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SUPERSEDING
(see 6.1)

MILITARY HANDBOOK

CRITERIA FOR PREPARATION OF GEAR AND SPLINE ENGINEERING DRAWINGS

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FSC 3020

DEPARTMENT OF DEFENSE
Washington, DC 20301

CRITERIA FOR PREPARATION OF GEAR AND SPLINE ENGINEERING DRAWINGS

MIL-HDBK-400

1. This standardization handbook was developed by the Department of Defense in accordance with established procedure.

2. This publication was approved on 15 January 1985 for printing and inclusion in the Military Standardization Handbook series.

3. This document specifies special requirements and selects those options required for the preparation, interpretation, and revision of gear and spline engineering drawings prepared by or for the Department of Defense.

4. Every effort has been made to reflect current criteria for the various gear and spline types depicted in this handbook.

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 From 1426) appearing at the end of this document or by letter.

FOREWORD

The proper specification of gear and spline data on drawings has been a controversial subject for many years. Gear and spline data depicted on drawings prepared by contractors for the Government has varied considerably. Problems of interpretation have been encountered because of the varied methods of specifying gear and spline data on drawings. The problems have ranged from omission to over-specification of data that impaired the quality and decreased the reliability of secondary procurement parts.

To alleviate gear and spline specification problems, a technical committee, to be known as the USATACOM Gear and Spline Technical Committee, was formed early in 1958. The committee was made up of personnel having known gear and spline talents and product design, manufacturing, tooling, and product assurance.

The objective of the committee was to develop a series of formats to provide necessary guidance for uniform specification of gear and spline data on tank-automotive drawings. The initial set of formats entitled, “STANDARD DATA PRESENTATION FOR GEARS, SPLINES AND SERRATIONS,” was published in September 1958 for use by tank-automotive design activities. Even though the standard data presentation formats had proven their worth as a guide and reference in the establishment of uniform design practice, the formats were not contractually binding. Consequently, the permissible latitude in the method of specifying gear and spline engineering data by defense contractors allowed certain variations and inadequacies to creep into drawings.

In 1965, the committee recognized the need for expanding the scope of gear and spline requirements for preparation of engineering drawings. It was agreed that a harmonious interface of applicable military and industrial standards was needed. A decision was made to prepare a handbook consolidating all the gear and spline drawing preparation requirements under one cover.

As a handbook it provides a convenient means of implementing uniform engineering drawing preparation practices. It further provides regulatory control over various types of gears and splines, assuring adequate specification of data essential to design, competitive procurement, manufacture, and acceptance of gear and spline components for the Department of Defense (DoD).

In addition, the handbook will serve as a textbook for specialized programs of instruction, for centralized or local training, and as a preparedness measure for accelerated training of Government and contractor personnel during mobilization.

MIL-HDBK-400
NOTICE 1
20 March 1988

MILITARY HANDBOOK

CRITERIA FOR PREPARATION OF GEAR AND SPLINE ENGINEERING DRAWINGS

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NEW PAGE	DAGE	SUPERSEDED PAGE	DATE
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1. SCOPE

1.1 Purpose. The purpose of this handbook is to standardize the specification of gears and splines on engineering drawings and related documents. In so doing, it will clarify interpretation of these items making them more suitable for competitive procurement by both, the Government and prime contractors responsible for the quality of gear products procured under subcontracts.

1.2 Scope. This handbook covers parallel, intersecting, and nonintersecting axes gears, whose respective pitch surfaces of revolution are cylinders, cones and hyperboloida. It limits its coverage of splines to involute, parallel sided and straight nonparallel sided tooth forms. It does not attempt to cover either helical or tapered splines. Coverage of gear and spline types is, however, broad enough to permit adequate specification of special gear and spline configurations by supplementing or modifying comparable types within the scope of this handbook.

1.3 Application. This handbook is applicable to all non engineering drawings and related documents utilized in the procurement of gears and splines. It is intended as a reference guide to be used in bot,h the development of new engineering drawings and related documents, and in the review and/or revision of those already .in existence. It is also applicable to any contract in which it is specifically referenced.

1.4 General. Because this handbook will be. utilized in both the specification of new gears and splines as well as updating of existing data. flexibility is sometimes required for the latter. This flexibility is provided by permitting certain types of data to be considered as non-mandatory in the updating of existing data. The type of data under discussion is data not absolutely essential to the manufacture and inspection of the product. While this data may be very helpful in the expansion or alteration of product application by the design engineer. it is often difficult to obtain. Original design criteria and calculations required to establish this data are frequently no longer available. Gear and spline design sheets, formulas. and tables were included in this pamphlet primarily for new designs. However. the user will find them convenient for reestablishing design criteria required for updating existing gear and spline specifications.

1.5 Cost reduction techniques. The use of cost reduction techniques in engineering drawing preparation maybe used when these techniques do not impair the reproducibility quality of MIL-M-9868, clarity and design disclosure requirements for the kind(s) and levels of engineering drawings being prepared. Specifically, techniques currently identified as photographic drafting and use of permanently adhering, non-fading, front printed and mounted decals and paste-ons for repetitive features should be used to the maximum extent practicable.

1.6 Policy Engineering drawings or related documents released and/or approved for the competitive procurement of gears and splines by DoD shall be complete in their specification of data. Nomenclature, characteristics, and methods of delineating gear and spline specifications shall be in accordance with the instructions for each type(s) of gear or spline within the scope of this handbook. Minimum acceptable data required will vary with the function and quality characteristics considered necessary for the particular application. In all instances, additional data may be specified when required. Delineation of additional data shall be in accordance with the requirements specified within the scope of this handbook. In updating an existing drawing, it will not be necessary to alter the drawing to make it look like the data requirements of this handbook. On the other hand, it will be necessary to add omissions of data required as minimum, identify reference data, correct finity of dimensioning, and update nomenclature.

1.7 Objective. The specification of gear and spline data has been subjected to considerable controversy in the use of terminology, and in the specification of both insufficient and excessive data. Such inconsistencies make truly competitive procurement impossible. It is the objective of this handbook to overcome or alleviate this problem.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. Unless otherwise specified, the following specifications, standards, and handbooks of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DoDISS) specified in the solicitation form a part of this specification to the extent specified herein.

SPECIFICATIONS

FEDERAL

DOD-D-1000	- Drawings, Engineering and Associated Lists.
GGG-W-366	- Wire, Measuring; Gear, Thread, and General Purpose.

MILITARY

MIL-M-9868	- Microfilming of Engineering Documents, 35mm.

STANDARDS

FEDERAL

DOD-STD-100	- Engineering Drawing Practices.

MILITARY

MIL-STD-45662	- Calibration Systems Requirements.

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

2.2 Other publications. The following document(s) form a part of this specification to the extent specified herein. The issues of the documents which are indicated as DoD adopted shall be the issue listed in the current DoDISS and the supplement thereto, if applicable.

AMERICAN GEAR MANUFACTURERS ASSOCIATION (AGMA)

341.02	- System Design of General Industrial Coarse-Pitch Cylindrical Worm Gearing.
342.02	- System Design of General Industrial Double-Enveloping Wormgears.
374.04	- Design for Fine-Pitch Worm Gearing.
390.03	- Gear Handbook Volumn I, DoD Adopted.

(Application for copies of AGMA publications should be addressed to the American Gear Manufacturers Association. 1901 North Ft. Myer Drive, Arlington VA 22209.)

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

B92.1	- Involute Splines and Inspection DoD Adopted.
Y14.5	- Dimensioning and Tolerancing DoD Adopted.

(Application for copies of ANSI publications should be addressed to American National Standards Institute, 1430 Broadway, New York, NY 10018.)

(Industry association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

3. DEFINITIONS

3.1 Definitions (gearing). For the purpose of this standard, all definitions and terminology relative to gearing, not shown, shall be as defined in the reference AGMA publication, Glossary - Terms Used in Gearing.

4. GENERAL REQUIREMENTS

4.1 Organization. The overall organization of the handbook is described in "CONTENTS". It will be noted that criteria used to classify the gears generally is based on the gear axis of rotation with respect to its mating applications. Paragraphs 5.1 through 5.8.18.5 contain specification requirements for gears in these general classifications. Splines, on the other hand, are classified by tooth form. Paragraphs 5.9 through 5.14.8.2 contain specification requirements for splines in these general classifications. Each gear or spline type begins with a table of contents for gears or splines by types within each general classification. Specifications peculiar to a specific type of gear or spline will be found in the general paragraphs at the beginning of each gear or spline type.

5. DETAILED REQUIREMENTS

5.1 Minimum drawing data for parallel axes gears.

5.1.1 General. This section contains minimum drawing data specifications for the ten types of parallel axes gears listed in the table of contents.

5.1.1.1 Interpretation. Lower case letters are used to present instructional text. Nomenclatures and characteristics required for drawing data presentation are depicted in capital letters.

5.1.1.2 Section organization. The following paragraph subdivision numbering sequence is typical throughout the section:

5.1.X.1 "Instructions to the designer" contains a complete drawing specification check list. It delineates the minimum requirements and provides an index of additional gear characteristics when required.

5.1.X.2 "View delineation" is intended to depict those gear characteristics that define the overall dimensions of the gear blank.

5.1.X.3 "Data specification" delineates the nomenclature and method of listing gear data, notes, and references in a uniform manner for each type of gear.

5.1.X.4 "Sectional view" introduces the method of clearly defining the major characteristics of a gear that previously presented problems of specification and interpretation. The tooth section definitizes the minimum and maximum profile control diameters and provides a precise method of listing tooth thickness at a specific diameter.

5.1.1.3 Special gear applications. Parallel axes gearing is used in special applications such as spiral gears and clutch gear splines.

5.1.1.3.1 Spiral gears. When helical gears are used to drive crossed-axes nonintersecting shafts, they are called "spiral" gears. Drawing information for spiral gears is detailed in 5.8.

5.1.1.3.2 "Clutch Gear" splines. Clutch gears are in reality splines that transmit motion to a shaft on an intermittent basis. Drawing specifications for this type of gear application are detailed in 5.9.1.4.

5.1.1.4 Appendix. Additional information required for the preparation of gear drawings is provided in the appendix.

5.1.1.4.1 Drawing examples. To assist the designer in the interpretation of the requirements of this handbook, several examples of drawings are included in the appendix. These sample drawings shall be construed as informational only. They are complete to the degree necessary to illustrate a condition. Actual drawings shall conform to textual requirements set forth in this handbook.

5.1.1.4.2 Measuring wires/balls. Specification of measuring wires or balls on drawings shall be to those sizes listed in the appendix.

5.1.1.4.3 Involute roll angle table. Involute profile controls require the specification of roll angles, as in profile charts. A table of roll angles is included in the appendix to aid in roll angle selection.

5.1.1.5 Mating gear part number. All gear drawings shall reference the originally designed mating gear part number under gear reference data as shown:

DESIGNED TO MATE WITH PART NUMBER. . . XXXXXXXXX

5.1.1.5.1 Exceptions. When a gear is used as an idler or planet gear, mounting center distances and part numbers of both mating gears shall be denoted under gear reference data. Whenever a gear of an existing design is used in another design set, the new mating part number shall not be added to the original gear drawing as an additional mating part number. However, the new design shall reference its mating part number as specified in 5.1.1.5.

5.1.1.6 Heat treat/finishing allowances. Dimensions and tolerances specified on drawings shall define the end item after heat treatment and finishing processes. These dimensions and tolerances shall be interpreted as final acceptance criteria.

5.1.2 External involute spur gear data (standard center distance).

5.1.2.1 Instructions to the designer.

5.1.2.1.1 Mandatory drawing requirements. Engineering drawings for this type of gear shall specify the following:

a. View delineation (see 5.1.2.2).
b. Sectional view (see 5.1.2.3).
c. Data specification (see 5.1.2.4).
d. Gear mounting characteristics as selected from 5.2.2.
e. Chamfers, radii, and fillets as selected from 5.2.3.
f. Additional data selected from Mandatory review below.
g. Material specification.
h. Heat treat specification as required.
i. Finish notes (e.g. plating, etc.)
j. Other notes as required.

5.1.2.1.1.1 Mandatory review. The designer will review the following paragraphs for methods of specifying additional gear characteristics when required.

5.2.4 Profile Charts.
5.2.5 Lead Charts.
5.2.6 Crowns.
5.2.7 Basic Rack Generatrix.
5.2.8 Index Tolerances.
5.2.9 Composite Tolerances.
5.2.10 Fine Pitch Gears.

5.1.2.2 View delineation. For clarity of interpretation, the following gear characteristics shall be delineated as shown in figure 1a.

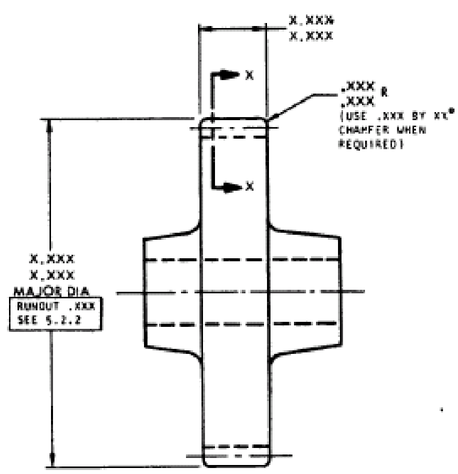


FIGURE 1a. External involute spur gear data (standard center distance).

5.1.2.3 Data specification. Minimum data and nomenclature requirements shall be specified as listed below:

EXTERNAL INVOLUTE SPUR GEAR DATA
(STANDARD CENTER DISTANCE)

NUMBER OF TEETH ____________________ XX
MINOR (ROOT) DIAMETER ____________________ X.XXX/X.XXX
MEASUREMENT OVER TWO .XXXXX DIAMETER WIRES
(OPTIONAL MEASUREMENT OF ARC TOOTH THICKNESS)____________ X.XXXX/X.XXXX
RUNOUT TOLERANCE OVER. XXX XX DIAMETER WIRE TO [ ] _______ .XXXX
PROFILE TOLERANCE ____________________ .XXXX
LEAD TOLERANCE ACROSS FACE WIDTH____________________.XXXX
PITCH (TOOTH-TO-TOOTH SPACING) TOLERANCE ____________________ .XXXX

GEAR NOTES

A. INVOLUTE PROFILE MUST BLEND WITH FILLET AND/OR APPROXIMATE RADIUS AT OR BELOW FORM DIAMETER SHOWN. NO STEP PERMITTED.
B. CHAMFERS, RADII, OR DEBURRING MUST NOT EXTEND BELOW PROFILE MAJOR DIAMETER AS SHOWN.
C. ALL TOOTH ELEMENT SPECIFICATIONS OF GEAR ARE RELATIVE TO MOUNTING DATUM [ ] .

GEAR REFERENCE DATA

DIAMETRAL PITCH ____________________ XX
PRESSURE ANGLE ____________________ XX°
BASE DIAMETER ____________________ X.XXXXXXX
MOUNTING CENTER DISTANCE ____________________ X.XXXX/X.XXXX
DESIGNED TO MATE WITH PART NUMBER ____________________ XXXXXXXX

GENERAL NOTES

a. Dimensional values are indicated by X’s to indicate units or the number of decimal places recommended in each instance.
b. When diametral pitch is not a whole number, it shall be shown to seven decimal places.
c. Add AGMA Quality/Class number under "GEAR REFERENCE DATA", when applicable.
d. Requirements of paragraphs 5.1.1.5 and 5.1.1.5.1 shall apply.

5.1.2.4 Sectional view. Tooth section and methods of delineating the gear characteristics shown in figure 1b are mandatory.

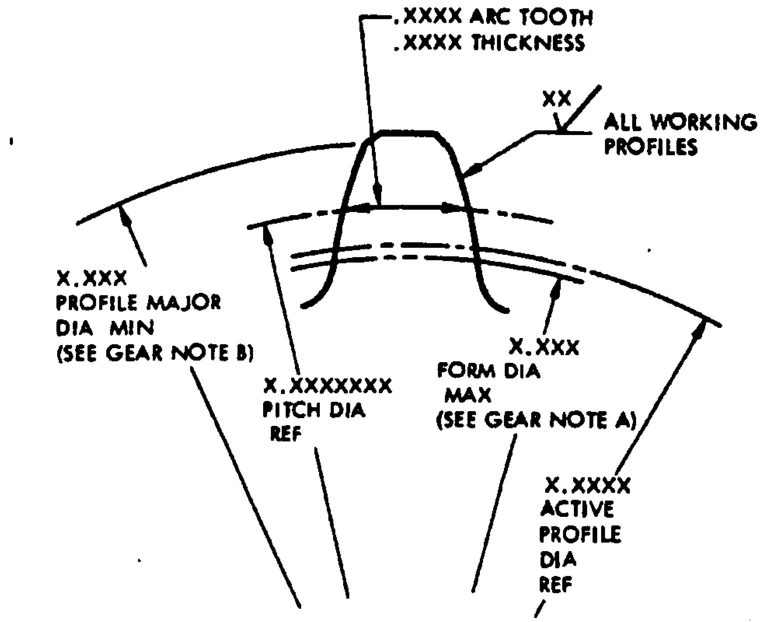


FIGURE 1b. Section X-X.

5.1.2.4.1 Applicable requirement. The cutting planet shown on figure 1a, shall appear on the same sheet as the sectional view shown above and both shall be identified with the same alphabetical series letter.

5.1.3 External involute spur gear data (nonstandard center distance).

5.1.3.1 Instructions to the designer.

5.1.3.1.1 Mandatory drawing requirements. Engineering drawings for this type of gear shall specify the following:

a. View delineation (see 5.1.3.2}.
b. Sectional view (see 5.1.3.3}.
c. Data Specification (see 5.1.3.4}.
d. Gear mounting characteristics as selected from 5.2.2.
e. Chamfers, radii, and fillets as selected from 5.2.3.
f. Additional data selected from Mandatory review below.
g. Material specification.
h. Heat treat specification as required.
i. Finish notes (e.g. plating, etc.}.
j. Other notes as required.

5.1.3.1.1.1 Mandatory review. The designer will review the following paragraphs for methods of specifying additional gear characteristics when required:

5.2.4 Profile Charts.
5.2.5 Lead Charts.
5.2.6 Crowns.
5.2.7 Basic Rack Generatrix.
5.2.8 Index Tolerances.
5.2.9 Composite Tolerances.
5.2.10 Fine Pitch Gears.

5.1.3.2 View delineation. For clarity of interpretation, the following gear characteristics shall be delineated as shown in figure 2a.

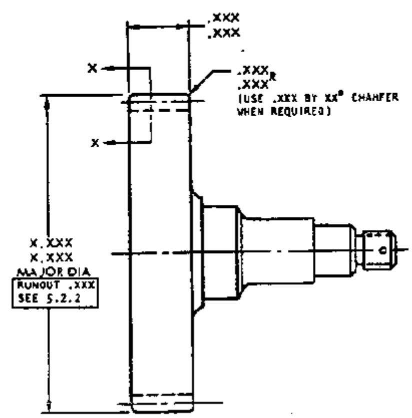


FIGURE 2a. External involute spur gear (nonstandard center distance).

5.1.3.3 Data specification. Minimum data and nomenclature requirements shall be specified as listed below.

EXTERNAL INVOLUTE SPUR GEAR DATA
(NON-STANDARD CENTER DISTANCE)

NUMBER OF TEETH	XX
MINOR (ROOT) DIAMETER	X.XXX/X.XXX
MEASUREMENT OVER TWO .XXXXX DIAMETER WIRES (OPTIONAL MEASUREMENT OF ARC TOOTH THICKNESS)	X.XXXX/X.XXXX
RUNOUT TOLERANCE OVER .XXXXX DIAMETER WIRE TO ☐	.XXXX
PROFILE TOLERANCE	.XXXX
LEAD TOLERANCE ACROSS FACE WIDTH	.XXXX
PITCH (TOOTH-TO-TOOTH SPACING) TOLERANCE	.XXXX

GEAR NOTES

A. INVOLUTE PROFILE MUST BLEND WITH FILLET AND/OR APPROXIMATE RADIUS AT OR BELOW FORM DIAMETER SHOWN. NO STEP PERMITTED.
B. CHAMFERS, RADII, OR DEBURRING MUST NOT EXTEND BELOW PROFILE MAJOR DIAMETER AS SHOWN.
C. ALL TOOTH ELEMENT SPECIFICATIONS OF GEAR ARE RELATIVE TO MOUNTING DATUM ☐ .

GEAR REFERENCE DATA

DIAMETRAL PITCH	XX
PRESSURE ANGLE	XX°
BASE DIAMETER	X.XXXXXXX
OPERATING PRESSURE ANGLE	XX.XXXXXXX°
OPERATING PITCH DIAMETER	X. XXXXXXX
OPERATING CENTER DISTANCE	X.XXXX/X.XXXX
DESIGNED TO MATE WITH PART NUMBER	XXXXXXXX

GENERAL NOTES

a. Dimensional values are indicated by X's to indicate units or the number of decimal places recommended in each instance.
b. When diametral pitch is not a whole number, it shall be shown to seven decimal places.
c. Add AGMA Quality/Class number under "GEAR REFERENCE DATA", when applicable.
d. Requirements of paragraphs 5.1.1.5 and 5.1.1.5.1 shall apply.

5.1.3.4 Sectional view. Tooth section and methods of delineating the gear characteristics shown in figure 2b are mandatory.

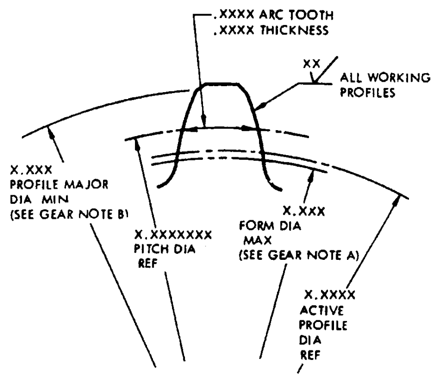


FIGURE 2b. Section X-X.

5.1.3.4.1 Applicable requirement. The cutting plane, shown on figure 2a, shall appear on the same sheet as the sectional view shown above and both shall be identified with the same alphabetical series letter.

5.1.4 External involute helical gear data (standard center distance).

5.1.4.1 Instructions to the designer.

5.1.4.1.1 Mandatory drawing requirements. Engineering drawings for this type of gear shall specify the following:

a. View delineation (see 5.1.4.2).
b. Sectional view (see 5.1.4.3).
c. Data specification (see 5.1.4.4).
d. Gear mounting characteristics as selected from 5.2.2.
e. Chamfers, radii, and fillets as selected from 5.2.3.
f. Additional data selected from Mandatory review below.
g. Material specification.
h. Heat treat specification as required.
i. Finish notes (e.g. plating, etc.).
j. Other notes as required.

5.1.4.1.1.1 Mandatory review. The designer will review the following paragraphs for methods of specifying additional gear characteristics when required:

5.2.4 Profile Charts.
5.2.5 Lead Charts.
5.2.6 Crowns.
5.2.7 Basic Rack Generatrix.
5.2.8 Index Tolerances.
5.2.9 Composite Tolerances.
5.2.10 Fine Pitch Gears.

5.1.4.2 View delineation. For clarity of interpretation, the following gear characteristics shall be delineated as shown in figure 3a.

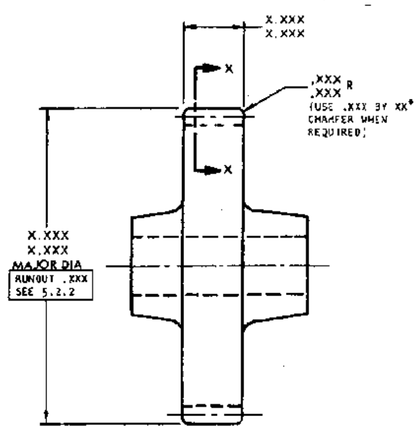


FIGURE 3a. External involute helical gear data (standard center distance).

5.1.4.3 Data specification. Minimum data and nomenclature requirements shall be specified as listed below.

EXTERNAL INVOLUTE HELICAL GEAR DATA
(STANDARD CENTER DISTANCE)

NUMBER OF TEETH ____ XX
HAND OF HELIX ____ XX
MINOR (ROOT) DIAMETER ___________________________________ X.XXX/X.XXX
MEASUREMENT OVER ___*___ .XXXXX DIAMETER WIRE
(OPTIONAL MEASUREMENT OF ARC TOOTH THICKNESS) _________ X.XXXX/X.XXXX
RUNOUT TOLERANCE OVER .XXXXX DIAMETER WIRE TO [ ] _____ .XXXX
PROFILE TOLERANCE ____ .XXXX
LEAD TOLERANCE ACROSS FACE WIDTH __________________________ .XXXX
PITCH (TOOTH-TO-TOOTH SPACING) TOLERANCE __________________ .XXXX

GEAR NOTES

A. INVOLUTE PROFILE MUST BLEND WITH FILLET AND/OR APPROXIMATE RADIUS AT OR BELOW FORM DIAMETER SHOWN. NO STEP PERMITTED.
B. CHAMFERS. RADII, OR DEBURRING MUST NOT EXTEND BELOW PROFILE MAJOR DIAMETER AS SHOWN.
C. ALL TOOTH ELEMENT SPECIFICATIONS OF GEAR ARE RELATIVE TO MOUNTING DATUM [ ] .

GEAR REFERENCE DATA

DIAMETRAL PITCH (NORMAL) _________________________________ XX
PRESSURE ANGLE (NORMAL) __________________________________ XX°
HELIX ANGLE ____ XX.XXXXXXX°
BASE DIAMETER ____ X.XXXXXX
LEAD ____ XX.XXXXXXX
MOUNTING CENTER DISTANCE _________________________________ X.XXXX/X.XXXX
DESIGNED TO MATE WITH PART NUMBER _________________________ XXXXXXXX

GENERAL NOTES

a. Dimensional values are indicated by X's to indicate units or the number of decimal places recommended in each instance.
b. When diametral pitch is not a whole number, it shall be shown to seven decimal places.
c. Add AGMA Quality/Class number under "GEAR REFERENCE DATA", when applicable.
d. Requirements of paragraphs 5.1.1.5 and 5.1.1.5.1 shall apply.

*Indicate one wire for odd number of teeth or two wires for even number of teeth.

5.1.4.4 Sectional view. Tooth section and methods of delineating the gear characteristics shown in figure 3b are mandatory.

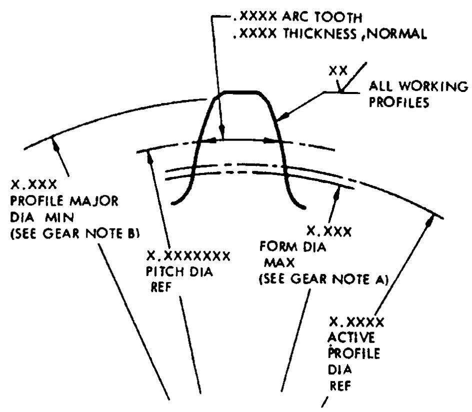


FIGURE 3b. Section X-X.

NOTE: TOOTH THICKNESS NOT IN TRANSVERSE PLANE.

5.1.4.4.1 Applicable requirement. The cutting planet shown on figure 3a, shall appear on the same sheet as the sectional view shown above and both shall be identified with the same alphabetical series letter.

5.1.5 External involute helical gear data (nonstandard center distance).

5.1.5.1 Instructions to the designer.

5.1.5.1.1 Mandatory drawing requirements. Engineering drawings for this type of gear shall specify the following:

a. View delineation (see 5.1.5.2).
b. Sectional view (see 5.1.5.3).
c. Data specification (see 5.1.5.4).
d. Gear mounting characteristics as selected from 5.2.2.
e. Chamfers, radii, and fillets as selected from 5.2.3.
f. Additional data selected from Mandatory review below.
g. Material specification.
h. Heat treat specification as required.
i. Finish notes (e.g. plating, etc.).
j. Other notes as required.

5.1.5.1.1.1 Mandatory review. The designer will review the following paragraphs for methods of specifying additional gear characteristics when required:

5.2.4 Profile Charts.
5.2.5 Lead Charts.
5.2.6 Crowns.
5.2.7 Basic Rack Generatrix.
5.2.8 Index Tolerances.
5.2.9 Composite Tolerances.
5.2.10 Fine Pitch Gears.

5.1.5.2 View delineation. For clarity of interpretation, the following characteristics shall be delineated as shown in figure 4a.

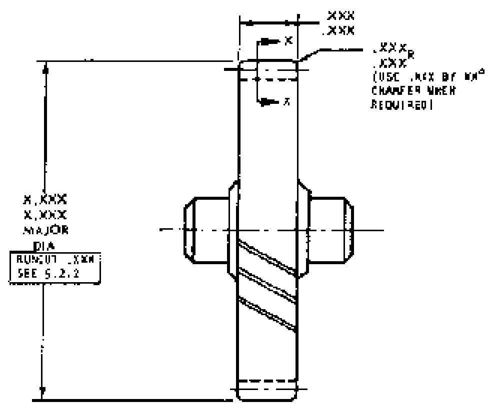


FIGURE 4a. External involute helical gear data (nonstandard center distance).

5.1.5.3 Data specification. Minimum data and nomenclature requirements shall be specified as listed below.

EXTERNAL INVOLUTE HELICAL GEAR DATA
(NONSTANDARD CENTER DISTANCE)

NUMBER OF TEETH ____________ XX
HAND OF HEL IX ____________
MINOR (ROOT) DIAMETER ____________ X.XXX/X.XXX
MEASUREMENT OVER__*__ .XXX XX DIAMETER WIRE
(OPTIONAL MEASUREMENT OF ARC TOOTH THICKNESS) ____________ X.XXXX/X.XXXX
RUNOUT TOLERANCE OVER. XXXXX DIAMETER WIRE TO [ ] ______ .XXXX
PROFILE TOLERANCE ____________ .XXXX
LEAD TOLERANCE ACROSS FACE WIDTH ____________ .XXXX
PITCH (TOOTH-TO-TOOTH SPACING) TOLERANGE ____________ .X XXX

GEAR NOTES

A. INVOLUTE PROFILE MUST BLEND WITH FILLET AND/OR APPROXIMATE RADIUS AT OR BELOW FORM DIAMETER SHOWN. NO STEP PERMITTED.
B. CHAMFERS, RADII, OR DEBURRING MUST NOT EXTEND BELOW PROFILE MAJOR DIAMETER AS SHOWN.
C. ALL TOOTH ELEMENT SPECIFICATIONS OF GEAR ARE RELATIVE TO MOUNTING DATUM [ ].

GEAR REFERENCE DATA

DIAMETRAL PITCH (NORMAL) ____________ XX
PRESSURE ANGLE (NORMAL) ____________ XX°
HELIX ANGLE ____________ XX.XXXXXXX°
BASE DIAMETER ____________ X.XXXXXXX
LEAD ____________ XX.XXXXXXX
OPERATING PRESSURE ANGLE ____________ XX.XXXX°
OPERATING PITCH DIAMETER ____________ X.XXXXXXX
OPERATING CENTER DISTANCE ____________ X.XXXX/X.XXXX
DESIGNED TO MATE WITH PART NUMBER ____________ XXXXXXXX

GENERAL NOTES

a. Dimensional values are indicated by X's to indicate units or the number of decimal places recommended in each instance.
b. When diametral pitch is not a whole number, it shall be shown to seven decimal places.
c. Add AGMA Quality/Class number under "GEAR REFERENCE DATA", when applicable.
d. Requirements of paragraphs 5.1.1.5 and 5.1.1.5.1 shall apply.

*Indicate one wire for odd number of teeth or two wires for even number of teeth.

5.1.5.4 Sectional view. Tooth section and methods of delineating the gear characteristics shown in figure 4b are mandatory.

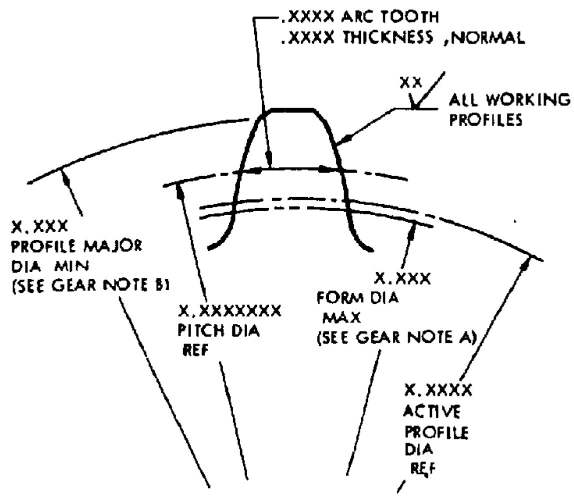


FIGURE 4b. Section X-X.

NOTE: TOOTH THICKNESS NOT IN TRANSVERSE PLANE.

5.1.5.4.1 Applicable requirement. The cutting plane, shown on figure 4a, shall appear on the same sheet as the sectional view shown above and both shall be identified with the same alphabetical series letter.

5.1.6 External involute double helical gear data (standard center distance).

5.1.6.1 Instructions to the designer.

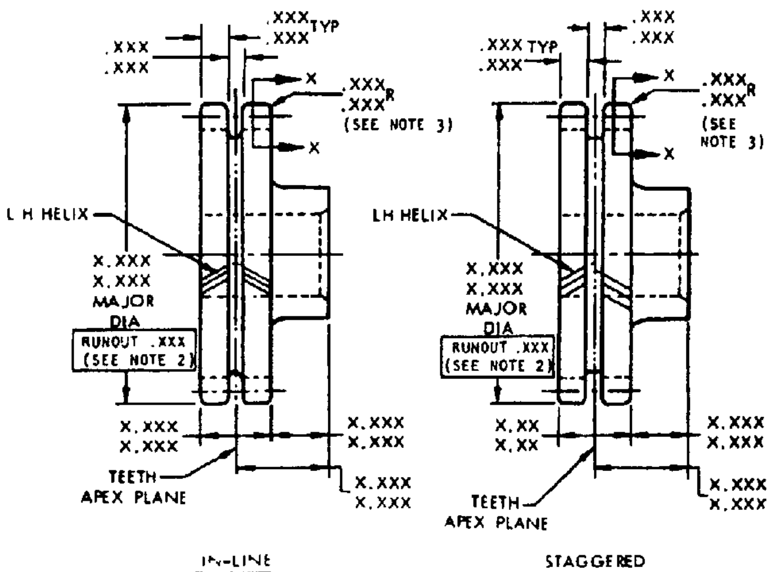
5.1.6.1.1 Mandatory drawing requirements. Engineering drawings for this type of gear shall specify the following:

a. View delineation (see 5.1.6.2).
b. Sectional view (see 5.1.6.3).
c. Data specification (see 5.1.6.4).
d. Gear mounting characteristics as selected from 5.2.2.
e. Chamfers, radii, and fillets as selected from 5.2.3.
f. Additional data selected from Mandatory review below.
g. Material specification.
h. Heat treat specification as required.
i. Finish notes (e.g. plating, etc.).
j. Other notes as required.

5.1.6.1.1.1 Mandatory review. The designer will review the following paragraphs for methods of specifying additional gear characteristics when required:

5.2.4 Profile Charts.
5.2.5 Lead Charts.
5.2.6 Crowns.
5.2.7 Basic Rack Generatrix.
5.2.8 Index Tolerances.
5.2.9 Composite Tolerances.
5.2.10 Fine Pitch Gears.

5.1.6.2 View delineation. For clarity of interpretation, the following gear characteristics shall be delineated as shown in figure 5a.



GEAR NOTES

1. Tooth arrangement shall indicate in-line or staggered teeth on drawing.
2. Select minor diameter runout from gear mounting characteristics paragraph 5.2.2.
3. Use .XXX by .XX° chamfer when required.
4. Where no gap or groove is present at the apex, the gear is called a "Sykes herringbone" gear.

FIGURE 5a. External involute double helical gear data (standard center distance).

5.1.6.3 Data specification. Minimum data and nomenclature requirements shall be specified as listed below.

EXTERNAL INVOLUTE DOUBLE HELICAL GEAR DATA
(STANDARD CENTER DISTANCE)

NUMBER OF TEETH	XX
MINOR (ROOT) DIAMETER	X.XXX/X.XXX
MEASUREMENT OVER __*_ .XXXXX DIAMETER WIRE (OPTIONAL MEASUREMENT OF ARC TOOTH THICKNESS)	X.XXXX/X.XXXX
RUNOUT TOLERANCE OVER .XXXXX DIAMETER WIRE TO [ ]	.XXXX
PROFILE TOLERANCE	.XXXX
LEAD TOLERANCE ACROSS FACE WIDTH	.XXXX
PITCH (TOOTH-TO-TOOTH SPACING) TOLERANCE	.XXXX

GEAR NOTES

A. INVOLUTE PROFILE MUST BLEND WITH FILLET AND/OR APPROXIMATE RADIUS AT OR BELOW FORM DIAMETER SHOWN. NO STEP PERMITTED.
B. CHAMFERS, RADII, OR DEBURRING MUST NOT EXTEND BELOW PROFILE MAJOR DIAMETER AS SHOWN.
C. ALL TOOTH ELEMENT SPECIFICATIONS OF GEAR ARE RELATIVE TO MOUNTING DATUM [ ] .
D. DIFFERENCE BETWEEN LEFT- AND RIGHT-HAND COUNTERPART GEAR TOOTH THICKNESS NOT TO EXCEED .XXXX.
E. INDEX RELATIONSHIP OF LEFT-HAND GEAR TEETH TO THE RIGHT-HAND GEAR TEETH NOT TO EXCEED .XXXX.

GEAR REFERENCE DATA

DIAMETRAL PITCH (NORMAL)	XX
PRESSURE ANGLE (NORMAL)	XX°
HELIX ANGLE	XX.XXXXXXX°
BASE DIAMETER	X.XXXXXXX
LEAD	XX.XXXXXXX
MOUNTING CENTER DISTANCE	X XXXX/X.XXXX
DESIGNED TO MATE WITH PART NUMBER	XXXXXXXX

GENERAL NOTES

a. Dimensional values are indicated by X's to indicate units or the number of decimal places recommended in each instance.
b. When diametral pitch is not a whole number, it shall be shown to seven decimal places.
c. Add AGMA Quality/Class number under "GEAR REFERENCE DATA", when applicable.
d. Requirements of paragraphs 5.1.1.5 and 5.1.1.5.1 shall apply.

*Indicate one wire for odd number of teeth or two wires for even number of teeth.

5.1.6.4 Sectional view. Tooth section and methods of delineating the gear characteristics as shown in figure 5b are mandatory.

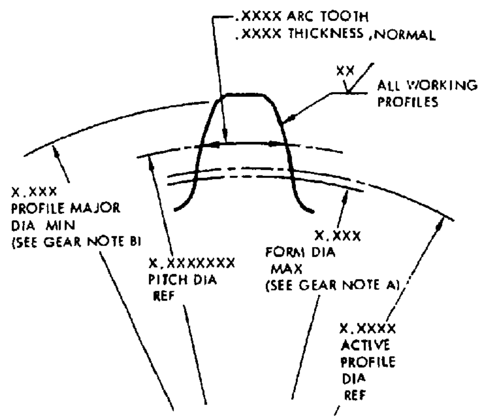


FIGURE 5b. SECTION X-X.

NOTE: TOOTH THICKNESS NOT IN TRANSVERSE PLANE.

5.1.6.4.1 Applicable requirements. The cutting plane, shown on figure 5a, shall appear on the same sheet as the sectional view shown above and both shall be identified with the same alphabetical series letter.

5.1.7 Internal involute spur gear data (standard center distance).

5.1.7.1 Instructions to the designer.

5.1.7.1.1 Mandatory drawing requirements. Engineering drawings for this type of gear shall specify the following:

a. View delineation (see 5.1.7.2).
b. Sectional view (see 5.1.7.3).
c. Data specification (see 5.1.7.4).
d. Gear mounting characteristics as selected from 5.2.2.
e. Chamfers, radii, and fillets as selected from 5.2.3.
i. Additional data selected from Mandatory review below.
g. Material specification.
h. Heat treat specification as required.
i. Finish notes (e.g. plating, etc.).
j. Other notes as required.

5.1.7.1.1.1 Mandatory review. The designer will review the following paragraphs for methods of specifying additional gear characteristics when required:

5.2.4 Profile Charts.
5.2.5 Lead Charts.
5.2.6 Crowns.
5.2.7 Basic Rack Generatrix.
5.2.8 Index Tolerances.
5.2.9 Composite Tolerances.
5.2.10 Fine Pitch Gears.

5.1.7.2 View delineation. For clarity of interpretation, the following gear characteristics shall be delineated as shown in figure 6a.

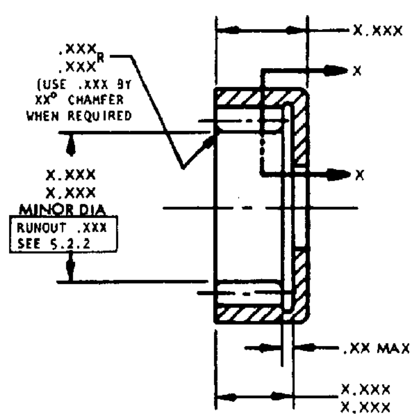


FIGURE 6a. Internal involute spur gear data (standard center distance).

5.1.7.3 Data specification. Minimum data and nomenclature requirements shall be specified as listed below.

NUMBER OF TEETH ______	XX
MAJOR (ROOT) DIAMETER ______	X.XXX/X.XXX
MEASUREMENT BETWEEN TWO .XXXXX DIAMETER WIRES (OPTIONAL MEASUREMENT OF ARC TOOTH THICKNESS) ______	X.XXXX/X.XXXX
RUNOUT TOLERANCE WITH .XXXXX DIAMETER WIRE TO [ ] ______	.XXXX
PROFILE TOLERANCE ______	.XXXX
LEAD TOLERANCE ACROSS FACE WIDTH ______	.XXXX
PITCH (TOOTH-TO-TOOTH SPACING) TOLERANCE ______	.XXXX

GEAR NOTES

A. INVOLUTE PROFILE MUST BLEND WITH FILLET AND/OR APPROXIMATE RADIUS AT OR ABOVE FORM DIAMETER SHOWN. NO STEP PERMITTED.
B. CHAMFERS, RADII, OR DEBURRING MUST NOT EXTEND ABOVE PROFILE MINOR DIAMETER AS SHOWN.
C. ALL TOOTH ELEMENT SPECIFICATIONS OF GEAR ARE RELATIVE TO MOUNTING DATUM [ ] .

GEAR REFERENCE DATA

DIAMETRAL PITCH ______	XX
PRESSURE ANGLE ______	XX°
BASE DIAMETER ______	X.XXXXXX
MOUNTING CENTER DISTANCE ______	X.XXXX/X.XXXX
DESIGNED TO MATE WITH PART NUMBER ______	XXXXXXXX

GENERAL NOTES

a. Dimensional values are indicated by X's to indicate units or the number of decimal places recommended in each instance.
b. When diametral pitch is not a whole number, it shall be shown to seven decimal places.
c. Add AGMA Quality/Class number under "GEAR REFERENCE DATA", when applicable.
d. Requirements of paragraphs 5.1.1.5 and 5.1.1.5.1 shall apply.

5.1.7.4 Sectional view. Tooth section and methods of delineating the gear characteristics shown in figure 6b are mandatory.

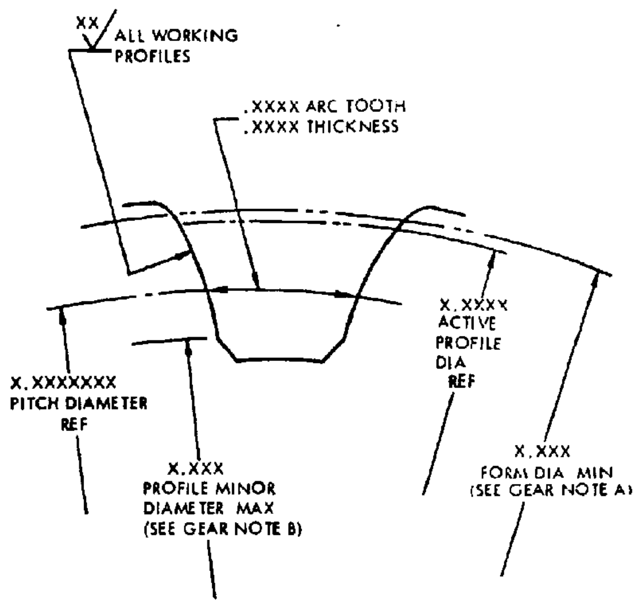


FIGURE 6b. SECTION X-X..

5.1.7.4.1 Applicable requirement. The cutting plane, shown on figure 6a, shall appear on the same sheet as the sectional view shown above and both shall be identified with the same alphabetical series letter.

5.1.8 Internal involute helical gear data (standard center distance).

5.1.8.1 Instructions to the designer.

5.1.8.1.1 Mandatory drawing requirements. Engineering drawings for this type of gear shall specify the following:

a. View delineation (see 5.1.8.2).
b. Sectional view (see 5.1.8.3).
c. Data specification (see 5.1.8.4).
d. Gear mounting characteristics as selected from 5.2.2.
e. Chamfers, radii, and fillets as selected from 5.2.3.
f. Additional data selected from Mandatory review below.
g. Material specification.
h. Heat treat specification as required.
i. Finish notes (e.g. plating, etc.).
j. Other notes as required.

5.1.8.1.1.1 Mandatory review. The designer will review the following paragraphs for methods of specifying additional gear characteristics when required:

5.2.4 Profile Charts.
5.2.5 Lead Charts.
5.2.6 Crowns.
5.2.7 Basic Rack Generatrix.
5.2.8 Index Tolerances.
5.2.9 Composite Tolerances.
5.2.10 Fine Pitch Gears.

5.1.8.2 View delineation. For clarity of interpretation, the following gear characteristics shall be delineated as shown in figure 7a.

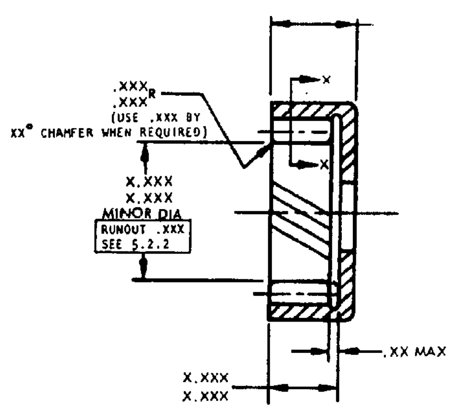


FIGURE 7a. Internal involute helical gear data (standard center distance).

5.1.8.3 Data specification. Minimum data and nomenclature requirements shall be specified as listed below.

INTERNAL INVOLUTE HELICAL GEAR DATA, (STANDARD CENTER DISTANCE)

NUMBER OF TEETH ____	XX
HAND OF HELIX ____	
MAJOR (ROOT) DIAMETER ____	X.XXX/X.XXX
MEASUREMENT BETWEEN TWO .XXXXX DIAMETER BALLS (OPTIONAL MEASUREMENT OF ARC TOOTH THICKNESS) ____	X.XXXX/X.XXXX
RUNOUT TOLERANCE WITH .XXXXX DIAMETER BALL TO ☐ ____	.XXXX
PROFILE TOLERANCE ____	.XXXX
LEAD TOLERANCE ACROSS FACE WIDTH ____	.XXXX
PITCH (TOOTH-TO-TOOTH SPACING) TOLERANCE ____	.XXXX

GEAR NOTES

A. INVOLUTE PROFILE MUST BLEND WITH FILLET AND/OR APPROXIMATE RADIUS AT OR ABOVE FORM DIAMETER SHOWN. NO STEP PERMITTED.
B. CHAMFERS, RADII, OR DEBURRING MUST NOT EXTEND ABOVE PROFILE MINOR DIAMETER AS SHOWN.
C. ALL TOOTH ELEMENT SPECIFICATIONS OF GEAR ARE RELATIVE TO MOUNTING DATUM ☐

GEAR REFERENCE DATA

DIAMETRAL PITCH (NORMAL) ____	XX
PRESSURE ANGLE (NORMAL) ____	.XX°
HELIX ANGLE ____	XX.XXXXXXX°
BASE DIAMETER ____	X.XXXXXXX
LEAD ____	XX.XXXXXXX
MOUNTING CENTER D.ISTANCE ____	X.XXXX/X.XXXX
DESIGNED TO MATE WITH PART NUMBER ____	XXXXXXXX

GENERAL NOTES

a. Dimensional values are indicated by X's to indicate units or the number of decimal places recommended in each instance.
b. When diametral pitch is not a whole number, it shall be shown to seven decimal places.
c. Add AGMA Quality/Class number under "GEAR REFERENCE DATA", when applicable.
d. Requirements of paragraphs 5.1.1.5 and 5.1.1.5.1 shall apply.

5.1.8.4 Sectional view. Tooth section and methods of delineating the gear characteristics as shown in figure 7b are mandatory.

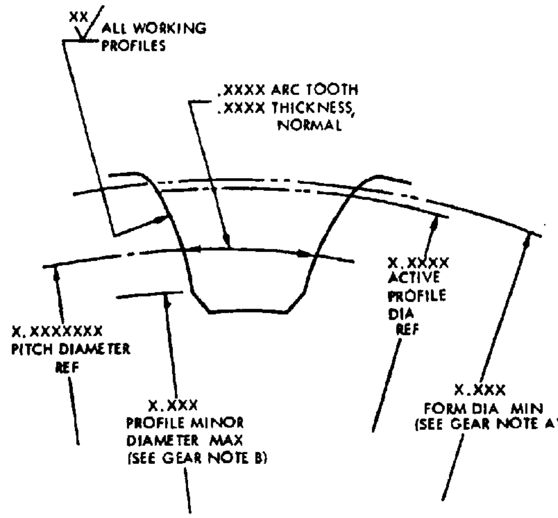


FIGURE 7b. SECTION X-X.

NOTE: TOOTH THICKNESS NOT IN TRANSVERSE PLANE.

5.1.8.4.1 Applicable requirement. The cutting plane, shown on figure 7a, shall appear on the same sheet as the sectional view shown above and both shall be identified with the same alphabetical series letter.

5.1.9 Internal involute double helical gear data (standard center distance).

5.1.9.1 Instructions to the designer.

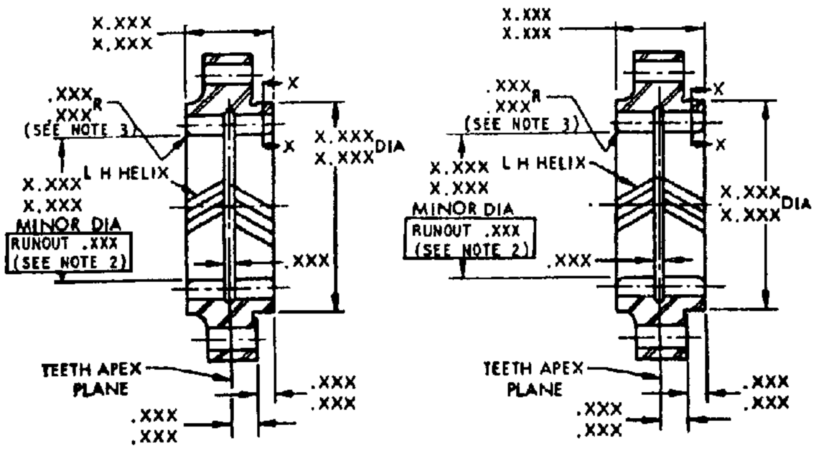
5.1.9.1.1 Mandatory drawing requirements. Engineering drawings for this type of gear shall specify the following:

a. View delineation (see 5.1.9.2).
b. Sectional view (see 5.1.9.3).
c. Data specification (see 5.1.9.4).
d. Gear mounting characteristics as selected from 5.2.2.
e. Chamfers, radii, and fillets as selected from 5.2.3.
f. Additional data selected from Mandatory review below.
g. Material specification.
h. Heat treat specification as required.
i. Finish notes (e.g. plating, etc.).
j. Other notes as required.

5.1.9.1.1.1 Mandatory review. The designer will review the following paragraphs for methods of specifying additional gear characteristics when required:

5.2.4 Profile Charts.
5.2.5 Lead Charts.
5.2.6 Crowns.
5.2.7 Basic Rack Generatrix.
5.2.8 Index Tolerances.
5.2.9 Composite Tolerances.
5.2.10 Fine Pitch Gears.

5.1.9.2 View delineation. For clarity of interpretation, the following gear characteristics shall be delineated as shown in figure 8a.



GEAR NOTES

1. Tooth arrangement shall indicate in-line or staggered teeth on drawing.
2. Select minor diameter runout from gear mounting characteristics paragraph 5.2.2.
3. Use .XXX by XX° chamfer when required.

FIGURE 8a. Internal involute double helical gear data, (standard center distance).

5.1.9.3 Data specification. Minimum data and nomenclature requirements shall be specified as listed below.

INTERNAL INVOLUTE DOUBLE HELICAL GEAR DATA, (STANDARD CENTER DISTANCE)

NUMBER OF TEETH ______	XX
MAJOR (ROOT) DIAMETER ______	X.XXX/X.XXX
MEASUREMENT BETWEEN TWO .XXXXX DIAMETER BALLS (OPTIONAL MEASUREMENT OF ARC TOOTH THICKNESS) ______	X.XXXX/X.XXXX
RUNOUT TOLERANCE WITH .XXXXX DIAMETER BALL TO ☐ ______	.XXXX
PROFILE TOLERANCE ______	.XXXX
LEAD TOLERANCE ACROSS FACE WIDTH ______	.XXXX
PITCH (TOOTH-TO-TOOTH SPACING) TOLERANCE ______	.XXXX

GEAR NOTES

A. INVOLUTE PROFILE MUST BLEND WITH FILLET AND/OR APPROXIMATE RADIUS AT OR ABOVE FORM DIAMETER SHOWN. NO STEP PERMITTED.
B. CHAMFERS, RADII, OR DEBURRING MUST NOT EXTEND ABOVE PROFILE MINOR DIAMETER AS SHOWN.
C. ALL TOOTH ELEMENT SPECIFICATIONS OF GEAR ARE RELATIVE TO MOUNTING DATUM ☐ .
D. DIFFERENCE BETWEEN LEFT- AND RIGHT-HAND COUNTERPART GEAR TOOTH THICKNESS NOT TO EXCEED .XXXX.
E. INDEX RELATIONSHIP OF LEFT-HAND GEAR TEETH TO THE RIGHT-HAND GEAR TEET NOT TO EXCEED .XXXX.

GEAR REFERENCE DATA

DIAMETRAL PITCH (NORMAL) ______	XX
PRESSURE ANGLE (NORMAL) ______	XX°
HELIX ANGLE ______	XX.XXXXXXX°
BASE DIAMETER ______	X.XXXXXXX
LEAD ______	XX.XXXXXXX
MOUNTING CENTER D.ISTANCE ______	X.XXXX/X.XXXX
DESIGNED TO MATE WITH PART NUMBER ______	XXXXXXXX

GENERAL NOTES

a. Dimensional values are indicated by X's to indicate units or the number of decimal places recommended in each instance.
b. When diametral pitch is not a whole number, it shall be shown to seven decimal places.
c. Add AGMA Quality/Class number under "GEAR REFERENCE DATA", when applicable.
d. Requirements of paragraphs 5.1.1.5 and 5.1.1.5.1 shall apply.

5.1.9.4 Sectional view. Tooth section and methods of delineating the gear characteristics as shown in figure 8b are mandatory.

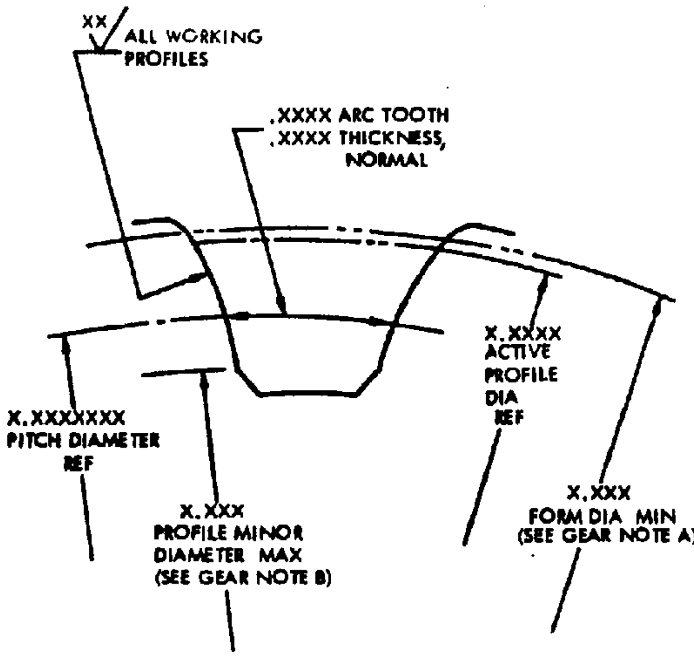


FIGURE 8b. SECTION X-X.

NOTE: TOOTH THICKNESS NOT IN TRANSVERSE PLANE

5.1.9.4.1 Applicable requirement. The cutting plane, shown on figure 8a, shall appear on the same sheet as the sectional view shown above and both shall be identified with the same alphabetical series letter.

5.1.10 Involute spur rack data.

5.1.10.1 Instructions to the designer.

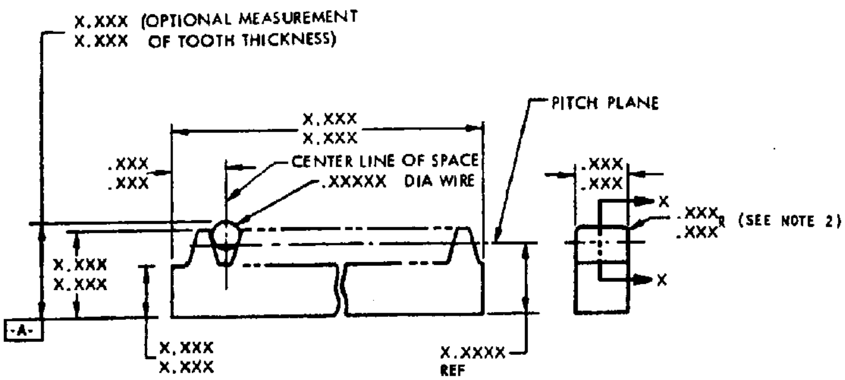
5.1.10.1.1 Mandatory drawing requirements. Engineering drawings for this type of gear shall specify the following:

a. View delineation (see 5.1.10.2).
b. Sectional view (see 5.1.10.3).
c. Data specification (see 5.1.10.4).
d. Gear mounting characteristics as selected from 5.2.2.
e. Chamfers, radii, and fillets as selected from 5.2.3.
f. Additional data selected from Mandatory review below.
g. Material specification.
h. Heat treat specification as required.
i. Finish notes (e.g. plating, etc.).
j. Other notes as required.

5.1.10.1.1.1 Mandatory review. The designer will review the following paragraphs for methods of specifying additional gear characteristics when required:

5.2.4 Profile Charts.
5.2.5 Lead Charts.
5.2.6 Crowns.
5.2.9 Composite Tolerances.
5.2.10 Fine Pitch Gears.

5.1.10.2 View delineation. For clarity of interpretation, the following spur rack characteristics shall be delineated as shown in figure 9a.



GENERAL NOTES

1. Choose datum surfaces according to gear mounting characteristics paragraph 5.2.2.
2. Use .XXX by XX° chamfer when required.

FIGURE 9a. Involute spur rack data.

5.1.10.3 Data specification. Minimum data and nomenclature requirements shall be specified as listed below.

INVOLUTE SPUR RACK DATA

NUMBER OF TEETH ________	XX
PITCH TOLERANCE (ADJACENT TEETH) ________	.XXXX
INDEX TOLERANCE ________	.XXXX
VARIATION OVER .XXXX DIAMETER WIRE TO DATUM [ ] ACROSS X.XX LENGTH INCLUDES VARIATION ACROSS FACE) ________	.XXXX
PROFILE TOLERANCE ________	.XXXX
LEAD TOLERANCE ACROSS FACE WIDTH ________	.XXXX

GEAR NOTES

A. TOOTH PROFILE MUST BLEND WITH FILLET AND/OR APPROXIMATE RADIUS AT OR BELOW LINE SHOWN. NO STEP PERMITTED.
B. CHAMFERS, RADII OR DEBURRING MUST NOT EXTEND BELOW MINIMUM PROFILE LINE AS SHOWN.
C. ALL TOOTH ELEMENT SPECIFICATIONS OF THE RACK ARE RELATIVE TO MOUNTING DATUM [ ] .

SPUR RACK REFERENCE DATA

PRESSURE ANGLE ________	XX°
DIAMETRAL PITCH ________	XX
LINEAR PITCH ________	.XXXXXXX
DESIGNED TO MATE WITH PART NUMBER ________	XXXXXXXX

GENERAL NOTES

a. Dimensional values are indicated by X's to indicate units or the number of decimal places recommended in each instance.
b. When diametral pitch is not a whole number, it shall be shown to seven decimal places.
c. Add AGMA Quality/Class number under "GEAR REFERENCE DATA", when applicable.
d. Requirements of paragraphs 5.1.1.5 and 5.1.1.5.1 shall apply.

5.1.10.4 Sectional view. Tooth section and methods of delineating the spur rack characteristics as shown in figure 9b are mandatory.

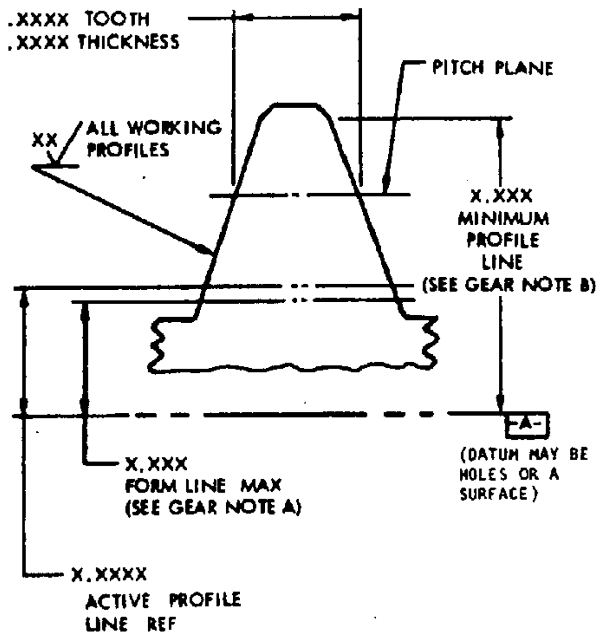


FIGURE 9b. SECTION X-X.

5.1.10.4.1 Applicable requirement. The cutting plane, shown on figure 9a, shall appear on the same sheet as the sectional view shown above and both shall be identified with the same alphabetical series letter.

5.1.11 Involute helical rack data.

5.1.11.1 Instructions to the designer.

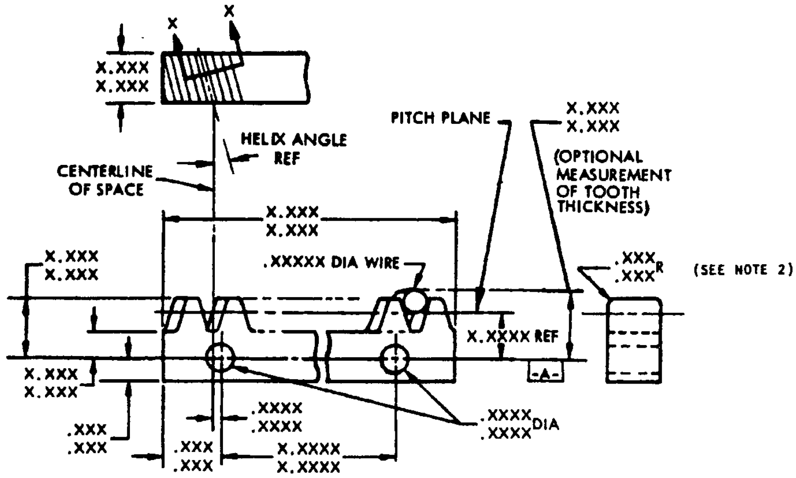
5.1.11.1.1 Mandatory drawing requirements. Engineering drawings for this type of gear shall specify the following:

a. View delineation (see 5.1.11.2).
b. Sectional view (see 5.1.11.3).
c. Data specification (see 5.1.11.4).
d. Gear mounting characteristics as selected from 5.2.2.
e. Chamfers, radii, and fillets as selected from 5.2.3.
f. Additional data selected from Mandatory review below.
g. Material specification.
h. Heat treat specification as required.
i. Finish notes (e.g. plating, etc.).
j. Other notes as required.

5.1.11.1.1.1 Mandatory review. The designer will review the following paragraphs for methods of specifying additional gear characteristics when required:

5.2.4 Profile Charts.
5.2.5 Lead Charts.
5.2.6 Crowns.
5.2.9 Composite Tolerances.
5.2.10 Fine Pitch Gears.

5.1.11.2 View delineation. For clarity of interpretation, the following helical rack characteristics shall be delineated as shown in figure 10a.



GENERAL NOTES

1. Choose datum surfaces according to gear mounting characteristics paragraph 5.2.2.
2. Use .XXX by XX° chamfer when required.

FIGURE l0a. Involute helical rack data.

5.1.11.3 Data specification. Minimum data and nomenclature requirements shall be specified as listed below.

INVOLUTE HELICAL RACK DATA

NUMBER OF TEETH ____	XX
HAND OF HEXLX ____	
NORMAL PITCH TOLERANCE (ADJACENT TEETH) ____	.XXXX
NORMAL INDEX TOLERANCE (ANY TWO TEETH) ____	.XXXX
VARIATION OVER .XXXX DIAMETER WIRE TO DATUM [ ] ACROSS X.XX LENGTH (INCLUDES VARIATION ACROSS FACE) ____	.XXXX
PROFILE TOLERANCE ____	.XXXX
LEAD TOLERANCE ACROSS FACE WIDTH ____	.XXXX

GEAR NOTES

A. TOOTH PROFILE MUST BLEND WITH FILLET AND/OR APPROXIMATE RADIUS AT OR BELOW LINE SHOWN. NO STEP PERMITTED.
B. CHAMFERS, RADII OR DEBURRING MUST NOT EXTEND BELOW MINIMUM PROFILE LINE AS SHOWN.
C. ALL TOOTH ELEMENT SPECIFICATIONS OF RACK ARE RELATIVE TO MOUNTING DATUM [ ]

HELICAL RACK REFERENCE DATA

PRESSURE ANGLE (NORMAL) ____	XX°
HELIX ANGLE ____	XX.XXXXXXX°
DIAMETRAL PITCH (NORMAL) ____	XX
LINEAR PITCH (NORMAL) ____	.XXXXXXX
DESIGNED TO MATE WITH PART NUMBER ____	XXXXXXXX

GENERAL NOTES

a. Dimensional values are indicated by X's to indicate units or the number of decimal places recommended in each instance.
b. When diametral pitch is not a whole number, it shall be shown to seven decimal places.
c. Add AGMA Quality/Class number under "GEAR REFERENCE DATA", when applicable.
d. Requirements of paragraphs 5.1.1.5 and 5.1.1.5.1 shall apply.

5.1.11.4 Sectional view. Tooth section and methods of delineating the helical rack characteristics as shown in figure 10b are mandatory.

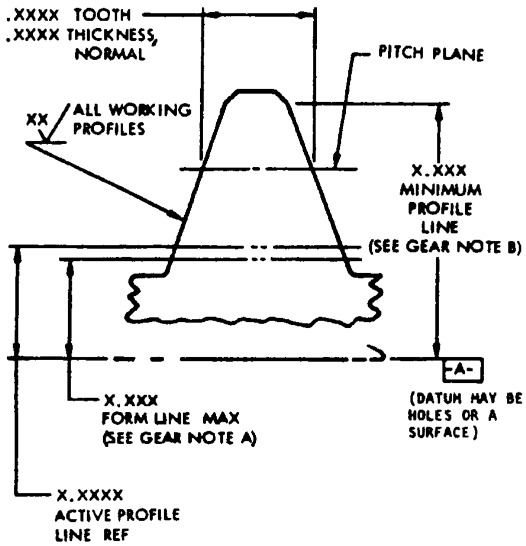


FIGURE 10b. SECTION X-X.

5.1.11.4.1 Applicable requirements. The cutting plane, shown on figure 10a, shall appear on the same sheet as the sectional view shown above and both shall be identified with the same alphabetical series letter.

5.2 ADDITIONAL AND SPECIAL DRAWING DATA FOR PARALLEL AXES GEARS.

5.2.1 General. This section contains both additional and special drawing data requirements for parallel axes gearing.

5.2.1.1 Additional drawing data. Paragraphs 5.2.2 and 5.2.3 contain additional (mandatory) gear drawing requirements with instructions for selection and specification.

5.2.1.2 Special drawing data. Paragraphs 5.2.4 through 5.2.10 contain instructions for specifying special features or modifications required for special gear applications.

5.2.2 Gear mounting characteristics.

5.2.2.1 Datum axis of a gear. All gears have one thing in common; they rotate about an axis. Dimensioning and tolerancing of engineering drawings are currently governed by ANSI Y14.5 which places considerable importance on the selection of datums that are functional relative to the design intent. It is important, therefore, that the functional axis of gear rotation be established as the datum for the measurement of all gear tolerances. That axis is determined by design analysis of the mounting conditions. For circular gears, these can be classified into four general groups; bore mounted, straddle mounted, cantilever mounted, and “pot” mounted. Methods for establishing datums for rack gears are also shown. The figures contained in paragraphs 5.2.2.2 through 5.2.2.8 illustrate typical applications of tolerances to gears which employ the various types of mountings. The tolerances are applied by means of the symbols standardized by ANSI Y14.5. The examples shown do not necessarily denote minimum data requirements as these can only be determined by detailed design analysis of the specific function in assembly.

5.2.2.1.1 Gear housing requirements. Specification of the datum on next assemblies shall be compatible with individual gear mounting datum specifications.

5.2.2.2 Bore mounted gears. A bore mounted gear is one where the bore of the gear serves to either fully or partially establish its functional axis of rotation. In figure 11 the bore shown is sufficiently long to fully establish this axis. However, the gear in figure 12 has a bore which is too short to offer positive control over lateral runout, therefore, it cannot serve as the primary datum.

5.2.2.2.1 Long bore. When the mounting bore is long relative to its diameter, as shown in figure 11, the bore becomes the primary datum. In this instance. all tolerances of radial runout, lateral runout, and gear tooth elements can be adequately specified relative to the single datum. For width measurements, of course, the method of dimensioning identifies the left hub end as an implied datum. When required, the implied datum may carry a secondary datum symbol as for a helical gear thrust surface.

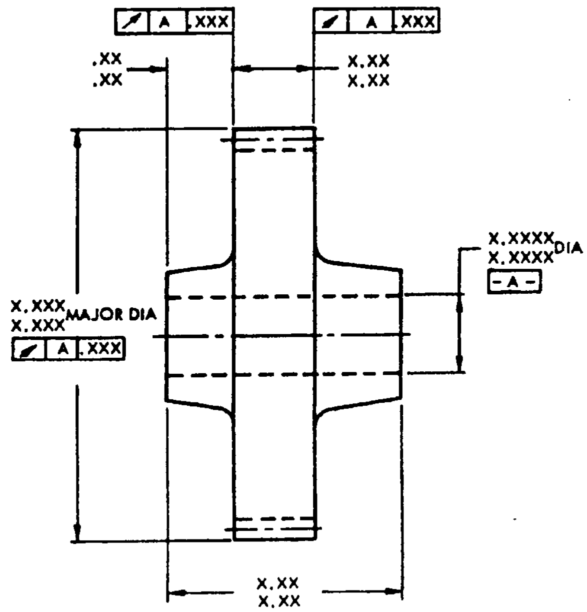


FIGURE 11. Long bore.

5.2.2.2.2 Short bore. As previously stated, the bore of the gear shown in figure 12 is too short to properly control lateral runout, therefore it cannot serve as a primary datum. It can, however, serve as a secondary datum (reference Appendix A of ANSI Y14.5). Lateral runout can be controlled in one of two ways; the gear may be flange mounted to a shaft or sandwiched between two bearing surfaces. The following two paragraphs will enable the designer to properly select the primary datum.

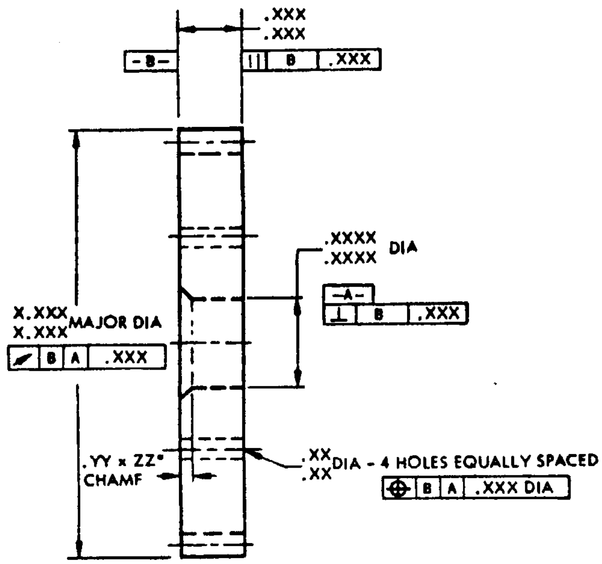


FIGURE 12. Short bore.

5.2.2.2.2.1 Flange mounted short bore. If the gear is flange mounted to a shaft, the bolt holes will surround the mounting bore so that the gear will pilot on the diameter of a flanged shaft and be bolted to the mounting flange for control of lateral runout. In this case the mounting face of the gear is selected as primary datum and the mounting bore as secondary datum. All tolerances of radial runout, gear tooth elements, and hole position must be specified to the compound datum with the primary datum appearing first in the symbol callout. Since both sides of the gear are fundamentally symmetrical, a chamfer or other means of identification must be added to complete the identity of the datum surface on the physical gear. The parallelism note would not be applicable in this example.

5.2.2.2.2.2 Sandwich mounted short bore. If the same gear was a spur gear mounted to a horizontal shaft and sandwiched between two bearing surfaces to control lateral runout in the assembly, both sides would be of equal importance. The designer must arbitrarily select one side as datum and provide a chamfer or other suitable means of identification. The bolt callout would not be used and parallelism of the two sides would be required if the thickness tolerance did not provide for sufficient control.

5.2.2.3 Bore diameter to length ratio. Since it was stated that the bore length illustrated in figure 11 was adequate to control lateral runout while the bore length in figure 12 was not, the question of an adequate length to diameter ratio is obvious. Although this question is beyond the intended scope of this handbook, the subject is sufficiently controversial to demand a generalized statement. As a practical rule of thumb, a bore length of 1 1/2 times its diameter is adequate to assure alignment in most instances and a bore length of 0.75 times its diameter or less is inadequate. Ratios between these two values are subject to considerable controversy and if lateral forces are present, 1 1/2 times the bore diameter is often inadequate.

5.2.2.4 Straddle mounted gears. A straddle mounted gear is one where the gear separation force is directed to a point on the axis of rotation which is between two bearing supports. The bearings may be applied externally or internally as shown below. In both examples, figures 13 and 14, the functional axis of rotation is established by the common axis of the two bearing diameters. Note that the callout symbol identifies this common axis as primary datum rather than one diameter as primary and the other as secondary. Application of the runout tolerance to each diameter relative to their common axis is used as the ANSI Y14.5 nearest equivalent of the coaxial tolerance. The internal straddle mounted gear is also a bore mounted gear, but the term straddle mounted is far more descriptive. You will note that the smaller bore is located relative to the common axis by means of a true position tolerance at MMC. This is done because its function is to provide clearance for the mounting shaft. A large percentage of production oriented designers would have normally identified this small bore as the primary datum and controlled the radial and lateral runout of the bearing bores relative to its axis. Their argument would be logically based on the fact that this bore is well suited to serve as a mounting surface during the machining of the bearing bores. The fallacy in this line of thinking is that this small bore is non-functional relative to establishing the axis of gear rotation. Since it would serve as an intermediate reference surface only, it would require the runout tolerances to be reduced by 50% to satisfy a production consideration. This in effect, would place unnecessary restriction on the possible methods of manufacture and is contrary to Government procurement policy. This same principle serves to explain why machining centers are not specified as datums in internal mounted gears.

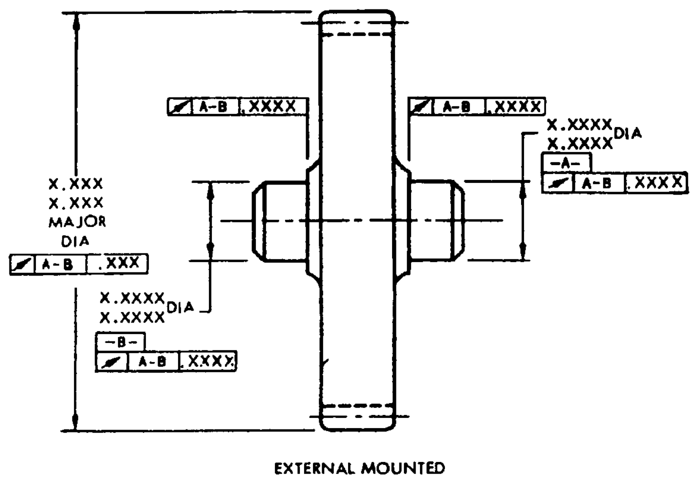


FIGURE 13. Straddle mounted gear.

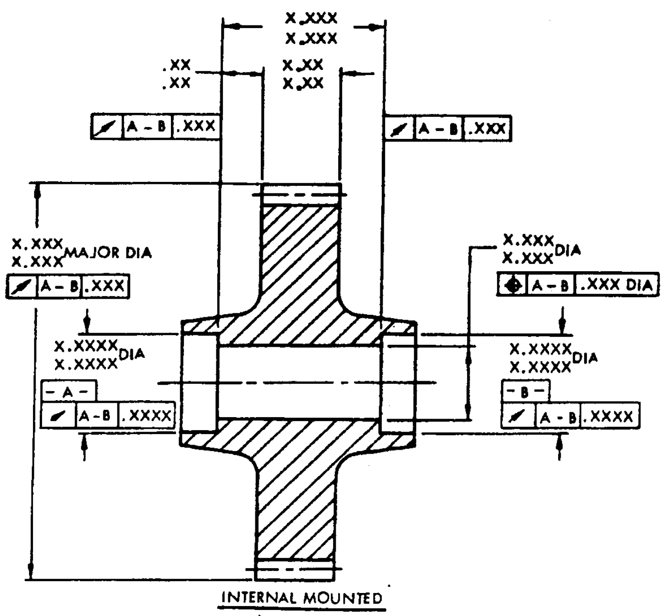


FIGURE 14. Straddle mounted gear.

5.2.2.5 Cantilever mounted gears. A cantilever mounted gear is one where the gear separation force is directed to a point on the axis of rotation which is not between the bearing points used to establish that axis of rotation. A typical example is illustrated in figure 15 where the axis of rotation is established by bearing diameters A and B. The common axis of the two datums is identified in the symbols as the primary datum, with neither diameter being given preference, even though diameter A will obviously have a greater influence on the readings than diameter B.

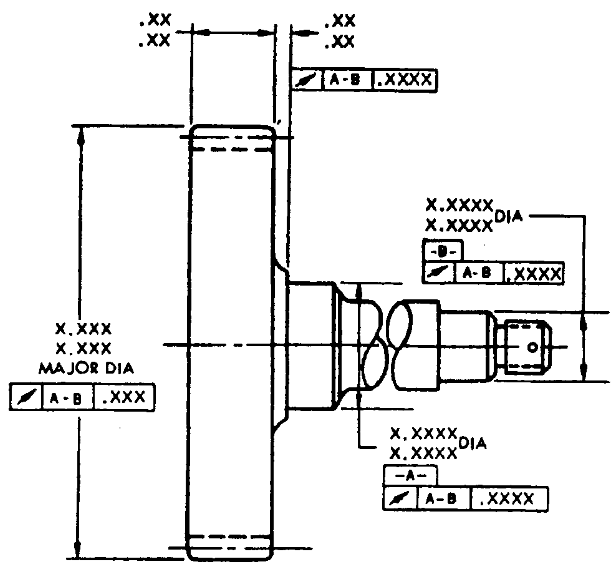


FIGURE 15. Cantilever mounted gear.

5.2.2.6 "Pot" mounted gears. A pot mounted gear is an internal gear which is mounted on the outside diameter of its own body. In the assembly, this is mounted inside a cavity or a "pot". It is most predominantly found in pump gears and planetary gears, with most applications resulting in a mounting diameter which is too short to serve as a primary datum. In figure 16, the mounting face is identified as the primary datum and the outside mounting diameter as secondary. As shown in figure 12, runout is related to the combination of primary and secondary datums and perpendicularity is specified for the secondary relative to the primary. Here also, a chamfer or similar means should be used to physically identify the primary datum.

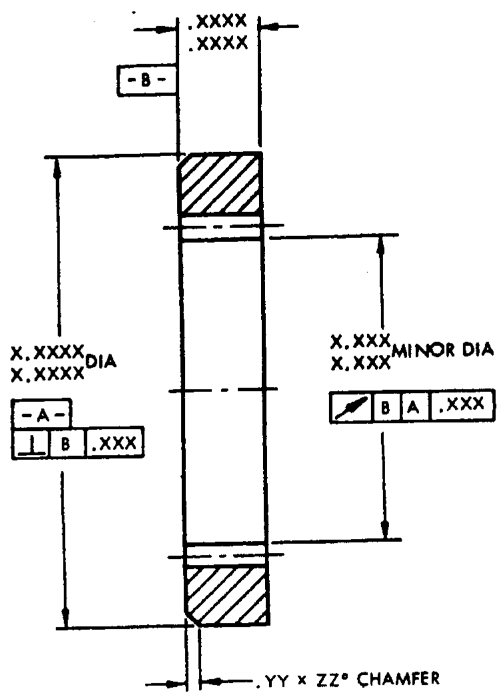


FIGURE 16. Pot mounted gear.

5.2.2.7 Surface mounted rack gears. Unlike circular gears, which rotate about an axis, rack gears are usually mounted on flat surfaces. Figure 17 illustrates the method of specifying three datum features. However, depending upon the type of tolerance (position or form) and the particular relationship required, it is sometimes necessary to specify only one or two datum features. In this example, datum feature A is a mounting surface to which the majority of functional gear characteristics are related, therefore it is selected as the primary datum feature. Datum feature B relates to functional lead of the gear and is therefore selected as the secondary datum feature. Since both sides of the rack gear are fundamentally symmetrical, a chamfer or other means of identification must be added to complete the identity of the datum surface on the physical gear. Datum feature C is selected as a tertiary datum feature relating to rack gear characteristics along the length of the rack (see para. 5.2.2.9 Datum selection).

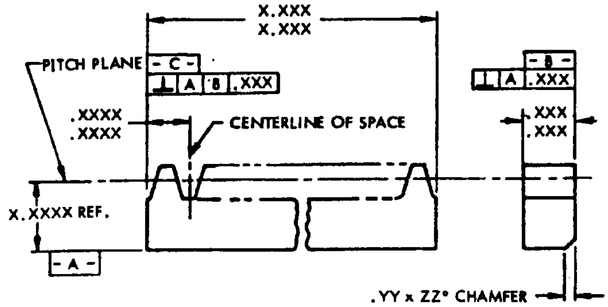


FIGURE 17. Surface mounted rack gear.

5.2.2.8 Dowel mounted rack gears. Figure 18 illustrates the method of specifying dowel hole datums. In this example, the dowel holes are functional in that they provide the common datum necessary for design, manufacture, inspection, and assembly of rack gears relative to the functional pitch plane of the gear. Interchangeability of rack gears is provided by tolerance control of the center distance dimension holes A and B. Datum C serves as the secondary datum and the identifies this surface (see para. 5.2.2.9 Datum selection).

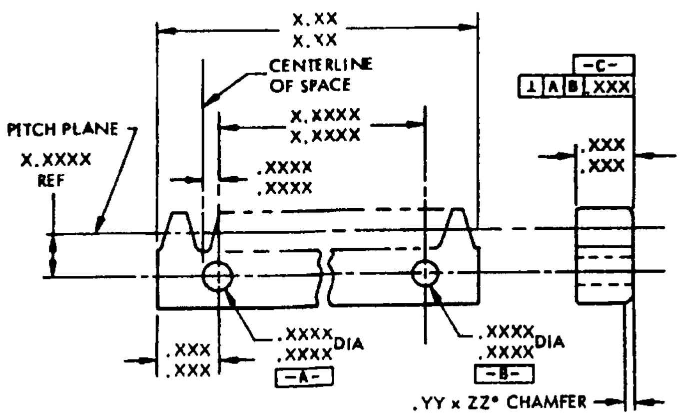


FIGURE 18. Dowel mounted rack gear.

5.2.2.9 Datum selection. Figures 17 and 18 illustrate the methods of specifying datum features for two common types of rack mounts. When mounting conditions or requirements differ as in sectional racks, short racks, and special applications, the designer shall specify datum precedence based on functional requirements with mating gear at assembly. Sequence of datum features, from left to right in the feature control symbol, may or may not be in alphabetical order.

5.2.3 Chamfers, radii and fillets. Figure 19 is a composite representing the methods of depicting chamfers, radii, and fillets. The designer will select from paragraphs 5.2.3.1 through 5.2.3.6 those features he deems most suitable for his design.

NOTE: All the required features should be depicted on an enlarged end view of a single tooth form.

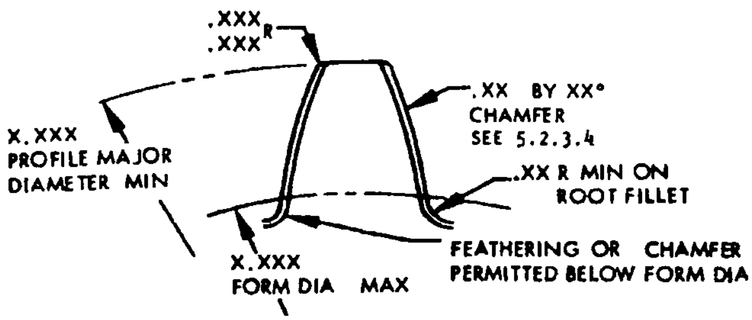


FIGURE 19. Composite end view X-X.

5.2.3.1 Tooth tip chamfers. Tooth tip chamfers will be depicted as shown on figure 20.

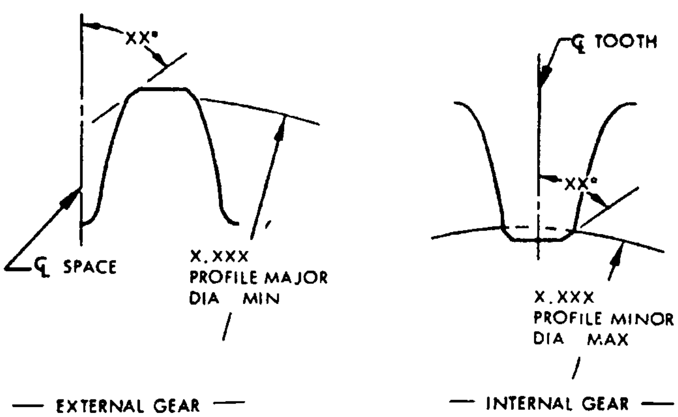


FIGURE 20. Tooth tip chamfers.

5.2.3.2 Tooth tip radii. Tooth tip radii shall be depicted as shown on figure 21.

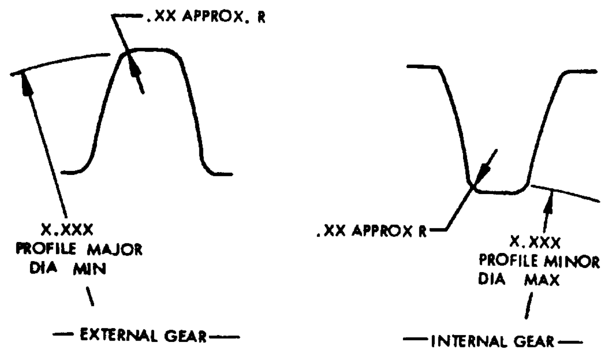


FIGURE 21. Tooth tip radii.

5.2.3.3 Tooth tip deburring. When no chamfer or radius is required on gear teeth, deburring limits shall be shown on the drawing as depicted on figure 22.

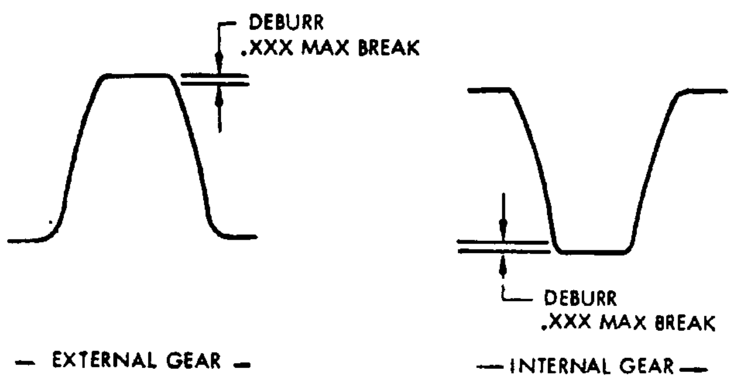


FIGURE 22. Tooth tip deburring.

5.2.3.4 Tooth end chambers. Figure 23 illustrates the method of showing end chamfers on spur gears.

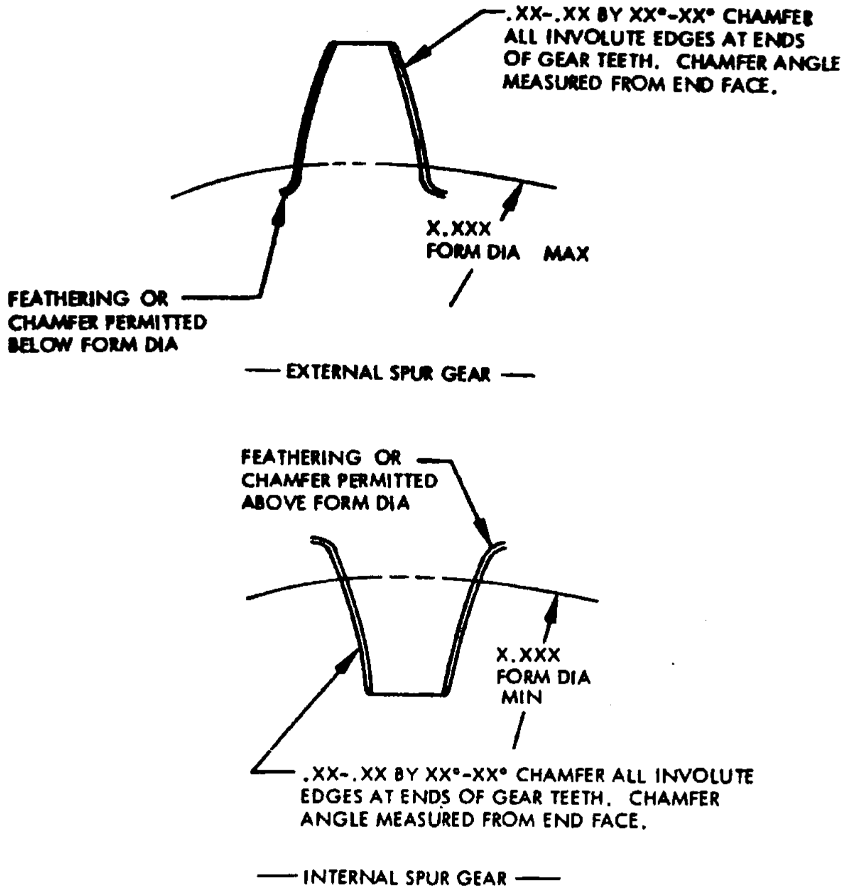


FIGURE 23. Tooth end chamfers.

5.2.3.4.1 Acute angle chamfers. Figure 24 illustrates the method of showing acute angle chamfers at ends of helical gear teeth.

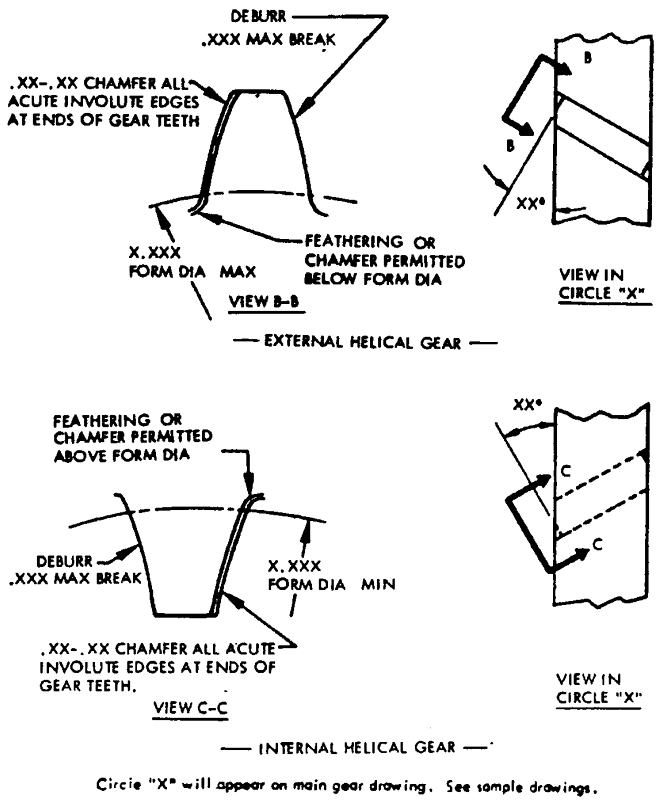


FIGURE 24. Acute angle chamfers.

5.2.3.5 Deburring. Gear tooth end deburring shall be depicted as shown on figure 25.

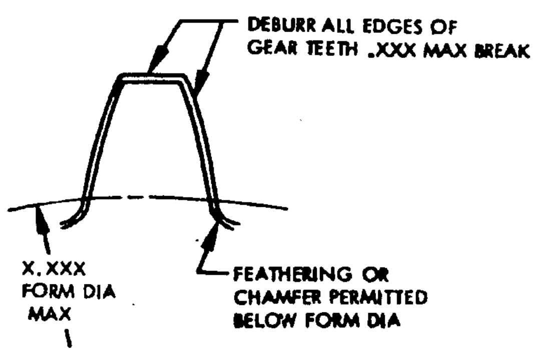


FIGURE 25. Deburring.

5.2.3.6 Fillets. On a flat root the fillet note shall be interpreted as the minimum radius of curvature allowed at the intersection of the flat root with the side of the gear tooth. Larger radius of curvature is allowed provided the limits for major or minor diameter and form diameter are met (see figure 26). When more precise fillet control is required, refer to paragraph 5.2.7 Basic rack generatrix and figure 32.

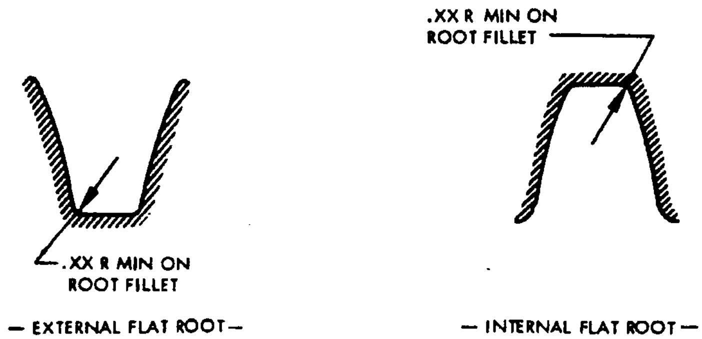
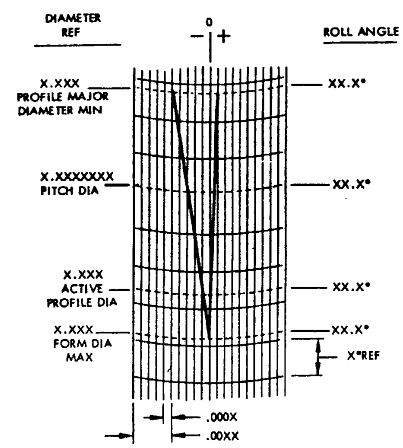


FIGURE 26. Fillets.

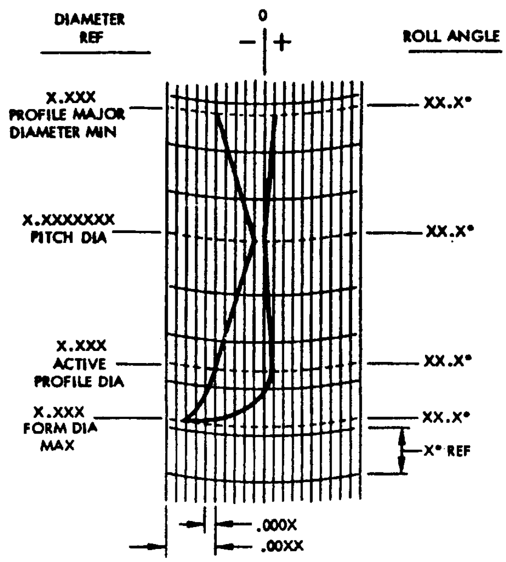
5.2.4 Profile charts. At relatively high pitch line velocities and/or relatively high loading conditions, it is often desirable to specify greater control over the profile than the mere specification of a numerical profile tolerance. It may even become necessary to modify the profile slightly. In such cases, it will be mandatory to omit the tabular form of profile tolerance and specify it in chart form similar to that shown in figure 27a or 27b. In addition, the numerical value of profile tolerance (.XXXX) in the "GEAR DATA" will be replaced by the statement "SEE CHART". For table of roll angles, see Appendix.



THE TRACE AS TAKEN FROM THE INVOLUTE PROFILE SHALL FALL WITHIN THE AREA LIMITS SHOWN.

FIGURE 27a. Involute profile tolerance chart.

5.2.4.1 Minimum chart requirements. All involute profile tolerance charts shall be shown vertically on drawings and will contain, as a minimum, the diameters, roll angles, chart coordinate identifications, title, and note(s) as shown in figures 27a or 27b. The tolerance bands illustrated in these figures are not to be considered as recommendations but as examples of many possible control forms.



THE TRACE AS TAKEN FROM THE INVOLUTE PROFILE SHALL FALL WITHIN THE AREA LIMITS SHOWN.

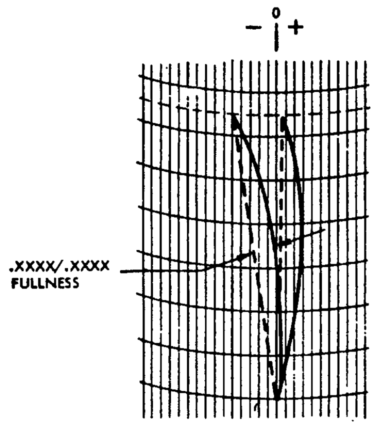
FIGURE 27b. Involute profile tolerance chart.

5.2.4.2 Additional chart data. In addition to the minimum chart requirements, it is sometimes necessary to specify additional profile controls in the form of curves on the chart or in the form of notes below the chart. The following two paragraphs provide examples of controlling profile features by the use of notes and/or chart curves.

5.2.4.2.1 Waviness control. When waviness of an involute profile must be controlled, the following note will be used:

DEVIATIONS FROM A STRAIGHT LINE OR A SMOOTH CURVE MAY NOT EXCEED .XXXX IN ANY X.X° OF ROLL.

5.2.4.2.2 Fullness profile control. Profiles are sometimes modified to gain a specific performance requirement. Fullness is depicted graphically in paragraph 5.2.6 and figure 30. Fullness is that portion of the vertical form of the elliptoid tooth as evidenced by the minus form at the tip and at the base of the tooth. When control of fullness is required, the following note(s) and chart additions may be used:

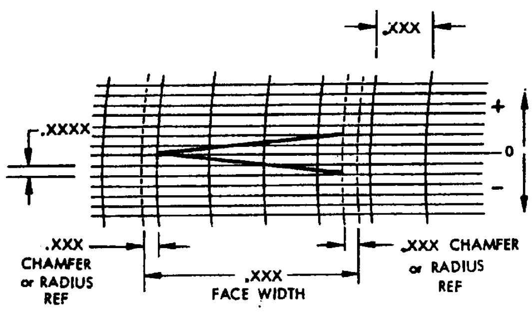


THE HIGH POINT OF THE FULLNESS SHALL BE BETWEEN
YY.Y° AND XX.X° OF ROLL.

FIGURE 28. Fullness profile chart.

5.2.5 Lead charts. Lead tolerance is the allowable deviation across the width of a tooth surface measured normal to the tooth surface established by a specified lead. It is generally listed in the "GEAR DATA" with a numerical value to four decimal places. However, when definitive control of lead is required, a lead chart may be shown horizontally on the drawing. In addition, the numerical value of lead tolerance (.XXXX) in the "GEAR DATA" will be replaced by the statement, "SEE CHART".

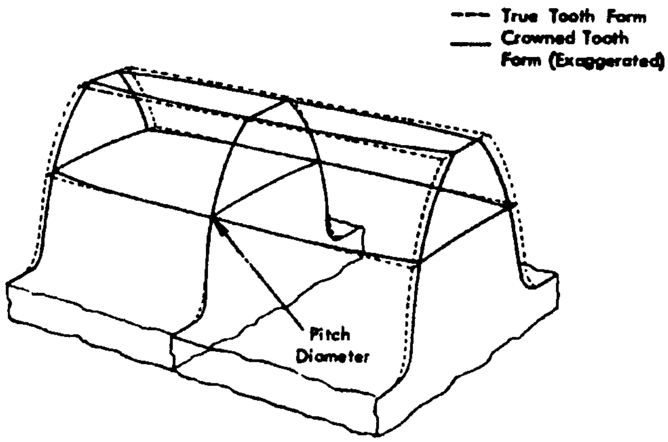
5.2.5.1 Lead tolerance on non-crowned teeth. All teeth that are not crowned and that require a lead tolerance chart, shall be shown as depicted in figure 29.



THE TRACE TAKEN SHALL FALL WITHIN THE PLUS OR MINUS WEDGE
SHOWN ON THE CHART. DEVIATIONS FROM A STRAIGHT LINE MAY
NOT EXCEED .XXXX IN ANY .XXX WIDTH.

FIGURE 29. Lead tolerance chart.

5.2.6 Crowns. All gears are subjected to gear tooth inaccuracies, manufacturing misalignments, shaft deflections, housing machining errors, hardening distortions, and deflections under load. These inaccuracies impair the running behavior of gears and cause undesirable noise and excessive wear. Crowned tooth forms avoid the danger of concentrated loads on the ends of gear teeth where they are most vulnerable. Crowning is specified as the amount that the end of the tooth is relieved on one side, and is measured as a lead variation of the tooth. When the crown is offset, a dimension indicating the center of the crown should be given and the amount of the crown shown at the thinnest end of the tooth.



NOTE: For pictorial view of fullness, see figure 28.

FIGURE 30. Fullness/crown illustration.

5.2.6.1 Crown delineation. When a gear is to be crowned, it can be specified as a part of gear data or as a section or view on the drawing.

5.2.6.1.1 Data specification. When the crown is specified in statement form, it shall be added to the GEAR DATA in the following manner:

CROWN ____ .XXXX/.XXXX

5.2.6.1.2 Drawing view. When the crown on a gear tooth is to be specifically located, it shall be shown as depicted in figure 31.

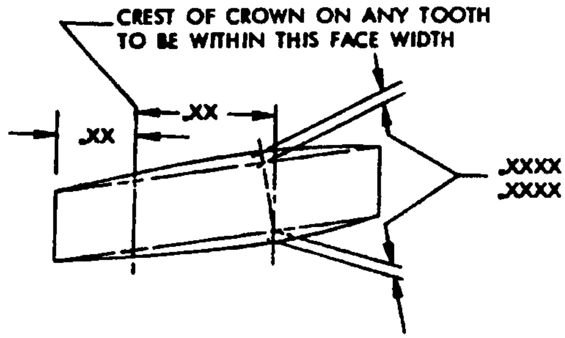


FIGURE 31. Gear tooth crown.

5.2.7 Basic rack generatrix. The beam strength of a gear is dependent upon the tooth fillet. When the stresses are high enough to warrant control of the tooth fillet, a rack generatrix may be specified on the drawing as shown in figure 32.

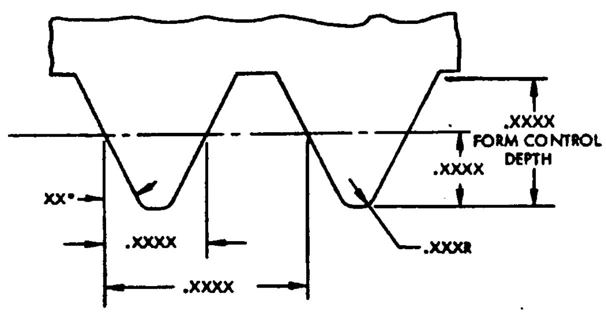


FIGURE 32. Basic rack generatrix.

5.2.8 Index tolerance. Index tolerance is the greatest difference in any two teeth (adjacent or otherwise) between the actual and the perfect spacing of teeth profiles. It is obtained from an index plate check or a dividing head check, or by the accumulation of pitch errors after correcting for runout. The index tolerance that is listed on a drawing is in addition to the error caused by runout, the runout being within drawing limits. Index error may be determined from the accumulation of base pitch error values. Index tolerance is specified for gears used in planetary systems and in precision indexing mechanisms such as aiming devices. It is mandatory when warranted by design analysis of the mechanism involved. When index tolerance is required on a gear, it will be depicted in the following manner in the GEAR DATA:

INDEX TOLERANCE (ANY TWO TEETH) ______________________ .XXXX

5.2.8.1 Index relationship. When two or more gears or splines are specified on the same part, the requirement for index relationship between the two must be specified. When the index relationship between the two is not required, the basic form of the note shown in figure 33 shall be applied.

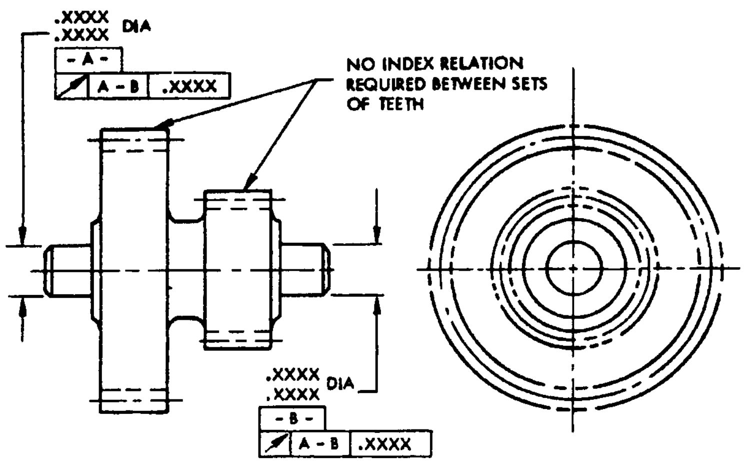


FIGURE 33. Index relationship (not controlled).

5.2.8.1.2 Index relationship controlled. When the index relationship must be controlled, one of the methods shown in figure 34a or 34b shall be applied.

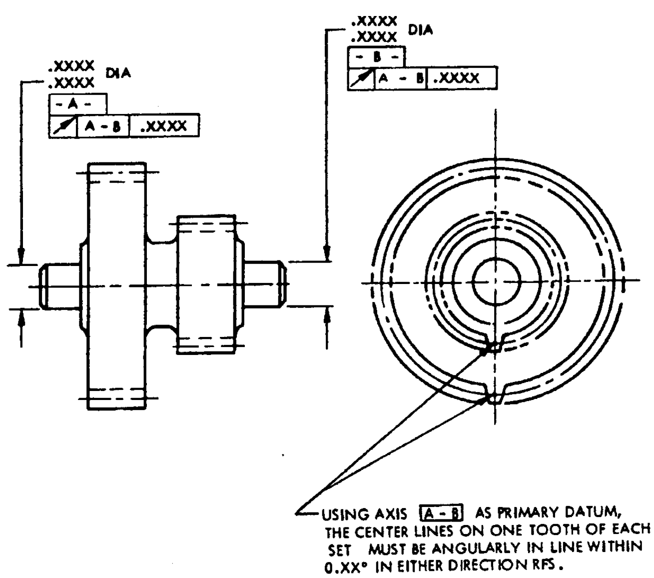


FIGURE 34a. Index relationship (controlled).

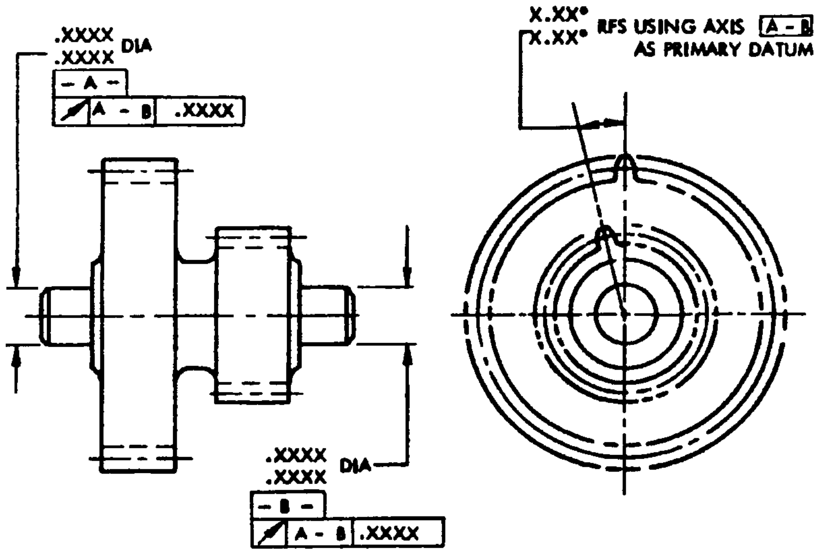


FIGURE 34b. Index relationship (controlled).

5.2.8.2 Index relationship callout. Because index relationships may also involve other features, firm rules for callout of tolerances are difficult to establish. In most instances, this type of index control does not lend itself readily to the use of the symbol form callout and detailed drawing notes will provide the most practical solution. In all instances, however, it is preferable to specify the index relationship tolerance in angular form and positively identify the requirement as "Regardless of Feature Size" (RFS) or "Maximum Material Condition" (MMC).

5.2.9 Composite tolerances. When a gear is functionally inspected by engaging it in intimate (metal to metal) contact with a specifically designed conjugate master gear, composite tolerances are utilized instead of the individual tolerances used in an analytical inspection. The manufacturing errors are then displayed as variations in center distance between the two gears. Coarse-pitch gears can be inspected analytically using individual tolerances or functionally using composite tolerances. On the other hand, fine-pitch gears are primarily inspected functionally, thus on a fine-pitch gear drawing it is mandatory to specify composite tolerances.

5.2.9.1 Total composite tolerance. This tolerance is the allowance in the center distance variation in one complete revolution of the gear being inspected. This includes the effects of variations in active profile, pitch lead, tooth thickness, and runout.

5.2.9.2 Tooth-to-tooth composite tolerance. This tolerance is the allowable center distance variation as the gear is rotated through any increment of (360/N) degrees, where N is the number of teeth on the gear under inspection.

5.2.9.3 Reference. To obtain the acceptable values of composite and tooth-to-tooth composite tolerances, refer to AGMA 390.03 publication entitled “AGMA GEAR HANDBOOK”, Volume 1.

5.2.9.4 Acceptability or rejection of gears. The method of presentation of gear data on a drawing can determine whether a gear will be accepted or rejected by the functional inspection method.

a. Whenever composite tolerances are listed on a gear drawing in the REFERENCE DATA in addition to the individual tolerances listed in the GEAR DATA, the gear may be inspected by either the analytical inspection or the functional inspection methods. However, when the tolerances are so listed, the gear being inspected by the functional method may be accepted but not rejected. If it does not pass the functional inspection it must be analytically inspected before being rejected.

b. If only the composite tolerances are listed on a gear drawing, the gear will be inspected to the listed tolerances and accepted or rejected on the basis of meeting or failing to meet the specified tolerances.

5.2.9.5 Data specification. Composite tolerances may be specified on the gear drawing under “REFERENCE DATA” but will be used in lieu of runout, profile, lead, and pitch tolerances when functionally inspected with a master gear.

5.2.9.6 Composite action inspection procedure. The inspection procedure for checking gears by the functional inspection method can be found in AGMA 390.03, Gear Handbook, Volume 1, Part III entitled "Measuring Methods and Practices".

5.2.10 Fine-pitch gears. Spur and helical gears of 20 through 120 diametral pitch are classified as fine-pitch gears. The main difference between the proportions of fine-pitch gears and those of coarse-pitch is in the clearance. In fine-pitch gearing, wear on the points of cutting tools is proportionally greater than in coarse-pitch tools. The fillet radius produced by such tooling will therefore be proportionally greater. The increased clearance in gearing of 20 diametral pitch and finer provides both for the relatively larger fillet and also for foreign material that tends to accumulate at the bottoms of the teeth.

5.2.10.1 Data specification. The data specification for fine-pitch gears shall be identical to coarse-pitch gearing with the following exceptions:

a. RUNOUT TOLERANCE, PROFILE TOLERANCE, LEAD TOLERANCE, and PITCH (TOOTH-TO-TOOTH SPACING) TOLERANCE shall be deleted from the GEAR DATA.

b. TOTAL COMPOSITE TOLERANCE and TOOTH-TO-TOOTH COMPOSITE TOLERANCE shall be added to the GEAR DATA.

5.2.10.2 Acceptance and rejection criteria. Acceptance and rejection of fine-pitch gears will be determined by the composite tolerances specified on the gear drawing. For guidance on interpretation of composite tolerances in gear data, refer to paragraph 5.2.9 “Composite tolerances”.

5.2.10.3 Master gear criteria. The master gear shall be designed to run in tight mesh with the inspected part gear at the calculated center distance. The outside diameter of the master gear will be designed so that it will inspect the part gear to the active profile diameter.

5.3 MINIMUM DRAWING DATA FOR INTERSECTING AXES GEARS.

5.3.1 General. This section contains minimum drawing data specifications for the three types of intersecting axes gears listed in the table of contents.

5.3.1.1 Interpretation. Lower case letters are used to present the instructional text. Nomenclature and characteristics required for drawing data presentation are depicted in capital letters.

5.3.1.2 Section organization. The following paragraph subdivision numbering sequence is typical throughout the section:

> 5.3.X.1 “Instructions to the designer” contains a complete drawing specification check list. It delineates the minimum requirements and provides an index of additional gear characteristics when required.
>
> 5.3.X.2 “View delineation” is intended to depict those gear characteristics that define the overall dimensions of the gear blank.
>
> 5.3.X.3 “Data specification” delineates the nomenclature and method of listing gear data, notes, and references in a uniform manner for each type of gear.

5.3.1.3 Appendix. Additional information required for the preparation of gear drawings is provided in the appendix.

5.3.1.3.1 Drawing examples. To assist the designer in the interpretation of the requirements of this handbook several examples of drawings are included in the Appendix. These sample drawings shall be construed as informational only. They are complete to the degree necessary to illustrate a condition. Actual drawings shall conform to textual requirements set forth in this handbook.

5.3.1.3.2 Measuring wires/balls. Specification of measuring wires or balls on drawings shall be to those sizes listed in the Appendix.

5.3.2 Bevel gear matched sets.

5.3.2.1 Instructions to the designer. For design, procurement, installation, and replacement purposes, mating Straight, Coniflex*, Spiral, and Zerol* bevel gears and pinions shall be specified on a matched set drawing. Installation drawings, maintenance manuals, and spare parts lists shall show the matched set drawing number only.

5.3.2.1.1 Mandatory drawing requirements. Engineering drawings for matched set bevel gears shall specify the following:

a. View delineation (see 5.3.2.2).
b. Data specification (see 5.3.2.3)

5.3.2.1.2 Mandatory review. The designer will review the following for methods of specifying additional gear characteristics when required.

5.4.4 Shaft angle and pitch angles.
AGMA 390.03 Tooth Contact Pattern
AGMA 390.03 Backlash

*Registered trade name

5.3.2.2 View delineation. For clarity of interpretation, the following matched set characteristics shall be delineated as shown in figure 35.

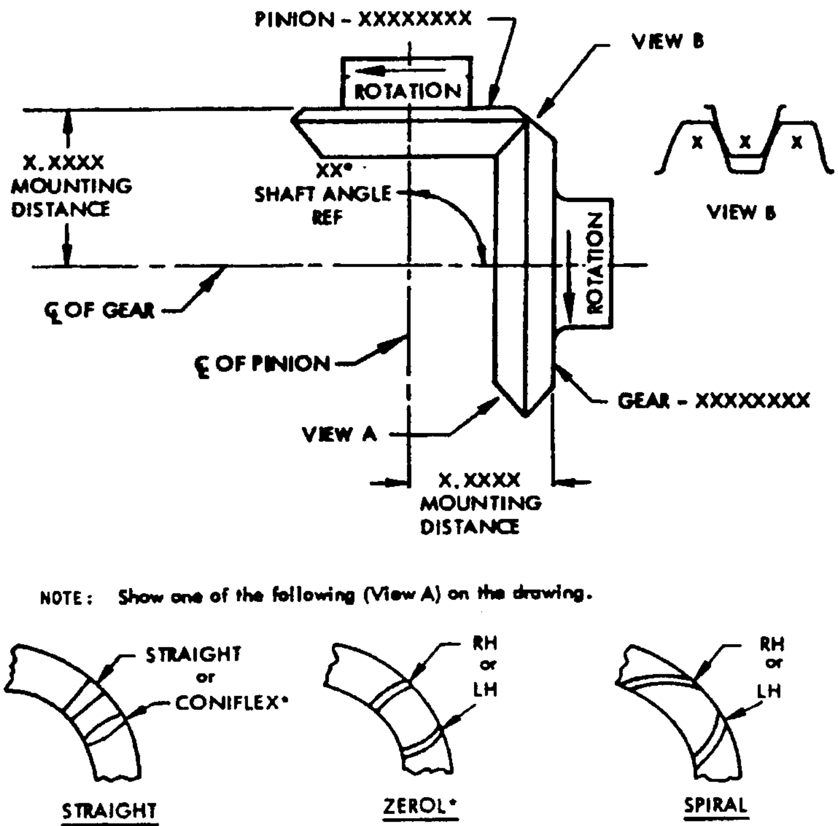


FIGURE 35. Matched gear set.

5.3.2.2.1 Miscellaneous information. The hand of spiral should be selected to give an axial thrust that tends to move both the gear and pinion out of mesh when the ratio, pressure angle, and spiral angle are such that it is possible. If this is not possible, the hand of spiral should be selected to give an outward thrust on the pinion. For gaging surface delineation, see paragraph 5.4.2.4.1.1.

*Registered trade name

5.3.2.3 Data specification. Minimum data and nomenclature requirements shall be specified as listed below.

MATCHED SET DATA

BACKLASH TO BE WITHIN .XXX TO .XXX AT X.XXXX AND X.XXXX RESPECTIVE MOUNTING DISTANCES.
BACKLASH VARIATION IN ONE REVOLUTION OF THE LARGER GEAR CANNOT EXCEED .XXX.

GEAR NOTES

A. THESE GEARS ARE TO BE MANUFACTURED. INSPECTED. PACKAGED OR ASSEMBLED. STOCKED. REPLACED. PERMANENTLY IDENTIFIED, AND RETAINED AS SERIALIZED MATCHED SETS ONLY.
B. MATCHED SET DRAWING NUMBER XXXXXXXX SHALL BE MARKED ON THE CONTAINER AND/OR SUPPLY IDENTIFICATION TAG.
C. PERMANENTLY IDENTIFY EACH GEAR OF THE MATCHED SET ON ANY READILY VISIBLE NON-FUNCTIONAL SURFACE:

ACTUAL MOUNTING DISTANCES
MATCHED SET SERIAL NUMBER
MATCHED SET NUMBER
MATING GEAR TEETH (SEE VIEW B)
ACTUAL BACKLASH OF MATING GEAR TEETH IDENTIFIED BY (X) AT TIGHTEST POINT OF MESH.

MATCHED SET REFERENCE DATA

GEAR TEETH RATIO ________________________________ XX TI 1
MAX. SPEED OF PINON _____________________________ XXX RPM
TYPE OF LOAD _________________ UNIFORM, LIGHT SHOCK, OR HEAVY SHOCK
TYPE OF SERVICE ___________________________________ FULL REVERSAL, ETC.

GENERAL NOTES

a. Add A.G.M.A. Quality/Class number under "MATCHED SET REFERENCE DATA" when applicable.
b. If a gaging surface is required, add the following marking characteristic to GEAR NOTE C above:

GAGING SURFACE ACTUAL DIMENSION "Y"

c. See paragraph 5.4.2.4.1.1 for additional information.
d. Backlash variation (.XXX) shall be less than the backlash difference specified.

5.3.3 Straight or Coniflex* bevel gear/pinion data.

5.3.3.1 Instructions to the designer.

5.3.3.1.1 Mandatory drawing requirements. Engineering drawings for this type of gear shall specify the following:

a. View delineation (see 5.3.3.2).
b. Data specification (see 5.3.3.3).
c. Gear mounting characteristics as selected from 5.4.2.
d. Tooth Form as selected from 5.4.3.
e. Chamfers, radii, and fillets as selected from 5.2.3.
f. Additional data as selected from Mandatory review below.
g. Material specification.
h. Heat treat specification as required.
i. Finish notes (e.g., plating, etc.).
j. Other notes as required.

5.3.3.1.1.1 Mandatory review. The designer shall review the following paragraph for methods of specifying additional gear characteristics when required.

5.2.8 Index Relationship.
5.4.4 Shaft angle and pitch angles.

5.3.3.1.2 Miscellaneous information. Applicable gear design sheets:

No. 1 - 90° Straight Bevel Gears
No. 2 - Angular Straight Bevel Gears (other than 90°)

5.3.3.2 View delineation. For clarity of interpretation, the following gear characteristics shall be delineated as shown in figure 36.

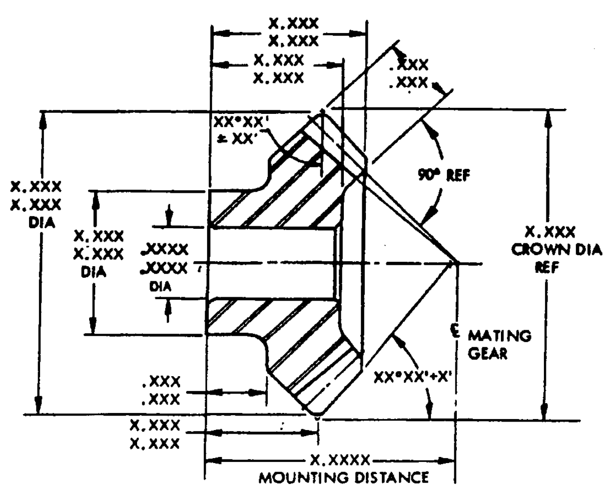


FIGURE 36. Straight or coniflex bevel gear/pinion data.

* Registered trade name.

5.3.3.3 Data specification. Minimum data and nomenclature requirements shall be specified as listed below.

STRAIGHT BEVEL GEAR DATA

TOOTH FORM ____
NUMBER OF TEETH ____ XX
ROOT ANGLE ____ XX°XX'
WHOLE DEPTH AT LARGE END (APPROX.) ____________________________ .XXX
CHORDAL TOOTH THICKNESS AT LARGE END ________________________ .XXX/.XXX

GEAR NOTES

A. REQUIREMENTS AS SPECIFIED ON MATCHED SET DRAWING NO. XXXXXXXX SHALL APPLY TO THIS GEAR.
B. MATES WITH XX TOOTH GEAR PART NO. XXXXXXXX.
C. THE TEETH ON THIS BEVEL GEAR SHALL BE MANUFACTURED UNDER THE CONTROL OF A BEVEL GEAR TESTING MACHINE.
D. FINISH ON WORKING SURFACES OF TEETH SHALL BE XX √
E. ALL TOOTH ELEMENT SPECIFICATIONS OF THE GEAR ARE RELATIVE TO THE MOUNTING DATUM [ ] .

GEAR REFERENCE DATA

DIAMETRAL PITCH ____ XX.
PITCH DIAMETER ____ X.XXXXXXX
PRESSURE ANGLE ____ XX°
CONE DISTANCE ____ X.XXXX
PITCH ANGLE ____ XX°XX'
CIRCULAR TOOTH THICKNESS AT LARGE END ____________________ .XXXX
ADDENDUM AT LARGE END ______________________________________ .XXX
CHORDAL ADDENDUM AT LARGE END ____________________________ .XXX
ROTATION (VIEWED FROM BACK OF PINION) ____________________ CLOCKWISE (GW) or COUNTERCLOCKWISE (CGW)

5.3.4 Spiral or Zerol* bevel gear/pinion data.

5.3.4.1 Instructions for the designer.

5.3.4.1.1 Mandatory drawing requirements. Engineering drawings for this type of gear shall specify the following:

a. View delineation (see 5.3.4.2).
b. Data specification (see 5.3.4.3).
c. Gear mounting characteristics as selected from 5.4.2.
d. Tooth form as selected from 5.4.3.
e. Chamfers, radii, and fillets as selected from 5.2.3.
f. Additional data selected from Mandatory review below.
g. Material specification.
h. Heat treat specification as required.
i. Finish notes (e.g., plating, etc.).
j. Other notes as required.

*Registered trade name.

5.3.4.1.1.1 Mandatory review. The designer will review the following paragraphs for methods of specifying additional gear characteristics when required.

5.2.8 Index Relationship.
5.4.4 Shaft Angle and Pitch Angles

5.3.4.1.1.2 Miscellaneous information. Applicable gear design sheets:

No. 3 90° Zerol* Bevel Gears
No. 4 Angular Zerol* Bevel Gears (other than 90°)
No. 5 90° Spiral Bevel Gears
No. 6 Angular Spiral Bevel Gears (other than 90°)

5.3.4.2 View delineation. For clarity of interpretation, the following gear characteristics shall be delineated as shown in figure 37.

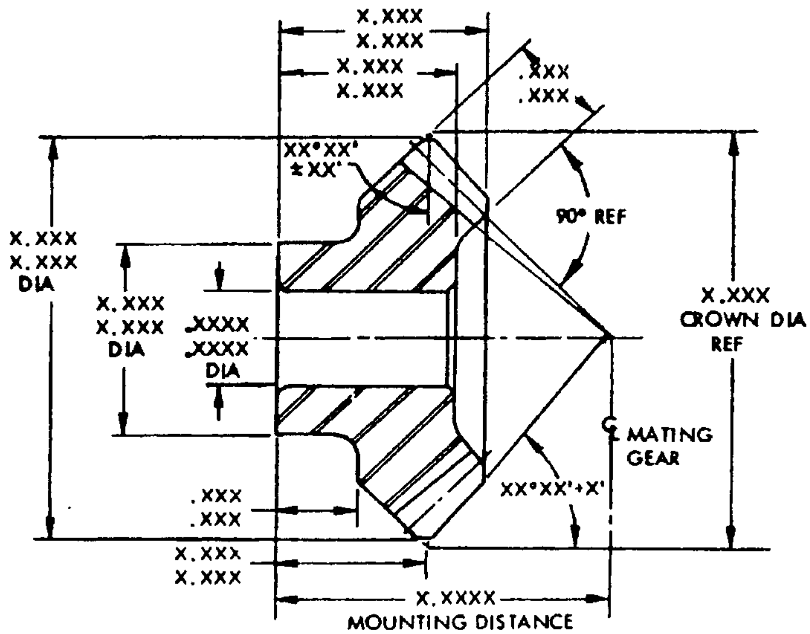


FIGURE 37. Spiral or Zerol* bevel gear/pinion data.

*Registered trade name

5.3.4.3 Data specification. Minimum data and nomenclature requirements shall be specified as listed below.

SPIRAL OR ZEROL* BEVEL GEAR DATA

TOOTH FORM	
NUMBER OF TEETH	XX
DIAMETRAL PITCH	XX
SPIRAL ANGLE	XX°
HAND OF SPIRAL	L.H. or R.H.
ROOT ANGLE	XX°XX'
WHOLE DEPTH AT LARGE END (APPROX.)	.XXX

GEAR NOTES

A. REQUIREMENTS AS SPECIFIED ON MATCHED SET DRAWING NO. XXXXXXXX SHALL APPLY TO THIS GEAR.
B. MATES WITH XX TOOTH GEAR PART NO. XXXXXXXX.
C. THE TEETH ON THIS SPIRAL (OR ZEROL*) BEVEL GEAR SHALL BE MANUFACTURED UNDER THE CONTROL OF A BEVEL GEAR TESTING MACHINE.
D. FINISH ON WORKING SURFACES OF TEETH SHALL BE XX√.
E. ALL TOOTH ELEMENT SPECIFICATIONS OF THE GEAR ARE RELATIVE TO THE MOUNTING DATUM [   ] .

GEAR REFERENCE DATA

PITCH DIAMETER	X. XXXXXXX
PRESSURE ANGLE	XX°
CONE DISTANCE	X.XXXX
PITCH ANGLE	XX°XX'
CIRCULAR TOOTH THICKNESS AT LARGE END	.XXXX
ADDENDUM AT LARGE END	.XXX
ROTATION (VIEWED FROM BACK OF PINION)	CW or CCW

*Registered trade name

5.4 ADDITIONAL AND SPECIAL DRAWING DATA FOR INTERSECTING AXES GEARING.

5.4.1 General. This section contains both additional and special drawing data requirements for intersecting axes gearing.

5.4.1.1 Additional drawing data. Paragraph 5.4.2 contains additional (mandatory) gear drawing requirements with instructions for selection and specification.

5.4.1.2 Special drawing data. The remaining paragraphs contain instructions for specifying special features or modifications required for special gear applications.

5.4.2 Gear mounting characteristics.

5.4.2.1 Bevel gear surfaces. Prior to establishment of datum surfaces the designer must be familiar with the differences in the various surfaces involved in the design, manufacture, acceptance inspection, assembly, function, and maintenance of bevel gear sets. The following paragraphs are intended to aid the designer in datum surface specification.

5.4.2.1.1 Bevel gear peculiarities. A modern bevel gear cutting machine in good condition will cut a gear which is very nearly perfect, provided that the blank is accurate and the machine is correctly set up and equipped with the proper cutting tools and work holding devices. If the gear was inspected without disturbing its location on the machine on which it was cut, no appreciable runout errors would be found. However, the gear must be removed from the machine and holding device for other operations. It is in operations other than the cutting that many errors develop which exist in the finished gear. It thus becomes obvious that cutting a good gear does not necessarily mean having a good finished gear, unless all the operations before and after cutting the teeth are controlled.

5.4.2.1.2 Important surfaces. The most important surfaces on a gear blank are the surfaces which are used for locating the gear radially and axially on the gear cutting machine. As a general rule, particularly in the case of unhardened gears, these are also the surfaces which are used for mounting the gears in the final assembly. Of equal importance in the case of hardened gears are the reference or locating surfaces which are provided for use in operations subsequent to the cutting of the teeth, such as the die quenching operation and the subsequent grinding of the mounting surfaces. When the size and shape of the gear permit, it is preferable to use the same locating surfaces for cutting, testing, quenching, and grinding, to avoid an accumulation of errors, and to eliminate the necessity of machining numerous surfaces to close tolerances.

5.4.2.1.3 Proof surfaces. One of the most important operations in the manufacture of accurate, hardened bevel gears is the grinding of the mounting bores, bearing diameters, and axial surfaces which are used for mounting the gears in the final assembly. In small lot production it is not always economically practical to provide special fixtures for holding the gear when grinding the bore. In such cases. it is necessary to machine axial and radial proof surfaces on the gear blank for indicating purposes when grinding. As a general rule these surfaces, both radial and axial, should be as near to the teeth as possible, so that when the gear is chucked for grinding with the surfaces running true, the teeth will be correspondingly true.

5.4.2.1.3.1 Proof surface specification. Drawings for bevel gears will specify the areas and limits for both radial and axial proof surfaces. Figure 38 depicts the method of specifying proof surfaces on existing gear blank configuration surfaces. Figure 44 depicts the method of specifying proof surfaces with allowable limits for altering the gear blank configuration.

5.4.2.2 Gaging surfaces. Frequently in bevel gearing a reference surface serves as an installation datum at assembly, as in the adjustment of backlash and tooth bearing patterns using gages and shims. This surface shall be identified as a gaging surface and controlled by its relationship to the functional axis of gear rotation and shall be considered as a minimum drawing requirement. An example of a gaging surface, required for assembly purposes, is depicted by figure 38.

5.4.2.3 Datum axis of bevel gears. As in all types of gears, bevel gears rotate about an axis. Considerable importance is placed on the selection of datums that are functional relative to the design intent. It is important, therefore, that the functional axis of gear rotation be established as the datum for the measurement of all gear characteristics. The functional axis is determined by a design analysis of the mounting conditions. Bevel gears may be classified into four general groups; bore mounted, shank mounted, spline mounted, and face mounted. Figures 38 through 49 illustrate various types of mounting conditions. Datum features and/or tolerancing shall be specified by means of symbols prescribed by the current issue of ANSI Y14.5 Dimensioning and Tolerancing.

5.4.2.3.1 Bevel gear housing requirements. Specification of datums on next up assemblies and housings shall be compatible with individual gear mounting datum specifications.

5.4.2.4 Bore mounted gears. Bevel gears require compound datums consisting of both axial and radial surfaces. The bores of bevel gears serve as a partial mounting datum providing radial locating control while the axial datum surface serves to control the axial mounting distance.

5.4.2.4.1 Long bore. When the mounting bore is long relative to its diameter, as shown in figure 38, the bore becomes the primary datum and the axial surface becomes the secondary datum. All tolerances of radial runout and gear tooth elements must be specified to the compound datum with the primary datum appearing first in the symbol callout.

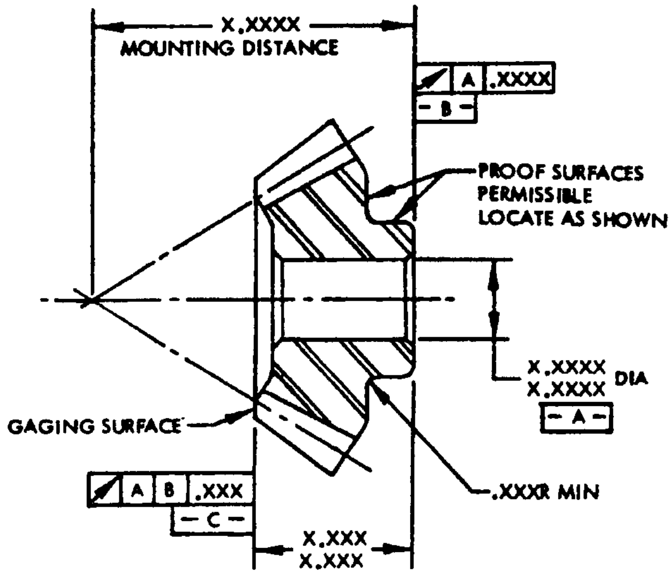


FIGURE 38. Bevel gear long bore.

5.4.2.4.1.1 Gaging surface delineation. When a gaging surface is used during bevel gear installation, the criteria shown on figure 39 will be added to the basic matched set drawing.

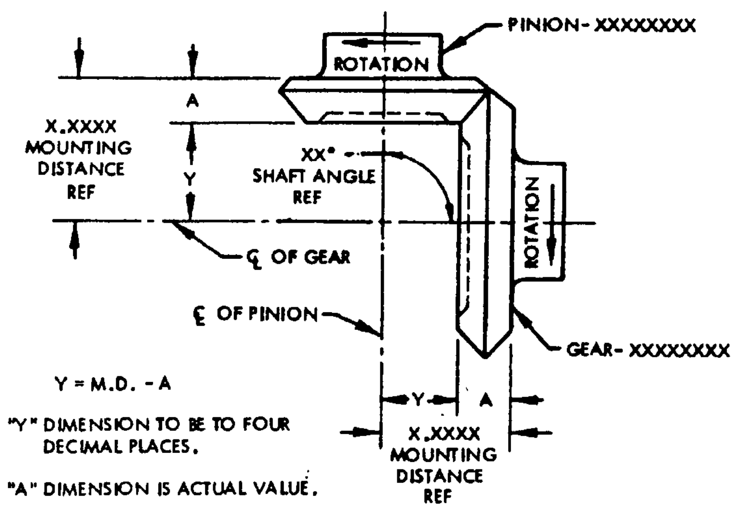
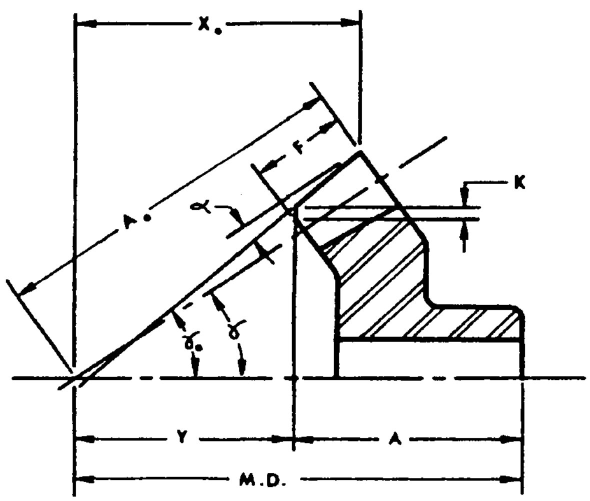


FIGURE 39. Gaging surface.

5.4.2.4.1.1.1 Up-assembly specification. It will be the responsibility of the designer to correlate the gaging surface data on the assembly drawings.

5.4.2.4.1.2 Determination of gaging surfaces. Determination of gaging surfaces is shown on figure 40.



It is customary to include a flat on bevel gear teeth for gaging purposes. Use of the flat is subject to the discretion of the designer.

The location of the flat is determined by the following equation

$$A = M.D. - X_o \quad \frac{F \cos}{\cos} \quad - \quad \frac{K}{\cot + \tan}$$

where A = distance from hub flat to gear tooth gaging flat
X_o = pitch apex to crown
K = desired length of flat
M.D. = mounting distance
F = tooth width

= face angle
= pitch angle
= addendum angle

It can be seen that the location of the flat on a bevel gear is dependent on the diametral pitch of the gear.

FIGURE 40. Location of gaging flat on bevel gears.

5.4.2.4.2 Short bore. The bevel pinion, shown in figure 41, is flange mounted to a shaft. The threaded holes surround the short mounting bore so that the gear will pilot on the diameter of a flanged shaft and be bolted to the mounting flange for control of lateral runout. In this case the axial mounting face of the pinion is selected as primary datum and the short mounting bore as secondary datum.

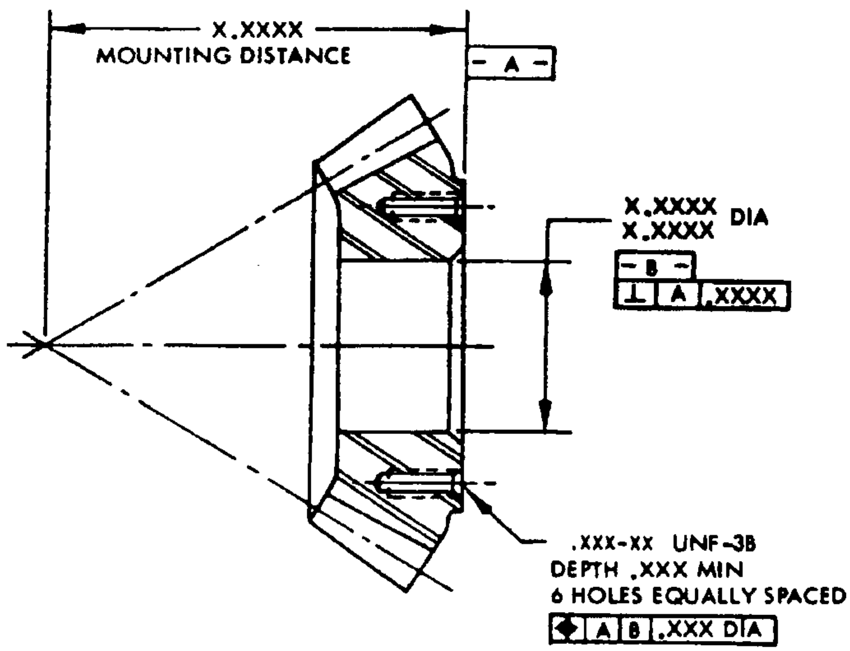


FIGURE 41. Bevel gear short bore.

5.4.2.5 Shank mounted gears. Shank type pinions generally are manufactured from a one piece blank, however, in some instances it is more economical to manufacture the gear and the shank separately. Two piece gear shanks must maintain the functional axis of gear rotation. Since bevel ring gears are similar to two piece shank type gears in that they bolt to a hub or carrier, the same methods of controlling the functional axis of gear rotation by proper datum surface specification will be used.

5.4.2.5.1 Straddle mounted gears. A straddle mounted gear is a gear located between two bearing supports as shown in figure 42. The functional axis of rotation is established by the common axis of the two bearing diameters. Note that the callout symbol identifies this common axis as primary datum rather than one diameter as primary and the other as secondary. Application of the run out tolerance to each diameter relative to their common axis is used as the ANSI Y14.5 nearest equivalent of the coaxial tolerance.

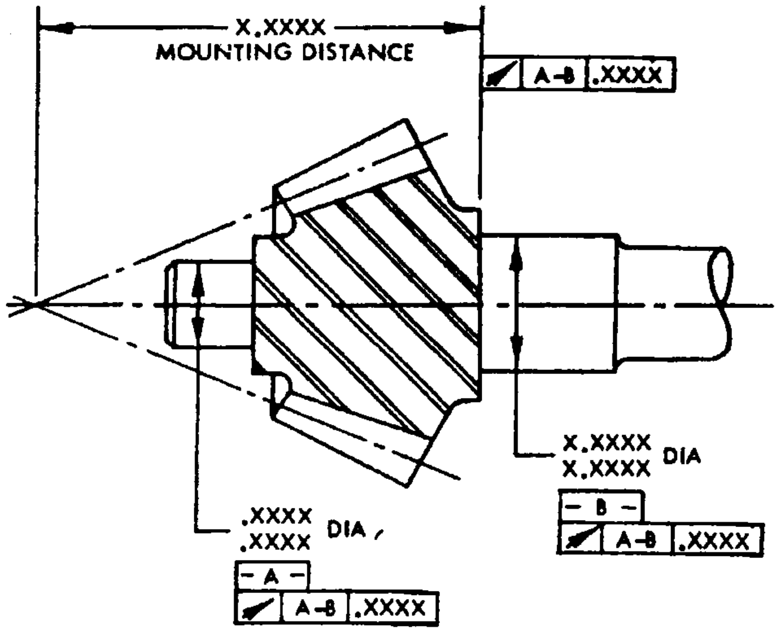


FIGURE 42. Straddle mounted gear.

5.4.2.5.2 Overhung mounted gear. An overhung mounted gear is a gear located outside the two bearing diameters forming the common axis of rotation as shown in figure 43.

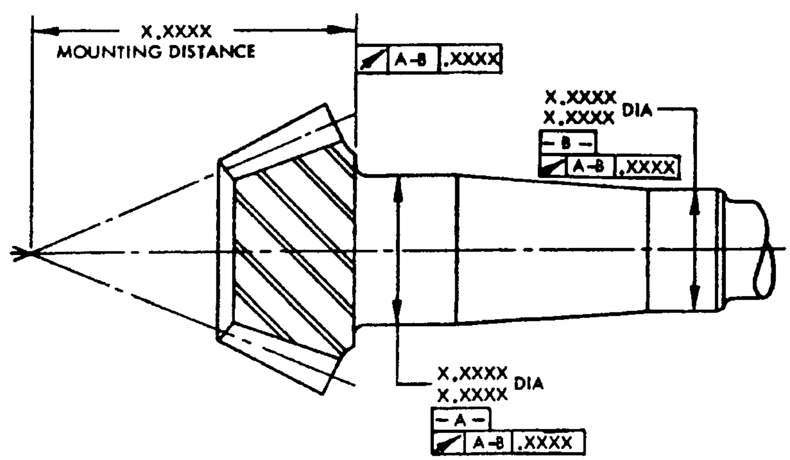


FIGURE 43. Overhung mounted gear.

5.4.2.6 Spline bore mounted gears. Splines serve two major functions in gearing. They can be used for driving and as a locating datum for the axis of rotation of the gear or they may be used solely for driving purposes.

5.4.2.6.1 Driving spline. The bevel gear shown in figure 44 is mounted on a cylindrical surface using the splines for driving only. Shown also is the method of specifying proof surfaces when controls are required. See paragraph 5.4.2.1.3 for further instructions on proof surfaces.

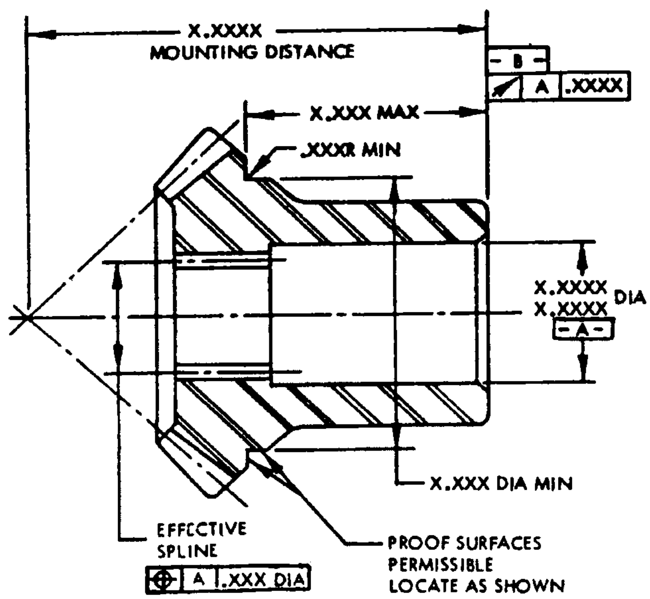


FIGURE 44. Driving spline.

5.4.2.6.2 Datum spline. The side fit type spline, shown in figure 45, establishes the axis of rotation and is also used for driving the gear. The primary datum A shown is the effective spline diameter and the axial thrust surface B is the secondary datum. For major or minor diameter fit splines, the respective major or minor diameters will serve as the primary datum.

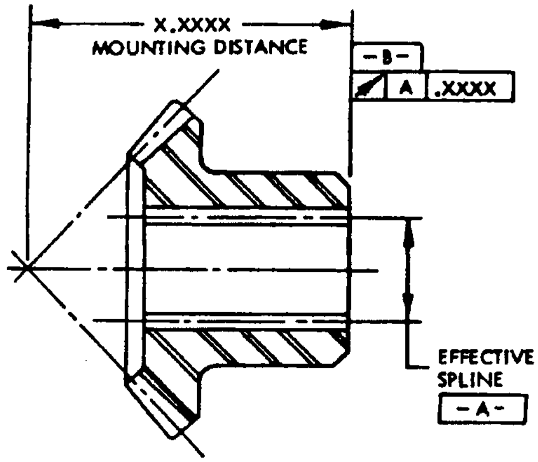


FIGURE 45. Datum spline.

5.4.2.7 Face mounted bevel ring gears. Bevel ring gears are usually a two piece construction consisting of the ring gear and a hub. The axial and radial surfaces used in mounting the ring gear to the hub must be controlled by proper datum specification relative to the functional axis of gear rotation.

5.4.2.7.1 Webless type. The bevel ring gear shown in figure 46 is flange mounted to a hub. The threaded holes surround the short mounting bore so that the gear will pilot on the diameter of a flanged hub and be bolted to the mounting flange for control of lateral runout. In this case, the axial mounting face of the gear is selected as primary datum and the short mounting bore serves as the secondary datum.

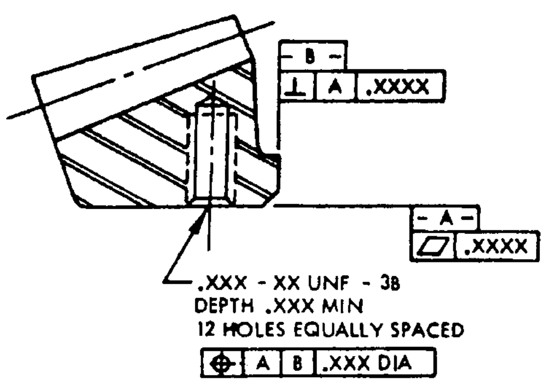


FIGURE 46. Webless type.

5.4.2.7.2 Webless counterbored type. The bevel ring gear shown in figure 47 is flange mounted to a hub. The axial mounting face of the gear serves as a primary datum. In this case, selection of the counterbore diameter as a secondary datum is preferred. It serves as a pilot, centralizing the gear and providing anvil support to the gear tooth thrust loads. Dimensioning and tolerancing of the small bore must assure clearance at assembly.

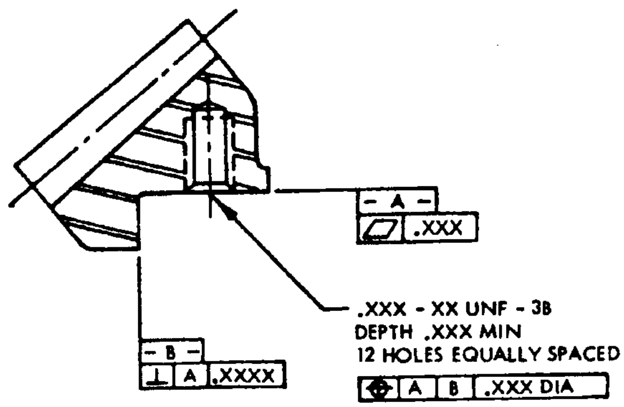


FIGURE 47. Webless counterbored type.

5.4.2.7.3 Web type. The bevel ring gear shown in figure 48 is flange mounted to a hub. The bolt holes surround the short mounting bore so that the gear will pilot on the diameter of a flanged hub and be bolted to the mounting flange for control of lateral runout. The axial mounting face serves as the primary datum and the short bore as the secondary datum. Spot facing of the bolt holes permits greater diameter bolt circles, providing greater strength and avoiding the stress risers created by turning bolt head clearance diameters.

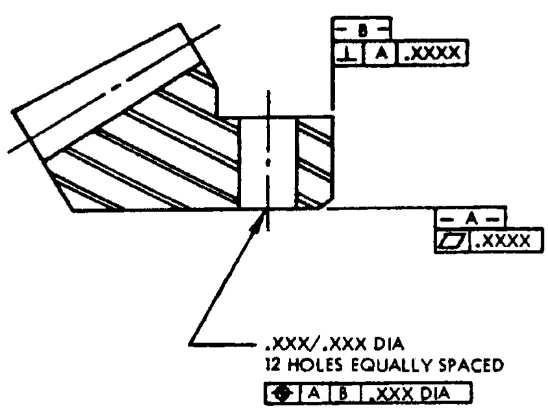


FIGURE 48. Web type.

5.4.2.7.4 Counterbored type with web. The bevel ring gear shown in figure 49 is flange mounted to a hub. The axial mounting face of the gear serves as a primary datum. Again, as in paragraph 5.4.2.7.2, the counterbore diameter serves as a secondary datum. It serves as a pilot, centralizing the gear and providing anvil support to the gear tooth loads. Dimensioning and tolerancing of the small bore must assure clearance at assembly.

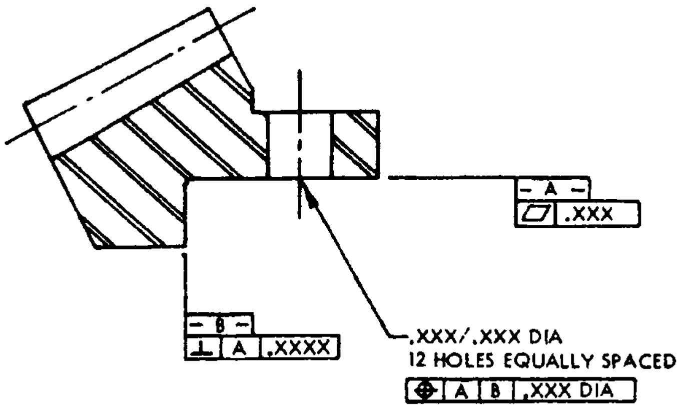


FIGURE 49. Counterbored web type.

5.4.3 Tooth form. Due to the flexibility of the machining system used to cut most bevel gears, many forms are possible. In general, it is customary to produce a desired profile on the teeth of the gear member and then to generate a conjugate profile on the teeth of the pinion. The following sub-paragraphs define the various tooth forms used in bevel gearing.

5.4.3.1 Involute teeth. Because of the wide acceptance of the involute profile for spur and helical gear teeth, it is quite natural to consider the use of involute profiles for bevel gear teeth. But the involute shape is not easily manufactured. Because of the spherical nature of bevel gears, the involute shape must be generated on the surface of a sphere. The spherical involute is produced on the sphere surface by a point on a great circle as it rolls on the two base circles. Such a tooth profile shape is difficult to produce because it would require a point cutting tool. It is, therefore, only of academic interest. In contrast to spur and helical gears, which almost invariably use the involute tooth form, bevel gears can be designed with any of five tooth forms listed in table I.

TABLE I. Involute tooth forms.

Tooth form	Bevel gear types	Production volume	Uses
Involute	All	None	Difficult to manufacture.
Octoid	Straight (Coniflex*) Spiral Zerol*	Small to moderate	Most bevel gears of coarser than 10 diametral pitch which do not lend themselves to higher production methods.
Spherical	Spiral Zerol*	Moderate to large	Principally used for gears of 10 diamterical pitch and finer.
Non-generated (Formate* and Helixfom*)	Spiral Zerol*	Large	Low cost; high quality. Limited to gears of 2.5:1 ratio and higher.
Revacycle*	Straight	Large	Principally automotive differential and farm implement gears.

* Registered trade names.

5.4.3.2 Octoid teeth. One of the advantages associated with the involute of a circlet used for spur gears, is that the involute rack has a straight profile. Similarly, the crown gear (corresponding to a spur gear rack) has straight profile teeth in the bevel tooth system. A crown gear is depicted in paragraph 5.4.4.3. The crown gear tooth form is known as an octoid because of the shape of the path of contact on the surface of the sphere. The octoid tooth form is widely used for generated bevel gear teeth because a simple reciprocating tool with a straight cutting edge can be used. Curved tooth bevel gears (spiral and zerol bevel) can be produced with the octoid tooth form by cutting the teeth with conical cutters. Because the cutter axes must be perpendicular to the root lines of the pinion and mating gear respectively, the axes of the two cutters will not coincide in the axial section when teeth with tapering depth are employed. When the pinion and gear are run together, this lack of coincidence of the two cutter axes results in a bias tooth bearing which, however, is corrected in practice.

5.4.3.3 Spherical teeth. The spherical tooth form was introduced to simplify the correction of bias resulting from the octoid tooth form for curved-tooth bevel gears. The teeth are produced with spherical cutters which match perfectly in the normal section through the gear teeth. Also, in the axial section, the centers of the two cutters coincide. The cutter axes are perpendicular to the root lines of the pinion and gear respectively. Because the spherical surface has the same curvature at every point and in every direction, the two cutters are conjugate to one another despite the fact that their axes do not coincide.

5.4.3.4 Non-generated teeth. Spiral bevel, zerol bevel, and hypoid gears are of two types, generated and non-generated. In appearance, theyare nearly identical, the difference being a slight variation in the profile shape of the teeth. In a generated pair, the teeth of both the gear and pinion are cut by the generating method whereas in a non-generated pair, only the pinion member is generated, the teeth of the gear being straight-sided. In generating a pinion to operate with a non-generated gear, the tooth profile is modified to compensate for the lack of profile curvature in the gear tooth.

5.4.3.4.1 Formate method. Non-generated gears were developed primarily for economic reasons. Since no generating roll is required when cutting the gear member, it can be cut several times faster than a generated gear of the same specifications. It takes no longer to cut the mating pinion than it does to cut the same pinion to run with a generated gear. For these reasons, the Formate type of gear is widely used in products that are manufactured in mass production quantities.

5.4.3.4.2 Helixform method. Formate and Helixform bevel gear pairs have non-generated teeth on the gear member (the larger member) of the pair. Until recently, Formate bevels were the choice of the automotive industry for rear-axle gears. Helixform bevels are similar to the Formate bevels except that the blade of the straight-sided cutter is given a helical feed during its rotation from one end of the tooth space to the other. Thus the tooth surfaces are given a slight twist which is not apparent to the casual observer. The Helixform method offers the advantages of reduced development time since it is a theoretically conjugate method. Also certain cutting changes can be made on the gear using features of the Helixform gear cutting machine which increases the ability to obtain the desired area and position of contact.

5.4.3.5 Revacycle teeth. The Revacycle process employs circular cutters with blades that project radially outward from the cutter body. The latest Revacycle machine is primarily a high production machine which, in addition to speed, has the further advantage of producing a gear having the localized type of tooth bearing. The actual Revacycle tooth profile differs from the involute tooth profile in that the curvature does not increase so rapidly from the tip to the flank of the tooth. Often the rate of change of curvature is negligible, and the tooth profiles may be considered circular. In other cases, the rate of change is considerable, but it is never as great as on an involute profile. In all cases the curvature on gear and pinion, as well as the rates of change of curvature, are so related in the design that there is a slight amount of ease-off, which permits the mating gears some latitude of adjustment in assembly. In the Revacycle process the cutter is the basic member. It has blades that extend radially outward from the cutter, so arranged that a group of roughing blades is followed by a group of finishing blades, followed in turn by a gap or open space for indexing the blank while the cutter is rotating. The roughing cut is taken when the cutter slide is moving in one direction; the finishing is done during the return stroke. A tooth space is roughed and finished in each revolution of the cutter. Most automotive differential “spider” and “side” gears are Revacycle bevel gears.

5.4.4 Shaft angle and pitch angles. The shaft angle is the angle between the two shafts which contains the contacting pitch cones (or engaging teeth). It is equal to the sum of the pitch angles of the two mating gears. The pitch angle and shaft angle relationship determines the nomenclature used for identifying special cases of bevel gear applications. Figures 50 through 57 illustrates typical applications of bevel gearing and the nomenclature required to identify special cases of bevel gearing based on shaft angles and pitch angles. All angles specified in the following figures shall be construed as informational only. They have been simplified to the degree necessary to clearly illustrate the pitch and shaft angle relationships that determine proper bevel gear identification and specification.

5.4.4.1 90° bevel gears. Figure 50 graphically illustrates that the sum of the pitch angles (60° + 30°) equals the shaft angle (90°). Since most bevel gear applications have a shaft angle of 90°, and both the pitch and shaft angles are specified on drawings, no further nomenclature identification is required. For a special case of 90° bevel gear nomenclature, see paragraph 5.4.4.5.1, Right angle miter gears.

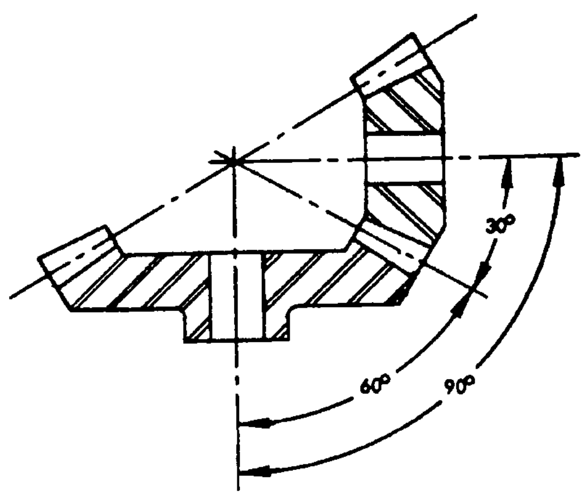


FIGURE 50. 90° bevel gears.

5.4.4.2 Angular bevel gears. The shafts of angular bevel gears operate at angles other than 90°. The shaft angle may be less than 90° (acute angle or greater than 90° (obtuse angle). Since many of the equations, tables, manufacturing methods, and installation techniques are not directly applicable to angular bevel gears, the prefix "ANGULAR" will be used on drawings to identify angular bevel gears. Specifically, the following gear data headings will serve as examples to geometrically identify angular bevel gears:

a. ANGULAR SPIRAL BEVEL GEAR DATA

b. ANGULAR CONIFLEX BEVEL GEAR DATA, etc.

5.4.4.2.1 Less than 90°. This type of bevel gear combination is sometimes called "Long cone distance angular bevel gears". Since both the pitch angle and the shaft angle are specified in the drawing gear data, the prefix "ANGULAR" will adequately identify these types of bevel gears. The example in figure 51 illustrates that the sum of the pitch angles (20° + 10°) equals the shaft angle (30°). For a special case of less than 90° bevel gear nomenclature, see paragraph 5.4.4.5.2 Acute angle miter gears.

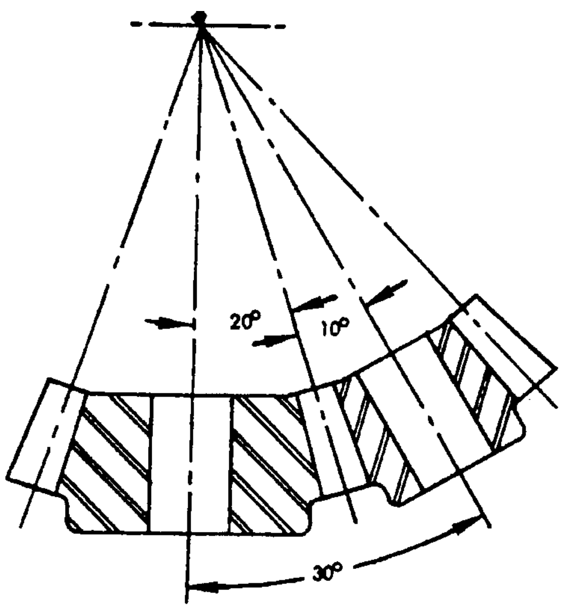


FIGURE 51. Long cone distance angular bevel gears.

5.4.4.2.2 Greater than 90°. In the example shown in figure 52, the sum of the pitch angles (75° + 45°) equals the shaft angle (120°). Since both the pitch angle and the shaft angle are specified in the drawing gear data, the prefix "ANGULAR" will adequately identify these types of bevel gears. For special cases of greater than 90° bevel gear nomenclature, see the following paragraphs:

5.4.4.3 Crown gear.
5.4.4.4 Internal bevel gear.
5.4.4.5.3 Obtuse angle miter gears

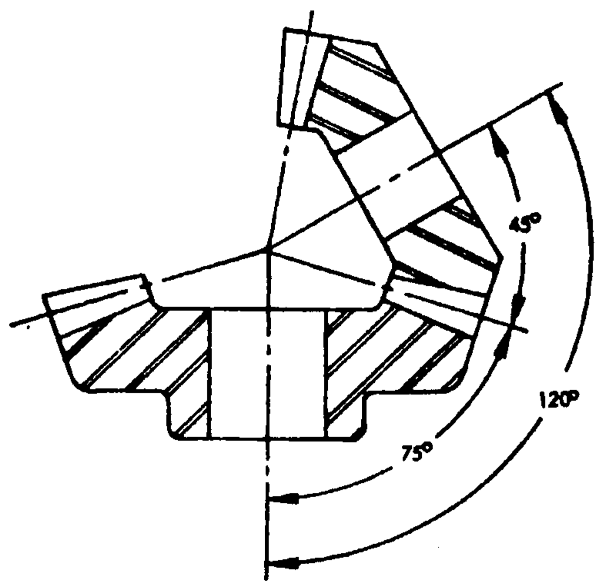


FIGURE 52. Greater than 90°.

5.4.4.3 Crown gear. A crown gear has a pitch angle of 90° and therefore a pitch surface at right angles to its axis. Such a gear corresponds to the rack in spur gearing and is the basic member in defining tooth proportions. It is also frequently used as the basic generating gear in certain bevel gear generators. Figure 53 below illustrates that the sum of the pitch angles (90° + 40°) equals the shaft angle (130°). Drawing specification requirements for this combination of gears shall be specified as follows:

a. Crown gear data heading shall read:

ANGULAR CONIFLEX CROWN GEAR DATA

b. Pinion gear data heading shall read:

ANGULAR CONIFLEX BEVEL PINION DATA

c. Pinion data (GEAR NOTE "B") shall be revised to read:

MATES WITH XX TOOTH CROWN GEAR PART NO. XXXXXXXX

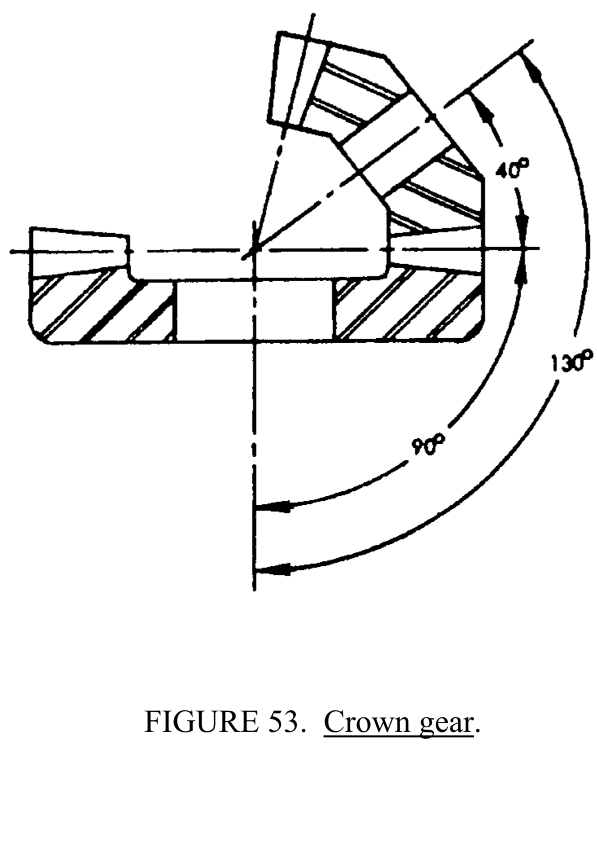


FIGURE 53. Crown gear.

5.4.4.4 Internal bevel gear. An internal bevel gear has a pitch angle that is greater than 90 degrees. Its pitch cone is inverted. Almost universally, bevel gears make contact externally; therefore internal bevel drives should be avoided. They are only of academic interest. In figure 54, the sum of the pitch angles (100° + 30°) equals the shaft angle (130°). Drawing specification requirements for internal bevel gear combinations shall be specified as follows:

a. Internal gear data heading shall read

INTERNAL STRAIGHT BEVEL GEAR DATA

b. Pinion gear data heading shall read:

ANGULAR STRAIGHT BEVEL PINION DATA

c. Pinion data (GEAR NOTE "B") shall be revised to read:

MATES WITH XX TOOTH INTERNAL GEAR PART NO. XXXXXXXX

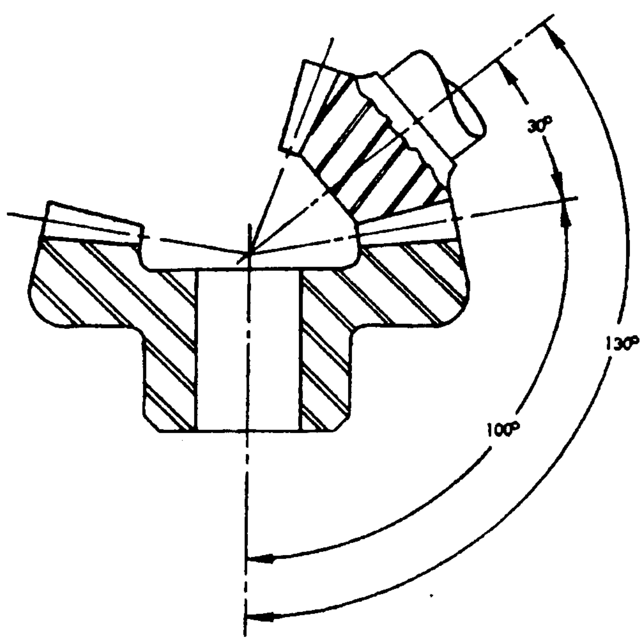


FIGURE 54. Internal bevel gear.

5.4.4.5 Miter gears. Miter gears are mating bevel gears with equal numbers of teeth (1:1 ratio) and with axes usually at right angles. For all purposes of design and application, miter gears shall be of the same diametral pitch, pressure angle and number of teeth. "MITER" shall replace the word "BEVEL" on drawing gear data heading for all types of miter gears. Additional nomenclature requirements for miter gears are depicted in paragraphs 5.4.4.5.1 through 5.4.4.5.3.

5.4.4.5.1 Right angle miter gears. In figure 55, the sum of the pitch angles (45° + 45°) equals the shaft angle (90°). Miter gears, having shafts at right angles to each other (90°), shall be identified as shown in the following gear data heading examples:

a. RIGHT ANGLE CONIFLEX MITER GEAR DATA

b. RIGHT ANGLE SPIRAL MITER GEAR DATA, etc.

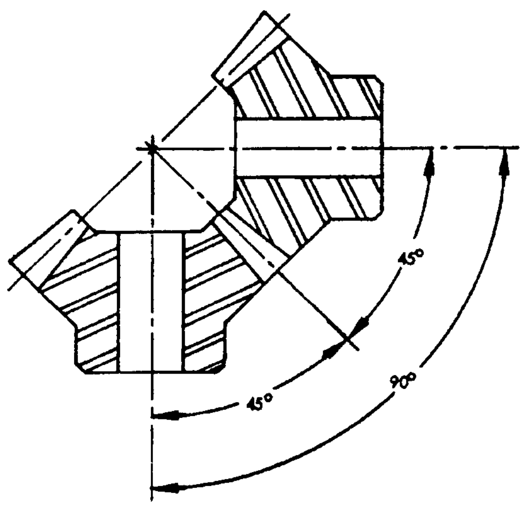


FIGURE 55. Right angle miter gears.

5.4.4.5.2 Acute angle miter gears. Figure 56 illustrates a pair of miter gears whose shaft angle is less than 90°. Specifically, the sum of the pitch angles (15° + 15°) equals the shaft angle (30°). The following examples of gear data headings depict the nomenclature to be used to identify acute angle miter gears:

a. ACUTE ANGLE CONIFLEX MITER GEAR DATA

b. ACUTE ANGLE SPIRAL MITER GEAR DATA, etc

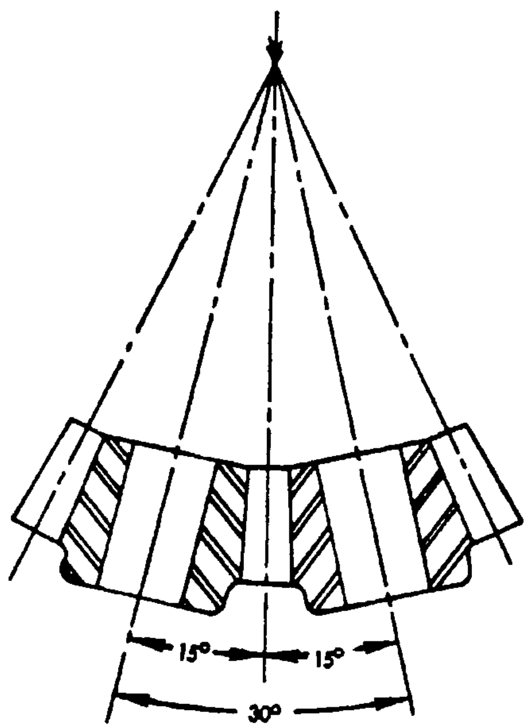


FIGURE 56. Acute angle miter gears.

5.4.4.5.3 Obtuse angle miter gears. When the shaft angle of miter gear is greater than 90°, the gears shall be identified as obtuse angle miter gears. Figure 57 illustrates that the sum of the pitch angle (50° + 50°) equals the shaft angle (100°). Nomenclature to be used to identify obtuse angle miter gears is depicted in the following examples of gear data headings:

a. OBTUSE ANGLE CONIFLEX MITER GEAR DATA

b. OBTUSE ANGLE SPIRAL MITER GEAR DATA, etc

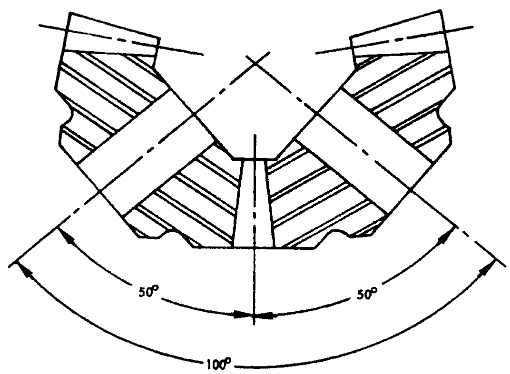


FIGURE 57. Obtuse angle miter gears.

5.5 GEAR DESIGN SHEETS.

5.5.1 General. The accuracy of a gear is dependent upon the accuracy and completeness of the data listed on a gear drawing.

5.5.1.1 Purpose. To assist the designer in the preparation of the gear manufacturing and inspection data. equations for the determination of the bevel gear dimensions have been provided in tabulated form.

5.5.1.2 Scope. It is not the intent of this handbook to provide a design procedure for the determination of the strength, durability, and life of gears but merely to determine the physical dimensions necessary for drawing preparation and manufacture. It is assumed that the designer will analyze the gear for strength, durability, and life based on its physical dimensions.

5.5.1.3 Utilization. The gear design sheets in this section are provided for the convenience of the designer, however their use is not mandatory. Use of the design sheets is encouraged. Reproduction to suitable working size and/or desired quantity is permissible.

GEAR DESIGN SHEET # 1
90° STRAIGHT BEVEL GEARS

Pinion Part Number		Gear Part Number	
$N_P =$ $N_G =$	$P =$ $\phi =$	$\Sigma = 90°$	$B =$
$N_P \div N_G =$	K (see Chart, Fig. 7) =		
Working Depth $= h_K = 2/P =$		Whole Depth $= h_T = 2.188/P + .002 =$	

TERMINOLOGY	EQUATION		VALUE
Pitch Diameter	$D_P = N_P \div P$; $D_G = N_G \div P$	D_P	
		D_G	
Pitch Angle	$\gamma_P = \tan^{-1}(N_P \div N_G)$	γ_P	
	$\Gamma_G = 90° - \gamma_P$	Γ_G	
$\sin \gamma_P = \cos \Gamma_G =$	$\cos \gamma_P = \sin \Gamma_G =$	$\tan \phi =$	
Outer Cone Distance	$A_o = D_G \div (2 \sin \Gamma_G)$	A_o	
Face Width	$F =< 10/P =< 1/3\ A_o$	F	
Addendum	$a_{oG} = \frac{.540}{P} + \frac{.460}{P(N_G \div N_P)^2}$	a_{oG}	
	$a_{oP} = h_K - a_{oG}$	a_{oP}	
Dedendum	$b_{oP} = (2.188 \div P) - a_{oP}$	b_{oP}	
	$b_{oG} = (2.188 \div P) - a_{oG}$	b_{oG}	
Dedendum Angle	$\delta_P = \tan^{-1}(b_{oP} \div A_o)$	δ_P	
	$\delta_G = \tan^{-1}(b_{oG} \div A_o)$	δ_G	
Face Angle	$\gamma_{oP} = \gamma_P + \delta_G$; $\Gamma_{oG} = \Gamma_G + \delta_P$	γ_{oP}	
		Γ_{oG}	
Root Angle	$\gamma_{RP} = \gamma_P - \delta_P$; $\Gamma_{RG} = \Gamma_G - \delta_G$	γ_{RP}	
		Γ_{RG}	
Outside Diameter	$D_{oP} = D_P + 2a_{oP} \cos \gamma_P$	D_{oP}	
	$D_{oG} = D_G + 2a_{oG} \cos \Gamma_G$	D_{oG}	
Pitch Apex To Crown	$x_{oP} = .5\ D_G - a_{oP} \sin \delta_P$	x_{oP}	
	$X_{oG} = .5\ D_P - a_{oG} \sin \Gamma_G$	X_{oG}	
Circular Thickness	$T_G = \pi/2P - (a_{oP} - a_{oG}) \tan \phi - K/P$	T_G	
	$t_P = \pi/P - T_G$	t_P	
Chordal Thickness	$t_{cP} = t_P - (t_P^3 \div 6D_P^2) - .5B$	t_{cP}	
	$T_{cG} = T_G - (T_G^3 \div 6D_G^2) - .5B$	T_{cG}	
Chordal Addendum	$a_{cP} = a_{oP} + (t_P^2 \cos \gamma_P \div 4D_P)$	a_{cP}	
	$a_{cG} = a_{oG} + (T_G^2 \cos \Gamma_G \div 4D_G)$	a_{cG}	
Tooth Angle	$\alpha_P = \frac{3438}{A_o}(.5t_P + b_{oP} \tan \phi)$ minutes	α_P	
	$\alpha_G = \frac{3438}{A_o}(.5T_G + b_{oG} \tan \phi)$ minutes	α_G	

GEAR DESIGN SHEET # 2 ANGULAR STRAIGHT BEVEL GEARS			
Pinion Part Number		Gear Part Number	
N_P N_G	$P =$ $\phi =$ $\Sigma =$	$\sin(180° - \Sigma) =$	
$\sin \Sigma =$ $\cos \Sigma =$	$B =$	$\cos(180° - \Sigma) =$	
Working Depth $= h_K = 2/P =$	Whole Depth $= h_T = 2.188/P + .002 =$		
TERMINOLOGY	EQUATION		VALUE
Pitch Diameter	$D_P = N_P \div P$; $D_G = N_G \div P$	D_P	
		D_G	
Pitch Angle (Σ Less Than 90°)	$\gamma_P = \tan^{-1} \dfrac{\sin \Sigma}{(N_G/N_P) + \cos \Sigma}$	γ_P	
	$\Gamma_G = \Sigma - \gamma_P$	Γ_G	
Pitch Angle (Σ Greater Than 90°)	$\gamma_P = \tan^{-1} \dfrac{\sin(180° - \Sigma)}{(N_G/N_P) - \cos(180° - \Sigma)}$	γ_P	
	$\Gamma_G = \Sigma - \gamma_P$	Γ_G	
$\sin \gamma_P = \cos \Gamma_G =$	$\cos \gamma_P = \sin \Gamma_G =$	$\tan \phi =$	
Outer Cone Distance	$A_o = D_G \div 2 \sin \Gamma_G$	A_o	
Face Width	$F = < 10/P = < 1/3\, A_o$	F	
$(N_P \div N_G) = \dfrac{\sin \gamma_P}{\sin \Gamma_G} =$	$m_{90} = \sqrt{\dfrac{N_G \cos \gamma_P}{N_P \cos \Gamma_G}} =$		
Addendum	$a_{OG} = \dfrac{.540}{P} + \dfrac{.460}{P(m_{90})^2}$	a_{OG}	
	$a_{OP} = h_K - a_{OG}$	a_{OP}	
Dedendum	$b_{OP} = (2.188 \div P) - a_{OP}$	b_{OP}	
	$b_{OG} = (2.188 \div P) - a_{OG}$	b_{OG}	
Dedendum Angle	$\delta_P = \tan^{-1}(b_{OP} \div A_o)$	δ_P	
	$\delta_G = \tan^{-1}(b_{OG} \div A_o)$	δ_G	
Face Angle	$\gamma_{OP} = \gamma_P + \delta_G$; $\Gamma_{OG} = \Gamma_G + \delta_P$	γ_{OP}	
		Γ_{OG}	
Root Angle	$\gamma_{RP} = \gamma_P - \delta_P$; $\Gamma_{RG} = \Gamma_G - \delta_G$	γ_{RP}	
		Γ_{RG}	
Outside Diameter	$D_{OP} = D_P + 2 a_{OP} \cos \gamma_P$	D_{OP}	
	$D_{OG} = D_G + 2 a_{OG} \cos \Gamma_G$	D_{OG}	
Pitch Apex To Crown	$x_{OP} = A_o \cos \gamma_P - a_{OP} \sin \gamma_P$	x_{OP}	
	$X_{OG} = A_o \cos \Gamma_G - a_{OG} \sin \Gamma_G$	X_{OG}	
Circular Thickness	$T_G = \pi/2P - (a_{OP} - a_{OG}) \tan \phi - K/P$	T_G	
	$t_P = \pi/P - T_G$; IF $N_P/N_G > .6, K = 0$	t_P	
Chordal Thickness	$t_{CP} = t_P - (t_P^3 \div 6 D_P^2) - .5B$	t_{CP}	
	$T_{CG} = T_G - (T_G^3 \div 6 D_G^2) - .5B$	T_{CG}	
Chordal Addendum	$a_{CP} = a_{OP} + (t_P^2 \cos \gamma_P \div 4 D_P)$	a_{CP}	
	$a_{CG} = a_{OG} + (T_G^2 \cos \Gamma_G \div 4 D_G)$	a_{CG}	

GEAR DESIGN SHEET # 3
90° ZEROL BEVEL GEARS

Pinion Part Number		Gear Part Number	
N_P =	N_G =	P =	Ø (see Table I) = ; B =
$N_P \div N_G$ =	K (see Chart, Fig. 5) =		Σ = 90°
Working Depth = $h_K = 2/P$ =		Whole Depth = h_T = 2.188/P + .002 =	

TERMINOLOGY	EQUATION		VALUE
Pitch Diameter	$D_P = N_P \div P$; $D_G = N_G \div P$	D_P	
		D_G	
Pitch Angle	$\gamma_P = \tan^{-1}(N_P \div N_G)$; $\Gamma_G = 90° - \gamma_P$	γ_P	
		Γ_G	
$\sin \gamma_P = \cos \Gamma_G$ =	$\cos \gamma_P = \sin \Gamma_G$ =	$\tan$ Ø =	
Outer Cone Distance	$A_o = D_G \div 2 \sin \Gamma_G$	A_o	
Face Width	$F = < 10/P = < .25 A_o$	F	
Addendum	$a_{oG} = \frac{.540}{P} + \frac{.460}{P(N_G \div N_P)^2}$; $a_{oP} = h_K - a_{oG}$	a_{oG}	
		a_{oP}	
Dedendum	$b_{oP} = h_T - a_{oP}$; $b_{oG} = h_T - a_{oG}$	b_{oP}	
		b_{oG}	
Change in Dedendum Angle for Ø = 20°	$\Delta\delta = \frac{3334}{PA_o} - \frac{150\sqrt{D_P}\sin\Gamma_G}{PA_o F} - \frac{7}{A_o}$	$\Delta\delta$	
Change in Dedendum Angle for Ø = 22 1/2°	$\Delta\delta = \frac{2434}{PA_o} - \frac{150\sqrt{D_P}\sin\Gamma_G}{PA_o F} - \frac{7}{A_o}$	$\Delta\delta$	
Change in Dedendum Angle for Ø = 25°	$\Delta\delta = \frac{1706}{PA_o} - \frac{150\sqrt{D_P}\sin\Gamma_G}{PA_o F} - \frac{7}{A_o}$	$\Delta\delta$	
Dedendum Angle	$\delta_P = \tan^{-1}(b_{oP} \div A_o) + \Delta\delta$	δ_P	
	$\delta_G = \tan^{-1}(b_{oG} \div A_o) + \Delta\delta$	δ_G	
Face Angle	$\gamma_{oP} = \gamma_P + \delta_G$; $\Gamma_{oG} = \Gamma_G + \delta_P$	γ_{oP}	
		Γ_{oG}	
Root Angle	$\gamma_{RP} = \gamma_P - \delta_P$; $\Gamma_{RG} = \Gamma_G - \delta_G$	γ_{RP}	
		Γ_{RG}	
Outside Diameter	$D_{oP} = D_P + 2a_{oP}\cos\gamma_P$	D_{oP}	
	$D_{oG} = D_G + 2a_{oG}\cos\Gamma_G$	D_{oG}	
Pitch Apex to Crown	$x_{oP} = .5 D_G - a_{oP}\sin\gamma_P$	x_{oP}	
	$X_{oG} = .5 D_P - a_{oG}\sin\Gamma_G$	X_{oG}	
Circular Thickness	$T_G = \pi/2P - (a_{oP} - a_{oG})\tan\phi - K/P$	T_G	
	$t_P = \pi/P - T_G$	t_P	

GEAR DESIGN SHEET # 4
ANGULAR ZEROL BEVEL GEARS

Pinion Part Number		Gear Part Number	
$N_P =$ $N_G =$	$P =$	$\phi = < \phi' =$	$\sin(180° - \Sigma) =$
$\sin \Sigma =$ $\cos \Sigma =$	$B =$	$\Sigma =$	$\cos(180° - \Sigma) =$
Working Depth $= h_K = 2/P =$		Whole Depth $= h_T = 2.188/P + .002 =$	

TERMINOLOGY	EQUATION		VALUE
Pitch Diameter	$D_P = N_P \div P$; $D_G = N_G \div P$	D_P	
		D_G	
Pitch Angle (Σ Less Than 90°)	$\gamma_P = \tan^{-1} \dfrac{\sin \Sigma}{(N_G \div N_P) + \cos \Sigma}$; $\Gamma_G = \Sigma - \gamma_P$	γ_P	
		Γ_G	
Pitch Angle (Σ Greater Than 90°)	$\gamma_P = \tan^{-1} \dfrac{\sin(180° - \Sigma)}{(N_G \div N_P) - \cos(180° - \Sigma)}$; $\Gamma_G = \Sigma - \gamma_P$	γ_P	
		Γ_G	
$\sin \gamma_P = \cos \Gamma_G =$	$\cos \gamma_P = \sin \Gamma_G =$	$\tan \phi =$	
Outer Cone Distance	$A_o = D_G \div 2 \sin \Gamma_G$	A_o	
Face Width	$F = < 10/P = < .25 A_o$	F	
$\dfrac{\sin \gamma_P}{\sin \Gamma_G} = \dfrac{N_P}{N_G} =$	$m_{90} = \sqrt{\dfrac{N_G \cos \gamma_P}{N_P \cos \Gamma_G}} =$	$\sin \phi' = \sqrt{\dfrac{1.15\, b_{oP}}{A_o \tan \gamma_P}} =$	
Addendum	$a_{oG} = \dfrac{.540}{P} + \dfrac{.460}{P(m_{90})^2}$; $a_{oP} = h_K - a_{oG}$	a_{oG}	
		a_{oP}	
Dedendum	$b_{oP} = h_T - a_{oP}$; $b_{oG} = h_T - a_{oG}$	b_{oP}	
		b_{oG}	
Change in Dedendum Angle for $\phi = 20°$	$\Delta\delta = \dfrac{3334}{PA_o} - \dfrac{300}{F}\sqrt{\dfrac{1}{2P^2 A_o(\tan \gamma_P + \tan \Gamma_G)}} - \dfrac{7}{A_o}$	$\Delta\delta$	
Change in Dedendum Angle for $\phi = 22\ 1/2°$	$\Delta\delta = \dfrac{2434}{PA_o} - \dfrac{300}{F}\sqrt{\dfrac{1}{2P^2 A_o(\tan \gamma_P + \tan \Gamma_G)}} - \dfrac{7}{A_o}$	$\Delta\delta$	
Change in Dedendum Angle for $\phi = 25°$	$\Delta\delta = \dfrac{1706}{PA_o} - \dfrac{300}{F}\sqrt{\dfrac{1}{2P^2 A_o(\tan \gamma_P + \tan \Gamma_G)}} - \dfrac{7}{A_o}$	$\Delta\delta$	
Dedendum Angle	$\delta_P = \tan^{-1}(b_{oP} \div A_o) + \Delta\delta$	δ_P	
	$\delta_G = \tan^{-1}(b_{oG} \div A_o) + \Delta\delta$	δ_G	
Face Angle	$\gamma_{oP} = \gamma_P + \delta_G$; $\Gamma_{oG} = \Gamma_G + \delta_P$	γ_{oP}	
		Γ_{oG}	
Root Angle	$\gamma_{RP} = \gamma_P - \delta_P$; $\Gamma_{RG} = \Gamma_G - \delta_G$	γ_{RP}	
		Γ_{RG}	
Outside Diameter	$D_{oP} = D_P + 2 a_{oP} \cos \gamma_P$	D_{oP}	
	$D_{oG} = D_G + 2 a_{oG} \cos \Gamma_G$	D_{oG}	
Pitch Apex To Crown	$X_{oP} = A_o \cos \gamma_P - a_{oP} \sin \gamma_P$	X_{oP}	
	$X_{oG} = A_o \cos \Gamma_G - a_{oG} \sin \Gamma_G$	X_{oG}	
Circular Thickness	$T_G = \pi/2P - (a_{oP} - a_{oG}) \tan \phi - K/P$	T_G	
	$t_P = \pi/P - T_G$; If $N_P/N_G > .6$, $K = 0$	t_P	

GEAR DESIGN SHEET # 5
90° SPIRAL BEVEL GEARS

Pinion Part Number			Gear Part Number		
N_P =	N_G =	P =	Ø =	Σ = 90°	Spiral Angle = 35°
Normal Backlash =		$N_P \div N_G$ =		K (see Chart, Fig. 4) =	
Working Depth = h_K = 1.700 ÷ P =			Whole Depth = h_T = 1.888 ÷ P =		

TERMINOLOGY	EQUATION		VALUE
Pitch Diameter	$D_P = N_P \div P$; $D_G = N_G \div P$	D_P	
		D_G	
Pitch Angle	$\gamma_P = \tan^{-1}(N_P \div N_G)$; $\Gamma_G = 90° - \gamma_P$	γ_P	
		Γ_G	
$\sin\gamma_P = \cos\Gamma_G$ =	$\cos\gamma_P = \sin\Gamma_G$ =	tan Ø =	
Outer Cone Distance	$A_o = D_G \div 2\sin\Gamma_G$	A_o	
Face Width	F = < 10/P = < .30A_o	F	
Addendum	$a_{oG} = \frac{.460}{P} + \frac{.390}{P(N_G \div N_P)^2}$; $a_{oP} = h_K - a_{oG}$	a_{oG}	
		a_{oP}	
Dedendum	$b_{oP} = h_T - a_{oP}$; $b_{oG} = h_T - a_{oG}$	b_{oP}	
		b_{oG}	
Clearance	$c = h_T - h_K$	c	
Dedendum Angle	$\delta_P = \tan^{-1}(b_{oP} \div A_o)$	δ_P	
	$\delta_G = \tan^{-1}(b_{oG} \div A_o)$	δ_G	
Face Angle	$\gamma_{oP} = \gamma_P + \delta_G$; $\Gamma_{oG} = \Gamma_G + \delta_P$	γ_{oP}	
		Γ_{oG}	
Root Angle	$\gamma_{RP} = \gamma_P - \delta_P$; $\Gamma_{RG} = \Gamma_G - \delta_G$	γ_{RP}	
		Γ_{RG}	
Outside Diameter	$D_{oP} = D_P + 2a_{oP}\cos\gamma_P$	D_{oP}	
	$D_{oG} = D_G + 2a_{oG}\cos\Gamma_G$	D_{oG}	
Pitch Apex to Crown	$x_{oP} = .5D_G - a_{oP}\sin\gamma_P$	x_{oP}	
	$X_{oG} = .5D_P - a_{oG}\sin\Gamma_G$	X_{oG}	
Circular Thickness	$T_G = \pi/2P - (a_{oP} - a_{oG})\frac{\tan\phi}{\cos\psi} - K/P$	T_G	
	$t_P = \pi/P - T_G$	t_P	
	$t_P = \pi/P - (T_G + B)$	t_P	

GEAR DESIGN SHEET # 6
ANGULAR SPIRAL BEVEL GEARS

Pinion Part Number		Gear Part Number	
N_P =	N_G =	P =	ϕ =
Σ =	sin (180° − Σ) =		
sin Σ =	cos Σ =	B =	cos (180° − Σ) =
Working Depth = h_K = 1.700 ÷ P =		Whole Depth = h_T = 1.888 ÷ P =	

TERMINOLOGY	EQUATION		VALUE
Pitch Diameter	$D_P = N_P \div P$; $D_G = N_G \div P$	D_P	
		D_G	
Pitch Angle (Σ Less Than 90°)	$\gamma_P = \tan^{-1} \dfrac{\sin\Sigma}{(N_G \div N_P) + \cos\Sigma}$; $\Gamma_G = \Sigma - \gamma_P$	γ_P	
		Γ_G	
Pitch Angle (Σ Greater Than 90°)	$\gamma_P = \tan^{-1} \dfrac{\sin(180° - \Sigma)}{(N_G \div N_P) - \cos(180° - \Sigma)}$; $\Gamma_G = \Sigma - \gamma_P$	γ_P	
		Γ_G	
$\sin\gamma_P = \cos\Gamma_G$ =	$\cos\gamma_P = \sin\Gamma_G$ =	tan ϕ =	
Outer Cone Distance	$A_o = D_G \div 2\sin\Gamma_G$ =	A_o	
Face Width	$F = < 10/P = < .30A_o$	F	
$(N_P \div N_G) = \dfrac{\sin\gamma_P}{\sin\Gamma_G}$ =	$m_{90} = \sqrt{\dfrac{N_G \cos\gamma_P}{N_P \cos\Gamma_G}} = \tan\Gamma_{90}$ =		
$N_{P90} = N_P \sin\Gamma_{90} \div \cos\gamma_P$ =			
Addendum	$a_{oG} = \dfrac{.460}{P} + \dfrac{.390}{P(m_{90})^2}$; $a_{oP} = h_K - a_{oG}$	a_{oG}	
		a_{oP}	
Dedendum	$b_{oP} = h_T - a_{oP}$; $b_{oG} = h_T - a_{oG}$	b_{oP}	
		b_{oG}	
Dedendum Angle	$\delta_P = \tan^{-1}(b_{oP} \div A_o)$; $\delta_G = \tan^{-1}(b_{oG} \div A_o)$	δ_P	
		δ_G	
Face Angle	$\gamma_{oP} = \gamma_P + \delta_G$; $\Gamma_{oG} = \Gamma_G + \delta_P$	γ_{oP}	
		Γ_{oG}	
Root Angle	$\gamma_{RP} = \gamma_P - \delta_P$; $\Gamma_{RG} = \Gamma_G - \delta_G$	γ_{RP}	
		Γ_{RG}	
Outside Diameter	$D_{oP} = D_P + 2a_{oP}\cos\gamma_P$; $D_{oG} = D_G + 2a_{oG}\cos\Gamma_G$	D_{oP}	
		D_{oG}	
Pitch Apex to Crown	$x_{oP} = A_o\cos\gamma_P - a_{oP}\sin\gamma_P$; $X_{oG} = A_o\cos\Gamma_G - a_{oG}\sin\Gamma_G$	x_{oP}	
		X_{oG}	
Circular Thickness	$T_G = \pi/2P - (a_{oP} - a_{oG})\dfrac{\tan\phi}{\cos\psi} - K/P$	T_G	
	$t_P = \pi/P - T_G$; For K see Gleason Handbook	t_P	
	$t_P = \pi/P - (T_G + B)$	t_P	

P		GEAR DESIGN SHEET SG-1 EXTERNAL SPUR GEAR TOOTH DIMENSIONS STANDARD CENTER DISTANCE				DATE:
Ø						SHEET 1 OF 3

Pressure Angle *	Ø		inv Ø		cos Ø		
Diametral Pitch *	P		sin Ø		tan Ø		
Gear Backlash at D	B_G		Circular Pitch	$p = \pi \div P$			
Pinion Backlash at D	B_P		Base Pitch	$p_b = \pi \cos Ø \div P$			

Addendum	a	$1 \div P$	Other		$\cos(90°/N_G)$	
Dedendum	b	$1.25 \div P$	Other		$\cos(90°/N_P)$	
Clearance	$\bar{c}$	$\bar{c} = b - a$		π (see note 3) =		

AGMA Quality/Class Number			Measuring Wire Diameter *	d_w	
Gear Major Diameter Runout	Q_G		Gear Major Diameter Tolerance	ΔD_{oG}	
Pinion Major Diameter Runout	Q_P		Pinion Major Diameter Tolerance	ΔD_{oP}	

TERMINOLOGY	FORMULA		SYMBOL	GEAR (G)	PINION (P)
Part Number *			-		
Drawing Number *			-	Rev.	Rev.
Number of Teeth *			N		
Pitch Diameter *	$N \div P$		D		
Base Diameter *	$D \cos Ø$		D_b		
Center Distance *	$(N_G + N_P) \div 2P$		C		+ .00
Tooth Thickness At Pitch Diameter * (Round off to 4 Decimal Places)	$\frac{\pi}{2P} - B_{min}$	Max	t		
*	$\frac{\pi}{2P} - B_{max}$	Min			
Major Diameter *	$D + 2a$	Max	D_o		
*	$D_{o_{max}} - \Delta D_o$	Min			
Minimum Tooth Tip Chamfer or Radius Height			Δtip_{min}		
Maximum Tooth Tip Chamfer or Radius Height			Δtip_{max}		
$\sec Ø_o$	$D_{o_{max}} \div D_b$		$\sec Ø_o$		
$\text{inv } Ø_o$	Table of Functions		$\text{inv } Ø_o$		
Tooth Thickness at D_o	$D_{o_{max}}\left(\frac{t_{min}}{D} + \text{inv } Ø - \text{inv } Ø_o\right)$		t_o		

P		GEAR DESIGN SHEET SG-1 EXTERNAL SPUR GEAR TOOTH DIMENSIONS STANDARD CENTER DISTANCE	SHEET 2 OF 3
Ø			

TERMINOLOGY	FORMULA	SYMBOL	GEAR (G)	PINION (P)
Top Land	$t_o - 2\,\Delta tip_{max}$ (should be greater than .005)			
Profile Major Diameter * *	$D_{o_{max}} - 2\,\Delta tip_{min}$ Max $D_{o_{min}} - 2\,\Delta tip_{max}$ Min	D_M		

$x = 2C_{min} \sin Ø$		$y = \sqrt{D^2_{MG_{max}} - D^2_{bG}}$		$z = \sqrt{D^2_{MP_{max}} - D^2_{bP}}$	
$x_1 = 2C_{max} \sin Ø$		$y_1 = \sqrt{D^2_{MG_{min}} - D^2_{bG}}$		$z_1 = \sqrt{D^2_{MP_{min}} - D^2_{bP}}$	

NOTE: x and x_1 must be greater than y and y_1 and z and z_1 respectively.

TERMINOLOGY	FORMULA	SYMBOL	GEAR (G)	PINION (P)
Active Profile Diameter * *	$\sqrt{(x - z)^2 + D^2_{bG}} - Q_p$ Gear $\sqrt{(x - y)^2 + D^2_{bP}} - Q_G$ Pinion	APD		(hatched)
Hob Displacement for Backlash	$B_{max} \div 2 \tan Ø$	Δe	(hatched)	
Minor Diameter * *	$D - 2b$ Max $D - 2b - 2\,\Delta e$ Min	D_R		
Form Diameter Max *	$\sqrt{\left(D_{R_{max}} + 2\bar{c}\right)^2 + \left(\frac{D - D_{R_{max}} - 2\bar{c}}{\tan Ø}\right)^2}$ $\left(D - D_{R_{max}} - 2\bar{c}\right.$ must be a positive value$\left.\right)$	D_F		
Contact ratio	$\left(y_1 + z_1 - x_1\right) \div 2p_b$ To assure continuity of action, value must be greater than 1.05, preferably 1.2 or greater.	m_p		
W_G ; W_P (may be positive or negative values)	$W_G = inv\,Ø + \frac{d_w}{D_{bG}} - \frac{\pi}{N_G}$ $W_P = inv\,Ø + \frac{d_w}{D_{bP}} - \frac{\pi}{N_P}$	W_G W_P		

P		GEAR DESIGN SHEET SG-1 EXTERNAL SPUR GEAR TOOTH DIMENSIONS STANDARD CENTER DISTANCE	SHEET 3 OF 3
Ø			

TERMINOLOGY	FORMULA		SYMBOL	GEAR (G)	PINION (P)
Involute at Wire Center	$W_G + \frac{t_{G_{max}}}{D_G}$; $W_P + \frac{t_{P_{min}}}{D_P}$	Max	inv $Ø_w$		
	$W_G + \frac{t_{G_{min}}}{D_G}$; $W_P + \frac{t_{P_{min}}}{D_P}$	Min			
sec $Ø_w$	Table of Functions	Max	sec $Ø_w$		
		Min			
tan $Ø_{w_{max}}$	Table of Functions		tan $Ø_w$		
Wire Contact Diameter	$\sqrt{(D_b \tan Ø_w - d_w)^2 + D_b^2}$		D_c		
Measurement over Wires (Even Teeth) *	$D_b \sec Ø_w + d_w$	Max	M_E		
*		Min			
Wire Clearance	$d_{w_c} = .5(M_{E_{min}} - 2d_w - D_{R_{max}})$ (value must be positive)		d_{w_c}		
Measurement over Wires (Odd Teeth) *	$D_b \cos(90^o/N) \sec Ø_w + d_w$	Max	M_o		
*		Min			
Face Width *			F		
COARSE PITCH GEARS				GEAR (G)	PINION (P)
Maximum Runout Tolerance of Pitch Diameter			*		
Lead Tolerance Across Face Width			*		
Pitch (Tooth-to-Tooth Spacing) Tolerance			*		
Profile Tolerance			*		

NOTES:

1. All values designated with an asterisk (*) shall be shown on drawing.
2. To insure accuracy, calculate to a minimum of seven decimal places.
3. Use π to a minimum of seven decimal places.
4. These calculations were performed to ______ decimal places.

P		GEAR DESIGN SHEET SG-2 EXTERNAL SPUR GEAR TOOTH DIMENSIONS NON-STANDARD CENTER DISTANCE	DATE:
Ø			SHEET 1 OF 4

Pressure Angle *	Ø		inv Ø		cos Ø		
Diametral Pitch *	P		tan Ø				
Gear Backlash at D_x	B_{xG}		Circular Pitch at D_x	$p_x = \pi D_x \div N$			
Pinion Backlash at D_x	B_{xP}		Base Pitch	$p_b = \pi \cos Ø \div P$			

Addendum	a	$1 \div P$	Other		$\cos(90^o/N_G)$	
Dedendum	b	$1.25 \div P$	Other		$\cos(90^o/N_P)$	
Clearance	$\bar{c}$	$\bar{c} = b - a$		Measuring Wire Diameter *	d_w	
AGMA Quality/Class Number				Operating Center Distance *	C_x	+.00

Operating Pitch Diameter *	$2NC_x \div (N_G + N_P)$	D_{xG}		D_{xP}	
$\sec Ø_x = D_x \div D_b$		Operating Pressure Angle *		$Ø_x$	
π (see note 3) =		inv $Ø_x$		sin $Ø_x$	
Gear Major Diameter Runout	Q_G		Gear Major Diameter Tolerance	ΔD_{oG}	
Pinion Major Diameter Runout	Q_P		Pinion Major Diameter Tolerance	ΔD_{oP}	

TERMINOLOGY	FORMULA		SYMBOL	GEAR (G)	PINION (P)
Part Number *			-		
Drawing Number *			-	Rev.	Rev.
Number of Teeth *			N		
Nominal Pitch Diameter *	$N \div P$		D		
Base Diameter *	$D \cos Ø$		D_b		
Actual Tooth Thickness at D_x	$.5p_x - B_{xG_{min}}$; $.5p_x - B_{xP_{min}}$	Max	t_x		
	$.5p_x - B_{xG_{max}}$; $.5p_x - B_{xP_{max}}$	Min			
Actual Tooth Thickness at D * (Round off to 4 Decimal Places) *	$D\left(\frac{t_x}{D_x} + \text{inv } Ø_x - \text{inv } Ø\right)$	Max	t		
		Min			
Hob Displacement for Backlash	$\left(t - \frac{\pi}{2P}\right) \div 2 \tan Ø$	Max	Δe		
		Min			

P		GEAR DESIGN SHEET SG-2 EXTERNAL SPUR GEAR TOOTH DIMENSIONS NON-STANDARD CENTER DISTANCE	SHEET 2 OF 4
Ø			

TERMINOLOGY	FORMULA	SYMBOL	GEAR (G)	PINION (P)
Major Diameter *	$D + 2a + 2\Delta e_{max}$ — Max	D_o		
*	$D_{o_{max}} - \Delta D_o$ — Min			
Minimum Tooth Tip Chamfer or Radius Height		Δtip_{min}		
Maximum Tooth Tip Chamfer or Radius Height		Δtip_{max}		
sec $Ø_o$	$D_{o_{max}} \div D_b$	sec $Ø_o$		
inv $Ø_o$	Table of Functions	inv $Ø_o$		
Tooth Thickness at D_o	$D_{o_{max}}\left(\frac{t_{min}}{D} + \text{inv } Ø - \text{inv } Ø_o\right)$	t_o		
Top Land	$t_o - 2\Delta tip_{max}$ (should be greater than .005)	L_T		
Profile Major Diameter *	$D_{o_{max}} - 2\Delta tip_{min}$ — Max	D_M		
	$D_{o_{min}} - 2\Delta tip_{max}$ — Min			

$x = 2C_{x_{min}} \sin Ø_x$		$y = \sqrt{D^2_{MG_{max}} - D^2_{bG}}$		$z = \sqrt{D^2_{MP_{max}} - D^2_{bP}}$	
$x_1 = 2C_{x_{max}} \sin Ø_x$		$y_1 = \sqrt{D^2_{MG_{min}} - D^2_{bG}}$		$z_1 = \sqrt{D^2_{MP_{min}} - D^2_{bP}}$	

NOTE: x and x_1 must be greater than y and y_1 and z and z_1 respectively.

TERMINOLOGY	FORMULA	SYMBOL	GEAR (G)	PINION (P)
Active Profile Diameter *	$\sqrt{(x - z)^2 + D^2_{bG}} - Q_P$ — Gear	APD		(hatched)
*	$\sqrt{(x - y)^2 + D^2_{bP}} - Q_G$ — Pinion		(hatched)	
Nominal Tooth Thickness at D	$D\left(\frac{.5p_x}{D_x} + \text{inv } Ø_x - \text{inv } Ø\right)$	t_{nom}		
Hob Displacement at Zero Backlash	$\left(t_{nom} - \frac{\pi}{2P}\right) \div 2 \tan Ø$	Δe_{nom}		
Minor Diameter *	$D - 2b + 2\Delta e_{nom}$ — Max	D_R		
*	$D - 2b + 2\Delta e_{min}$ — Min			

P		GEAR DESIGN SHEET SG-2 EXTERNAL SPUR GEAR TOOTH DIMENSIONS NON-STANDARD CENTER DISTANCE	SHEET 3 OF 4
Ø			

TERMINOLOGY	FORMULA		SYMBOL	GEAR (G)	PINION (P)
Form Diameter Maximum *	$\sqrt{\left(\frac{D_{R_{max}}+2\bar{c}}{2}\right)^2+\left(\frac{D-D_{R_{max}}-2\bar{c}}{\tan \emptyset}\right)^2}$ $(D - D_{R_{max}} - 2\bar{c}$ must be a positive value)		D_F		
Contact Ratio	$(y_1 + z_1 - x_1) \div 2p_b$ To assure continuity of action, value must be greater than 1.05 preferably 1.2 or greater		m_p		
W_G ; W_P (may be a positive or negative value)	$W_G = \text{inv } \emptyset + \frac{d_w}{D_{bG}} - \frac{\pi}{N_G}$		W_G		
	$W_P = \text{inv } \emptyset + \frac{d_w}{D_{bP}} - \frac{\pi}{N_P}$		W_P		
Involute at Wire Center	$W_G + \frac{t_{G_{max}}}{D_G}$; $W_P + \frac{t_{P_{max}}}{D_P}$	Max	inv $\emptyset_w$		
	$W_G + \frac{t_{G_{min}}}{D_G}$; $W_P + \frac{t_{P_{min}}}{D_P}$	Min			
sec $\emptyset_w$	Table of Functions	Max	sec $\emptyset_w$		
		Min			
tan $\emptyset_{w_{max}}$	Table of Functions		tan $\emptyset_w$		
Wire Contact Diameter	$\sqrt{(D_b \tan \emptyset_w - d_w)^2 + D_b^2}$		D_c		
Measurement Over Wires (Even Teeth) *	$D_b \sec \emptyset_w + d_w$	Max	M_E		
*		Min			
Wire Clearance	$d_{w_c} = .5\left(M_{e_{min}} - 2d_w - D_{R_{max}}\right)$ (value must be positive)		d_{w_c}		
Measurement over Wires (Odd Teeth) *	$D_b \cos(90^o/N) \sec \emptyset_w + d_w$	Max	M_o		
*		Min			
Face Width *			F		

P		GEAR DESIGN SHEET SG-2 EXTERNAL SPUR GEAR TOOTH DIMENSIONS NON-STANDARD CENTER DISTANCE	SHEET 4 OF 4
Ø			

COARSE PITCH GEARS		GEAR (G)	PINION (P)
Maximum Runout Tolerance of Pitch Diameter	*		
Lead Tolerance Across Face Width	*		
Pitch (Tooth-to-Tooth Spacing) Tolerance	*		
Profile Tolerance	*		

NOTES:

1. All values designated with an asterisk (*) shall be shown on drawing.
2. To insure accuracy, calculate to a minimum of seven decimal places.
3. Use π to a minimum of seven decimal places.
4. These calculations were performed to ______ decimal places.

P		GEAR DESIGN SHEET SG-3 EXTERNAL SPUR GEAR TOOTH DIMENSIONS LONG ADDENDUM-SHORT ADDENDUM STANDARD CENTER DISTANCE	DATE:
Ø			SHEET 1 OF 4

Pressure Angle *	Ø		inv Ø		cos Ø		
Diametral Pitch *	P		sin Ø		tan Ø		
Gear Backlash at D	B_G		Circular Pitch	$p = \pi \div P$			
Pinion Backlash at D	B_P		Base Pitch	$p_b = \pi \cos Ø \div P$			
Addendum a	$1 \div P$	Other		$\cos(90°/N_G)$			
Dedendum b	$1.25 \div P$	Other		$\cos(90°/N_P)$			
Clearance $\bar{c}$	$\bar{c} = b - a$		π (see note 3) =				
AGMA Quality/Class Number			Measuring Wire Diameter *	d_w			
Gear Major Diameter Runout	Q_G		Gear Major Diameter Tolerance	ΔD_{oG}			
Pinion Major Diameter Runout	Q_P		Pinion Major Diameter Tolerance	ΔD_{oP}			

TERMINOLOGY	FORMULA	SYMBOL	GEAR (G)	PINION (P)
Part Number *		-		
Drawing Number *		-	Rev.	Rev.
Number of Teeth *		N		
Pitch Diameter *	$N \div P$	D		
Base Diameter *	$D \cos Ø$	D_b		
Center Distance *	$(N_G + N_P \div 2P)$	C		+.00
Hob Displacement (Show Plus or Minus)	$e_G = -e_P$; $e_{P_{max}} = .5D_G \sin^2 Ø - a$ $e_P \leq e_{P_{max}}$; $e_{P_{min}} = a - .5D_P \sin^2 Ø$ $e_{P_{min}} < e_P < e_{P_{max}}$	e		
Hob Displacement for Backlash	$B_{min} \div 2 \tan Ø$ Min	Δe		
	$B_{max} \div 2 \tan Ø$ Max			
Total Hob Displacement (may be plus or minus)	$e - \Delta e_{min}$ Max	E		
	$e - \Delta e_{max}$ Min			

P		GEAR DESIGN SHEET SG-3 EXTERNAL SPUR GEAR TOOTH DIMENSIONS LONG ADDENDUM-SHORT ADDENDUM STANDARD CENTER DISTANCE	
Ø			SHEET 2 OF 4

TERMINOLOGY	FORMULA		SYMBOL	GEAR (G)	PINION (P)
Tooth Thickness at Pitch Diameter (Round off to 4 Decimal Places) *	$.5p + 2E_{max} \tan Ø$	Max	t		
*	$.5p + 2E_{min} \tan Ø$	Min			
Major Diameter *	$D + 2a + 2e$	Max	D_o		
*	$D_{o_{max}} - \Delta D_o$	Min			
Minimum Tooth Tip Chamfer or Radius Height			Δtip_{min}		
Maximum Tooth Tip Chamfer or Radius Height			Δtip_{max}		
sec $Ø_o$	$D_{o_{max}} \div D_b$		sec $Ø_o$		
inv $Ø_o$	Table of Functions		inv $Ø_o$		
Tooth Thickness at D_o	$D_{o_{max}} \left(\frac{t_{min}}{D} + \text{inv } Ø - \text{inv } Ø_o \right)$		t_o		
Top Land	$t_o - 2\Delta tip_{max}$ (should be greater than .005)		L_T		
Profile Major Diameter	$D_{o_{max}} - 2\Delta tip_{min}$	Max	D_M		
*	$D_{o_{min}} - 2\Delta tip_{max}$	Min			

$x = 2C_{min} \sin Ø$		$y = \sqrt{D^2_{MG_{max}} - D^2_{bG}}$		$z = \sqrt{D^2_{MP_{max}} - D^2_{bP}}$	
$x_1 = 2C_{max} \sin Ø$		$y_1 = \sqrt{D^2_{MG_{min}} - D^2_{bG}}$		$z_1 = \sqrt{D^2_{MP_{min}} - D^2_{bP}}$	

NOTE: x and x_1 must be greater than y and y_1 and z and z_1 respectively.

Active Profile Diameter *	$\sqrt{(x - z)^2 + D^2_{bG}} - Q_P$	Gear	APD		
*	$\sqrt{(x - y)^2 + D^2_{bP}} - Q_G$	Pinion			

P		GEAR DESIGN SHEET SG-3 EXTERNAL SPUR GEAR TOOTH DIMENSIONS LONG ADDENDUM-SHORT ADDENDUM STANDARD CENTER DISTANCE SHEET 3 OF 4
Ø		

TERMINOLOGY	FORMULA	SYMBOL	GEAR (G)	PINION (P)
Minor Diameter *	$D - 2b + 2e$ Max	D_R		
*	$D - 2b + 2E_{min}$ Min			
Form Diameter Maximum *	$\sqrt{\left(D_{R_{max}} + 2\bar{c}\right)^2 + \left(\frac{D - D_{R_{max}} - 2\bar{c}}{\tan Ø}\right)^2}$ $\left(D - D_{R_{max}} - 2\bar{c}\right.$ must be a positive value$\left.\right)$	D_F		
Contact Ratio	$\left(y_1 + z_1 - x_1 \div 2p_b\right)$ To assure continuity of action, value must be greater than 1.05 preferably 1.2 or greater	m_p		
W_G ; W_P (may be a positive or negative value)	$W_G = \text{inv } Ø + \frac{d_w}{D_{bG}} - \frac{\pi}{N_G}$ $W_P = \text{inv } Ø + \frac{d_w}{D_{bP}} - \frac{\pi}{N_P}$	W_G W_P		
Involute at Wire Center	$W_G + \frac{t_{G_{max}}}{D_G}$; $W_P + \frac{t_{P_{max}}}{D_P}$ Max	inv $Ø_w$		
	$W_G + \frac{t_{G_{min}}}{D_G}$; $W_P + \frac{t_{P_{min}}}{D_P}$ Min			
sec $Ø_w$	Table of Functions Max	sec $Ø_w$		
	Min			
tan $Ø_{w_{max}}$	Table of Functions	tan $Ø_w$		
Wire Contact Diameter	$\sqrt{\left(D_b \tan Ø_w - d_w\right)^2 + D_b^2}$	D_c		
Measurement Over Wires (Even Teeth) *	$D_b \sec Ø_w + d_w$ Max	M_E		
*	Min			
Wire Clearance	$d_{w_c} = .5\left(M_{e_{min}} - 2d_w - D_{R_{max}}\right)$ (value must be positive)	d_{w_c}		

P		GEAR DESIGN SHEET SG-3 EXTERNAL SPUR GEAR TOOTH DIMENSIONS LONG ADDENDUM-SHORT ADDENDUM STANDARD CENTER DISTANCE	SHEET 4 OF 4
Ø			

TERMINOLOGY	FORMULA	SYMBOL	GEAR (G)	PINION (P)
Measurement over Wires (Odd Teeth) * Max	$D_b \cos(90^o/N) \sec Ø_w + d_w$ Max	M_o		
* Min	Min			
Face Width *		F		

COARSE PITCH GEARS	GEAR (G)	PINION (P)
Maximum Runout Tolerance of Pitch Diameter *		
Lead Tolerance Across Face Width *		
Pitch (Tooth-to-Tooth Spacing) Tolerance *		
Profile Tolerance *		

NOTES:

1. All values designated with an asterisk (*) shall be shown on drawing.
2. To insure accuracy, calculate to a minimum of seven decimal places.
3. Use π to a minimum of seven decimal places.
4. These calculations were performed to _____ decimal places.

P_n		GEAR DESIGN SHEET HG-1 EXTERNAL HELICAL GEAR TOOTH DIMENSIONS STANDARD CENTER DISTANCE	DATE:
ϕ_n			SHEET 1 OF 4

Normal Diametral Pitch *	P_n		Helix Angle *	ψ	
Normal Pressure Angle *	ϕ_n		$\sin \psi$		$\cos \psi$	
$\tan \phi = \tan \phi_n \div \cos \psi$			$\sin \phi_n$		$\tan \phi_n$	
Transverse Pressure Angle	ϕ		$\cos \psi_b = \sin \phi_n \div \sin \phi$		
Normal Backlash of Gear	B_{nG}		$\sin \phi$		$\cos \phi$	
Normal Backlash of Pinion	B_{nP}		$\text{inv}\ \phi$		π (see note 3) =

Addendum	a	$1 \div P_n$	Other		Normal Circular Pitch	$p_n = \pi \div P_n$	
Dedendum	b	$1.25 \div P_n$	Other		Circular Pitch	$p = \pi \div P_n \cos \psi$	
Clearance	$\bar{c}$	$\bar{c} = b - a$			AGMA Quality/Class Number		
Base Pitch		$p_b = p \cos \phi$			Measuring Wire Diameter *	d_w	
Gear Major Diameter Runout			Q_G		Gear Major Diameter Tolerance	ΔD_{oG}	
Pinion Major Diameter Runout			Q_P		Pinion Major Diameter Tolerance	ΔD_{oP}	

TERMINOLOGY	FORMULA	SYMBOL	GEAR (G)	PINION (P)
Part Number *		-		
Drawing Number *		-	Rev.	Rev.
Number of Teeth *		N		
Pitch Diameter *	$N \div P_n \cos \psi$	D		
Base Diameter *	$D \cos \phi$	D_b		
Center Distance *	$(N_G + N_P) \div 2P_n \cos \psi$	C		+.00
Normal Tooth Thickness at Pitch Diameter (Round off to 4 Decimal Places) *	$.5p_n - B_{nG_{min}}$; $.5p_n - B_{nP_{min}}$ Max	t_n		
*	$.5p_n - B_{nG_{max}}$; $.5p_n - B_{nP_{max}}$ Min			
Transverse Arc Tooth Thickness	$t_{nG_{max}} \div \cos \psi$; $t_{nP_{max}} \div \cos \psi$ Max	t		
	$t_{nG_{min}} \div \cos \psi$; $t_{nP_{min}} \div \cos \psi$ Min			

P_n		GEAR DESIGN SHEET HG-1 EXTERNAL HELICAL GEAR TOOTH DIMENSIONS STANDARD CENTER DISTANCE		SHEET 2 OF 4
ϕ_n				

TERMINOLOGY	FORMULA	SYMBOL	GEAR (G)	PINION (P)
Major Diameter *	$D + 2a$ Max	D_o		
*	$D_{o_{max}} - \Delta D_o$ Min			
Minimum Tooth Tip Chamfer or Radius Height		Δtip_{min}		
Maximum Tooth Tip Chamfer or Radius Height		Δtip_{max}		
sec ϕ_o	$D_{o_{max}} \div D_b$	sec ϕ_o		
inv ϕ_o	Table of Functions	inv ϕ_o		
Tooth Thickness at D_o	$D_{o_{max}} \left(\frac{t_{min}}{D} + \text{inv}\ \phi - \text{inv}\ \phi_o \right)$	t_o		
Top Land	$t_o - 2\Delta\ tip_{max}$ (should be greater than .010)	L_T		
Profile Major Diameter *	$D_{o_{max}} - 2\Delta\ tip_{min}$ Max	D_M		
*	$D_{o_{min}} - 2\Delta\ tip_{max}$ Min			

$x = 2C_{min} \sin \phi$		$y = \sqrt{D^2_{MG_{max}} - D^2_{bG}}$		$z = \sqrt{D^2_{MP_{max}} - D^2_{bP}}$	
$x_1 = 2C_{max} \sin \phi$		$y_1 = \sqrt{D^2_{MG_{min}} - D^2_{bG}}$		$z_1 = \sqrt{D^2_{MP_{min}} - D^2_{bP}}$	

NOTE: x and x_1 must be greater than y and y_1 and z and z_1 respectively.

TERMINOLOGY	FORMULA	SYMBOL	GEAR (G)	PINION (P)
Active Profile Diameter *	$\sqrt{(x - z)^2 + D^2_{bP}} - Q_P$ Gear	APD		
*	$\sqrt{(x - y)^2 + D^2_{bP}} - Q_G$ Pinion			
Hob Displacement for Backlash	$B_{nG_{max}} \div 2\tan \phi_n ; B_{nP_{max}} \div 2\tan \phi_n$	Δe		
Minor Diameter *	$D - 2b$ Max	D_R		
*	$D - 2b - 2\Delta e$ Min			

P_n		GEAR DESIGN SHEET HG-1 EXTERNAL HELICAL GEAR TOOTH DIMENSIONS STANDARD CENTER DISTANCE	SHEET 3 OF 4
ϕ_n			

TERMINOLOGY	FORMULA		SYMBOL	GEAR (G)	PINION (P)
Form Diameter Max *	$\sqrt{\left(D_{R_{max}} + 2\bar{c}\right)^2 + \left(\frac{D - D_{R_{max}} - 2\bar{c}}{\tan \phi}\right)^2}$ $\left(D - D_{R_{max}} - 2\bar{c}\right.$ must be a positive value$\left.\right)$		D_F		
Face Width *			F		
Total Contact Ratio	$\left[\left(y_1 + z_1 - x_1\right) \div 2p_b\right] + \frac{F \sin \psi}{P_n}$		m_p		
W_G ; W_P (may be positive or negative values)	$W_G = \text{inv}\,\phi + \frac{d_w \sec \psi_b}{D_{bG}} - \frac{\pi}{N_G}$		W_G		
	$W_P = \text{inv}\,\phi + \frac{d_w \sec \psi_b}{D_{bP}} - \frac{\pi}{N_P}$		W_P		
Involute at Wire Center	$W_G + \frac{t_{G_{max}}}{D_G}$; $W_P + \frac{t_{P_{max}}}{D_P}$	Max	inv ϕ_w		
	$W_G + \frac{t_{G_{min}}}{D_G}$; $W_P + \frac{t_{P_{min}}}{D_P}$	Min			
sec ϕ_w	Table of Functions	Max	sec ϕ_w		
		Min			
tan $\phi_{w_{max}}$	Table of Functions		tan ϕ_w		
Wire Contact Diameter	$\sqrt{\left(D_b \tan \phi_w - d_w \cos \psi_b\right)^2 + D_b^2}$		D_c		
Measurement * Over Wires * (Even Teeth)	$D_b \sec \phi_w + D_w$	Max	M_E		
		Min			
Wire Clearance	$d_{w_c} = .5\left(M_{E_{min}} - 2d_w - D_{R_{max}}\right)$ (value must be positive)		d_{w_c}		

P_n		GEAR DESIGN SHEET HG-1 EXTERNAL HELICAL GEAR TOOTH DIMENSIONS STANDARD CENTER DISTANCE	SHEET 4 OF 4
ϕ_n			

TERMINOLOGY	FORMULA		SYMBOL	GEAR (G)	PINION (P)
Measurement * Over One Wire * (Odd Teeth)	$\frac{1}{2}$ M_E	Max	M_o		
		Min			
Lead *	$\pi N \div P_n \sin \psi$		L		

COARSE PITCH GEARS		GEAR (G)	PINION (P)
Maximum Runout Tolerance of Pitch Diameter	*		
Lead Tolerance Across Face Width	*		
Pitch (Tooth-To-Tooth Spacing) Tolerance	*		
Profile Tolerance	*		

NOTES:

1. All values designated with an asterisk (*) shall be shown on drawing.
2. To insure accuracy, calculate to a minimum of seven decimal places.
3. Use π to a minimum of seven decimal places.
4. These calculations were performed to _____ decimal places.

P_n		GEAR DESIGN SHEET HG-2 EXTERNAL HELICAL GEAR TOOTH DIMENSIONS NON-STANDARD CENTER DISTANCE	DATE:
ϕ_n			SHEET 1 OF 4

Normal Diametral Pitch *	P_n		Helix Angle *	ψ			
Normal Pressure Angle *	ϕ_n		$\sin \psi$		$\cos \psi$		
$\sin \phi_n$		$\tan \phi_n$		$\tan \phi = \tan \phi_n \div \cos \psi$			
$\cos \phi_n$		Transverse Pressure Angle	ϕ		$\cos \phi$		
inv ϕ		$\sin \phi$		$\cos \psi_b = \sin \phi_n \div \sin \phi$			

Normal Gear Backlash at D	B_{nG}		Addendum	a	$1 \div P_n$	Other	
Normal Pinion Backlash at D	B_{nP}		Dedendum	b	$1.25 \div P_n$	Other	
Operating Center Distance *	C_x	+.00	Clearance	$\bar{c}$	b - a		
Operating Pitch Diameter *	$2NC_x \div (N_G + N_P)$		D_{xG}		D_{xP}		
Circular Pitch	$p = \pi \div P_n \cos \psi$		Base Pitch	$p_b = p \cos \phi$			
Normal Circular Pitch	$p_n = \pi \div P_n$		π (see note 3) =				
Circular Pitch at D_x	$p_x = \pi D_x \div N$		$\cos \phi_x = D_b \div D_x$				
Operating Pressure Angle *	ϕ_x		$\sin \phi_x$		inv ϕ_x		
AGMA Quality/Class Number			Measuring Wire Diameter *	d_w			
Gear Major Diameter Runout	Q_G		Gear Major Diameter Tolerance	ΔD_{oG}			
Pinion Major Diameter Runout	Q_P		Pinion Major Diameter Tolerance	ΔD_{oP}			

TERMINOLOGY	FORMULA		SYMBOL	GEAR (G)	PINION (P)
Part Number *			-		
Drawing Number *			-	Rev.	Rev.
Number of Teeth *			N		
Pitch Diameter *	$N \div P_n \cos \psi$		D		
Base Diameter *	$D \cos \phi$		D_b		
Backlash In Transverse Plane at D_x	$B_{x_{min}} = \dfrac{B_{n_{min}} \cos \phi}{\cos \phi_n \cos \psi \cos \phi_x}$	Min	B_x		
	$B_{x_{max}} = \dfrac{B_{n_{max}} \cos \phi}{\cos \phi_n \cos \psi \cos \phi_x}$	Max			

P_n		GEAR DESIGN SHEET HG-2 EXTERNAL HELICAL GEAR TOOTH DIMENSIONS NON-STANDARD CENTER DISTANCE	SHEET 2 OF 4
ϕ_n			

TERMINOLOGY		FORMULA		SYMBOL	GEAR (P)	PINION (P)
Actual Transverse Tooth Thickness at D_x		$.5p_x - B_{x_{min}}$	Max	t_x		
		$.5p_x - B_{x_{max}}$	Min			
Normal Tooth Thickness at D (Round off to 4 Decimal Places)	*	$D\left(\frac{t_x}{D_x} + \text{inv } \phi_x - \text{inv } \phi\right) \cos \psi$	Max	t_n		
	*		Min			
Total Hob Displacement		$\left(t_n - \frac{\pi}{2P_n}\right) \div 2\tan \phi_n$	Max	Δe		
			Min			
Major Diameter	*	$D + 2a + 2\Delta e_{max}$	Max	D_o		
	*	$D_{o_{max}} - \Delta D_o$	Min			
Minimum Tooth Tip Chamfer or Radius Height				Δtip_{min}		
Maximum Tooth Tip Chamfer or Radius Height				Δtip_{max}		
sec ϕ_o		$D_{o_{max}} \div D_b$		sec ϕ_o		
inv ϕ_o		Table of Functions		inv ϕ_o		
Tooth Thickness at D_o		$D_{o_{max}}\left(\frac{t_{n_{min}}}{D \cos \psi} + \text{inv } \phi - \text{inv } \phi_o\right)$		t_o		
Top Land		$t_o - 2\,\Delta tip_{max}$ (should be greater than .010)		L_T		
Profile Major Diameter	*	$D_{o_{max}} - 2\,\Delta tip_{min}$	Max	D_M		
	*	$D_{o_{min}} - 2\,\Delta tip_{max}$	Min			

$x = 2C_{x_{min}} \sin \phi_x$		$y = \sqrt{D^2_{MG_{max}} - D^2_{bG}}$		$z = \sqrt{D^2_{MP_{max}} - D^2_{bP}}$	
$x_1 = 2C_{x_{max}} \sin \phi_x$		$y_1 = \sqrt{D^2_{MG_{min}} - D^2_{bG}}$		$z_1 = \sqrt{D^2_{MP_{min}} - D^2_{bP}}$	

NOTE: x and x_1 must be greater than y and y_1 and z and z_1 respectively.

P_n		GEAR DESIGN SHEET HG-2 EXTERNAL HELICAL GEAR TOOTH DIMENSIONS NON-STANDARD CENTER DISTANCE	SHEET 3 OF 4
ϕ_n			

TERMINOLOGY	FORMULA	SYMBOL	GEAR (G)	PINION (P)
Active Profile Diameter *	$\sqrt{(x - z)^2 + D_{bG}^2} - Q_P$ Gear	APD		(hatched)
*	$\sqrt{(x - y)^2 + D_{bP}^2} - Q_G$ Pinion		(hatched)	
Normal Nominal Tooth Thickness at D	$D\left(\frac{.5p_x}{D_x} + inv\ \phi_x - inv\ \phi\right) \cos \psi$	t_{n_N}		
Hob Displacement at Zero Backlash	$\left(t_{n_N} - \frac{\pi}{2P_n}\right) \div 2\tan \phi_n$	Δe_{nom}		
Minor Diameter *	$D - 2b + 2\ \Delta e_{nom}$ Max	D_R		
*	$D - 2b + 2\ \Delta e_{min}$ Min			
Form Diameter Max *	$\sqrt{\left(D_{R_{max}} + 2\bar{c}\right)^2 + \left(\frac{D - D_{R_{max}} - 2\bar{c}}{\tan \phi}\right)^2}$ $\left(D - D_{R_{max}} - 2\bar{c}\right.$ must be a positive value$\left.\right)$	D_F		
Face Width *		F		
Total Contact Ratio	$\left[\left(y_1 + z_1 - x_1\right) \div 2p_b\right] + \frac{F \sin \psi}{p_n}$	m_p		
W_G ; W_P (may be positive or negative values)	$W_G = inv\ \phi_x + \frac{d_w}{D_{bG} \cos \psi_b} - \frac{\pi}{N_G}$	W_G		
	$W_P = inv\ \phi_x + \frac{d_w}{D_{bP} \cos \psi_b} - \frac{\pi}{N_P}$	W_P		
Involute at Wire Center	$W_G + \frac{t_{xG_{max}}}{D_{xG}}$; $W_P + \frac{t_{xP_{max}}}{D_{xP}}$ Max	$inv\ Q_w$		
	$W_G + \frac{t_{xG_{min}}}{D_{xG}}$; $W_P + \frac{t_{xP_{min}}}{D_{xP}}$ Min			

P_n		GEAR DESIGN SHEET HG-2 EXTERNAL HELICAL GEAR TOOTH DIMENSIONS NON-STANDARD CENTER DISTANCE	SHEET 4 OF 4
$\emptyset_n$			

TERMINOLOGY	FORMULA		SYMBOL	GEAR (G)	PINION (P)
sec $\emptyset_w$	Table of Functions	Max	sec $\emptyset_w$		
		Min			
tan $\emptyset_{w_{max}}$	Table of Functions		tan $\emptyset_w$		
Wire Contact Diameter	$\sqrt{\left(D_b \tan \emptyset_w - d_w \cos \psi_b\right)^2 + D_b^2}$		D_c		
Measurement Over Wires (Even Teeth) *	$D_b \sec \emptyset_w + d_w$	Max	M_E		
*		Min			
Wire Clearance	$d_{w_c} = \left(.5\, M_{E_{min}} - 2d_w - D_{R_{max}}\right)$ (value must be positive)		d_{w_c}		
Measurement Over One Wire (Odd Teeth) *	$\frac{1}{2} M_E$	Max	M_o		
*		Min			
Lead *	$\pi N \div P_n \sin \psi$		L		

COARSE PITCH GEARS		GEAR (G)	PINION (P)
Maximum Runout Tolerance of Pitch Diameter	*		
Lead Tolerance Across Face Width	*		
Pitch (Tooth-to-Tooth Spacing) Tolerance	*		
Profile Tolerance	*		

NOTES:

1. All values designated with an asterisk (*) shall be shown on drawing.
2. To insure accuracy, calculate to a minimum of seven decimal places.
3. Use π to a minimum of seven decimal places.
4. These calculations were performed to ______ decimal places.

P_n		GEAR DESIGN SHEET HG-3 EXTERNAL HELICAL GEAR TOOTH DIMENSIONS LONG ADDENDUM-SHORT ADDENDUM STANDARD CENTER DISTANCE	DATE:
ϕ_n			SHEET 1 OF 4

Normal Diametral Pitch *	P_n		Helix Angle *		ψ	
Normal Pressure Angle *	ϕ_n		$\sin\psi$		$\cos\psi$	
$\tan\phi = \tan\phi_n \div \cos\psi$			$\sin\phi_n$		$\tan\phi_n$	
Transverse Pressure Angle	ϕ		$\cos\psi_b = \sin\phi_n \div \sin\phi$			
Normal Gear Backlash at D	B_{nG}		$\sin\phi$		$\cos\phi$	
Normal Pinion Backlash at D	B_{nP}		$\text{inv}\ \phi$		π (see note 3) =	

Addendum	a	$1 \div P_n$	Other		Normal Circular Pitch	$p_n = \pi \div P_n$	
Dedendum	b	$1.25 \div P_n$	Other		Circular Pitch	$p = \pi \div P_n \cos\psi$	
Clearance	$\bar{c}$	$\bar{c} = b - a$		Measuring Wire Diameter *	d_w		
Base Pitch	$p_b = p\cos\phi$			AGMA Quality/Class Number			
Gear Major Diameter Runout	Q_G		Gear Major Diameter Tolerance	ΔD_{oG}			
Pinion Major Diameter Runout	Q_P		Pinion Major Diameter Tolerance	ΔD_{oP}			

TERMINOLOGY	FORMULA	SYMBOL	GEAR (G)	PINION (P)
Part Number *		-		
Drawing Number *		-	Rev.	Rev.
Number of Teeth *		N		
Pitch Diameter *	$N \div P_n \cos\psi$	D		
Base Diameter *	$D\cos\phi$	D_b		
Center Distance *	$(N_G + N_P) \div 2P_n \cos\psi$	C		+.00
Hob Displacement (Show plus or minus)	$e_G = -e_P$; $e_{P_{max}} = .5D_G\sin^2\phi_n - a$ $e_P \leq e_{P_{max}}$; $e_{P_{min}} = a - .5D_P\sin^2\phi_n$	e		
Hob Displacement for Backlash	$B_{nG_{min}} \div 2\tan\phi_n ; B_{nP_{min}} \div 2\tan\phi_n$ Min	Δe		
	$B_{nG_{max}} \div 2\tan\phi_n ; B_{nP_{min}} \div 2\tan\phi_n$ Max			

P_n		GEAR DESIGN SHEET HG-3 EXTERNAL HELICAL GEAR TOOTH DIMENSIONS LONG ADDENDUM-SHORT ADDENDUM STANDARD CENTER DISTANCE		SHEET 2 OF 4
$\emptyset_n$				

TERMINOLOGY	FORMULA		SYMBOL	GEAR (G)	PINION (P)
Total Hob Displacement (may be plus or minus)	$e - \Delta e_{min}$	Max	E		
	$e - \Delta e_{max}$	Min			
Normal Tooth Thickness at D *	$.5p_n + 2E_{max} \tan \emptyset_n$	Max	t_n		
(Round off to 4 Decimal Places) *	$.5p_n + 2E_{min} \tan \emptyset_n$	Min			
Transverse Arc Tooth Thickness	$t_{n_{max}} \div \cos \psi$	Max	t		
	$t_{n_{min}} \div \cos \psi$	Min			
Major Diameter *	$D + 2a + 2e$	Max	D_o		
*	$D_{o_{max}} - \Delta D_o$	Min			
Minimum Tooth Tip Chamfer or Radius Height			Δtip_{min}		
Maximum Tooth Tip Chamfer or Radius Height			Δtip_{max}		
$\sec \emptyset_o$	$D_{o_{max}} \div D_b$		$\sec \emptyset_o$		
$\text{inv } \emptyset_o$	Table of Functions		$\text{inv } \emptyset_o$		
Tooth Thickness at D_o	$D_{o_{max}} \left(\frac{t_{min}}{D} + \text{inv } \emptyset - \text{inv } \emptyset_o\right)$		t_o		
Top Land	$t_o - 2\Delta tip_{max}$ (should be greater than .010)		L_T		
Profile Major Diameter *	$D_{o_{max}} - 2\Delta tip_{min}$	Max	D_M		
*	$D_{o_{min}} - 2\Delta tip_{max}$	Min			

$x = 2C_{min} \sin \emptyset$		$y = \sqrt{D^2_{MG_{max}} - D^2_{bG}}$		$z = \sqrt{D^2_{MP_{max}} - D^2_{bP}}$	
$x_1 = 2C_{max} \sin \emptyset$		$y_1 = \sqrt{D^2_{MG_{min}} - D^2_{bG}}$		$z_1 = \sqrt{D^2_{MP_{min}} - D^2_{bP}}$	

NOTE: x and x_1 must be greater than y and y_1 and z and z_1 respectively.

P_n		GEAR DESIGN SHEET HG-3 EXTERNAL HELICAL GEAR TOOTH DIMENSIONS LONG ADDENDUM-SHORT ADDENDUM STANDARD CENTER DISTANCE	SHEET 3 OF 4
ϕ_n			

TERMINOLOGY		FORMULA		SYMBOL	GEAR (G)	PINION (P)
Active Profile Diameter	*	$\sqrt{(x - z)^2 + D_{bG}^2} - Q_P$	Gear	APD		
	*	$\sqrt{(x - y)^2 + D_{bP}^2} - Q_G$	Pinion			
Minor Diameter	*	$D - 2b + 2e$	Max	D_R		
	*	$D - 2b + 2E_{min}$	Min			
Form Diameter Max	*	$\sqrt{\left(D_{R_{max}} + 2\bar{c}\right)^2 + \left(\frac{D - D_{R_{max}} - 2\bar{c}}{\tan \phi}\right)^2}$ $\left(D - D_{R_{max}} - 2\bar{c}\right.$ must be a positive value$\left.\right)$		D_F		
Face Width	*			F		
Total Contact Ratio		$\left[\left(y_1 + z_1 - x_1\right) \div 2p_b\right] + \frac{F \sin \psi}{p_n}$		m_p		
W_G ; W_P (may be positive or negative values)		$W_G = \text{inv } \phi + \frac{d_w}{D_{b_G} \cos \psi_b} - \frac{\pi}{N_G}$		W_G		
		$W_P = \text{inv } \phi + \frac{d_w}{D_{b_P} \cos \psi_b} - \frac{\pi}{N_P}$		W_P		
Involute at Wire Center		$W_G + \frac{t_{G_{max}}}{D_G}$; $W_P + \frac{t_{P_{max}}}{D_P}$	Max	inv ϕ_w		
		$W_G + \frac{t_{G_{min}}}{D_G}$; $W_P + \frac{t_{P_{min}}}{D_P}$	Min			
sec ϕ_w		Table of Functions	Max	sec ϕ_w		
			Min			
tan $\phi_{w_{max}}$		Table of Functions		tan ϕ_w		

P_n		GEAR DESIGN SHEET HG-3 EXTERNAL HELICAL GEAR TOOTH DIMENSIONS LONG ADDENDUM-SHORT ADDENDUM STANDARD CENTER DISTANCE	SHEET 4 OF 4
$\emptyset_n$			

TERMINOLOGY	FORMULA	SYMBOL	GEAR (G)	PINION (P)
Wire Contact Diameter	$\sqrt{\left(D_b \tan \emptyset_w - d_w \cos \psi_b\right)^2 + D_b^2}$	D_c		
Measurement Over Wires (Even Teeth) *	$D_b \sec \emptyset_w + d_w$ Max	M_E		
*	Min			
Wire Clearance	$d_{w_c} = .5\left(M_{E_{min}} - 2d_w - D_{R_{max}}\right)$ (value must be positive)	d_{w_c}		
Measurement Over One Wire (Odd Teeth) *	$\frac{1}{2} M_E$ Max	M_o		
*	Min			
Lead *	$\pi N \div P_n \sin \psi$	L		

COARSE PITCH GEARS		GEAR (G)	PINION (P)
Maximum Runout Tolerance of Pitch Diameter	*		
Lead Tolerance Across Face Width	*		
Pitch (Tooth-to-Tooth Spacing) Tolerance	*		
Profile Tolerance	*		

NOTES:

1. All values designated with an asterisk (*) shall be shown on drawing.
2. To insure accuracy, calculate to a minimum of seven decimal places.
3. Use π to a minimum of seven decimal places.
4. These calculations were performed to ______ decimal places.

5.6 MINIMUM DRAWING DATA FOR NONINTERSECTING AXES GEARS.

5.6.1 General. This section contains minimum drawing data specifications for the nonintersecting axes gears listed in the table of contents.

5.6.1.1 Interpretation. Lower case letters are used to present the instructional text. Nomenclature and characteristics required for drawing data presentation are depicted in capital letters.

5.6.1.2 Section organization. The following paragraph subdivision numbering sequence is typical throught the section:

> 5.6.X.1 "Instructions to the designer" contains a complete drawing specification check list. It delineates the minimum requirements and provides an index of additional gear characteristics when required.
>
> 5.6.X.2 "View delineation" is intended to depict those gear characteristics that define the overall dimensions of the gear blank.
>
> 5.6.X.3 "Data specification" delineates the nomenclature and method of listing gear data, notes, and references in a uniform manner for each type of gear.

5.6.1.3 Appendix. Additional information required for the preparation of gear drawings is provided in the appendix.

5.6.1.3.1 Drawing examples. To assist the designer in the interpretation of the requirements of this handbook several examples of drawings are included in the appendix. These sample drawings shall be construed as informational only. They are complete to the degree necessary to illustrate a condition. Actual drawings shall conform to textual requirements set forth in this handbook.

5.6.1.3.2 Measuring wires/balls. Specification of measuring wires or balls on drawings shall be to those sizes listed in table II.

5.6.2 Hypoid gear matched sets.

5.6.2.1 Instructions to the designer. For design, procurement, installation, and replacement purposes, mating hypoid gears and pinions shall be specified on a matched set drawing. Installation drawings, maintenance manuals, and spare parts lists shall show the matched set drawing number only.

5.6.2.1.1 Mandatory drawing requirements. Engineering drawings for matched set hypoid gears shall specify the following:

a. View delineation (see 5.6.2.2).
b. Data specification (see 5.6.2.3).

5.6.2.2 View delineation. For clarity of interpretation, the following matched set characteristics shall be delineated as shown in figure 58.

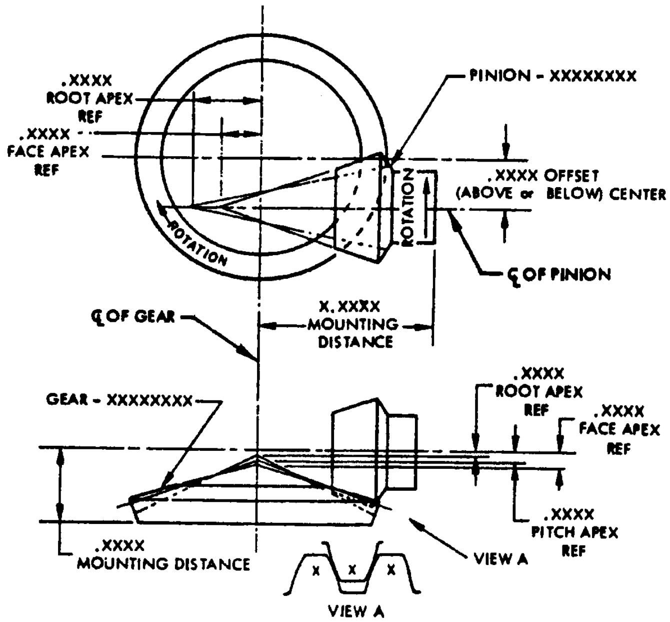


FIGURE 58. Hypoid gears (matched set).

5.6.2.2.1 Miscellaneous information. The hand of spiral should be selected to give an axial thrust that tends to move the gear and the pinion out of mesh. On hypoids, when the pinion is below center, the pinion hand of spiral should always be left-handed. With the pinion above center, the pinion hand should be right-handed. For gaging surface delineation, see 5.7.2.

5.6.2.3 Data specification. Minimum data and nomenclature requirements shall be specified as listed below.

MATCHED SET DATA

BACKLASH TO BE WITHIN .XXX TO .XXX AT X.XXXX AND X.XXXX RESPECTIVE MOUNTING DISTANCES.
BACKLASH VARIATION IN ONE REVOLUTION OF THE LARGER GEAR CANNOT EXCEED .XXX.

GEAR NOTES

A. THESE GEARS ARE TO BE MANUFACTURED. INSPECTED. PACKAGED OR ASSEMBLED. STOCKED. REPLACED, PERMANENTLY IDENTIFIED, AND RETAINED AS SERIALIZED MATCHED SETS ONLY.
B. MATCHED SET DRAWING NUMBER XXXXXXXX SHALL BE MARKED ON THE CONTAINER AND/OR SUPPLY IDENTIFICATION TAG.
C. PERMANENTLY IDENTIFY EACH GEAR OF THE MATCHED SET ON ANY READILY VISIBLE NON-FUNCTIONAL SURFACE:

ACTUAL MOUNTING DISTANCES
MATCHED SET SERIAL NUMBER
MATCHED SET NUMBER
MATING GEAR TEETH (SEE VIEW A)
ACTUAL BACKLASH OF MATING GEAR TEETH IDENTIFIED BY (X) AT TIGHTEST POINT OF MESH

MATCHED SET REFERENCE DATA

GEAR TEETH RATIO ____ XX TO 1
MAX. SPEED OF PINION _____________________________________ XXX RPM
TYPE OF LOAD ___________________ UNIFORM, LIGHT SHOCK, OR HEAVY SHOCK
TYPE OF SERVICE _______________________________________ FULL REVERSAL, ETC.

GENERAL NOTES

a. Add A.G.M.A. Quality/Class number under "MATCHED SET REFERENCE DATA", when applicable.
b. If a gaging surface is required, add the following marking characteristic to GEAR NOTE C above:

GAGING SURFACE ACTUAL DIMENSION "Y"

c. See paragraph 5.7.2 for additional information.
d. Backlash variation (.XXX) shall be less than the backlash difference specified.

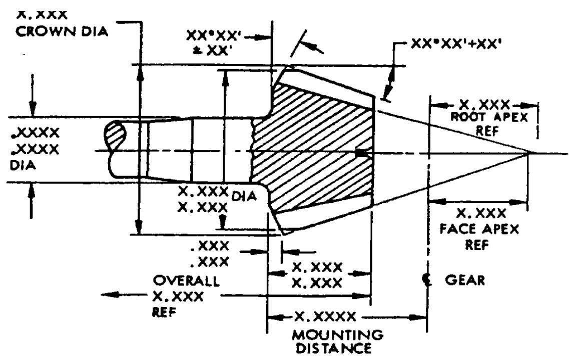
5.6.3 Hypoid pinion data.

5.6.3.1 Instructions to the designer.

5.6.3.1.1 Mandatory drawing requirements. Engineering drawings for this type of gear shall specify the following:

a. View delineation (see 5.6.3.2).
b. Data specification (see 5.6.3.3).
c. Chamfers, radii, and fillets as selected from 5.2.3.
d. Additional data as selected from Mandatory review below.
e. Material specification.
f. Heat treat specification as required.
g. Finish notes (e.g., plating, etc.).
h. Other notes as required.

5.6.3.2 View delineation. For clarity of interpretation, the following hypoid pinion characteristics shall be delineated as shown in figure 59.



NOTE: To determine the hand of spiral, the pinion must be to the right of the vertical centerline of the gear front face as shown below. When the pinion is offset above center, the pinion has a R.H. spiral and the gear has a L.H. spiral. When the pinion is offset below center, the pinion has a L.H. spiral and the gear has a R.H. spiral.

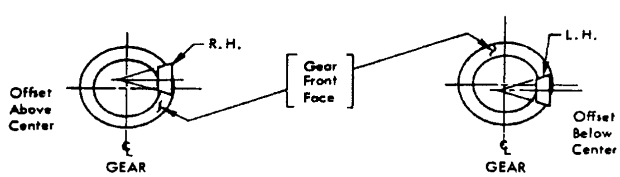


FIGURE 59. Hypoid pinion characteristics.

5.6.3.3 Data specification. Minimum data and nomenclature requirements shall be specified as listed below:

HYPOID PINION DATA

TOOTH FORM ______	
NUMBER OF TEETH ______	XX
ROOT ANGLE ______	XX°XX'
SPIRAL ANGLE ______	XX°
HAND OF SPIRAL ______	L.H. or R.H.

GEAR NOTES

A. REQUIREMENTS AS SPECIFIED ON MATCHED SET DRAWING NO. XXXXXXXX SHALL APPLY TO THIS GEAR.
B. MATES WITH XX TOOTH GEAR PART NO. XXXXXXXX.
C. THE TEETH ON THIS HYPOID PINION SHALL BE MANUFACTURED UNDER THE CONTROL OF A GEAR TESTING MACHINE .
D. FINISH ON WORKING SURFACE OF TEETH SHALL BE XX √.
E. ALL TOOTH ELEMENT SPECIFICATIONS OF THE GEAR ARE RELATIVE TO THE MOUNTING DATUM [ ] .

PINION REFERENCE DATA

OFFSET OF PINION BELOW (or ABOVE) CENTER ______	X.XXXX
PRESSURE ANGLE - DRIVE* ______	XX.XXXX°
PRESSURE ANGLE - COAST* ______	XX.XXXX°
SHAFT ANGLE ______	XX°
CUTTER DIAMETER ______	X.XXX
ROTATION (VIEWED FROM BACK OF PINION) ______	CW or CCW

Note: *BASIC AVERAGE PRESSURE ANGLE may be substituted

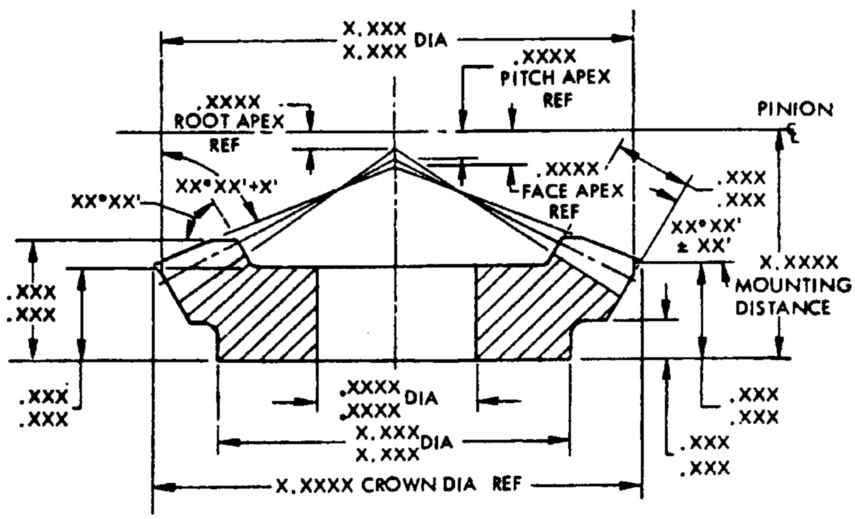
5.6.4 Hypoid gear data.

5.6.4.1 Instructions to the designer.

5.6.4.1.1 Mandatory drawing requirements. Engineering drawings for this type of gear shall specify the following:

a. View delineation (see 5.6.4.2).
b. Data specification (see 5.6.4.3).
c. Chamfers, radii, and fillets as selected from 5.2.3.
d. Additional data selected from Mandatory review below.
e. Material specification.
f. Heat treat specification as required.
g. Finish notes (e.g., plating, etc.).
h. Other notes as required.

5.6.4.2 View delineation. For clarity of interpretation, the following hypoid gear characteristic shall be delineated as shown in figure 60.



NOTE: For hand of spiral, see figure 59.

FIGURE 60. Hypoid gear.

5.6.4.3 Data specification. Minimum data and nomenclature requirements shall be specified as listed below.

HYPOID GEAR DATA

TOOTH FORM ______	
NUMBER OF TEETH ______	XX
DIAMETRAL PITCH ______	XX
ROOT ANGLE ______	XX°XX'
SPIRAL ANGLE ______	XX°
HAND OF SPIRAL ______	L.H. or R.H.

GEAR NOTES

A. REQUIREMENTS AS SPECIFIED ON MATCHED SET DRAWING NO. XXXXXXXX SHALL APPLY TO THIS GEAR.

B. MATES WITH XX TOOTH PINION PART NO. XXXXXXXX.

C. THE TEETH ON THIS HYPOID GEAR SHALL BE MANUFACTURED UNDER THE CONTROL OF A GEAR TESTING MACHINE

D. FINISH ON WORKING SURFACES OF TEETH SHALL BE XX √ .

E. ALL TOOTH ELEMENT SPECIFICATIONS OF THE GEAR ARE RELATIVE TO THE MOUNTING DATUM [ ] .

GEAR REFERENCE DATA

PITCH DIAMETER ______	X.XXXXXXX
OFFSET OF PINION BELOW (or ABOVE) CENTER ______	X.XXX
PRESSURE ANGLE – DRIVE* ______	XX.XXXX°
PRESSURE ANGLE – COAST* ______	XX.XXXX°
PITCH ANGLE ______	XX°XX
SHAFT ANGLE ______	XX°
CUTTER DIAMETER ______	X.XXX

Note: *BASIC AVERAGE PRESSURE ANGLE may be substituted.

5.7 ADDITIONAL AND SPECIAL DRAWING DATA FOR NONINTERSECTING AXES GEARING.

5.7.1 General. This section contains drawing data requirements for nonintersecting axes gearing.

5.7.2 Gaging surface delineation. When a gaging surface is used during hypoid gear installation, the criteria shown on figure 61 shall be added to the basic match set drawing.

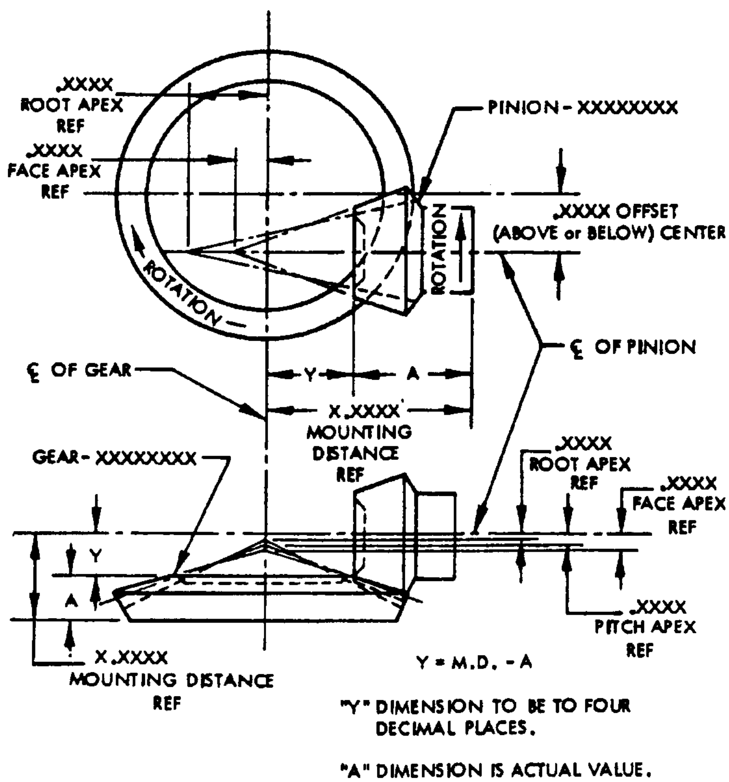


FIGURE 61. Gaging surface delinaeation.

5.7.2.1 Up-assembly specification. It shall be the responsibility of the designer to correlate the gaging surface data on the assembly drawings.

5.8 SPECIAL GEARS.

5.8.1 General. This section contains minimum drawing data specifications for special gears.

5.8.1.1 Definition. Special gears are those gears for which complete data specifications are not always available. This category includes patented and proprietary types of gearing. Drawings for some of these types of gearing may sometimes require sole source or source control type drawings, the requirements of which are contained in DOD-D-1000 and DOD-STD-100. The designer must consider performance requirements on drawings for those cases where complete data is not available.

5.8.1.2 Interpretation. Lower case letters are used to present the instructional text. Nomenclature and/or characteristics required for drawing data presentation are depicted in capital letters.

5.8.1.3 Section organization. The following paragraph subdivision numbering sequence is typical throughout the section (although each subdivision will not necessarily apply to each special gear):

> 5.8.X.1 "Instructions to the designer" contains a complete drawing specification check list. It delineates the minimum requirements and provides an index of additional gear characteristics when required.
>
> 5.8.X.2 "View delineation" is intended to depict those gear characteristics that define the overall dimensions of the gear blank.
>
> 5.8.X.3 "Data specification" delineates the nomenclature and method of listing gear data, notes, and references in a uniform manner for each type of gear.
>
> 5.8.X.4 "Sectional view" introduces the method of clearly defining the major characteristics of a gear that previously presented problems of specification and interpretation. The tooth section definitizes the minimum and maximum profile control diameters and provides a precise method of listing tooth thickness at a specific diameter.

5.8.1.4 Special spur and helical gear applications. Included in this chapter are special applications of spur and helical gearing operating on crossed-axes nonintersecting shafts. Requirements for this type of gearing are contained in this section.

5.8.1.5 Appendix. Additional information for some types of special gears is provided in the appendix.

5.8.1.5.1 Drawing examples. To assist the designer in the interpretation of the requirements of this handbook, several examples of drawings are included in the appendix. These sample drawings shall be construed as informational only. They are complete to the degree necessary to illustrate a condition. Actual drawings shall conform to textual requirements set forth in this handbook.

5.8.1.5.2 Measuring wires/balls. Specification of measuring wires or balls on drawings shall be to those sizes listed in table II.

5.8.1.5.3 Involute roll angle table. A table of roll angles is included in the appendix to aid in roll angle selection as required.

5.8.1.6 Mating gear part number. Mating gear part numbers for gears in this chapter are specified in one of two ways, namely, matched sets and individually interchangeable gearing.

5.8.1.6.1 Matched set gearing. Instructions for referencing mating gear part numbers include the matched set drawing number.

5.8.1.6.2 Individually interchangeable gearing. Gear drawings shall reference the originally designed mating gear part number under gear reference data as shown:

DESIGNED TO MATE WITH PART NUMBER . . . XXXXXXXX

5.8.1.6.2.1 Exceptions. Whenever a gear of an existing design is used in another design set, the new mating part number shall not be added to the original gear drawing as an additional part number. However, the new design shall reference its mating part number as specified in paragraph 5.8.1.6.2.

5.8.1.7 Heat treat/finishing allowances. Dimensions and tolerances specified on drawings shall define the end item after heat treatment and/or finishing processes. These dimensions and tolerances shall be interpreted as final acceptance criteria.

5.8.1.8 Installation instructions. The designer shall review the next assembly drawing and/or housing drawings for datum specifications that will assure proper mounting requirements of gearing in this section. The designer should consider the following characteristics to determine whether controls are necessary:

a. Backlash specifications.
b. Tooth contact patterns.
c. Datum surface specifications.
d. Direction of gear rotation.
e. Thrust faces.
f. Shims and methods of shimming.
g. Special lubricants.

5.8.1.9 Development stage. Designers should familiarize themselves with the entire gear assembly during the development stage when prototypes are being developed and tested. They should avail themselves of data obtained during this stage. This data should include housing deflections, effect of heat, backlash increases or decreases, surface durability, special lubricants, shaft deflections, torque, etc. Also, the data should be evaluated so that allowances and/or compensation can be included in the design of the gear sets. Such data is also helpful in the development of the field service maintenance requirements.

5.8.2 Crossed axes helical (spiral) gear data.

a. Definition. Crossed axes helical (spiral) gears are gears that operate on crossed axes shafts. These gears are sometimes referred to as nonthroated involute worms. The driving gear is called the "driver" while the driven gear is the "follower". The action between these gears is sliding. Minimum sliding conditions exist, and maximum efficiency is attained when both gears have the same helix angle, which is also one-half of the shaft angle. When the helix angles are different, the larger angle should always be on the driver (see figure 62).

b. Pressure angle. The 14-1/2° full-depth involute basic rack form (normal basic rack form on helical gears) is the most frequently used because it provides the greatest amount of contact.

c. Applications. Spiral gears are used to transmit power from one shaft to another when these shafts are not parallel and do not intersect. Power is transmitted with a sliding action; and because the area of tooth contact is limited, they should not be used under heavy load conditions. From a single direction of rotation of the pinion shaft, the gear shaft can be made to rotate in either direction by selection of a suitable helix angle.

   Spiral gears are principally gears of convenience, having the special advantage that relatively small amounts of power can be transmitted by nonintersecting shafts at any angle, providing the shafts pass near enough to mount gears. Also, ratios may be altered without change of pitch or center distance.

5.8.2.1 Instructions to the designer.

5.8.2.1.1 Mandatory drawing requirements. Engineering drawings for this type of gear shall specify the following:

a. View delineation (see 5.8.2.2).
b. Sectional view (see 5.8.2.3).
c. Data specification (see 5.8.2.4).
d. Gear mounting characteristics as selected from 5.2.2.
e. Chamfers, radii, and fillets as selected from 5.2.3.
f. Additional data selected from Mandatory review below.

g. Material specification.
h. Heat treat specification as required.
i. Finish notes (e.g., plating, etc.).
j. Other notes as required.

5.8.2.1.1.1 Mandatory review. The designer will review the following paragraphs for methods of specifying additional gear characteristics when required.

5.2.4 Profile Charts
5.2.5 Lead Charts
5.2.6 Crowns
5.2.7 Basic Rack Generatrix
5.2.8 Index Tolerances
5.2.9 Composite Tolerances
5.2.10 Fine Pitch Gears

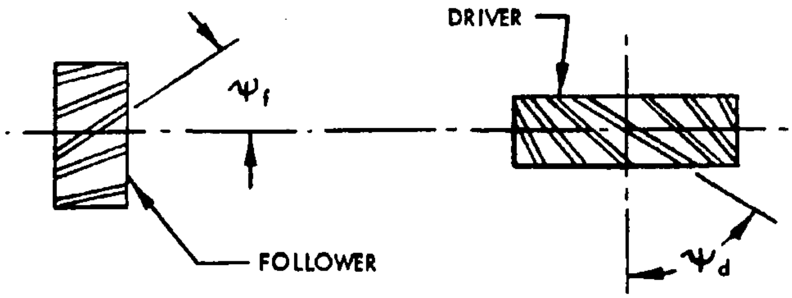


FIGURE 62. Spiral gears

5.8.2.2 Data specification. The data for crossed axes helical gears shall be identical to that used for helical gears. In addition, the SHAFT ANGLE shall be delineated under GEAR REFERENCE DATA and the gear data shall be titled, "CROSSED AXES HELICAL GEAR DATA".

5.8.3 Single enveloping worm gear matched sets.

5.8.3.1 Instructions to the designer. For design, procurement, installation, and replacement purposes, mating worm gears and worms shall be specified on a matched set drawing. Installation drawings, maintenance manuals, and spare parts lists shall show the matched set drawing number only.

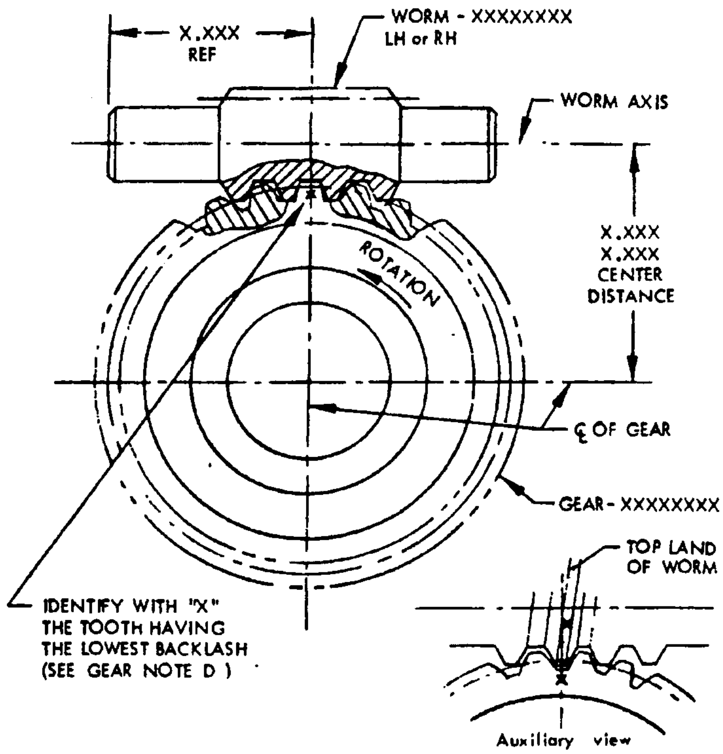
5.8.3.1.1 Mandatory drawing requirements. Engineering drawings for worm gear matched sets shall specify the following.

a. View delineation (see 5.8.3.2).
b. Data specification (see 5.8.3.3).

5.8.3.1.2 Drawing title block requirement. The designer shall use the following nomenclature in the title block of the drawing to identify the type of matched set:

SINGLE ENVELOPING WORM GEAR MATCHED SET

5.8.3.2 View delineation. For clarity of interpretation, the following matched set characteristics shall be delineated as shown in figure 63.



NOTE: View shown in figure 63 is for single start worms. For multiple start worms, identification with "X" will be as shown in auxiliary view at right with note stating "IDENTIFY WITH "X", ON TOP OF LAND OF WORM AND BASE OF MATING SPACE OF GEAR, THE TOOTH HAVING THE LOWEST BACKLASH (SEE GEAR NOTE D)".

FIGURE 63. Worm gears.

5.8.3.3 Data specification. Minimum data and nomenclature requirements shall be specified as listed below:

MATCHED SET DATA

BACKLASH OF. XXX TO. XXX IN TRANSVERSE PLANE OF WORM GEAR WITH MATING WORM NO. XXXXXXXX AT X.XXX CENTER DISTANCE HAVING ZERO AXIAL DISPLACEMENT.

GEAR NOTES

A. THESE GEARS ARE TO BE MANUFACTURED, INSPECTED, PACKAGED OR ASSEMBLED, STOCKED, REPLACED, PERMANENTLY IDENTIFIED, AND RETAINED AS SERIALIZED MATCHED SETS ONLY. SERIAL NUMBERS SHALL NOT BE DUPLICATED.
B. MATCHED SET DRAWING NUMBER XXXXXXXX SHALL BE MARKED ON THE CONTAINER AND/OR SUPPLY IDENTIFICATION TAG.
C. DIRECTION OF ROTATION SHOWN ON WORM GEAR IS MANDATORY DURING MATCHING.
D. PERMANENTLY IDENTIFY EACH MATCHED SET ON ANY READILY VISIBLE NONFUNCTIONAL SURACE:

    ACTUAL CENTER DISTANCE
    MATCHED SET SERIAL NUMBER
    MATCHED SET NUMBER
    MATING GEAR TEETH (AS SHOWN)
    ACTUAL BACKLASH OF TOOTH IDENTIFIED BY (X)

MATCHED REFERENCE DATA

GEAR RATIO ______________________________ XX TO 1
MAX. SPEED OF WORM ______________________________ XXX RPM
TYPE OF LOAD ____________________ UNIFORM, LIGHT SHOCK, OR HEAVY SHOCK
TYPE OF SERVICE ______________________________ CONSTANT OR INTERMITTENT

GENERAL NOTES

a. Tooth contact patterns shall be specified as shown in AGMA Standard 341.02.
b. When more restrictive controls for worm contact patterns are required, they shall be specified in accordance with results obtained during development and testing stage.

5.8.4 Single enveloping worm data.

5.8.4.1 Instructions to the designer.

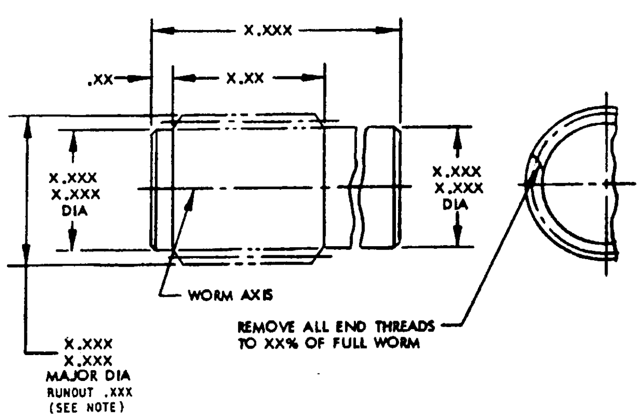
5.8.4.1.1 Mandatory drawing requirements. Engineering drawings for this type of gear shall specify the following:

a. View delineation (see 5.8.4.2).
b. Data specification (see 5.8.4.3).
c. Gear mounting characteristics as selected from 5.2.2.
d. Radii and fillets as selected from 5.2.3.
e. Additional data selected from 5.8.4.1.1.
f. Material specification.
g. Heat treat specification as required.
h. Finish notes (e.g. plating, etc.).
i. Other notes as required.

5.8.4.1.1.1 Additional data. The designer will review the following latest publications for method of specifying additional and miscellaneous characteristics as required:

AGMA 341.02	- System Design of General Industrial Coarse Pitch Cylindrical Wormgearing.
AGMA 374.04	- Design for Fine-Pitch Wormgearing.
AGMA 390.03	- AGMA Gear Handbook.

5.8.4.2 View delineation. For clarity of interpretation, the following gear characteristics shall be delineated as shown on figure 64.



NOTE: Select major diameter runout from gear mounting characteristics, paragraph 5.2.2.

FIGURE 64. Single enveloping worm.

5.8.4.3 Data specification. Minimum data and nomenclature requirements shall be specified as listed below:

WORM DATA

TOOTH FORM ______	
NUMBER OF THREADS (STARTS) ______	X
DIAMTERAL PITCH (NORMAL) ______	XX
AXIAL LINEAR PITCH ______	.XXXX
LEAD ANGLE (LH or RH) ______	X°X'
PRESSURE ANGLE (NORMAL) ______	XX°
MINOR DIAMETER ______	X.XXX.X,XXX
FORM DIAMETER (MAX.) ______	X.XXX
MEASUREMENT OVER THREE .XXXXX DIAMETER WIRES __	X.XXX/X.XXX
PROFILE TOLERANCE ______	.XXXX
TO [ ] ______	.XXXX
AXIAL LINEAR PITCH TOLERANCE ______	.XXXX

WORM NOTES

A. REQUIREMENTS AS SPECIFIED ON MATCHED SET DRAWING NO XXXXXXXX SHALL APPLY TO THIS WORM.
B. MATES WITH XX TOOTH GEAR PART NO. XXXXXXXX.
C. FINISH ON WORKING SURFACE OF TEETH SHALL BE XX √
D. ALL TOOTH ELEMENT SPECIFICATIONS OF THE WORM ARE RELATIVE TO THE MOUNTING DATUM [ ] .

WORM REFERENCE DATA

SHAFT ANGLE ______	XX°
LEAD ______	XX.XXXXXXX
TOOTH THICKNESS (NORMAL) ______	.XXXX/.XXXX
PITCH DIAMETER ______	X.XXXXXXX
BASE DIAMETER (see Note a) ______	X.XXXXXXX

GENERAL NOTES

a. Base diameter. Specify for involute tooth form only.

b. Dimensional values are indicated by X's to indicate units or the number of decimal places recommended in each instance.

5.8.5 Single enveloping worm gear data.

5.8.5.1 Instructions to the designer.

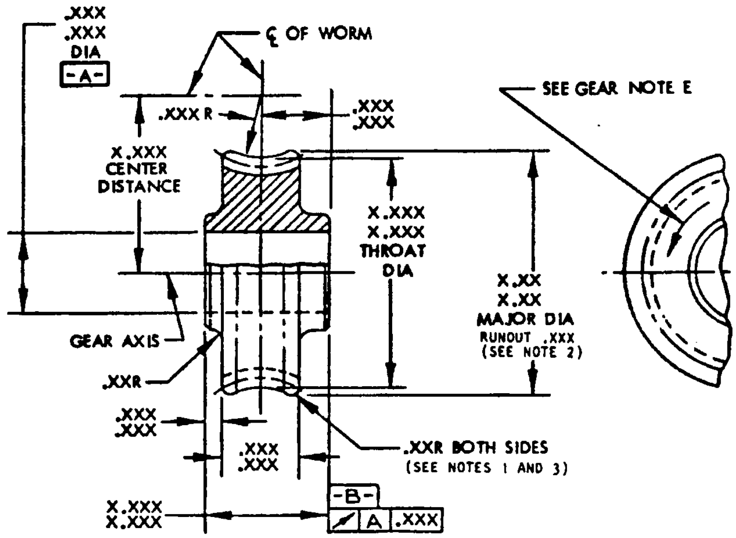
5.8.5.1.1 Mandatory drawing requirements. Engineering drawings for the type of gear shall specify the following:

a. View delineation (see 5.8.5.2).
b. Data specification (see 5.8.5.3).
c. Gear mounting characteristics as selected from 5.2.2.
d. Chamfer, radii, and fillets as selected from 5.2.3.
e. Additional data selected from 5.8.5.1.1.
f. Material specification.
g. Heat treat specification as required.
h. Finish notes (e.g. plating, etc.).
i. Other notes as required.

5.8.5.1.1.1 Additional data. The designer will review the following latest publications for methods of specifying additional and miscellaneous characteristics as required:

AGMA 341.02	- System Design of General Industrial Coarse Pitch Cylindrical Wormgearing.
AGMA 374.04	- Design for Fine-Pitch Wormgearing.
AGMA 390.03	- AGMA Gear Handbook.

5.8.5.2 View delineation. For clarity of interpretation, the following gear characteristics shall be delineated as shown in figure 65.



NOTES:

1. Use .XXX by XX° Chamfer in lieu of .XXX/.XXXR when required.
2. Select major diameter runout from gear mounting characteristics, paragraph 5.2.2.
3. When the gear is symmetrical, replace one of the radii by a chamfer on the thrust side to identify side as a datum surface.
4. The rotation of the worm gear should be selected based on thrust face datum. (Ref. - B - as shown.)

FIGURE 65. Single enveloping worm gear.

5.8.5.3 Data specification. Minimum data and nomenclature requirements shall be specified as listed below:

WORM GEAR DATA

NUMBER OF TEETH	XX
PRESSURE ANGLE (NORMAL)	XX°
CIRCULAR PITCH (TRANSVERSE)	.XXXX
CIRCULAR TOOTH THICKNESS (BASIC) (TRANSVERSE)	.XXXX
HELIX ANGLE	XX.XXXXXXX°
HAND OF HELIX	
MINOR DIAMETER	X.XXX/X.XXX

WORM GEAR NOTES

A. REQUIREMENTS AS SPECIFIED ON MATCHED SET DRAWING NO. XXXXXXXX SHALL APPLY TO THIS GEAR.
B. MATES WITH WORM PART NO. XXXXXXXX.
C. FINISH ON WORKING SURFACES OF TEETH SHALL BE XX√
D. ALL TOOTH ELEMENT SPECIFICATIONS OF THE GEAR ARE RELATIVE TO THE MOUNTING DATUM [ ] .
E. PERMANENTLY IDENTIFY ROTATION OF WORM GEAR AS SHOWN.

WORM GEAR REFERENCE DATA

DIAMETRAL PITCH (NORMAL)	XX
PITCH DIAMETER	X.XXXXXXX
ADDENDUM	.XXX

GENERAL NOTE

Dimensional values are indicated by X'S to indicate units or the number of decimal places recommended in each instance.

5.8.6.1 Instructions to the designer. For design, procurement, installation, and replacement purposes, mating worm gears and worms shall b specified on a matched set drawing. Installation drawings, maintenance manuals, and spare parts lists shall show the matched set drawing number only.

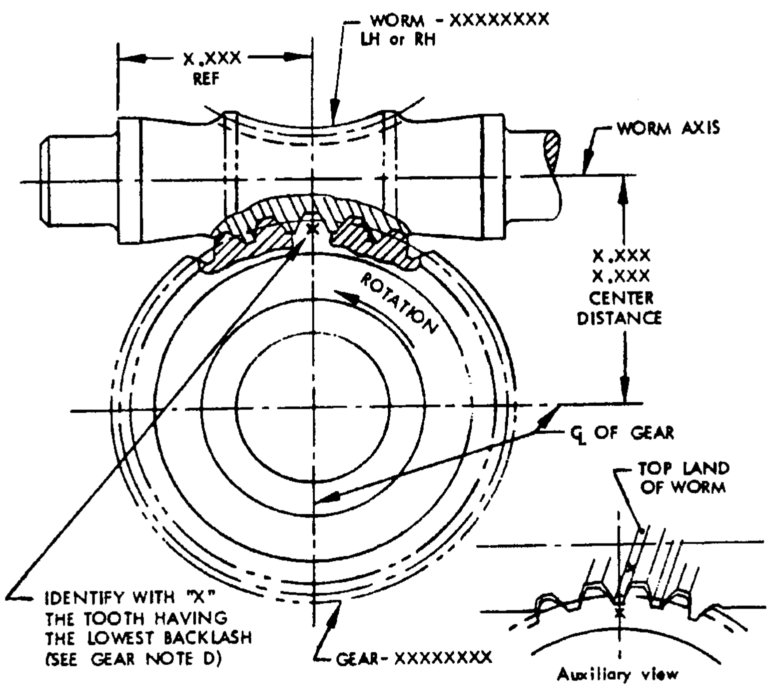
5.8.6.1.1 Mandatory drawing requirements. Engineering drawings for worm gear matched sets shall specify the following:

a. View delineation (see 5.8.6.2).
b. Data specification (see 5.8.6.3).

5.8.6.1.2 Drawing title block requirement. The designer shall use the following nomenclature in the title block of the drawing to identify the type of matched set.

"DOUBLE ENVELOPING WORM GEAR MATCHED SET"

5.8.6.2 View delineation. For clarity of interpretation, the following matched set characteristics shall be delineated as shown in figure 66.



NOTE: View shown is for single start worms. For multiple start worms, identification with "X" will be show in auxiliary view at right with note stating "IDENTIFY WITH "X", ON TOP LAND OF WORM AND BASE OF MATING SPACE OF GEAR, THE TOOTH HAVING THE LOWEST BACKLASH (SEE GEAR NOTE D)".

FIGURE 66. Double enveloping worm gear.

5.8.6.3 Data specification. Minimum data and nomenclature requirements shall be specified as listed below:

MATCHED SET DATA

BACKLASH OF. XXX TO .XXX IN TRANSVERSE PLANE OF WORM GEAR WITH MATING WORM NO. XXXXXXXX AT X.XXX CENTER DISTANCE HAVING ZERO AXIAL DISPLACEMENT.

GEAR NOTES

A. THESE GEARS ARE TO BE MANUFACTURED, INSPECTED, PACKAGED OR ASSEMBLED, STOCKED, REPLACED, PERMANENTLY IDENTIFIED, AND RETAINED AS SERIALIZED MATCHED SETS ONLY. SERIAL NUMBERS SHALL NOT BE DUPLICATED.
B. MATCHED SET DRAWING NUMBER XXXXXXXX SHALL BE MARKED ON THE CONTAINER AND/OR SUPPLY IDENTIFICATION TAG.
C. DIRECTION OF ROTATION SHOWN ON WORM GEAR IS MANDATORY DURING MATCHING.
D. PERMANENTLY IDENTIFY EACH MATCHED SET ON ANY READILY VISIBLE NONFUNCTIONAL SURFACE:

ACTUAL CENTER DISTANCE
MATCHED SET SERIAL NUMBER
MATCHED SET NUMBER
MATING GEAR TEETH (AS SHOWN)
ACTUAL BACKLASH OF TOOTH IDENTIFIED BY (X)

MATCHED SET REFERENCE DATA

GEAR RATIO ____ XX TO 1
MAX. SPEED OF WORM ________________________________ XXX RPM
TYPE OF LOAD ________________ UNIFORM, LIGHT SHOCK, OR HEAVY SHOCK
TYPE OF SERVICE ___________________________ CONSTANT OR INTERMITTENT

5.8.7 Double enveloping worm data.

5.8.7.1 Instructions to the designer.

5.8.7.1.1 Mandatory drawing requirements. Engineering drawings for this type of gear shall specify the following:

a. View delineation (see 5.8.7.2).
b. Data specification (see 5.8.7.3).
c. Gear mounting characteristics as selected from 5.2.2.
d. Chamfers, radii, and fillets as selected from 5.2.3.
e. Additional data selected from 5.8.7.1.1.
f. Material specification.
g. Heat treat specification as required.
h. Finish notes (e.g. plating, etc.).
i. Other notes as required.

5.8.7.1.1.1 Additional data. The designer will review the following latest publications for methods of specifying additional and miscellaneous characteristics as required:

AGMA 341.02	- System Design of General Industrial Coarse Pitch Cylindrical Wormgearing.
AGMA 342.02	- System Design of General Industrial Double Enveloping Wormgears.
AGMA 374.04	- Design for Fine-Pitch Wormgearing.
AGMA 390.03	- AGMA Gear Handbook.

5.8.7.2 View delineation. For clarity of interpretation, the following gear characteristics shall be delineated as shown in figure 67.

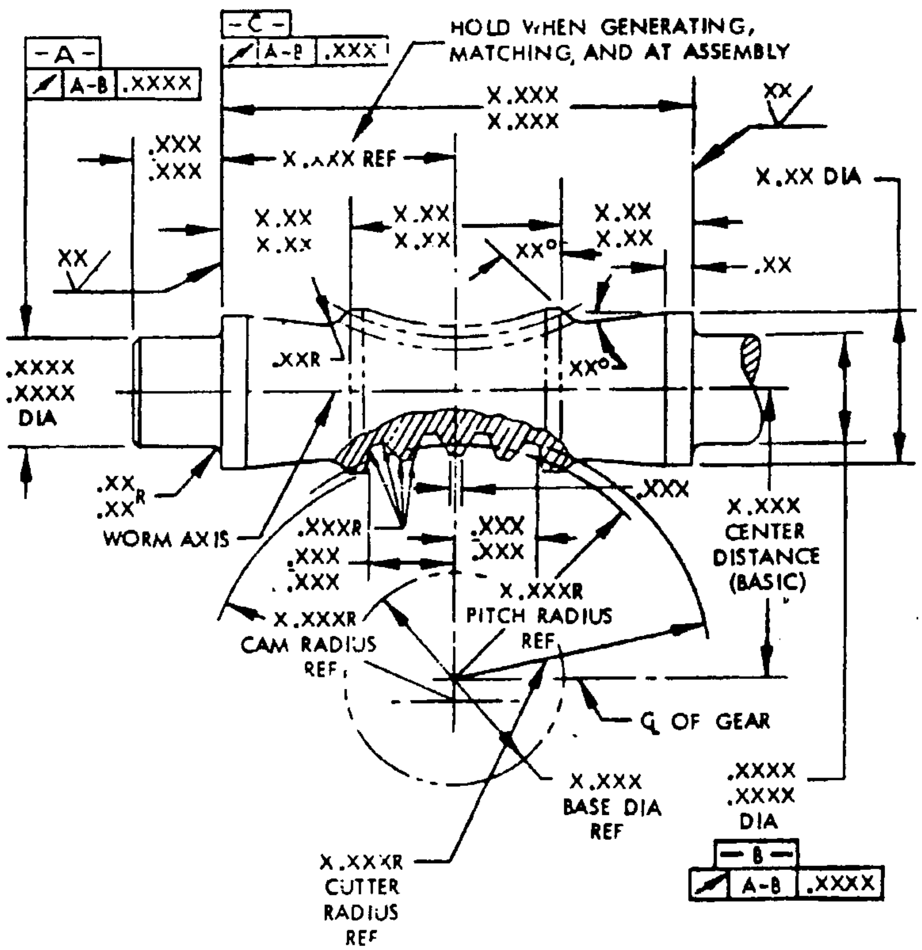


FIGURE 67. Double enveloping worm.

5.8.7.3 Data specification. Minimum data and nomenclature requirements shall be specified as listed below:

WORM DATA

NUMBER OF THREADS (STARTS)	X
CIRCULAR PITCH	.XXXXX
AVERAGE HELIX ANGLE	XX°
HAND OF HELIX	
MAJOR DIAMETER	X.XXX/X.XXX
THROAT DIAMETER	X.XXX/X.XXX
NORMAL TOOTH THICKNESS AT .XXX DEPTH AND AT X.XXX THROAT DIAMETER	.XXXX
WORKING DEPTH	.XXX
WHOLE DEPTH (APPROX.)	.XXX

WORM NOTES

A. REQUIREMENTS AS SPECIFIED ON MATCHED SET DRAWING NO. XXXXXXXX SHALL APPLY TO THIS WORM.
B. MATES WITH XX TOOTH GEAR PART NO. XXXXXXXX.
C. FINISH ON WORKING SURFACES OF TEETH SHALL BE XX√.
D. ALL TOOTH ELEMENT SPECIFICATIONS OF THE WORM ARE RELATIVE TO MOUNTING DATUM [A – B | C].

WORM REFERENCE DATA

GEAR RATIO	XX TO 1
PRESSURE ANGLE	XX°
PITCH DIAMETER	X.XXXXXXX
BASE DIAMETER	X.XXXXXXX

GENERAL NOTE

Dimensional values are indicated by X's to indicate units or the number of decimal places recommended in each instance.

5.8.8 Double enveloping worm gear data.

5.8.8.1 Instructions to the designer.

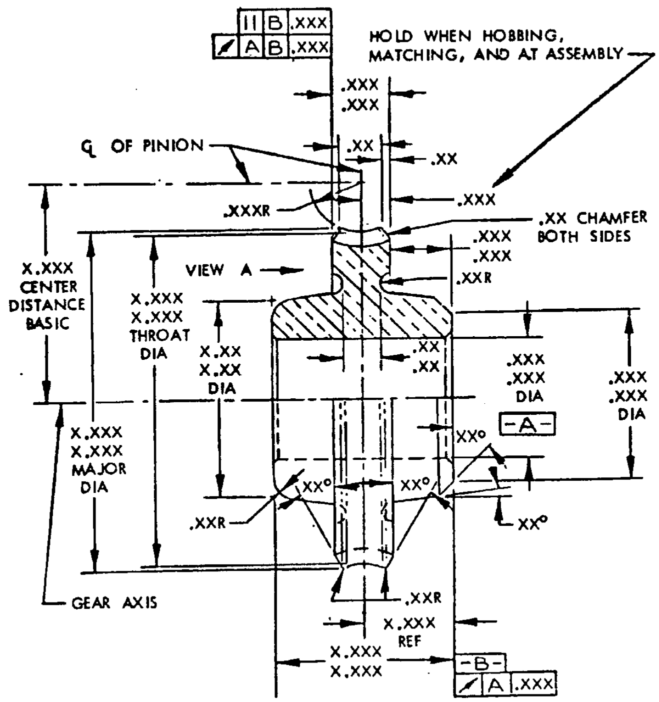
5.8.8.1.1 Mandatory drawing requirements. Engineering drawings for this type of gear shall specify the following:

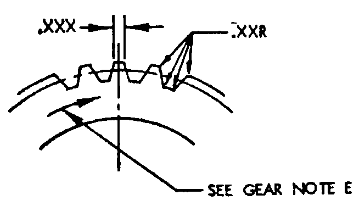
a. View delineation (see 5.8.8.2).
b. Data specification (see 5.8.8.3).
c. Gear mounting characteristics as selected from 5.2.2.
d. Chamfers, radii, and fillets as selected from 5.2.3.
e. Additional data selected from 5.8.8.1.1.
f. Material specification.
g. Heat treat specification as required.
h. Finish notes (e.g. plating, etc.).
i. Other notes as required.

5.8.8.1.1.1 Additional data. The designer will review the following latest publications for methods of specifying additional and miscellaneous characteristics as required:

AGMA 341.02	- System Design of General Industrial Coarse Pitch Cylindrical Wormgearing.
AGMA 342.02	- System Design of General Industrial Double Enveloping Wormgears.
AGMA 374.04	- Design for Fine-Pitch Wormgearing.
AGMA 390.03	- AGMA Gear Handbook.

5.8.8.2 View delineation. For clarity of interpretation, the following gear characteristics shall be delineated as shown in figure 68.





VIEW A

NOTES:

a. Add squareness, concentricity, parallelism, and runout symbols to datum A B as required.

b. In the symmetrical example shown above, the chamfer on the hub end serves to identify the thrust face (- B -). Installation or next assembly drawings should refer to this chamfer for proper installation.

FIGURE 68. Double enveloping worm gear data.

5.8.8.3 Data specification. Minimum data and nomenclature requirements shall be specified as listed below:

WORM GEAR DATA

NUMBER OF TEETH	XX
PRESSURE ANGLE	XX°
CIRCULAR PITCH	.XXXXX
AVERAGE HELIX ANGLE	XX°
HAND OF HELIX	
NORMAL TOOTH THICKNESS AT .XXX DEPTH AND AT X.XXX THROAT DIAMETER	.XXXX
WORKING DEPTH	.XXX
WHOLE DEPTH (APPROX.)	.XXX

WORM GEAR NOTES

A. REQUIREMENTS AS SPECIFIED ON MATCHED SET DRAWING NO. XXXXXXXX SHALL APPLY TO THIS GEAR.
B. MATES WITH WORM PART NO. XXXXXXXX.
C. FINISH ON WORKING SURFACES OF TEETH SHALL BE XX√
D. ALL TOOTH ELEMENT SPECIFICATIONS OF THE GEAR ARE RELATIVE TO MOUNTING DATUM | A | B | .
E. PERMANENTLY IDENTIFY ROTATION OF WORM GEAR AS SHOWN.

WORM GEAR REFERENCE DATA

GEAR RATIO	XX TO 1
PITCH DIAMETER	X.XXXXXXX
BASE DIAMETER	X.XXXXXXX

GENERAL NOTE

Dimensional values are indicated by X's to indicate units or the number of decimal places recommended in each instance.

5.8.9 Spiroid* gear matched sets.

5.8.9.1 Instructions to the designer. For design, procurement, installation and replacement purposes, mating Spiroid gears and pinions shall be specified on a matched set drawing. Installation drawing, maintenance manuals, and spare parts lists shall show the matched set drawing number only.

5.8.9.1.1 Mandatory drawing requirements. Engineering drawings for this type of gear shall specify the following:

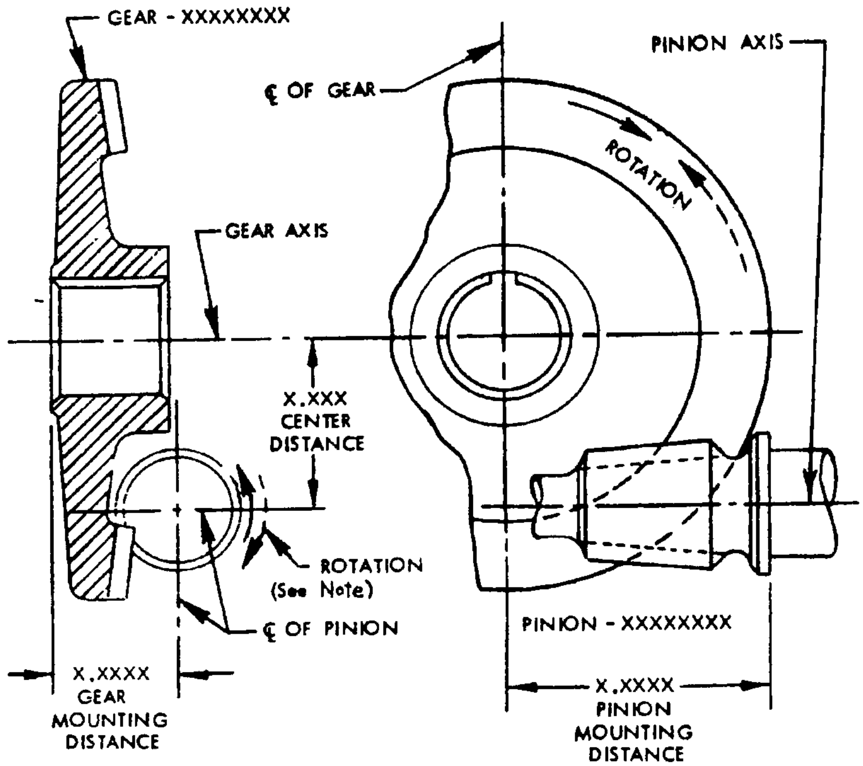
a. View delineation (see 5.8.9.2).
b. Data specification (see 5.8.9.3)

5.8.9.1.2 Drawing title block requirement. The designer shall use the following nomenclature in the title block of the drawing to identify the type of matched set:

SPIROID GEAR MATCHED SET

* Registered trade name

5.8.9.2 View delineation. For clarity of interpretation, the following gear characteristics shall be delineated as shown in figure 39.



NOTE: The direction of the arrows determines the gear rotation in relation to the pinion. Show one of the following under pinion rotation:

————————▶	LOW PRESSURE ANGLE SIDE DRIVING
◀- - - - - - - - - - - -	HIGH PRESSURE ANGLE SIDE DRIVING

FIGURE 69. Spiroid gear matched set.

5.8.9.3 Data specification. Minimum data and nomenclature requirements shall be specified as listed below:

MATCHED SET DATA

BACKLASH TO BE WITHIN .XXX TO .XXX AT X.XXXX AND X.XXXX RESPECTIVE MOUNTING DISTANCES.

GEAR NOTES

A. THESE GEARS ARE TO BE MANUFACTURED, INSPECTED, PACKAGED OR ASSEMBLED, STOCKED, REPLACED, PERMANENTLY IDENTIFIED, AND RETAINED AS SERIALIZED MATCHED SETS ONLY. SERIAL NUMBERS SHALL NOT BE DUPLICATED.
B. MATCHED SET DRAWING NUMBER XXXXXXXX SHALL BE MARKED ON THE CONTAINER AND/OR SUPPLY IDENTIFICATION TAG.
C. PERMANENTLY IDENTIFY EACH MATCHED SET ON ANY READILY VISIBLE NONFUNCTIONAL SURFACE:

ACTUAL MOUNTING DISTANCES
MATCHED SET SERIAL NUMBER
MATCHED SET NUMBER
ACTUAL BACKLASH OF MATING GEAR TEETH
IDENTIFIED BY (X) AT TIGHTEST POINT OF MESH

MATCHED SET REFERENCE DATA

GEAR RATIO ____________________ XX TO 1
MAX. SPEED OF PINION ____________________ XXX RPM
TYPE OF LOAD ____________________ UNIFORM, LIGHT SHOCK, OR HEAVY SHOCK
TYPE OF SERVICE ____________________ CONSTANT OR INTERMITTENT

5.8.10 Spiroid* pinion data.

5.8.10.1 Instructions to the designer.

5.8.10.1.1 Mandatory drawing requirements. Engineering drawings for this type of gear shall specify the following:

a. View delineation (see 5.8.10.2).
b. Sectional view (see 5.8.10.3).
c. Data specification (see 5.8.10.4).
d. Gear mounting characteristics as selected from 5.2.2.
e. Chamfers, radii, and fillets as selected from 5.2.3.
f. Additional data selected from Mandatory review below.
g. Material specification.
h. Heat treat specification as required.
i. Finish notes (e.g. plating, etc.).
j. Other notes as required.

*Registered trade name.

5.8.10.1.1.1 Mandatory review. The designer will review the following paragraph for methods of specifying additional gear characteristics when required:

5.4.4 - Shaft angles.

5.8.10.2 View delineation. For clarity of interpretation, the following gear characteristics shall be delineated as shown in figure 70a.

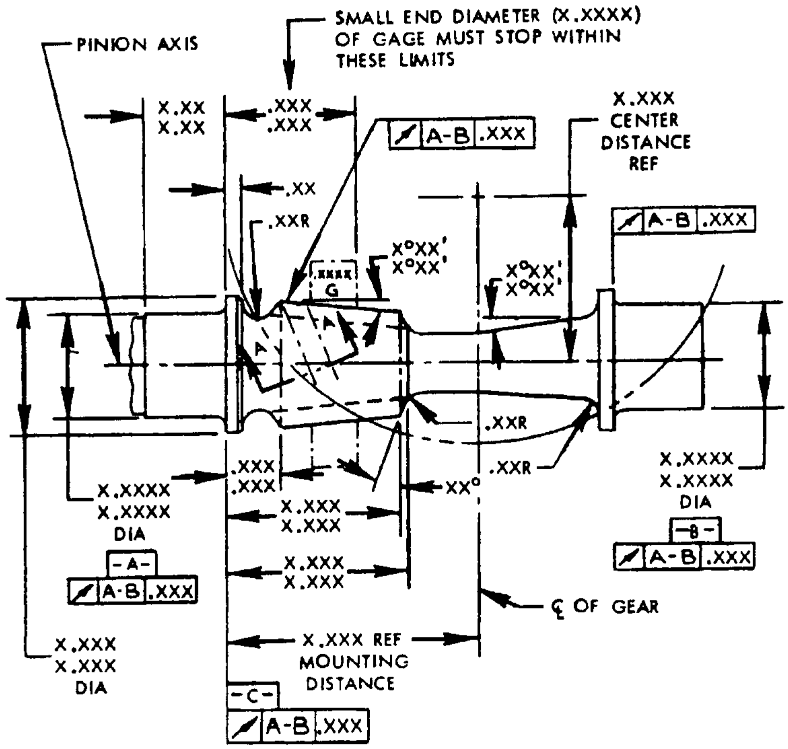


FIGURE 70a. Spiroid pinion data.

5.8.10.2.1 Applicable requirement. Sectional view, figure 70b, shall appear on the same sheet as the cutting plane shown above and both shall be identified with the same alphabetical series letter.

5.8.10.2.2 Datum. Figure 70a, pinion depicts a straddle mount type. For other types of mounting datums, see paragraph 5.4.2.

5.8.10.3 Data specification. Minimum data and nomenclature requirements shall be specified as listed below:

SPIROID PINION DATA

NUMBER OF THREADS (LH OR RH)	X
MAJOR DIAMETER	X.XXX/X.XXX
WHOLE DEPTH	.XXX
CENTER DISTANCE	X.XXX
ZERO PLANE RADIUS	.XXX
TOLERANCE CLASS	

SPIROID PINION NOTES

A. REQUIREMENTS AS SPECIFIED ON MATCHED SET DRAWING NO. XXXXXXXX SHALL APPLY TO THIS PINION.
B. MATES WITH XX TOOTH GEAR PART NO. XXXXXXXX.
C. FINISH ON WORKING SURFACES OF TEETH SHALL BE XX √
D. ALL TOOTH ELEMENT SPECIFICATIONS OF THE PINION ARE RELATIVE TO MOUNTING DATUM | A – B | C | .

SPIROID PINION REFERENCE DATA

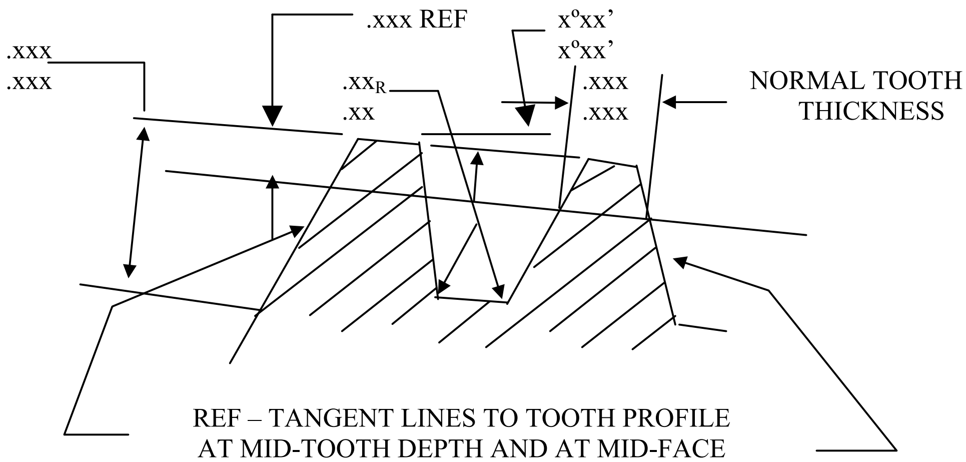
PRESSURE ANGLE - LOW	XX.XX°
PRESSURE ANGLE - HIGH	XX.XX°
GEAR RATIO	XX TO 1
LEAD	XX.XXXXXXX
MEAN THREAD ANGLE*	XX°XX□
TAPER ANGLE	XX°
BACKLASH	.XXX/.XXX
SUMMARY SHEET NO.	XXXXXXXX

* MEASURED AT MID-TOOTH DEPTH AND AT MID-FACE OF PINION.

GENERAL NOTE

Dimensional values are indicated by X's to indicate units or the number of decimal places recommended in each instance.

5.8.10.4 Sectional view. Tooth section and methods of delineating the following gear characteristics are mandatory as shown in figure 70b.



NORMAL THREAD TO LEAD ANGLE

FIGURE 70b. Section A-A.

5.8.10.4.1 Applicable requirements. The cutting plane, shown in figure 70a, shall appear on the same sheet as the sectional view shown above and both shall be identified with the same alphabetical series letter.

5.8.11 Spiroid* gear data.

5.8.11.1 Instructions to the designer.

5.8.11.1.1 Mandatory drawing requirements. Engineering drawings for this type of gear shall specify the following:

a. View delineation (see 5.8.11.2).
b. Data specification (see 5.8.11.3).
c. Gear mounting characteristics as selected from 5.4.2.
d. Chamfers, radii, and fillets as selected from 5.2.3.
e. Additional data selected from Mandatory review below.
f. Material specification.
g. Heat treat specification as required.
h. Finish notes (e.g. plating, etc.).
i. Other notes as required.

5.8.11.1.1.1 Mandatory review. The designer will review the following paragraph for methods of specifying additional gear characteristics when required:

5.4.4 Shaft angles.

* Registered trade name

5.8.11.2 View delineation. For clarity of interpretation, the following gear characteristics shall be delineated as shown in figure 71.

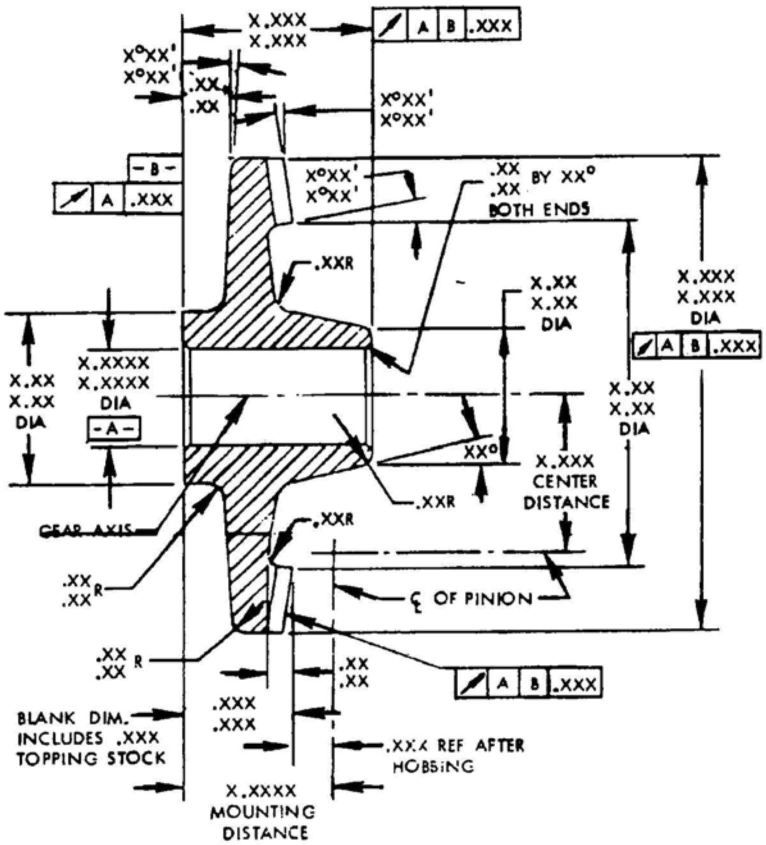


FIGURE 71. Spiroid gear data.

5.8.11.3 Data specification. Minimum data and nomenclature requirements shall be specified as listed below.

SPIROID GEAR DATA

NUMBER OF TEETH	XX
SHAFT ANGLE	XX°XX'
HOB ZERO PLANE RADIUS	.XXX
CUTTING DISTANCE	X.XXX

SPIROID GEAR NOTES

A. REQUIREMENTS AS SPECIFIED ON MATCHED SET DRAWING NO. XXXXXXXX SHALL APPLY TO THIS GEAR.
B. MATES WITH PINION PART NO. XXXXXXXX.
C. FINISH ON WORKING SURFACES OF TEETH SHALL BE XX√.
D. ALL TOOTH ELEMENT SPECIFICATIONS OF THE GEAR ARE RELATIVE TO MOUNTING DATUM [A|B].

SPIROID GEAR REFERENCE DATA

GEAR RATIO	XX TO 1
TOLERANCE CLASS	X
HOB NUMBER	XXXXX
INDEX GEARS	XX/XX
SUMMARY SHEET NUMBER	XXXXX

GENERAL NOTE

Dimensional values are indicated by X's to indicate units or the number of decimal places recommended in each instance.

5.8.12 Helicon* gear matched sets.

5.8.12.1 Instructions to the designer. For design, procurement, installation, and replacement purposes, mating Helicon gears and pinions shall be specified on a matched set drawing. Installation drawings, maintenance manuals, and spare parts lists shall show the matched set drawing number only.

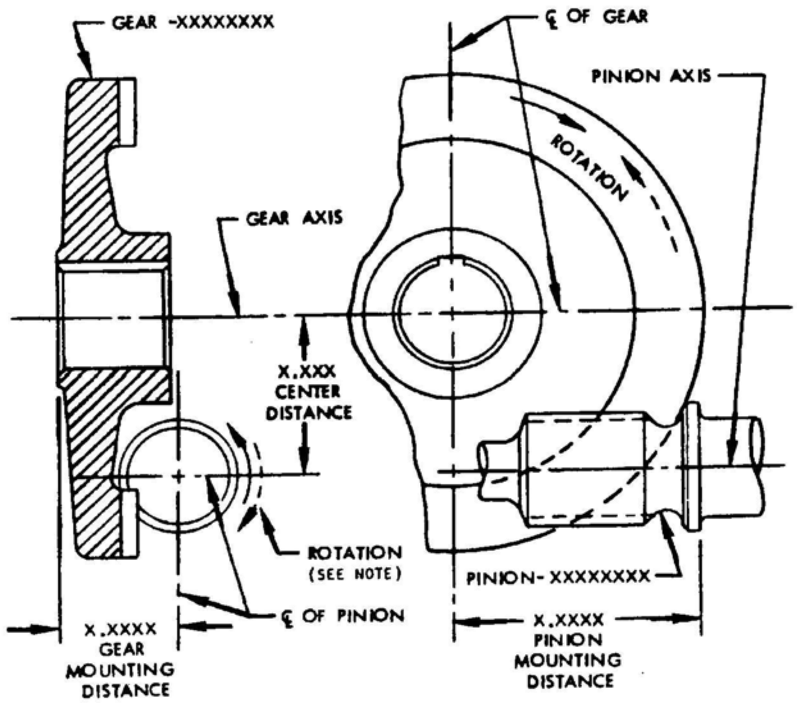
5.8.12.1.1 Mandatory drawing requirements. Engineering drawings for matched set Helicon gears shall specify the following:

a. View delineation (see 5.8.12.2).
b. Data specification (see 5.8.12.3).

5.8.12.1.2 Drawing title block requirement. The designer shall use the following nomenclature in the title block of the drawing to identify the type of matched set:

HELICON GEAR MATCHED SET

5.8.12.2 View delineation. For clarity of interpretation, the following gear characteristics shall be delineated as shown in figure 72.



NOTE: The direction of the arrows determines the gear rotation in relation to the pinion. Show one of the following under pinion rotaton:

⟶ LOW PRESSURE ANGLE SIDE DRIVING
⟵ – – – – HIGH FRESSURE ANGLE SIDE DRIVING

FIGURE 72. Helicon gear matched set.

5.8.12.3 Data specification. Data and nomenclature requirement shall be specified as listed below.

MATCHED SET DATA

BACKLASH TO BE WITHIN .XXX TO .XXX AT X.XXXX AND X.XXXX RESPECTIVE MOUNTING DISTANCES.

GEAR NOTES

A. THESE GEARS ARE TO BE MANUFACTURED, INSPECTED, PACKAGED OR ASSEMBLED, STOCKED, REPLACED, PERMANENTLY IDENTIFIED, AND RETAINED AS SERIALIZED MATCHED SETS ONLY SERIAL NUMBERS SHALL NOT BE DUPLICATED.
B. MATCHED SET DRAWING NUMBER XXXXXXXX SHALL BE MARKED ON THE CONTAINER AND/OR SUPPLY IDENTIFICATION TAG.
C. PERMANENTLY IDENTIFY EACH GEAR OF THE MATCHED SET ON ANY READILY VISIBLE NON-FUNCTIONAL SURFACE:

ACTUAL MOUNTING DISTANCES
MATCHED SET SERIAL NUMBER
MATCHED SET NUMBER
ACTUAL BACKLASH OF MATING GEAR TEETH IDENTIFIED BY (X) AT TIGHTEST POINT OF MESH

MATCHED SET REFERENCE DATA

GEAR RATIO ____ XX TO 1
MAX. SPEED OF PINION ______________________________ XX RPM
TYPE OF LOAD ________ UNIFORM, LIGHT SHOCK, OR HEAVY SHOCK
TYPE OF SERVICE _________________ CONSTANT OR INTERMITTENT

5.8.13 Helicon* pinion data.

5.8.13.1 Instructions to the designer.

5.8.13.1.1 Mandatory drawing requirements. Engineering drawings for this type of gear shall specify the following:

a. View delineation (see 5.8.13.2).
b. Sectional view (see 5.8.13.3).
c. Data specification (see 5.8.13.4).
d. Gear mounting characteristics as selected from 5.4.2.
e. Chamfers, radii, and fillets as selected from 5.2.3.
f. Additional data selected from Mandatory review below.
g. Material specification.
h. Heat treat specification as required.
i. Finish notes (e.g. plating, etc.).
j. Other notes as required.

* Registered trade name.

5.8.13.1.1.1 Mandatory review. The designer will review the following paragraph for methods of specifying additional gear characteristics when required:

5.4.4 Shaft angles.

5.8.13.2 View delineation. For clarity of interpretation, the following gear characteristics shall be delineated as shown in figure 73a.

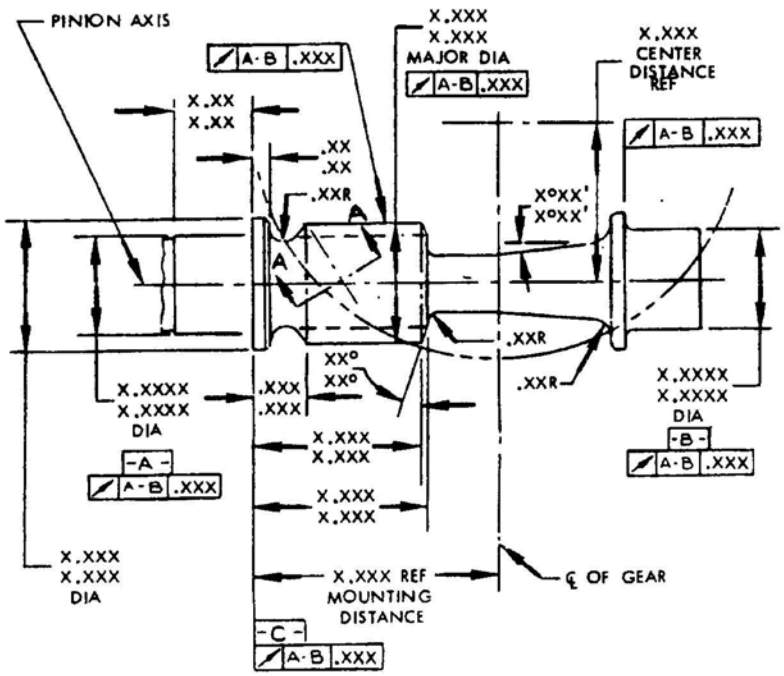


FIGURE 73a. Helicon pinion data.

5.8.13.2.1 Applicable requirement. Sectional view, figure 73b, shall appear on the same sheet as the cutting plane shown above and both shall be identified with the same alphabetical series letter.

5.8.13.2.2 Datum. Figure 73a, pinion depicts a straddle mount. For other types of mounting datums, see paragraph 5.4.2.

5.8.13.3 Data specification. Minimum data and nomenclature requirements shall be specified as listed below.

HELICON PINION DATA.

NUMBER OF THREADS (LH or RH)	X
WHOLE DEPTH	.XXX
CENTER DISTANCE	X.XXX
ZERO PLANE RADIUS	.XXX
TOLERANCE CLASS	

HELICON PINION NOTES.

A. REQUIREMENTS AS SPECIFIED ON MATCHED SET DRAWING NO. XXXXXXXX SHALL APPLY TO THIS PINION.
B. MATES WITH XX TOOTH GEAR PART NO. XXXXXXXX.
C. FINISH ON WORKING SURFACES OF TEETH SHALL BE XX √.
D. ALL TOOTH ELEMENT SPECIFICATIONS OF THE PINION ARE RELATIVE TO MOUNTING DATUM | A – B | C |

HELICON PINION REFERENCE DATA

PRESSURE ANGLE - LOW	XX.XXº
PRESSURE ANGLE - HIGH	XX.XXº
GEAR RATIO	XX TO 1
LEAD	XX.XXXXXXX
MEAN THREAD ANGLE*	XX'XXº
TAPER ANGLE	XXº
BACKLASH	.XXX/.XXX
SUMMARY SHEET NO.	XXXXXXXX

* MEASURED AT MID-TOOTH DEPTH AND AT MID-FACE OF PINION.

GENERAL NOTE

Dimensional values are indicated by X's to indicate units or the number of decimal places recommended in each instance.

5.8.13.4 Sectional view. Tooth section and methods of delineating the following gear characteristics are mandatory as shown in figure 73b.

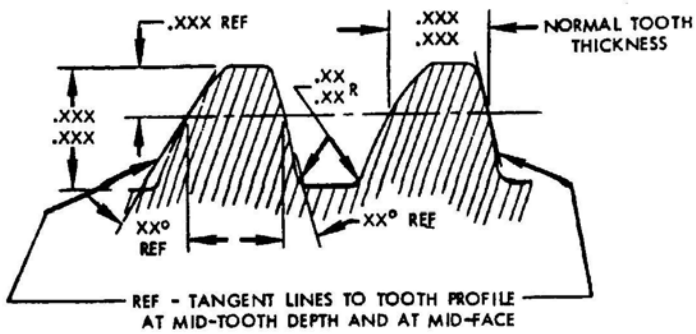


FIGURE 73b. SECTION A-A.

5.8.13.4.1 Applicable requirement. Cutting plane, shown in figure 73a, shall appear on the same sheet as the sectional view shown above and both shall be identified with the same alphabetical series letter.

5.8.14 Helicon* gear data.

5.8.14.1 Instructions to the designer.

5.8.14.1.1 Mandatory drawing requirements. Engineering drawings for this type of gear shall specify the following:

a. View delineation (see 5.8.14.2).
b. Data specification (see 5.8.14.3).
c. Gear mounting characteristics as selected from 5.4.2.
d. Chamfers, radii, and fillets as selected from 5.2.3.
e. Additional data selected from Mandatory review below.
f. Material specification.
g. Heat treat specification as required.
h. Finish notes (e.g. plating, etc.).
i. Other notes as required.

* Registered trade name.

5.8.14.1.1.1 Mandatory review. The designer will review the following paragraph for methods of specifying additional gear characteristics when required:

5.4.4 Shaft Angles.

5.8.14.2 View delineation. For clarity of interpretation, the following gear characteristics shall be delineated as shown in figure 74.

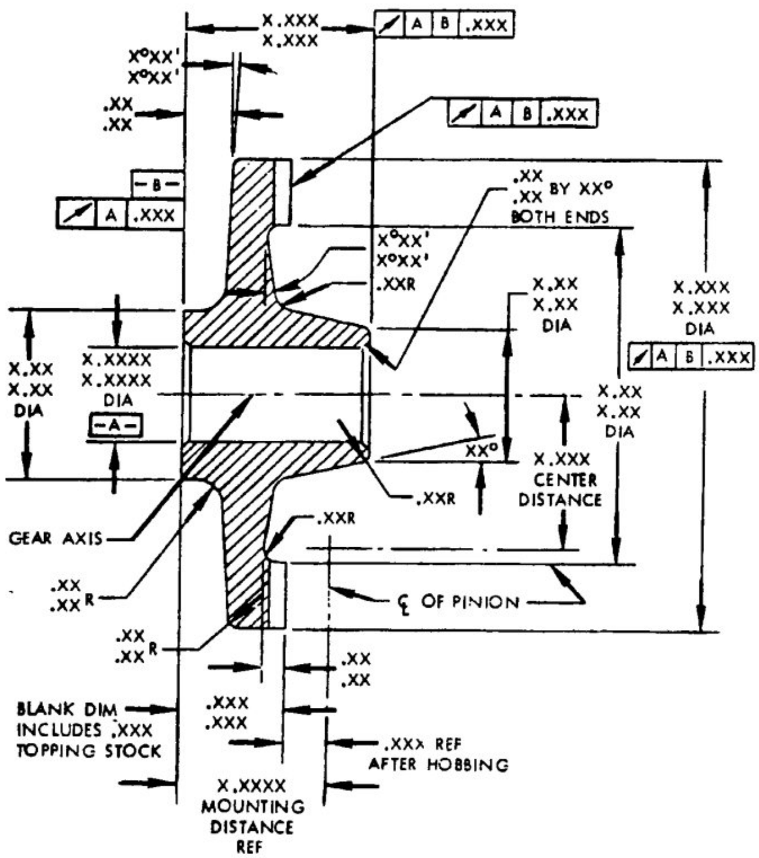


FIGURE 74. Helicon gear data.

5.8.14.3 Data specification. Minimum data and nomenclature requirements shall be specified as listed below.

HELICON GEAR DATA

NUMBER OF TEETH	XX
SHAFT ANGLE	XX°XX'
HOB ZERO PLANE RADIUS	.XXX
CUTTING DISTANCE	X.XXX

HELICON GEAR NOTES

A. REQUIREMENTS AS SPECIFIED ON MATCHED SET DRAWING NO. XXXXXXXX SHALL APPLY TO THIS GEAR.
B. MATES WITH PINION PART NO. XXXXXXXX.
C. FINISH ON WORKING SURFACES OF TEETH SHALL BE XX√.
D. ALL TOOTH ELEMENT SPECIFICATIONS OF THE GEAR ARE RELATIVE TO MOUNTING DATUM | A | B |

HELICON GEAR REFERENCE DATA

GEAR RATIO	XX TO 1
TOLERANCE CLASS	X
HOB NUMBER	XXXXX
INDEX GEARS	XX/XX
SUMMAR SHEET NO.	XXXXX

GENERAL NOTE

Dimensional values are indicated by X's to indicate units or the number of decimal places recommended in each instance.

5.8.15 Planoid* gears.

a. Application. Planoid gears are another type of skew axis gearing used to connect nonparallel, nonintersecting shafts which are designed with a pinion offset of approximately one-sixth to one-third of the gear diameter. Their application is similar to hypoid gearing, and they are usually used for ratios in the 1.5:1 to 10:1 range. The tooth flanks of the gear are plane surfaces. The basic member of the gear set is the gear because all tooth design specifications are applied to it.

b. Manufacturing information. The gear teeth on planoid gears are straight and unsymmetrical and may be radially placed or skewed on the blank. They may be milled, ground, or broached. Both sides of the teeth are cut in one pass. The pinion teeth are cut in a continuous generating operation similar to hobbing. Tools for cutting these gears are special for each particular ratio and center distance.

* Registered trade name.

c. Mounting. Planoid pinions can be cantilever mounted or with a sturdy, large-diameter through-shaft. Another method uses a large supporting bearing as a short-straddle mounting, close to the pinion.

5.8.16 Face gears.

a. Face gear characteristics. Face gears have a similar function to that of bevel gears. Their teeth are designed to run with a spur or helical pinion, the latter having greater load capacity and smoother action. Face gear teeth are unusual in that they are of changing shape along their length, the large end being toward the center and the small end at the outside. The active pressure angle increases from inside to outside face (from heel to toe). A feature of face gears is the ability to move the pinion along its axis without affecting tooth contact or efficiency of the system. As a result, face gears are often used where ease of assembly is important. Load-carrying capacity is limited for spur gears (especially for ratios under 3:1) because of restriction on the face width of the gear. An advantage of face gears over bevel or hypoid gears is that the mounting distance of the pinion to the cone apex is not critical.

b. Face gear types. Where the axes of the face gear and pinion intersect, the face gear is called "on-center", and where the axes do not intersect, it is called an "offset" face gear.

c. Manufacturing data. The mating pinion may have either spur or helical teeth, and the cutter used for the gear usually has the same number of teeth as the mating pinion and is generated on the design pinion center distance.

5.8.17 Beveloid* gears.

a. Beveloid gear characteristics. Beveloid gears are basically fine-pitch (from 20-64) gears and primarily find application in instrumentation where accurate indexing and/or backlash control is required. The gears will run with any involute gear or rack of the same base pitch. Backlash can be adjusted to zero or any amount without affecting smooth rolling action.

b. Definition. A beveloid gear is an involute gear with tapered tooth thickness, tapered root, and in most cases, tapered outside diameter. All sections normal to the axis have a common base circle diameter and, thus, the same involutes; but the tooth thickness at any diameter increases linearly from the front face to the back face of the gear. The gear has the general appearance of a bevel gear, but each transverse section represents a spur gear.

* Registered trade name.

c. Advantages. Beveloid gearing offers the following advantages in use, design, and manufacture:

1. Accurate transmission of motion.
2. Unlimited meshing combinations.
3. Freedom of gear arrangement.
4. Elimination of mounting errors effect.
5. Elimination or control of backlash.
6. Centralized tooth contact.
7. Reduced gear noise and smooth operation.
8. Precision dimensional control.

d. Limitations. Beveloid gearing has two inherent limitations namely:

1. Point contact.
2. Undercutting of gear teeth.

e. Beveloid applications. The variety of ways in which Beveloid gears can be used is suggested by the following cases:

1. Beveloid combinations with intersecting axes.
2. Beveloid gears on parallel axes.
3. Beveloid gears on skew axes.
4. Multiple beveloid take-off with coplanar axes.
5. Beveloid differential.
6. Beveloid in mesh with spur gear.
7. Beveloid in mesh with helical gear.
8. Beveloid in mesh with worm.
9. Beveloid worm in mesh with spur or helical gear.
10. Beveloid gear in mesh with rack.

5.8.17.1 Instructions to the designer.

5.8.17.1.1 Design information. The infrequent use of these gears in ordnance applications precludes the preparation of detailed formats for Beveloid gears. To guide the designer in drawing preparation of Beveloid gear data, consult the spur, helical, bevel, and worm gear sections of the handbook.

5.8.18 Harmonic Drive*.

a. Harmonic Drive characteristics. The Harmonic Drive is a class of constant-ratio mechanical drive systems for power transmission, angular positioning or motion conversion. Its operating principle is based on a continuous deflection wave generated in a flexing spline element which achieves a high mechanical leverage between concentric parts. It can change speeds with reduction ratios up to one million to one and transmits motion through sealed enclosures.

* Registered trade name.

b. Properties. The Harmonic Drive has several unique anrl inherent properties, namely:

1. High-ratio speed reduction or speed increase possible in a single stage.
2. In operation, many spline teeth are in simultaneous engagement to carry torque loads.
3. Spline teeth come into contact with an almost pure radial motion and have essentially zero sliding velocity, even at high input speeds.
4. Spline teeth in contact are practically stationary. Dynamic loading, under normal operating conditions, is negligible, and splines are thus capable of transmitting torques nearly in proportion to their static strengths.
5. Regions of tooth engagement and application of load torque are usually diametrically opposed and result in a force couple that is symmetrical and balanced.
6. Diametrically opposed spline mesh and large number of teeth in simultaneous engagement result in a statistical averaging of errors in individual tooth shape and placement.
7. With the flexible spline formed as an integral section of a flexible cylindrical wall, positive transmission of mechanical motion through the wall can be achieved.

c. Advantages. The Harmonic Drive offers some of the most comprehensive combinations of advantages in high ratio power transmission. A list of these advantages includes.

1. Minimum weight.
2. Maximum torque capacity with minimum size and weight.
3. Low to zero backlash.
4. Positive drive through a hermetic seal.
5. High reduction ratios with mechanical simplicity.
6. Versatility.
7. Reversibility.
8. High mechanical efficiency.
9. Coaxial input and output shafts.
10. High response rate.
11. Simple, stepless, no-backlash phase adjustment.

d. Limitations. The Harmonic Drive is primarily used for low speed, high torque applications. It should generally not be specified for reduction ratios below 50:1, since it is essentially a high-ratio transmission and is generally limited to the lower horsepower ranges (under 100 hp).

5.9 Minimum drawing data for involute splines.

5.9.1 General. This section contains minimum drawing data specifications for the six types of involute splines listed in the table of contents.

5.9.1.1 Interpretation. Lower case letters are used to present the instructional text. Nomenclature and characteristics required for drawing data presentation are depicted in capital letters.

5.9.1.2 Section organization. The following paragraph subdivision number sequence is typical throughout the section:

5.9.X.1 "Instructions to the designer" contains a complete drawing specification check list. It delineates the minimum requirements and provides an index of additional spline characteristics when required.

5.9.X.2 "Data specification" is intended to depict those spline characteristics that define the overall dimensions of the spline blank, and delineates the nomenclature and method of listing spline data, notes, and references in a uniform manner for each type of spline.

5.9.1.3 Appendix. Additional information required for the preparation of spline drawings is provided in the appendix.

5.9.1.3.1 Drawing examples. To assist the designer in the interpretation of the requirements of this handbook. several examples of drawings are included in the appendix. These sample drawings shall be construed as informational only. They are complete to the degree necessary to illustrate a condition. Actual drawings shall conform to textual requirements set forth in this handbook.

5.9.1.3.2 Measuring wires/balls. Specification of measuring wires or balls on drawings shall be to those sizes listed in table II.

5.9.1.4 "Clutch Gear" splines. Clutch gears are in reality splines that transmit motion to a shaft on an intermittent basis. Instructions for specifying this type of spline are outlined in paragraph 5.10.1.3 (Gears vs. splines).

5.9.1.5 Fractional diametral pitches. Generally, the diametral pitch of splines is specified as a fraction, such as 16/32. The numerator of the fraction (16) is used to determine the pitch diameter, circular pitch. And the tooth thickness. The denominator (32) determines the addendum, dedendum, clearance, and consequently, the depth of the tooth.

5.9.1.6 Analytical inspection. When it is necessary to control the effective variations by analytical inspection, the profile, lead, and index tolerances shall be removed from the SPLINE REFERENCE DATA and specified under the SPLINE DATA. This would hold true for other characteristics that the designer intends to control since reference dimensions are not inspected.

5.9.1.7 New drawing preparation. To assure intended fits of splines, both the spline and its mate shall be designed at the same time.

5.9.1.8 Updating drawing requirements. In the process of updating drawings, the designer shall consider interchangeability of updated components with those already in service or storage.

5.9.1.9 Heat/treat finishing allowances. Dimensions and tolerances specified on drawings shall define the end item after heat treatment and/or finishing processes. These dimensions and tolerances shall be interpreted as final acceptance criteria.

5.9.2 External involute spline data (flat root side fit).

5.9.2.1 Instructions to the designer.

5.9.2.1.1 Mandatory drawing requirements. Engineering drawings for this type of spline shall specify the following:

a. Data specification (see 5.9.2.2).
b. Spline datum characteristics as selected from 5.10.2.
c. Chamferst radii, and fillets as selected from 5.10.3.
d. Additional data selected from mandatory review below.
e. Material specification.
f. Heat treat specification as required.
g. Finish notes (e.g. plating, etc.).
h. Other notes as required.

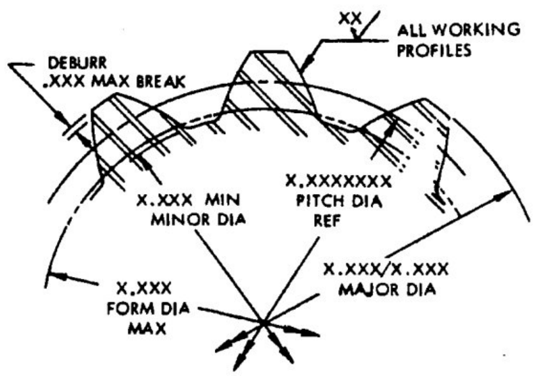
5.9.2.1.1.1 Mandatory review. The designer will review the following paragraphs for methods of specifying additional spline characteristics when required:

5.10.4 Shaft End Splines
5.10.5 Index Relationship
5.10.6 Minor Diameter Fits
5.10.7 Involute/Straight Sided Mating
5.10.8 Measurements with Pins

5.9.2.1.1.2 Miscellaneous information.

a. Sectional views depicted under "Data specification" shall be identified to the proper location on the part.
b. Add ANSI B92.1 under "SPLINE REFERNCE DATA" when spline dimensioning and tolerancing conform to this standard.
c. Dimensional values are indicated by X's to show units or the number of decimal places recommended in each instance.
d. When control of backlash is critical (looseness or interference fits), the MINIMUM EFFECTIVE TOOTH THICKNESS will be shown under SPLINE DATA instead of under SPLINE REFERENCE DATA.

5.9.2 .2 Data specification. Minimum data and nomenclature requirements shall be specified as shown in figure 7 5.



NUMBER OF TEETH ______	XX
DIAMETRAL PITCH ______	XX/XX
PRESSURE ANGLE ______	XX°
CIRCULAR TOOTH THICKNESS AT PITCH DIAMETER	
MAX EFFECTIVE ______	.XXXX
MIN ACTUAL ______	.XXXX

SPLINE REFERENCE DATA

BASE DIAMETER ______	X.XXXXXXX
MEASUREMENT OVER TWO DIAMETER PINS ______	X.XXXX/X.XXXX
PROFILE TOLERANCE	+.XXXX
(ZERO AT X.XXX DIAMETER) ______	-.XXXX
LEAD TOLERANCE ACROSS	
LENGTH OF ENGAGEMENT ______	.XXXX
TOTAL INDEX TOLERANCE MAX (ANY TWO TEETH) ______	.XXXX
CIRCULAR TOOTH THICKNESS AT PITCH DIAMETER	
MIN EFFECTIVE ______	.XXXX
MAX ACTUAL ______	.XXXX
MATING SPLINE PART NUMBER ______	XXXXXXXX

FIGURE 75 External involute spline data (flat root side fit).

5.9.3 Internal involute spline data (flat root side fit).

5.9.3.1 Instructions to the designer.

5.9.3.1.1 Mandatory drawing requirements. Engineering drawings for this type of spline shall specify the following:

a. Data specification (see 5.9.3.2).
b. Spline datum characteristics as selected from 5.10.2.
c. Chamfers, radii, and fillets as selected from 5.10.3.
d. Additional data selected from mandatory review below.
e. Material specification.
f. Heat treat specification as required.
g. Finish notes (e.g. plating, etc.).
h. Other notes as required.

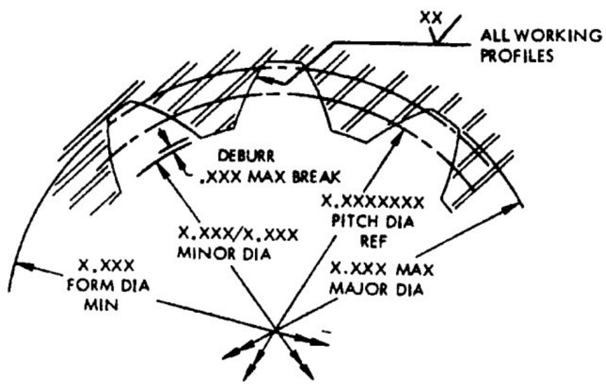
5.9.3.1.1.1 Mandatory review. The designer will review the following paragraphs for methods of specifying additional spline characteristics when required :

5.10.4 Shaft End Splines
5.10.5 Index Relationship
5.10.6 Minor Diameter Fits
5.10.8 Measurements With Pins

5.9.3.1.1.2 Miscellaneous information.

a. Sectional views depicted under "Data specification" shall be identified to the proper location on the part.
b. Add ANSI B92.1 under "SPLINE REFERNCE DATA" when spline dimensioning and tolerancing conform to this standard.
c. Dimensional values are indicated by X's to show units or the number of decimal places recommended in each instance.
d. When control of backlash is critical (looseness or interference fits), the MAXIMUM EFFECTIVE SPACE WIDTH will be shown under SPLINE DATA instead of under SPLINE REFERENCE DATA.

5.9.3.2 Data specification. Minimum data and nomenclature requirements shall be specified as shown in figure 76.



NUMBER OF TEETH	XX
DIAMETRAL PITCH	XX/XX
PRESSURE ANGLE	XXº
CIRCULAR SPACE WIDTH AT PITCH DIAMETER	
MAX ACTUAL	.XXXX
MIN EFFECTIVE	.XXXX

SPLINE REFERENCE DATA

BASE DIAMETER	X.XXXXXXX
MEASUREMENT BETWEEN TWO .XXXXX DIAMETER PINS	X.XXXX/X.XXXX
PROFILE TOLERANCE	+.XXXX
(ZERO AT X.XXX DIAMETER)	-.XXXX
LEAD TOLERANCE ACROSS X.XX	
LENGTH OF ENGAGEMENT	.XXXX
TOTAL INDEX TOLERANCE MAX (ANY TWO TEETH)	.XXXX
CIRCULAR SPACE WIDTH AT PITCH DIAMETER	
MIN ACTUAL	.XXXX
MAX EFFECTIVE	.XXXX
MATING SPLINE PART NUMBER	XXXXXXXX

FIGURE 76 Internal involute spline data (flat root side fit).

5.9.4 External involute spline data (flat root major diameter fit).

5.9.4.1 Instructions to the designer.

5.9.4.1.1 Mandatory drawing requirements. Engineering drawings for this type of spline shall specify the following:

a. Data specification (see 5.9.4.2).
b. Spline datum characteristics as selected from 5.10.2.
c. Chamfers, radii, and fillets as selected from 5.10.3.
d. Additional data selected from mandatory review below.
e. Material specification.
f. Heat treat specification as required.
g. Finish notes (e.g. plating, etc.).
h. Other notes as required.

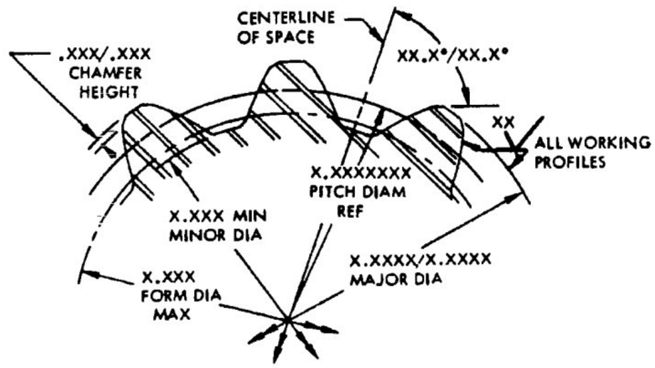
5.9.4.1.1.1 Mandatory review. The designer will review the following paragraphs for methods of specifying additional spline characteristics when required:

5.10.4 Shaft End Splines
5.10.5 Index Relationship
5.10.6 Minor Diameter Fits
5.10.7 Involute/Straight Sided Mating
5.10.8 Measurements with Pins

5.9.4.1.1.2 Miscellaneous information.

a. Sectional views depicted under "Data specification" shall be identified to the proper location on the part.
b. Add ANSI B92.1 under "SPLINE REFERNCE DATA" when spline dimensioning and tolerancing conform to this standard.
c. Dimensional values are indicated by X's to show units or the number of decimal places recommended in each instance.
d. When control of backlash is critical (looseness or interference fits), the MINIMUM EFFECTIVE TOOTH THICKNESS will be shown under SPLINE DATA instead of under SPLINE REFERENCE DATA.

5.9.4.2 Data specification. Minimum data an3 nomenclature requirements shall be specified as shown in figure 77.



NUMBER OF TEETH	XX
DIAMETRAL PITCH	XX/XX
PRESSURE ANGLE	XX°
CIRCULAR TOOTH THICKNESS AT PITCH DIAMETER	
MAX EFFECTIVE	.XXXX
MIN ACTUAL	.XXXX

NOTE: THE MAJOR DIAMETER AND EFFECTIVE SPLINE MUST BE CONCENTRIC AT MAXIMUM MATERIAL CONDITIONS.

SPLINE REFERENCE DATA

BASE DIAMETER	X.XXXXXXX
MEASUREMENT OVER TWO .XXXXX DIAMETER PINS	X.XXXX/X.XXXX
PROFILE TOLERANCE	+.XXXX
(ZERO AT X.XXX DIAMETER)	-.XXXX
LEAD TOLERANCE ACROSS	
LENGTH OF ENGAGEMENT	.XXXX
TOTAL INDEX TOLERANCE MAX (ANY TWO TEETH)	.XXXX
CIRCULAR TOOTH THICKNESS AT PITCH DIAMETER	
MIN EFFECTIVE	.XXXX
MAX ACTUAL	.XXXX
MATING SPLINE PART NUMBER	XXXXXXXX

FIGURE 77. External involute spline data (flat root major diameter fit).

5.9.5 Internal involute spline data (flat root major diameter fit).

5.9.5.1 Instructions to the designer.

5.9.5.1.1 Mandatory drawing requirements. Engineering drawings for this type of spline shall specify the following:

a. Data specification (see 5.9.5.2).
b. Spline datum characteristics as selected from 5.10.2.
c. Chamfers, radii, and fillets as selected from 5.10.3.
d. Additional data selected from mandatory review below.
e. Material specification.
f. Heat treat specification as required.
g. Finish notes (e.g. plating, etc.).
h. Other notes as required.

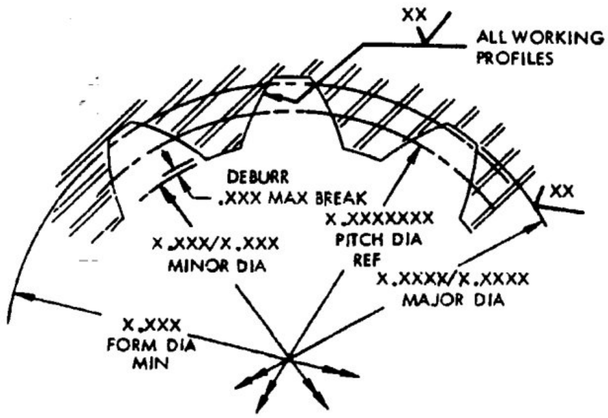
5.9.5.1.1.1 Mandatory review. The designer will review the following paragraphs for methods of specifying additional spline characteristics when required :

5.10.4 Shaft End Splines
5.10.5 Index Relationship
5.10.6 Minor Diameter Fits
5.10.8 Measurements with Pins

5.9.5.1.1.2 Miscellaneous information.

a. Sectional views depicted under "Data specification" shall be identified to the proper location on the part.
b. Add ANSI B92.1 under "SPLINE REFERNCE DATA" when spline dimensioning and tolerancing conform to this standard.
c. Dimensional values are indicated by X's to show units or the number of decimal places recommended in each instance.
d. When control of backlash is critical (looseness or interference fits), the MAXIMUM EFFECTIVE SPACE WIDTH will be shown under SPLINE DATA instead of under SPLINE REFERENCE DATA.

5.9.5.2 Data specification. Minimum data and nomenclature requirements shall be specified as shown in figure 78.



NUMBER OF TEETH ______________________________ XX
DIAMETRAL PITCH ______________________________ XX/XX
PRESSURE ANGLE ______________________________ XX°
CIRCULAR SPACE WIDTH AT PITCH DIAMETER
MAX ACTUAL ______________________________ .XXXX
MIN EFFECTIVE______________________________ .XXXX
NOTE: THE MAJOR DIAMETER AND EFFECTIVE SPLINE MUST BE CONCENTRIC AT MAXIMUM MATERIAL CONDITIONS.

SPLINE REFERENCE DATA

BASE DIAMETER ______________________________ X.XXXXXXX
MEASUREMENT BETWEEN TWO .XXXXX DIAMETER PINS ____ X.XXXX/X.XXXX
PROFILE TOLERANCE +.XXXX
(ZERO AT X.XXX DIAMETER) ______________________ -.XXXX
LEAD TOLERANCE ACROSS X.XX
LENGTH OF ENGAGEMENT ______________________ .XXXX
TOTAL INDEX TOLERANCE MAX (ANY TWO TEETH) __________ .XXXX
CIRCULAR TOOTH THICKNESS AT PITCH DIAMETER
MIN ACTUAL ______________________________ .XXXX
MAX EFFECTIVE ______________________________ .XXXX
MATING SPLINE PART NUMBER ______________________ XXXXXXXX

FIGURE 78. Internal involute spline data (flat root major diameter fit).

5.9.6 External involute spline data (fillet root side fit).

5.9.6.1 Instructions to the designer.

5.9.6.1.1 Mandatory drawing requirements. Engineering drawings for this type of spline shall specify the following:

a. Data specification (see 5.9.6.2).
b. Spline datum characteristics as selected from 5.10.2.
c. Chamfers, radii, and fillets as selected from 5.10.3.
d. Additional data selected from mandatory review below.
e. Material specification.
f. Heat treat specification as required.
g. Finish notes (e.g. plating, etc.).
h. Other notes as required.

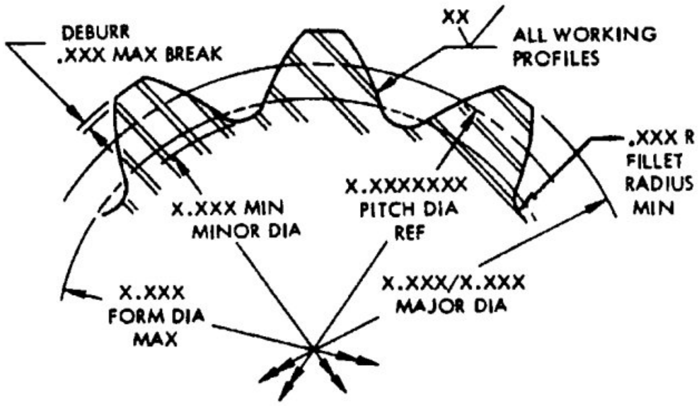
5.9.6.1.1.1 Mandatory review. The designer will review the following paragraphs for methods of specifying additional spline characteristics when required :

5.10.4 Shaft End Splines
5.10.5 Index Relationship
5.10.7 Involute/Straight Sided Mating
5.10.8 Measurements with Pins

5.9.6.1.1.2 Miscellaneous information.

a. Sectional views depicted under “Data specification” shall be identified to the proper location on the part.
b. Add ANSI B92.1 under “SPLINE REFERNCE DATA” when spline dimensioning and tolerancing conform to this standard.
c. Dimensional values are indicated by X's t o show units or the number of decimal places recommended in each instance.
d. When control of backlash is critical (looseness or interference fits), the MINIMUM EFFECTIVE TOOTH THICKNESS will be shown under SPLINE DATA instead of under SPLINE REFERENCE DATA.

5.9.6.2 Data specification. Minimum data and nomenclature requirements shall be specified as shown in figure 79.



NUMBER OF TEETH	XX
DIAMETRAL PITCH	XX/XX
PRESSURE ANGLE	°XX
CIRCULAR TOOTH THICKNESS AT PITCH DIAMETER	
MAX EFFECTIVE	.XXXX
MIN ACTUAL	.XXXX

SPLINE REFERENCE DATA

BASE DIAMETER	X.XXXXXXX
MEASUREMENT OVER TWO .XXXXX DIAMETER PINS	X.XXX/X.XXX
PROFILE TOLERANCE	+.XXXX
(ZERO AT X.XXX DIAMETER)	-.XXXX
LEAD TOLERANCE ACROSS X.XX	
LENGTH OF ENGAGEMENT	.XXXX
TOTAL INDEX TOLERANCE MAX (ANY TWO TEETH)	.XXXX
CIRCULAR TOOTH THICKNESS AT PITCH DIAMETER	
MIN EFFECTIVE	.XXXX
MAX ACTUAL	.XXXX
MATING SPLINE PART NUMBER	XXXXXXXX

FIGURE 79. External involute spline data (fillet root side fit).

5.9.7 Internal involute spline data (fillet root side fit).

5.9.7.1 Instructions to the designer.

5.9.7.1.1 Mandatory drawing requirements. Engineering drawings for this type of spline shall specify the following:

a. Data specification (see 5.9.7.2).
b. Spline datum characteristics as selected from 5.10.2.
c. Chamfers, radii, and fillets as selected from 5.10.3.
d. Additional data selected from mandatory review below.
e. Material specification.
f. Heat treat specification as required.
g. Finish notes (e.g. plating, etc.).
h. Other notes as required.

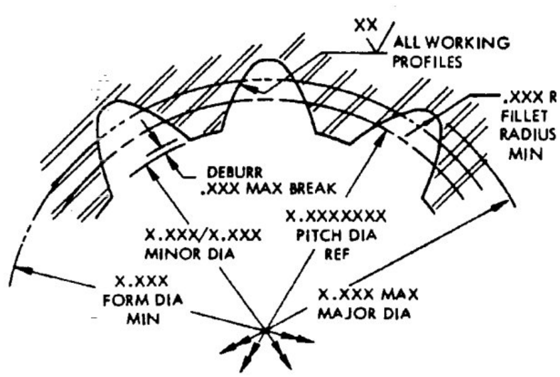
5.9.7.1.1.1 Mandatory review. The designer will review the following paragraphs for methods of specifying additional spline characteristics when required :

5.10.4 Shaft End Splines
5.10.5 Index Relationship
5.10.8 Measurements with Pins

5.9.7.1.1.2 Miscellaneous information.

a. Sectional views depicted under "Data specification" shall be identified to the proper location on the part.
b. Add ANSI B92.1 under "SPLINE REFERNCE DATA" when spline dimensioning and tolerancing conform to this standard.
c. Dimensional values are indicated by X's to show units or the number of decimal places recommended in each instance.
d. When control of backlash is critical (looseness or interference fits), the MAXIMUM EFFECTIVE SPACE WIDTH will be shown under SPLINE DATA instead of under SPLINE REFERENCE DATA.

5.9.7.2 Data specification. Minimum data and nomenclature requirements shall be specified as shown in figure 80.



NUMBER OF TEETH ______ XX
DIAMETRAL PITCH ______ XX/XX
PRESSURE ANGLE ______ ºXX
CIRCULAR SPACE WIDTH AT PITCH DIAMETER
MAX ACTUAL ______ .XXXX
MIN EFFECTIVE ______ .XXXX

SPLINE REFERENCE DATA

BASE DIAMETER ______ X.XXXXXXX
MEASUREMENT BETWEEN TWO .XXXXX DIAMETER PINS ______ X.XXXX/X.XXXX
PROFILE TOLERANCE +.XXXX
(ZERO AT X.XXX DIAMETER) ______ -.XXXX
LEAD TOLERANCE ACROSS X.XX
LENGTH OF ENGAGEMENT ______ .XXXX
TOTAL INDEX TOLERANCE MAX (ANY TWO TEETH) ______ .XXXX
CIRCULAR TOOTH THICKNESS AT PITCH DIAMETER
MIN ACTUAL ______ .XXXX
MAX EFFECTIVE ______ .XXXX
MATING SPLINE PART NUMBER ______ XXXXXXXX

FIGURE 80. Internal involute spline data (fillet root side fit).

5.10 Additional and special drawing data for involute splines.

5.10.1 General. This section contains both additional and special drawing data requirements for involute splines.

5.10.1.1 Additional drawing data. Paragraphs 5.10.2 and 5.10.3 contain additional (mandatory) spline drawing requirements with instructions for selection and specification.

5.10.1.2 Special drawing data. Paragraphs 5.10.4 through 5.10.8 contain instructions for specifying special features or modifications required for special spline applications.

5.10.1.3 Gears vs splines. Circular gears and splines are similar in appearance. Both have teeth regularly spaced around their periphery and, for the most part, both commonly use involute profiles. The difference between a gear and a spline does not depend on the shape or size of the teeth; it depends on the functional engagement of the two. A alpine application consists of two splined members, one external and one internal. When properly assembled, all teeth of the external member will simultaneously fit into corresponding spaces of the internal member. The text of this handbook does not recognize any difference in the meaning between the terms "spline" and "serration". If the mating spline-like members engage with each other in such a manner that all teeth are not in simultaneous engagement, but rather that they engage only a few teeth at a time, progressively changing the teeth in contact and driving at other than a one-to-one ratio, they are gears. When the application is that of a spline, it is mandatory that both members be specified as splines. When the application is that of a gear, it is mandatory that they be specified as gears. A fairly common abuse of this practice is found in synchromesh transmissions. The synchronizer assembly couples to the gear in spline engagement. For many years, the terminology applied to that splined portion of the gear itself and to the mating splined member of the synchronizer assembly has been "CLUTCH GEAR". On a large percentage of engineering drawings, the spline of this "CLUTCH GEAR" is found to be incorrectly specified as a gear. In cases such as'this, it is mandatory that it be both identified and specified as a spline. The term "CLUTCH GEAR" is only permissible if it is enclosed in quotation marks and followed by the word SPLINE as shown below:

"CLUTCH GEAR" SPLINE

There is also an occasional design in which a single member is used both as a gear and a spline by engaging with the two other members. In such instances, that member must be specified both as a gear and a spline. It must be accompanied by a note stating "THIS FEATURE MUST MEET THE ACCEPTANCE CRITERIA OF BOTH A SPLINE AND A GEAR" to eliminate any possibility of doubt.

5.10.2 Spline datum characteristics.

5.10.2.1 Datum relationship of a spline. Gears and splines are both utilized to transmit power in the form of rotary torque. The gear transmits this power directly from its functional axis of rotation. Because of this, its teeth must be precisely located relative to this functional axis of rotation. Theoretically, a spline transmits power simultaneously through all its teeth. Therefore, in most instances, the location of its teeth relative to its functional axis of rotation is of secondary importance. There are many exceptions, of course, caused by a wide variety of considerations. For discussion purposes along these lines, splines are best related to three general categories of loose side fit, noninterference major diameter fit, and interference fit. The splines illustrated in figures 81 through 88 illustrate typical applications of tolerances to splines which employ the various types of mounting and/or functional requirements. The examples shown do not necessarily denote minimum data requirements as these can only be determined by detailed design analysis of the specific function in assembly. The intent of the examples shown is to provide a variety of conditions of spline applications from which a designer may select proper spline datum features and/or tolerancing shall be specified by means of symbols prescribed by the current issue of ANSI Y14.5, “Dimensioning and Tolerancing” for engineering drawings. Application of the runout tolerance to each diameter relative to their common axis is used as the ANSI Y14.5 nearest equivalent of the coaxial tolerance.

5.10.2.2 Nonfunctional axis spline. Where it is necessary to control a nominally coaxial relationship between two features merely to assure fit at assembly, the use of true position tolerance is recommended. The tolerance for the feature should be given on a Maximum Material Condition (MMC) basis; while for the datum feature A, a tolerance may be given either on a MMC or a Regardless of Feature Size (RFS) basis. This type of spline is usually used in hand operated applications such as crank handles, bell cranks, etc. In figure 81, the shaft diameter is the datum to which the effective spline must be positioned to assure fit of the mating spline at MMC. The relationship of the effective spline axis relative to the major diameter datum surface is usually determined by the use of the concentricity band of the Go-Composite gage.

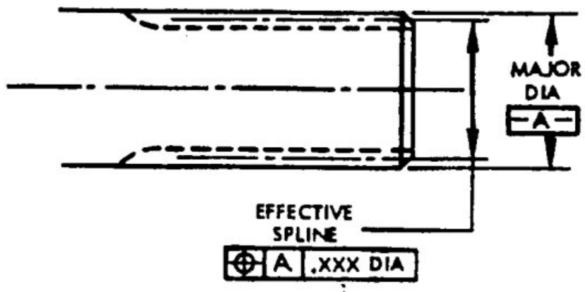


FIGURE 81. Nonfunctional axis spline.

5.10.2.3 Loose side fit splines. Loose side fit splines are utilized to provide ease of assembly and axial motion between mating parts. The fit clearance is often used to permit minor misalignment between mating parts. Frequently, its only design function relative to the true axis of rotation is to prevent severe vibration caused by excessive out-of-balance conditions present in rotating shafts. In the torsion bar example, figure 82, we see a typical splined shaft made from a forging. The true functional axis is established by the location of the splines themselves and no individual bearing diameters are involved. In this instance, the only kinematic design requirement for the splines to be located on the true axis of rotation is balance control. Unless high speeds are present, high precision is not required. Because of this, a reference axis is arbitrarily selected as the primary consideration of convenience. In this case, precision safety centers are specified as the datum axis, both for control over location of the splines and as the basis for balance control. In addition to the obvious inconvenience of using the splines themselves as datums, establishment of each spline axis with any degree of repeatability would involve RFS considerations. In the case of a side fit spline, the functional axis would relate to MMC. The resultant error between these two would be greater than the probable difference between the true functional axis of rotation and the axis of precision safety centers. While an occasional exception may be found, as a general rule the tooth element variations of a loose side fit spline may be adequately specified relative to a nonfunctional reference axis if the true functional axis is inconvenient t o utilize for this purpose. Judgement must be based on detailed analysis of the complete design requirements of the particular application. Naturally, whenever true functional relationships can be conveniently utilized, these are preferable.

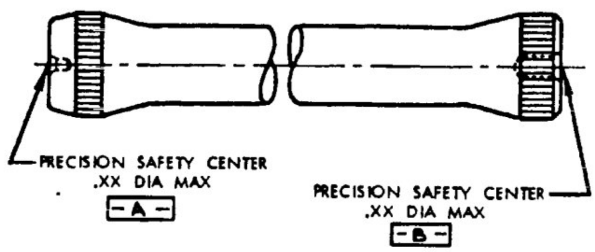


FIGURE 82. Loose side fit splines.

5.10.2.4 Straddle mounted spline. A straddle mounted spline is one where the spline is located between two external bearing supports. In figure 83, the major diameter fit spline serves to locate a gear concentric with the bearing diameters A and B. The functional axis of rotation of the gear is assured only when the spline major diameter is properly specified to the bearing axis established by diameters A and B as shown below. The callout symbol identifies this common axis as primary datum rather than one diameter as primary and the other as secondary.

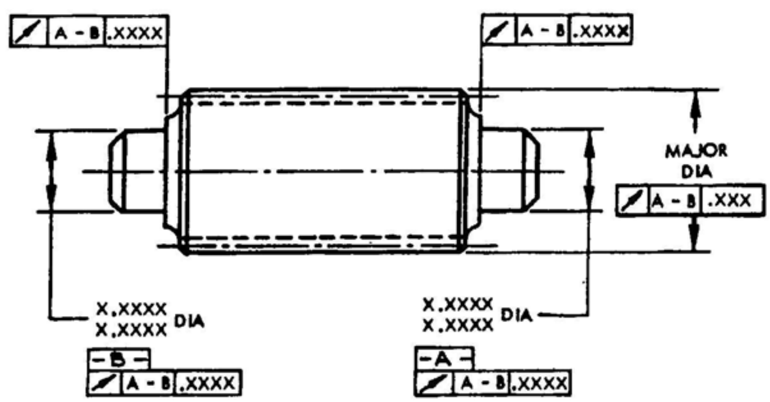


FIGURE 83. Straddle mounted spline.

5.10.2.5 Cantilever mounted splines. A cantilever mounted spline is one where the spline is not between the bearing points used to establish that axis of rotation. A typical example is illustrated in figure 84 where the axis of rotation is established by bearing diameters A and B. The functional axis of rotation of a mounted gear on the spline is assured only when the spline major diameter is properly specified to the bearing axis established by diameters A and B as shown below. The callout symbol identifies this common axis as primary datum rather than one diameter as primary and the other as secondary. The common axis of the two datums is identified in the symbols as the primary datum, with neither diameter being given preference, even though diameter A will obviously have a greater influence on the readings than diameter B.

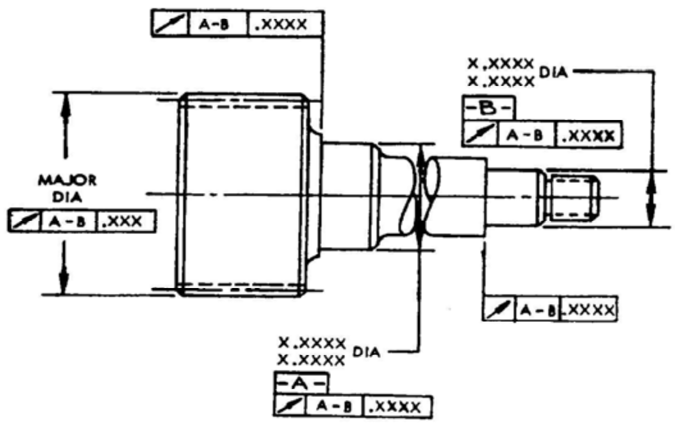


FIGURE 84. Cantilever mounted spline.

5.10.2.6 Power transmission splines. Splines serve two major functions in power transmission. They can be used for driving and as a locating datum for the axis of rotation of a gear or they may be used solely for driving purposes

5.10.2.6.1 Driving spline. The bevel gear shown in figure 85 is mounted on a cylindrical surface using the splines for driving only.

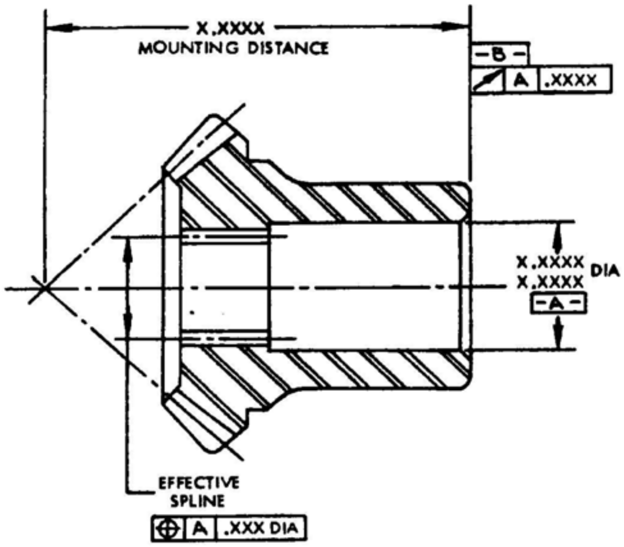


FIGURE 85. Driving spline.

5.10.2.6.2 Datum spline. The side fit type spline, shown in figure 86, establishes the axis of rotation and is also used for driving the gear. The primary datum A shown is the effective spline diameter and the axial thrust surface B is the secondary datum. For major or minor diameter fit splines, the respective major or minor diameters will serve as the primary datum. All tolerances of runout, true position, parallelism, etc., should be specified relative to the effective spline A.

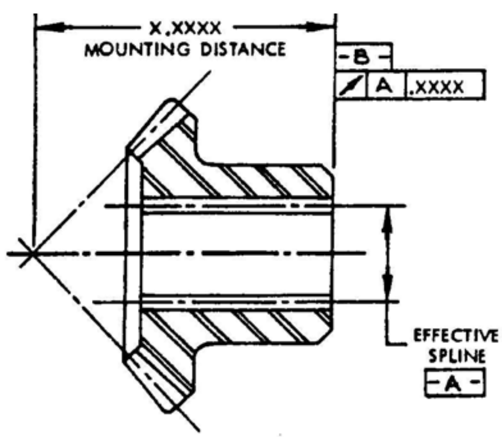


FIGURE 86. Datum spline.

5.10.2.7 Short effective spline. The length of the spline depicted in figure 87 is too short to properly control lateral runout, therefore, it cannot serve as the primary datum. It can, however, serve as a secondary datum (Reference ANSI Y14.5). Lateral runout can be controlled in one of two ways, the gear may be flange mounted to a shaft or sandwiched between two bearing surfaces.

5.10.2.7.1 Flange mounted short effective spline. If the gear is flange mounted to a shaft, the bolt holes will surround the mounting bore so that the gear will pilot on the spline of a flanged shaft and be bolted to the mounting flange for control of lateral runout. In this case the mounting face of the gear is selected as primary datum and the splined shaft as secondary datum. All tolerances of radial runout and hole position must be specified to the compound datum with the primary datum appearing first in the symbol callout. Gear tooth elements shall be specified relative to the effective spline datum. Since both sides of the gear are fundamentally symmetrical, a chamfer or other means of identification must be added to complete the identity of the datum surface on the physical gear.

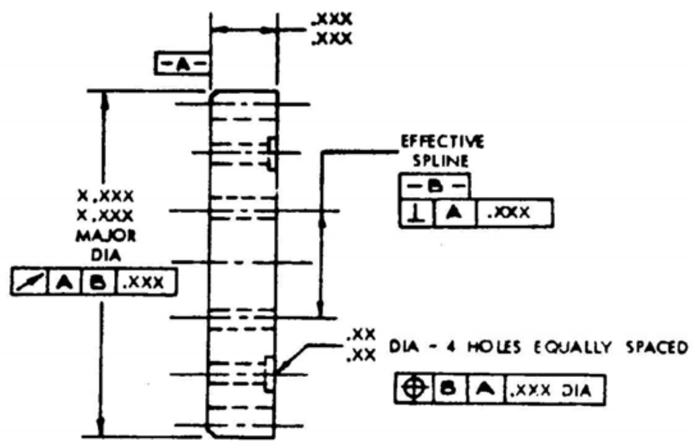


FIGURE 87. Flange mounted short effective spline.

5.10.2.7.2 Sandwich mounted short effective spline. If the same gear was a spur gear mounted to a horizontal shaft and sandwiched between two bearing surfaces to control lateral runout in the assembly, both sides would be of equal importance. The designer must arbitrarily select one side as datum and provide a chamfer o r other suitable means of identification. The bolt callout would not be used and parallelism of the two sides would be required if the thickness tolerance did not provide for sufficient control (see figure 88).

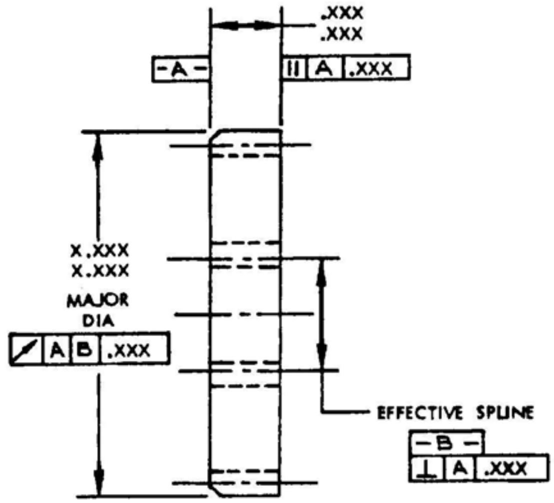


FIGURE 88. Sandwich mounted short effective spline.

5.10.3 Chamfers, radii, and fillets. Figure 89 is a composite representing the methods of depicting chamfers, radii, and fillets. The designer shall select from paragraphs 5.10.3.1 through 5.10.3.6 those features he deems most suitable for his design. All the required features should be depicted on an enlarged end view of a single tooth form.

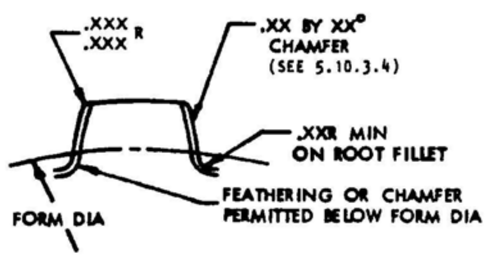


FIGURE 89. Chamfers, radii, and fillets.

5.10.3.1 Tooth tip chamfers. Tooth tip chamfers shall be depicted as shown in figure 90.

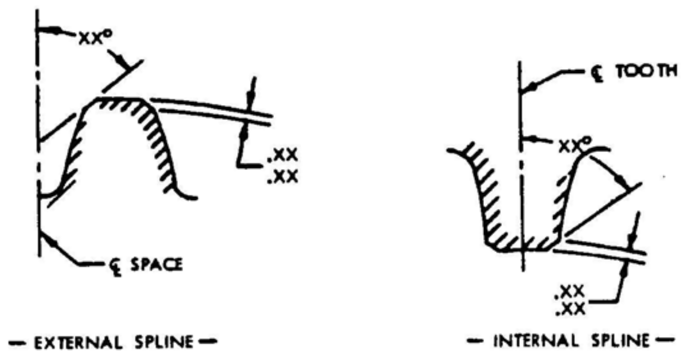


FIGURE 90. Tooth tip chamfers.

5.10.3.2 Major diameter corner clearance. The clearance on flat root major diameter fit splines can be depicted as shown in figure 91. The designer will select either method A or B. However, caution should be used in the finer pitches and with smaller numbers of teeth to make sure that the major diameter chamfer is not so great that the remaining top land would be so small that the fit would be ineffective. When this occurs, only method B should be used.

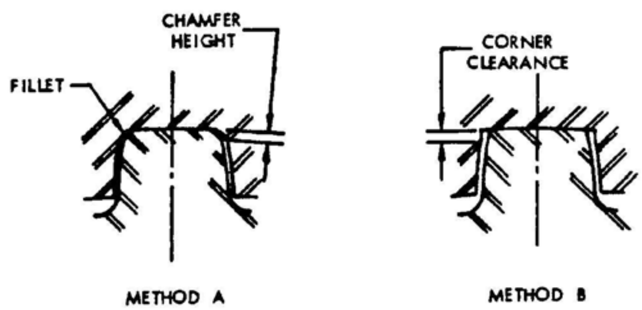


FIGURE 91. Major diameter corner clearance.

5.10.3.3 Tooth tip radii. Tooth tip radii shall be depicted as shown in figure 92.

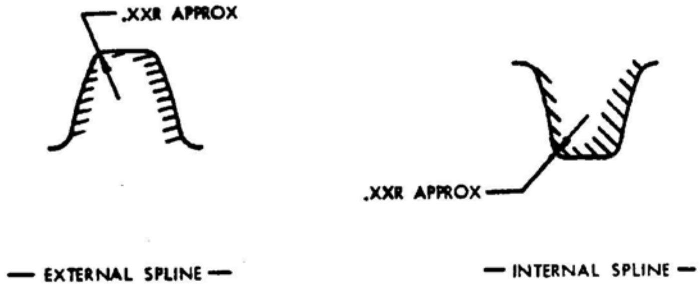


FIGURE 92. Tooth tip radii.

5.10.3.4 Tooth end chamfers. Figure 93 illustrates the method of showing end chamfers on involute splines.

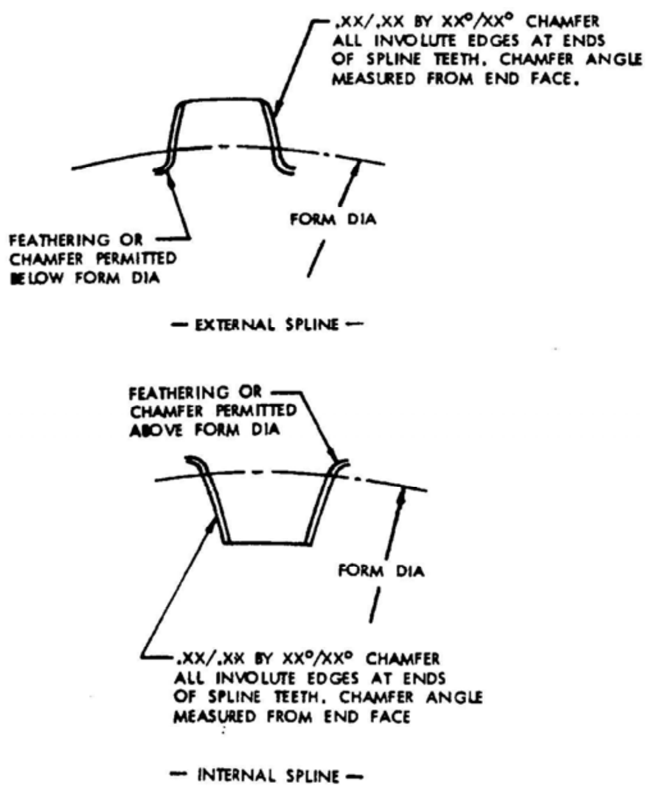


FIGURE 93. Tooth end chamfers.

5.10.3.5 Deburring. Spline tooth end deburring shall be depicted as shown in figure 94.

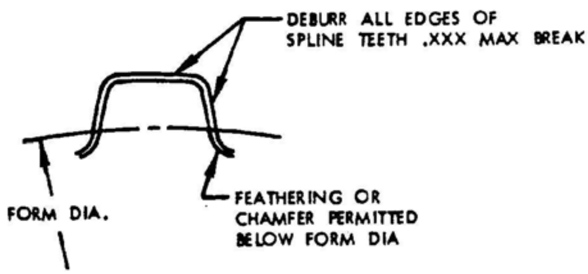


FIGURE 94. Deburring.

5.10.3.6 Fillets. On flat root side and major diameter fit splines, the fillet note shall be interpreted as the minimum radius of curvature allowed at the intersection of the flat root with the side of the spline tooth. Larger radius of curvature is allowed provided the limits for major or minor diameter and form diameter are met (see figure 95).

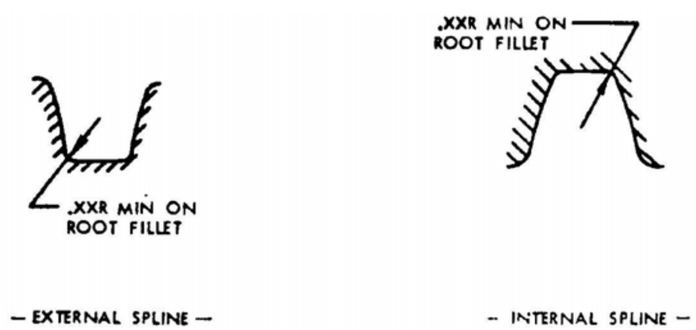


FIGURE 95. Fillets.

5.10.4 Shaft end splines. To assure freedom from interferences in a spline assembly and to prevent cutting into a shoulder on shaft end splines, the cutter radius with limits shall be depicted on the drawing. Limits may be shown as unilateral, bilateral, maximum, and minimum methods of tolerancing to suit the design requirements.

5.10.4.1 Splining with radius runout. In figure 96, the maximum cutter radius is used to assure full length of spline and prevent cutting into shoulder surfaces.

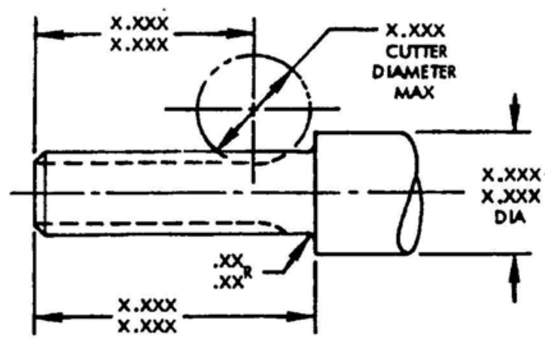


FIGURE 96. Splining with radius runout.

5.10.4.2 Splining into undercuts. Shafts may be prepared and splines manufactured as shown in figure 97 allowing the forming or cutting tools to extend beyond both effective ends of the spline. In the following examples, a cutter radius with limits is not a requirement on the drawing.

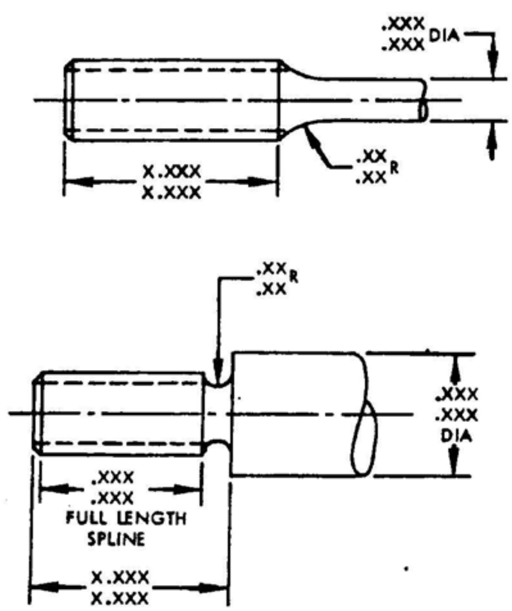


FIGURE 97. Splining into undercuts.

5.10.5 Index relationship. When splines and gears are specified on the same part, the requirements for index relationship between them must be specified to assure proper assembly and operating conditions. For proper presentation of index relationship between gears and splines, refer to figures 33, 34a and 34b.

5.10.6 Minor diameter fit. The minor diameter fit spline is a fit at the root of the external spline. On this spline fit, the dedendum of the external spline equals the addendum of the internal spline. The minor diameter fit spline is seldom used. Its only advantage is that the root diameter of the external spline is formed by the same operation as the sides of the teeth. This tends to guarantee that the root diameter will be concentric with the tooth sides. The designer shall select the type of spline best suited for his design.

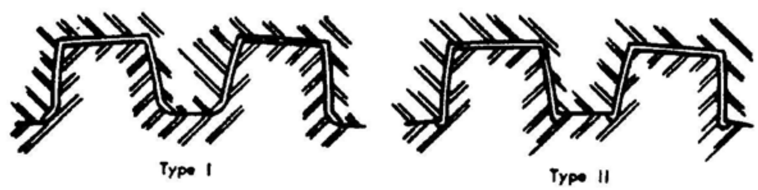


FIGURE 98. Minor diameter fit.

5.10.6.1 External minor diameter fit. Corner clearance of external minor diameter fit splines shall be depicted on the drawing by one of the methods shown in figure 99.

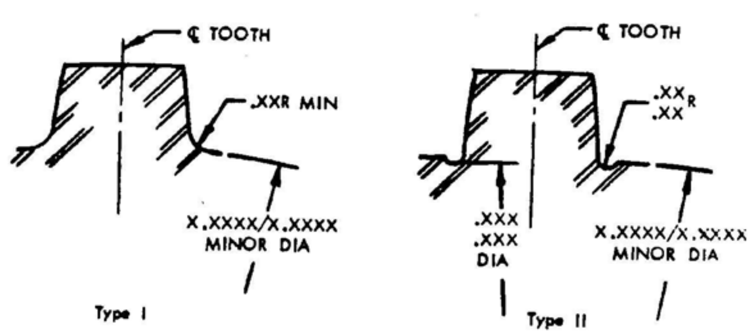


FIGURE 99. External minor diameter fit.

5.10.6.2 External minor diameter fit specification. This type of fit shall be identified by the spline data heading in the following manner:

EXTERNAL INVOLUTE SPLINE DATA
FLAT ROOT MINOR DIAMETER FIT

5.10.6.3 Internal minnr diameter fit. Corner clearance of internal minor diameter fit splines shall be depicted on the drawing by one of the methods shown in figure l00.
FIGURE 100.

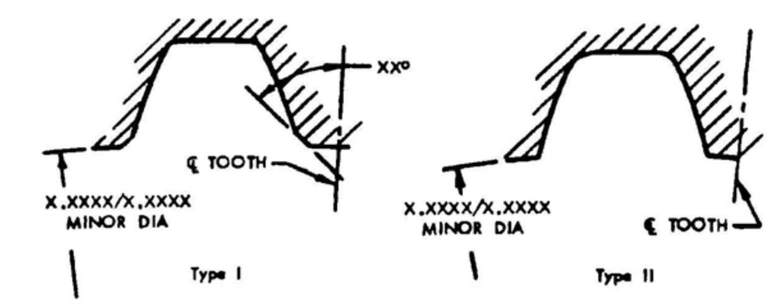


FIGURE 100. Internal minor diameter fit.

5.10.6.4 Internal minor diameter fit specification. This type of fit shall be identified by the spline data heading in the following manner:

5.10.7 Involute/straight sided mating. On internal 45° splines, straight profiles may be specified as optional with involute profiles if the deviation of the straight side from the involute is compatible with design requirements. The external spline is always designed with involute profiles. The internal straight sided profile localizes the tooth contact.

5.10.7.1 Internal form angle. The internal form angle is that angle, the legs of which are tangent at the pitch line to the involute profiles which bound the basic space. This angle is constant for a given number of teeth and values are listed in table 65 of ANSI B92.1.

5.10.7.2 Profile tolerances. The tolerances on profile of internal straight sided 45° splines are stated in terms of internal form angle variations and are listed in table 66 of ANSI B92.1. The profile is allowed to deviate farther in the direction of the space, to the limit of the theoretical involute profile.

5.10.8 Measurement with pins. Actual space width and actual tooth thickness may be measured with pins. These measurements do not determine the fit between mating parts but may be used as a part of analytical inspection of splines to evaluate the effective space width or tooth thickness by approximation.

5.10.8.1 Measuring pins. Measuring pins are held within 0.000025 inch for roundness and size, and are calibrated between flat parallel measuring contacts. The diameters of measuring pins are based on equation G = 1.7280/P for internal 30° and 37.5° pressure angle splines and G = 1.9200/P for external 30° and 37.5° pressure angle splines. The 1.92 series is used for all 45° pressure angle splines, including internal straight sided splines. These pins contact the tooth approximately at the mid-point of the profile. Exact pitch line contact is not necessary. Use pins listed in table II for standard wire sizes.

5.10.8.2 Measurement with two pins. Because the values of pin measurement listed in ANSI B92.1 are based on the length of engagement (one-half of the pitch diameter), gear design calculation sheets (number 7 and 8) are provided for use whenever the length of engagement is other than one-half of the pitch diameter. All values shall be carried to seven decimal places for accuracy.

5.10.8.3 Measurement with three pins. Measurements with three pins are sometimes preferred for small splines. If three pins are used for measurements, a plug must be used for checking both even and odd numbers of teeth. Calculations for three pin measurement of splines shall conform to the method depicted in ANSI B92.1.

GEAR DESIGN SHEET #7	OVER TWO PINS MEASUREMENT EXTERNAL INVOLUTE SPLINES		
PART NUMBER		TYPE AND FIT	
NO.	ITEM	VALUE	
1.	N = NUMBER OF TEETH		
2.	P = DIAMETRAL PITCH		
3.	Ø = PRESSURE ANGLE		
4.	d = MEASURING PIN DIAMETER		
5.	D = PITCH DIAMTER = N ÷ P		
6.	D_b = BASE DIAMETER = D cos Ø		
7.	π ÷ N		
8.	d ÷ D_b = (4) ÷(6)		
9.	Inv Ø (Table of functions)		
10.	(9) + (8) - (7) (MAY BE POSITIVE OR NEGATIVE VALUE)		
11.	MAXIMUM EFFECTIVE TOOTH THICKNESS (ANS B92.1)		
12.	MACHINING TOLERANCE (ANS B92.1) ** (CLASS)		
13.	MINIMUM EFFECTIVE TOOTH THICKNESS = (11) – (12)		
14.	TOTAL IDEX TOLERANCE * (CLASS)		
15.	TWICE POSITIVE PROFILE TOLERANCE * (CLASS)		
16.	LEAD TOLERANCE * (CLASS)		
17.	60% ALLOWABLE TOLERANCES = 0.60 [(14) + (15) + (16)]		
		MAXIMUM	MININIMUM
18.	MAXIMUM ACTUAL TOOTH THICKNESS (11) – (17)		
19.	MINIMUM ACTUAL TOOTH THICKNESS (13) – (17)		
20.	MAX. (t ÷ D) = (18) ÷ (5); MIN. (t ÷D) = (19) ÷ (5)		
21.	Inv. $Ø_b$ = (20) + (10) (ALGEBRAIC SUM)		
22.	Sec $Ø_b$ = FROM (21)		
23.	EVEN TEETH: D_b sec $Ø_b$ = (6) (22)		
24.	EVEN TEETH: MEASUREMENT OVER PINS = (23) + (4)		
25.	ODD TEETH: cos $(90/N)^o$		
26.	ODD TEETH: (6) (25) (22)		
	ODD TEETH: MEASUREMENT OVER PINS = (26) + (4)		

TO INSURE ACCURACY, CARRY OUT CALCULATIONS TO A MINIMUM OF SEVEN DECIMAL PLACES.
REFER TO PARAGRAPH 5.10.8.2- MEASUREMENT WITH TWO PINS,
THE FOLLOWING TABLES ARE LISTED IN ANS B92.1.
*TABLE 3 **TABE 64

GEAR DESIGN SHEET # 8	BETWEEN TWO PINS MEASUREMENT INTERNAL INVOLUTE SPLINES		
PART NUMBER		TYPE AND FIT	
NO.	ITEM	VALUE	
1.	N = NUMBER OF TEETH		
2.	P = DIAMETRAL PITCH		
3.	Ø = PRESSURE ANGLE		
4.	d = MEASURING PIN DIAMETER		
5.	D = PITCH DIAMTER = N ÷ P		
6.	D_b = BASE DIAMETER = D cos Ø		
7.	d ÷ D_b = (4) ÷ (6)		
8.	Inv Ø (Table of functions)		
9.	(8) – (7) (MAY BE POSITIVE OR NEGATIVE VALUE)		
10.	MINIMUM EFFECTIVE SPACE WIDTH (ANS B92.1)		
11.	MACHINING TOLERANCE (ANS B92.1) *(CLASS)		
12.	MAXIMUM EFFECTIVE SPACE WIDTH = (10) = (11)		
13.	TOTAL INDEX TOLERANCE * (CLASS)		
14.	TWICE POSITIVE PROFILE TOLERANCE * (CLASS)		
15.	LEAD TOLERANCE * (CLASS)		
16.	60% ALLOWABLE TOLERANCE = 0.60 [(13) + (14) + (15)]		
		MINIMUM	MAXIMUM
17.	MINIMUM ACTUAL SPACE WIDTH = (10) + (16)		
18.	MAXIMUM ACTUAL SPACE WIDTH = (12) + (16)		
19.	MAX. (s ÷ D) = (18) ÷ (5); MIN. (s ÷ D) = (17) ÷ (5)		
20.	Inv $Ø_1$ = (19) + (9) (ALGEBRAIC SUM)		
21.	Sec $Ø_1$ = FROM (20)		
22.	EVEN TEETH: D_b sec $Ø_1$ = (6) (20)		
23.	EVEN TEETH: MEASUREMENT BETWEEN PINS = (22) – (4)		
24.	ODD TEETH: Cos (90/N)º		
25.	ODD TEETH: (6) (24) (21)		
26.	ODD TEETH: MEASUREMENT BETWEEN PINS = (25) – (4)		

TO INSURE ACCURACY, CARRY OUT CALCULATIONS TO A MINIMUM OF SEVEN DECIMAL PLACES.

REFER TO PARAGRAPH 5.10.8.2- MEASWEMENT WITH TWO PINS, THE FOLLOWING TABLE ARE LISTED IN ANS.B92.1.

*TABLE 3 **TABE 64

5.11 MINIMUM DRAWING DATA FOR PARALLEL SIDED SPLINES.

5.11.1 General. This section contains minimum drawing data specifications for the six types of parallel sided splines listed in the table of contents.

5.11.1.1 Interpretation. Lower case letters are used to present the instructional text. Nomenclature and/or characteristics required for drawing data presentation are depicted in capital letters.

5.11.1.2 Section organization. The following paragraph subdivision numbering sequence is typical throughout the section:

5.11.X.1 "Instructions to the designer" contains a complete drawing specification check list. It delineates the minimum requirements and provides an index of additional spline characteristics when required.

5.11.X.2 "Data specification" is intended to depict those spline characteristics that define the overall dimensions of the spline blank and delineates the nomenclature and method of listing spline data, notes, and references in a uniform manner for each type of spline.

5.11.1.3 Appendix. Additional information required for the preparation of spline drawings is provided in the appendix.

5.11.1.3.1 Drawing examples. To assist the designer in the interpretation of the requirements of this handbook several examples of drawings are included in the appendix. These sample drawings shall be construed as informational only. They are complete to the degree necessary to illustrate a condition. Actual drawings shall conform to textual requirements set forth in this handbook.

5.11.1.3.2 Measuring wires/balls. Specification of measuring wires or balls on drawings shall be to those sizes listed in table II.

5.11.2 External parallel sided spline data (flat root side fit).

5.11.2.1 Instructions to the designer.

5.11.2.1.1 Mandatory drawing requirements. Engineering drawings for this type of spline shall specify the following

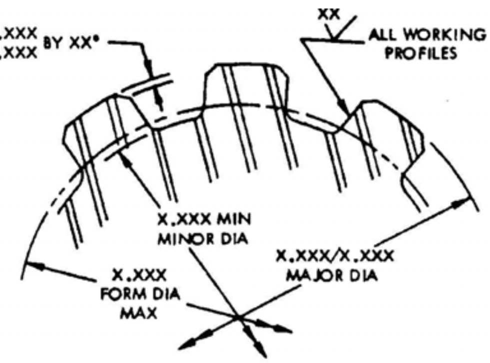
a. Data specification (see 5.11.2.2).
b. Spline datum characteristics as selected from 5.12.2.
c. Chamfers, radii, and fillets as selected from 5.12.3.
d. Additional data selected from Mandatory review below.
e. Material specification.
f. Heat treat specification as required.
g. Finish notes (e.g. plating, etc.).
h. Other notes as required.

5.11.2.1.1.1 Mandatory review. The designer will review the following paragraphs for methods of specifying additional spline characteristics when required:

5.12.4 Shaft End Splines
5.12.5 Index Relationships
5.12.7 Measurements With Pins

5.11.2.1.1.2 Miscellaneous information. Sectional views depicted under "Data specification" shall be identified to the proper location on the part.

5.11.2.2 Data specification. Minimum data and nomenclature requirements shall be specified as shown in figure 101.



NUMBER OF TEETH	XX
CHORDAL TOOTH THICKNESS	
MAX EFFECTIVE	.XXXX
MIN ACTUAL	.XXXX

SPLINE REFERENCE DATA

MEASUREMENT OVER TWO .XXXXX DIAMETER PINS	X.XXXX/X.XXXX
PROFILE TOLERANCE	+.XXXX
(ZERO AT X.XXX DIAMETER)	-.XXXX
LEAD TOLERANCE ACROSS X.XX LENGTH OF	
ENGAGEMENT	.XXXX
TOTAL INDEX TOLERANCE MAX (ANY TWO TEETH)	.XXXX
CHORDAL TOOTH THICKNESS	
MIN EFFECTIVE	.XXXX
MAX ACTUAL	.XXXX
MATING SPLINE PART NUMBER	XXXXXXXX

FIGURE 101. External parallel sided spline data (flat root side fit).

5.11.3 Internal parallel sided spline data (flat root side fit).

5.11.3.1 Instructions to the designer.

5.11.3.1.1 Mandatory drawing requirements. Engineering drawings for this type of spline shall specify the following:

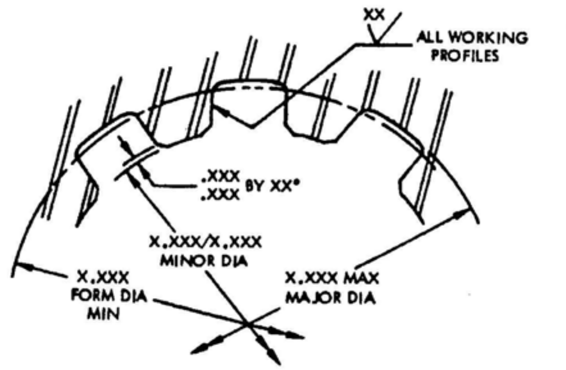
a. Data specification (see 5.11.3.2).
b. Spline datum characteristics as selected from 5.12.2.
c. Chamfers, radii, and fillets as selected from 5.12.3.
d. Additional data selected from Mandatory review below.
e. Material specification.
f. Heat treat specification as required.
g. Finish notes (e.g. plating, etc.).
h. Other notes as required.

5.11.3.1.1.1 Mandatory review. The designer will review the following paragraphs for methods of specifying additional spline characteristics when required:

5.12.4 Shaft End Splines
5.12.5 Index Relationship

5.11.3.1.1.2 Miscellaneous information. Sectional views depicted under "Data specification" shall be identified to the proper location on the part.

5.11.3.2 Data specification. Minimum data and nomenclature requirements shall be specified as shown in figure 102.



NUMBER OF TEETH	XX
CHORDAL SPACE WIDTH	
MAX ACTUAL	.XXXX
MIN EFFECTIVE	.XXXX

SPLINE REFERENCE DATA

PROFILE TOLERANCE	+.XXXX
(ZERO AT X.XXX DIAMETER)	-.XXXX
LEAD TOLERANCE ACROSS X.XX LENGTH OF ENGAGEMENT	.XXXX
TOTAL INDEX TOLERANCE MAX (ANY TWO TEETH)	.XXXX
CHORDAL SPACE WIDTH	
MIN ACTUAL	.XXXX
MAX EFFECTIVE	.XXXX
MATING SPLINE PART NUMBER	XXXXXXXX

FIGURE 102. Internal parallel sided spline data (flat root major side fit).

5.11.4 External parallel sided spline data (flat root major diameter fit).

5.11.4.1 Instructions to the designer.

5.11.4.1.1 Mandatory drawing requirements. Engineering drawings for this type of spline shall specify the following:

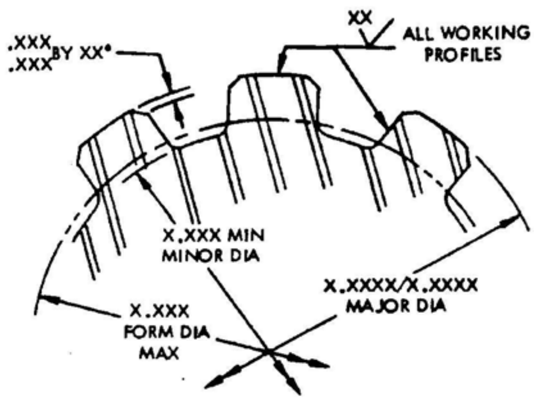
a. Data specification (see 5.11.4.2).
b. Spline datum characteristics as selected from 5.12.2.
c. Chamfers, radii, and fillets as selected from 5.12.3.
d. Additional data selected from Mandatory review below.
e. Material specification.
f. Heat treat specification as required.
g. Finish notes (e.g. plating, etc.).
h. Other notes as required.

5.11.4.1.1.1 Mandatory review. The designer will review the following paragraphs for methods of specifying additional spline characteristics when required:

5.12.4 Shaft End Splines
5.12.5 Index Relationship
5.12.7 Measurements With Pins

5.11.4.1.1.2 Miscellaneous information. Sectional views depicted under "Data specification" shall be identified to the proper location on the part.

5.11.4.2 Data specification. Minimum data and nomenclature requirements shall be specified as shown in figure 103.



NUMBER OF TEETH ____ XX
CHORDAL TOOTH THICKNESS
MAX EFFECTIVE ____ .XXXX
MIN ACTUAL ____ .XXXX
NOTE: THE MAJOR DIAMETER AND EFFECTIVE SPLINE MUST BE CONCENTRIC AT MAXIMUM MATERIAL CONDITIONS.

SPLINE REFERENCE DATA

MEASUREMENT OVER TWO .XXXXX DIAMETER PINS __________ X.XXXX/X.XXXX
PROFILE TOLERANCE +.XXXX
(ZERO AT X.XXX DIAMETER) ______________________________ -.XXXX
LEAD TOLERANCE ACROSS X.XX LENGTH OF
ENGAGEMENT ____ .XXXX
TOTAL INDEX TOLERANCE MAX (ANY TWO TEETH) ___________ .XXXX
CHORDAL TOOTH THICKNESS
MIN EFFECTIVE ____ .XXXX
MAX ACTUAL ____ .XXXX
MATING SPLINE PART NUMBER ______________________________ XXXXXXXX

FIGURE 103. External parallel sided spline data (flat root major diameter fit).

5.11.5 Internal parallel sided spline data (flat root major diameter fit).

5.11.5.1 Instructions to the designer.

5.11.5.1.1 Mandatory drawing requirements. Engineering drawings for this type of spline shall specify the following:

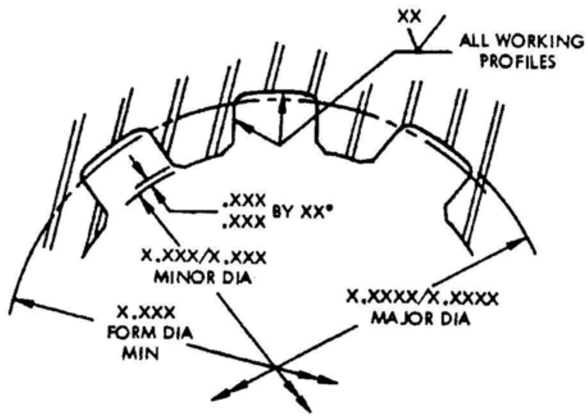
a. Data specification (see 5.11.5.2).
b. Spline datum characteristics as selected from 5.12.2.
c. Chamfers, radii, and fillets as selected from 5.12.3.
d. Additional data selected from Mandatory review below.
e. Material specification.
f. Heat treat specification as required.
g. Finish notes (e.g. plating, etc.).
h. Other notes as required.

5.11.5.1.1.1 Mandatory review. The designer will review the following paragraphs for methods of specifying additional spline characteristics when required:

5.12.4 Shaft End Splines
5.12.5 Index Relationship

5.11.5.1.1.2 Miscellaneous information. Sectional views depicted under “Data specification” shall be identified to the proper location on the part.

5.11.5.2 Data specification. Minimum data and nomenclature requirements shall be specified as shown in figure 104.



NUMBER OF TEETH ______________________________________ XX
CHORDAL SPACE WIDTH
    MAX ACTUAL ____ .XXXX
    MIN EFFECTIVE ______________________________________ .XXXX
NOTE: THE MAJOR DIAMETER AND EFFECTIVE SPLINE MUST BE CONCENTRIC AT MAXIMUM MATERIAL CONDITIONS.

SPLINE REFERENCE DATA

PROFILE TOLERANCE +.XXXX
    (ZERO AT X.XXX DIAMETER) __________________________ -.XXXX
LEAD TOLERANCE ACROSS X.XX LENGTH OF
    ENGAGEMENT ____ .XXXX
TOTAL INDEX TOLERANCE MAX (ANY TWO TEETH) _______ .XXXX
CHORDAL SPACE WIDTH
    MIN ACTUAL ____ .XXXX
    MAX EFFECTIVE ______________________________________ .XXXX
MATING SPLINE PART NUMBER ___________________________ XXXXXXXX

FIGURE 104. Internal parallel sided spline data (flat root major diameter fit).

5.11.6 External parallel sided spline data (flat root minor diameter fit).

5.11.6.1 Instructions to the designer.

5.11.6.1.1 Mandatory drawing requirements. Engineering drawings for this type of spline shall specify the following:

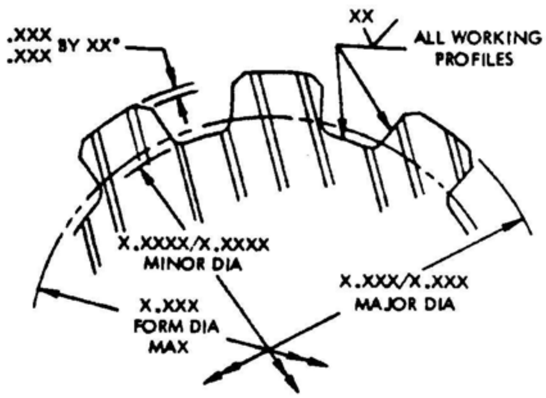
a. Data specification (see 5.11.6.2).
b. Spline datum characteristics as selected from 5.12.2.
c. Chamfers, radii, and fillets as selected from 5.12.3.
d. Additional data selected from Mandatory review below.
e. Material specification.
f. Heat treat specification as required.
g. Finish notes (e.g. plating, etc.).
h. Other notes as required.

5.11.6.1.1.1 Mandatory review. The designer will review the following paragraphs for methods of specifying additional spline characteristics when required:

5.12.4 Shaft End Splines
5.12.5 Index Relationship
5.12.7 Measurements With Pins

5.11.6.1.1.2 Miscellaneous information. Sectional views depicted under "Data specification" shall be identified to the proper location on the part.

5.11.6.2 Data specification. Minimum data and nomenclature requirements shall be specified as shown in figure 105.



NUMBER OF TEETH ______________________________________ XX
CHORDAL TOOTH THICKNESS
MAX EFFECTIVE ______________________________________ .XXXX
MIN ACTUAL ____ .XXXX
NOTE: THE MINOR DIAMETER AND EFFECTIVE SPLINE MUST BE CONCENTRIC AT MAXIMUM MATERIAL CONDITIONS.

SPLINE REFERENCE DATA

MEASUREMENT OVER TWO .XXXXX DIAMETER PINS _____ X.XXXX/X.XXXX
PROFILE TOLERANCE +.XXXX
(ZERO AT X.XXX DIAMETER) __________________________ -.XXXX
LEAD TOLERANCE ACROSS X.XX LENGTH OF
ENGAGEMENT ____ .XXXXX
TOTAL INDEX TOLERANCE MAX (ANY TWO TEETH) ______ .XXXX
CHORDAL TOOTH THICKNESS
MIN EFFECTIVE ______________________________________ .XXXX
MAX ACTUAL ____ .XXXX
MATING SPLINE PART NUMBER __________________________ XXXXXXXX

FIGURE 105. External parallel sided spline data (flat root minor diameter fit).

5.11.7 Internal parallel sided spline data (flat root minor diameter fit).

5.11.7.1 Instructions to the designer.

5.11.7.1.1 Mandatory drawing requirements. Engineering drawings for this type of spline shall specify the following:

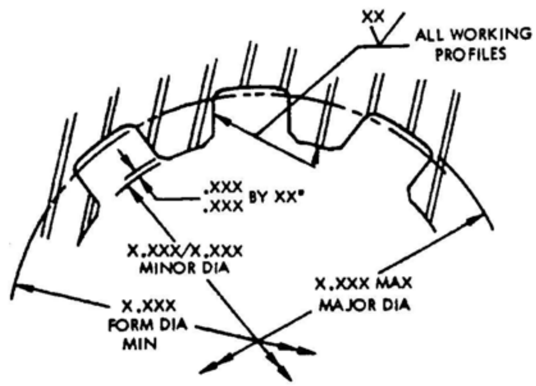
a. Data specification (see 5.11.7.2).
b. Spline datum characteristics as selected from 5.12.2.
c. Chamfers, radii, and fillets *as* selected from 5.12.3.
d. Additional data selected from Mandatory review below.
e. Material specification.
f. Heat treat specification as required.
g. Finish notes (e.g. plating, etc.).
h. Other notes as required.

5.11.7.1.1.1 Mandatory review. The designer will review the following paragraphs for methods of specifying additional spline characteristics when required:

5.12.4 Shaft End Splines
5.12.5 Index Relationship

5.11.7.1.1.2 Miscellaneous information. Sectional views depicted under "Data specification" shall be identified to the proper location on the part.

5.11.7.2 Data specification. Minimum data and nomenclature requirements shall be specified as shown in figure 106.



NUMBER OF TEETH ________________________ XX
CHORDAL SPACE WIDTH
MAX ACTUAL ________________________ .XXXX
MIN EFFECTIVE ________________________ .XXXX
NOTE: THE MINOR DIAMETER AND EFFECTIVE SPLINE MUST BE CONCENTRIC AT MAXIMUM MATERIAL CONDITIONS.

SPLINE REFERENCE DATA

PROFILE TOLERANCE +.XXXX
(ZERO AT X.XXX DIAMETER) ________________ -.XXXX
LEAD TOLERANCE ACROSS X.XX LENGTH OF
ENGAGEMENT ________________________ .XXXX
TOTAL INDEX TOLERANCE MAX (ANY TWO TEETH) __________ .XXXX
CHORDAL SPACE WIDTH
MIN ACTUAL ________________________ .XXXX
MAX EFFECTIVE ________________________ .XXXX
MATING SPLINE PART NUMBER ________________ XXXXXXXX

FIGURE 106. Internal parallel sided spline data (flat root minor diameter fit).

5.12 ADDITIONAL AND SPECIAL DRAWING DATA FOR PARALLEL SIDED SPLINES.

5.12.1 General. This section contains both additional and special data requirements for parallel sided splines.

5.12.1.1 Additional drawing data. Paragraphs 5.12.2 and 5.12.3 contain additional (mandatory) spline drawing requirements with instructions for selection and specification.

5.12.1.2 Special drawing data. Paragraphs 5.12.4 through 5.12.7 contain instructions for specifying special features or modifications required for special spline applications.

5.12.2 Spline datum characteristics. The utilization of datum characteristics of parallel sided splines on drawings does not differ from those of involute splines. Because of the similarity of depicting datum characteristics of parallel sided splines, it is not necessary to present a complete outline of these characteristics. The designer can apply the datum characteristics of involute splines to parallel sided splines by referring to paragraph 5.10.2 in the previous section on Invplute Splines.

5.12.3 Chamfers, radii, and fillets. Refer to paragraph 5.10.3 to determine the proper presentation of chamfers, radii, and fillets on drawings for parallel sided splines.

5.12.4 Shaft end splines. To properly depict shaft ends of parallel sided splines, refer to paragraph 5.10.4.

5.12.5 Index relationship. To properly illustrate the index relationship of parallel sided splines, refer to paragraph 5.10.5.

5.12.6 Minor diameter fits. The drawings and data for parallel sided minor diameter fit splines shall be similar to that described in paragraph 5.10.6. The only difference will be in the heading for the spline data which shall read for external splines,

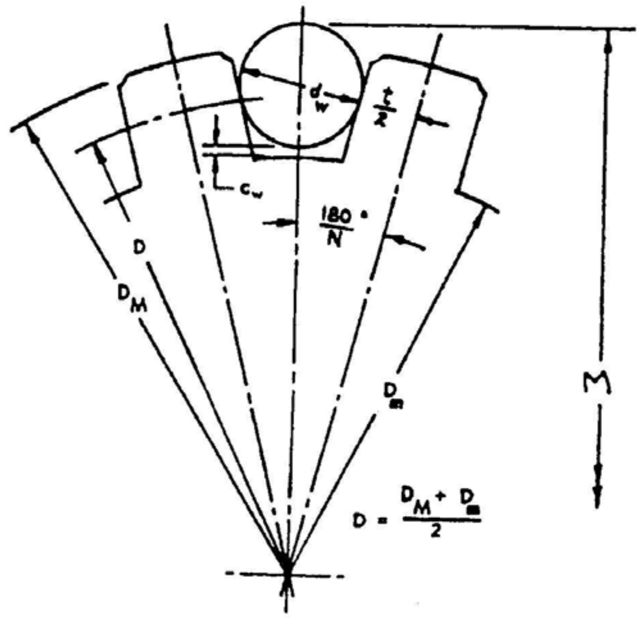
EXTERNAL PARALLEL SIDED SPLINE DATA
FLAT ROOT MINOR DIAMETER FIT

and for internal splines,

INTERNAL PARALLEL SIDED SPLINE DATA
FLAT ROOT MINOR DIAMETER FIT

5.12.7 Measurement with pins. Actual tooth thickness of an external parallel sided spline may be measured with pins. The measurement does not determine the fit between mating parts but may be used as a part of analytical inspection of splines to evaluate the effective tooth thickness by approximation.

5.12.7.1 Measuring pins. The correct measuring pin for determining pin measurement of an external parallel sided spline can be obtained by using the equation for ideal size wire as listed on figure 107 and then selecting the next larger size standard wire from table II for standard wire sizes.



IDEAL WIRE SIZE

$$d_w^* = \sqrt{D^2 - t^2}\ \tan \frac{180°}{N} - t$$

SELECT NEXT LARGER SIZE STANDARD WIRE

$d_w =$

NOTE: When larger wire is used, be sure contact point of wire to sides of teeth does not contact at major diameter or at chamfer.

MEASUREMENT OVER WIRES

$$M = \frac{d_w + t}{\sin \frac{180°}{N}} + d_w$$

WIRE CLEARANCE

$$c_w = .5(M - 2d_w - D_m) > .005$$

IF INTERFERENCE OCCURS, USE LARGER SIZE STANDARD WIRE (See Appendix).

FIGURE 107. Measurement over pins of external parallel sided spline.

5.13 MINIMUM DRAWING DATA FOR STRAIGHT SIDED SPLINES.

5.13.1 General. This section contains minimum drawing data specifications for the six types of straight sided splines listed in the table of contents.

5.13.1.1 Interpretation. Lower case letters are used to present the instructional text. Nomenclature and characteristics required for drawing data presentation are depicted in capital letters.

5.13.1.2 Section organization. The following paragraph subdivision numbering sequence is typical throughout the section:

> 5.13.X.1 "Instructions to the designer" contains a complete drawing specification check list. It delineates the minimum requirements and provides an index of additional spline characteristics when required.
>
> 5.13.X.2 "Data specification" is intended to depict those spline characteristics that define the overall dimensions of the spline blank and delineates the nomenclature and method of listing spline data, notes, and references in a uniform manner for each type of spline.

5.13.1.3 Appendix. Additional information required for the preparation of spline drawings is provided in the appendix.

5.13.1.3.1 Drawing examples. To assist the designer in the interpretation of the requirements of this handbook several examples of drawings are included in the appendix. These sample drawings shall be construed as informational only. They are complete to the degree necessary to illustrate a condition. Actual drawings shall conform to textual requirements set forth in this handbook.

5.13.1.3.2 Measuring wires/balls. Specification of measuring wires or balls on drawings shall be to those sizes listed in table II.

5.13.2 External straight sided spline data (flat root side fit).

5.13.2.1 Instructions to the designer.

5.13.2.1.1 Mandatory drawing requirements. Engineering drawings for this type of spline shall specify the following:

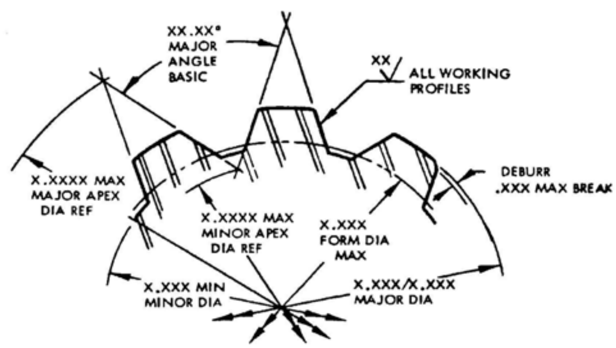
a. Data specification (see 5.13.2.2).
b. Spline datum characteristics as selected from 5.14.2.
c. Chamfers, radii, and fillets as selected from 5.14.3.
d. Additional data selected from Mandatory review below.
e. Material specification.
f. Heat treat specification as required.
g. Finish notes (e.g. plating, etc.).
h. Other notes as required.

5.13.2.1.1.1 Mandatory review. The designer will review the following paragraphs for methods of specifying additional spline characteristics when required :

5.14.4 Shaft End Splines
5.14.5 Index Relationship
5.14.6 Minor Diameter Fits
5.14.8 Measurements With Pins

5.13.2.1.1.2 Miscellaneous information. Sectional views depicted under "Data specification" shall be identified to the proper location on the part.

5.13.2.2 Data specification. Minimum data and nomenclature requirements shall be specified as shown in figure 108.



NUMBER OF TEETH ________	XX
CIRCULAR TOOTH THICKNESS AT PITCH DIAMETER	
MAX EFFECTIVE ________	.XXXX
MIN ACTUAL ________	.XXXX

SPLINE REFERENCE DATA

DIAMETRAL PITCH ________	XX/XX
PITCH DIAMETER ________	X.XXXXXXX
MEASUREMENT OVER TWO .XXXXX DIAMETER PINS ________	X.XXXX/X.XXXX
PROFILE TOLERANCE	+.XXXX
(ZERO AT X.XXX DIAMETER) ________	-.XXXX
LEAD TOLERANCE ACROSS X.XX LENGTH OF	
ENGAGEMENT ________	.XXXX
TOTAL INDEX TOLERANCE MAX (ANY TWO TEETH) ________	.XXXX
CIRCULAR TOOTH THICKNESS AT PITCH DIAMETER	
MIN EFFECTIVE ________	.XXXX
MAX ACTUAL ________	.XXXX
MATING SPLINE PART NUMBER ________	XXXXXXXX

FIGURE 108. External straight sided spline data (flat root side fit).

5.13.3 Internal straight sided spline data (flat root side fit).

5.13.3.1 Instructions to the designer.

5.13.3.1.1 Mandatory drawing requirements. Engineering drawings for this type of spline shall specify the following:

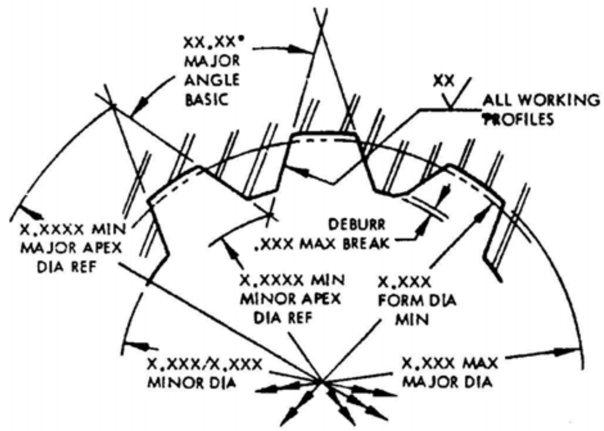
a. Data specification (see 5.13.3.2).
b. Spline datum characteristics as selected from 5.14.2.
c. Chamfers, radii, and fillets as selected from 5.14.3.
d. Additional data selected from Mandatory review below.
e. Material specification.
f. Heat treat specification as required.
g. Finish notes (e.g. plating, etc.).
h. Other notes as required.

5.13.3.1.1.1 Mandatory review. The designer will review the following paragraphs for methods of specifying additional spline characteristics when required:

5.14.4 Shaft End Splines
5.14.5 Index Relationship
5.14.6 Minor Diameter Fits
5.14.7 Straight Sided/Involute Mating
5.14.8 Measurements With Pins

5.13.3.1.1.2 Miscellaneous information. Sectional views depicted under “Data specification” shall be identified to the proper location on the part.

5.13.3.2 Data specification. Minimum data and nomenclature requirements shall be specified as shown in figure 109.



NUMBER OF TEETH	XX
DIAMETRAL PITCH	XX/XX
CIRCULAR SPACE WIDTH AT PITCH DIAMETE	
MAX ACTUAL	.XXXX
MIN EFFECTIVE	.XXXX

SPLINE REFERENCE DATA

PITCH DIAMETER	X.XXXXXXX
MEASUREMENT BETWEEN TWO .XXXXX DIAMETER PINS	X.XXXX/X.XXXX
PROFILE TOLERANCE	+.XXXX
(ZERO AT X.XXX DIAMETER)	-.XXXX
LEAD TOLERANCE ACROSS X.XX LENGTH OF	
ENGAGEMENT	.XXXX
TOTAL INDEX TOLERANCE MAX (ANY TWO TEETH)	.XXXX
CIRCULAR SPACE WIDTH AT PITCH DIAMETER	
MIN ACTUAL	.XXXX
MAX EFFECTIVE	.XXXX
MATING SPLINE PART NUMBER	XXXXXXXX

FIGURE 109. Internal straight sided spline data (flat root side fit).

5.13.4 External straight sided spline data (flat root major diameter fit).

5.13.4.1 Instructions to the designer.

5.13.4.1.1 Mandatory drawing requirements. Engineering drawings for this type of spline shall specify the following:

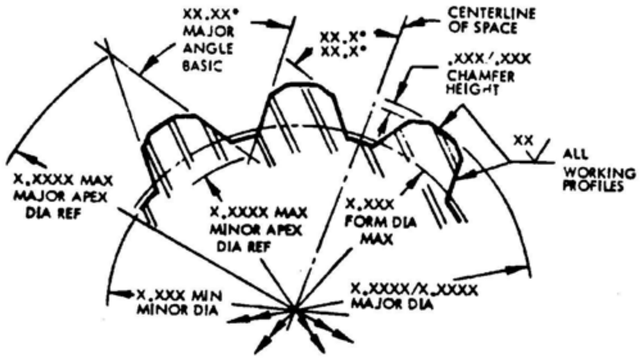
a. Data specification (see 5.13.4.2).
b. Spline datum characteristics as selected from 5.14.2.
c. Chamfers, radii, and fillets as selected from 5.14.3.
d. Additional data selected from Mandatory review below.
e. Material specification.
f. Heat treat specification as required.
g. Finish notes (e.g. plating, etc.).
h. Other notes as required.

5.13.4.1.1.1 Mandatory review. The designer will review the following paragraphs for methods of specifying additional spline characteristics when required:

5.14.4 Shaft End Splines
5.14.5 Index Relationship
5.14.6 Minor Diameter Fits
5.14.8 Measurements With Pins

5.13.4.1.1.2 Miscellaneous information. Sectional views depicted under "Data specification" shall be identified to the proper location on the part.

5.13.4.2 Data specification. Minimum data and nomenclature requirements shall be specified as shown in figure 110.



NUMBER OF TEETH ______	XX
DIAMETRAL PITCH ______	XX/XX
CIRCULAR TOOTH THICKNESS AT PITCH DIAMETER	
MAX EFFECTIVE ______	.XXXX
MIN ACTUAL ______	.XXXX

NOTE: THE MAJOR DIAMETER AND EFFECTIVE SPLINE MUST BE CONCENTRIC AT MAXIMUM MATERIAL CONDITIONS.

SPLINE REFERENCE DATA

PITCH DIAMETER ______	.XXXXXXX
MEASUREMENT OVER TWO .XXXXX DIAMETER PINS ______	X.XXXX/X.XXXX
PROFILE TOLERANCE	+.XXXX
(ZERO AT X.XXX DIAMETER) ______	-.XXXX
LEAD TOLERANCE ACROSS X.XX LENGTH OF	
ENGAGEMENT ______	.XXXX
TOTAL INDEX TOLERANCE MAX (ANY TWO TEETH) ______	.XXXX
CIRCULAR TOOTH THICKNESS AT PITCH DIAMETER	
MIN EFFECTIVE ______	.XXXX
MAX ACTUAL ______	.XXXX
MATING SPLINE PART NUMBER ______	XXXXXXXX

FIGURE 110. External straight sided spline data (flat root major diameter fit).

5.13.5 Internal straight sided spline data (flat root major diameter fit).

5.13.5.1 Instructions to the designer.

5.13.5.1.1 Mandatory drawing requirements. Engineering drawings for this type of spline shall specify the following:

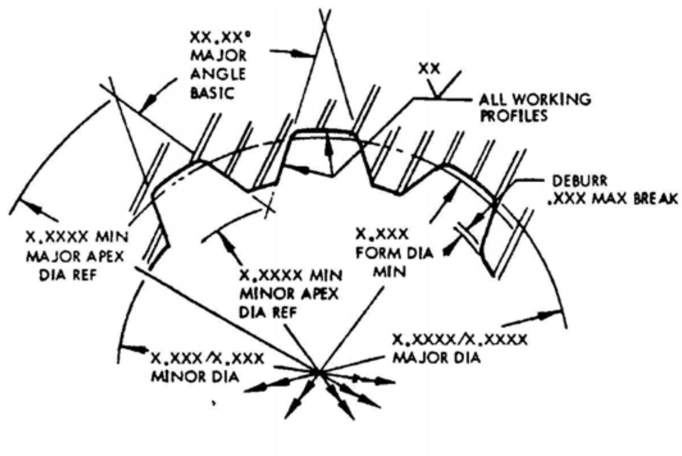
a. Data specification (see 5.13.5.2).
b. Spline datum characteristics as selected from 5.14.2.
c. Chamfers, radii, and fillets as selected from 5.14.3.
d. Additional data selected from Mandatory review below.
e. Material specification.
f. Heat treat specification as required.
g. Finish notes (e.g. plating, etc.).
h. Other notes as required.

5.13.5.1.1.1 Mandatory review. The designer will review the following paragraphs for methods of specifying additional spline characteristics when required:

5.14.4 Shaft End Splines
5.14.5 Index Relationship
5.14.6 Minor Diameter Fits
5.14.7 Straight Sided/Involute Mating
5.14.8 Measurements With Pins

5.13.5.1.1.2 Miscellaneous information. Sectional views depicted under "Data specification" shall be identified to the proper location on the part.

5.13.5.2 Data specification. Minimum data and nomenclature requirements shall be specified as shown in figure 111.



NUMBER OF TEETH ________________________	XX
DIAMETRAL PITCH ________________________	XX/XX
CIRCULAR SPACE WIDTH AT PITCH DIAMETER	
MAX ACTUAL ________________________	.XXXX
MIN EFFECTIVE ________________________	.XXXX

NOTE: THE MAJOR DIAMETER AND EFFECTIVE SPLINE MUST BE CONCENTRIC AT MAXIMUM MATERIAL CONDITIONS.

SPLINE REFERENCE DATA

PITCH DIAMETER ________________________	X.XXXXXXX
MEASUREMENT BETWEEN TWO .XXXXX DIAMETER PINS ___	X.XXXX/X.XXXX
PROFILE TOLERANCE	+.XXXX
(ZERO AT X.XXX DIAMETER) ________________	-.XXXX
LEAD TOLERANCE ACROSS X.XX LENGTH OF	
ENGAGEMENT ________________________	.XXXX
TOTAL INDEX TOLERANCE MAX (ANY TWO TEETH) ________	.XXXX
CIRCULAR SPACE WIDTH AT PTTCH DIAMETER	
MIN ACTUAL ________________________	.XXXX
MAX EFFECTIVE ________________________	.XXXX
MATING SPLINE PART NUMBER ________________	XXXXXXXX

FIGURE 111. Internal straight sided spline data (flat root major diameter fit).

5.13.6 External straight sided spline data (fillet root side fit).

5.13.6.1 Instructions to the designer.

5.13.6.1.1 Mandatory drawing requirements. Engineering drawings for this type of spline shall specify the following:

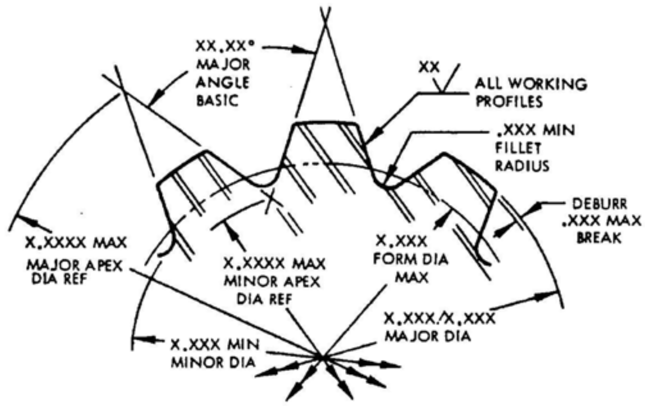
a. Data specification (see 5.13.6.2).
b. Spline datum characteristics as selected from 5.14.2.
c. Chamfers, radii, and fillets as selected from 5.14.3.
d. Additional data selected from Mandatory review below.
e. Material specification.
f. Heat treat specification as required.
g. Finish notes (e.g. plating, etc.).
h. Other notes as required.

5.13.6.1.1.1 Mandatory review. The designer will review the following paragraphs for methods of specifying additional spline characteristics when required:

5.14.4 Shaft End Splines
5.14.5 Index Relationship
5.14.6 Minor Diameter Fits
5.14.8 Measurements With Pins

5.13.6.1.1.2 Miscellaneous information. Sectional views depicted under "Data specification" shall be identified to the proper location on the part.

5.13.6.2 Data specification. Minimum data and nomenclature requirements shall be specified as shown in figure 112.



NUMBER OF TEETH	XX
DIAMETRAL PITCH	XX/XX
CIRCULAR TOOTH THICKNESS AT PITCH DIAMETER	
MAX EFFECTIVE	.XXXX
MIN ACTUAL	.XXXX

SPLINE REFERENCE DATA

PITCH DIAMETER	X.XXXXXXX
MEASUREMENT OVER TWO .XXXXX DIAMETER PINS	X.XXXX/X.XXXX
PROFILE TOLERANCE	+.XXXX
(ZERO AT X.XXX DIAMETER)	-.XXXX
LEAD TOLERANCE ACROSS X.XX LENGTH OF	
ENGAGEMENT	.XXXX
TOTAL INDEX TOLERANCE MAX (ANY TWO TEETH)	.XXXX
CIRCULAR TOOTH THICKNESS AT PITCH DIAMETER	
MIN EFFECTIVE	.XXXX
MAX ACTUAL	.XXXX
MATING SPLINE PART NUMBER	XXXXXXXX

FIGURE 112. External straight sided spline data (fillet root side fit).

5.13.7 Internal straight sided spline data (fillet root side fit).

5.13.7.1 Instructions to the designer.

5.13.7.1.1 Mandatory drawing requirements. Engineering drawings for this type of spline shall specify the following:

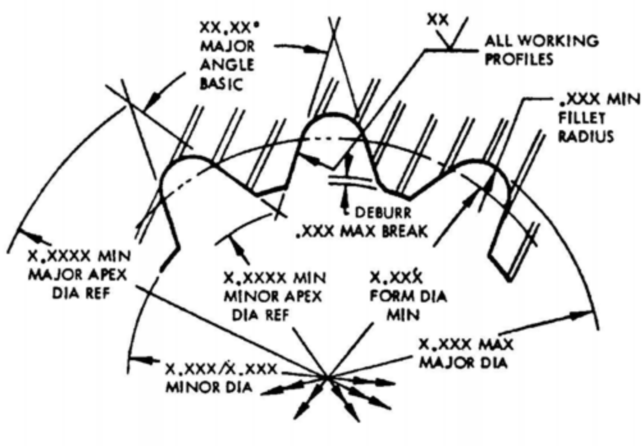
a. Data specification (see 5.13.7.2).
b. Spline datum characteristics as selected from 5.14.2.
c. Chamfers, radii, and fillets as selected from 5.14.3.
d. Additional data selected from Mandatory review below.
e. Material specification.
f. Heat treat specification as required.
g. Finish notes (e.g. plating, etc.).
h. Other notes as required.

5.13.7.1.1.1 Mandatory review. The designer will review the following paragraphs for methods of specifying additional spline characteristics when required:

5.14.4 Shaft End Splines
5.14.5 Index Relationship
5.14.6 Minor Diameter Fits
5.14.7 Straight Sided/Involute Mating
5.14.8 Measurements With Pins

5.13.7.1.1.2 Miscellaneous information. Sectional views depicted under "Data specification" shall he identified t o the proper location on the part.

5.13.7.2 Data specification. Minimum data and nomenclature requirements shall be specified as shown in figure 113.



NUMBER OF TEETH	XX
DIAMETRAL PITCH	XX/XX
CIRCULAR SPACE WIDTH AT PITCH DIAMETER	
MAX ACTUAL	.XXXX
MIN EFFECTIVE	.XXXX

SPLINE REFERENCE DATA

PITCH DIAMETER	X.XXXXXXX
MEASUREMENT BETWEEN TWO .XXXXX DIAMETER PINS	X.XXXX/X.XXXX
PROFILE TOLERANCE	+.XXXX
(ZERO AT X.XXX DIAMETER)	-.XXXX
LEAD TOLERANCE ACROSS X.XX LENGTH OF	
ENGAGEMENT	.XXXX
TOTAL INDEX TOLERANCE MAX (ANY TWO TEETH)	.XXXX
CIRCULAR SPACE WIDTH AT PITCH DIAMETER	
MIN ACTUAL	.XXXX
MAX EFFECTIVE	.XXXX
MATING SPLINE PART NUMBER	XXXXXXXX

FIGURE 113. Internal straight sided spline data (fillet root side fit).

5.14 ADDITIONAL AND SPECIAL DRAWING DATA FOR STRAIGHT SIDED SPLINES.

5.14.1 General. This section contains both additional and special drawing data requirements for straight sided splines.

5.14.1.1 Additional drawing data. Paragraphs 5.14.2 and 5.14.3 contain additional (mandatory) spline drawing requirements with instructions for selection and specification.

5.14.1.2 Special drawing data. Paragraphs 5.14.4 through 5.14.8 contain instructions for specifying special features or modifications required for special spline applications.

5.14.2 Spline datum characteristics. Datum characteristics of straight sided splines are similar in nature to those of involute splines. The designer shall refer to paragraph 5.10.2 to properly depict the datum characteristics of straight sided splines on drawings.

5.14.3 Chamfers, radii, and fillets. Refer t o paragraph 5.10.3 to determine the proper presentation of chamfers, radii, and fillets on drawings for straight sided splines.

5.14.4 Shaft end splines. To properly illustrate shaft ends of straight sided splines, refer to paragraph 5.10.4.

5.14.5 Index relationship. To properly illustrate the index relationship of straight sided splines, refer to paragraph 5.10.5.

5.14.6 Minor diameter fits. The drawings and data for straight sided minor diameter fit splines shall be similar to that described in paragraph 5.10.6. The only difference will be in the heading for spline data which shall read for external splines,

EXTERNAL STRAIGHT SIDED SPLINE DATA
(FLAT ROOT MINOR DIAMETER FIT)

and for internal splines,

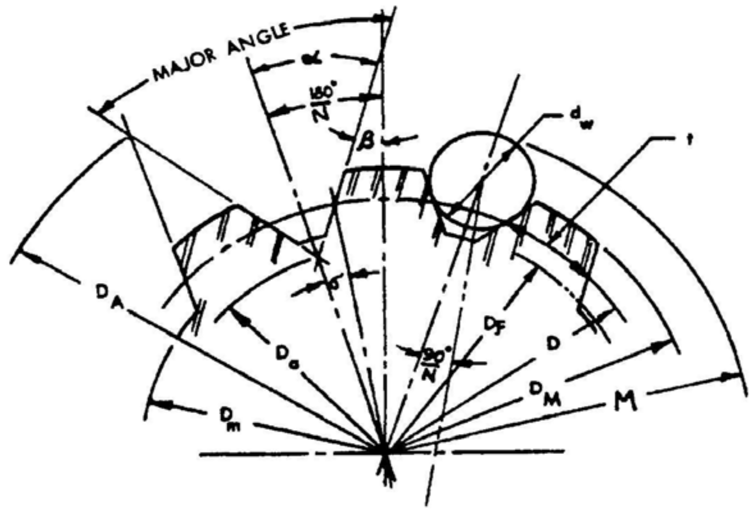
INTERNAL STRAIGHT SIDED SPLINE DATA
(FLAT ROOT MINOR DIAMETER FIT)

5.14.7 Straight sided/involute mating. For information on straight sided/involute mating splines, refer to paragraph 5.10.7.

5.14.8 Measurement with pins. The actual tooth thickness and actual space width of straight sided splines may be measured with pins. These measurements do not determine the fit between mating parts but may be used as a part of analytical inspection of splines to evaluate the effective tooth thickness or effective space width by approximation.

5.14.8.1 Measuring pins. The correct measuring pin for determining pin measurement on straight sided splines can be obtained by using the equations for ideal size wire as listed on figures 114 and 115 and then selecting the next larger size standard wire from table II for standard wire sizes.

5.14.8.2 Measuring with two pins. The values of over and between pin measurements may be calculated using the equations listed on figures 114 and 115. All calculations shall be carried to seven decimal places for accuracy.



$$\sigma = \frac{\pi}{N} - \frac{t}{D} \qquad \beta = \alpha - \frac{180^\circ}{N} \qquad d_w{}^* = D \sin\sigma \sec\alpha$$

Select next larger standard size wire

$d_w =$

$$D_a = D\left(\cos\sigma - \frac{\sin\sigma}{\tan\alpha}\right) \qquad D_A = D_a \frac{\sin\alpha}{\sin\beta}$$

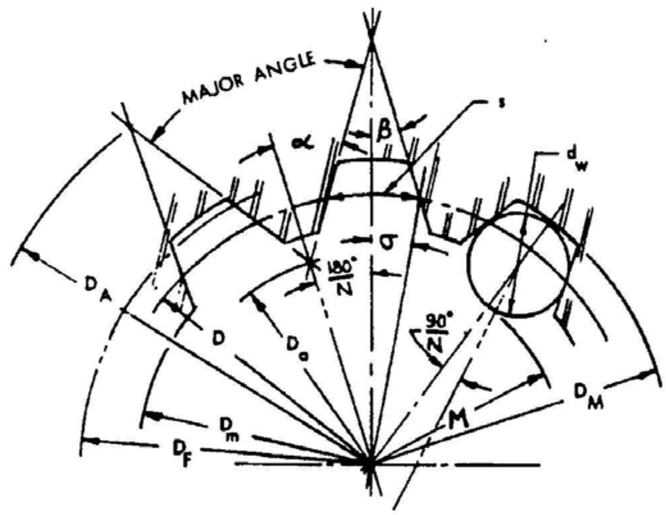
$$D_{cw} = \sqrt{(D_A \cos\beta - d_w / \tan\beta)^2 + (D_A \sin\beta)^2}$$

$$\frac{3D + D_m}{4} < D_{cw} < \frac{3D + D_F}{4}$$

Measurement over Wires (Even) $M = D_a + d_w(1 + \csc\alpha)$

Measurement over Wires (Odd) $M = (D_a + d_w \csc\alpha)\cos(90/N) + d_w$

FIGURE 114. Measurement of external straight sided splines.



$$\hat{\sigma} = \frac{s}{D} \qquad \beta = \alpha - \frac{180°}{N} \qquad d_w{}^{*} = D \sin\sigma \sec\beta$$

Select next larger standard size wire

$d_w =$

$$D_A = D\left(\frac{\sin\sigma}{\tan\beta} + \cos\sigma\right) \qquad D_a = D_A\left(\frac{\sin\beta}{\sin\alpha}\right)$$

$$D_{cw} = \sqrt{(D_A \cos\beta - d_w / \tan\beta)^2 + (D_A \sin\beta)^2}$$

$$\frac{3D + D_m}{4} < D_{cw} < \frac{3D + D_F}{4}$$

Measurement between Wires (Even) $M = D_A - d_w(\csc\beta + 1)$

Measurement between Wires (Odd) $M = (D_A - d_w \csc\beta)\cos(90/N) - d_w$

FIGURE 115. Measurement of internal straight sided splines.

5.14.8.3 Legend of symbols. The following is a legend of symbols for figures 114 and 115.

D = Reference Diameter or Pitch Diameter

D_a = Minor Apex Diameter

D_A = Major Apex Diameter

D_{cw} = Contact Diameter with Measuring Wire

D_F = Form Diameter

D_m = Minor Diameter

D_M = Major Diameter

d_w = Measuring Wire Diameter (Actual)

d_w^* = Measuring Wire Diameter (Ideal)

M = Measurement Over or Between Wires

N = Number of Teeth

s = Actual Circular Space Width at Pitch or Reference Diameter

t = Actual Circular Tooth Thickness at Pitch or Reference Diameter

α = Major Semi-Angle

β = Minor Semi-Angle

σ = Space Semi-Angle

6. NOTES

6.1 Supersession data. This handbook supersedes USA TACOM Pamphlet No. 11-46, 31 August 1973.

6.2 Subject term (key word) listing.

Engineering drawings, gear and spline
Gear and spline, preparation of engineering drawings
Spline and gear, preparation of engineering drawings

Custodian:
Army - AT
Air Force - 99

Review activities:
Army - ME

Preparing activity:
Army - AT

(Project 3020-0109)

APPENDIX

10.1 General. For convenience, the appendix contains tables, examples, formulas, etc., frequently used by the designer in the preparation of gear and spline drawings.

a. It is recommended that designers familiarize themselves with the instructions outlined in the text prior to the use of the tables and formulas.

b. To assist the designer in the interpretation of the requirements of this handbook, several examples of drawings are included in the appendix. These sample drawings shall be construed as informational only and are complete to the degree necessary to illustrate a condition. Actual drawings shall comply with the instructions set forth in the handbook.

c. Specification of measuring wire or ball sizes on drawings shall be to sizes listed in the table and/or according to the instructions contained in the appendix.

d. Involute profile controls require the specification of roll angles, as in profile charts. A table of roll angles is listed here for the convenience of the user.

e. Specific instructions for the use of all tables and formulas are outlined in the text.

10.2 Wire size policy. Recent practice has shown that measurement of gears, splines, and serrations is frequently accomplished through the use of two or three identical sized wires or pins. This method necessitates the use of proper diameter of measuring wire or pin in order to obtain reliable readings. The reasons for using this method are cost and procurement considerations, especially for small quantities. It is sometimes used in the early production of large orders.

a. It is desirable to use wires that contact the profile at or near the pitch diameters and/or reference diameter. With such wires the measurement at or near the pitch diameter is least affected by profile deviations. To illustrate this, consider figure 116 which shows a full line depicting a true outline and a dotted line showing a profile of the same pitch diameter but with a profile deviation. The same conditions would affect circular gears, splines, and serrations. The wire (B) contacts both outlines at or near the pitch diameter, and the measurement will be affected very little by profile deviations. It is evident from the same figure that a maximum wire (M) will give false results unless the profile deviation is considered in the computation.

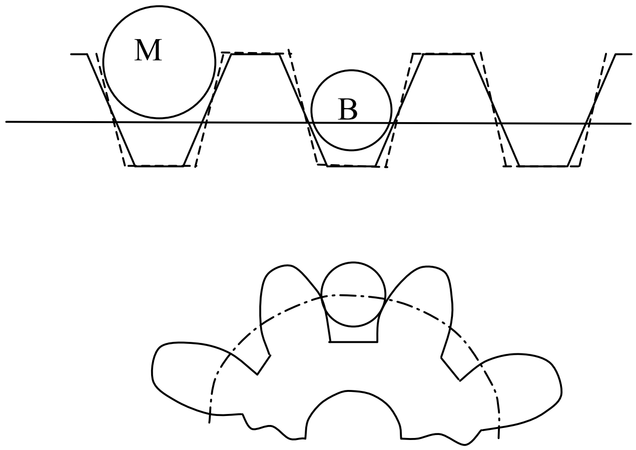


FIGURE 116. Profile deviations.

b. The majority of the wires listed in the table for standard measuring wire sizes were derived from the formulas listed below.

Formula	Use
(1) $G = \frac{1.92}{P}$	(a) Enlarged pinions (b) External involute splines (c) 45º Involute splines (serrations) (d) Alternate for 14 1/2º and 20º pressure angle standard addendum gears.
(2) $G = \frac{1.728}{P}$	(a) External standard addendum spur and helical gears. (b) Internal splines
(3) $G = \frac{1.68}{P}$	(a) For 14 1/2º internal gears above 31 teeth and 20º gears above 14 teeth. (b) Alternate for internal splines. (c) Alternate for standard addendum gears.
(4) $G = \frac{1.44}{P}$	(a) Internal standard addendeum gears.

where G = wire size
P = diametral pitch

c. The measurement over wires should be greater than the maximum outside diameter of the external gear, spline or serration being measured; otherwise there is a risk of interference with the measuring device. Similarly, the measurements between wires must be less than the minimum inside diameter of an internal gear, spline or serration.

d. Thread wires have been included in the table to provide wire sizes for special cases or conditions that could not be fulfilled by gear and spline proportioned wires. Specification of thread wires on drawings shall be limited to special design applications.

e. Specification of wire sizes on drawings shall be depicted to five decimal places as given in the table.

f. Calibrated steel balls are used for measuring internal helical gears and splines. Generally, they are available commercially in fractional sizes in increments of 1/32 inch. Specification of balls on drawings shall be limited to only those cases where the contact configuration is such that standard measuring wires cannot be used.

g. Flats for clearance on some wires, such as those for measuring 30º flat root internal involute splines, are commercially made to 0.8 of the diameter. Specification of flatted measuring wires on drawings shall be limited to only those cases where the depth of the spline is such that standard measuring wires will not clear. When flatted wires are used, the following end view of the wire (see figure 117) shall be added to the drawing:

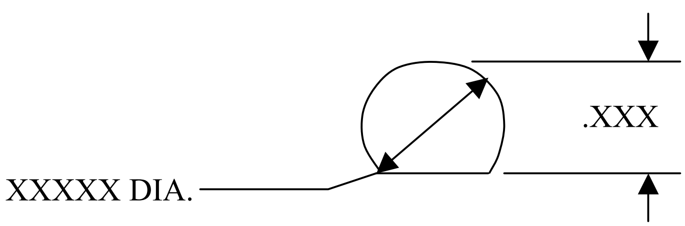


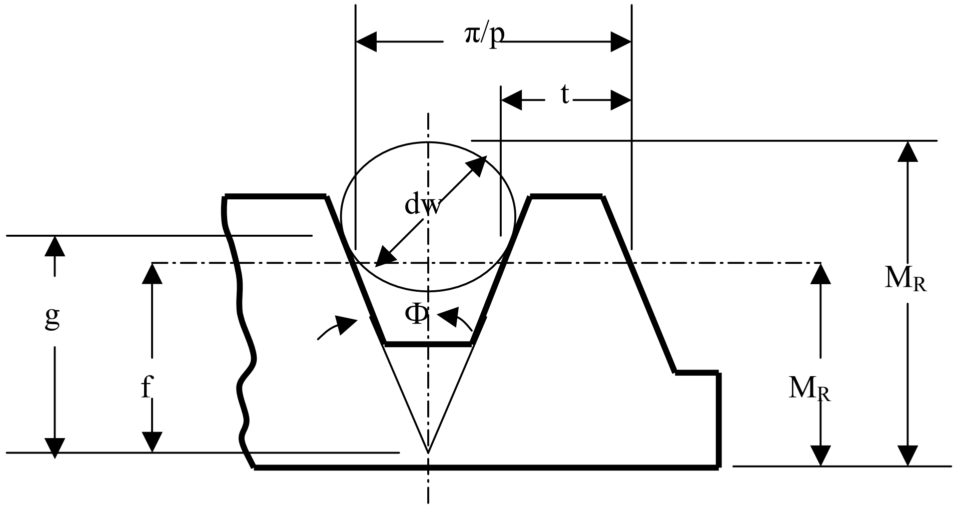
FIGURE 117. Flatted wire.

h. Measuring wires shall be selected from table 11 below. The table represents commercially available wires in three accuracy categories necessary to economically fulfill the requirements of MIL-STD-45662, entitled "Calibration System Requirements". The words "wire" and "pins" are used synonymously.

TABLE II. Standard measuring wire sizes (inches).

.00500	.00722	.00802	.00840	.00864	.00902	.00960	.01031
.01125	.01155	.01203	.01312	.01350	.01400	.01443	.01500
.01604	.01680	.01728	.01750	.01800	.01924	.02000	.02062
.02100	.02138	.02160	.02221	.02250	.02333	.02400	.02406
.02625	.02667	.02700	.02887	.03000	.03207	.03228	.03500
.03600	.03608	.03689	.04000	.04124	.04200	.04304	.04320
.04441	.04500	.04667	.04800	.04811	.05000	.05020	.05143
.05164	.05249	.05250	.05333	.05400	.05774	.06000	.06171
.06250	.06415	.06456	.06545	.06857	.07000	.07200	.07217
.07636	.07855	.08000	.08248	.08400	.08608	.08640	.08727
.09000	.09333	.09600	.09623	.10000	.10286	.10329	.10497
.10500	.10667	.10800	.11547	.12000	.12343	.12500	.12911
.13091	.13714	.14000	.14400	.15000	.15273	.15709	.16000
.16800	.17215	.17280	.17454	.18000	.18666	.18750	.19200
.20000	.20571	.20658	.21000	.21333	.21600	.24000	.24686
.25000	.25822	.27428	.28000	.28800	.30000	.31250	.32000
.33600	.34430	.34560	.36000	.37500	.38400	.38734	.40000
.42000	.43200	.43750	.48000	.50000	.51645	.56000	.56250
.57600	.60000	.62500	.64000	.67200	.68750	.69120	.70000
.72000	.75000	.76800	.80000	.81250	.84000	.86400	.87500
.90000	.93750	.96000	1.00000	1.44000	1.68000	1.72800	1.92000

REFERENCE: Federal specification GGG-W-366 Wire, Measuring; Gear, Thread, and General Purpose.

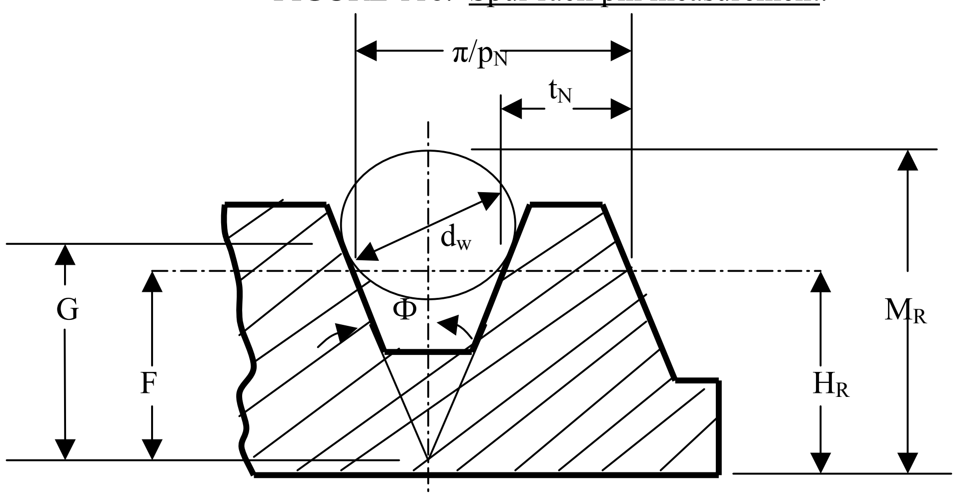


$M_R = H_R + (g – f) + .5d_w \sin Φ + .5 d_w$

$M_R = H_R + .5 d_w (1 + \sin Φ) + g - f$

$$M_R = H_R + .5 d_w (1 + \sin Φ) + \frac{d_w \cos^2 Φ}{2 \sin Φ} - \frac{π/p - t}{2 \tan Φ}$$

FIGURE 118. Spur rack pin measurement.

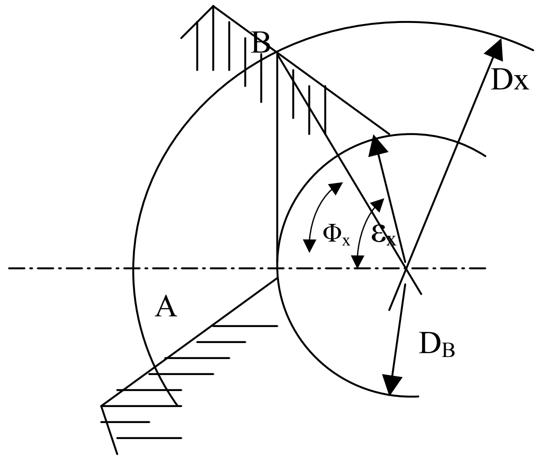


$M_R = H_R + (g – f) + .5d_w \sin Φ + .5 d_w$

$M_R = H_R + .5 d_w (1 + \sin Φ_N) + g - f$

$$M_R = H_R + .5 d_w (1 + \sin ΦN) + \frac{d_w \cos^2 Φ_N}{2 \sin Φ_N} - \frac{π/p_N - t_N}{2 \tan Φ_N}$$

FIGURE 119. Helical rack pin measurement.



D_B = Base diameter

Dx =Any diameter

Φ_x = Pressure angle at Dx

ε_x = Roll angle at Dx

A = Point of tangency on base circle

B = Point of involute at diameter Dx

To find a roll angle for a given diameter:
sec Φx = Dx/D_B Using sec Φx, find roll angle from table by interpolation.

To find a diameter for a given angle:
Using table III, find secΦx for a given roll anle and multiply y the base diameter.

$$Dx = D_B \sec \Phi x$$

FIGURE 120. Roll angle.

TABLE III. Involute roll angle table for unit base circle.

ε_x	$\frac{D_x}{D_B} = \sec \Phi_x$	ε_x	$\frac{D_x}{D_B} = \sec \Phi_x$	ε_x	$\frac{D_x}{D_B} = \sec \Phi_x$	ε_x	$\frac{D_x}{D_B} = \sec \Phi_x$
0.1	1.000 00	1.1	1.000 18	2.1	1.000 67	3.1	1.001 46
0.2	1.000 01	1.2	1.000 22	2.2	1.000 74	3.2	1.001 56
0.3	1.000 01	1.3	1.000 26	2.3	1.000 81	3.3	1.001 66
0.4	1.000 02	1.4	1.000 30	2.4	1.000 88	3.4	1.001 76
0.5	1.000 04	1.5	1.000 34	2.5	1.000 95	3.5	1.001 86
0.6	1.000 05	1.6	1.000 39	2.6	1.001 03	3.6	1.001 97
0.7	1.000 07	1.7	1.000 44	2.7	1.001 11	3.7	1.002 08
0.8	1.000 10	1.8	1.000 49	2.8	1.001 19	3.8	1.002 20
0.9	1.000 12	1.9	1.000 55	2.9	1.001 28	3.9	1.002 31
1.0	1.000 15	2.0	1.000 61	3.0	1.001 37	4.0	1.002 43

TABLE III. Involute roll angle table for unit base circle - Continued.

ε_x	$\frac{D_x}{D_B} = \sec \Phi_x$	ε_x	$\frac{D_x}{D_B} = \sec \Phi_x$	ε_x	$\frac{D_x}{D_B} = \sec \Phi_x$	ε_x	$\frac{D_x}{D_B} = \sec \Phi_x$
4.1	1.002 56	8.1	1.009 94	12.1	1.022 06	16.1	1.038 73
4.2	1.002 68	8.2	1.010 19	12.2	1.022 42	16.2	1.039 20
4.3	1.002 81	8.3	1.010 44	12.3	1.022 78	16.3	1.039 68
4.4	1.002 94	8.4	1.010 69	12.4	1.023 15	16.4	1.040 16
4.5	1.003 08	8.5	1.010 94	12.5	1.023 52	16.5	1.040 64
4.6	1.003 22	8.6	1.011 20	12.6	1.023 90	16.6	1.041 12
4.7	1.003 36	8.7	1.011 46	12.7	1.024 27	16.7	1.041 61
4.8	1.003 50	8.8	1.011 73	12.8	1.024 65	16.8	1.042 10
4.9	1.003 65	8.9	1.011 99	12.9	1.025 03	16.9	1.042 59
5.0	1.003 80	9.0	1.012 26	13.0	1.025 42	17.0	1.043 09
5.1	1.003 95	9.1	1.012 53	13.1	1.025 80	17.1	1.043 59
5.2	1.004 11	9.2	1.012 81	13.2	1.026 20	17.2	1.044 09
2.3	1.004 27	9.3	1.013 09	13.3	1.026 59	17.3	1.044 59
5.4	1.004 43	9.4	1.013 37	13.4	1.026 98	17.4	1.045 10
5.5	1.004 60	9.5	1.013 65	13.5	1.027 38	17.5	1.045 60
5.6	1.004 77	9.6	1.013 94	13.6	1.027 79	17.6	1.046 12
5.7	1.005 94	9.7	1.014 23	13.7	1.028 19	17.7	1.046 63
5.8	1.005 11	9.8	1.014 52	13.8	1.028 60	17.8	1.047 15
5.9	1.005 29	9.9	1.014 82	13.9	1.029 01	17.9	1.047 67
6.0	1.005 47	10.0	1.015 12	14.0	1.029 42	18.0	1.048 19
6.1	1.005 65	10.1	1.015 42	14.1	1.029 84	18.1	1.048 71
6.2	1.005 84	10.2	1.015 72	14.2	1.030 25	18.2	1.049 24
6.3	1.006 03	10.3	1.016 03	14.3	1.030 68	18.3	1.049 77
6.4	1.006 22	10.4	1.016 34	14.4	1.031 10	18.4	1.050 30
6.5	1.006 41	10.5	1.016 65	14.5	1.031 53	18.5	1.050 84
6.6	1.006 61	10.6	1.016 97	14.6	1.031 96	18.6	1.051 37
6.7	1.006 81	10.7	1.017 29	14.7	1.032 39	18.7	1.051 91
6.8	1.007 02	10.8	1.017 61	14.8	1.032 82	18.8	1.052 46
6.9	1.007 23	10.9	1.017 93	14.9	1.033 26	18.9	1.053 00
7.0	1.007 44	11.0	1.018 26	15.0	1.033 70	19.0	1.053 55
7.1	1.007 65	11.1	1.018 59	15.1	1.034 14	19.1	1.054 10
7.2	1.007 86	11.2	1.018 93	15.2	1.034 59	19.2	1.054 65
7.3	1.008 08	11.3	1.019 26	15.3	1.035 04	19.3	1.055 21
7.4	1.008 31	11.4	1.019 60	15.4	1.035 49	19.4	1.055 77
7.5	1.008 53	11.5	1.019 94	15.5	1.035 95	19.5	1.056 33
7.6	1.008 76	11.6	1.020 29	15.6	1.036 40	19.6	1.056 89
7.7	1.008 99	11.7	1.020 64	15.7	1.036 86	19.7	1.057 46
7.8	1.009 22	11.8	1.020 99	15.8	1.037 33	19.8	1.058 03
7.9	1.009 46	11.9	1.021 34	15.9	1.037 79	19.9	1.058 60
8.0	1.009 70	12.0	1.021 70	16.0	1.038 26	20.0	1.059 17

TABLE III. Involute roll angle for unit base circle - Continued.

ε_x	$\frac{D_x}{D_B} = \sec \Phi_x$	ε_x	$\frac{D_x}{D_B} = \sec \Phi_x$	ε_x	$\frac{D_x}{D_B} = \sec \Phi_x$	ε_x	$\frac{D_x}{D_B} = \sec \Phi_x$
20.1	1.059 75	24.1	1.084 86	28.1	1.113 79	32.1	1.146 25
20.2	1.060 33	24.2	1.085 54	28.2	1.114 56	32.2	1.147 10
20.3	1.060 91	24.3	1.086 22	28.3	1.115 33	32.3	1.147 96
20.4	1.061 49	24.4	1.086 90	28.4	1.116 11	32.4	1.148 81
20.5	1.062 08	24.5	1.087 59	28.5	1.116 88	32.5	1.149 67
20.6	1.062 67	24.6	1.088 27	28.6	1.117 66	32.6	1.150 54
20.7	1.063 26	24.7	1.088 96	28.7	1.118 44	32.7	1.151 40
20.8	1.063 86	24.8	1.089 66	28.8	1.119 22	32.8	1.152 27
20.9	1.064 45	24.9	1.090 35	28.9	1.120 01	32.9	1.153 14
21.0	1.065 05	25.0	1.091 05	29.0	1.120 80	33.0	1.154 01
21.1	1.065 65	25.1	1.091 75	29.1	1.121 59	33.1	1.154 88
21.2	1.066 26	25.2	1.092 45	29.2	1.122 38	33.2	1.155 75
21.3	1.066 87	25.3	1.093 15	29.3	1.123 17	33.3	1.156 63
21.4	1.067 47	25.4	1.093 86	29.4	1.123 97	33.4	1.157 51
21.5	1.068 09	25.5	1.094 57	29.5	1.124 76	33.5	1.158 39
21.6	1.068 70	25.6	1.095 28	29.6	1.125 56	33.6	1.159 27
21.7	1.069 32	25.7	1.095 99	29.7	1.126 37	33.7	1.160 15
21.8	1.069 94	25.8	1.096 71	29.8	1.127 17	33.8	1.161 04
21.9	1.070 56	25.9	1.097 42	29.9	1.127 98	33.9	1.161 92
22.0	1.071 18	26.0	1.098 14	30.0	1.128 79	34.0	1.162 81
22.1	1.071 81	26.1	1.098 87	30.1	1.129 60	34.1	1.163 71
22.2	1.072 44	26.2	1.099 59	30.2	1.130 41	34.2	1.164 60
22.3	1.073 07	26.3	1.100 32	30.3	1.131 22	34.3	1.165 50
22.4	1.073 71	26.4	1.101 05	30.4	1.132 04	34.4	1.166 39
22.5	1.074 34	26.5	1.101 78	30.5	1.132 86	34.5	1.167 29
22.6	1.074 98	26.6	1.102 51	30.6	1.133 68	34.6	1.168 19
22.7	1.075 62	26.7	1.103 25	30.7	1.134 50	34.7	1.169 10
22.8	1.076 27	26.8	1.103 99	30.8	1.135 33	34.8	1.170 00
22.9	1.076 91	26.9	1.104 73	30.9	1.136 16	34.9	1.170 91
23.0	1.077 56	27.0	1.105 47	31.0	1.136 99	35.0	1.171 82
23.1	1.078 21	27.1	1.106 22	31.1	1.137 82	35.1	1.172 73
23.2	1.078 87	27.2	1.106 96	31.2	1.138 65	35.2	1.173 64
23.3	1.079 52	27.3	1.107 71	31.3	1.139 49	35.3	1.174 56
23.4	1.080 18	27.4	1.108 46	31.4	1.140 32	35.4	1.175 47
23.5	1.080 84	27.5	1.109 22	31.5	1.141 16	35.5	1.176 39
23.6	1.081 51	27.6	1.109 98	31.6	1.142 01	35.6	1.177 31
23.7	1.082 17	27.7	1.110 73	31.7	1.142 85	35.7	1.178 23
23.8	1.082 84	27.8	1.111 49	31.8	1.143 70	35.8	1.179 16
23.9	1.083 51	27.9	1.112 26	31.9	1.144 54	35.9	1.180 08
24.0	1.084 19	28.0	1.113 02	32.0	1.145 39	36.0	1.181 01

TABLE III. Involute roll angle table for unit base circle - Continued.

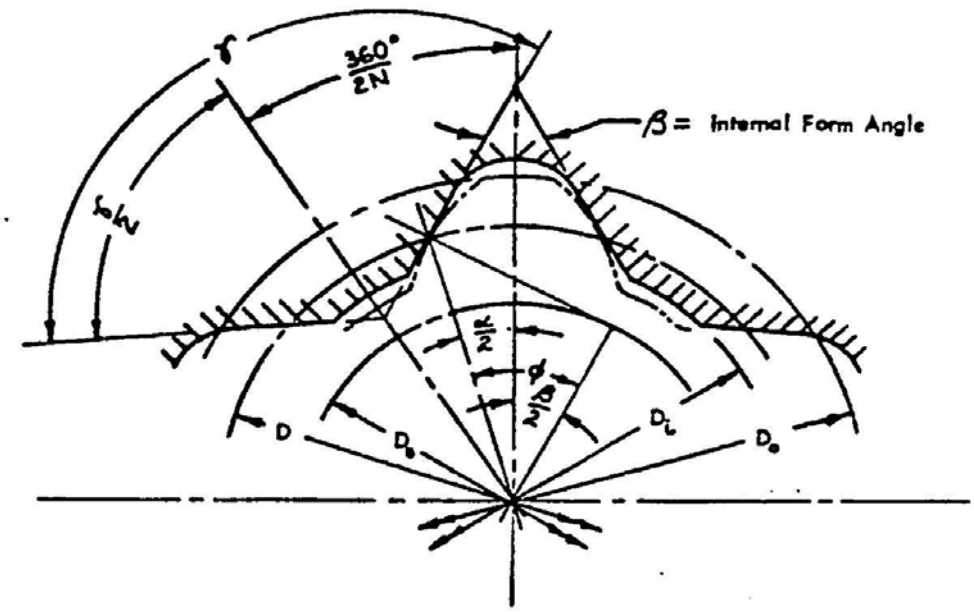
ε_x	$\frac{D_x}{D_B} = \sec \Phi_x$	ε_x	$\frac{D_x}{D_B} = \sec \Phi_x$	ε_x	$\frac{D_x}{D_B} = \sec \Phi_x$	ε_x	$\frac{D_x}{D_B} = \sec \Phi_x$
36.1	1.181 94	40.1	1.220 91	44.1	1.261 91	48.1	1.305 67
36.2	1.182 87	40.2	1.221 98	44.2	1.262 98	48.2	1.306 79
36.3	1.183 80	40.3	1.222 04	44.3	1.264 04	48.3	1.307 91
36.4	1.184 74	40.4	1.223 11	44.4	1.265 11	48.4	1.309 04
36.5	1.185 68	40.5	1.224 18	44.5	1.266 18	48.5	1.310 17
36.6	1.186 61	40.6	1.225 25	44.6	1.267 25	48.6	1.311 29
36.7	1.187 55	40.7	1.226 33	44.7	1.268 33	48.7	1.312 42
36.8	1.188 50	40.8	1.227 40	44.8	1.269 40	48.8	1.313 56
36.9	1.189 44	40.9	1.228 48	44.9	1.270 48	48.9	1.314 69
37.0	1.190 39	41.0	1.229 55	45.0	1.271 55	49.0	1.315 82
37.1	1.191 33	41.1	1.230 63	45.1	1.272 63	49.1	1.316 96
37.2	1.192 28	41.2	1.231 71	45.2	1.273 71	49.2	1.318 09
37.3	1.193 24	41.3	1.232 80	45.3	1.274 80	49.3	1.319 23
37.4	1.194 19	41.4	1.233 88	45.4	1.275 88	49.4	1.320 37
37.5	1.195 14	41.5	1.234 96	45.5	1.276 96	49.5	1.321 51
37.6	1.196 10	41.6	1.235 05	45.6	1.278 05	49.6	1.322 65
37.7	1.197 06	41.7	1.236 14	45.7	1.279 14	49.7	1.323 79
37.8	1.198 02	41.8	1.237 23	45.8	1.280 23	49.8	1.324 94
37.9	1.198 98	41.9	1.238 32	45.9	1.281 32	49.9	1.326 08
38.0	1.199 94	42.0	1.239 41	46.0	1.282 41	50.0	1.327 23
38.1	1.200 91	42.1	1.240 93	46.1	1.283 50	50.1	1.328 38
38.2	1.201 88	42.2	1.241 96	46.2	1.284 60	50.2	1.329 53
38.3	1.202 85	42.3	1.243 00	46.3	1.285 69	50.3	1.330 68
38.4	1.203 82	42.4	1.244 04	46.4	1.286 79	50.4	1.331 83
38.5	1.204 79	42.5	1.245 08	46.5	1.287 89	50.5	1.322 99
38.6	1.205 76	42.6	1.246 12	46.6	1.288 99	50.6	1.334 14
38.7	1.206 74	42.7	1.247 16	46.7	1.290 09	50.7	1.335 30
38.8	1.207 72	42.8	1.248 50	46.8	1.291 20	50.8	1.336 45
38.9	1.208 70	42.9	1.249 25	46.9	1.292 30	50.9	1.337 61
39.0	1.209 68	43.0	1.250 29	47.0	1.293 41	51.0	1.338 77
39.1	1.210 66	43.1	1.251 34	47.1	1.294 51	51.1	1.339 93
39.2	1.211 65	43.2	1.252 39	47.2	1.295 62	51.2	1.341 10
39.3	1.212 63	43.3	1.253 44	47.3	1.296 73	51.3	1.342 26
39.4	1.231 62	43.4	1.254 50	47.4	1.297 85	51.4	1.343 42
39.5	1.214 61	43.5	1.255 55	47.5	1.298 96	51.5	1.344 59
39.6	1.215 60	43.6	1.256 61	47.6	1.300 07	51.6	1.345 76
39.7	1.216 60	43.7	1.257 67	47.7	1.301 19	51.7	1.346 93
39.8	1.217 59	43.8	1.258 73	47.8	1.302 31	51.8	1.348 10
39.9	1.218 59	43.9	1.259 79	47.9	1.303 43	51.9	1.349 27
40.0	1.219 59	44.0	1.260 85	48.0	1.304 55	52.0	1.350 44

TABLE III. Involute roll angle table for unit base circle - Continued.

ε_x	$\frac{D_x}{D_B}$ = sec Φ_x	ε_x	$\frac{D_x}{D_B}$ = sec Φ_x	ε_x	$\frac{D_x}{D_B}$ = sec Φ_x	ε_x	$\frac{D_x}{D_B}$ = sec Φ_x
52.1	1.351 61	56.1	1.399 53	60.1	1.4492	64.1	1.5005
52.2	1.352 79	56.2	1.400 76	60.2	1.4505	64.2	1.5018
52.3	1.353 96	56.3	1.401 98	60.3	1.4518	64.3	1.5031
52.4	1.355 14	56.4	1.403 20	60.4	1.4530	64.4	1.5044
52.5	1.356 32	56.5	1.404 43	60.5	1.4543	64.5	1.5059
52.6	1.357 50	56.6	1.405 65	60.6	1.4556	64.6	1.5071
52.7	1.358 68	56.7	1.406 88	60.7	1.4568	64.7	1.5084
52.8	1.359 86	56.8	1.408 11	60.8	1.4581	64.8	1.5097
52.9	1.361 05	56.9	1.409 34	60.9	1.4594	64.9	1.5110
53.0	1.362 23	57.0	1.410 57	61.0	1.4606	65.0	1.5123
53.1	1.363 42	57.1	1.411 80	61.1	1.4619	65.1	1.5136
53.2	1.364 60	57.2	1.413 03	61.2	1.4632	65.2	1.5149
53.3	1.365 79	57.3	1.414 27	61.3	1.4645	65.3	1.5162
53.4	1.366 98	57.4	1.415 5	61.4	1.4657	65.4	1.5175
53.5	1.368 17	57.5	1.416 7	61.5	1.4670	65.5	1.5188
53.6	1.369 36	57.6	1.1480	61.6	1.4683	65.6	1.5202
53.7	1.370 56	57.7	1.4192	61.7	1.4696	65.7	1.5215
53.8	1.371 75	57.8	1.4204	61.8	1.4709	65.8	1.5228
53.9	1.372 94	57.9	1.4217	61.9	1.4721	65.9	1.5241
54.0	1.374 14	58.0	1.4229	62.0	1.4734	66.0	1.5254
54.1	1.375 34	58.1	1.4242	62.1	1.4747	66.1	1.5267
54.2	1.376 54	58.2	1.4254	62.2	1.4760	66.2	1.5281
54.3	1.377 74	58.3	1.4267	62.3	1.4773	66.3	1.5294
54.4	1.378 94	58.4	1.4279	62.4	1.4785	66.4	1.5307
54.5	1.380 14	58.5	1.4292	62.5	1.4798	66.5	1.5320
54.6	1.381 34	58.6	1.4304	62.6	1.4811	66.6	1.5333
54.7	1.382 55	58.7	1.4316	62.7	1.4824	66.7	1.5347
54.8	1.383 76	58.8	1.4329	62.8	1.4837	66.8	1.5360
54.9	1.384 96	58.9	1.4341	62.9	1.4850	66.9	1.5373
55.0	1.386 17	59.0	1.4354	63.0	1.4863	67.0	1.5386
55.1	1.387 38	59.1	1.4367	63.1	1.4876	67.1	1.5400
55.2	1.388 59	59.2	1.4379	63.2	1.4889	67.2	1.5413
55.3	1.389 80	59.3	1.4392	63.3	1.4902	67.3	1.5426
55.4	1.391 01	59.4	1.4404	63.4	1.4915	67.4	1.5440
55.5	1.392 23	59.5	1.4417	63.5	1.4927	67.5	1.5453
55.6	1.393 44	59.6	1.4429	63.6	1.4940	67.6	1.5466
55.7	1.394 66	59.7	1.4442	63.7	1.4953	67.7	1.5480
55.8	1.395 88	59.8	1.4454	63.8	1.4966	67.8	1.5493
55.9	1.397 09	59.9	1.4467	63.9	1.4979	67.9	1.5506
56.0	1.398 31	60.0	1.4480	64.0	1.7992	68.0	1.5520

TABLE III. Involute roll angle table for unit base circle - Continued.

ε_x	$\frac{D_x}{D_B} = \sec \Phi_x$		ε_x	$\frac{D_x}{D_B} = \sec \Phi_x$		ε_x	$\frac{D_x}{D_B} = \sec \Phi_x$		ε_x	$\frac{D_x}{D_B} = \sec \Phi_x$
68.1	1.5533		70.1	1.5802		72.1	1.6073		74.1	1.6348
68.2	1.5547		70.2	1.5815		72.2	1.6087		74.2	1.6362
68.3	1.5560		70.3	1.5829		72.3	1.6101		74.3	1.6376
68.4	1.5573		70.4	1.5842		72.4	1.6114		74.4	1.6390
68.5	1.5586		70.5	1.5856		7.25	1.6128		74.5	1.6403
68.6	1.5600		70.6	1.5869		72.6	1.6142		74.6	1.6417
68.7	1.5613		70.7	1.5883		72.7	1.6155		74.7	1.6431
68.8	1.5627		70.8	1.5896		72.8	1.6169		74.8	1.6445
68.9	1.5640		70.9	1.5910		72.9	1.6183		74.9	1.6459
69.0	1.5653		71.0	1.5923		73.0	1.6197		75.0	1.6473
69.1	1.5667		71.1	1.5937		73.1	1.6210			
69.2	1.5680		71.2	1.5951		73.2	1.6224			
69.3	1.5694		71.3	1.5964		73.3	1.6238			
69.4	1.5707		71.4	1.5978		73.4	1.6252			
69.5	1.5721		71.5	1.5991		73.5	1.6265			
69.6	1.5734		71.6	1.6005		73.6	1.6279			
69.7	1.5748		71.7	1.6019		73.7	1.6293			
69.8	1.5761		71.8	1.6032		73.8	1.6307			
69.9	1.5775		71.9	1.6046		73.9	1.6320			
70.0	1.5788		72.0	1.6060		74.0	1.6334			



N = Number of Splines.

ϕ = Pressure Angle at D.

D = Pitch Diameter.

D_b = Base Diameter.

D_o = Major Diameter of External Involute Spline.

D_i = Minor Diameter of Straight Sided Spline.

$$\alpha^\circ = \left(\frac{1.7708}{\pi N}\right) 360^\circ$$

$$\beta^\circ = 2\phi - \frac{203}{N}$$

$$\gamma^\circ = \beta + \frac{360^\circ}{N} = 2\phi + \frac{157}{N}$$

FIGURE 121. Determination of angles on internal straight sided spline mating with external involute spline.

10.3 Examples of drawing presentation.

a. In the past, gear drawing data has been shown in various locations on a drawing. When this is done on a drawing that has many sections and views shown, space for the gear and spline data is sometimes at a premium and the data is listed haphazardly in any available empty space. Such a procedure makes it difficult for the manufacturer to locate the necessary data except after a diligent search.

b. All future gear and spline drawings shall have the gear and spline data shown in the upper left hand area on the drawing. All additional gear and spline drawing data (sections, views, etc.) shall be shown as close to the gear and spline data as possible. Whenever multiple sets of gears and spline data must be listed on a drawing (as on a cluster gear), additional sheets shall be used to record all the data necessary for a concise, accurate presentation of gear and spline data. A cluttered drawing will only present problems for the manufacturer. Thus for the sake of clarity, multiple sheet drawings may be required.

c. All material, heat treat, and finish notes shall be shown in the lower left hand area on the drawing.

d. No gear or spline data shall be shown on the right side of the drawing beneath the revision block except when all space on the drawing has been utilized. In such a case a reasonable space (approximately 6-8 inches) should be left for revisions and the remaining space may be used for drawing purposes. If the space left is too small, an additional sheet to the drawing may be adviseable instead of using the revision block area.

e. It is recommended that a D size drawing sheet or larger be used for all gear and spline drawings whenever possible. All gear and spline drawing information will ordinarily fit on this size drawing sheet and present a clear concise picture of the desired product.

f. Figures 123 through 136 depict a few samples of drawings that show the desired method of gear and spline data presentation. These drawings shall be construed as informational only. they are complete to the degree necessary t o illustrate a condition. Actual drawings shall conform to textual requirements set forth in this handbook.

g. For further information on drawing preparation with respect to basic space allotment, see the current edition of DOD-STD-100, titled “Engineering Drawing Practices”.

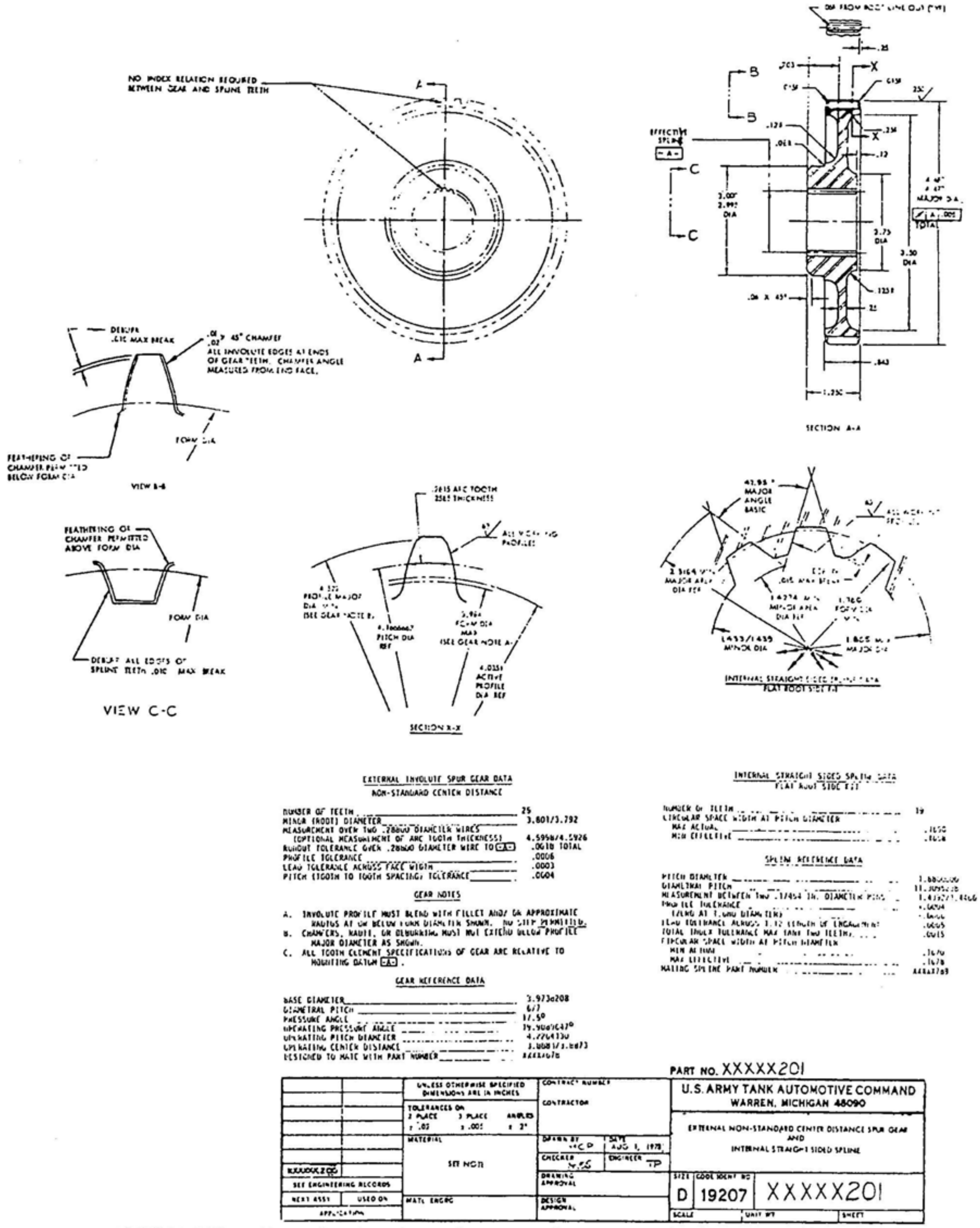


FIGURE 122. Example drawing of external non-standard center distance

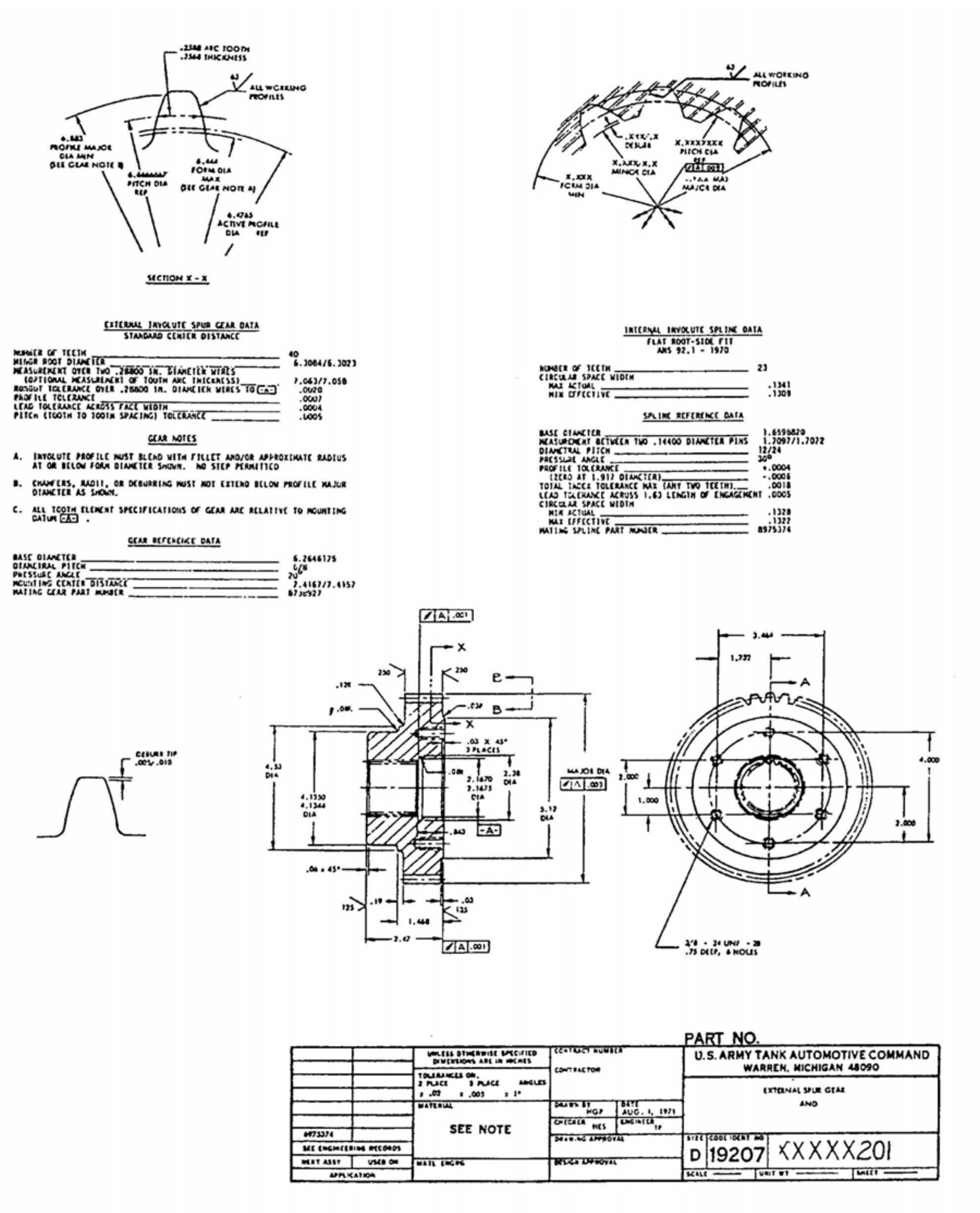


FIGURE 123. Example drawing of external spur gear.

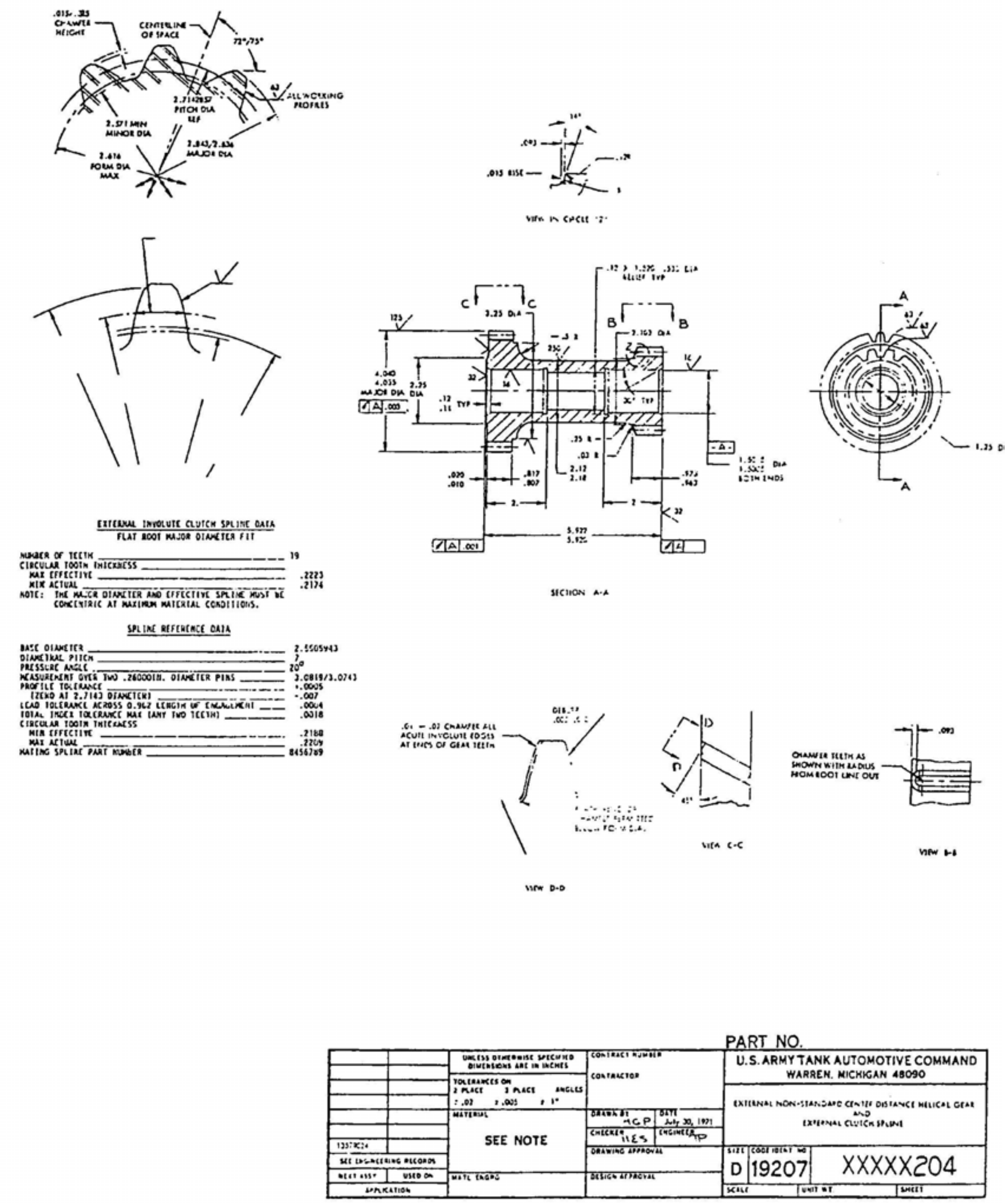


FIGURE 124. Example of external non-standard cener
Distance helical gear and external clutch spline

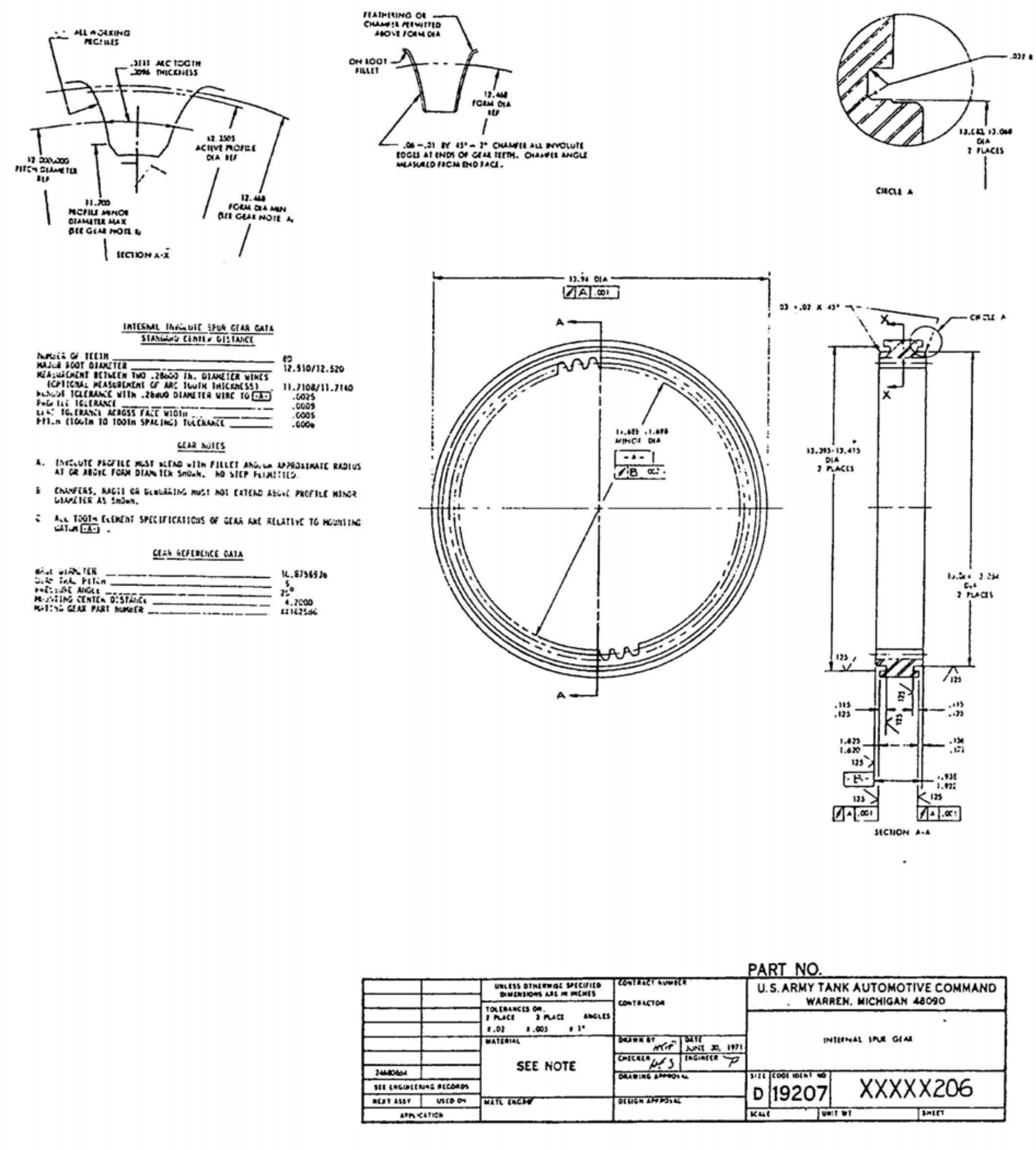
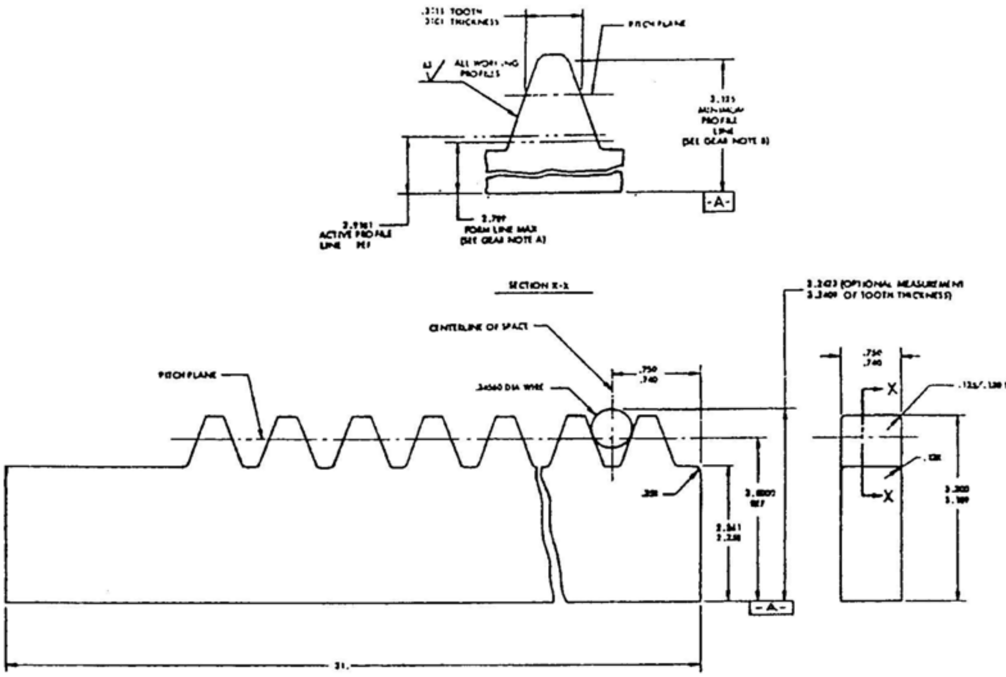


FIGURE 125. Example drawing of internal spur gear.



INVOLUTE SPUR RACK DATA

NUMBER OF TEETH	40
PITCH TOLERANCE (ADJACENT TEETH)	.0007
INDEX TOLERANCE (ANY TWO TEETH)	.0002
VARIATION OVER .34560 IN DIAMETER WIRE TO DATUM [-A-] ACROSS 28 IN. LENGTH (INCLUDES VARIATION ACROSS FACE)	.0019
PROFILE TOLERANCE	.0005
LEAD TOLERANCE ACROSS FACE	.0003

GEAR NOTES

A. TOOTH PROFILE MUST BLEND WITH FILLET AND/OR APPROXIMATE RADIUS AT OR BELOW THE FORM LINE SHOWN. NO STEP PERMITTED.

B. CHAMFERS, RADII, OR DEBURRING MUST NOT EXTEND BELOW MINIMUM PROFILE LINE AS SHOWN.

C. ALL TOOTH ELEMENT SPECIFICATIONS OF RACK ARE RELATIVE TO MOUNTING DATUM [-A-].

SPUR RACK REFERENCE DATA

DIAMETRAL PITCH	5
LINEAR PITCH	.6283185
PRESSURE ANGLE	20°
MATING GEAR PART NUMBER	6282602

PART NO.

	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	CONTRACT NUMBER		U.S. ARMY TANK AUTOMOTIVE COMMAND WARREN, MICHIGAN 48090
	TOLERANCES ON 2 PLACE ±.02, 3 PLACE ±.005, ANGLES ±2°	CONTRACTOR		
	MATERIAL	DRAWN BY IP	DATE SEPT 15, 1971	INVOLUTE SPUR RACK
8765432		CHECKER TEB	ENGINEER TP	
SEE ENGINEERING RECORDS		DRAWING APPROVAL		SIZE D / CODE IDENT NO. 19207 / XXXXX209
NEXT ASSY / USED ON	MAT'L ENGRG	DESIGN APPROVAL		SCALE / UNIT WT. / SHEET
APPLICATION				

FIGURE 126. Example drawing of involute spur rack.

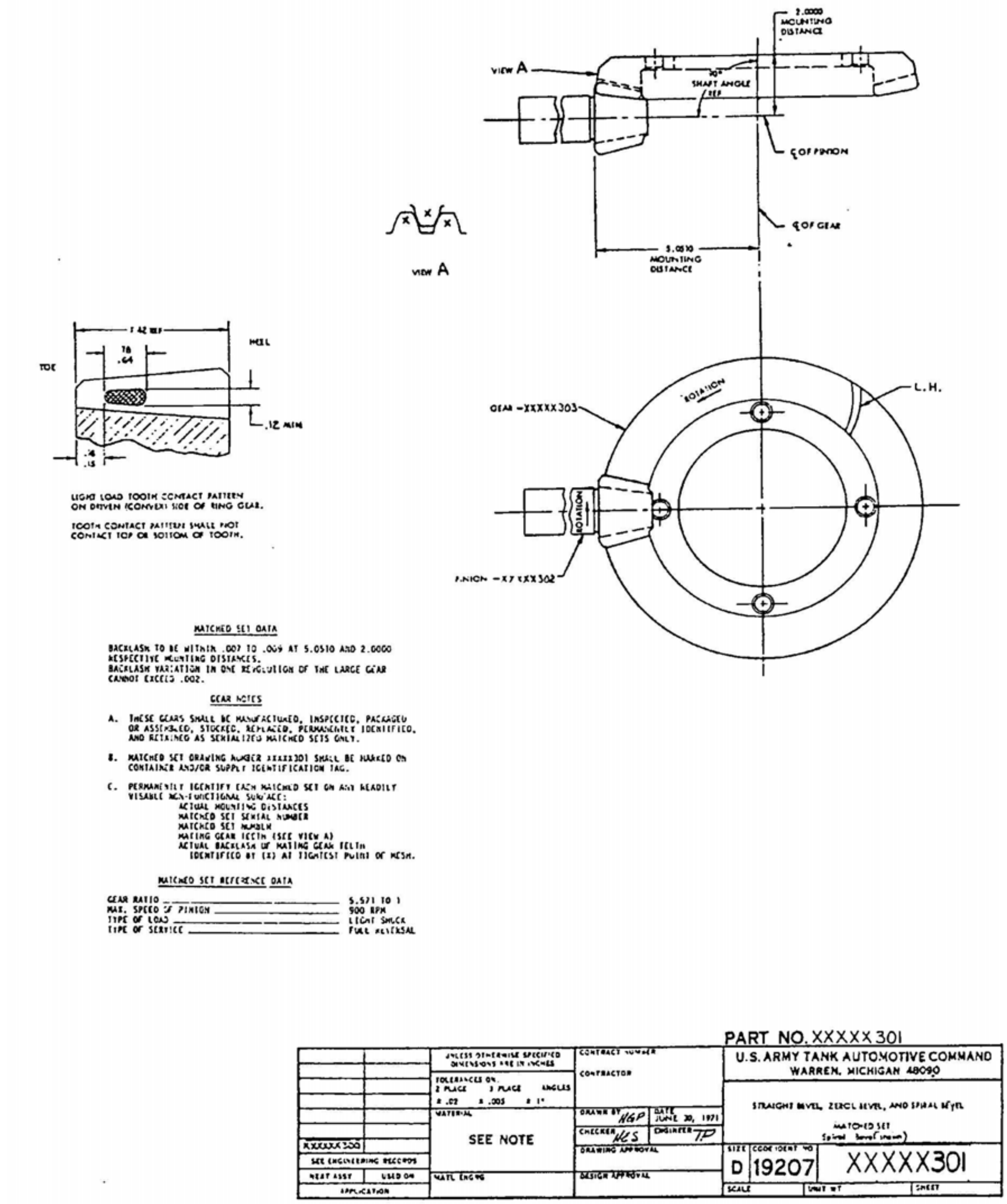


FIGURE 127. Example drawing of straight bevel, zerol bevel, and spiral bevel matched set.

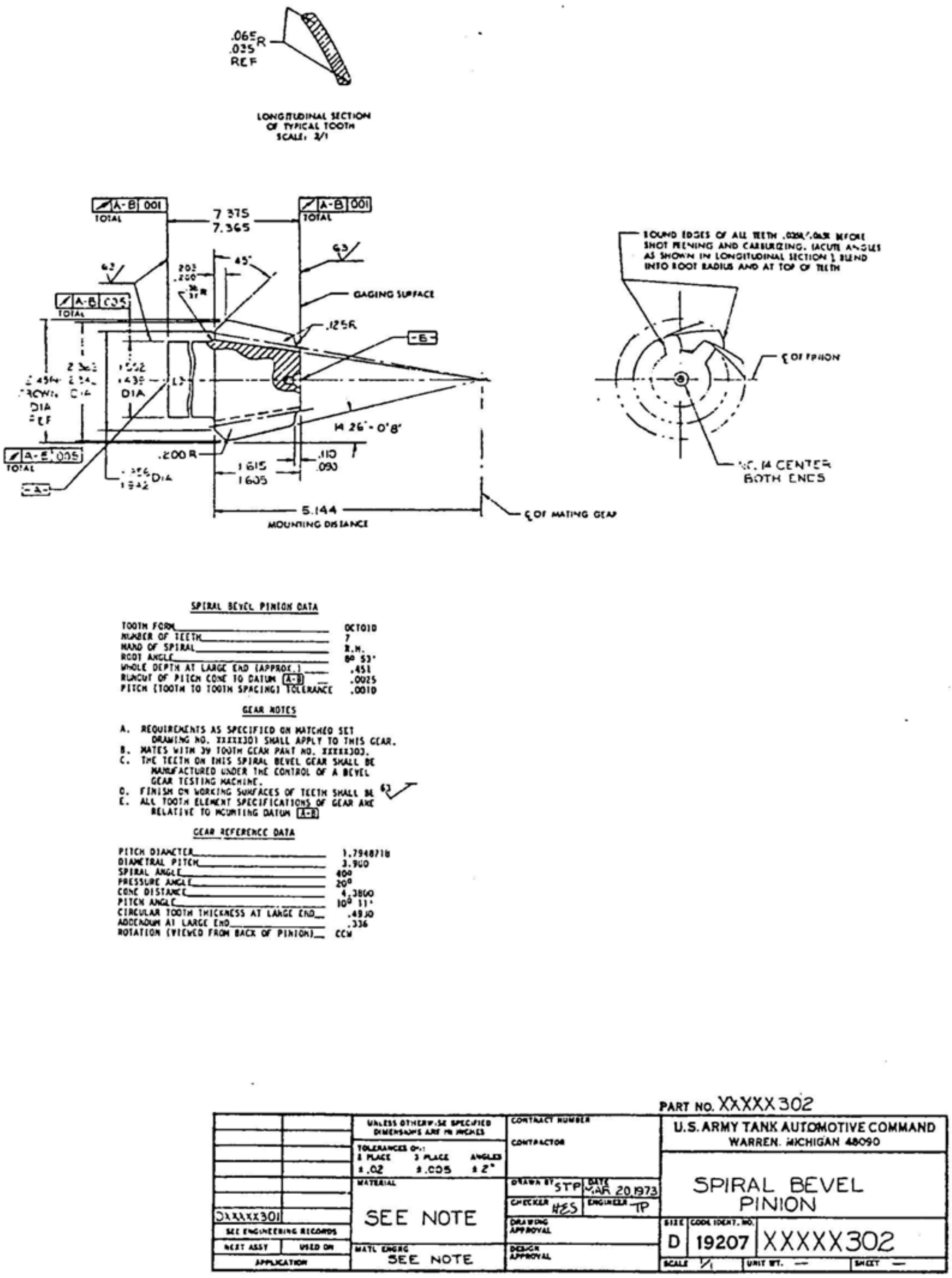


FIGURE 128. Example drawing of spiral bevel pinion.

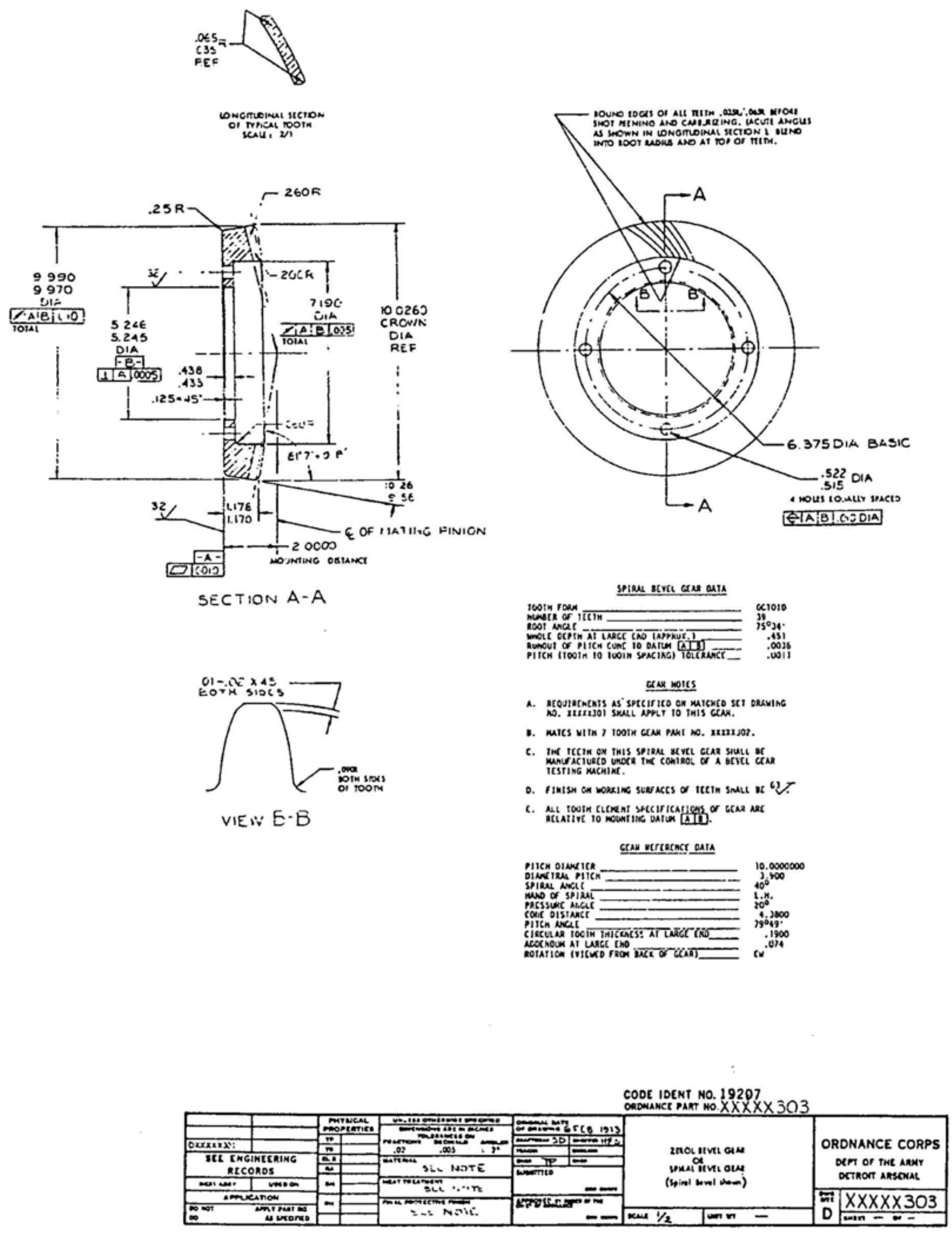


FIGURE 129. Example of drawing of zerol bevel gear or spiral bevel gear.

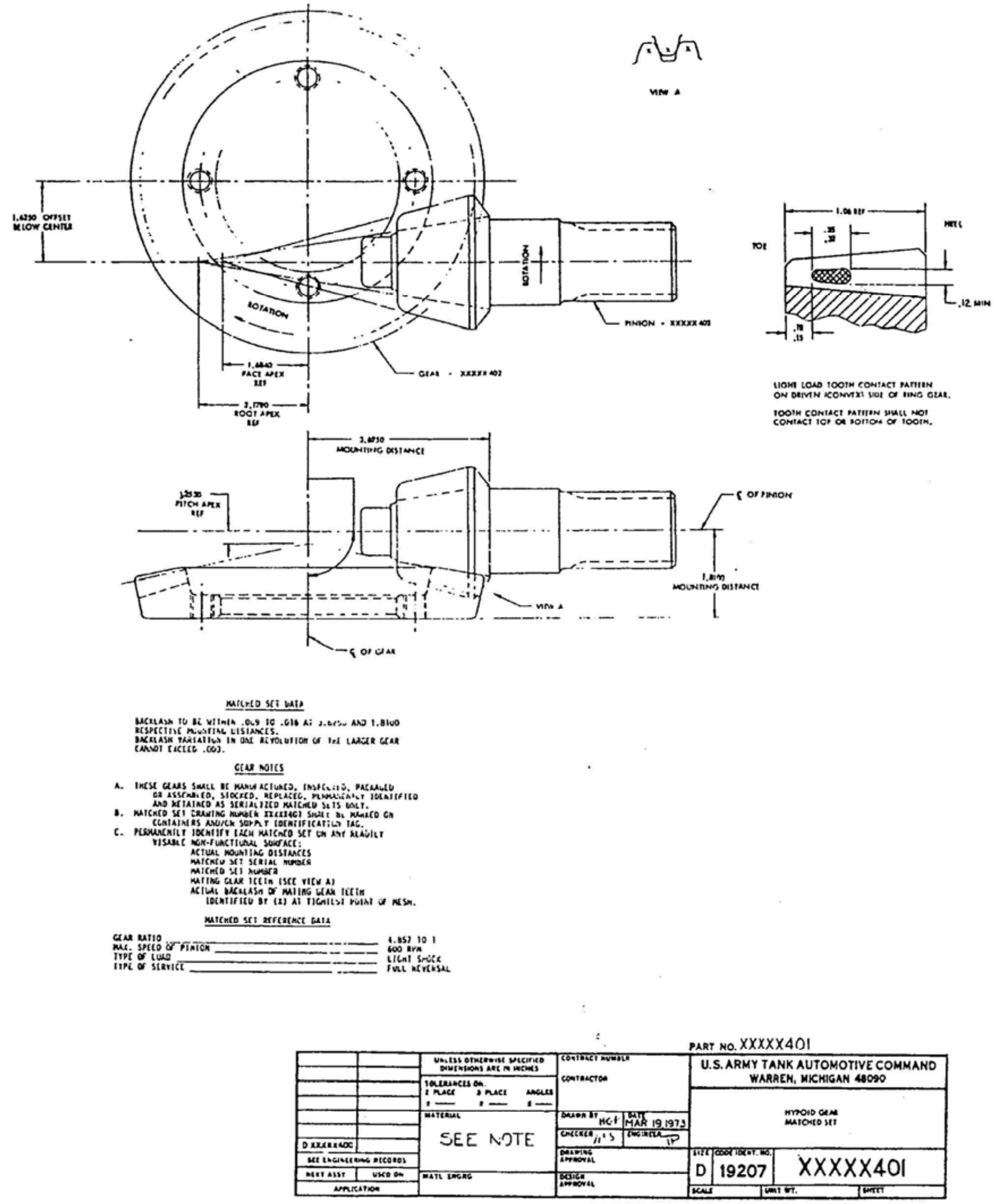


FIGURE 130. Example drawing of hypoid gear matched set.

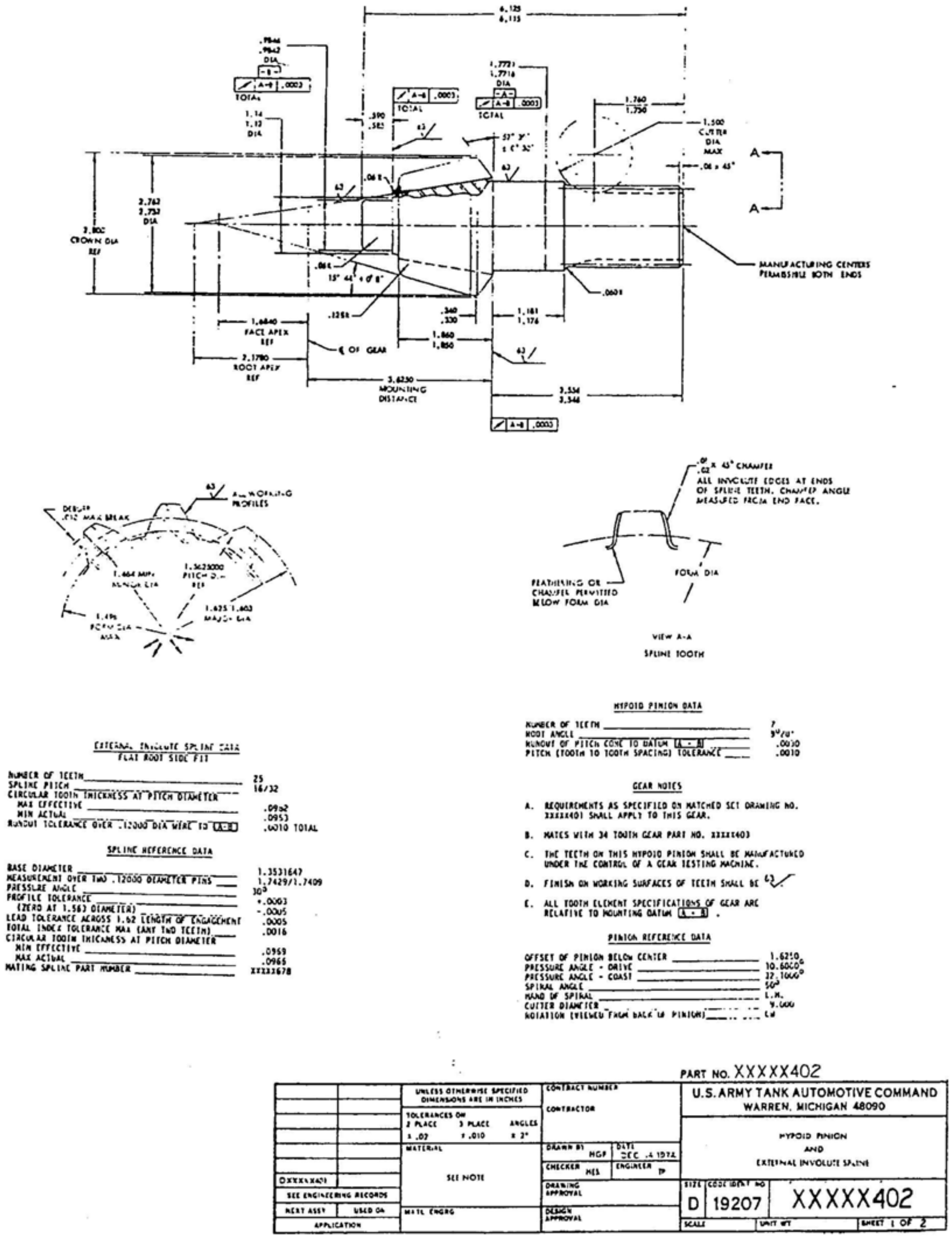


FIGURE 31a. Example drawing of hypoid pinion and external involute spline.

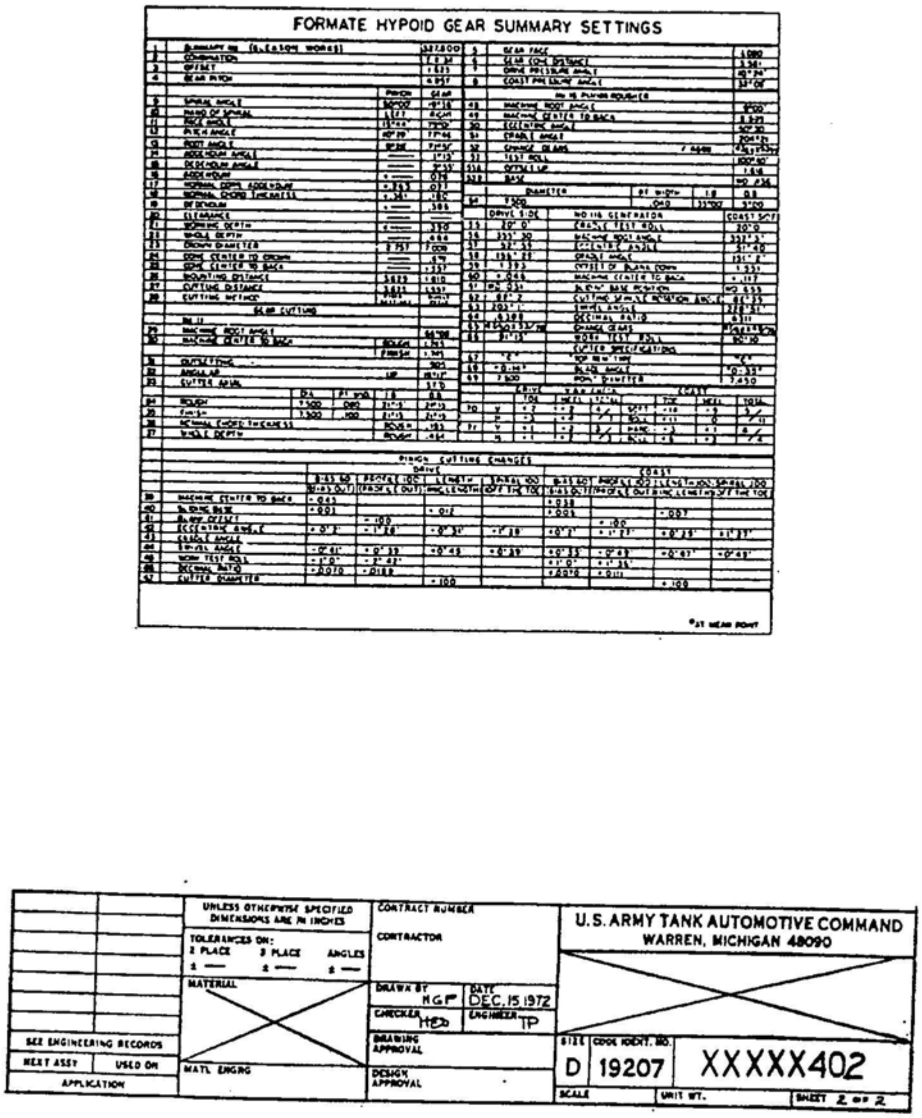


FIGURE 131b. Example drawing of formate hypoid gear summary settings.

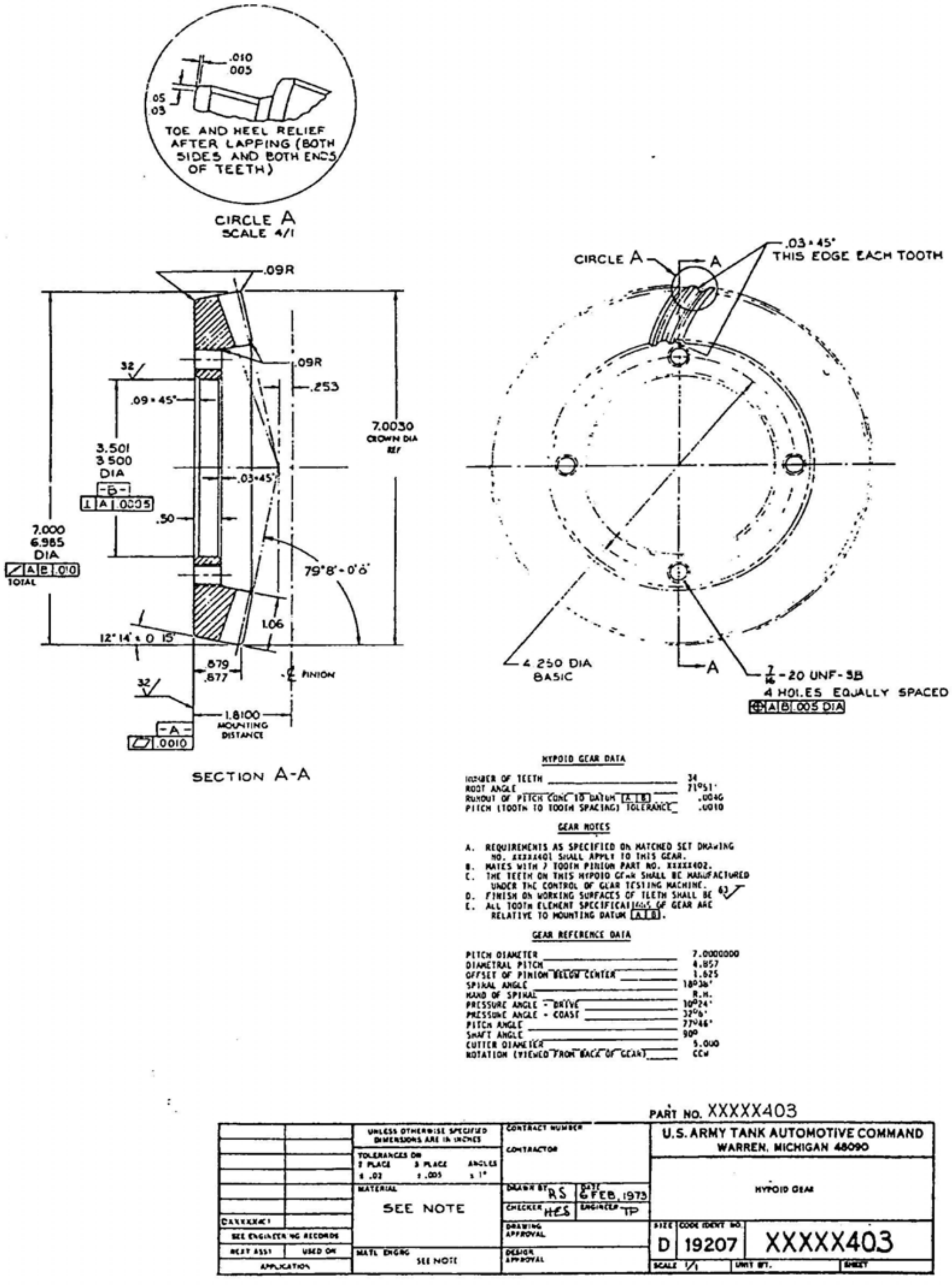


FIGURE 132. Example drawing of hypoid gear.

FIGURE 132. Example drawing of hypoid gear.

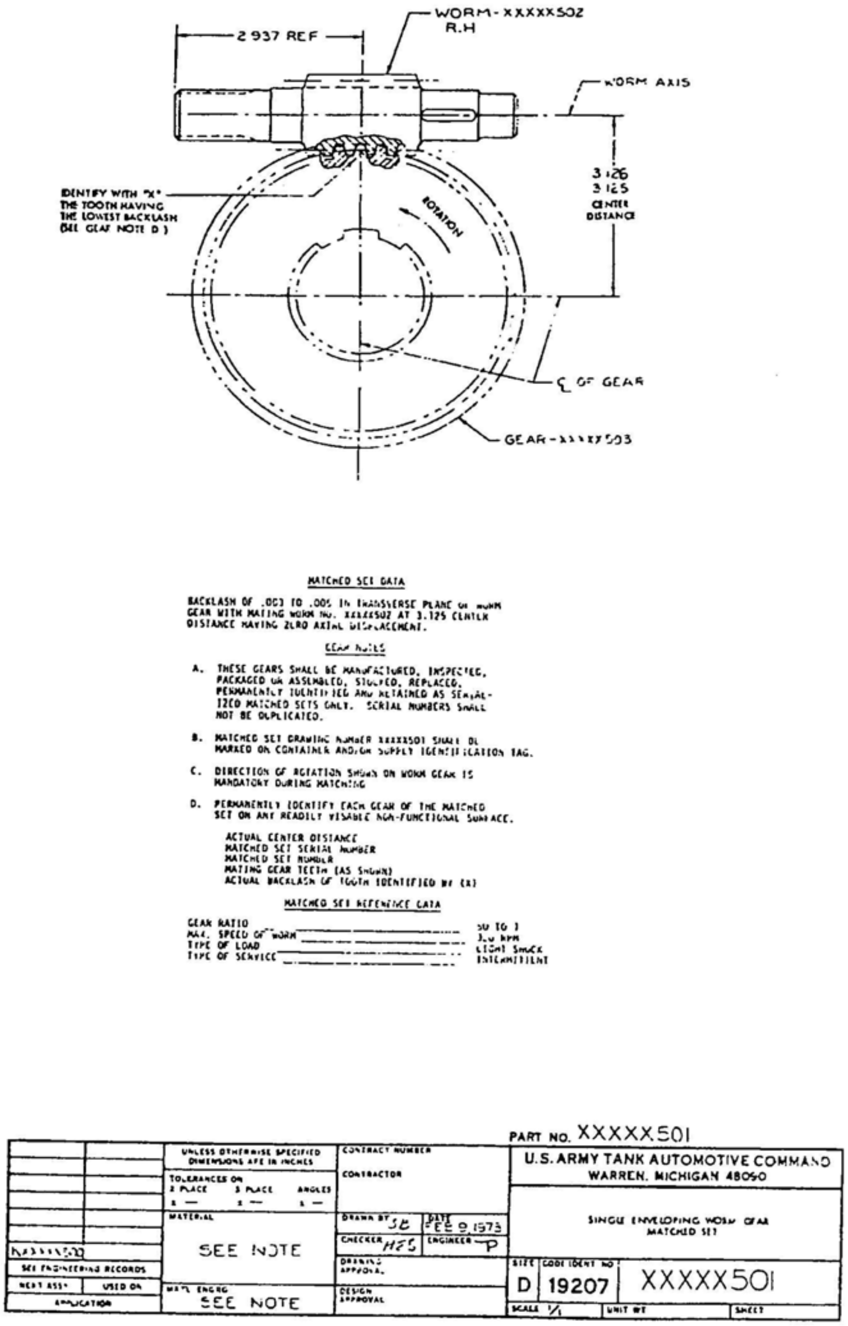


FIGURE 133. Example drawing of single enveloping worn gear matched set.

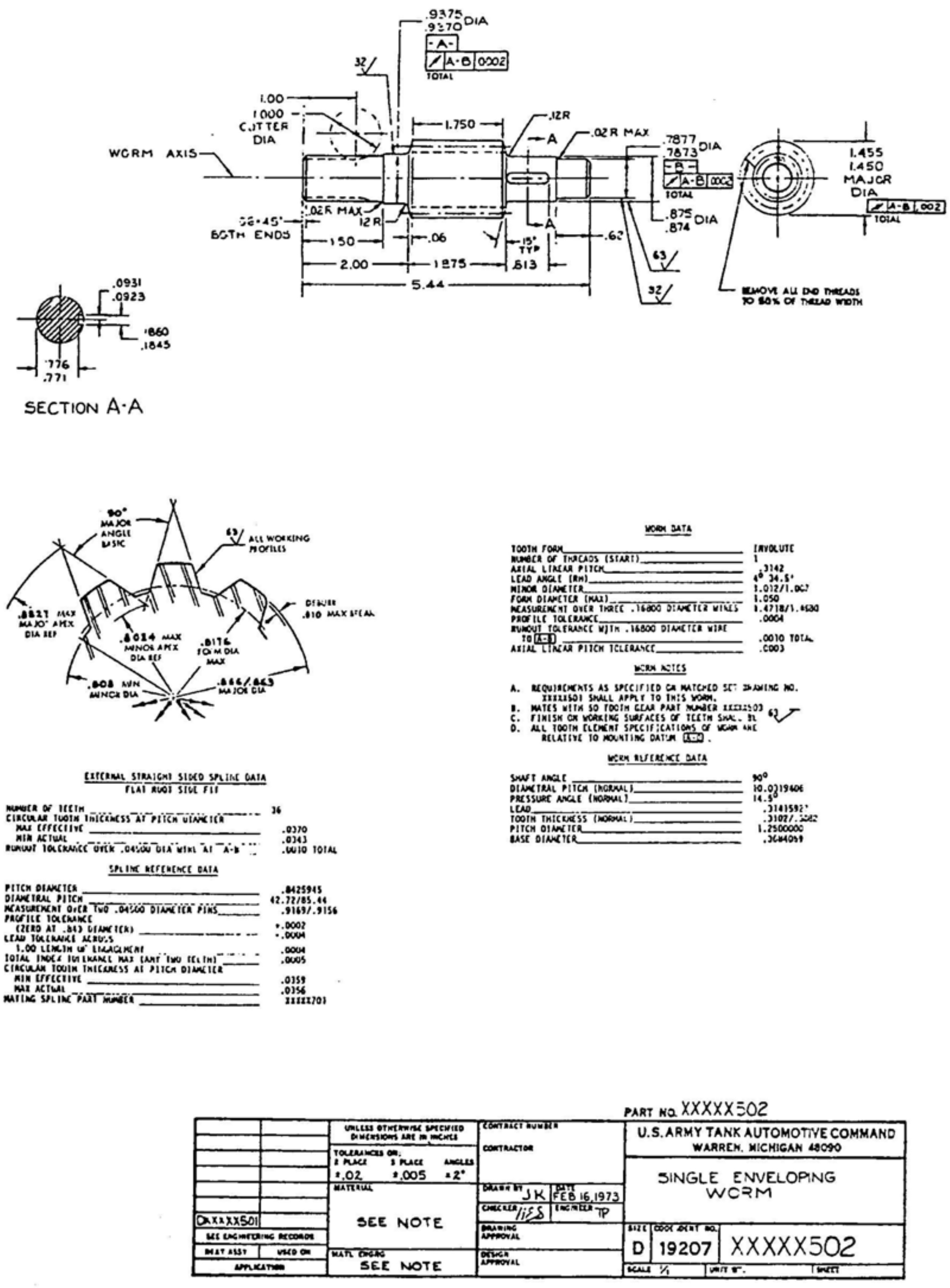


FIGURE 134. Example drawing of single enveloping worm.

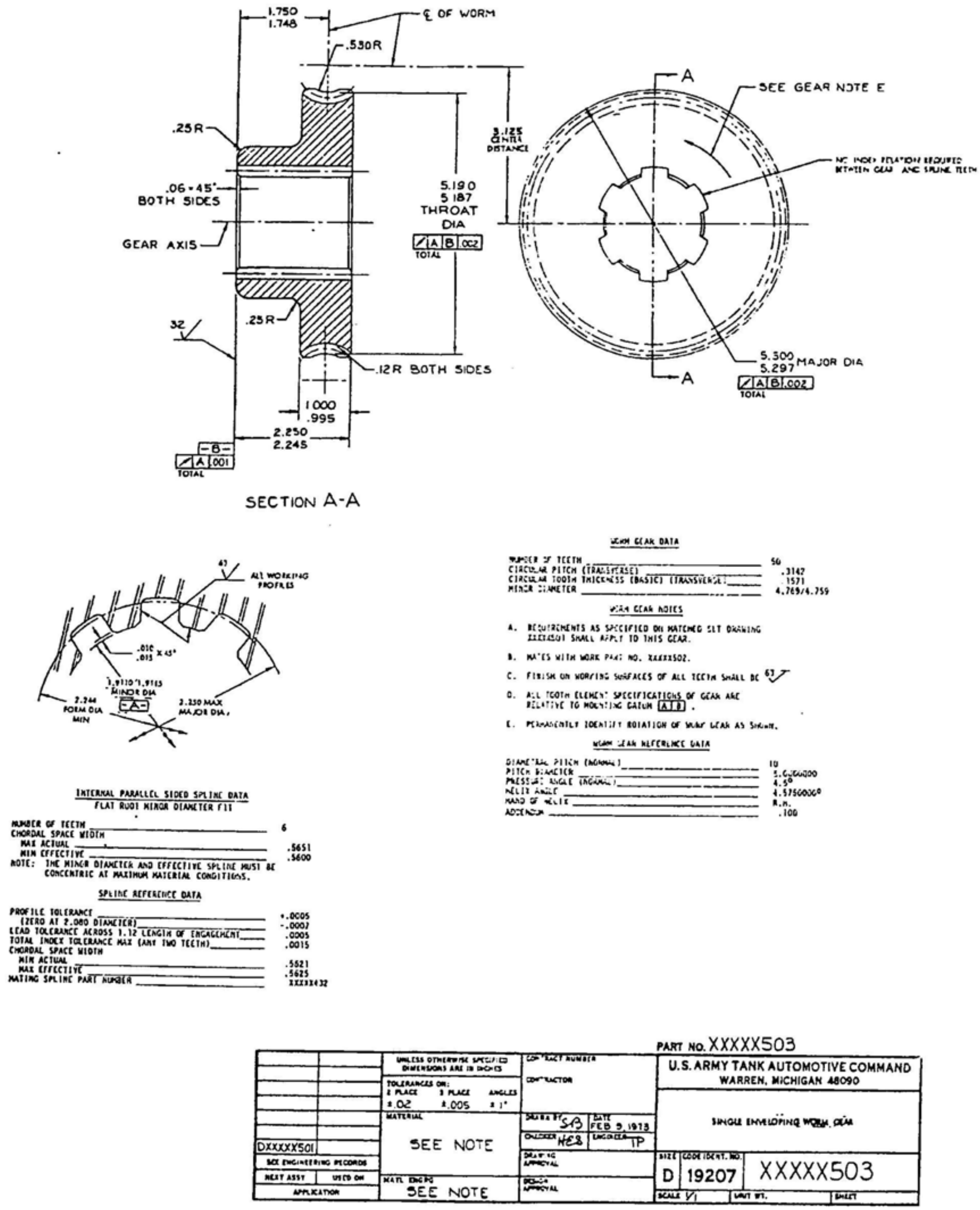


FIGURE 135. Example drawing of single enveloping worm gear.

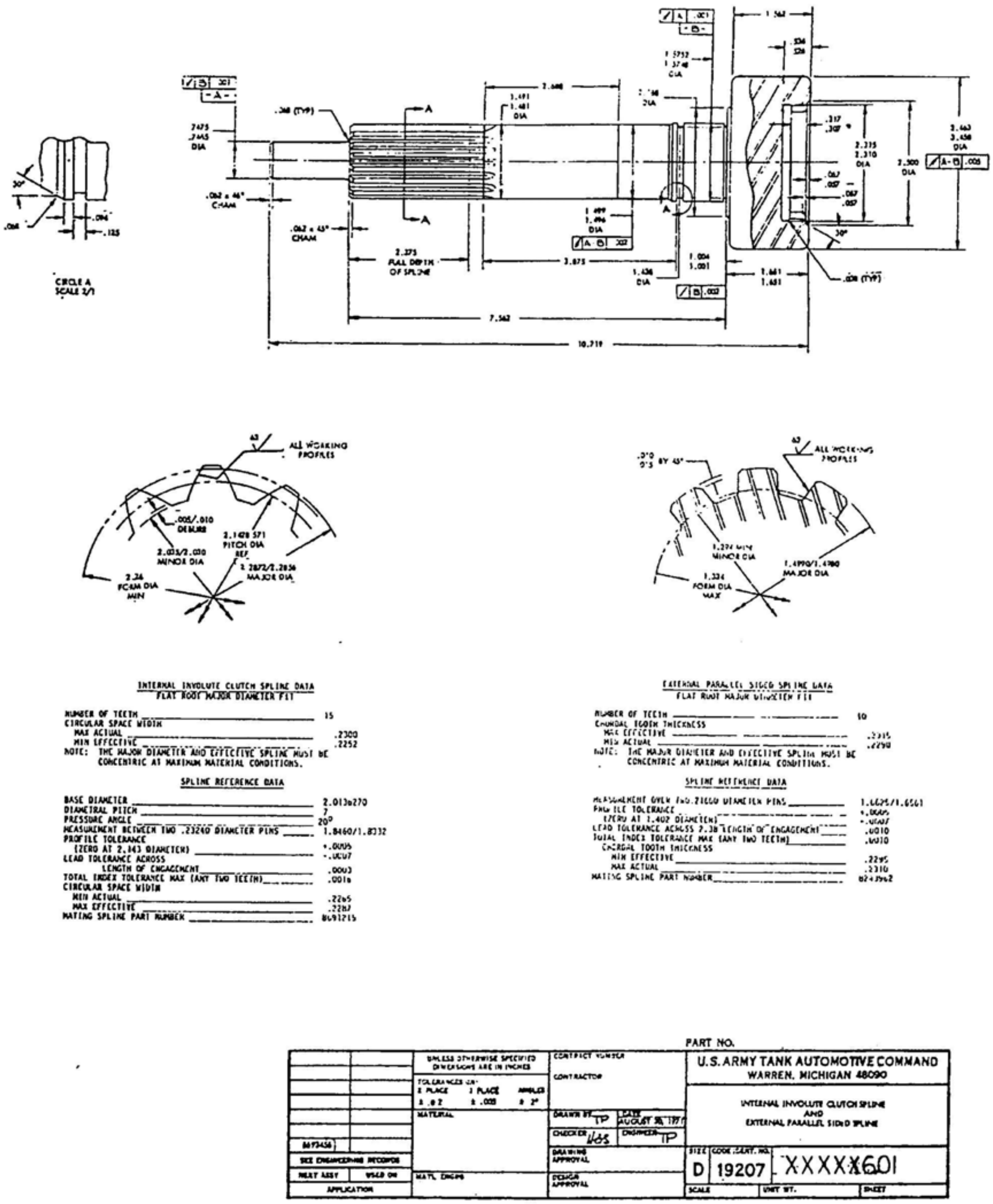


FIGURE 136. Example drawing of internal involute clutch spline and external parallel sided spline.