weapons when the depth of the cannelure and therefore the work done on the brass case is proportionally greater.

5.4.11.2 Crimping. Variations in bullet pull can be caused by differences both in the crimping tool and in the method of using it. With hand operated machines there can be differences between operators. Power operated machines are normally used for assembly of rounds for ballistic acceptance testing and as far as possible the crimping machines that are used at the fill factory. The degree of matching should be checked by carrying out bullet pull tests on rounds assembled at the range and at the filling factory.

5.4.12 Temperature conditioning. The ballistic effect of variations of charge temperature may conceal variations in ballistics due to other causes, therefore efforts are made to ensure that all rounds are fired at the same temperature and that this temperature is as close as possible to the standard temperature of 21°C. For this reason charges are conditioned in a temperature controlled chamber for sufficient time before firing to ensure that the whole charge reaches the required temperature.

5.4.13 Mounting of cannon. This is an important factor in the control of testing. Testing has shown that the use of a "Facility Mount" will have a significant influence on velocities. See TM 9-3305 for a more detailed description of cannon mounting.

5.5 Propellant effects.

5.5.1 General. Ballistic phenomena associated with propellant can be divided into two categories.

5.5.1.1 Propellant effects independent of the gun. These are related to conditions of manufacture and storage, box differences and deterioration.

5.5.1.2 Propellant effects associated with the condition of the gun. Interference and differential wear may cause round to round variation.

5.5.2 Charge weight of lot being tested.

5.5.2.1 Charge verification. The charge weight to be used for each lot will be decided after consideration of results of recent production and the CV assessment. With the information available it will usually be possible to make a fairly close estimate of the weight required.

5.5.2.2 As-fired charge weight. Ideally the as-fired charge weight should not vary from the RCW for the assessed muzzle velocity by more than 1%. If, for any reason, a correction of more than 1% is necessary and the history of ballistic testing for the particular system does not support a wider limit the final RCW is to be confirmed by a second firing at the new weight. Where there is little evidence on which to base an estimate it may be more economical to carry out a small charge determination before firing the ballistic acceptance test series.

5.5.2.3 Approximate charge weight. The approximate charge weight quoted in the drawing for the cartridge or charge assembly is the weight of propellant estimated during the early stages of development. It may be marked on the ammunition and on ammunition packages. It will not necessarily produce the range table ballistics published for the ammunition with any production lot of propellant and should only be taken as a guide to the weight of propellant present in the round or charge. The exact weight filled for any particular lot in order to achieve the range table ballistics is the RCW.

5.5.3 Container differences.

5.5.3.1 Standards. Propellant standards may be stored inside metal containers which are themselves hermetically sealed. They should be kept in dry conditions at temperatures maintained between 13 and 18°C. It is assumed that if propellant is homogeneous at standardization it will remain so under the conditions stated above, but it has been found that charges assembled from different containers when fired comparatively can give significantly different ballistics. Various reasons for this may be advanced, as, for example.

a. That the propellant was not as homogenous as had been thought.

b. That the ballistic differences are associated with differences in the balance of moisture and solvent content and distribution. It should be noted that granular and in particular single base propellants appear to be most susceptible.

5.5.3.2 Volatiles. Examination of records of total volatile matter estimations has shown very little correlation with ballistic performance over a period of several years. Isolated cases have been recorded, however, where correlation has been so exact as to allow selection of reliable containers by tests of total volatile matter. It has been estimated theoretically that an addition of 1% of volatile matter is equivalent to a decrease of 5% in MV.

5.5.3.3 Defective containers. Serious container differences are comparatively rare. The presence of an occasional bad container as a standard should be evident in analysis of test results. This calls for extra vigilance in subsequent tests. There have been cases, however, of standard lots which have shown obvious signs of having two different levels during use, the new level gradually replaces the old one. In such cases a new standard lot has to be made, and the question of derivation of comparative or absolute ballistics for a new standard lot has to be answered on the merits of the case.

5.5.3.4 Firing procedure. Early recognition of container differences is essential when conducting ballistic acceptance tests. It is therefore advisable to use, as a routine, a method of container selection which will show container differences at once. This can be done by using standard charges from three (3) different containers in every test series and firing them as alternate standard charges in the normal test series as follows:

T_1ABC T_2ABC T_3ABC T_1ABC T_2ABC T_3ABC

where:

T_1 - standard container 1
T_2 - standard container 2
T_3 - standard container 3
ABC - lots being tested

5.5.3.5 Opened containers. The system is not infallible as the known container will have been open on a previous occasion and the change in gaseous conditions within the container may affect the condition of the propellant. Analysis of the performance of a standard by containers during supplementary standardization is possible if the mean performance of each gun tube is near the grand mean. This sometimes shows that one or more containers have given results consistently different from the mean. Should this container affect be repeated, consideration should be given to making another standard lot.

5.5.4 Deterioration.

5.5.4.1 General. All propellants deteriorate in time as a result of chemical change. A stabilizer is always added to retard the accumulation of the products of decomposition and the consequent acceleration of decomposition reactions. In achieving this, the stabilizing agent is consumed. The general effect of decomposition is to cause a fall in ballistics. The rate of chemical deterioration is markedly affected by temperature, increasing by a factor of about 1.7 for every 5°C increase in temperature.

5.5.4.2 Effects on ballistics. It is not possible to relate the ballistic effects of deterioration to temperature by any general formula since the actual ballistics achieved depend on a complex interaction of chemical and physical factors which are not completely understood. Thus the effect of high humidity at high temperature on the ballistics of picrite propellants are much greater than can be accounted for by changes in chemical composition of the propellant alone. Detailed discussion of these questions is beyond the scope of this standard. It is sufficient to note that under carefully controlled conditions of storage in temperate climates the rate of chemical deterioration is extremely slow and the effect on ballistics is insignificant for at least twenty-five years.

5.5.5 Interference.

5.5.5.1 General. Ballistic acceptance tests and many ballistic trials are based on the assumption that by direct comparison, factors whose absolute effects are unknown, or uncontrollable, are eliminated. The validity of this assumption is limited by mutual interference between charges whose behavior is different in the gun. The word "behavior" is used here advisably because two charges having different behavior in the gun may exhibit the same performance when fired round for round but different performance when fired independently. Some of the differences which can cause differences in behavior are:

a. Composition of propellant.

b. Size of propellant

c. Weights of the same type of propellant.

d. Temperature of the same type of propellant.

e. Force and vivacity.

f. Charge design of the same type of propellant.

5.5.5.2 Order of fire. The effect is difficult to detect with certainty and more difficult to measure, but is sometimes indicated by the differences betwen A_1, A_2, and A_3 etc., in the series A_1, B_1, A_2, B_2, A_3, B_3, etc., since A cannot be affected by B. Interference can be avoided by using a different order of fire, in which variants are separated.

5.5.5.3 Muzzle velocity differences. As a guide only charges which can be expected to give differences in performance greater than 3% in MV or 5% in pressure should not be fired alternately for comparison. The anti-interference order of fire has the disadvantage that it spoils the comparison of regularity between variants especially in quick wearing guns.

5.5.6 Differential wear.

5.5.6.1 General. Charges of different types which match ballistically in new gun tubes can give ballistics which do not match in worn gun tubes. This effect is known as differential wear.

5.5.6.2 Factors. Theoretically propellant factors affecting velocity degradation with tube wear are force, vivacity, and shape. Trials have shown clearly that vivacity is the dominant factor in differential wear. Although it may also depend on force and shape, it has not been possible to establish this on a firm basis. A lower vivacity leads to a greater drop in velocity with wear. Although the quantitative effect depends upon the propellant charge/gun combination, the typical figure is that a 1% change in relative vivacity leads to a change on the order of a 2% drop in velocity with wear.

5.5.6.3 Propellant type. Modern propellants are manufactured to fairly close limits in force and vivacity so differential wear between lots of the same type of propellant is not significant. Differential wear usually occurs with charges of different types of propellant. It may occur with design changes of the charge, igniter or projectile. Differential wear can occur at any early stage in gun tube life if ballistic hump is present.

5.5.6.4 Early detection. For ballistic acceptance tests it is important to detect the effect of differential wear at an early stage. Two tests in gun tubes of different ages will show if there is differential wear between the standard lot and the lots being tested. If present it may be necessary to make a new standard lot or to limit ballistics acceptance tests to relatively new gun tubes. Differential wear and interference may occur simultaneously and any test for differential wear may be upset unless an anti-interference order of fire is used.

5.6 Fixed charge weight. It is not always necessary to determine the RCW by performing a ballistic acceptance test. For economic reasons, charges can be filled to a FCW. This should be established by comparing lot to lot dispersion with the specification performance required for filling. If lot to lot dispersion falls within the control limits of the specification, the use of an FCW is feasible. The occasions when an FCW is acceptable are describe below:

a. When variations in ballistic performance are not important (i.e., this is the case with some smoke rounds) it is reasonable to fill to the nominal charge weight which will become in these circumstances the FCW. Since the use of this category of round is comparatively limited, production lots are likely to be small and intermittent.

b. The reliability of the lower charges in some multiple of composite charge equipment is often very good. In these circumstances, the consistency permits filling to an FCW.

5.7 Issuance of load authorization.

5.7.1 General. The criteria for the testing of propellants will be included in their specifications. In addition to the data obtained during ballistic acceptance testing for the issuance of load authorization of propellants, consideration is also given to the results of all Quality Control measures taken during the manufacture of a propellant. These will include:

a. Inspection of materials prior to the commencement of manufacture.

b. Checks on the conduct of manufacturing procedures.

c. The performance of the propellant during closed bomb testing and the result of checks on its chemical and physical properties.

d. Expiration date for validity of load authorization.

5.7.2 Inspection of materials. As indicated in section 4.3 descriptions of the detailed measures necessary to ensure the conformity of materials used in the manufacture of propellant are given in the relevant specification and therefore are not required as part of this standard. Assurance of conformity is, however, an indispensible condition to the commencement of propellant manufacture. Formal Quality Control procedures are required and note will be taken of the results at the issuance of load authorization.

5.7.3 Checks on manufacturing procedures. An approved method of manufacture will be a requirement in the specification for a propellant. Formal Quality Control procedures are necessary to show that the manufacturing process conforms with the approved method of manufacture. Note will be taken of these checks at load authorization.

5.7.4 Test during manufacture. Test normally made during manufacture consist of:

a. Tests to confirm that the physical properties, chemical compostion, density and stability of the propellant conform with the specification.

b. Closed bomb testing to assure close functional relationship with the standard lot of propellant.

(1) Round to round dispersion limits for force and vivacity are normally imposed for control of homogeneity and reflect good blending practice rather than quantitative performance in the gun. When these limits are exceeded, it is normal to repeat the closed bomb firings, to reblend the lot or in rare cases to waive the closed bomb dispersion limit pending firing tests in the gun.

(2) If a lot of propellant does not satisfy closed bomb test requirements it may be submitted for ballistic acceptance testing at the discretion of the Quality Assurance Analyst. However, the propellant lot shall normally meet the closed bomb requirements before being submitted for gun testing. Where good correlation exists between closed bomb test results and ballistic acceptance test results the former may be taken as a useful indication of a propellant's gun performance. In such circumstances a propellant which is to be loaded to a fixed charge weight (FCW) may be accepted by the QAA without ballistic testing. When it is intended to load the propellant to a RCW it is necessary to submit the propellant for ballistic testing.

5.7.5 Performance during ballistic acceptance testing. The authorization to load propellant mainly depends upon the extent to which it meets the performance requirements for ballistic acceptance testing contained in the item specification. The normal requirements are outlined in section 4.7. It is required that:

a. The assessed muzzle velocity or the assessed pressure for the equipment/propellant combination should be attained as specified.

b. The RCW required to attain the assessed MV or pressure should be loadable.

c. In the case of an assessed MV, the mean expected pressure applicable to the MV should be within the upper or lower limits specified, and the upper limit for the maximum pressure applicable to the MV of an individual round should not be exceeded.

d. In the case of an assessed pressure the MV applicable to the assessed pressure should not normally be outside the upper or lower limit specified. When a small spread in velocity is required the following procedure may be adopted.,

(1) Adjust to an assessed velocity unless pressure is above the upper limit for presssure.

(2) If it is above, adjust to an assessed pressure (upper limit for pressure as above). Only reject if velocity is then below the specification figure.

e. The uniformity requirement defined in terms of a recognized statistical parameter for a specified number of rounds should not be exceeded.

f. When appropriate, the firings should be within specified limits.

5.7.6 Expiration date of charge assessment. Propellant lots must be loaded within a stipulated period as per SB 742-1 from their original assessment date. A reassessment must be done before a propellant which has exceeded the period can be loaded. The reassessement will normally include chemical, physical and ballistic testing. The results of these tests will be compared with the original test results. If there is a disagreement between the old and the new results the propellant may be submitted to gun testing. An exception to this rule is that single and triple base propellant of US manufacture in Level A pack (metal-lined containers) need not be reassessed unless five years have expired between date of charges assessment and date of loading.

"Certain provisions of this standard are the subject of Quadripartite Standardization Agreement 560. When amendment, revision, or cancellation of this standard is proposed which will modify the international agreement concerned, the preparing activity will take appropriate action through international standardization channels including departmental standardization offices to change the agreement or make other appropriate accomodations."

Review activity:
Army-TE

Preparing activity:
Army-AR
(Project 1376-A285)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE
DOD-STD-1469 (AR)	Ballistic Acceptance Test Requirements

3a. NAME OF SUBMITTING ORGANIZATION

b. ADDRESS *(Street, City, State, ZIP Code)*

4. TYPE OF ORGANIZATION *(Mark one)*

- [ ] VENDOR
- [ ] USER
- [ ] MANUFACTURER
- [ ] OTHER *(Specify)*: ______

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional

b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional

c. MAILING ADDRESS *(Street, City, State, ZIP Code)* – Optional

8. DATE OF SUBMISSION *(YYMMDD)*

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