SECTION 1: INTRODUCTION

1.1 Service Table of Limits:

This Table of Limits is provided to serve as a guide to all service and maintenance personnel engaged in assembly, repair, and overhaul of TITAN® engines. This document is applicable to engine models:

a) O/IO/DIO-320
b) O/IO/DIO-340S
c) O/IO/DIO-360

For more information on suffix designations and their meaning, consult the applicable Operation or Assembly Manual.

When utilizing this document for assembly of a new engine, only the "Mfr. Min. & Max." columns apply. Service limits DO NOT apply.

1.2 Definitions:

REF (1st column)	The numbers in the first column identified as "REF" are shown as a reference number to locate the area described in the "Nomenclature" column. This number will be found in a diagram at the end of each section indicating a typical section where the limit is applicable.
Model (2nd column)	The letter or letter and number in this column are used as symbols to designate the engine models to which the specific limits are applicable.
Nomenclature (3rd column)	This is a brief description of the dimension or fit specified in the adjacent columns and indicated in the diagram at end of each section.
Dimensions (4th & 5th columns)	The dimensions shown in column 4 are the minimum and maximum dimensions for the part as manufactured (i.e. in "new" condition). The dimensions shown in column 5 indicate the service limit that must not be exceeded. Unless it can be restored to these service limits, any part that exceeds this dimension must not be reassembled into an engine. Note only column 4 applies to new assemblies.
Clearance (6th & 7th columns)	Like the dimensions shown in the 4th and 5th columns, the clearance represents the fit between the two mating surfaces as controlled during manufacture and as a service limit representing permissible wear. Clearances may sometimes be found to disagree with limits for mating parts; for example, maximum diameter of cylinder minus minimum diameter of piston exceeds limit for piston and barrel clearance. In such instances, the specified maximum clearance must not be exceeded. Note only column 6 applies to new assemblies.

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1.3 Special Notes:

There are several notes referred to in the following tables. These notes are listed below with their separate definitions.

(A) These fits are either shrink fits controlled by careful assembly, fits that may readily be adjusted, or fits where wear does not normally occur. In each case, the fit must be held to manufacturing tolerance (new limits).

(B) Side clearance on piston rings must be measured with face of ring flush with piston.

(D) The dimensions shown are measured at the bottom of the piston skirt at right angles to the piston pin.

(E) Permissible wear of the crankshaft (rod and main bearing journals) is minus 0.0015 on the diameter.

(F) Measure Valve Guide Height from the valve spring seat counterbore in the cylinder head to the top of valve guide.

(G) Ring gap is measured within 4 inches from bottom. Ring gap at top of travel must not be less than .0075.

(H) Exhaust valves may have exhaust valve guides that are .002 in. over the maximum ID limit, any time up to 300 hours of service. After 300 hours of service, ID of exhaust valve guide may increase .0005 inch during each 100 hour of operation up to the recommended overhaul time for the engine, or not to exceed .008 inch over the basic ID.

(I) Piston skirt clearance is measured approximately 1-inch from the end of the barrel skirt.

(J) Limits for magneto gears are applicable only to those engines utilizing a magneto ignition system.

(K) Engines utilizing the AEC Cold Induction System only.

L Loose fit; wherein a definite clearance is mentioned between the mating surfaces.

(M) No service limits apply to crankcase bearing bores. Furthermore, verification of the size must be made using air gages with masters calibrated to NIST.

T Tight fit; shrink or interference fit.

The illustrations shown are typical of the referenced limit or fit described in the Table and in no instance are these illustrations intended to represent a specific part or engine model unless specified. This table of limits is intended to be used in conjunction with the appropriate TITAN® Engine Manuals.

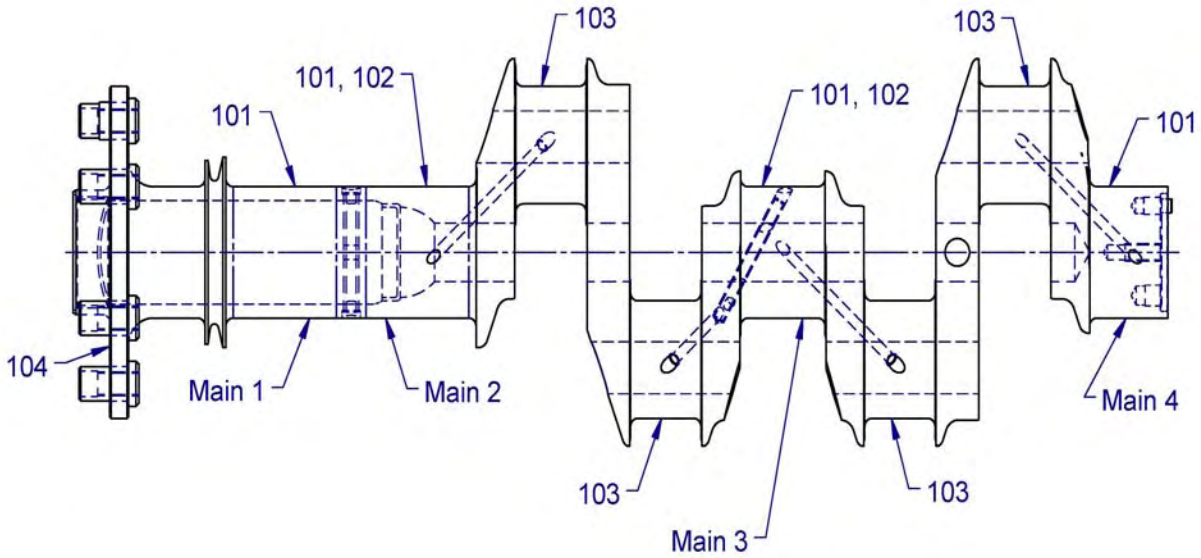
SECTION 2: TABLE OF LIMITS

	REF	Model(s)	Nomenclature	Dimensions		Clearances	
				Mfr. Min. & Max (New)	Service Max.	Mfr. Min. & Max (New)	Service Max.
Crankshaft Inspection	101	ALL	Diameter of Main Bearing Journal on Crankshaft	2.3745 2.3750	**(E)**		
	102	ALL	Crankshaft Run-Out at Center Mains				
			Mounted on No. 1 and 4 Mains Max. Run-Out No. 2 Main			.002	.002
			Mounted on No. 1 and 4 Mains Max. Run-Out No. 3 Main			.005	.0075
			Mounted on No. 2 and 4 Mains Max. Run-Out No. 3 Main			.003	.0045
	103	ALL	Diameter of Connecting Rod Journal on Crankshaft	2.1235 2.1250	**(E)**		
	104	ALL	Crankshaft Prop. Flange Run-Out			.002	.005
Conn. Rod Inspection	105	ALL	Connecting Rod Bearing Bore Diameter (Measured At Axis 30° on Each Side)	2.2870 2.2875			
	106	ALL	Connecting Rod Parallel Convergence			.010 in 10 Inches	
	107	ALL	Connecting Rod Twist			.012 in 10 Inches	
	108	ALL	Finished ID of Connecting Rod bushing	1.1254 1.1262			
Crankshaft and Conn. Rod Assembly	109	ALL	Connecting Rod Bearing and Crankshaft Journal Clearance			.0008L .0038L	.0050L
	110	ALL	Connecting Rod Side Clearance			.004L .010L	.016L
	111	ALL	Fit between Crankshaft Gear and Crankshaft on Diameter			.0005T .0010L	**(A)**
	112	ALL	Fit between Crankshaft Gear and Crankshaft at Mating Flange			NO CLEARANCE PERMISSIBLE	
Crankcase Inspection	113	ALL	Crankcase Bearing Bore Diameter (All Except Front) (Thick Wall Bearing)	2.6865 2.6875	**(M)**		
		ALL	Crankcase Bearing Bore Diameter (All Except Front) (Thin Wall Bearing)	2.566 2.567	**(M)**		
	114	ALL	Crankcase (Front Main) Bearing Bore Diameter (Thin Wall Bearing)	2.566 2.567	**(M)**		
	115	ALL	ID of Lifter Bore in Crankcase	.7187 .7200	.7203		
Camshaft Inspection	116	ALL	Camshaft Main Journal Diameter	1.027 1.028	**(A)**		
	117	ALL	Camshaft Run-Out at Center Bearing Journal			.000 .001	.006

	REF	Model(s)	Nomenclature	Dimensions		Clearances	
				Mfr. Min. & Max (New)	Service Max.	Mfr. Min. & Max (New)	Service Max.
Lifter Assembly Inspection	118	ALL	OD of Lifter Body	.7169 .7177	.7166		
	119	ALL	Hydraulic Plunger Assembly and Lifter Body Clearance			.0010L .0047L	.0067L
	120	ALL	Pushrod Socket and Lifter Body Clearance			.002L .005L	.0070L
Crankcase, Crankshaft, & Camshaft Assembly	121	ALL	Main Bearings and Crankshaft (Thin Wall Bearing, ~.09 Wall)			.0015L .0045L	.0060L
			Main Bearings and Crankshaft (Thick Wall Bearing, ~.16 Wall)			.0011L .0041L	.0050L
	122	ALL	Clearance of Crankshaft and Crankcase Front End Clearance (Crankshaft Against Oil Slinger Face)			.009L .016L	.026L
	123	ALL	Clearance of Front Face of Crankshaft Oil Slinger to Front Face of Recess in Crankcase (Crankshaft Against Thrust Face)			.002L .007L	**(A)**
	124	ALL	Clearance of Lifter Body to Crankcase			.0010L .0033L	.004L
	125	ALL	Clearance of Camshaft to Crankcase Main Journal Diameter			.002L .004L	.006L
	126	ALL	Camshaft End Clearance			.002L .009L	.015L
Cylinder Inspection	201	ALL	Finished ID Exhaust Valve Guide **(H)**	.4985 .4995			
	202	ALL	Finished ID Intake Valve Guide	.4040 .4050			
	203	ALL	Finished ID of Valve Rocker Shaft (Bushing) in Cylinder Head	.6246 .6261	.6270		
	204	ALL	Exhaust Valve Guide Height **(F)**	.765 .785			
	205	ALL	Intake Valve Guide Height **(F)**	.705 .725			
Piston and Rings Assembly	206	ALL	Diameter of Piston Pin	1.1241 1.1246			
	207	ALL	Diameter of Piston Pin Hole in Piston	1.1249 1.1254			
	208	ALL	Piston and Piston Pin Clearance			.0003L .0014L	.0018L
	209	ALL	Piston Ring and Piston Side Clearance (Compression) **(B)**			.0015L .0050L	.008L
	210	ALL	Piston Ring and Piston Side Clearance (Oil Regulating) **(B)**			.002L .004L	.006L
	211	ALL	Piston Ring Gap (Compression) **(G)**			.030 .050	.067
	212	ALL	Piston Ring Gap (Oil Regulating) **(G)**			.015 .030	.047

	REF	Model(s)	Nomenclature	Dimensions		Clearances	
				Mfr. Min. & Max (New)	Service Max.	Mfr. Min. & Max (New)	Service Max.
Cylinder Valve Assembly	213	ALL	OD Exhaust Valve Stem	.4935 .4945			
	214	ALL	OD Intake Valve Stem	.4022 .4030	.4010		
	215	ALL	Exhaust Valve Stem and Guide Clearance			.004L .006L	**(A)**
	216	ALL	Intake Valve Stem and Valve Guide			.0010L .0028L	.006L
	217	ALL	Exhaust Valve and Valve Rotocap Clearance			.000 .004L	.005L
	218	ALL	Piston Skirt Clearance (in Cylinder Bore) **(I)**				.018L
Cylinder Assy to Engine	219	ALL	Connecting Rod Bushing and Piston Pin			.0008L .0021L	.0025L
	220	ALL	OD Valve Rocker Shaft	.6241 .6245	.6231		
	221	ALL	Finished ID of Rocker Arm Bushing	.6252 .6263	.6270		
	222	ALL	Valve Rocker Shaft and Valve Rocker Bushing in Cylinder Head			.0001L .0013L	.0025L
Cylinder Assy to Engine	223	ALL	Valve Rocker Shaft and Valve Rocker Bushing in Rocker Arm			.0007L .0017L	.004L
	224	ALL	Valve Rocker and Cylinder Head – Side Clearance			.005L .013L	.016L
	225	ALL	Dry Lifter Clearance			.028L .080L	
Idler Gear & Engine Assy	301	ALL	Crankshaft Idler Gear and Crankshaft Idler Gear Shaft Clearance			.001L .003L	.005L
	302	ALL	Crankshaft Idler Gear(s) End Clearance			.005L .040L	.055L
Oil Pump & Accessory Case Assy	303	ALL	Width of Oil Pump Impellers	.747 .749	.746		
	304	ALL	Oil Pump Drive Shaft and Oil Pump Body			.0010L .0025L	.004L
	305	ALL	Oil Pump Drive Shaft and Accessory Case			.0015L .0030L	.006L
	306	ALL	Oil Pump Impellers Diameter Clearance			.002L .006L	.008L
	307	ALL	Oil Pump Impeller Side Clearance			.002L .0045L	.005L
	308	ALL	Oil Pump Idler Impeller Shaft and Oil Pump Body			.0005L .0020L	.003L
	309	ALL	Oil Pump Idler Impeller Shaft and Accessory Case			.0010L .0025L	.0035L

	REF	Model(s)	Nomenclature	Dimensions		Clearances	
				Mfr. Min. & Max (New)	Service Max.	Mfr. Min. & Max (New)	Service Max.
Fuel Pump Drive & Accessory Case Assy	310	O & DIO Models	Fuel Pump Plunger and Accessory Case			.0015L .003L	.005L
	311	IO Models	Fuel Pump Idler Gear and Shaft Clearance			.001L .003L	.005L
	312	IO Models	Fuel Pump Idler Gear End Clearance			.010L .045L	.055L
	313	IO Models	Fuel Pump Drive Shaftgear and Adapter Clearance			.0010L .0025L	.004L
	314	IO Models	Fuel Pump Drive Shaftgear End Clearance			.035L .069L	.079L
Accessory Gear Train Assy	315	ALL	Prop Governor Gear and Adapter Clearance			.0010L .0025L	.005L
	316	ALL	Prop Governor Gear End Clearance			.002L .024L	.034L
	317	ALL	Vacuum Pump Gear and Adapter Clearance			.0010L .0030L	.0045L
	318	ALL	Vacuum Pump Gear End Clearance			.010L .057L	.075L
	319	ALL	Tachometer Shaft and Accessory Case Clearance			.0015L .0035L	.006L
	320	**(J)**	Magneto Gear and Bushing in Magneto			.0015L .0035L	.0055L
Gear Backlash	401	ALL	Crankshaft Idler Gear(s) and Crankshaft Gear Backlash			.004 .015	.020
	402	ALL	Camshaft Gear and Crankshaft Idler Gear Backlash			.004 .015	.020
	403	ALL	Oil Pump Impellers Backlash			.008 .015	.020
	404	IO Models	Fuel Pump Idler Gear and Crankshaft Idler Gear Backlash			.004 .015	.020
	405	IO Models	Fuel Pump Idler Gear and Fuel Pump Drive Gear Backlash			.004 .015	.020
	406	ALL	Camshaft Gear and Vacuum Pump Gear Backlash			.004 .015	.020
	407	ALL	Propeller Governor Drive Gear and Crankshaft Idler Gear Backlash			.004 .015	.020
	408	**(J)**	Magneto Drive Gears and Crankshaft Idler Gears Backlash			.004 .015	.020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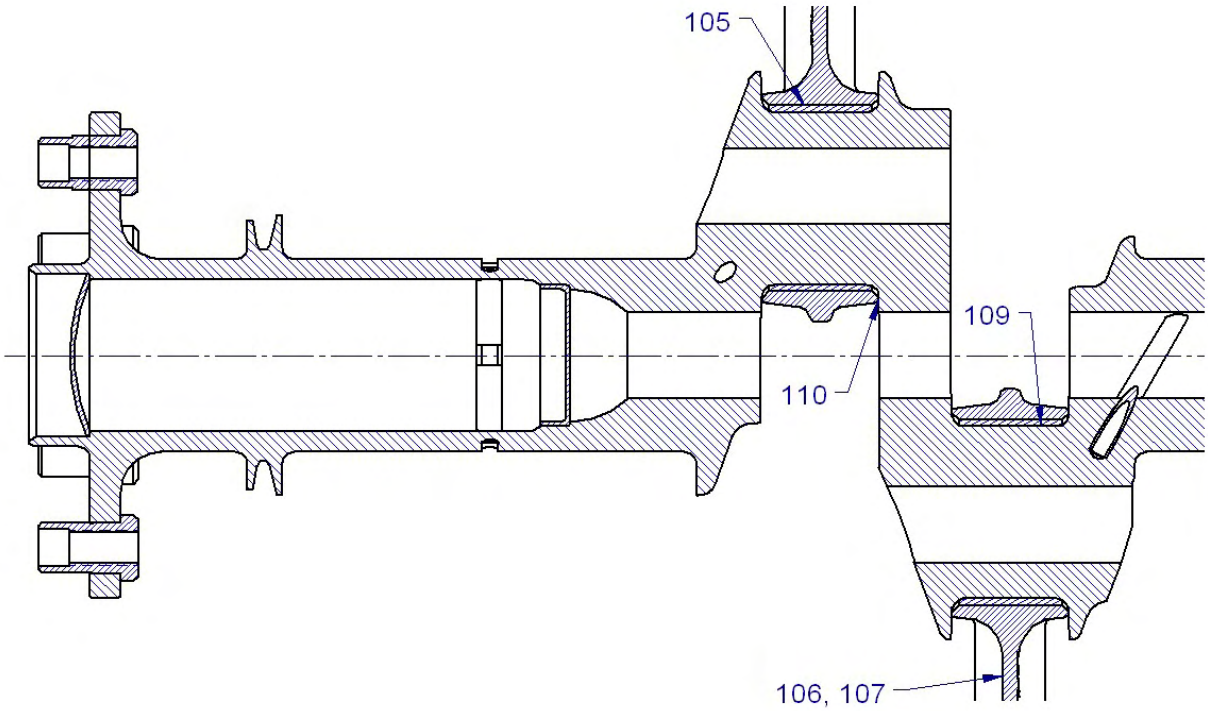
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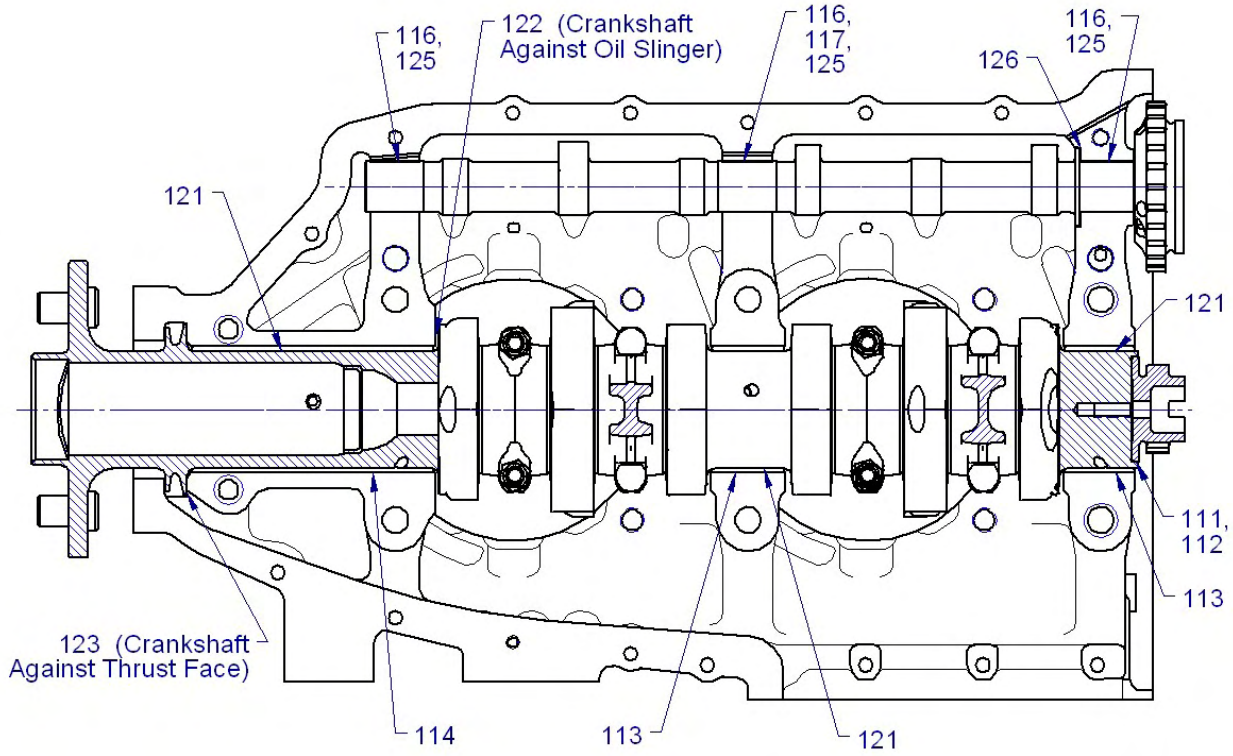
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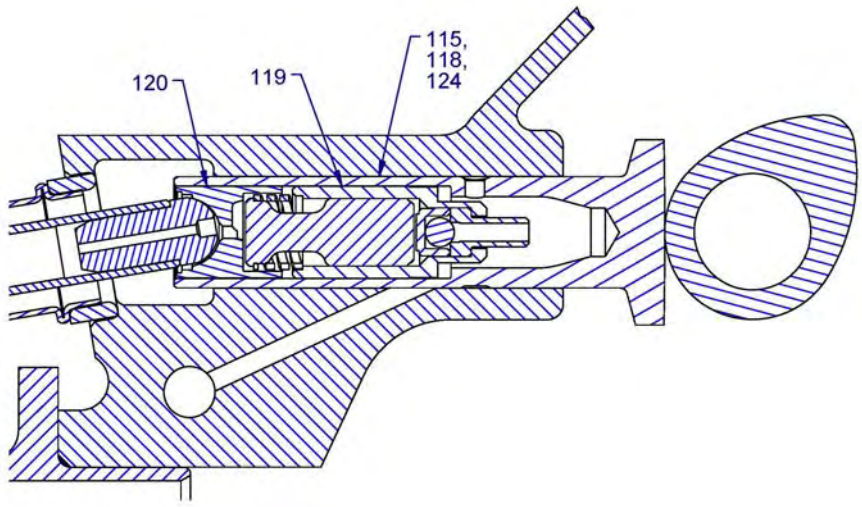
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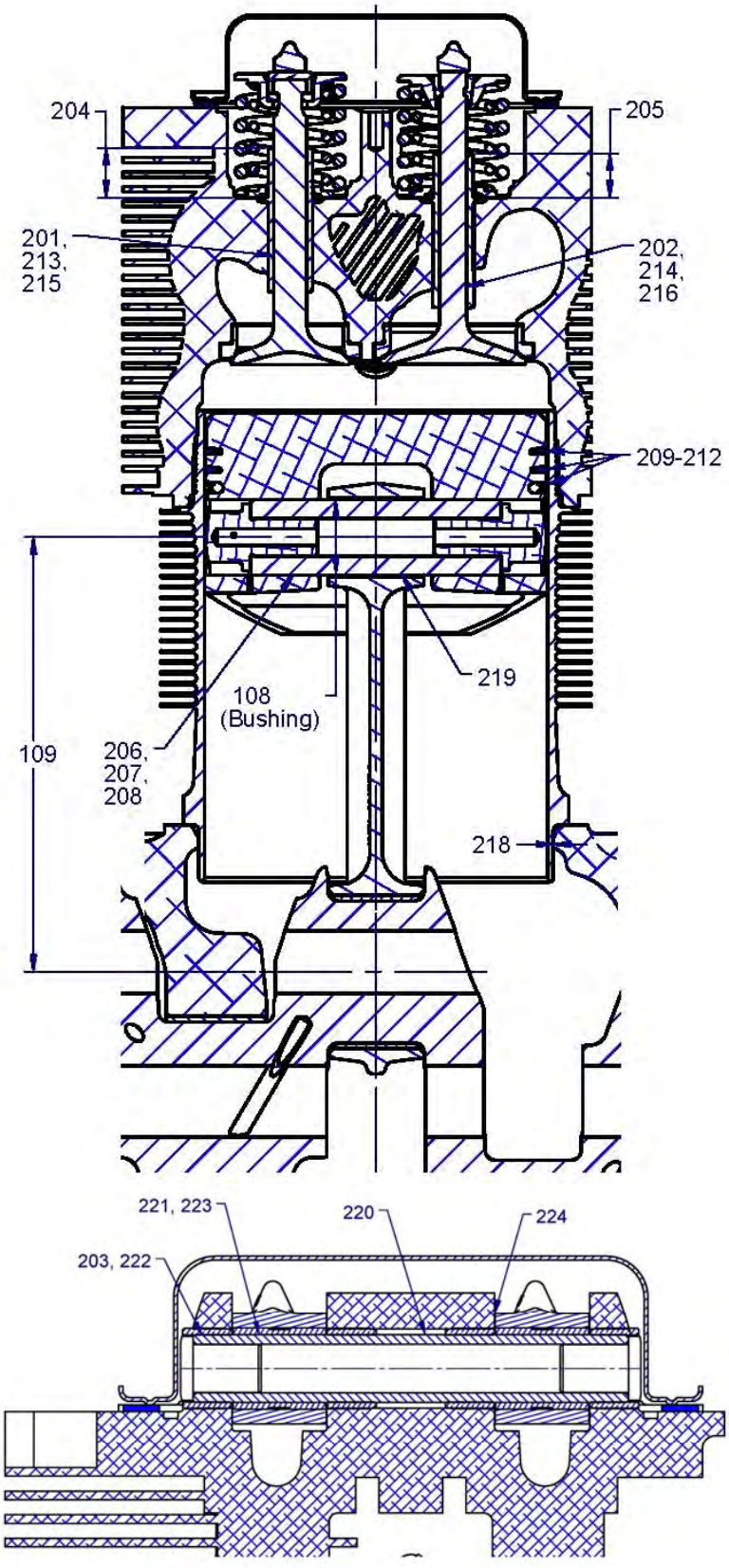
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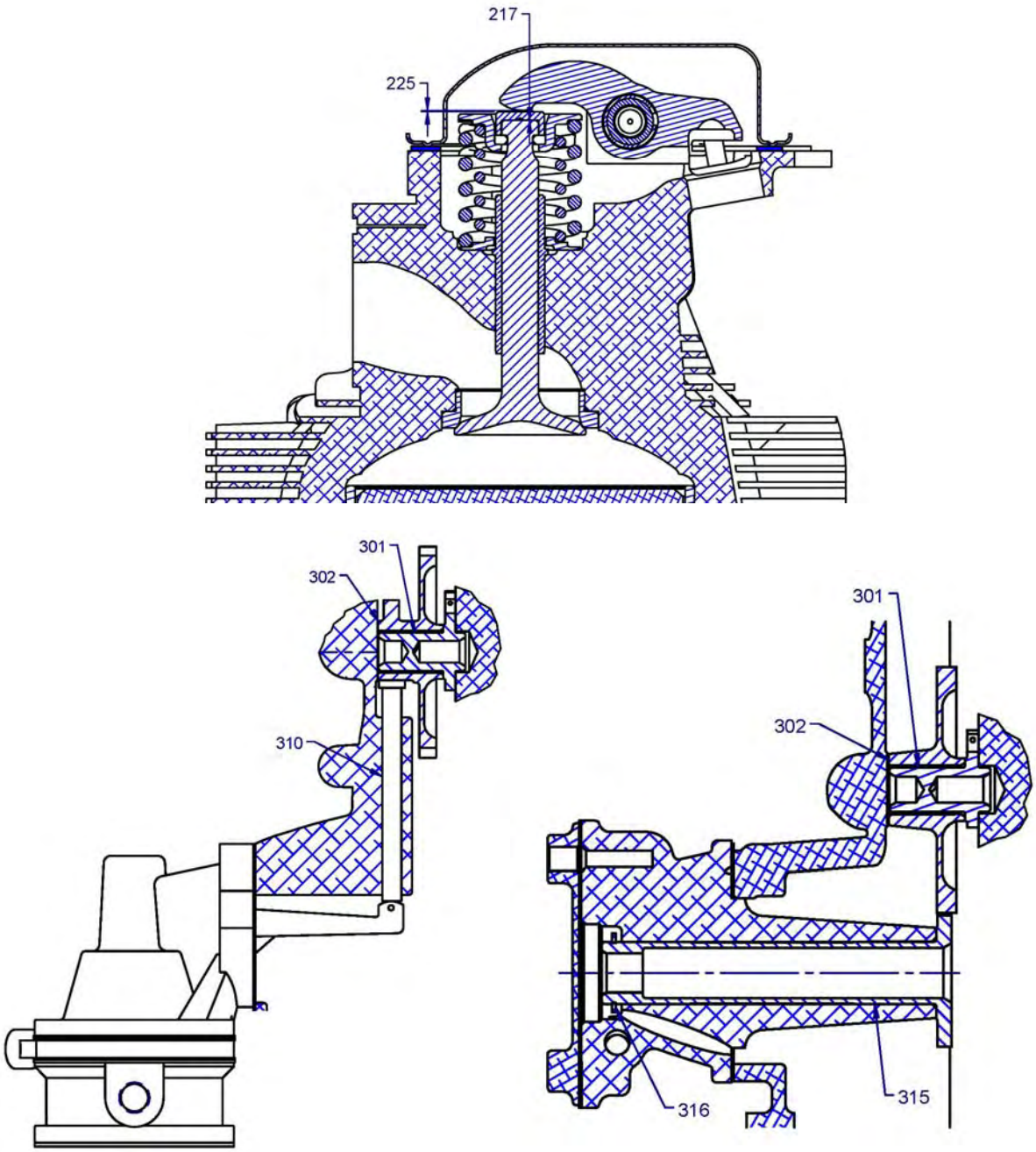
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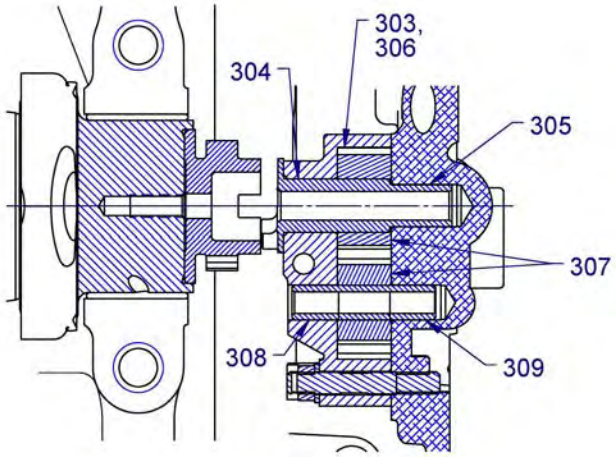
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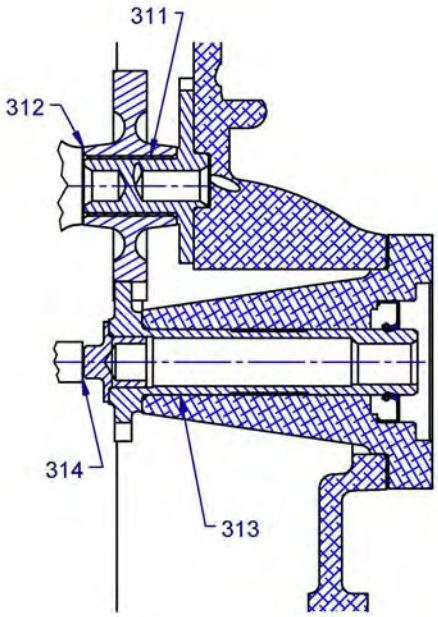
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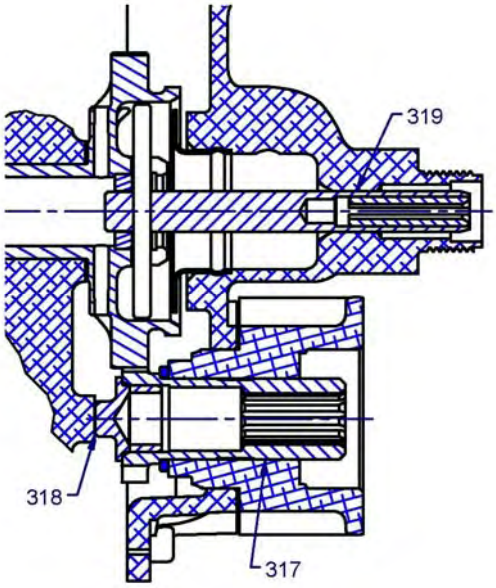
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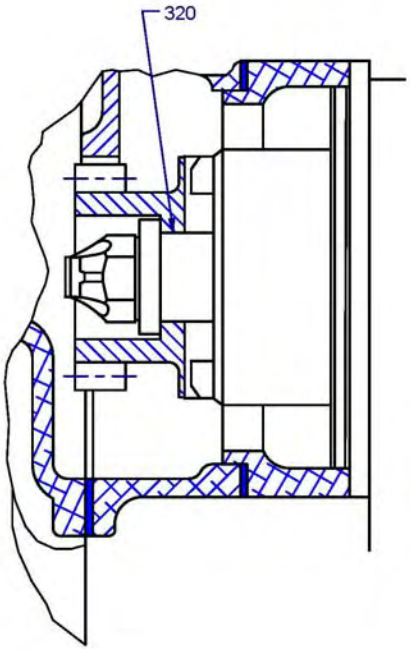
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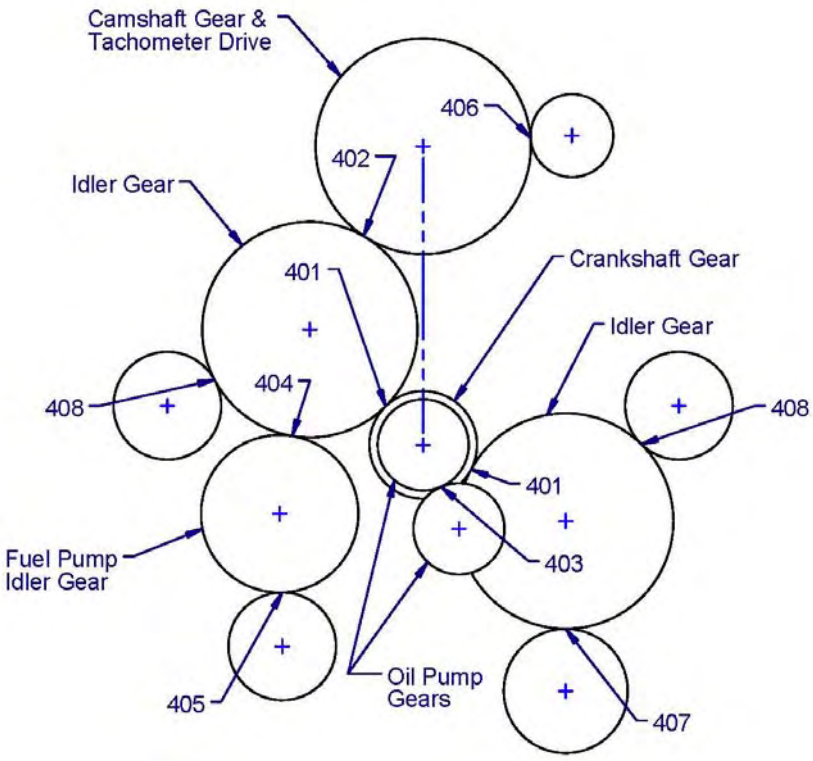
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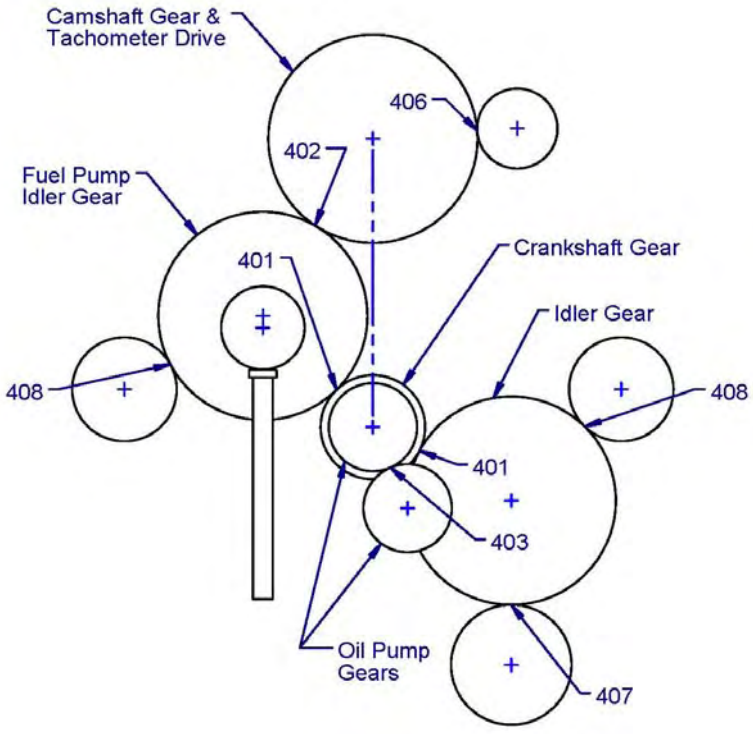
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SECTION 3: SPRING INSPECTION DATA

REF	Model(s)	Nomenclature	Part No.	Wire Data (in)	Free Length (in)	Length at Comp. Load (in)	Compressed Load (lbs)		
							Mfr. Min.	Mfr. Max.	Service Min.
701	ALL	Outer Valve Springs	AEL11800	.177	2.50	1.30	112	122	109
702	ALL	Inner Valve Spring	AEL11795	.135	1.94	1.17	61	67	58
703	ALL	Oil Pressure Relief Valve Spring	AEL61084	.054	2.18	1.30	8.5	9.5	8.3
			AEL68668	.054	2.04	1.30	7.1	7.8	6.9
			AEL77467	.054	1.90	1.30	6.4	7.1	6.2
			AEL11713	.059	2.12	1.44	10.8	11.9	10.5
			AEL18085	.065	1.94	1.40	14.5	15.5	14.2
704	ALL	Oil Cooler Bypass Spring		.0465		1.94	6.50	7.25	6.41

SECTION 4: STUD SETTING HEIGHTS & DRIVING TORQUES

REF	Part No.	Thread Size	Stud Location and Function	Torque Limits (in-lbs)	Setting Height (in)
801	AEL25C9	1/4-20UNC	Pushrod Shroud Retainer Stud (Cylinder Head)	15	.48
802	AEL25C10	1/4-20UNC			
803	AEL31C12	5/16-18UNC	Exhaust Port Studs (Cylinder Driving Torque)	40	.81
804	AEL38-13	3/8-16UNC	Cylinder Hold Down Studs (Crankcase Driving Torque)	100	.78–82
805	AEL50-15	1/2-13UNC	Cylinder Hold Down Studs (Crankcase Driving Torque)	250	.84–.88
806	AEL38D17	3/8-16UNC	Stud above Camshaft (Crankcase Driving Torque)	100	1.27–1.36
807	AEL75154		Anchored Thrubolt (Crankcase)	250	5.47–5.54
808	AEL31C12	5/16-18UNC	Starter Mount Pad Stud, Rear (Crankcase)	25	.70–.74
809	AEL31C13	5/16-18UNC	Starter Mount Pad Stud, Front (Crankcase)	25	.90–.94
810	AEL13793	5/16-18UNC	Idler Gear Shaft Stud (Left Boss, Crankcase)	25	.49–.53
811	AEL61400	1/4-20UNC	Oil Sump Flange Studs (Crankcase Gasket Surface)	15	.63
812	AEL25C12	1/4-20UNC			.95
813	AEL31C15	5/16-18UNC	Carburetor/Injector Mount Studs (Oil Sump)	25	1.13
814	AEL25C22	1/4-20UNC	Vaccum Pump Pad Studs (Accessory Case with Vacuum Pump Adapter)	15	2.25
815	AEL31C12	5/16-18UNC	Right Magneto Pad Studs (Accessory Case)	25	.94
816	AEL31C19	5/16-18UNC	Left Magneto Pad Studs (Accessory Case)	25	1.81
817	AEL31C12	5/16-18UNC	Left Magneto Pad Studs (Electronic Ignition System Ready, Accessory Case)	25	.94
818	AEL31CD17	5/16-18UNC	Oil Pump Studs (Accessory Case)	25	1.47
819	AEL31C12	5/16-18UNC	Prop Governor Pad Studs (Accessory Case)	25	.75
820	AEL31C19	5/16-18UNC	Fuel Pump Pad Studs (IO Prefix only, Accessory Case)	25	1.72

NOTE: Unless otherwise specified, the stud setting height may vary by ±1/32 inch.

SECTION 5: SPECIAL TORQUE REQUIREMENTS

REF	Model(s)	Thread Size	Nomenclature	Torque Limits (in-lbs)
901	ALL	3/8-24UNF	Connecting Rod Nuts	480
902	ALL	1/2-20UNF	Cylinder Hold Down Nuts	600
903	ALL	3/8-24UNF	Cylinder Hold Down Nuts	300
904	ALL	1/4-20UNC	Slotted Nuts on Lower Crankcase Rib	55–60
905	ALL	3/8-24UNC	Slotted Nut behind Camshaft Gear on Crankcase	300
906	ALL	1/4-20UNC	Pushrod Shroud Retainer Nut	50
907	ALL	1/4-20UNC	Rocker Box Screws	50
908	ALL	5/16-18UNC	Oil Pump Attachment Nuts	150–204
909	IO Models	1/4-20UNC	Fuel Pump Idler Gear Shaft Bolts	70–80
910	ALL	1 1/4-12UNF	Oil Pressure Relief Valve	300 min. Tighten 90° after contact
911	ALL	1-1/8-12UNF	Oil Fill Tube	300
912	ALL	1/4 Hex Head and Below	Hose Clamps (Worm Type)	20
	ALL	5/16 Hex Head and Above	Hose Clamps (Worm Type)	45
913	ALL		B-Nut on Cylinder Oil Drain Tubes	75–125
914	ALL	1/4-18NPT	Prop Governor Elbow in Crankcase	130
915	ALL	9/16-18UNF	Nut on Adjustable Elbow on Prop Governor Adapter	110
916	ALL		B-Nuts on Prop Governor Oil Line	215–280
917	ALL	1-14UNS	Temperature Control Valve or Plug	300
918	ALL	3/4-16UNF	Oil Filter	192–216
919	O & DIO Models	9/16-18UNF	Nut on Adjustable Elbow on Diaphragm Fuel Pump	110
920	ALL	3/8-16UNC	Allen Head Screw (Diaphragm Fuel Pump)	225–250
921	IO & DIO Models	1/8-27NPT	Injector Nozzle or Primer Nozzle in Cylinder Head	55–60
922	IO & DIO Models	1/8-27NPT	Fittings and Pipe Plugs in Manifold Valve	50–60
923	IO & DIO Models		B-Nuts on Fuel Injection and Primer Lines	40–45
924	IO & DIO Models	#10-24UNC	Screws attaching Fuel Manifold Valve to Bracket	15–20
925	IO & DIO Models	1/4-20UNC	Screw attaching Fuel Manifold Bracket to Crankcase	40–50
926	**(K)**	5/16-18UNC	Socket Head Screws securing Throttle Body or Servo to Cold Induction Plenum	70–80
927	ALL		Fuel Hoses (#4, Steel Fittings)	135–190
928	ALL		Fuel Hoses (#6, Steel Fittings)	215–280
929	IO Models	5/16-18UNC	Fuel Pump Attachment Nuts	144–180
930	**(J)**		Magneto Nut (to attach gear to magneto)	120–300
931	**(J)**	10-32UNF	Magneto Plate Screws (To attach ignition cable outlet plate to magneto)	15
932	ALL	18MM	Spark Plugs	420
933	ALL	14MM	Spark Plugs	180
934	ALL	5/8-24UNEF	Spark Plug Lead B-Nut	90–95
935	ALL	3/4-20UNEF	Spark Plug Lead B-Nut	110–120
936	ALL	5/16-18UNC	Idler Shaft Bolts	200
937	ALL	5/16-18UNC	Idler Shaft Nut	150–200

SECTION 6: STANDARD TORQUE

(UNLESS OTHERWISE LISTED ABOVE)

6.1 General Torque: Bolts, Screws, & Nuts

Table 1: Bolts, Screws, & Nuts

Nominal Thread	Torque		Thread	Torque	
	(in-lbs)	(ft-lbs)		(in-lbs)	(ft-lbs)
#10	49	———	1/2	900	75
1/4	96	———	9/16	1320	110
5/16	204	17	5/8	1800	150
3/8	360	30	3/4	3240	270
7/16	600	50			
THIN NUTS (1/2 DIA OF BOLT) - 1/2 LISTED TORQUE					

6.2 General Torque: Pipe Plugs & Fittings

Table 2: Pipe Plugs & Fittings

Thread (NPT)	Torque (in-lbs)
1/16-27	40
1/8-27	40
1/4-18	85
3/8-18	110
1/2-14	160

6.3 General Torque: Crush Type Gaskets

Table 3: Crush Type Gaskets

Thread Pitch (threads per inch)	Angle of Turn
8	67°
10	67°
12	90°
14	90°
16	135°
18	135°
20	135°
24	180°
28	180°

6.4 Prop Attaching Bolts: Torque limits for propeller attaching bolts to be supplied by propeller or airframe manufacturer.

6.5 Notes:

1. Install all crush type gaskets with the broken surface against the housing into which the plug or part is being threaded. Turn the part until the sealing surfaces are in contact and then tighten to the angle of turn listed for the appropriate thread size.

2. Lubricate threads using 50 weight aviation engine oil unless a specific lubricant is designated unless otherwise specified.