MILITARY STANDARD

CARBURIZING, GASEOUS ATMOSPHERE PROCESS FOR

NO DELIVERABLE DATA DOCUMENT

AREA MFFP

DEPARTMENT OF DEFENSE
Washington, DC 20301

Carburizing, Gaseous Atmosphere, Process for

MIL-STD-1878(AT)

1. This Military Standard is approved for use by US Army Tank-Automotive Command, Department of the Army, and is available for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: US Army Tank-Automotive Command, ATTN: DRSTA-GSS, Warren, MI 48090, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document, or by letter.

FOREWORD

This Military Standard establishes the requirements and procedures for gas carburizing and heat treating and finishing operations used for parts in the manufacturing of carburized tank engine components.

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1. SCOPE

1.1 Scope. This standard covers the requirements and procedures for gas carburizing, heat treating and finishing operations used for parts in the manufacture of carburized tank engine components.

1.1.1 Limitations. Processes not covered by this standard include homogeneous, high temperature and vacuum carburizing.

1.2 Purpose. Purpose for gas carburizing is to produce a carbon enriched surface of controlled carbon content that when subsequently heat treated will meet the specified mechanical properties.

2. APPLICABLE DOCUMENTS

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

SPECIFICATIONS
MILTIARY

MIL-I-6868	- Magnetic Particle, Inspection Process.
MIL-H-6875	- Heat Treatment of Steels (Aerospace Practice, Process for).

STANDARDS
MILITARY

MIL-STD-867	- Temper Etch Inspection.
MIPD-G-62410	- General Heat Treatment.
MIL-H-6868	- Magnetic Particle Inspection.
MIPD-G-62439	- Gears, Material Acceptance Criteria for.

(Copies of specifications, standards, drawings, and publications required by suppliers in connection with specific acquisition functions should be obtained from the acquisition activity or as directed by the contracting officer.) MIPD Specifications and Standards can be obtained from US Army Automotive Tank-Command (TACOM) DRSTA-GSS, Warren, MI 48090.

2.2 Non-Government documents. The following documents of the issue in effect on date of invitation for bids or request for proposal, form a part of this standard to the extent specified herein.

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

AMS 2418	- Copper Plating.
AMS 2750	- Pyrometry.
AS 478	- Identification Marking Methods.
SAE J415	- Definition of Heat Treating Terms, Information Report.
SAE J423	- Methods of Measuring Case Depth, Recommended Practices.

(Copies may be obtained from the Society of Automotive Engineers, Inc., 400 Commonwealth Avenue, Warrendale, PA 15096.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM E3	- Metallographic Specimens, Methods of, Preparation of.
ASTM E18	- Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials, Standard Test Methods for.
ASTM E44	- Heat Treatment of Metals, Standard Definitions of Terms Relating to.

ASTM E384 - Microhardness of Materials, Standard Test Method for.

ASTM E407 - Microetching Metals and Alloys, Standard Methods for.

(Copies of the above publications may be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

2.3 Other publications.

AMERICAN SOCIETY FOR METALS (ASM)

Properties and Selection of Metals, Volume 1, 9th Edition
Heat Treating, Volume 4, 9th Edition.

(Copies of the above publications may be obtained from the American Society for Metals, Metals Park, Ohio 44073.)

3. DEFINITIONS. Definitions of terms relating to Heat Treatment (Gas Carburizing) are amply covered in numerous documents. The most appropriate sources are those shown in SAE J415, ASTM E44, and ASM Volume 1, 9th edition

4. GENERAL REQUIREMENTS

4.1 Carburizing equipment.

4.1.1 Furnaces. Carburizing furnaces shall be of the batch or continuous design, capable of meeting the requirements of MIL-H-6875.

4.1.1.1 Temperature uniformity. After the charge, consisting of parts, container and fixturing, if any, has reached the desired carburizing temperature in the working zone, the furnace shall be capable of maintaining the temperature to within $\pm$ 25°F ($\pm$ 15°C) in that zone.

4.1.1.2 Heating media. Heating media of the furnace shall be maintained separate from the protective carburizing atmosphere throughout the cycle in the furnace.

4.1.1.3 Seals and vestibules. Seals and vestibules shall be provided to prevent air leakage from entering the protective atmosphere chamber.

4.1.1.4 Forced circulation. Carburizing zone(s) shall have positive (forced) circulation to distribute the atmosphere evenly throughout the furnace and promote temperature uniformity.

4.1.1.5 Temperature control equipment. Sufficient number of thermocouples shall be placed in the working zone(s) to provide an accurate temperature survey of the furnace. They shall be encased in suitable protection tubes to prevent contamination by the gas carburizing atmosphere.

4.1.1.5.1 Instrumentation. All thermocouples, zone control, and indicating shall be provided with recording instrumentation in accordance with AMS 2750.

4.1.2 Gas carburizing media. Source for carbon enrichment shall be provided from a hydrocarbon gas. Most gas carburizing furnaces use in addition to the hydrocarbon gas, a carrier or diluent, for better control of the surface carbon available to the parts and to minimize furnace maintenance problems associated with sooting.

4.1.2.1 Carrier gas. Carrier gas most frequently used is furnished from external endothermic gas generators.

4.1.2.2 Mixing and flow rates. Depending upon furnace design, mixing of the hydrocarbon and carrier gases is external to the furnace with the flow rates being adjusted to produce a case of uniform depth and carbon content.

4.1.3 Safety precautions. Gas carburizing atmospheres are highly toxic, highly flammable, and form explosive mixtures. Furnace construction shall incorporate the necessary safety equipment and warning devices to minimize the probability of accidental explosions occurring.

4.2 Hardening equipment. It shall be the responsibility of the contractor to designate on the drawing or specification the options for hardening as follows:

a. Direct quench from the carburizing temperature or from some lower temperature, approximately 1550°F (845°C).
b. Cool in the reducing furnace atmosphere to about 900°F (480°C) then air cooled to room temperature.

Choice depends primarily on:

1. Grade steel being carburized.
2. Part configuration and size.
3. Need for selective carburizing.
4. Manufacturing sequence processing necessitates machining operations between the carburizing and hardening operation.
5. Processing cost.

4.2.1 Furnaces. Furnace construction and operating parameters for parts being reheated for hardening after carburizing are, except for austenitizing temperature and time selected, the same as for carburizing. A protective atmosphere shall be maintained in equilibrium with the surface carbon of the parts being heated for hardening during the cycle.

4.3 Quench facilities. Facilities required to quench carburized parts directly after carburizing or after reheating are the same.

4.3.1 Location of quenching equipment. Unless otherwise specified, quench facilities shall be located in an integral quench chamber associated with the austenitizing furnace providing a protective atmosphere above the quench media.

4.3.1.1 Press quenching. Location of facilities are external from the austenitizing furnace. They are designed for single quenching of parts, such as ring gears as an effective method of reducing distortion. Procedure involves handling by an operator. Expediency in placing the part in the quench fixture is necessary to minimize oxidation of critical surfaces.

4.3.2 Size tank. Mass (free) quenching requires the tank containing the quenching media shall be of suitable size and content to completely immerse the parts, container, and fixturing if any.

4.3.3 Circulation. Quench media shall be agitated by forced circulation directed around and through the parts to provide the desired metallurgical properties.

4.3.4 Temperature control. Quench media shall have the temperature controlled in accordance with AMS 2750 to provide the desired metallurgical properties and minimize the change in dimensional tolerances due to distortion.

4.3.4.1 Oil quenchant. Optimum temperature for oil quenching depends upon (a) type of oil, (b) freedom from contaminants, ie. water, sludge and insolubles, (c) desire to minimize distortion, and (d) meet hardness requirements. For practical reasons, oils are generally maintained at temperatures between 100° and 200°F (38° to 93°C). Generally, heat treat practitioners operate in the range 120° to 160°F (24° to 71°C).

4.4 Tempering equipment. Unless otherwise specified, all carburized and hardened parts shall be tempered as a final heat treat operation. Tempering temperature shall be consistent with case hardness requirements, normally 300° to 375°F (149° to 190°C), and the time period shall be not less than 1 hour at temperature.

4.4.1 Furnaces. Furnaces, batch or continuous, designed for tempering steel parts are generally of the recirculating or forced air convection type. This distributes the air evenly throughout the heating chamber and promotes temperature uniformity.

4.4.1.1 Temperature uniformity. After the charge has reached the desired tempering temperature, the furnace shall be capable of maintaining the temperature to within ± 10°F (± 5°C) throughout the load.

4.4.1.2 Temperature control instrumentation. All thermocouples, zone control and indicating shall be provided with recording instrumentation in accordance with AMS 2750.

5. DETAIL REQUIREMENTS

5.1 Preparation and handling prior to carburizing.

5.1.1 Heat treatment.

5.1.1.1 Forgings. Unless otherwise specified, all forgings to be processed shall be iso-thermally annealed or normalized to a desired microstructure for subsequent machining in accordance with MIPD-G-62410. Bar stock for processing shall be in the condition specified in the applicable material specification.

5.1.1.2 Rough machined parts. Unless otherwise specified, rough machined parts shall be a) normalized, hardened and tempered to a hardness range Rockwell HRC 24-32 or b) normalized and tempered to a hardness range Rockwell HRC 24-32, in accordance with MIPD-G-62410.

5.1.1.3 Finished machined parts. Machined parts shall be as close to final dimension as possible before being carburized to minimize removal of the most beneficial portion of the case during final finishing operations. Typical stock allowances for gears and splines depending upon type, size, material, and tolerances permitted before and after the carburizing and hardening cycles are shown in table I.

5.1.2 Surface preparation.

5.1.2.1 Cleanliness. All parts, work trays and fixtures shall be thoroughly cleaned and free from moisture prior to being charged into the carburizing or hardening furnace. Scale, oils, lubricants, residues from prior operations, rust preventatives, and water all have either an adverse reaction on the part, furnace equipment, or the thermochemical balance of the protective atmosphere.

5.1.2.2 Decarburization. Surfaces to be carburized shall be free from any decarburization.

5.1.2.3 Selective carburization. Part surfaces not to be carburized shall be masked by electrodepositon of copper in accordance with AMS 2418. Alternate procedures for selective carburizing are to (a) carburize all over, machine the case from the surface to be free of carburization, then harden or (b) copper plate all over and machine the copper plate from the surface to be carburized. Machine stock tolerances in these areas must be incorporated.

5.1.2.3.1 Plating thickness. Copper plating to be effective as a carbon stop-off shall be deposited in a thickness of 0.8 to 1.2 mils (0.0008 to 0.0012 inch).

5.1.3 Furnace loading. Unless otherwise specified, test samples shall accompany the parts when the load is charged into the furnace. Size, shape and quantity of parts per load shall be such as to permit free access of the protective gas atmosphere and provide uniformity of hardening.

5.1.3.1 Test samples. Sufficient quantity of test samples or test parts shall be distributed within the load to represent carburizing and subsequent hardening conditions of the parts.

5.1.3.1.1 Sample material. Unless otherwise specified, samples shall be of same material as the parts being processed.

5.1.3.1.2 Sample configuration. Unless otherwise specified, samples shall be approximately the same cross sectional area and shape of parts being processed. Fracture test washer, figure 1, and load washer, figure 2, represent typical samples suitable for use in most instances.

5.2 Dimensional controls. Factors other than part shape and size that affect dimensions are:

a. Residual stresses in part prior to heat treatment.
b. Stresses induced by nonuniform heat treatment.
c. Methods of loading or fixturing parts during carburizing and hardening.
d. Growth of surfaces during carburizing.
e. Quench media temperature and severity of quench.
f. Microstructure developed in case.
g. Base chemical composition of steel.

5.2.1 Cold treatment. When specified, parts shall be subjected to a cold treatment (sub-zero) as soon as possible after quenching to enhance the transformation of austenite and provide a stable microstructure. Parts shall be cooled in a freezer to a temperature within the range -90^{o} to -150^{o}F (-68^{o} to -101^{o}C) and held for one hour minimum. Upon removal from the cold chamber, the parts shall be allowed to heat up to room temperature and then tempered to the specified surface (case) hardness.

5.3 Copper plate removal. Plating shall be removed by immersing parts in a copper stripping solution consisting of 4 pounds Chromic acid, 5 fluid ounces Sulfuric acid, and water to make 1 gallon. Time of immersion in the solution and the temperature of solution shall be such to permit complete removal of plating without promoting the tendency towards hydrogen embrittlement. Other means of copper stripping eliminating the need for baking, may be used provided approval is received prior to rise (see 6.4).

Caution Note: Stripping shall never be performed by reversing the current in the copper plating bath.

5.3.1 Baking (Stress relief). This process shall be used immediately after copper stripping to eliminate the susceptibility of parts to hydrogen embrittlement. When required, it may also be used to relieve final grinding stresses. The cycle involves heating the parts in the temperature range 275 to 300^{o}F (135^{o} to 150^{o}C) per 2 hours minimum.

5.3.2 Stripping-Tempering option. Upon approval by the accepting Government agency, the processing sequence may be altered to incorporate copper stripping immediately before tempering and the subsequent bake cycle deleted. Sufficient prior testing must substantiate that this modification has no deleterious affect on the part function and quality.

5.3.3 Replating. When specified, parts shall be replated in accordance with 5.1.2.3.1 prior to a subsequent hardening and tempering operation.

5.4 Carbon potential. Carbon potential of the gas carburizing atmosphere and the surface carbon content of the steel shall be specified on the engineering drawing along with the carburizing temperature, cycle and case depth required. Unless otherwise specified, the processor should aim for 0.90 ± .10 percent carbon on the surface.

5.4.1 Carburizing temperature. Unless otherwise specified, the carburizing cycle shall be performed in the temperature range 1550° - 1700°F (843° to 927°C). Most common temperature in commercial practice is 1700°F (927°C).

5.4.2 Control instrumentation. Automatic equipment for sampling and controlling the gas carburizing atmosphere and carbon potential during the cycle are preferred for reliability and reproducibility of results. Commercial units available can be made either as part of the furnace installation or portable. Effectiveness of manually operated devices varies with the skill of the operator.

5.5 Metallurgical parameters. Preference for determining case depth, hardness, and microstructure is to use actual parts for evaluation. If impracticable, test samples (see 5.1.3.1) shall be selected representing the work load.

5.5.1 Case depth. Case depth requirements, total or effective, shall designated on the engineering drawing along with the carburizing and hardening temperatures and cycles. For gears, general practice is to specify effective case depth as measured to Rockwell HRC 50, equivalent at the pitch circle contact point of tooth (see figure 3). Variables affecting the carburizing operation are temperature, time, type of cycle, carbon potential, and the base carbon content of the steel.

5.5.1.1 Measurement of case depth. Method of measurement depends upon the interpretation and reliability of results (see SAE J423).

5.5.1.1.1 Macroexamination. Fracture test washers, figure 1, designed for inclusion in batch loaded furnaces, shall be used for process control. Samples shall be removed periodically during the carburizing cycle and tested as follows to provide a close approximation of the total case depth:

a. Remove washer directly from the carburizing zone and quench immediately in agitated water.
b. Fracture washer at the notched groove.
c. Using a calibrated eyepiece at 20x magnification, Brinell glass or equivalent, measure the perpendicular distance from the carburized surface to the case-core interface. This distance will represent the total case.
d. Repeat steps a, b, and c throughout the cycle until the desired case depth is obtained.

5.5.1.1.2 Chemical method. This is a time consuming method of determining the carbon potential of the furnace atmosphere by analyzing the load washer for percent carbon from the surface to the core. Samples, when properly prepared, machined and analyzed will provide an accurate measurement of case depth. This method may be used to verify a rejectable case structure (see 5.5.3.1).

5.5.1.1.3 Effective case depth. Measurement shall be by either of the following two methods.

5.5.1.1.3.1 Microhardness traverse survey. This method shall be used as the referee method in case of any dispute. Load washer processed through the entire carburizing and hardening cycle with the parts, shall be prepared in accordance with SAE J423 or ASTM E3. Hardness survey shall be conducted in accordance with ASTM E384 from surface to core using an appropriate load and selection of increments to avoid stress deformation between indentations. First impression shall be taken at a point 0.002 inch from the carburized surface. The effective case depth is the perpendicular distance from the finished surface of the case to point of Rockwell HRC50 equivalent.

5.5.1.1.3.2 Microscopic etch. Surface of the test sample (see 5.5.1.1.3.1) shall be chemically etched in a 2 to 5 percent nital solution in accordance with ASTM E407 for a time sufficient to reveal the microstructure. Effective case depth is the distance from the surface to metallographic structures, usually 50 percent martensite which have been shown to be equivalent to Rockwell HRC50.

5.5.2 Hardness.

5.5.2.1 Case. Requirements as specified on the engineering drawing, shall be measured in accordance with ASTM E18 on the finished part and at the location(s) shown. If check locations are not specified, hardness scales chosen shall be such as not to be detrimental to part integrity.

5.5.2.2 Core. Requirements when specified, i.e. gear teeth, will require destructive evaluation and the location to be defined. Unless otherwise specified, break through core determination will not be acceptable.

5.5.3 Microstructure. Metallurgical samples prepared for microhardness survey (see 5.5.1.1.3.1) may be repolished, etched in two (2) percent nital solution, and microstructurally examined at an appropriate magnification to evaluate the case and core structure. Resampling of the load washer or sampling of a part are options for the processor.

5.5.3.1 Case. Criteria for acceptance or rejection of the case shall be determined accordingly:

a. Acceptable. Case structure shall consist of tempered martensite with some random dispersed small carbide. The amount and distribution of carbides below the maximum grind stock removal allowance may vary from a fine dispersion to a maximum amount of dispersed free carbides approaching a network.

b. Rejectable. Case structures shall not evidence any massive carbides or carbide network. Retained austenite which is operator dependent of etching technique, shall when viewed a 500x magnification not be present in deleterious amounts for the part performance characteristics. The percentage as revealed by X-ray diffraction shall be correlated with the visual interpretation. Intergranular type oxidation shall not be evident on any ground or lapped surfaces.

5.5.3.2 Core. Core structure, depending upon the area examined, shall consist of lower carbon martensite with varying degrees of acicular, or blocky, ferrite permitted.

5.6 Finishing operations. Parts processed with machining stock allowance shall, after carburizing and hardening, be finish ground to the specified dimensions. Parts processed as a finish machined product, prior to carburizing and hardening, shall only be capable of being finish lapped to dimensional requirements.

5.7 Surface discontinuities. Unless otherwise specified, all gears shall be magnetic particle inspected in accordance with MIL-H-6868 to verify the acceptance limits in MlPD-G-62439 and other specifications related to the surface integrity. This method shall be used in preference to temper etch inspection (see 5.7.1) for the detection of grinding cracks.

5.7.1 Temper etch. Unless otherwise specified, all gears shall be temper etch inspected in accordance with MIL-STD-867.

5.8 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 other facility acceptable to the acquisition activity. The acquisition activity reserves the right to perform any tests necessary to assure that the product conforms to the requirements of this standard.

5.8.1 Standardization/monitoring of equipment.

5.8.1.1 Temperature uniformity. Prior to carburizing and subsequent heat treatment, the processor shall have the furnaces certified for temperature uniformity in accordance with MIL-H-6875.

5.8.1.2 Thermocouples and furnace instrumentation. The accuracy of temperature measuring and controlling instruments shall be checked at 3 month intervals by comparison test with precision potentiometer type instruments of known accuracy used with a calibrated thermocouple (see AMS 2750). Tests shall be rerun following each redesign or reconstruction of the furnace. The test thermocouple shall be located within 3 inches (76 mm) of the furnace control thermocouple. The check shall be made at a normal working temperature with and without a production load in the furnace. If instruments are replaced or not used during a 3 month interval, they shall be checked before use.

5.8.1.3 Atmosphere control instrumentation. The accuracy of instruments used for analyzing and controlling the carbon potential of furnace atmospheres shall be checked as often as necessary to insure that the equipment is operating properly and shall be calibrated as required.

5.8.1.4 Hardness testing facilities. The accuracy of test equipment used to determine the microhardness traverse and the case and core hardness shall be checked as often as necessary in accordance with ASTM E18 and ASTM E384, respectively, to ensure the equipment is operating properly and shall be calibrated as required.

5.8.2 Technique approval.

5.8.2.1 Process data. Written procedures shall be established for processing the parts in accordance with the engineering requirements. The results of inspection shall at all times be correlated with the procedures to determine processing trends.

5.8.2.2 Preproduction sample. Unless otherwise specified, sufficient number of parts representing the processing procedure shall be evaluated for conformance to the specified requirements by the processor and accepting Government agency. These parts may be selected from the first production heat treat lot unless prohibited by the Government representative.

5.8.2.3 Acceptance criteria. In case of dispute relative to metallurgical parameters (see 5.5) as measured or observed on test samples (figures 1 and 2), lot acceptance shall be based on part conformance as evaluated by destructive analysis.

5.9 Rejection, retest, rework.

5.9.1 Rejection. Failure of a test sample or part to meet the specified requirements after carburizing and subsequent heat treatment, shall be cause for rejection and subject to disposition by the Government agency for retest or rework.

5.9.2 Retest. Failure of any retest samples or parts to meet the specified requirements, shall be cause for rejection with no additional testing being permitted.

5.9.3 Rework. Samples or parts not complying with the specified requirements (see 5.9.1) shall, with Government approval, be reprocessed to correct deficiencies attributable to the process. Part shall not be recarburized more than once.

5.10 Records retention.

5.10.1 Furnaces. Furnace certifications made in accordance with MIL-H-6875 shall be made available upon reasonable notice, to the Government representative.

5.10.2 Test equipment. Maintenance records for the instrumentation used for analyzing and controlling the carbon potential of the furnace atmosphere and hardness testing shall be made available upon reasonable notice to the Government representative.

5.10.3 Heat treat processing log. Unless otherwise specified, the processor shall maintain a log showing the following information:

a. Purchase order number.
b. Part number with latest revision by date.
c. Type material, certification provided.
d. Metallurgical requirements.
   Carburizing cycle
   Hardening cycle
   Quenching cycle
   Case depth (total or effective) and location
   Hardness (case/core, if specified) and location
   Cold treatment (if specified)
e. Quantity submitted (including test parts and samples).
f. Lot identity.
g. Furnaces used, work order number assigned by date.
h. Processing data.
   Temperature(s) Carburizing/Hardening
   Time(s) Carburizing/Hardening
   Atmosphere(s) Carburizing/Hardening
   Quench media
   Tempering temperature
i. Results of evaluation (test part or sample).
   Case depth
   Case/core hardness
   Case/core microstructure

5.10.3.1 Log retention. Retention of the log shall be agreed upon between the processor and accepting Government agency for not less than 2 years.

5.11 Reports of inspection. Unless otherwise specified, the processor shall furnish certified documentation in triplicate to the Government agency, listing the purchase order number, part number, number of parts, date processed, processing work order number, and results of evaluation on test parts or samples.

5.11.1 Government evaluation samples. Unless otherwise specified, the processor shall submit duplicate test parts or samples (see 5.1.3.1) for Government verification of the following conditions:

a. Fracture washer, carburized and water quenched.
b. Load washer, carburized, hardened and tempered to specified requirements.

5.12 Marking.

5.12.1 Identification control.

5.12.1.1 Serialized parts. For purposes of traceability, permanent marking shall be performed at all stages of operation from receipt of raw material to completion of the finished part. Method of identification, (see AS 478) regardless of type, shall be on noncritical surfaces.

5.12.1.2 Acceptable parts. Parts which conform satisfactorily to applicable inspection requirements shall be marked in a manner and location harmless to the part and which will preclude removal, smearing, or obliteration by subsequent handling. When subsequent processing which would remove identification is planned, the applicable symbol shall be affixed to the records accompanying the parts.

6. NOTES

6.1 Furnace restrictions.

6.1.1 Atmosphere. Furnaces designed for and allocated to the gas carburizing or hardening processes, shall be restricted for that purpose only. Use of ammonia in the furnace atmosphere shall at no time be permitted.

6.1.2 Temperature. Furnaces designed for gas carburizing at the temperatures specified in 5.4.1 should not be used for high temperature gas carburizing.

6.2 Personnel. Gas carburizing and heat treatment of parts in accordance with this standard shall be subject to control and regulation by competent personnel as may be necessary during the process to produce the specified properties.

6.3 Deviations. Based on the chemistry of the parts being processed, high side versus low side heat analysis, coupled with variables in the carburizing and hardening cycle, deviations can occur affecting the case depth and core hardness tolerances. Those deviating from the specification shall be subject to arbitration and disposition by the accepting Government agency.

6.4 Copper plate removal. At the discretion of the plating source and concurrence from the acquisition activity, copper plate may be removed by immersing in an alkaline solution known commercially as Enstrip C, manufactured by Enthone Inc., New Haven, Connecticut 06508. Details on the process and disposal of the waste solutions are available on request. Use of Enstrip C eliminates the need for post baking operations.

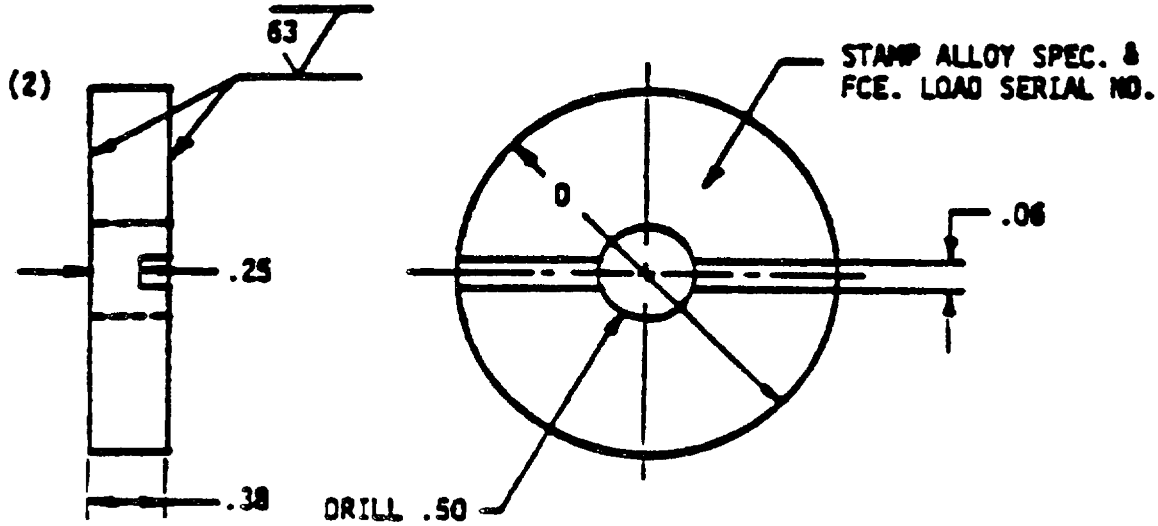


Figure 1. Fracture Washer

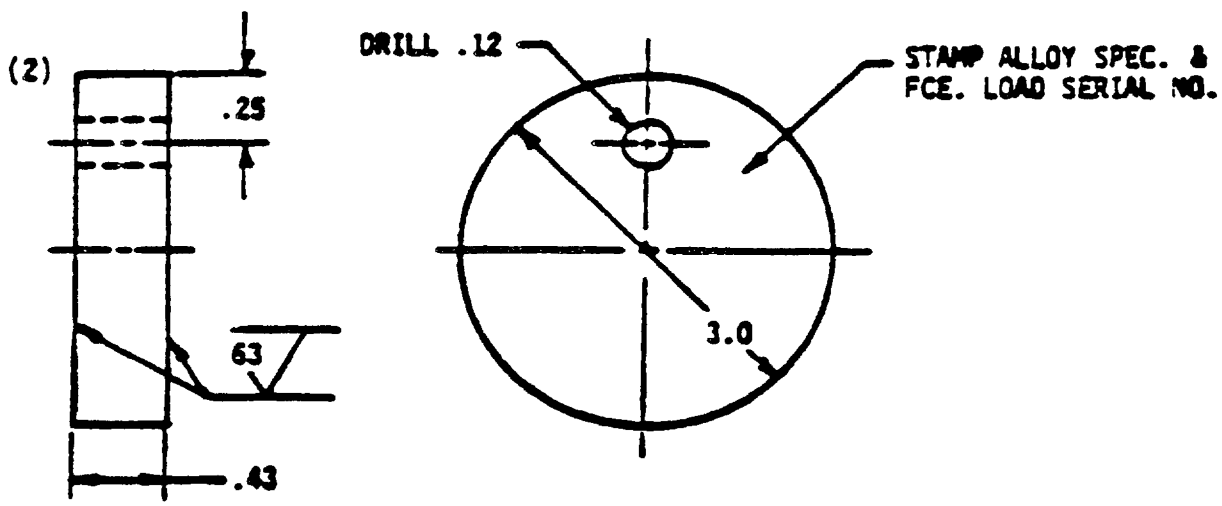
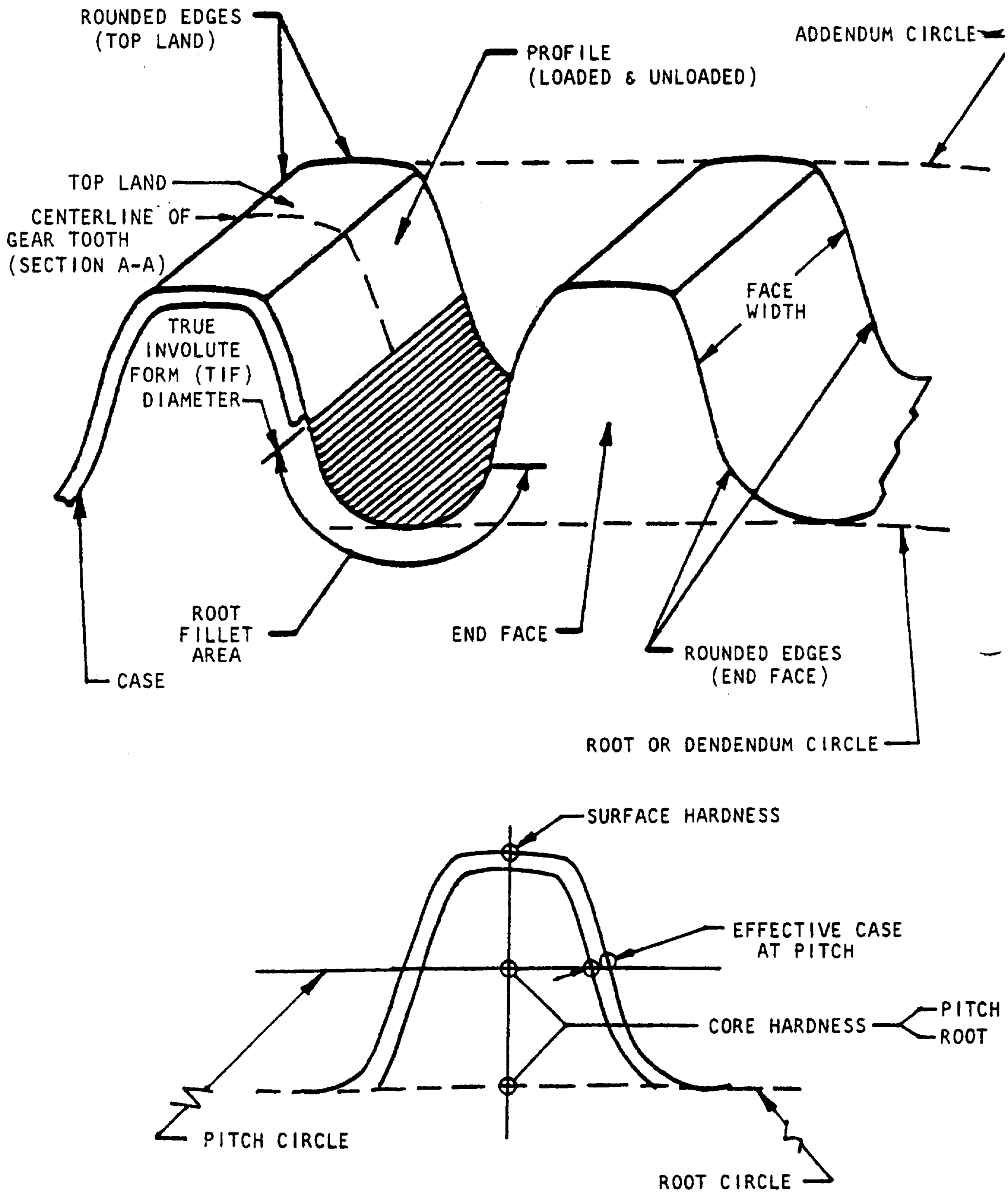


Figure 2. Load Washer

Note:

1. **Diameter D may be either 1.25 or 1.50**

(2) **Break both OD edges 0.03 x 45°**



SECTION A-A

FIGURE 3. Tooth nomenclature.

TABLE I. Carburized case depth stock allowance.

Diametrical pitch (3)	Case depth range (inch) (2)	Grinding stock allowance (inch)
20.00 - 24.99	.010 - .015	.0005 - .0025
16.00 - 19.99	.012 - .018	.0010 - .0030
13.00 - 15.99	.014 - .022	.0020 - .0040
(1)	.016 - .024	.0025 - .0045
9.00 - 12.99	.018 - .028	.0030 - .0050
(1)	.024 - .036	.0035 - .0055
6.00 - 8.99	.028 - .040	.0040 - .0060
4.00 - 5.99	.038 - .050	.0045 - .0065
(1)	.045 - .060	.0050 - .0070
3.00 - 3.99	.050 - .065	.0060 - .0085
2.40 - 2.99	.060 - .075	.0070 - .0095

Notes:

(1) Non-standard ranges to be used only with permission of the procuring activity.

(2) The acceptable total carburized case depth on splines which are not finish ground shall be the engineering drawing case thickness plus the applicable machining stock allowance.

(3) Diametral Pitch $(P_d) = \frac{(N_G)\ \text{Number of teeth}}{(D)\ \text{Diameter of pitch circle}}$

Custodian:
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Project No. MFFP-A260

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STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE

3a. NAME OF SUBMITTING ORGANIZATION	4. TYPE OF ORGANIZATION *(Mark one)*
	☐ VENDOR ☐ USER ☐ MANUFACTURER ☐ OTHER *(Specify)*: ______
b. ADDRESS *(Street, City, State, ZIP Code)*	

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional	*b.* WORK TELEPHONE NUMBER *(Include Area Code)* – Optional
c. MAILING ADDRESS *(Street, City, State, ZIP Code)* – Optional	8. DATE OF SUBMISSION *(YYMMDD)*

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