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MILITARY SPECIFICATION

PROPELLANT FOR 20MM AMMUNITION

This specification has been approved by the Naval Air Systems Command, Department of the Navy.

1. SCOPE

1.1 This specification covers propellant for use in ammunition for the 20MM Naval Aircraft Guns, MARK 11 and MARK 12. As used in this document, the word "powder" is synonymous with "propellant."

2. APPLICABLE DOCUMENTS

2.1 The following documents of the issue in effect on date of invitation for bids or request for proposal form a part of this specification to the extent specified herein:

SPECIFICATIONS

Military

| | |
|---|---|
| MIL-D-98 | Diphenylamine, Technical |
| MIL-G-155 | Graphite, Dry (For Use in Ammunition) |
| MIL-P-193 | Potassium Sulfate (For Ordnance Use) |
| MIL-N-244 | Nitrocellulose |
| MIL-E-463 | Ethyl Alcohol (For Ordnance Use) |
| MIL-P-1394 | Primer, Electric, M52A3B1 |
| MIL-L-18618 | Lead Carbonate, Basic, Dry (For Ordnance Use) |
| MIL-M-19719 | Methyl Centralite (For Ammunition Use) |

Federal

| | |
|---|---|
| O-A-51 | Acetone, Technical |

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STANDARDS

Military

| | |
|---|---|
| MIL-STD-129 | Marking For Shipment and Storage |
| MIL-STD-286 | Propellant, Solid: Sampling, Examination and Testing |

DRAWINGS

Naval Air Systems Command

| | |
|---|---|
| DL 517534 | Case, Cartridge, 20MM, MARK 5 MOD 0 |
| DL 2176062-1 | Projectile, 20MM, MARK 11 MOD 1 |
| IL 2838594 | Gun System, 20MM MARK 12 MOD 0 and Supplementary Equipment |
| LD 288379 | Packing Box, MARK 7 MOD 3 (For Smokeless Powder) |
| LD 522056 | Pod, Gun, MARK 4 MOD 0 (MARK 11 Gun) |

Department of the Army

| | |
|---|---|
| SK7553247 | Action, Test, Electric, 20MM Assembly, List of Parts and Drawings |
| A7585089 | Piston, Long |
| D7259361 | Gage, Air Space, 20MM Case |
| D7548066 | Primer, Electric, M52A3B1, Assembly |

Naval Ordnance Systems Command

| | |
|---|---|
| SK679810 | Barrel, Copper Pressure Gauge Test, MARK 100 Series, 20MM Ammunition |
| SK679811 | Barrel, Electric Gauge Test, MARK 100 Series, 20MM Ammunition |

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PUBLICATIONS

Naval Ordnance Systems Command

| | |
|---|---|
| NAVORD Instruction 8010.24 | Marking of Federal Stock Numbers and Nomenclature on Ammunition |

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other publications. The following document forms a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply:

Code of Federal Regulations

| | |
|---|---|
| 49 CFR 171-190 | Hazardous Materials Regulations, Department of Transportation |

(Application for copies of Code of Federal Regulations should be addressed to the Superintendent of Documents, Government Printing Office, Washington, DC 20402. Orders for the above publication should cite "the latest edition and supplements thereto.)"

3. REQUIREMENTS

3.1 Materials. The materials used in the manufacture of the propellant shall comply with the following:

3.1.1 Nitrocellulose. Nitrocellulose, grade C, type I or II of MIL-N-244, shall be used in the manufacture of all 20MM propellant.

3.1.2 Methyl centralite. Methyl centralite deterrent shall conform to MIL-M-19719, class 2.

3.1.3 Ethyl alcohol. Ethyl alcohol shall conform to MIL-E-463, grade 2.

3.1.4 Graphite. Graphite shall conform to MIL-G-155, grade III or grade IV.

3.1.5 Potassium sulfate. Potassium sulfate shall conform to MIL-P-193, type I.

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3.1.6 Diphenylamine. Diphenylamine shall conform to MIL-D-98.

3.1.7 Acetone. Acetone shall conform to O-A-51.

3.1.8 Lead carbonate. Lead carbonate shall conform to MIL-L-18618.

3.2 Chemical and physical properties. The finished propellant shall be graphite glazed. The chemical properties of table I are provided as a guide in meeting the other requirements of the specification. They shall be determined as specified in 4.6.1 for information only. The stability properties of the propellant shall comply with the requirements of table II when determined in accordance with 4.6.1.9.

TABLE I

PROPELLANT CHEMICAL AND PHYSICAL PROPERTIES

| | |
|---|---|
| Nitrocellulose (NC) (nominal) (%): | 91.4 |
| Diphenylamine (DPA) (%): | 0.70 - 1.00 |
| Potassium sulfate ($K_2SO_4$) (%): | 1.50 (max) |
| Lead carbonate ($PbCO_3$) (%): | 0.60 - 1.00 |
| Deterrent - methyl centralite (MC) (%): | 5.0 (min) |
| Coating - graphite (%): | 0.40 (max) |
| Dust and foreign matter (%): | 0.075 (max) |
| Total volatiles (TV) (%): | 2.35 (max) |
| External moisture (%): | 0.75 - 1.25 |
| Residual solvents (%): | 1.10 (max) |
| Hygroscopicity (%): | 1.75 (max) |

TABLE II

PROPELLANT STABILITY PROPERTIES

| | |
|---|---|
| Heat test, stability (°C): | 134.5 |
| Time to discoloration (minutes): | 25 (min) |
| Time to explosion (minutes): | 5 (min) |

3.2.1 Form. The propellant shall be of cylindrical grain form with single perforation.

3.2.2 Loading. The propellant shall load satisfactorily in loading machines of the type currently in use for the production loading of the appropriate ammunition.

3.2.2.1 Linear compression. The bulk density of the propellant shall be such that the linear compression of the propellant when subjected to the test of 4.6.1.12.1 shall be not greater than 0.10 inch.

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3.2.2.2 Weight variation. When subjected to the test of 4.6.1.12.2 the weight of each of 50 consecutive propellant charges loaded from machines of the type currently in use for the production loading of the appropriate ammunition shall be the assessed charge weight ±5 grains.

3.3 Preproduction powder assessment. Unless otherwise specified, a preproduction lot of 770 pounds shall be furnished the government prior to starting on full production (see 4.3).

3.3.1 Charge weight and pressure assessment. The preproduction powder charge weight and pressure assessment firings shall be performed as specified in 4.6.2.1.

3.3.1.1 Charge weight. A charge weight shall be determined as specified in 4.6.2.1.1 to produce a velocity equal to the mean of the two master powder groups in that barrel on that day.

3.3.1.2 Pressure. The assessed pressure of the powder, calculated as specified in 4.6.2.1.2, shall not exceed 58,000 pounds per square inch (psi) copper (cu).

3.3.2 Charge weight verification, MARK 11 cyclic rate computations and ballistic requirements. These firings shall be performed as specified in 4.6.2.2.

3.3.2.1 Charge weight verification. According to the procedures specified in 4.6.2.2.1, a charge weight shall be determined. This charge weight shall be within five grains of the charge weight assessed in 3.3.1.1.

3.3.2.2 MARK 11 cyclic rate computations. The MARK 11 cyclic rates shall be computed for the master and preproduction powders as specified in 4.6.2.2.2. The computed rate of the test powder shall be within 200 rounds per minute (rpm) of the computed rate of the master powder in that barrel on that day.

3.3.2.3 Ballistic requirements.

3.3.2.3.1 Maximum chamber pressure. The mean maximum corrected chamber pressure, computed as specified in 4.6.2.2.3, shall not exceed 69,600 psi (pressure-time (p-t)), and the standard deviation shall not exceed 3,000 psi (p-t).

3.3.2.3.2 Muzzle velocity. Excluding the conditioning round, the mean muzzle velocity of the preproduction powder rounds at the assessed charge weight shall be within 50 feet per second (fps) of the mean muzzle velocity of the master powder rounds in that barrel on that day. The standard deviation of the preproduction powder shall not exceed the standard deviation of the master powder by more than 10 fps.

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3.3.2.3.3 Action time. The action time (see 6.6.2) for any single round at the assessed charge weight shall not exceed 0.0033 second (sec). The mean action time for any group of rounds at the assessed charge weight shall not exceed 0.0030 sec.

3.3.3 Functional tests. Functional tests in the MARK 11 and MARK 12 guns shall be performed as specified in 4.6.2.3.

3.3.3.1 MARK 11. The cyclic rate of the preproduction powder shall be within 150 rpm of the cyclic rate of the master powder in the same gun on the same day when both are fired as specified in 4.6.2.3.1.

3.3.3.2 MARK 12. The cyclic rate of the preproduction powder shall be within 75 rpm of the cyclic rate of the master powder in the same gun on the same day when both are fired as specified in 4.6.2.3.2. The mean muzzle velocity of the preproduction powder at the assessed charge weight shall be within 50 fps of the mean muzzle velocity of the master powder in that gun on that day. The standard deviation of the preproduction powder shall not exceed 30 fps.

3.4 Production powder assessment.

3.4.1 Charge weight and pressure assessment. The production powder charge weight and pressure assessment firings shall be performed as specified in 4.6.3.1.

3.4.1.1 Charge weight. A charge weight shall be determined as specified in 4.6.3.1.1 to produce a velocity equal to the mean of the two master powder groups in that barrel on that day.

3.4.1.2 Pressure. The assessed pressure of the powder, calculated as specified in 4.6.3.1.2, shall not exceed 58,000 psi (cu).

3.4.2 Charge weight verification, MARK 11 cyclic rate computations and ballistic requirements. These firings shall be performed as specified in 4.6.3.2.

3.4.2.1 Charge weight verification. According to the procedures specified in 4.6.3.2.1, a charge weight shall be determined. This charge weight shall be within five grains of the charge weight assessed in 3.4.1.1.

3.4.2.2 MARK 11 cyclic rate computations. The MARK 11 cyclic rates shall be computed for the master and production powders as specified in 4.6.3.2.2. The computed rate of the test powder shall be within 200 rpm of the computed rate of the master powder in that barrel on that day.

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3.4.2.3 Ballistic requirements.

3.4.2.3.1 Maximum chamber pressure. The mean maximum corrected chamber pressure, computed as specified in 4.6.3.2.3, shall not exceed 69,600 psi (p-t), and the standard deviation shall not exceed 3,000 psi (p-t).

3.4.2.3.2 Muzzle velocity. Excluding the conditioning round, the mean muzzle velocity of the production powder rounds at the assessed charge weight shall be within 50 fps of the mean muzzle velocity of the master powder rounds in that barrel on that day. The standard deviation of the production powder shall not exceed the standard deviation of the master powder by more than 10 fps.

3.4.2.3.3 Action time. The action time for any single round at the assessed charge weight shall not exceed 0.0033 sec. The mean action time for any group of rounds at the assessed charge weight shall not exceed 0.0030 sec.

3.4.3 Functional tests. Functional testing shall be performed on the MARK 11 and MARK 12 guns at the discretion of the procuring activity.

3.4.3.1 MARK 11. The cyclic rate of the production powder shall be within 150 rpm of the cyclic rate of the master powder in that gun on that day when both are fired as specified in 4.6.3.3.1.

3.4.3.2 MARK 12. The cyclic rate of the production powder shall be within 75 rpm of the cyclic rate of the master powder in that gun on that day when both are fired as specified in 4.6.3.3.2. The mean muzzle velocity of the production powder at the assessed charge weight shall be within 50 fps of the mean muzzle velocity of the master powder in that gun on that day. The standard deviation of the production powder shall not exceed 30 fps.

3.5 Master powder standardization.

3.5.1 Charge weight and pressure assessment. The master powder charge weight and pressure assessment firings shall be performed as specified in 4.6.4.1.

3.5.1.1 Charge weight. A charge weight shall be determined as specified in 4.6.4.1.1 to produce a velocity of 3,320 fps in a new Mann barrel (see 6.6.3).

3.5.1.2 Pressure. The pressure produced by the assessed charge weight, calculated as specified in 4.6.4.1.2, shall be the assessed pressure of the powder and shall not exceed 58,000 psi (cu).

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3.5.2 Charge weight verification, MARK 11 cyclic rate computations and ballistic requirements. These firings shall be performed as specified in 4.6.4.2.

3.5.2.1 Charge weight verification. According to the procedures specified in 4.6.4.2.1, a charge weight shall be determined. This charge weight shall be within five grains of the charge weight assessed in 3.5.1.1.

3.5.2.2 MARK 11 cyclic rate computations. The MARK 11 cyclic rates shall be computed as specified in 4.6.4.2.2 and shall not differ by more than 150 rpm.

3.5.2.3 Ballistic requirements.

3.5.2.3.1 Maximum chamber pressure. The mean maximum chamber pressure of the assessed charge weight rounds shall not exceed 69,600 psi (p-t), and the standard deviation shall not exceed 3,000 psi (p-t).

3.5.2.3.2 Muzzle velocity. Excluding the conditioning round, the mean muzzle velocity of the assessed charge weight rounds shall be 3,320 $\pm$ 50 fps, and the standard deviation shall not exceed 20 fps.

3.5.2.3.3 Action time. The action time for any single round at the assessed charge weight shall not exceed 0.0033 sec. The mean action time for any group of rounds at the assessed charge weight shall not exceed 0.0030 sec.

3.5.3 Functional tests. Functional tests in the MARK 11 and MARK 12 guns shall be performed as specified in 4.6.4.3.

3.5.3.1 MARK 11. A functional test for cyclic rates shall be fired as specified in 4.6.4.3.1. Excluding the conditioning burst, each rate shall be 4,000 $\pm$ 200 rpm. The two rates shall not differ by more than 150 rpm.

3.5.3.2 MARK 12. A functional test for cyclic rates and muzzle velocities shall be fired as specified in 4.6.4.3.2. Excluding the conditioning burst, each rate shall be 1,000 $\pm$ 75 rpm, and the mean muzzle velocity of each burst, excluding the first round, shall be 3,320 $\pm$ 50 fps. The standard deviation for each burst shall not exceed 30 fps.

3.6 Test guns (see 4.6.5). Before firing for powder assessment, guns to be used for ballistic measurements shall be broken in by firing a sufficient number of cutting rounds to eliminate erratic ballistics caused by wearing of the barrel. Guns chosen for acceptance testing of powder shall not be used for experimental powders of nonstandard composition. The first round of all firings for velocity shall be considered a conditioning round and be excluded from the data.

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3.6.1 Mann barrels.

3.6.1.1 Mann barrel, copper (see 4.6.5.1). When qualifying a Mann barrel (cu) for use in acceptance testing, it shall be fired with a master powder as specified in 4.6.5.1.1. The mean muzzle velocity of the data rounds shall be 3,320 ± 50 fps with a standard deviation not to exceed 20 fps. The mean chamber pressure of the data rounds shall not deviate from the assessed pressure of the master powder by more than 2,500 psi (cu).

3.6.1.2 Mann barrel, pressure-time (see 4.6.5.2). When qualifying a Mann barrel (p-t) for use in acceptance testing, it shall be fired with a master powder as specified in 4.6.5.2.1. The mean muzzle velocity of the data rounds shall be 3,320 ± 50 fps with a standard deviation not to exceed 20 fps. The mean maximum chamber pressure of the data rounds shall not deviate from the assessed pressure of the master powder by more than 3,000 psi (p-t). Pressure (psi) (cu) times 1.2 = Pressure (psi) (p-t).

3.6.2 Automatic guns (see 4.6.5.3).

3.6.2.1 MARK 11. When fired as specified in 4.6.5.3.1, the cyclic rate shall be 4,000 ± 200 rpm.

3.6.2.2 MARK 12. When fired as specified in 4.6.5.3.2, the mean velocity of the master powder data rounds shall be 3,320 ± 50 fps with a standard deviation not to exceed 30 fps. The cyclic rate of the burst shall be 1,000 ± 75 rpm.

4. QUALITY ASSURANCE

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Classification of inspections. The inspection requirements specified herein are classified as follows:

(a) Preproduction inspection (see 4.3)

(b) Production inspection (see 4.4)

(c) Master propellant inspection (see 4.5)

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4.3 Preproduction inspection. Prior to quantity production, a preproduction sample of 770 pounds of powder shall be prepared and delivered by the contractor for testing to an agency designated by the procuring activity. This powder shall be manufactured by the same procedures and processes and at the same location which the contractor will use for execution of the contract. The preproduction sample shall meet the requirements of 3.2 and 3.3 when tested in accordance with 4.6.1 and 4.6.2 or it shall be rejected. The contractor shall be advised of the results of the preproduction inspection, and will be authorized by the procuring activity to proceed with production if the results are acceptable. Accepted samples shall become the property of the Government and shall be included in the quantity specified in the contract schedule. A new preproduction sample shall be required when a change in procedures, processes, different location of manufacture, or a gap of more than 60 days in production occurs.

4.4 Production lot inspection. The production lot shall meet the requirements of 3.2 and 3.4 when tested in accordance with 4.6.1 and 4.6.3 or it shall be rejected.

4.4.1 Production lot. Unless otherwise specified in the contract or purchase order, a production lot shall consist of 50,000 pounds. If a lot is re-treated, it shall constitute a new lot and shall be subjected to complete acceptance inspection.

4.4.2 Production lot sampling. Six full boxes (see 5.1.1) of propellant shall be selected at random from the lot. From each selected box the quantities of propellant specified in table III shall be taken. Sampling shall be done taking care not to handle the propellant grains with the hands or allow the open boxes to be contaminated. Samples for all categories of table III shall be prepared by combining the material from the six boxes. In each case, the container for the individual samples shall be labeled with the correct sample type as indicated in table III. Each sample shall be sealed with a government seal and forwarded to the test activities designated by the procuring activity (see 6.2). Unless otherwise specified in the contract or project order, all samples for test purposes shall be provided at the expense of the contractor.

TABLE III

SAMPLE QUANTITIES

| Chemical | Ballistic | Surveillance | Loading |
|---|---|---|---|
| 1 lb | 37 lb | 1 lb | 3 lb |

4.5 Master propellant inspection. The master propellant shall be an acceptable production lot and shall meet the requirements of 3.2 and 3.5. The master propellant used in the acceptance testing of production lots shall be of the same type as the propellant being tested.

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4.6 Tests.

4.6.1 Chemical and physical property testing. Tests shall be conducted in accordance with applicable test methods specified herein or given in MIL-STD-286 to determine compliance with 3.2. Equivalent procedures or equipment may be used upon prior approval by the procuring activity.

4.6.1.1 Diphenylamine. Tests for the diphenylamine content shall be conducted in accordance with method 201.1.4 of MIL-STD-286.

4.6.1.2 Lead carbonate. Tests for the lead carbonate content of the propellant shall be conducted in accordance with method 311.1.3 of MIL-STD-286.

4.6.1.3 Graphite. Tests for the graphite content of all propellant covered by this specification shall be conducted in accordance with method 308.1.3 of MIL-STD-286.

4.6.1.4 Nitrocellulose. Tests for the nitrocellulose content of all propellant covered by this specification shall be conducted in accordance with method 209.2.1 of MIL-STD-286.

4.6.1.5 External moisture. Tests for the external moisture content of the propellant shall be conducted in accordance with method 102.1.3 of MIL-STD-286.

4.6.1.6 Methyl centralite. The methyl centralite content shall be determined in accordance with the following method:

(a) Equipment

(1) Model 21 Perkin-Elmer Infrared Spectrophotometer or equivalent.

(2) Matched 0.1-millimeter sample cells with sodium chloride windows for use with the spectrophotometer.

(3) Soxhlet extraction apparatus.

(b) Materials

(1) Methyl centralite, recrystallized from an ethanol-water mixture. The material shall be white and free from foreign materials with a solidification point not lower than 120.5°C nor higher than 122.0°C when determined by the procedure in MIL-M-19719.

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(2) Reagent grade dichloromethane and 1,2-dichloroethane (ethylene dichloride).

(c) Procedures

(1) Place duplicate accurately weighed 5-gram samples in a Soxhlet extraction apparatus and extract with dichloromethane for 16 to 20 hours. Remove the dichloromethane by evaporation in a stream of dry air. Quantitatively transfer the residue to a 25-milliliter (ml) volumetric flask using ethylene dichloride solvent and dilute to volume. Fill the sample cell with the solution while using ethylene dichloride in the reference cell. Scan the sample from 1420 $cm^{-1}$ to 1320 $cm^{-1}$ and determine the maximum absorbance. Refer the absorbance to the standard curve to obtain the concentration of methyl centralite and calculate the percentage of methyl centralite in the sample.

(2) Prepare the standard curve by weighing 0.15-, 0.20-, 0.25-, and 0.30-gram samples of methyl centralite (those standards are suitable for powders with 3 to 6 percent methyl centralite), and dilute to 25 ml with ethylene dichloride. Determine the absorbance of each of the standard solutions by the procedure described above for the samples. Prepare the standard curve by plotting absorbance versus concentration of methyl centralite for each standard.

4.6.1.7 Potassium sulfate. The following procedure shall be used to determine the potassium sulfate content:

(a) Weigh accurately to 0.1 milligram (mg) accuracy a 5-gram sample of the propellant. Place this sample in a 400-ml beaker and add 30 ml of concentrated nitric acid.

(b) Heat on a hot plate until the violent reaction subsides. Remove from the hot plate and add 10 ml of concentrated nitric acid.

(c) Place the sample on the hot plate behind a suitable shield and continue to heat until the organic material has been oxidized and the sample is light colored.

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(d) Cool the sample, add 250 ml of distilled water, heat to boiling, and add 10 ml of 10 percent barium chloride solution.

(e) Place the sample on a steam bath for a minimum of 4 hours. Filter the precipitated barium sulfate through a tared filtering crucible of fine porosity.

(f) Wash the precipitate thoroughly with hot distilled water and ignite it at 750°C.

(g) Cool and weigh the residue.

(h) Determine the potassium sulfate content as follows:

$$\text{Percentage of } K_2SO_4 = 74.65 \times \frac{\text{Weight of } BaSO_4}{\text{Weight of sample}}$$

4.6.1.8 Dust and foreign matter. The tests for the dust and foreign matter content of all propellant covered herein shall be conducted in accordance with method 501.1.3 of MIL-STD-286.

4.6.1.9 Heat test. The heat tests shall be conducted in accordance with method 404.1.2 of MIL-STD-286.

4.6.1.10 Total volatiles. The tests for the total volatile content of all propellant covered herein shall be conducted in accordance with method 103.3 of MIL-STD-286.

4.6.1.10.1 Residual solvent. The tests for the residual solvent content of all propellant covered herein shall be conducted in accordance with method 103.4.1 of MIL-STD-286.

4.6.1.11 Hygroscopicity. Tests for the hygroscopicity of all propellant covered by this specification shall be conducted in accordance with method 503.1.3 of MIL-STD-286.

4.6.1.12 Loading.

4.6.1.12.1 Linear compression. Determine the linear compression of the propellant assessed charge weight by machine loading 10 cartridge cases. The 10 cases used shall be 20MM Cases, MARK 5 MOD 0. They shall be 100 percent inspected for compliance with DL 517534. With an air space gauge as shown on Drawing D7259361, measure the linear distance between the top of the propellant column and the mouth of the cartridge case. Subtract the seating depth of the projectile as determined from DL 2176062 from this measurement to determine the air space. A negative reading indicates compression which shall not exceed the limit specified in 3.2.2.1.

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4.6.1.12.2 Weight variation. The test propellant at its assessed charge weight shall be production loaded into 50 20MM Cases, MARK 5 MOD 0. Each charge so loaded shall be verified by weighing the propellant charge on a balance sensitive to ±0.5 grain by weight. Care shall be exercised to prevent the propellant from losing or gaining moisture. The extreme variation in the charge weights shall not exceed the limits as specified in 3.2.2.2.

4.6.2 Preproduction powder assessment.

4.6.2.1 Charge weight and pressure assessment (Mann barrel, copper). The preproduction powder charge weight and pressure shall be determined from one firing series in one Mann barrel. The Mann barrel (see 4.6.5.1) shall be fired as follows (see 3.3):

(a) 11 rounds (10 data rounds) at estimated charge weight from probing rounds (see 6.6.4).

(b) 11 rounds (10 data rounds) master powder.

(c) 11 rounds (10 data rounds) at estimated charge weight from probing rounds plus 15 grains.

(d) 11 rounds (10 data rounds) master powder.

(e) 11 rounds (10 data rounds) at estimated charge weight from probing rounds minus 15 grains.

4.6.2.1.1 Charge weight determination. The mean velocity shall be computed for each charge weight. A least squares curve shall be fitted to the means of the test powder velocities. From this curve a charge weight shall be determined to produce a velocity equal to the mean of the two master powder data groups in that barrel on that day.

4.6.2.1.2 Pressure. The mean pressure shall be computed for each charge weight. If the mean of the test rounds at the highest charge weight should lie below or on the extrapolation of a straight line through the mean pressures produced by the rounds at the estimated charge weight and the rounds at the lower charge weight, then the straight line shall be used for pressure assessment. If the mean of the rounds at the highest charge weight should lie above the straight line, a curve fitted by eye to the means shall be used for pressure assessment. A pressure correction, either positive or negative, that is equal to the assessed pressure for the master powder minus the grand mean pressure produced by the master powder in that barrel on that day, shall be added algebraically to the pressure determined. This corrected pressure shall be the assessed pressure of the test powder and shall not exceed 58,000 psi (cu).

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4.6.2.2 Charge weight verification and MARK 11 cyclic rate computations (Mann barrel, p-t). The assessed charge weight verification and cyclic rate computations shall be made on data from one Mann barrel (see 4.6.5.2) fired as follows (see 3.3.2):

(a) 11 rounds (10 data rounds) at assessed charge weight.

(b) 6 rounds (5 data rounds) master powder.

(c) 11 rounds (10 data rounds) at assessed charge weight plus 15 grains.

(d) 6 rounds (5 data rounds) master powder.

(e) 11 rounds (10 data rounds) at assessed charge weight minus 15 grains.

4.6.2.2.1 Charge weight verification. The mean velocity shall be computed for each charge weight. A least squares curve shall be fitted to the means of the test powder. From the curve, a charge weight shall be determined that will produce a velocity of 3,320 fps in an average new Mann barrel. This charge weight shall be within five grains of the charge weight assessed in 4.6.2.1.1. Should the verification charge weight and the assessed charge weight differ by more than five grains, a charge determination shall be made on another Mann barrel (p-t). The mean of the two charge weights determined from the Mann barrel (p-t) firings shall be within five grains of the charge weight assessed in 4.6.2.1.1. If this requirement cannot be met, the tests of 4.6.2.1 and 4.6.2.2 may be repeated once.

4.6.2.2.2 MARK 11 cyclic rate computations. Using the means of the assessed charge weight data for the appropriate powder, MARK 11 rates shall be computed for the master and test powders from the equation:

MARK 11 rate = -3159.1 + 119.84 x Impulse (see 6.6.1).

If two Mann barrels (p-t) are fired, computations shall be made for both and the mean taken as the computed rate.

4.6.2.2.3 Maximum chamber pressure. A pressure correction, either positive or negative, that is equal to the assessed pressure for the master powder minus the mean pressure produced by the master powder in that barrel on that day, shall be added algebraically to the mean pressure produced by the test powder at its assessed charge weight. If two Mann barrels (p-t) are fired, the pressure shall be calculated for each, and the mean shall be the maximum corrected chamber pressure.

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4.6.2.3 Functional tests.

4.6.2.3.1 MARK 11. A functional test for cyclic rates (see 3.3.3.1) shall be fired in one MARK 11 gun as follows (see 3.4.1):

(a) 51 rounds for gun conditioning.

(b) 101 rounds of master powder at assessed charge.

(c) 101 rounds of test powder at assessed charge.

4.6.2.3.2 MARK 12. A functional test for rates and muzzle velocities (see 3.3.3.2) shall be fired in one MARK 12 gun as follows:

(a) 25 rounds for gun conditioning.

(b) 25 rounds of master powder at assessed charge weight.

(c) 25 rounds of test powder at assessed charge weight.

4.6.3 Production powder assessment.

4.6.3.1 Charge weight and pressure assessment (Mann barrel, copper). The production powder charge weight and pressure shall be determined from one firing series in one Mann barrel. The Mann barrel (see 4.6.5.1) shall be fired as follows:

(a) 11 rounds (10 data rounds) at estimated charge weight from probing rounds.

(b) 11 rounds (10 data rounds) master powder.

(c) 11 rounds (10 data rounds) at estimated charge weight from probing rounds plus 15 grains.

(d) 11 rounds (10 data rounds) master powder.

(e) 11 rounds (10 data rounds) at estimated charge weight from probing rounds minus 15 grains.

4.6.3.1.1 Charge weight determination. The mean velocity shall be computed for each charge weight. A least squares curve shall be fitted to the means of the production powder. From this curve, a charge weight shall be determined to produce a velocity equal to the mean of the two master powder groups in that barrel on that day.

4.6.3.1.2 Pressure. The mean pressure shall be computed for each charge weight. If the mean of the test rounds at the highest charge weight should lie below or on the extrapolation of a straight line through the

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mean pressures produced by the test rounds at the estimated charge weight and the rounds at the lowest charge weight, then the straight line shall be used for pressure assessment. If the mean of the rounds at the highest charge weight would lie above the straight line, a curve fitted by eye to the means shall be used for pressure assessment. A pressure correction, either positive or negative, that is equal to the assessed pressure for the master powder minus the grand mean pressure produced by the master powder in that barrel on that day, shall be added algebraically to the pressure determined. This corrected pressure shall be the assessed pressure for the test powder and shall not exceed 58,000 psi (cu).

4.6.3.2 Charge weight verification and MARK 11 cyclic rate computations (Mann barrel, p-t). The assessed charge weight verification and cyclic rate computations shall be determined from data on one Mann barrel (see 4.6.5.2) and fired as follows (see 3.4.2).

(a) 11 rounds (10 data rounds) at assessed charge weight.

(b) 6 rounds (5 data rounds) master powder.

(c) 11 rounds (10 data rounds) at assessed charge weight plus 15 grains.

(d) 6 rounds (5 data rounds) master powder.

(e) 11 rounds (10 data rounds) at assessed charge minus 15 grains.

4.6.3.2.1 Charge weight verification. The mean velocity shall be computed for each charge weight. A least squares curve shall be fitted to the means of the test powder. From this curve, a charge weight shall be determined to produce a velocity equal to the grand mean of the master powder in that barrel on that day. Should this charge weight differ by more than five grains from the one assessed in 4.6.3.1.1, a second verification shall be made on another Mann barrel (p-t). The mean of the two charge weights determined from the Mann barrels (p-t) shall be within five grains of the charge weight assessed in 4.6.3.1. If this requirement cannot be met, the tests of 4.6.3.1 and 4.6.3.2 may be repeated once.

4.6.3.2.2 MARK 11 cyclic rate computations. Using the means of the assessed charge weight data for the appropriate powder, MARK 11 rates shall be computed for the master and test powders from the equation:

MARK 11 rate = -3159.1 + 119.84 x Impulse (see 6.6.1).

If two Mann barrels (p-t) are fired, computations shall be made for both and the mean taken as the computed rate.

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4.6.3.2.3 Maximum chamber pressure. A pressure correction, either positive or negative, that is equal to the assessed pressure for the master powder minus the mean pressure produced by the master powder in that barrel on that day, shall be added algebraically to the mean pressure produced by the test powder at its assessed charge weight. If two Mann barrels (p-t) are fired, the pressure shall be calculated for each and the mean shall be the maximum corrected chamber pressure.

4.6.3.3 Functional tests (see 3.4.3).

4.6.3.3.1 MARK 11. A functional test for cyclic rates (see 3.4.3.1) shall be fired in one MARK 11 gun as follows:

(a) 51 rounds for gun conditioning.

(b) 101 rounds of master powder at assessed charge weight.

(c) 101 rounds of test powder at assessed charge weight.

4.6.3.3.2 MARK 12. A functional test for cyclic rates and muzzle velocities (see 3.4.3.2) shall be fired in one MARK 12 gun as follows:

(a) 25 rounds for gun conditioning.

(b) 25 rounds of master powder at assessed charge weight.

(c) 25 rounds of test powder at assessed charge weight.

4.6.4 Master powder standardization.

4.6.4.1 Charge weight and pressure assessment (Mann barrel, copper). The master powder charge weight and pressure shall be determined from firings conducted in three new Mann barrels on each of 5 days. Each Mann barrel (see 4.6.5.1) shall be fired as follows (see 3.5.1):

(a) 11 rounds (10 data rounds) at estimated charge weight.

(b) 11 rounds (10 data rounds) at estimated charge weight plus 15 grains.

(c) 11 rounds (10 data rounds) at estimated charge weight minus 15 grains.

4.6.4.1.1 Charge weight determination. Using the velocity data on the three barrels for all 5 days, the grand mean shall be computed for each charge weight. A least squares curve shall be fitted to these means. From this curve, a charge weight shall be determined to produce a velocity of 3,320 fps in an average new barrel.

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4.6.4.1.2 Pressure. Using the pressure data on the three barrels for all 5 days, the grand mean shall be computed for each charge weight. If the mean of the rounds at the highest charge weight should lie below or on the extrapolation of a straight line through the mean pressures produced by the rounds at the estimated charge weight and the rounds at the lowest charge weight, then the straight line shall be used for pressure assessment. If the mean of the rounds at the highest charge weight should lie above the straight line, a curve fitted by eye to the grand means shall be used for pressure assessment. The pressure produced by the assessed charge weight shall be the assessed pressure of the powder and shall not exceed 58,000 psi (cu).

4.6.4.2 Charge weight verification and MARK 11 cyclic rate computations (Mann barrel p-t). Two new Mann barrels shall be fired (see 4.6.5.2) on each of 3 days as follows (see 3.5.2):

(a) 11 rounds (10 data rounds) at assessed charge weight.

(b) 11 rounds (10 data rounds) at assessed charge weight plus 15 grains.

(c) 11 rounds (10 data rounds) at assessed charge weight minus 15 grains.

4.6.4.2.1 Charge weight verification. The grand mean velocity for each charge weight on each barrel shall be determined over all 3 days. A least squares curve shall be fitted to the means of each barrel. From these curves, charge weights shall be determined that will produce a velocity of 3,320 fps in an average new barrel. The mean of these charge weights shall be within five grains of the charge weight assessed in 4.6.4.1.1. Should the verification charge weight and the assessed charge weight differ by more than five grains, a charge determination shall be made on another new Mann barrel (p-t). The mean of the charge weights determined from the three Mann barrel (p-t) firings shall be within five grains of the charge weight assessed in 4.6.4.1.1. If this requirement cannot be met, the tests of 4.6.4.1 and 4.6.4.2 may be repeated once.

4.6.4.2.2 MARK 11 cyclic rate computations. Using the grand means of the assessed charge weight data for each barrel over all 3 days, the MARK 11 rates shall be computed from the equation:

MARK 11 rate = -3159.1 + 119.84 x Impulse (see 6.6.1).

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4.6.4.3 Functional tests.

4.6.4.3.1 MARK 11. A functional test for cyclic rates (see 3.5.3.1) shall be fired in one MARK 11 gun as follows:

(a) 51 rounds for gun conditioning.

(b) 101 rounds of master powder candidate at assessed charge weight.

(c) 101 rounds of master powder candidate at assessed charge weight.

4.6.4.3.2 MARK 12. A functional test for cyclic rates and muzzle velocities (see 3.5.3.2) shall be fired in one MARK 12 gun:

(a) 25 rounds for gun conditioning.

(b) 25 rounds of master powder candidate at assessed charge weight.

(c) 25 rounds of master powder candidate at assessed charge weight.

4.6.5 Test guns. Before firing for powder assessment, guns to be used for ballistic measurements shall be broken in by firing a sufficient number of cutting rounds to eliminate erratic ballistics caused by wearing of the barrel. Guns chosen for acceptance testing of powder shall not be used for experimental powders of nonstandard composition. The first round of all firings shall be considered a conditioning round and be excluded from the data, except in the calculation of cyclic rates.

4.6.5.1 Mann barrel, copper. The Mann barrel counterpart of the MARK 11 machine gun barrel is drilled to accept a copper crusher piston and assembled in accordance with SK679810 and SK7553247 using the long piston as specified in A7585089.

4.6.5.1.1 Mann barrel, tests. These Mann barrels shall be subjected to a test of 11 master powder rounds (10 data rounds) (see 3.6.1.1).

4.6.5.2 Mann barrel, pressure-time. The Mann barrel counterpart of the MARK 11 machine gun barrel is drilled to accept piezoelectric gauges in the gun chamber area and assembled in accordance with SK679811 and SK7553247. All data parameters should be obtained from the Mann barrel firing, although some of the data are not used for the acceptance or rejection of a powder lot. These data provide an overall look at the powder and should be compared to the master powder data. This comparison serves as a basis for the requirement of the functional test of production lots of powder.

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4.6.5.2.1 Mann barrel, tests. These Mann barrels shall be subjected to a test of six master powder rounds (5 data rounds) (see 3.6.1.2).

4.6.5.3 Automatic guns. All of the rounds of a burst shall be included in cyclic rate computations, but the first round of each burst is considered a conditioning round and shall not be included in velocity computations.

4.6.5.3.1 MARK 11. The 20MM MARK 11 machine guns used in acceptance testing of powder shall be assembled in accordance with the drawings listed on LD 522056. The MARK 11 machine gun shall be subjected to a burst of 101 master powder rounds (see 3.6.2.1).

4.6.5.3.2 MARK 12. The 20MM MARK 12 MOD 0 guns used in acceptance testing of powder shall be assembled in accordance with the drawings listed on IL 2838594 with the feeder switch installed. The MARK 12 gun shall be subjected to a burst of 25 master powder rounds (24 velocity data rounds) (see 3.6.2.2).

4.6.6 Components, test.

4.6.6.1 Projectile. MARK 11 projectiles from a previously accepted production lot shall be screened, and selected projectiles shall weigh 1700 $\pm$ 5 grains and conform to the drawings listed on DL 2176062-1.

4.6.6.2 Cases. Cases shall be MARK 5 MOD 0 cases from a previously accepted production lot and conform to the drawings listed on DL 517534.

4.6.6.2.1 Case, drilled for Mann barrel, copper. Cases used for firings in the Mann barrel (cu) shall be modified to facilitate the taking of pressure. The case shall have been drilled with a No. 19 (0.166 inch) drill 2.10 $\pm$ 0.010 inch from centerline of the hole to the base of the case. The drilled hole shall be covered with a piece of cellulose tape of sufficient size to assure positive sealing.

4.6.6.2.2 Case, drilled for Mann barrel, p-t. Cases used for firings in the Mann barrel (piezoelectric) shall be modified to facilitate the taking of pressure. The case shall have been drilled with a No. 19 (0.166 inch) drill 3.055 $\pm$ 0.010 inch from centerline of the hole to the base of the case. The drilled hole shall be covered with a piece of cellulose tape of sufficient size to assure positive sealing.

4.6.6.3 Primer. M52A3B1 primers from a previously accepted production lot shall be used, preferably not more than 2 years of age, and shall conform to MIL-P-1394 and D7548066.

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4.6.6.4 Master powder. The master powder used in the assessment of test powder shall be of the same type and general chemical composition as the powder being tested. All master powder rounds shall utilize the master powder assessed charge weight and assigned components.

4.6.6.5 Assembly. All firings for velocities shall be with rounds utilizing calibration components as specified in 4.6.6.2.1 through 4.6.6.3. All rounds shall be rubber crimped so that the projectile can be removed by a static pull-out force between 1300 and 1700 pounds, when the rate of travel of the test head is controlled to 0.125 and 0.250 inch per minute, inclusive.

4.6.6.6 Temperature conditioning. The propellant and ammunition components of the data rounds shall be temperature conditioned at 70° ± 3°F for a minimum of 48 hours prior to firing.

4.6.6.7 Loading procedure for Mann barrels (copper and p-t). The rounds shall be kept base down during handling. As each round is removed from the box, it shall be aligned to the approximate position for loading into the barrel. The round shall be passed through a magnetizing coil, rotated end over end through 360 degrees, and then loaded into the barrel. Minor adjustment for correct alignment of the case holes with the pressure ports shall be made as the round is loaded.

4.6.6.8 Range. All propellant acceptance firings shall be conducted on a range that is equipped with instruments and accessories of proven acceptability that have been previously checked and are known to be in satisfactory working condition.

## 5. PREPARATION FOR DELIVERY

5.1 Packing.

5.1.1 Level B. The powder shall be packed in clean containers complying with LD 288379 or as otherwise approved by the procuring activity. All containers shall be tested with compressed air for air tightness by the manufacturer. All containers shall withstand a minimum internal pressure of 3 psig for 1 minute without leakage.

5.2 Marking. Packing markings shall be in accordance with 49 CFR 171-190, MIL-STD-129, and NAVORD Instruction 8010.24.

## 6. NOTES

6.1 Intended use. This propellant is designed for use in ammunition for 20MM Naval Aircraft Guns, MARK 11 and MARK 12.

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6.2 Ordering data. Procurement documents shall specify the following:

(a) Title, number, and date of this specification.

(b) Production lot test activity (see 4.4.2).

(c) Preproduction lot test activity (see 4.3).

(d) Production lot size (see 4.4.1).

(e) That the safety precaution requirements of the Contractors' Safety Manual for Ammunition, Explosives, and Related Dangerous Material, DOD 4145.26M are applicable. NOTE: When this specification is used as part of the description of work to be accomplished by a Government activity, the safety precaution requirements of Ammunition Ashore, OP 5, are applicable.

6.3 Level B. The degree of packing which will afford adequate protection against damage during multiple shipments. These packs are designed to be shipped and handled under cover and stored in warehouses or other structures affording equivalent protection from weather.

6.4 Surveillance. Surveillance tests at 65.5°C will be conducted at the Naval Ordnance Station, Indian Head, Maryland, for information purposes.

6.5 Master powder. Copies of assessments for Navy 20MM Aircraft gun master powders may be obtained from the procuring activity.

6.6 Definitions.

6.6.1 Impulse. The impulse area (psi per second) is the area under the pressure time curve from the initial pressure rise to the projectile's emergence from the barrel.

6.6.2 Action time. The action time (milliseconds) is read from the close of the firing key to the projectile's emergence from the barrel.

6.6.3 New Mann barrel. A Mann barrel (p-t or cu) having fired sufficient cutting rounds to eliminate erratic ballistics but less than 250 total rounds.

6.6.4 Probing rounds. Rounds fired in a Mann barrel (cu) prior to preproduction or production tests to obtain estimates of the ballistic performance of a lot of powder at various charge weights.

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6.6.5 Conditioning rounds. Unless otherwise specified, rounds for gun conditioning shall be from any previously accepted lot of 20MM, MARK 100 series, target practice type ammunition.

6.6.6 Muzzle velocity. The velocity (fps) is taken at a point forward of the muzzle and corrected to the muzzle. The conditioning round or rounds are never included in muzzle velocity calculations.

6.6.7 Estimated charge weight. A charge weight estimated from probing rounds to give near service velocities.

Preparing activity:
Navy (AS)
Project No. 1376-N117

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# STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

OMB Approval
No. 22-R255

INSTRUCTIONS: The purpose of this form is to solicit beneficial comments which will help achieve procurement of suitable products at reasonable cost and minimum delay, or will otherwise enhance use of the document. DoD contractors, government activities, or manufacturers/vendors who are prospective suppliers of the product are invited to submit comments to the government. Fold on lines on reverse side, staple in corner, and send to preparing activity. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements. Attach any pertinent data which may be of use in improving this document. If there are additional papers, attach to form and place both in an envelope addressed to preparing activity.

DOCUMENT IDENTIFIER AND TITLE: MIL-P-81994 (AS) Propellant for 20MM Ammunition

NAME OF ORGANIZATION AND ADDRESS

CONTRACT NUMBER

MATERIAL PROCURED UNDER A

☐ DIRECT GOVERNMENT CONTRACT ☐ SUBCONTRACT

1. HAS ANY PART OF THE DOCUMENT CREATED PROBLEMS OR REQUIRED INTERPRETATION IN PROCUREMENT USE?
   A. GIVE PARAGRAPH NUMBER AND WORDING.

   B. RECOMMENDATIONS FOR CORRECTING THE DEFICIENCIES

2. COMMENTS ON ANY DOCUMENT REQUIREMENT CONSIDERED TOO RIGID

3. IS THE DOCUMENT RESTRICTIVE?
   ☐ YES ☐ NO (If "Yes", in what way?)

4. REMARKS

SUBMITTED BY (Printed or typed name and address - Optional)

TELEPHONE NO.

DATE

DD FORM 1 JAN 72 1426 REPLACES EDITION OF 1 JAN 66 WHICH MAY BE USED