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2 July 1963

MILITARY SPECIFICATION

CARTRIDGE, ENGINE STARTER MXU-4A/A

1. SCOPE

1.1 This specification covers the requirements for one type of solid propellant engine starter cartridge, designated MXU-4A/A.

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

Federal

PPP-B-636	Box, Fiberboard
PPP-C-96	Can, Metal, 28 Gage and Lighter

Military

MIL-P-116	Preservation, Methods of
MIL-T-5021	Tests, Aircraft and Missile Welding Operators, Qualification
MIL-I-6866	Inspection, Penetrant Method of
MIL-S-27266	Starter, Engine, Cartridge and Pneumatic, Shaft Drive, General Specification for

STANDARDS

Military

MIL-STD-100	Engineering Drawing Practices
MIL-STD-105	Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-129	Marking for Shipment and Storage
MIL-STD-130	Identification Marking of U. S. Military Property
MIL-STD-143	Specifications and Standards, Order of Precedence for the Selection of
MIL-STD-210	Climatic Extremes for Military Equipment

MIL-STD-414	Sampling Procedures and Tables for Inspection by Variables for Percent Defective
MIL-STD-453	Inspection, Radiographic
MIL-STD-704	Electric Power, Aircraft, Characteristics and Utilization of
MIL-STD-810	Environmental Test Methods for Aerospace and Ground Equipment
MIL-STD-831	Test Reports, Preparation of
MIL-STD-1167	Ammunition, Data Card
MIL-STD-1168	Lot Numbering of Ammunition
MS33586	Metals, Definition of Dissimilar

PUBLICATIONS

Air Force-Navy Aeronautical Bulletins

No. 438	Age Controls for Synthetic Rubber Parts

U. S. Air Force Specification Bulletin

No. 508	Ballistic Nomenclature, Rocket Motor and Gas Generator Performance

Air Force Manual

AFM 71-4	Packaging and Handling of Dangerous Materials for Transportation by Military Aircraft

Air Force Tech Ord

T.O. 11A-1-47	Explosive Hazard Classification Procedure

(Copies of documents required by suppliers 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 documents form 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:

SAE AERONAUTICAL SPECIFICATIONS

AMS 2645	Fluorescent Penetrant Inspection
AMS 2650	Fluoroscopic X-Ray Inspection

(Applications for copies of SAE aeronautical specifications should be addressed to the Society of Automotive Engineers, Incorporated, 485 Lexington Avenue, New York, New York 10017.)

49-CFR 71-78 Interstate Commerce Commission Regulations For Transportation of Explosives and Other Dangerous Articles

(The Interstate Commerce Commission Regulations are now a part of the Code of Federal Regulations (1949) Edition - Revised (1950), available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C. Orders for the above publication should cite "49 CFR 71-78 Rev 1950.")

3. REQUIREMENTS

3.1 Preproduction. This specification makes provisions for preproduction testing.

3.2 Components. Normally, the cartridge assembly shall consist of the following parts:

a. Solid propellant

b. Case

c. Igniter assembly

d. Weatherseal

e. Screen.

3.3 Model specification. A cartridge model specification conforming to the format outlined in the appendix of this specification shall be prepared by the contractor and three copies submitted to the procuring activity for approval prior to preproduction testing.

3.3.1 Definitions and symbols. Terms, their definitions, and symbols used in the model specification shall be in accordance with 6.3 and AF Specification Bulletin 508. In case of conflict between the definitions of AF Specification Bulletin 508 and this specification, this specification shall govern.

3.3.2 Design criteria. The design criteria for the cartridge performance shall be included in the model specification in the format of table I and shall not exceed the limits of table I.

3.3.3 Design drawings. Design drawings constitute a part of the model specification and shall be maintained and updated as controlled documents.

3.3.4 Model. A full scale cutaway model of the cartridge shall be submitted.

3.4 Selection of specifications and standards. Specifications and standards for necessary commodities and services not specified herein shall be selected in accordance with MIL-STD-143.

TABLE I

Design Performance Criteria at Sea Level

Parameter	Temp (°F)	Limit of Range
1. Ignition delay (t_d), sec	-65 +160	0.60 max 0.25 max
2. Ignition pressure rise rate after first indication of pressure, psig	-65 +160	Given on figure 3 Given on figure 3
3. Maximum pressure during ignition (P_i), psig	-65 +160	3/ 1550
4. Maximum pressure following ignition (P_{max}), psig 1/	-65 +160	850 1400
5. Minimum pressure following ignition cycle through tailoff (P_{min}), psig	-65 +160	550 1050
6. Average chamber pressure ($\bar{P}_a$), psig 2/	-65 +160	650 4/ Min. 1350 4/ Max.
7. Pressure-Time integral (δ Pdt), psig-sec X 10^{-4}	-65 +160	1.60 Max. 5/ 1.60 Max. 5/
8. Action time (t_a), sec	-65 +59 +160	To be given in the model specification
9. Burn time (t_b) sec	-65 +59 +160	18-22 13-19 11-14

1/ End of ignition phase shall be defined in the model specification.

2/ To be determined as follows: Determine area under the pressure-time curve encompassed by action time; Divide the area by the burn time to obtain average pressure, $\bar{P}$, in pounds per square inch gage.

3/ To be given in model specification not to exceed 1550 psig.

4/ Average pressure to be given in model specification. Allowable range not to exceed 150 psig at -65°F and 200 psig at +160°F.

5/ Allowable range not to exceed 1000 psig-sec.

3.5 Materials

3.5.1 Fungus-proof materials. Materials that are nutrients for fungi shall not be used where it is practical to avoid them. Where used and not hermetically sealed, they shall be treated with a suitable fungicidal agent acceptable to the procuring activity.

3.5.2 Metals. Metals shall be of the corrosion-resistant type or suitably treated to resist corrosion due to fuels, salt spray, rain, humidity, and all other environmental conditions likely to be met in storage or normal service. The use of any protective coating that will crack, chip, or scale with age or extremes of environmental conditions shall be avoided.

3.5.3 Dissimilar metals. Unless suitably protected against electrolytic corrosion, dissimilar metals shall not be used in intimate contact with each other. Dissimilar metals are defined in MS33586.

3.6 Age. Cartridge propellant grain, igniter, and squib shall be no more than 6 months old from date of manufacture to date of delivery of the cartridge assembly.

3.7 Design. The cartridge shall be designed to operate in a cartridge starter breech having internal dimensions as shown on figure 1 and as further defined in 3.11.5.

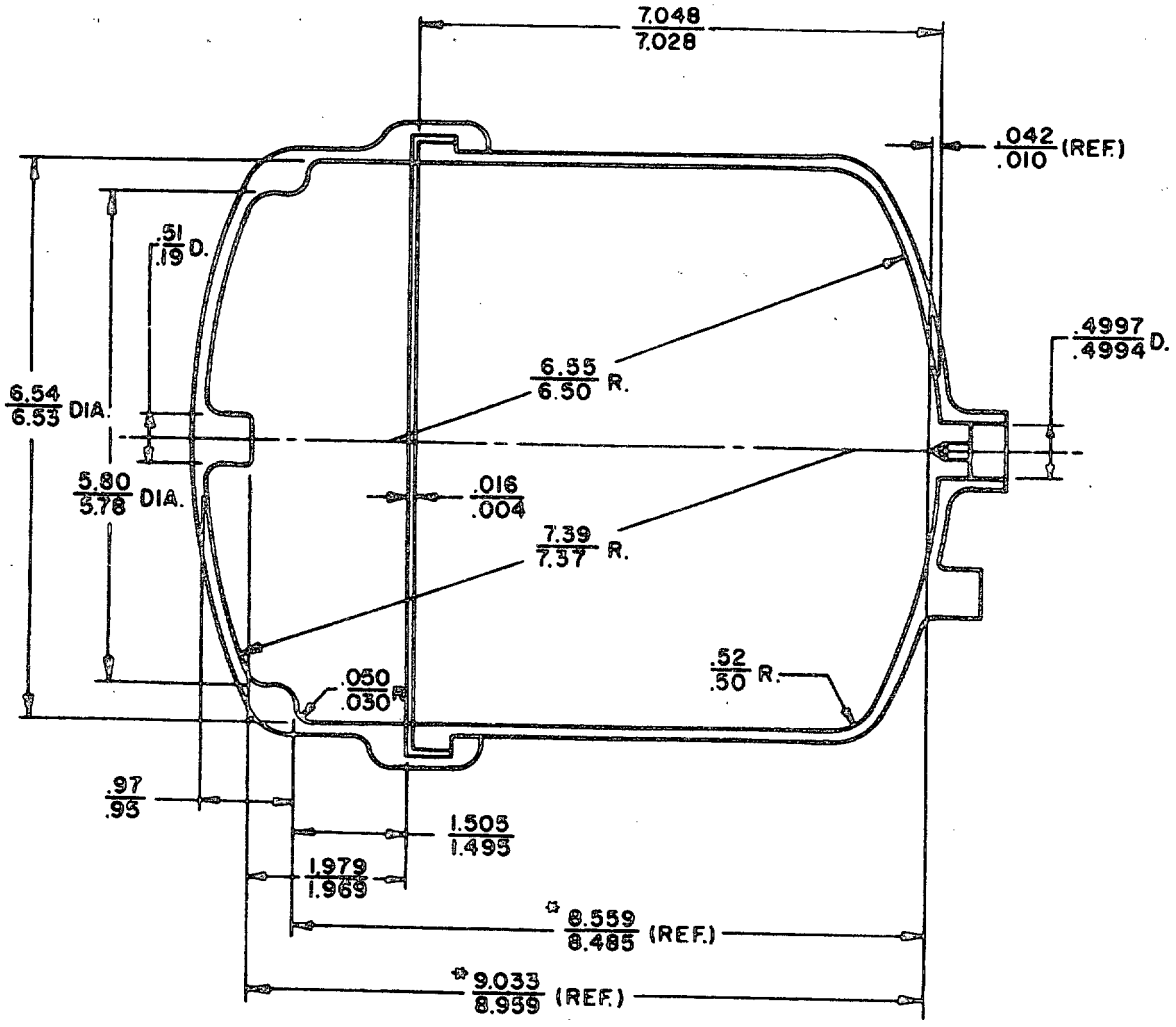
3.7.1 Effect on metal. The cartridge shall not adversely affect the design life of any starter components due to the chemical properties of the cartridge exhaust gas. The cartridge contractor shall define in the model specification the chemical and metallurgical effect of the cartridge exhaust gases on aluminum and metals incorporated in the starters specified in 3.7.2.

3.7.2 Compatibility. The cartridge shall be so designed as to be compatible with cartridge starters conforming to MIL-S-27266. A compatibility test shall be conducted by the cartridge manufacturer to demonstrate compatibility of the cartridge with current starters. The procuring activity shall be contacted for copies of the latest test schedule and starters to be tested.

3.7.3 Electrical firing. The cartridge shall be designed to fire electrically after manual insertion into the starter breech.

3.7.4 Transportability. The cartridge sealed in its storage container shall be transportable in any attitude within the ambient air temperature range defined in MIL-STD-210 for cold and hot atmosphere up to a pressure altitude of 80,000 feet.

3.7.5 Reliability. The cartridge shall be designed to operate with a minimum reliability of 0.990 with a 90 percent confidence level. Satisfactory compliance with test requirements of this specification will have demonstrated compliance with this requirement.



* EXTREME LIMITS OF TOLERANCE STACKUP

FIGURE 1. Interior Dimensions of Cartridge Breech

3.8 Construction. The cartridge shall be so constructed as to provide the requirements specified herein. It shall be built to withstand all conditions encountered during shipment, storage, installation, and service.

3.9 Performance. Specific cartridge performance characteristics shall be called out in the model specification. The cartridge shall operate within the limits specified in table 1 and figure 3 when fired in a breech having internal dimensions as shown on figure 1 and as further defined in 3.11.5, when the breech is connected to a nozzle and volume simulator as shown on figure 2.

3.9.1 Altitude. There shall be no deviation from the performance rating of this specification after the cartridge has been exposed to altitudes up to 80,000 feet while in its sealed storage container.

3.9.2 Temperatures. The cartridge shall ignite and operate satisfactorily throughout the temperature range of -65 to +160°F.

3.9.3 Attitudes. While installed in the starter breech, the cartridge shall perform satisfactorily in any attitude.

3.9.4 Ratings. The cartridge shall meet the performance criteria specified in table I for standard sea-level static conditions.

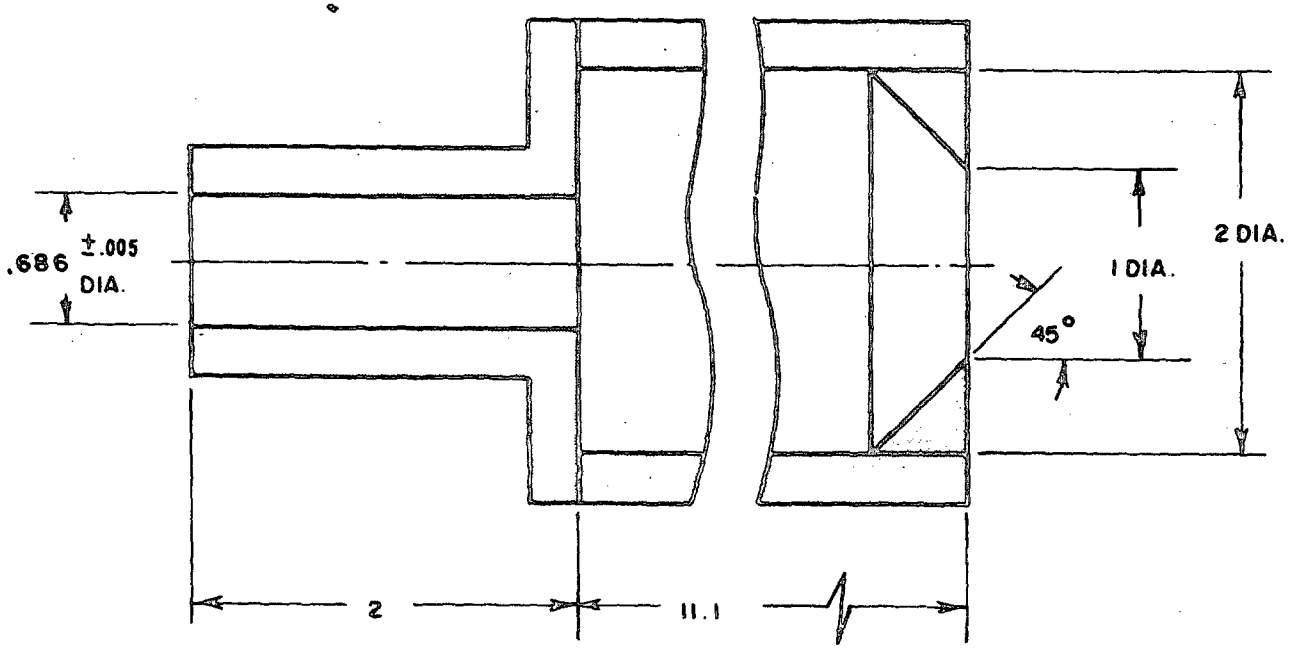
3.9.5 Flame temperature. The measured gas temperature for any firing from -65° to +160°F shall not exceed 2,100°F. The contractor shall specify in the model specification the adiabatic flame temperature of the propellant as defined in AF Specification Bulletin 508.

3.9.6 Performance variation. The standard deviation for each parameter at -65° and +160°F shall be specified in table II of the model specification.

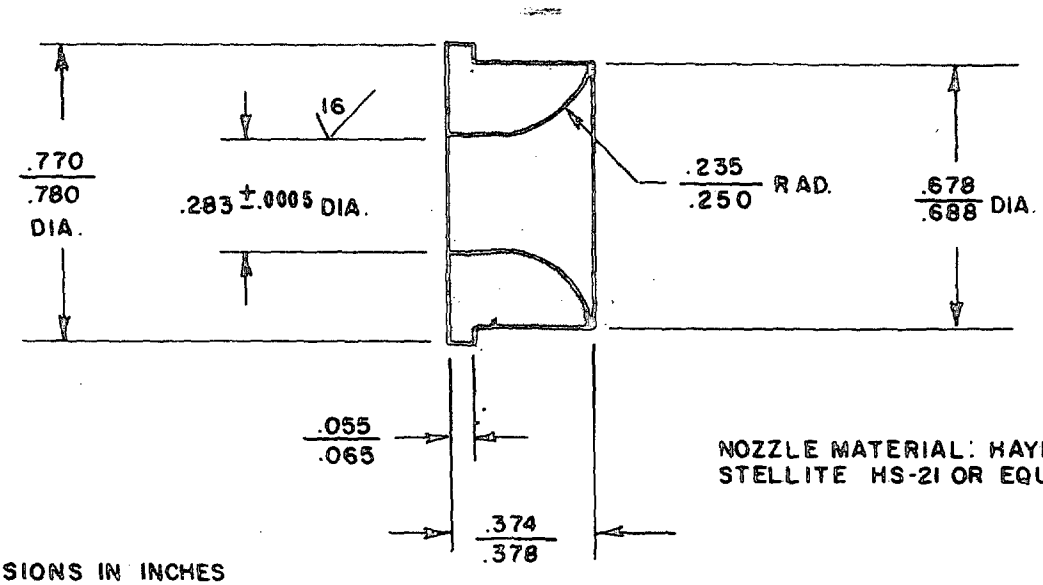
3.9.7 Environmental conditions. The cartridge shall not suffer any detrimental effects during or after exposure to temperature cycling, extreme temperature, salt spray, and humidity as anticipated in service.

3.9.7.1 Storage life (in metal container). When sealed in its individual metal storage container and exposed for a minimum of 3 years to temperature cycling ranging from -65° to +160°F, in any attitude, the cartridge shall not deteriorate to such extent that it cannot meet the performance requirements specified herein. In addition, the cartridge shall withstand exposure to 300°F for 2 hours without producing a hazardous condition during subsequent operation.

3.9.7.2 Storage life (out of container). The cartridge, removed from the container, shall withstand exposure to temperatures ranging from -65° to +160°F, in any attitude, for 45 days without deteriorating to such extent that it cannot meet the performance requirements.



WALL THICKNESS APPROXIMATELY $\frac{1}{4}$



NOZZLE MATERIAL: HAYNES STELLITE HS-21 OR EQUAL

DIMENSIONS IN INCHES
UNLESS OTHERWISE SPECIFIED
TOLERANCES: DECIMALS ±.010
ANGLES ±2°

FIGURE 2. Standard Test Orifice and Volume Simulator

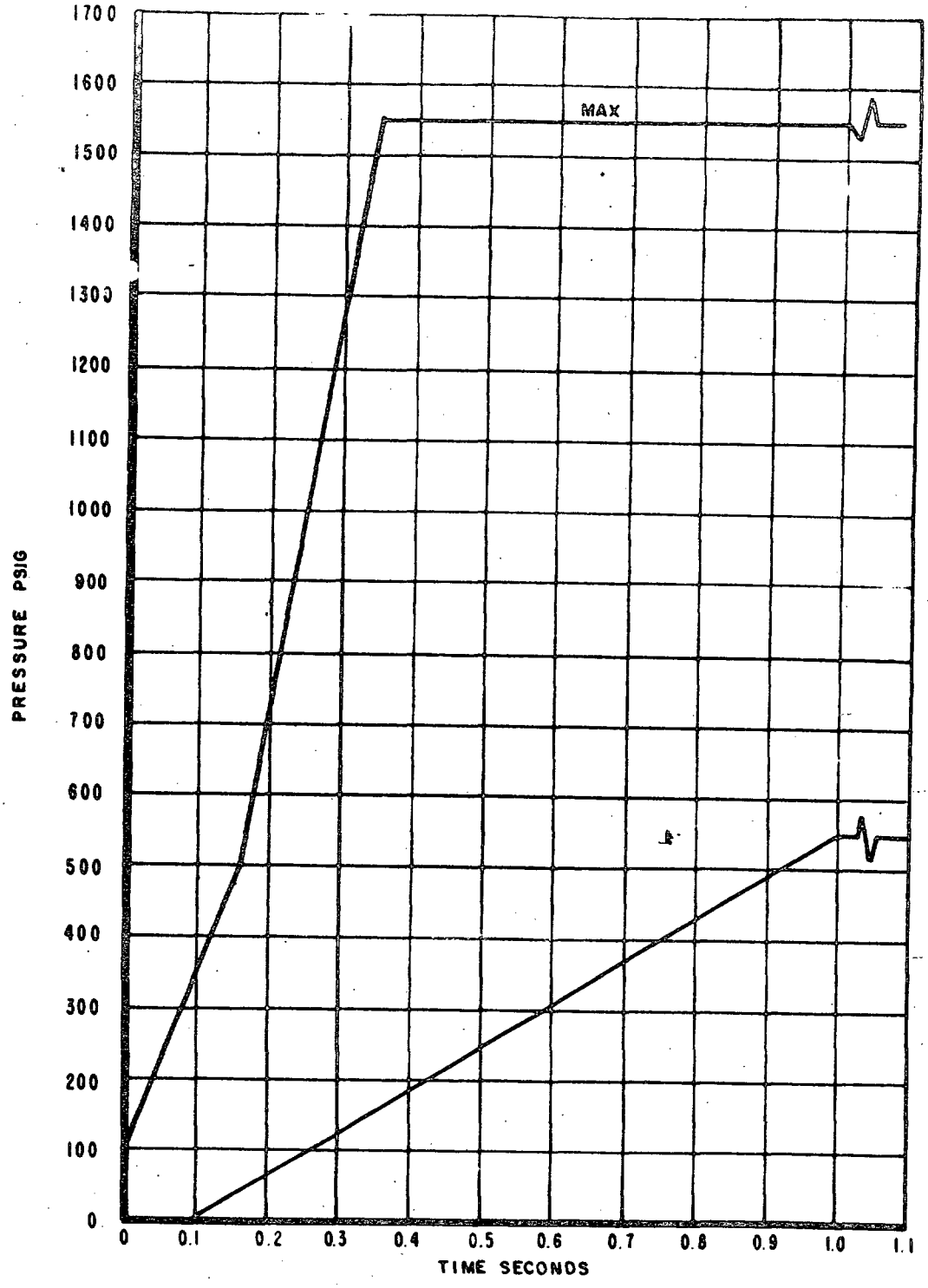


FIGURE 3. Ignition Envelope

3.9.7.3 Auto-ignition. When exposed to the extreme environmental conditions specified in section 4, there shall be no auto-ignition of the cartridge or emission of combustible gases.

3.9.7.4 Vibration. The cartridge shall be designed to withstand the vibration environment anticipated during service life.

3.9.8 Drop requirement. The cartridge shall not be damaged to the point it will not function when dropped onto a concrete floor from a height of 4 feet.

3.10 Solid propellant. The grain of the solid propellant shall be free of physical defects which would prevent the cartridge from meeting specified performance parameters. The propellant shall be neutral burning with respect to pressure versus time. Following environmental cycling tests, the grain dimensions shall remain within specification limits.

3.10.1 Ballistic, physical, and mechanical properties. The ballistic, physical, and mechanical properties of the propellant shall be as specified in the model specification.

3.10.2 Auto-ignition temperature. There shall be no auto-ignition of the cartridge or components when it is exposed to a temperature of 350°F for 1 hour or 300°F for 8 hours. The auto-ignition temperature for the propellant and ignition system shall be graphically presented in the model specification in the format of figure 4. The maximum safe temperature for extended storage shall be noted.

3.10.3 Propellant weight. The weight of the propellant shall be determined by the performance requirements, and the allowable tolerances shall be stated in the model specification.

3.10.4 Restrictor and bonding agent. The composition of the restrictor and bonding agent shall be specified in the model specification.

3.10.5 Processing. The propellant, restrictor, and bonding-agent processing specifications shall be listed in the model specification. These processing specifications shall be submitted for approval with the model specification.

3.10.6 Corrosion. The corrosive effect of the exhaust gases from propellant or ignition materials shall not reduce the design life of the starter or any airframe materials with which the gases may come in contact. The corrosive content and effect of the exhaust gases shall be specified in the model specification.

3.10.7 Erosion. Solids in the exhaust gases shall be held to a minimum to limit erosion and avoid accumulation of solids in critical starter parts. The erosive effect of propellant and ignition materials shall be specified in the model specification.

3.10.8 Smoke. The light transmitted through the exhaust gases shall not be less than 75 percent.

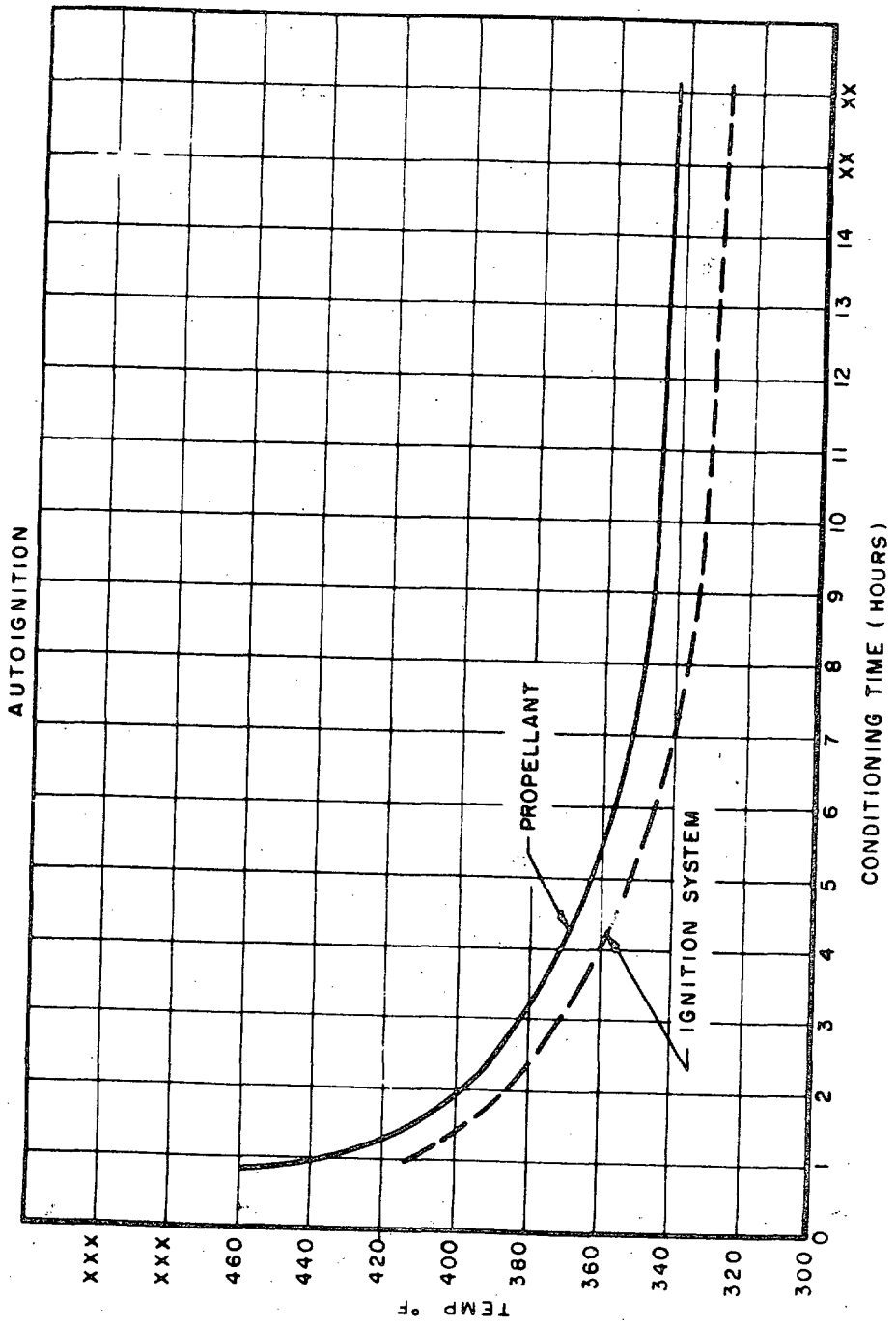


FIGURE 4. Conditioning Time (Hours)

3.10.9 Toxicity. The toxic effect of the exhaust gases shall not be hazardous to personnel exposed to these gases during starter bench tests and aircraft operation. The toxic properties shall be specified in the model specification.

3.10.10 Afterburning. There shall be no flaming at breech mating surfaces during or after operation of the cartridge. The cartridge exhaust gases shall not be capable of sustaining ignition.

3.11 Case

3.11.1 Maximum operating case temperature. The cartridge case shall be so designed that the external surface temperature of breech caps of all starters specified in 3.7.2 shall not exceed 700°F under any operating condition.

3.11.2 Expendability. The cartridge case shall contain all of the cartridge components and shall be expendable; no reloading provisions will be considered.

3.11.3 Removal after firing. After the cartridge has been in the breech for a minimum of 1 minute after firing, the cartridge case shall be easily removable in one piece by personnel wearing thick gloves. No cleaning of the breech shall be necessary before reloading. No afterburning shall occur when the cartridge is removed from the breech 1 minute after firing.

3.11.4 Weather seals. Weather seals incorporated in the cartridge shall be of such design and material as required to permit the cartridge to meet the performance requirements specified herein. The burst pressure of the weather seals shall be specified in the model specification.

3.11.5 Breech seal. The cartridge design shall incorporate a positive seal at the starter breech parting line capable of insuring operation in an explosive atmosphere. The seal shall be designed to operate in a starter breech dome conforming to figure 1 and a mating breech cap which is out of round up to 0.035 inch. The breech seal shall also operate when the gap is between 0.002 and 0.050 inch. Handling and installing the cartridge in the breech shall not detrimentally affect the breech seal.

3.12 Igniter assembly. An electrically fired igniter assembly shall be provided to ignite the main propellant charge and to assure proper ignition of the propellant in accordance with the performance requirements specified herein. The igniter assembly characteristics shall be specified in the model specification.

3.12.1 Ignition. The cartridge shall ignite satisfactorily when a voltage of 15 to 32V dc is applied with an external resistance of 10.0 ±0.5 ohm. The ignition delay shall not exceed 0.60 second at any temperature.

3.12.2 Prefire checking. The igniter design shall be such as to permit prefire checking of the igniter system. The electrical resistance of the igniter circuit and the

maximum safe test current for prefiring checking shall be specified in the model specification. In no case shall ignition occur when test current up to 0.05 amp is applied for any length of time.

3.12.2.1 Electroexplosive devices. The cartridge shall be designed to preclude spurious functioning or degradation in reliability or performance from environmental electromagnetic radiation.

3.12.3 Safety provisions and arming. The igniter shall be shorted during shipment and handling to prevent firing due to accidentally applied or induced current or accidental impact. The shorting device shall be easily removed with heavy gloves, remain with the cartridge, and be capable of being reapplied. Firing shall be effected by actuation of a remote switch.

3.12.4 Contact pin. The electrical contact pin shall be springloaded to provide a resilient connection with the contact pin in the starter breech.

3.13 Other components. The description and performance characteristics of other cartridge components required shall be specified in the model specification.

3.14 Particle screen. A screen shall be incorporated at the cartridge exhaust to reduce to a minimum the size of propellant particles delivered to the starter nozzle assembly. The screen, which shall serve as one end of the cartridge case, shall have a maximum hole size of 0.11 inch in diameter. Maximum projection of the particle screen after firing shall be 0.375 inch when measured from the end of the cartridge case.

3.15 Insulators. The composition, physical, mechanical, and thermodynamic properties of all insulators used in the cartridge shall be specified in the model specification.

3.16 Interchangeability

3.16.1 Part numbering of interchangeable parts. All parts having the same manufacturer's part number shall be functionally and dimensionally interchangeable. The item identification and part number requirements of MIL-STD-100 shall govern the manufacturer's part numbers and changes thereto.

3.16.2 Configuration drawings (envelope)

3.16.2.1 Drawing and data (with proposal). The following preliminary data shall be furnished to the procuring activity with the submission of the proposal:

a. Assembly drawing

b. Preliminary model specification in accordance with the appendix of this specification.

3.16.2.2 Drawings and data (with model specification). The contractor shall furnish the following data to the procuring activity concurrent with submission of the model specification:

a. A complete set of cartridge drawings which shall include assemblies and detail parts with identifying part number

b. Packing drawing for cartridge (complete set)

c. All contractor specifications listed in the model specification.

3.17 Performance curves. Performances curves shall be specified in the model specification and shall include the typical values and performance limits listed therein.

3.18 Weight

3.18.1 Without storage container. The weight of the complete cartridge without the sealed storage container shall not exceed 12.5 pounds and shall be specified in the model specification.

3.18.2 With storage container. The weight of the complete cartridge with the sealed storage container shall not exceed 14 pounds and shall be specified in the model specification.

3.19 Inspection methods

3.19.1 Radiographic inspection. Radiographic inspection shall be in accordance with MIL-STD-453. When radiographic inspection is used, the laboratory at which the inspection is conducted shall be certified in accordance with MIL-STD-453.

3.19.2 Fluoroscopic X-ray inspection. Fluoroscopic X-ray inspection shall be in accordance with SAE Specification AMS 2650.

3.19.3 Fluorescent penetrant inspection. Fluorescent penetrant inspection shall be in accordance with MIL-I-6866 or SAE Specification AMS 2645.

3.19.4 Hydrostatic test. Hydrostatic test methods shall be approved by the procuring activity.

3.20 Fusion welding. All operators performing fusion welding shall be certified in accordance with MIL-T-5021.

3.21 Explosive classification. The cartridge shall be classified "fire hazard, class 2" which shall be determined in accordance with T.O. 11A-1-47.

3.22 Operating and installation instructions. Operating and installation instructions shall be legible and shall be applied to the cartridge by stenciling or decalcomania.

3.23 Identification of product. Equipment, assemblies, and parts shall be marked for identification in accordance with MIL-STD-130. The lot and batch number and explosive markings shall be included on the cartridge.

3.23.1 Lot numbering and marking. The lot numbering and marking shall be in accordance with MIL-STD-1168.

3.23.2 Synthetic rubber parts. Components containing synthetic rubber parts shall be marked in accordance with ANA Bulletin No. 438.

3.24 Ammunition data cards. Completed ammunition data cards shall be provided and shall be prepared in accordance with MIL-STD-1167.

3.25 Workmanship. The workmanship and finish shall be of sufficiently high grade to insure satisfactory operation and durability consistent with the application and storage life requirements of the cartridge.

3.25.1 Cleaning. The cartridge shall be thoroughly cleaned and loose, spattered, or excess solder, metal chips, and other foreign material removed during and after final assembly.

4. QUALITY ASSURANCE PROVISIONS

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, the supplier may utilize his own facilities or any commercial laboratory acceptable to the Government. The Government reserves the right to perform any inspections deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Classification of tests. The inspection and testing of cartridges shall be classified as follows:

a. Preproduction tests

b. Acceptance tests.

4.3 Test conditions. Unless otherwise specified, the following test conditions shall apply:

4.3.1 Temperatures (cartridge removed from storage container)

4.3.1.1 Ambient temperature. Ambient temperature tests shall be conducted with the temperature of the cartridge within the range of 10° to 110°F.

4.3.1.2 Low temperature. Low temperature tests shall be conducted with the temperature of the cartridge at -65°F.

4.3.1.3 Normal temperature. Normal temperature tests shall be conducted with the temperature of the cartridge at +59°F.

4.3.1.4 High temperature. High temperature tests shall be conducted with the temperature of the cartridge at +160°F.

4.3.2 Standard atmospheric conditions. When the pressure and temperature existing at the time of the test are not specified, it is understood that the test is to be made at atmospheric pressure (approximately 29.92 inches Hg) and at room temperature (approximately 77°F).

4.3.3 Conditioning time. Conditioning time for the cartridge shall be such that all parts of the cartridge will reach a temperature within ±5°F of the temperature specified. During the conditioning time, the temperature of the conditioning chamber shall not vary more than ±5°F from the specified temperature conducting time and will be designated in the model specification per figure 5.

4.3.4 Transfer time. Unless otherwise specified, the cartridge and component transfer time between conditioning chambers shall not exceed 5 minutes.

4.3.5 Cartridge breech. Unless otherwise specified, the cartridge shall be fired in a breech conforming to the dimensions shown on figures 1 and 2.

4.3.5.1 Out-of-specification breech. Firings of cartridges in groups II, III, and IV shall be conducted in a breech dome conforming dimensionally to figure 1, with the breech cap machined out of round by 0.0350 inch on the I.D. In addition, the cap joint gap shall be 0.050 inch.

4.3.6 Cartridge position. The cartridge shall be fired in breech positions simulating those to be employed in various starter applications.

4.3.7 Dimensional units. All dimensions shall be expressed in the English gravitational system of units.

4.3.8 Temperature corrections. Performance characteristics shall not be corrected for ambient air temperature.

4.3.9 Pressure corrections. Performance characteristics shall not be corrected for ambient pressure.

4.3.10 Test apparatus

4.3.10.1 Accuracy. For all cartridge and component tests, the test apparatus shall be such as to insure that reported data will have a steady-state accuracy of ±2 percent of the maximum rated value, except that the temperature shall be accurate within ±2°F and the weight shall be accurate within ±0.2 percent. All apparatus shall be

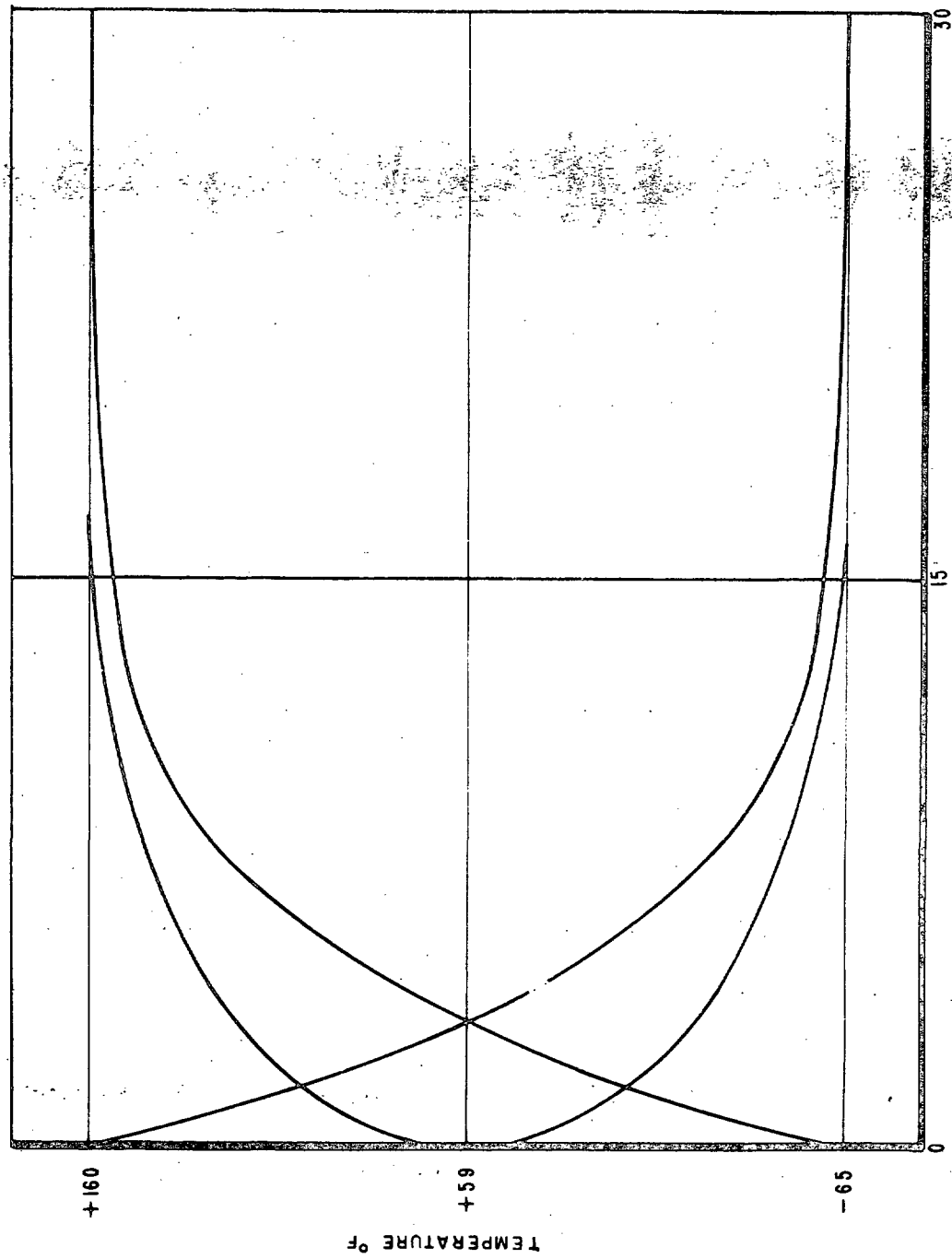


Figure 5. Lapse Time To Reach A Stabilized Temp.

calibrated frequently enough to insure that this degree of accuracy is maintained. Calibration records shall be retained by the testing agency for 2 years, and furnished to the procuring activity upon request.

4.3.10.2 Automatic recording equipment. Automatic recording equipment shall be used to obtain data during those parts of cartridge and component tests that require evaluation of time versus cartridge or component variables.

4.4 Preproduction testing

4.4.1 Test samples. The test sample groups shall be in accordance with table II.

4.4.2 Test data

4.4.2.1 Data summary sheet. A summary sheet for each cartridge firing shall be prepared in accordance with table III.

4.4.2.1.1 Limits. Performance limits specified herein shall be superimposed on all curves.

4.4.2.2 Statistical summary sheet. A statistical summary sheet based on the data resulting from test firings shall be prepared for the parameters of average chamber pressure, pressure-time integral, and maximum pressure during ignition. These sheets shall be prepared in accordance with the format of table IV. The data from individual groups will be combined for analysis per the following arrangement, and evaluated in accordance with MIL-STD-414 using an AQL of 1.0.

A. I

B. II, III, IV

C. I, II, III & IV.

4.4.2.3 Disposition of preproduction test data. Preproduction test data shall be retained by the testing agency for 3 years and furnished to the procuring activity upon request.

4.4.3 Reports

4.4.3.1 Final report. Following completion of all cartridge preproduction tests, a final report shall be submitted which shall include a record of all information pertaining to the cartridge tests. This report shall be prepared in accordance with MIL-STD-831 and, in conjunction with the component and compatibility test reports, shall normally be used as a basis for approval of the preproduction tests.

4.4.3.2 Component test reports. Separate test reports covering all tests conducted on each type of component shall be submitted. These reports shall be prepared in accordance with MIL-STD-831.

TABLE II

PREPRODUCTION TESTING

PARAGRAPH	TEST	TEST GROUPS AND NUMBER OF SAMPLES						
		I	II	III	IV	V	VI	VII
		25	40	6	6	12	3	*
4.6.5	Statistical firings	25						
4.6.6	Environmental cycling test							
4.6.6.1	Desert conditions		20					
4.6.6.2	Arctic conditions		20					
4.6.7	Vibration test			6				
4.6.8	Drop Test			6				
4.6.9	Forty-five days out of container			6	6			
4.6.10	Salt spray test				6			
4.6.11	Long term aging						♦	
	90 day					6		
	180 day					6		
4.6.12	Cleanliness and smoke test	(5)						
4.6.13	Hot breech loading test						3	
4.6.14	Compatibility testing							*

* The number of cartridges required for compatibility testing shall be specified by the procuring activity.

TABLE III

PREPRODUCTION DATA SUMMARY SHEET

Date _____

Test _____
(Note if retest)

I CARTRIDGE INFORMATION

Drawing number _____
Cartridge lot No. _____
Cartridge serial No. _____

II IGNITER INFORMATION

Type _____
Initiator or squib resistance - before conditioning _____
- after conditioning _____

III PHYSICAL DATA

Propellant weight _____ lb
Cartridge weight - before firing _____ lb
after firing _____ lb

IV ACTUAL TEST CONDITIONS

Conditioning Time hrs. at ___°F
Ambient air temperature at firing _____°F
Breech temperature before firing _____°F

V REDUCED DATA

Igniter current used A; AT 15 V
Ignition delay time _____ sec
Maximum pressure during ignition _____ psig
Maximum pressure following ignition _____ psig
Average chamber pressure _____ psig
Pressure-time integral _____ psig/sec
Action time _____ sec
Burn time _____ sec

VI PERFORMANCE AND REMARKS

1. Results of teardown inspection.
2. Pressure-time trace with point of firing-switch action shown.
3. Plot of Ignition Transient.

TABLE IV

Acceptance Statistical Summary Sheet

Temp Condition _____ Date _____

Parameter	Ave Press	Ign Delay	Act. Time	Burn Time	Max Pign	Max P	Int pdt	Min P
Spec Limits								
Min	–	–	–	–	–	–	–	–
Max	–	–	–	–	–	–	–	–
Cart. Firing Record								
1								
2								
3								
4								
5								
–								
–								
$\bar{X}$								
S								
QU								
QL								
P								
M								

Cartridge Lot No. _____ No. of Cartridges in Lot _____
Prop. Batch Nos. _____
Ignition Lot Nos. _____
Ambient Air Temperature _____°F
Breech Temperature _____°F
Ignition Current _____ Amps at 15-18 V.

4.4.3.3 Compatibility test report. Separate compatibility test reports covering all cartridge-starter compatibility tests shall be submitted. These reports shall be prepared in accordance with MIL-STD-831.

4.4.4 Test groups. Cartridges shall be divided into test groups as shown in table II. Each propellant batch in the test quantity shall be represented as equally as possible in the test groups. Prior to initiation of testing, a list showing the serial numbers and lot numbers of cartridges assigned to each test group shall be submitted to the procuring activity.

4.4.5 Preproduction tests. The preproduction tests shall consist of all the tests specified under 4.6.

4.4.5.1 Preproduction test performance. Preproduction test firings shall meet the performance requirements specified in table I.

4.5 Acceptance tests. Acceptance tests shall consist of:

a. Individual test

b. Sampling tests.

4.5.1 Individual test. Each cartridge shall be subjected to the examination of product tests described under 4.6.1 through 4.6.3.

4.5.2 Sampling tests

4.5.2.1 Lot. A lot shall consist of not more than 1300 nor less than 1000 cartridges, unless otherwise approved by procuring activity, produced in a continuous production period without changes in processes or raw material. The lot may consist of cartridges produced from several propellant batches, provided each batch is individually identified during the following cartridge assembly.

4.5.2.2 Sampling plan. In order to determine that cartridges meet the performance requirements, samples of assembled cartridges shall be selected at random from each lot and be subjected to test in a breech having a preset parting line gap of 0.035 inch. The number of samples for each test temperature shall be chosen in accordance with table A-2, using an inspection level II of MIL-STD-414. The data from the firings shall be reduced using the procedure of example B-2 of MIL-STD-414 for single specification limits and the procedure of example B-3 for double specification limits with an AQL of 1.0 percent. Since ballistic performance is specified at two temperature conditions (hot and cold), the acceptance at each temperature shall be independently determined and failure to meet specified performance at either condition shall be cause for rejection. In no instance shall the data obtained from acceptance test samples at one temperature be combined with the test data obtained at a different temperature for the purpose of determining lot acceptance.

4.5.2.3 Reduced sampling plan. If 10 successive cartridge lots are successfully acceptance tested without a retest, inspection level I shall then be used to determine the lot sample size. If a subsequent lot fails, inspection level II shall then be used until 10 successive lots are once again successfully tested.

4.5.2.4 Retest of a lot. In the event the estimated percent defective of a lot exceeds the maximum allowable, that temperature condition(s) causing the failure may be retested in accordance with the following:

a. If at inspection level I, draw new random samples in accordance with inspection level II

b. If at inspection level II, draw new random samples using inspection level III.

Only one such retest shall be allowed. Failure to meet performance requirements or exceeding the estimated percent defective as calculated from the retest shall be cause for rejection. A lot that is rejected may be analyzed for the cause of failure and then reworked and submitted for acceptance test. In such case inspection level II shall be used. No part of any reworked lot may be submitted for acceptance with other lots or parts thereof.

4.5.2.5 Cartridge components. Sampling plans for components and individual parts shall be in accordance with MIL-STD-105 and MIL-STD-414.

4.5.2.6 Storage container test. Production leak test shall be conducted with a pressure differential of 10 PSI maintained for 15 seconds. A detailed test procedure and sampling plan will be specified in the Model Specification.

4.5.3 Acceptance test data

4.5.3.1 Statistical summary sheet. A statistical summary sheet based on the data resulting from the firings of each lot of cartridges submitted for acceptance shall be prepared for the values of pressure time integral (double specification limit), and average chamber pressure (single specification limit), as specified in the performance ratings table of the model specification. Each parameter shall be deemed acceptable at each temperature if the estimated percent defective is less than or equal to the maximum allowable percent defective, M, for the sample size involved. These sheets shall be prepared in accordance with table IV. In addition, for those units not statistically analyzed, lot acceptance and rejection criteria shall be applied independently to each of the performance parameters as specified in the model specification.

4.5.3.2 Disposition of acceptance test data. Acceptance test data and acceptance data summary sheets shall be retained by the testing agency for 3 years and furnished to the procuring activity or authorized representative upon request.

4.6 Test methods

4.6.1 Examination of product. The cartridge shall be examined to determine compliance with requirements specified herein, and in the applicable specifications and drawings, with respect to materials, workmanship, finish, markings, and dimensions.

4.6.2 Propellant. The contractor shall sample and perform tests on each batch of propellant to determine if the batch meets the requirements of the specification under which it is produced. A batch shall consist of all propellant produced in a single mixing operation.

4.6.2.1 Propellant grain. Each solid propellant grain shall be visually inspected for voids, cracks, low-density areas, and separation of restrictor from the propellant. Any such condition shall be cause for rejection of the grain.

4.6.3 Igniters. All igniters shall be tested for proper electrical resistance.

4.6.3.1 Electroexplosive devices. Electroexplosive devices or ignition squibs shall be tested in accordance with the magnetic test specified in 4.6.3.1.1.

4.6.3.1.1 Magnetic test. The cartridge shall survive in an electromagnetic field intensity of 100_{W} per square meter. Approved testing shall be performed to establish a no-fire reliability of 0.999 with a confidence level of 95 percent. Tests shall include exposure to electromagnetic fields, and pulsed and continuous wave, with frequencies ranging from 100 kilocycles to 40 gigacycles. Testing shall include: Evaluation of the RF sensitivity of the basic electroexplosive element; evaluation of the uninstalled cartridge in all normal modes of storage, transporting, handling, and installing; and evaluation of the complete ignition system in the installed configuration.

4.6.4 Additional inspections. Additional component inspections for the purpose of demonstrating other components or special features shall be specified in the model specification.

4.6.4.1 Storage container test

4.6.4.1.1 A preproduction container leak test shall be conducted individually at a 13.7 psi differential held for 30 seconds. A detailed procedure shall be submitted with the preproduction test procedure.

4.6.5 Statistical firing tests

4.6.5.1 High temperature. Ten of the cartridges in group I shall be conditioned to and fired at the high temperature.

4.6.5.2 Normal temperature. Five of the cartridges in group I shall be conditioned to and fired at the normal temperature.

4.6.5.3 Low temperature. The remaining ten cartridges in group I shall be conditioned to and fired at the low temperature.

4.6.6 Environmental cycling tests

4.6.6.1 Desert conditions. Twenty cartridges from Group II shall be tested as follows.

4.6.6.1.1 Simulated flight line - 50 cycles as follows:

50°F	8 hours	Uncontrolled humidity	Sea level pressure
160°F	8 hours	Uncontrolled humidity	Sea level pressure

Withdraw, inspect, and leak check all cans at this point. Test fire 4 cartridges at 160°F and 4 at +59°F. Proceed with the remainder of 12 cartridges through the next step.

4.6.6.1.2 Simulated aircraft storage, cartridge in container - 25 cycles as follows:

-65°F	10 hours	Uncontrolled humidity	60,000 feet
140°F	10 hours	Uncontrolled humidity	Sea level pressure

Withdraw, inspect and leak check all cans at this point. Test fire 6 cartridges at +160°F and the other 6 at -65°F.

4.6.6.2 Arctic conditions. Twenty cartridges from group II shall be tested as follows.

4.6.6.2.1 Simulated flight line - 50 cycles as follows:

-65°F	6 hours	Uncontrolled humidity	Sea level pressure
+80°F	10 hours	Uncontrolled humidity	Sea level pressure

Withdraw, inspect, and leak check all cans at this point. Test fire 4 cartridges at +160°F and 4 at -65°F. Proceed with the remainder of 12 cartridges through the next step.

4.6.6.2.2 Simulated aircraft storage, cartridge in container - 25 cycles as follows:

-65°F	8 hours	Uncontrolled humidity	Sea level pressure
+160°F	8 hours	Uncontrolled humidity	60,000 feet

Withdraw, inspect, and leak check all cans at this point. Test fire cartridges at +160°F and the other at -65°F.

4.6.7 Vibration test. The cartridges in group III, in their individual storage containers, shall be vibrated in accordance with MIL-STD-810, method 514, equipment

ass I, mounting A, utilizing curve B of figure 514-1. The cartridges shall be vibrated with the input applied through:

a. The center of gravity in a direction parallel with the longitudinal axis

b. The center of gravity in a direction perpendicular to the longitudinal axis.

The cartridges shall be conditioned to and vibrated at high temperature for the first half of the specified time period, and then conditioned to and vibrated at low temperature for the second half of the specified time period. The cartridges shall be fastened to the vibration equipment by means of two steel tie-down straps placed about the periphery of the containers.

4.6.8 Drop test. The six cartridges in group III shall be removed from their individual storage containers and conditioned to the high, normal, and low temperatures, respectively, prior to each drop. The cartridges shall be subjected to a drop of 4 feet onto solid, reinforced concrete as follows:

a. Three cartridges (one each from the high, normal, and low temperature levels) with longitudinal axis vertical, to impact on screen end

b. Three cartridges (one each from the high, normal, low temperature levels) with longitudinal axis at a 45° angle from the horizontal, to impact on the igniter end.

4.6.9 Forty-five days out-of-container. The six cartridges in group III and six in roup IV shall be utilized for this test. Group IV cartridges shall be removed from ir metal shipping containers and, together with the group III cartridges, shall be maintained at 50°F and 95 percent relative humidity for 12 hours (to include 1 hr. max. temperature change time); the temperature shall then be increased to 160°F for 12 hours (to include 1 hr. max. temperature change time) with the relative humidity remaining at 95 percent. This cycle shall be repeated for a total of 45 times. The six group III cartridges shall then be fired (3 at -65° and 3 at +160°F) and shall meet the performance requirements of table I. The six group IV cartridges shall be used for the next test.

4.6.10 Salt spray. Following the 45-day out-of-container test, the cartridges in group IV shall be subjected to a salt spray test in accordance with MIL-STD-810. The cartridges shall be fired (3 at -65°F and 3 at +160°F) at the completion of this test and shall meet the performance requirements of table I.

4.6.11 Long term aging. The cartridges in test group V shall be divided into two groups and subjected to a long term aging test by storing for 3 months and 6 months at +160°F. The cartridges shall then be disassembled, examined, reassembled, and fired, and shall meet the performance parameters.

4.6.12 Cleanliness and smoke test. A test to demonstrate the cleanliness and transparency of the cartridge exhaust gases shall be conducted (evaluate 5 ea. Group I)

using the procedure specified herein and a test fixture setup as illustrated by figure 6. The equipment and procedure used shall be specified in the contractor's model specification.

4.6.12.1 Equipment

4.6.12.1.1 Light. The light source shall be of a projector type, using a G.E. Mazda 100 watt, 120 volt lamp or equivalent.

4.6.12.1.2 Photoelectric cell. The photoelectric cell shall be an Atomic Research Lab. Inc. photon meter and pickup cell or equivalent, modified per figure 6.

4.6.12.1.3 Recorder. A CEC MODEL 5-124 ocillograph recorder or equivalent shall be used to measure the voltage drop across the photocell.

4.6.12.1.4 Test stand. A standard MXU-4A/A test breech shall be mounted horizontally on a rigid stand with the nozzle 42 inches minimum above ground level.

4.6.12.2 Test setup

4.6.12.2.1 Cartridge position. Cartridges shall be fired within a standard test breech positioned per 4.6.12.1.4.

4.6.12.2.2 Light position. The light beam when focused on the photocell shall l perpendicular to the path of the exhaust stream. Position the photoelectric cell so the direct sunlight will not strike it. The variable resistance of the recorder shall be adjusted to obtain a reading of 100 percent prior to testing. A zero light condition shall be established with the light source disconnected.

4.6.12.3 Test performance. Five cartridges at ambient temperature shall be fired in a standard test breech. Data required for each test include a smoke level trace, a pressure versus time curve, and the exhaust gas temperature.

4.6.12.4 Data reduction. Each test shall exhibit an integrated average percent of light transmitted as specified in 3.10.8 of this specification when computed for the burn time established by the pressure versus time trace.

4.6.13 Hot breech loading test. One cartridge from Group VI shall be inserted into a standard flight breech that is at ambient temperature. The cartridge shall be fired, and within 1 minute following initiation of the firing, it shall be removed in one piece without difficulty (no tools being required) and without afterburning. Immediately following the removal, another cartridge shall be inserted into the breech and soaked for 8 hours, with only natural cooling affecting the breech temperature. Upon completion of the soak period, the cartridge shall be fired, then removed within 1 minute without difficulty and without afterburning. This procedure of 8-hour soaking and then firing shall be repeated with the other cartridges in Group VI.

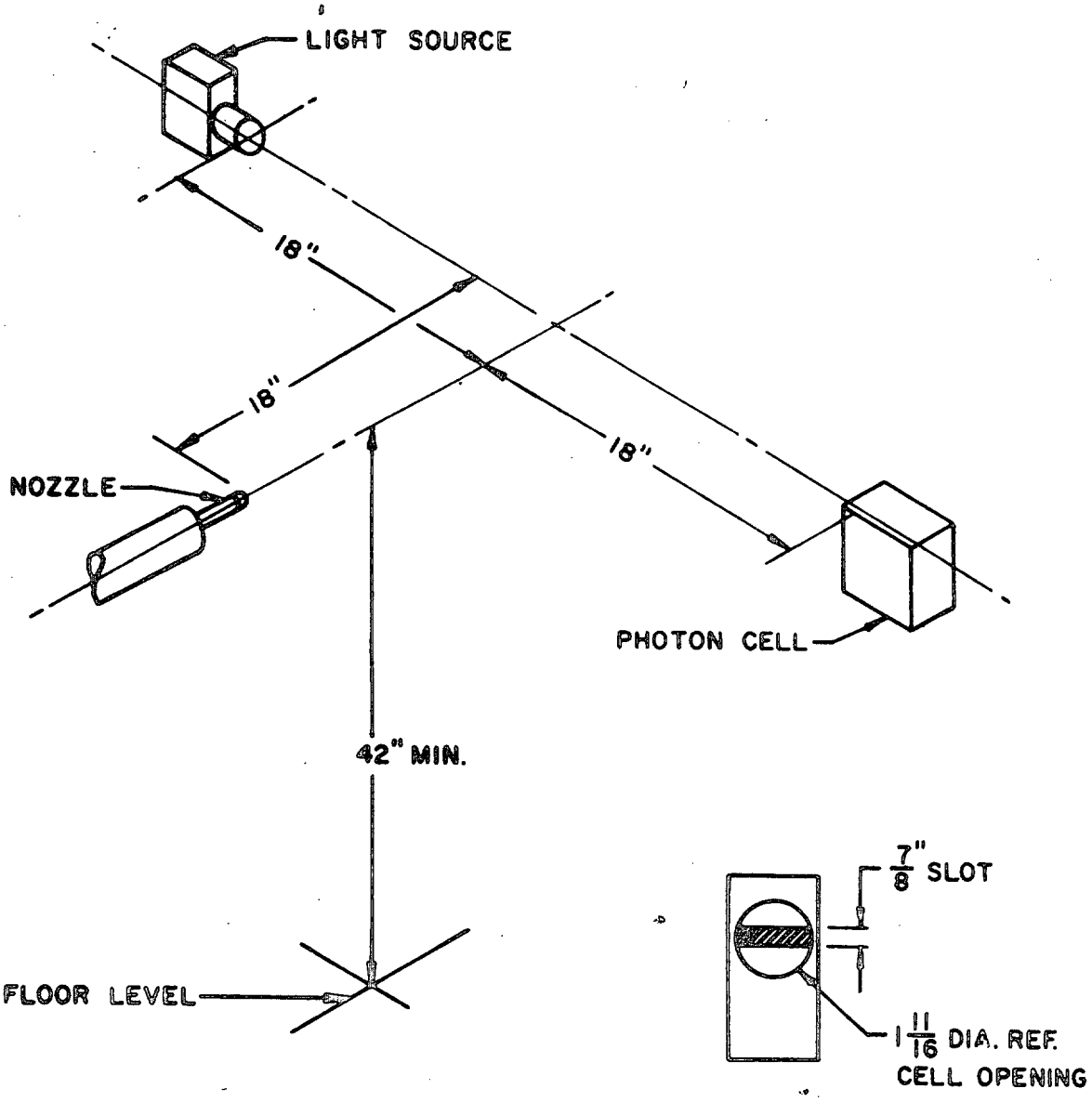


FIGURE 6. Smoke Test

4.6.14 Compatibility test. To demonstrate cartridge-starter compatibility, the cartridge shall be subjected to compatibility tests in accordance with the requirements specified for each starter designed to use the MXU-4A/A cartridge. Copies of the current compatibility test procedure may be obtained from the procuring activity. Compatibility shall be evaluated based on over-all cartridge performance throughout the test, i.e., hangfires, misfires, breech seal effectiveness, solids, buildup, erosion, corrosion, etc.; and on performance deterioration of the starter in both cartridge and pneumatic modes based on initial and final starter calibration.

4.6.15 Additional tests. Additional cartridge tests for the purpose of demonstrating other special features of the cartridge may be required by the procuring activity. These tests shall be specified in the model specification.

4.6.16 Teardown inspection. After completion of the required tests, the cartridges shall be examined and photographed.

5. PREPARATION FOR DELIVERY

5.1 Preservation and packaging - all levels

5.1.1 Preservation. Each cartridge shall be individually preserved in accordance with MIL-P-116, method 1A-5, or any alternate of this method approved by the procuring activity. Container size shall be in accordance with dimensions shown on figure 7.

5.1.2 Packaging. The container shall conform to PPP-C-96, type I, except that it shall be capable of maintaining a 15 psi pressure differential. The contractor shall establish test and inspection procedures to insure that each metal container is properly sealed, and shall include these procedures in the model specification.

5.2 Packing-all levels. Four cartridges packaged as specified in 5.1.2 shall be packed in a fiberboard box conforming to PPP-B-636, type I or II, class 2, grade 3.

5.3 Marking. Exterior and interior containers shall be marked in accordance with MIL-STD-129, AFM 71-4, and 49-CFR 71-78. The shipment marking nomenclature shall be:

CARTRIDGE, ENGINE STARTER MXU-4A/A.

6. NOTES

6.1 Intended use. The MXU-4A/A cartridge covered by this specification is of the solid-propellant type and is intended for use in cartridge starters to start J52, J57, J75, J79, and TF33 engines in aeronautical vehicles.

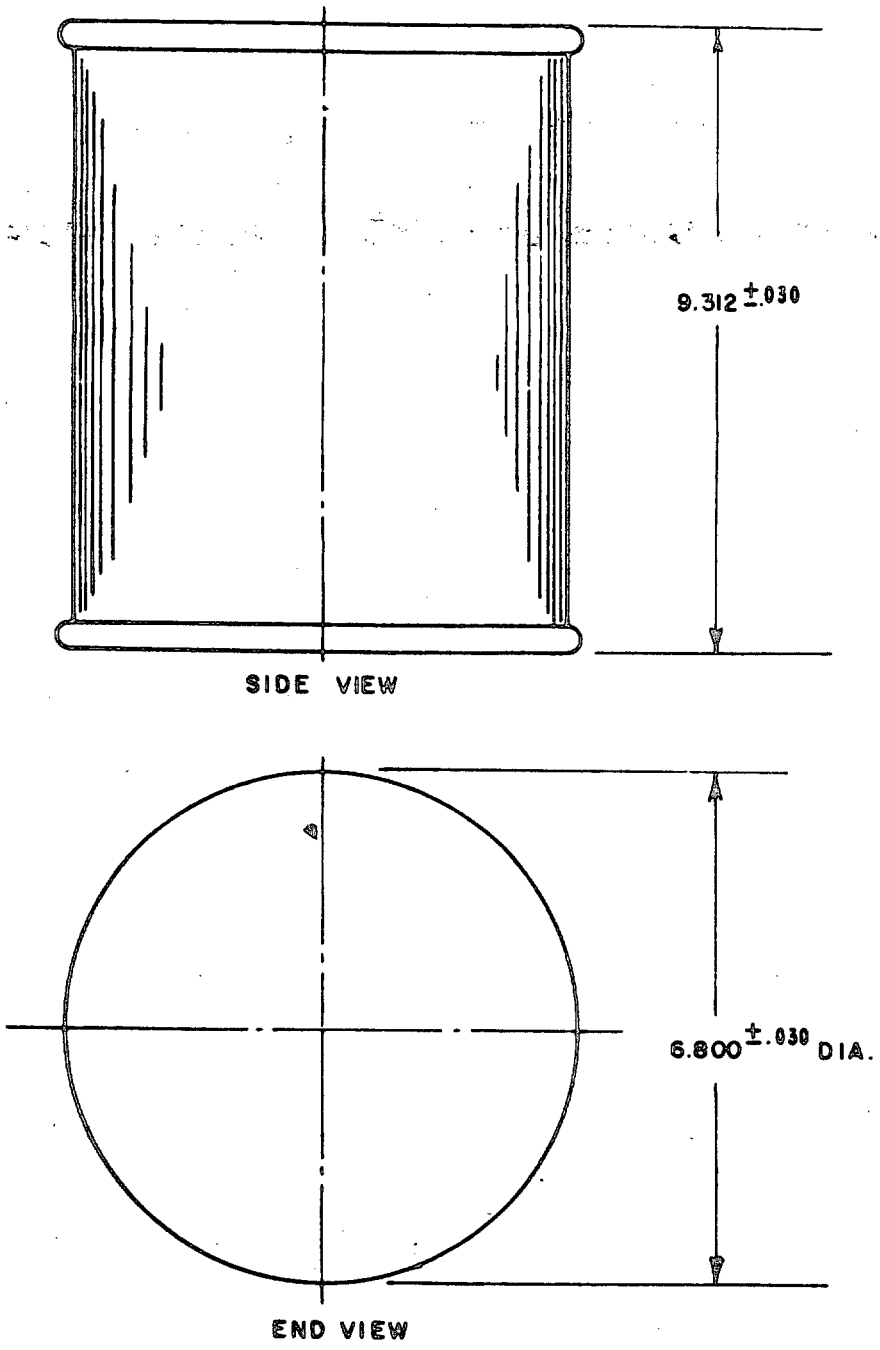


FIGURE 7. MXU-4A/A Cartridge Storage Container

6.2 Ordering data. Procurement documents should specify the following:

a. Title, number, and date of this specification

b. Number of copies of model specification to be submitted.

6.3 Definitions and symbols. Definitions and symbols applicable to this specification and the model specification are as follows:

6.3.1 Ballistic. Ballistic definitions are in accordance with Air Force Specification Bulletin 508 except as specified herein. The symbols for ballistic parameters are also in accordance with Air Force Specification Bulletin 508.

6.3.2 Action time. Action time is the elapsed time between the intersection of tangents to ascending and descending portions of the pressure-time curve with the time axis.

6.3.3 Average chamber pressure. The average chamber pressure is the area under the pressure-time curve encompassed by action time divided by the burn time.

6.3.4 Ignition delay time. Ignition delay time is the elapsed time from zero time to the point of initial pressure rise.

6.3.5 Burn time. Burn time is the elapsed time between the point where the pressure has risen to 50 percent of the maximum chamber pressure following ignition and the point where the pressure has fallen to 50 percent of the maximum chamber pressure following ignition.

6.3.6 Effective throat area. Effective throat area is the product of the geometric area and the flow coefficient of the nozzle used.

6.3.7 Misfire. A misfire is failure of the cartridge to ignite even though the electrical ignition system has continuity and shows no other electrical malfunction.

6.3.8 Hangfire. A hangfire is an abnormal delay between functioning of the igniter and establishment of the equilibrium burning pressure of the cartridge.

6.3.9 Rating. A rating is the value of some characteristic of performance as specified in the model specification.

6.3.10 Estimate. An estimate is a predicted value of performance.

6.3.11 Standard conditions. Standard conditions are the values of air temperature and pressure given in ASTIA Document 110233, ARDC Model Atmosphere 1956.

6.3.12 Transfer time. Transfer time is the time interval from the removal of the cartridge or component from one conditioning chamber to the insertion of the cartridge

or component into another conditioning chamber, or the time interval from the removal of the cartridge or component from the conditioning chamber to the initiation of testing.

6.3.13 Solid propellant grain. Solid propellant grain is a chemical formulation containing both fuel and oxidizer which, upon ignition, will produce a hot gas.

6.3.14 Restrictor. A restrictor is material bonded to the solid propellant grain to limit burning to desired areas.

6.3.15 Bonding agent. The bonding agent is a chemical compound used to produce adherence between the solid propellant grain and the restrictor.

6.3.16 Insulator. The insulator is material which may be placed between the solid propellant grain and the case to keep case and breech temperatures within desired limits.

6.3.17 Case. The case is the shell which contains the cartridge parts.

6.3.18 Igniter assembly. The igniter assembly is the device which initiates combustion of the solid propellant grain.

6.3.19 Particle screen. The particle screen is the end of the cartridge case oriented toward the hot gas duct which filters solid particles by particle size.

6.3.20 Weather seal. The weather seal is a thin material used to cover openings in the cartridge case in order to protect the inside of the cartridge from the surrounding atmosphere during the period between the time the cartridge is removed from its container and the time it is fired.

6.3.21 Inhibitor. The inhibitor is composed of chemical compounds added to the solid propellant grain to keep the burning rate within desired limits.

6.3.22 Squib. The squib is an electrochemical device used to transform electric energy into thermal energy in order to initiate the igniter material.

6.4 Limitation of demonstrations. Demonstrations required of a cartridge and its components for the purpose of establishing a service-type approval or production acceptance will be limited to those tests specified herein as modified by the individual cartridge model specification. This limitation of demonstrations will not relieve the cartridge manufacturer of responsibility for fulfilling all model specification requirements.

6.5 Storage life. A surveillance plan designed to demonstrate that the cartridge meets the requirements of 3.9.7.1 will be submitted to the procuring activity for approval. This plan will not be a part of the model specification but will be submitted

concurrently. Unless otherwise specified by the procuring activity, the cartridge contractor will not be responsible for conducting the surveillance testing.

6.6 Asterisks are not used in this revision to identify changes with respect to the previous issue, due to the extensiveness of the changes.

Custodian:
Air Force - 11

Preparing activity:
Air Force - 11

Review activities:
Air Force - 70

APPENDIX

CARTRIDGE, ENGINE STARTER MXU-4A/A
MODEL SPECIFICATION FOR

(OUTLINE AND INSTRUCTIONS FOR PREPARATION)

10. SCOPE

10.1 This appendix establishes the format to be used by manufacturers in the preparation of specifications for engine starter cartridges.

20. APPLICATION

20.1 A complete model specification shall be prepared in accordance with the outline and instructions specified herein. Classified portions of the model specification shall be submitted in a separate addendum. For each specific cartridge model, new cartridge model designations will be assigned by the procuring activity. When a new model designation is assigned, a new cartridge model specification shall normally be prepared with a new specification number assigned thereto by the cartridge manufacturer. No new cartridge model designation shall be implemented by appendixes or variants to an existing model specification, and in no case shall amendments be used for this purpose. Changes to a cartridge model specification shall not be submitted to the procuring activity by means of amendments prior to the time the cartridge model specified is approved and becomes a part of the contract. Changes to an approved cartridge model specification that has been released and forms a part of a contract will be acceptable in amendment form. Each amendment shall be approved and shall include and supersede the previous amendment. A model specification may be revised only to incorporate previously approved amendments. Such a revision must be complete and individual revised pages will not be accepted at any time.

20.2 The headings and numbering of sections and paragraphs in the model specification correspond to those of the basic specification for the specific data needed only in the model specification. Paragraphs that need not be included in the model specification have been omitted from the format. When the model specification does not refer to a particular requirement of the basic specification, this shall be interpreted as compliance therewith. When departures from the requirements of the basic specification are necessary, the details of such departures shall be stated as specified requirements and shall bear the same section headings, paragraph headings, and numbering as the basic specification.

20.3 Parenthetical sentences, phrases, and words are included herein for guidance in inserting proper information and data related thereto. Parenthetical statements shall not be copied in the model specification.

20.4 The specification number shall be the number assigned by the cartridge manufacturer. When a revised model specification is submitted, it shall be designated by a dash and a letter after the number, and a revision date followed by a listing of previous revisions and dates, if applicable. The listing of previous revisions and dates shall be shown on page 1 only. The specification number and the revision suffix letter shall be shown on subsequent pages.

20.5 To permit preliminary evaluation of a proposed cartridge design, or release of approved cartridge performance characteristics in connection with a design competition, the cartridge manufacturer shall submit a preliminary model specification to be used until superseded by a complete approved model specification required for a production contract.

20.6 To permit easy interpolation, all curves shall be presented on graph paper having an adequate number of subdivisions.

(Number and Title: The number and title shall be as follows)

(Specification No.)_____
(Date)_____
(a) Revised____ (Date)_____
(b) Revised____ (Date)_____

Model Specification

CARTRIDGE, ENGINE STARTER MXU-4A/A

(Name of Contractor)

(Contractor's Model Designation)

1. SCOPE

1.1 Scope. This specification covers the requirements for one type of solid propellant engine starter cartridge for aeronautical vehicles, designated MXU-4A/A.

1.2 Classification. The _____ (insert type and model) cartridge is a _____ (insert a brief description of the salient features of this model cartridge).

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. (List number, title, date, and revision letter or amendment number, where applicable, of referenced specification.)

3. REQUIREMENTS

3.3.2 Design criteria. Design criteria is presented in table I.

3.7.1 Effect on metal. (Specify the chemical and metallurgical effect of the cartridge exhaust gases on aluminum and metals incorporated in the starters specified in 3.7.2.)

3.9 Performance. (Specify basis upon which performance was established.)

3.9.2 Temperatures. The cartridge shall perform within the envelope of performance defined in table I between the temperature limits of -65° and +160°F.

3.9.4 Performance ratings. Performance ratings of the cartridge for standard sea level static conditions as determined by preproduction testing are listed in table II.

TABLE I

DESIGN CRITERIA AT SEA LEVEL

Parameter	Temp °F	Average	Standard Deviation
1. Ignition delay (t_d), sec	-65	----	----
	+59	----	----
	+160	----	----
2. Ignition pressure rise rate after first indication of pressure, psig	-65	----	----
	+59	----	----
	+160	----	----
3. Maximum pressure during ignition (P_i), psig	-65	----	----
	+59	----	----
	+160	----	----
4. Maximum pressure following ignition (P_{max}) 1/	-65	----	----
	+59	----	----
	+160	----	----
5. Minimum pressure following ignition cycle through tailoff (P_{min}), psig	-65	----	----
	+59	----	----
	+160	----	----
6. Average chamber pressure (P_a) psig 2/	-65	----	----
	+59	----	----
	+160	----	----
7. Pressure-action-time integral ($\int P dt$) psig sec x 10-4	-65	----	----
	+59	----	----
	+160	----	----
8. Action time (t_a), sec	-65	----	----
	+59	----	----
	+160	----	----
9. Burn time (t_b), sec	-65	----	----
	+59	----	----
	+160	----	----

1/ (Define end of ignition phase).

2/ Determine area under the pressure-time curve encompassed by action time. Divide the area by the burn time to obtain average chamber pressure, P, in pounds per square inch.

TABLE II

Performance Ratings at Sea Level

Parameter	Temp °F	Range Min.	Range Max.	Standard Deviation	
1. Ignition delay (t_d) sec	-65				
	+59				
	+160				
2. Ignition pressure rise rate after first indication of pressure, psig	-65				
	+59				
	+160				
3. Maximum pressure during ignition (P_i) psig	-65				
	+59				
	+160				
4. Maximum pressure following ignition (Pmax) psig 1/	-65				
	+59				
	+160				
5. Minimum pressure following ignition ignition cycle through tailoff (Pmin) psig	-65				
	+59				
	+160				
6. Average chamber pressure ($\bar{P}_o$) psig 2/	-65				
	+59				
	+160				
7. Pressure-action time integral ($\int$ Pdt) psi - sec x 10-4	-65				
	+59				
	+160				
8. Action time (ta) sec	-65				
	+59				
	+160				
9. Burn time (t_b), sec	-65				
	+59				
	+160				

1/ (Define end of ignition phase.)

2/ Determine area under the pressure-time curve encompassed by action time. Divide the area by the burn time to obtain average pressure, $\bar{P}$, in pounds per square inch.

3.9.5 Flame temperature. (The measured gas temperature for the max. condition experienced is _____ at -65/+59/160°F. The adiabatic flame temperature as defined in Bulletin 508 shall be given.)

3.10 Propellant. (Specify the propellant formulation in the model specification. Include a brief description of components, such as fuel, oxidizer, plasticizer, curing agents, inhibitors, and additives. Reference manufacturer's material specifications.)

3.10.1 Ballistic, physical, and mechanical properties

3.10.1.1 Ballistic

a. (Specify temperature coefficient of chamber pressure, temperature coefficient of burn rate, pressure exponent, characteristic exhaust velocity, molecular weight, specific impulse, flame temperature (calculated and measured), ratio of specific heats, heat capacity at constant pressure, and exhaust gas composition in percentage by weight.)

b. The variation of chamber pressure with area ratio (K_n) and burn rate is shown on figure ___. (Prepare figure in accordance with figure 8.)

3.10.1.2 Physical and mechanical. The physical and mechanical properties of the propellant and their variation with temperature are shown on the following figures:

a. Stress, strain, and modulus of elasticity (figure 9).

b. The propellant thermal conductivity is _____ (specify units).

c. The density is _____ $lb/in.^3$.

3.10.2 Auto-ignition temperature

a. The main propellant auto-ignition level shall be illustrated by a time versus temperature plot. (Ref. figure 4.)

b. The igniter component auto-ignition level shall be illustrated by a time versus temperature plot. (Ref. figure 4.)

3.10.4 Restrictor and bonding agent. (State restrictor and bonding agent formulation in percentage by weight. Reference manufacturer's material specifications.)

3.10.5 Processing. (Reference the manufacturer's processing specifications for propellant, restrictor, and bonding agent.)

3.10.6 Corrosion. (Specify corrosive effect of exhaust gases.)

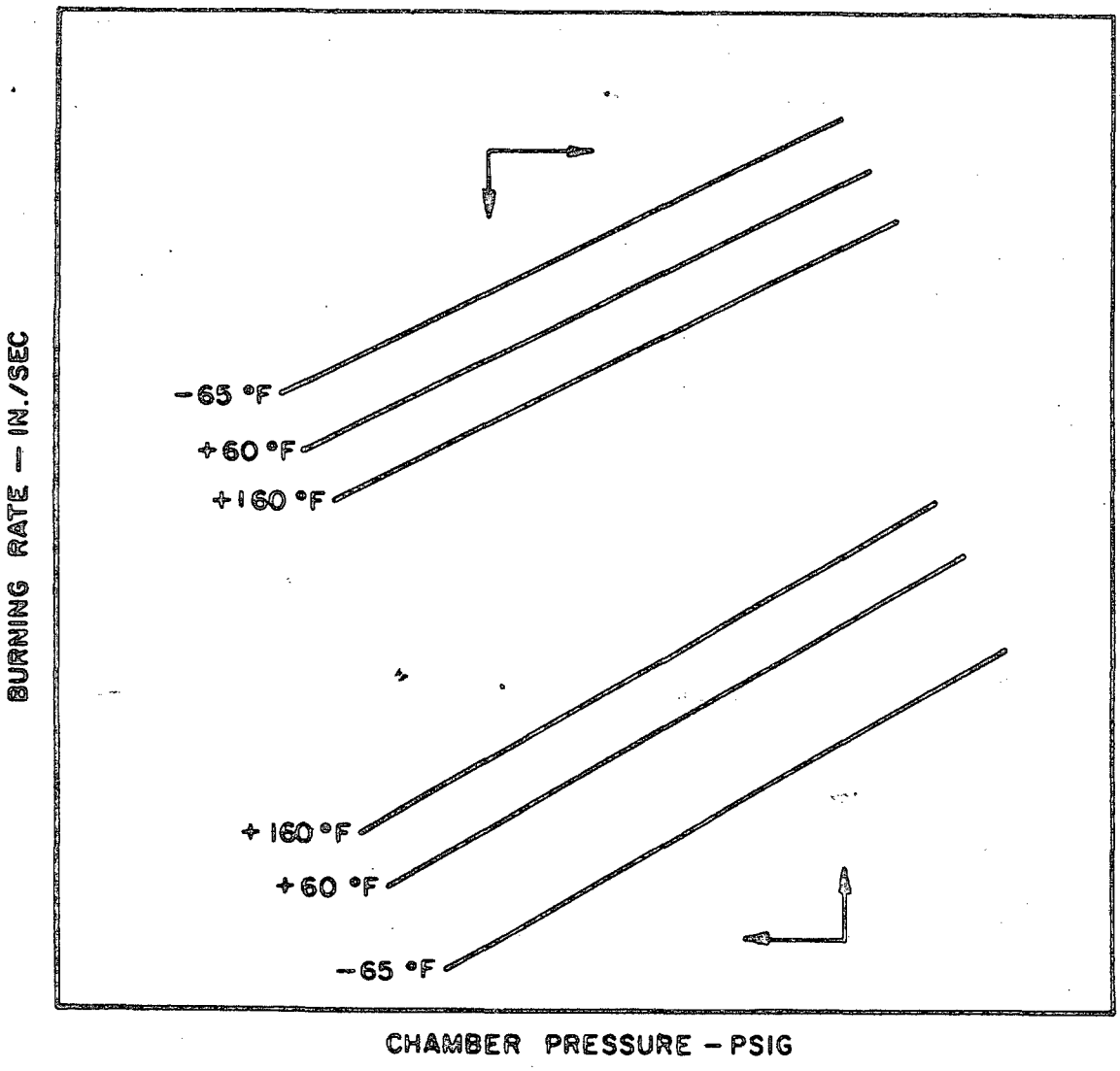


FIGURE 8. Variation of Chamber Pressure with Area Ratio and Burn Rate

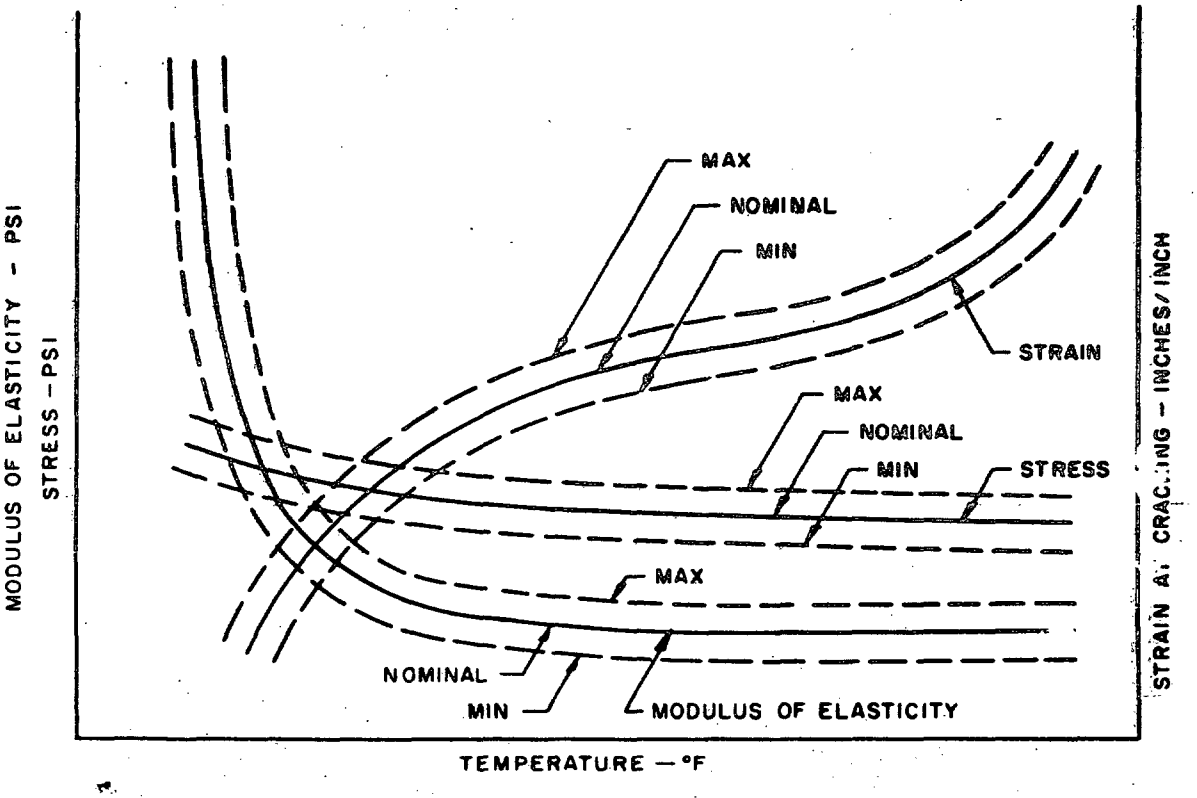


FIGURE 9. Variation of Propellant (Insulator) Stress, Strain and Modulus of Elasticity with Temperature

3.10.7 Erosion. (Specify erosive effect of exhaust gases.)

3.10.8 Smoke. The minimum percent of light transmitted through the exhaust gases when the cartridge is tested in accordance with the cleanliness smoke test is _____.

3.10.9 Toxicity. (Specify the toxic properties of the exhaust gases.)

3.11 Case

3.11.4 Weather seals. (Describe weather seals used and specify their burst pressure.)

3.12 Igniter assembly. (Give a brief description of the igniter composition including formulation in percentages by weight. Also list components such as fuel, oxidizer, binder, and squibs. Reference manufacturer's specifications for materials and processes.)

3.12.2 Prefiring check. (Describe details of test connections and test equipment required for prefiring check. Include a typical curve showing voltage applied to the igniter versus cartridge ignition delay time.) The electrical resistance of the igniter circuit is _____ ± _____ ohms. Maximum safe test current for prefiring check is _____ amperes. Minimum current required to insure satisfactory operation is _____ amperes.

3.12.3 Safety and arming. (Specify safety provisions and the arming provisions.)

3.13 Other components. (Describe briefly and specify the performance characteristics of any other components of the cartridge not previously described.)

3.14 Electrical power. (Specify electrical power requirements data in accordance with MIL-STD-704.

3.15 Insulators

a. (Specify the physical and mechanical properties of all insulators.)

b. (Specify the thermodynamic properties of all insulators.)

c. (Reference the manufacturer's processing specification for each insulator.)

d. (Specify the composition of all insulators.)

3.17 Performance curves. Cartridge performance shall be as shown on figures ___ through ____. These curves indicate performance attained under specified conditions. (Prepare the following performance curves in accordance with instructions specified herein and illustrate the performance obtainable. Where applicable, superimpose dotted curves showing the tolerance on performance.)

3.17.1 Typical chamber pressure versus time curve with definitions of parameters is shown on figure____. (Draw this curve in accordance with figure 10.)

3.17.2 Typical sea level chamber pressure versus time curves: (Select reproduction traces for the indicated temperature shall be reproduced with applicable limits superimposed.)

a. -65°F, figure _____

b. +59°F, figure _____

c. +160°F, figure _____.

3.19.3 Curve showing the variation in average chamber pressure with temperature at sea level is shown on figure ___. (Draw this curve in accordance with figure 11.)

3.19.4 Curves showing the variation of chamber pressure with area ratio (K_n) and burn rate are shown on figure ____. (Draw this curve in accordance with figure 8.)

3.18 Weight

3.18.1 Without metal storage container. The weight of the complete cartridge without the sealed storage metal container is _____ ± _____ pounds. The weight of specific items is as follows: (List weight plus tolerance of each major component, such as propellant charge, case, screen, restrictor, igniter, et cetera.)

3.18.2 With metal storage container. The weight of the complete cartridge with sealed metal storage container is _____ ± _____ pounds.

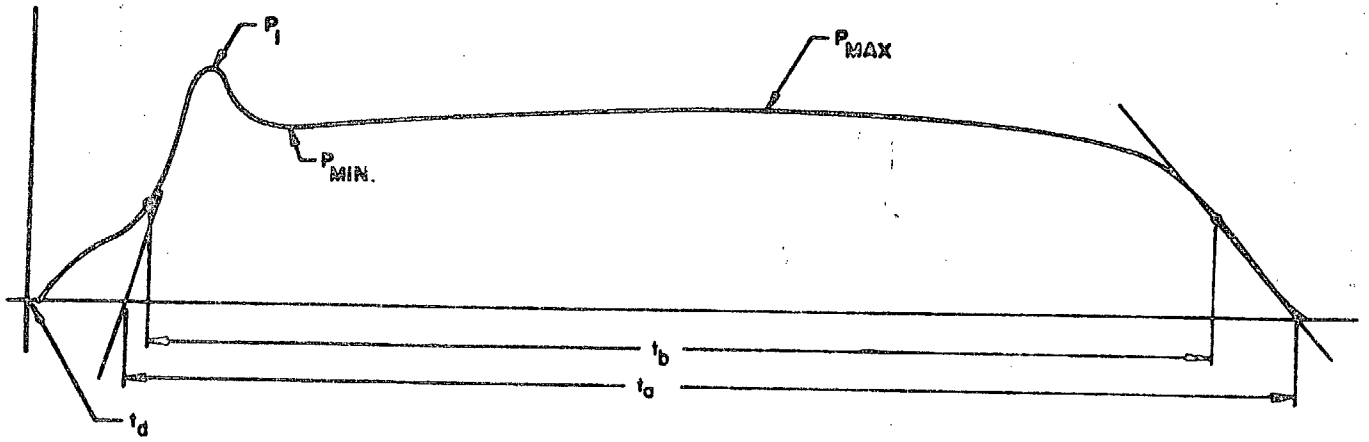
3.26 General additional requirements. (Specify any additional information or requirements which are not covered by required statements herein or by any deviations to MIL-C-27505.)

4. QUALITY ASSURANCE PROVISIONS

4.2 Classification of tests. The inspection and testing of cartridges shall be in accordance with MIL-C-27505 and as specified herein.

4.6.2.1 Lot definition. (The nominal lot size shall be indicated and a definitive procedure outlined for propellant movement (by weight) from raw material to finished grain.)

4.6.2.5 Cartridge components. List the inspection points and AQL for all major items from initial inspection through final assembly.



SYMBOL	PARAMETER	DEFINITION
$\bar{P}$	Average chamber pressure	Area under the pressure-time curve encompassed by action time divided by burn time.
$\int Pdt$	Pressure-time integral	Area under the pressure-time curve encompassed by action time
t_a	Action time	Elapsed time between the intersection of tangents to ascending and descending portions of the pressure time curve with the time axis.
t_b	Burn time	Elapsed time between the point where the pressure has risen to 50 percent of the maximum chamber pressure (P_{max}) and the point where the pressure has fallen to 50 percent of the maximum chamber pressure (P_{max}).
t_d	Ignition delay time	Elapsed time from zero time to the point of initial pressure rise.
P_i	Max pressure during ignition	Highest chamber pressure developed by the cartridge during ignition.
P_{max}	Max pressure following ignition	Highest chamber pressure developed by the cartridge under normal operating condition excluding ignition.
P_{min}	Min pressure following ignition	Lowest chamber pressure developed by the cartridge excluding ignition.

FIGURE 10. Chamber Pressure vs Time Curve with Definitions of Parameters

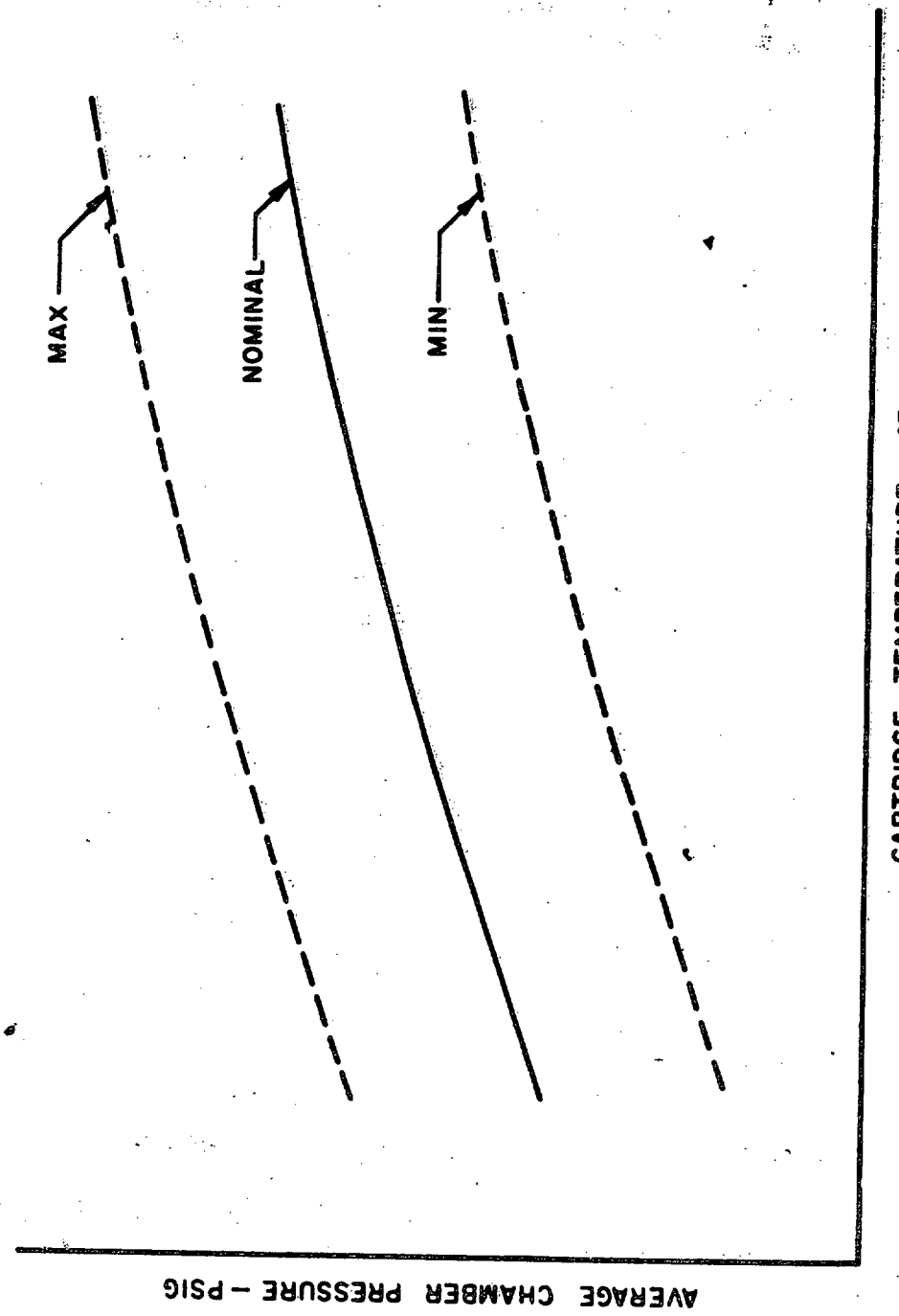


FIGURE 11. Variation of Average Chamber Pressure with Cartridge Temperature at Sea Level

4.6.4 Additional tests. (Specify any additional tests considered necessary for demonstrating special features of the cartridge or that may be required by the procuring activity.)

5. PREPARATION FOR DELIVERY. Preparation for delivery shall be as specified in MIL-C-27505.

5.1.2 Packaging. (Specify test and inspection procedures to insure that each metal container is properly pressurized and sealed.)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

OMB Approval
No. 22-R255

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