Fundamentals
M7
MAINTENANCE PRACTICES

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M7.6
Fits and Clearances

EASA Part-66
CAT B1

Training Manual

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M7 MAINTENANCE PRACTICES

M7.6 FITS AND CLEARANCES

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COMMON FITS AND CLEARANCES

Fits

System of Fits

A fit specifies how tight or loose a connection between two interleaved parts is. Instead of “fit“ the denomination “seat“ was used in the past.

In the single-part-production the parts which have to be assembled are matched individually. In mass production this would be noneconomic. The components have to be, independently from whom or where they have been produced, assembled without rework and in case interchanged.

This **interchange construction** is only possible, if there are common guidelines (standards) for fits. So in the course of time company standards for fits. then **DIN** standards for fits (for Germany) and finally international standards for fits ISO (**I**nternational **O**rganization for **S**tandardization) were developed.

Shaft

A “Shaft“ is the denomination in the standards for fits for every round part, which should be joined into a hole, despite it might normally be called pin, axis, bolt or stud.

Basic Size (Nominal Size)

The basic size is the developed size in the design of the part and noticed in the drawing; look opposite, there are for example the basic sizes 40, 20 and 30.

Tolerance

The basic size can not be complied exactly in the production process. A certain difference has to be tolerated. The tolerance specifies which difference between the upper and lower limit has to be tolerated.

Base Line

At the base line the deviation from the basic size is zero. The dimension 0 is not described in the drawing in the case that no misunderstanding is expected. On opposite in case d the lower limit is = 0.

Upper Limit

The upper limit is the highest allowed size in the production. You can calculate it from the basic size and the upper deviation:

(Case c: Upper limit= 30 mm — 0,04 mm = 29,96 mm).

Lower Limit

The lower limit is the lowest allowed size and can be calculated from the basic size and the lower deviation.:

(Case c: Lower limit = 30 mm — 0,06 mm = 29,94 mm).

Actual size

Is the actual size of the component (Finished size).

Examples:

+ 0,009 upper deviation

Example: Basic size D = 25

- 0,004 lower deviation

Upper limit = 25mm + 0,009mm= 25,009mm

Tolerance =25,009mm - 24,996mm = 0,013mm

Lower limit = 25mm - 0,004mm = 24,996mm

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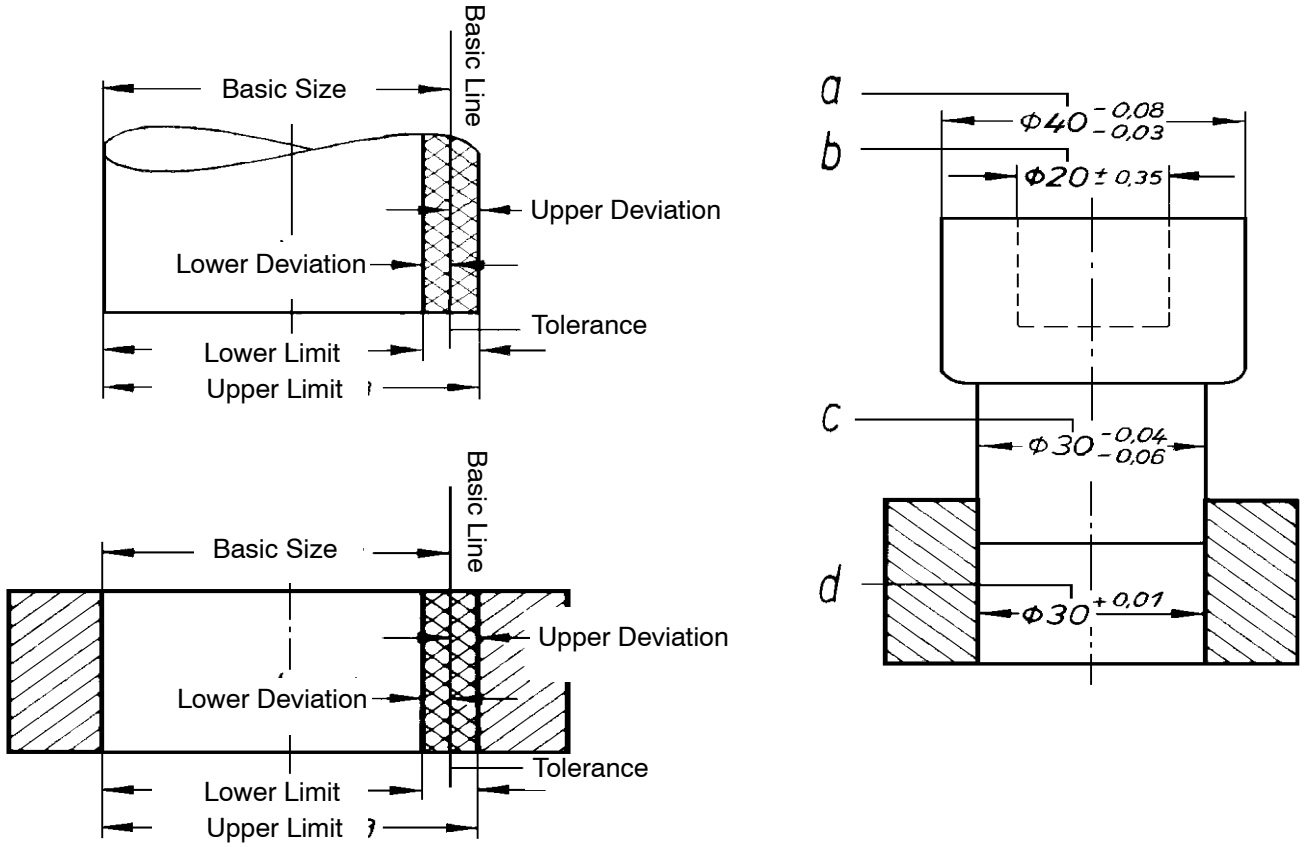


Figure 1 Fits and Clearances

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Clearance and Interference

Clearance

Clearance is the difference between the diameters of a shaft and a hole if the hole diameter is larger then the shaft diameter. Due to the fact that both, shaft and hole, have a certain tolerance, the parts have normally different clearances when looking at large quantities.

The maximum clearance will result if a shaft at the lower limit diameter is joined with a hole at the upper limit diameter.

The minimum clearance will result through a combination of upper limit diameter shaft and lower limit diameter hole.

Interference

Interference is the difference between the diameters of a shaft and a hole if the shaft diameter is larger then the hole diameter. The tolerances of the shaft and the hole generate a upper and a lower interference.

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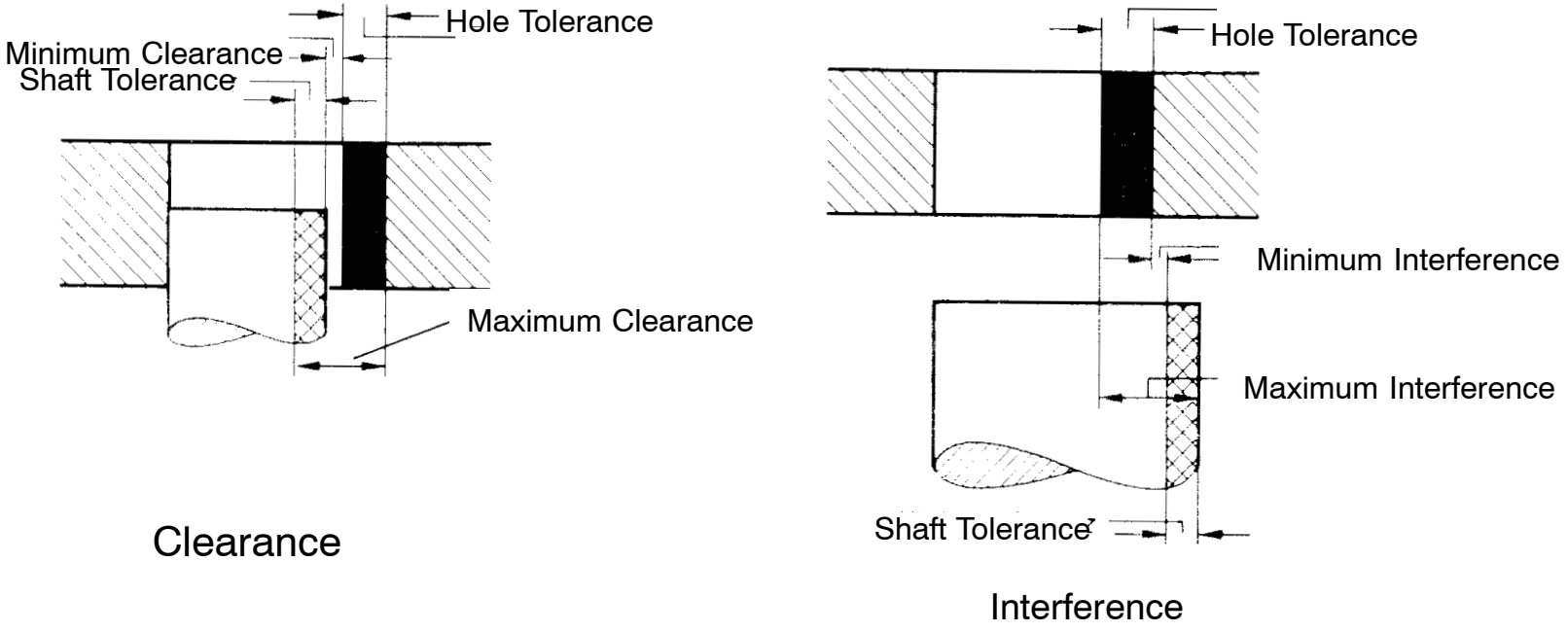


Figure 2 Clearance and Interference

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Systems and Types of Fits

General

To create different fits in the production process you can choose between the hole basis system of fits and the shaft basis system of fits.

The Hole Basis System of Fits

In the hole basis system of fits all hole diameter are created in **H–Tolerance** regardless of the desired fit.

The lower limit diameter of each hole goes up to the basic line and is equal to the basic size. The upper limit diameter is larger then the nominal diameter with the value of the tolerance.

The hole basis system of fits is used for components of machine tools, power machines, cars, railroads and aircrafts.

The Shaft Basis System of Fits

In the shaft basis system of fits all shafts are produced with a **h–Tolerance,** regardless of the desired fit. The upper limit diameter of the shaft goes up to the basic line and is equal to the basic size. The lower limit diameter of the shaft is smaller then the basic size with the value of the tolerance.

The shaft basis system is used for components for transmissions, hoists, weaving machines, agricultural machines and fine mechanics.

TYPE OF FITS

General

Depending on the application, the joined components are produced with a specific clearance or interference. Therefor it is made a difference between the types of fits:

Clearance Fit

In this assembly there is a space between the two parts., e. g. bearings.

Transition Fit

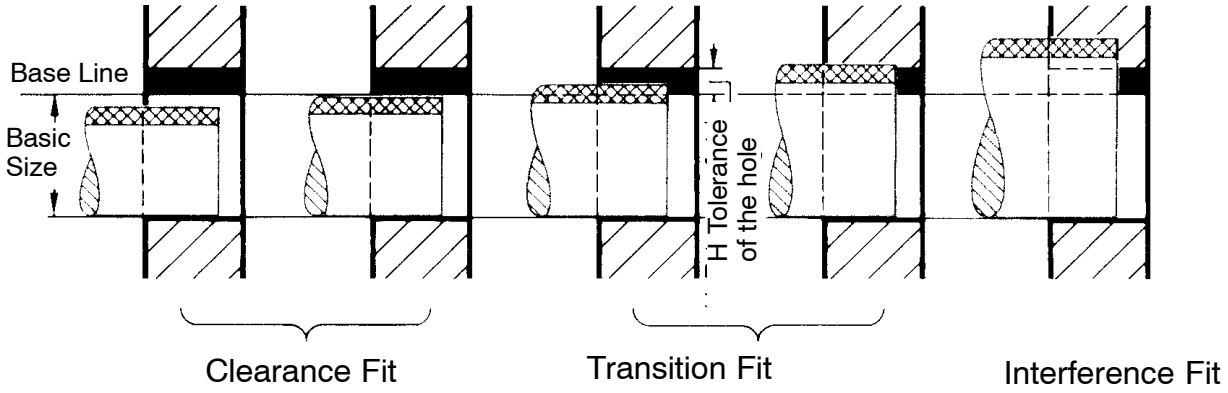
This is a range of fits which can be either clearance or interference. Here the tolerance fields of hole and shaft are overlapping.

Interference Fit

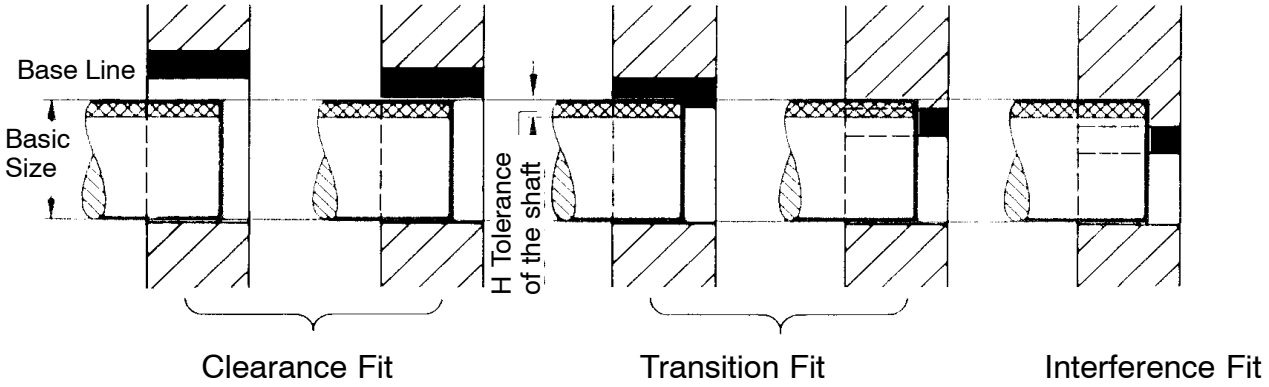
In this fit there is always a interference before the assembly, e. g. a bearing bushing in the corresponding housing.

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Hole Basis System of Fits



Shaft Basis System of Fits

Figure 3 Systems and Types of Fits

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DRILL SIZES OF HOLES FOR FASTENING ELEMENTS

GENERAL

When a repair of the airframe is done the tolerances of holes for the fastener, that will be inserted, have normally to be taken out of the Structural Repair Manual (SRM ATA 51–4X-XX).

Inside the SRM's the appropriate tolerances for the holes are listed in a tabular form. The type of fastener, the specified type of fit and the material in which the fastener will be inserted has to be taken into account, when choosing the right tolerance.

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A340-200/300
STRUCTURAL REPAIR MANUAL
FASTENERS - HOLE AND DRILL DATA - METALLIC STRUCTURE

1. General

A. This topic gives the specified hole dimensions referred to the applicable type of fastener and general drilling information.

B. Table 21 shows a list of the applicable standard twist-drill sizes necessary for the fastener holes. These drills are available from general tool suppliers.

C. Special tools (for example drill reamer, hand reamer, etc.) necessary for making the special hole for TAPER-LOK fastener are given in Chapter 51-42-11.

2. Hole Data

A. General

(1) The dimensions of a fastener hole have an important relation to the strength of the fastened joint.

(2) Clearance fit, transition fit or interference fit fasteners are used depending on the loading.

(3) Deburr the hole using suitable deburring tool.

NOTE: A twist-drill is not permitted for this step.

B. Hole Sizes

(1) The hole dimensions given in this Paragraph are standard to the aircraft structure.

(2) The necessary dimensions for the radius and chamfer of the hole are given in Figure 1 and Table 2.

(3) Refer to Chapter 51-40-00 to identify the applicable table in this Topic for the concerned fastener.

(4) The list that follows is an index of fasteners together with their applicable tables:

Fastener Type and Hole Fit	Table
Standard Solid Rivets - Aluminum Alloy	3
Standard Solid Rivets - Monel	3
Standard Solid Rivets - Titanium	3
Standard Solid Rivets - Titanium Bimetal (CHERRY-BUCK)	6
Standard Solid Rivets - Titanium Columbium (E-Z BUCK)	3

Table 1

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STRUCTURAL REPAIR MANUAL

NOMINAL RIVET DIAMETER		HOLE DIAMETERS <1>			
		MAX.		MIN.	
mm	in.	mm	in.	mm	in.
1.6	1/16	1.75	0.069	1.65	0.065
2.4	3/32	2.57	0.101	2.46	0.097
2.8	7/64	2.95	0.116	2.84	0.112
3.2	1/8	3.35	0.132	3.25	0.128
3.6	9/64	3.76	0.148	3.66	0.144
4.0	5/32	4.17	0.164	4.06	0.160
4.4	11/64	4.57	0.180	4.47	0.176
4.8	3/16	4.95	0.195	4.85	0.191
5.2	13/64	5.36	0.211	5.26	0.207
5.6	7/32	5.77	0.227	5.66	0.223
6.0	15/64	6.17	0.243	6.07	0.239
6.4	1/4	6.55	0.258	6.45	0.254
6.8	17/64	6.96	0.274	6.83	0.269
8.0	5/16	8.15	0.321	8.03	0.316
9.6	3/8	9.75	0.384	9.63	0.379

Standard and Oversize Hole Diameters for Solid Rivets (Aluminum Alloy, Titanium, Titanium Columbium (E-Z-Buck) and Monel)

Table 3

1> For the underhead radius/chamfer values refer to Paragraph 2.B.(5)(a) above.

(7) Blind Rivets (HUCK, CHERRY, CHERRYMAX, AVDEL, CHOBERT)

NOMINAL RIVET DIAMETER		HOLE DIAMETERS <1>			
		MAX.		MIN.	
mm	in.	mm	in.	mm	in.
2.4	3/32	2.54	0.101	2.46	0.097
3.2	1/8	3.35	0.132	3.28	0.129
3.6	9/64	3.71	0.146	3.63	0.143
4.0	5/32	4.17	0.164	4.06	0.160
4.4	11/64	4.57	0.180	4.47	0.176
4.8	3/16	4.98	0.196	4.88	0.192
5.2	13/64	5.31	0.209	5.21	0.205

Standard and Oversize Hole Diameters for Blind Rivets (HUCK, CHERRY, CHERRYMAX, AVDEL, CHOBERT)

Table 4

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Figure 4 Extracts From Airbus SRM (1)

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A340-200/300
STRUCTURAL REPAIR MANUAL

NOMINAL BLIND BOLT DIAMETER		HOLE DIAMETERS <1>			
		MAX.		MIN.	
mm	in.	mm	in.	mm	in.
4.17	0.164	4.22	0.166	4.17	0.164
4.57	0.180	4.62	0.182	4.57	0.180
4.83	0.190	4.88	0.192	4.83	0.190
5.05	0.199	5.11	0.201	5.05	0.199
5.46	0.215	5.51	0.217	5.46	0.215
5.79	0.228	5.84	0.230	5.79	0.228
6.32	0.249	6.40	0.252	6.35	0.250
6.60	0.260	6.65	0.262	6.60	0.260
7.01	0.276	7.06	0.278	7.01	0.276
7.32	0.288	7.44	0.292	7.37	0.290
7.92	0.312	7.98	0.314	7.92	0.312
8.31	0.327	8.36	0.329	8.31	0.327

Standard and Oversize Hole Diameters for Blind Bolts
Table 7

<1> For the underhead radius/chamfer values refer to Figure 1 and Table 2.

(10) Pins (threaded) - (HI-LOK, HI-LITE, BULLNOSE), Bolts and Pins (swaged)

DIAMETER DASH NUMBER		STANDARD HOLE DIAMETERS - TRANSITION FIT <1>							
		IN ALUMINUM ALLOY				IN STEEL AND TITANIUM			
		MAX.		MIN.		MAX.		MIN.	
HL, DAN, ABS	ASNA, NAS, NSA	mm	in.	mm	in.	mm	in.	mm	mm
5	2	4.160	0.1638	4.125	0.1624	-	-	-	-
6	3	4.821	0.1898	4.780	0.1882	4.833	0.1903	4.813	0.1895
8	4	6.350	0.2500	6.310	0.2484	6.357	0.2503	6.337	0.2495
10	5	7.940	0.3126	7.900	0.3110	7.950	0.3130	7.925	0.3120
12	6	9.530	0.3752	9.490	0.3736	9.537	0.3755	9.512	0.3745
14	7	11.120	0.4378	11.080	0.4362	11.130	0.4382	11.100	0.4370
16	8	12.710	0.5004	12.670	0.4988	12.717	0.5007	12.687	0.4995
18	9	14.287	0.5625	14.247	0.5609	14.297	0.5629	14.262	0.5615
20	10	15.875	0.6250	15.836	0.6235	15.884	0.6254	15.849	0.6240
24	12	19.052	0.7501	19.013	0.7485	19.064	0.7506	19.024	0.7490

Standard Hole Diameters - Transition Fit in Aluminum Alloy, Steel and Titanium for Pins (threaded), Bolts and Pins (swaged)
Table 8

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A340-200/300
STRUCTURAL REPAIR MANUAL

DIAMETER DASH NUMBER		STANDARD HOLE DIAMETERS - CLEARANCE FIT <1>			
HLT, HST, HL, DAN, ABS	NAS, ASNA, NSA	MAX.		MIN.	
		mm	in.	mm	in.
32	16	25.451	1.0020	25.400	1.0000
36	18	28.626	1.1270	28.575	1.1250

Standard Hole Diameters - Clearance Fit - Pins (threaded) and Bolts
Table 11

<1> For the underhead radius/chamfer values refer to Figure 1 and Table 2.

DIAMETER DASH NUMBER		OVERSIZE HOLE DIAMETERS - CLEARANCE FIT <1>							
		1st OVERSIZE (NOMINAL DIA. +0.4 mm (1/64 in.))				2nd OVERSIZE (NOMINAL DIA. +0.8 mm (1/32 in.))			
		MAX.		MIN.		MAX.		MIN.	
HL, HLT, HST, ABS, DAN	ASNA, NSA, NAS	mm	in.	mm	in.	mm	in.	mm	in.
6	3	5.210	0.2051	5.159	0.2031	5.606	0.2207	5.555	0.2187
8	4	6.797	0.2676	6.746	0.2656	7.193	0.2832	7.142	0.2812
10	5	8.385	0.3301	8.334	0.3281	8.781	0.3457	8.730	0.3437
12	6	9.972	0.3926	9.921	0.3906	10.368	0.4082	10.317	0.4062
14	7	11.560	0.4551	11.509	0.4531	11.956	0.4707	11.905	0.4687
16	8	13.147	0.5176	13.096	0.5156	13.543	0.5332	13.492	0.5312
18	9	14.735	0.5801	14.684	0.5781	15.131	0.5957	15.080	0.5937
20	10	16.322	0.6426	16.271	0.6406	16.718	0.6582	16.667	0.6562
24	12	19.497	0.7676	19.446	0.7656	19.893	0.7832	19.842	0.7812
28	14	22.672	0.8926	22.621	0.8906	23.068	0.9082	23.020	0.9063
32	16	25.847	1.0176	25.796	1.0156	26.246	1.0333	26.195	1.0313
36	18	29.022	1.1426	28.971	1.1406	29.418	1.1582	29.368	1.1562

Oversize Hole Diameters - Clearance Fit for Pins (threaded) and Bolts
Table 12

<1> For the underhead radius/chamfer values refer to Figure 1 and Table 2.

BOLT DIAMETER NUMBER		STANDARD HOLE DIAMETERS - TRANSITION FIT (CLOSE TOLERANCE) <1>			
HL, DAN, ABS	ASNA, NAS, NSA	MAX.		MIN.	
		mm	in.	mm	in.
6	3	4.823	0.1899	4.803	0.1891
8	4	6.347	0.2499	6.327	0.2491

Standard Hole Diameters - Transition Fit (Close Tolerance) - Pins (threaded) and Bolts
Table 13

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Figure 5 Extracts From Airbus SRM (2)

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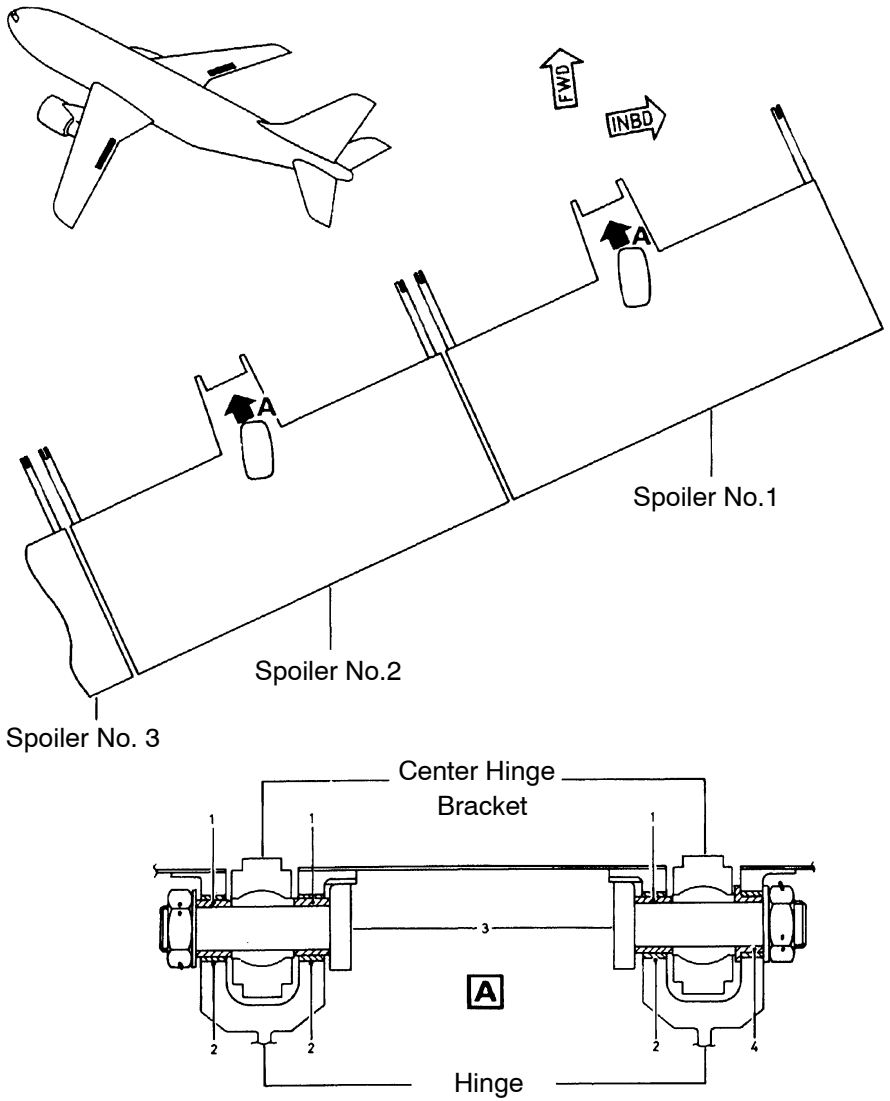
WEAR LIMITS

GENERAL

Since shafts and bearings absorb and transmit loads through the flight operation they have to be checked frequently in the maintenance up on wear because of their stress. There are special wear limits for the different components in tabular in the Aircraft Maintenance Manual (AMM).

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A300

AIRCRAFT MAINTENANCE MANUAL

FITS AND CLEARANCES (Ref. Fig. 601)

NOTE : Limits annotated with an asterisk *, only apply while there is a thickness of chrome plating remaining on the bearing surfaces.

Detail and Item No.	Original Mfg Limits				In Service Wear Limits		
	Dimension inches (Millimeters)		Assy. Clearance Inch.(Milli.)		Dimension Limits Inch.(Milli.)		Max. Allow clear in. (mm)
	Min.	Max.	Min.	Max.	Min.	Max.	
A							
OD1	1.1242 (28.555)	1.1247 (28.567)			1.1235 (28.537)		
			0.0003 (0.008)	0.0020 (0.050)			0.0040 (0.101)
ID2	1.1250 (28.575)	1.1262 (28.605)			1.1275 (28.638)		
ID1	0.8750 (22.225)	0.8762 (22.255)				0.8775 (22.288)	
			0.0003 (0.008)	0.0020 (0.050)			0.0040 (0.101)
OD3	0.8742 (22.205)	0.8747 (22.217			0.8735 (22.187) *		
OD3	0.8742 (22.205)	0.8747 (22.217			0.8735 (22.187) *		
			0.0003 (0.008)	0.0020 (0.050)			0.0040 (0.101)
ID4	0.8750 (22.225)	0.8762 (22.255)				0.8775 (22.288)	

Figure 6 Outer Airbrakes - Wear Limits (A300)

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Standard Methods for Checking Shafts & Bearings

Roundness Measuring Instruments

Roundness measuring instruments are precision instruments, which are used to measure out-of-rounds, radial run outs, bends, wear e. g. of shafts, gears, bearings.

They can also be used for checking out-of-rounds of a disk, the backlash in gears or the axle end play of a bedded shaft.

Out-of-round technically describes geometrical forms and profiles that differ from a circle or circular movement periodically. The deviation can be intended (e. g. a out-of-round planetary drive), but it also can be a result of wear or friction.

Testing Methods

The out-of-round of a shaft can be detected through a dial test indicator (DTI) which is assembled onto a stand and then located in order to adjust its measuring head on the surface of the shaft.

A preload is then applied to the DTI by pressing it against the shaft so that the pointer deflects and shows a value about the half of the maximal value of the DTI.

After zeroing the DTI the shaft has only to be turned. The DTI shows then the out-of-round of the shaft by the deviation of the pointer in both directions.

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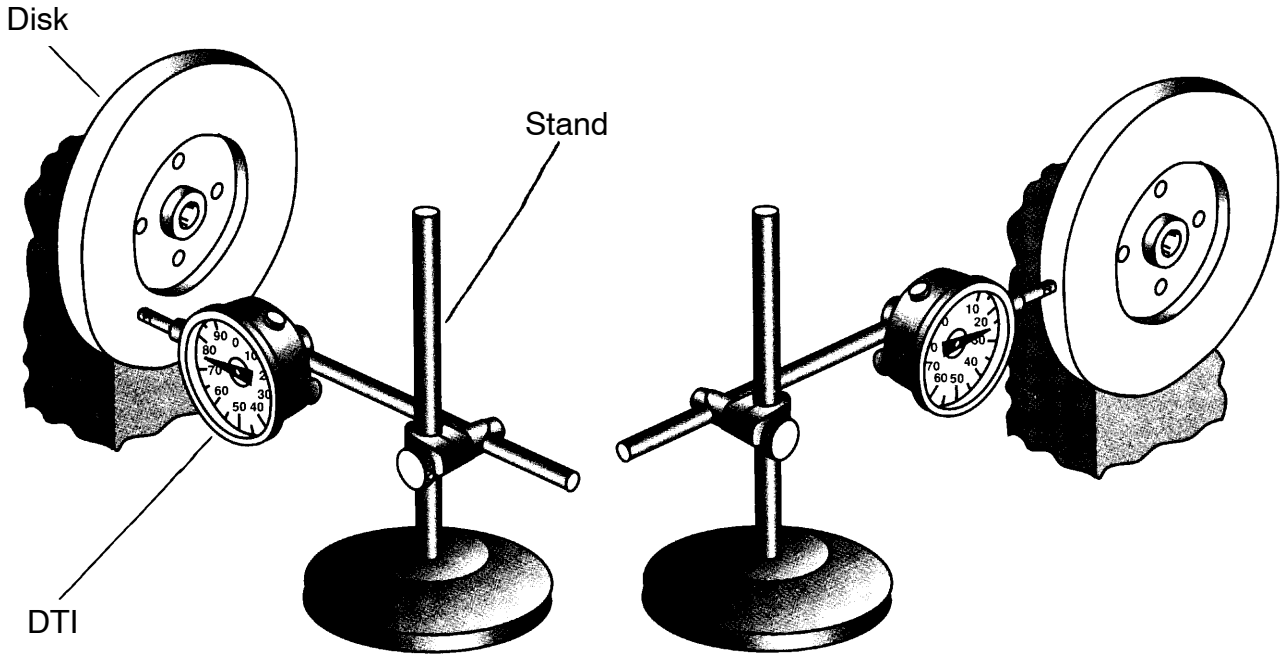


Figure 7 Using Roundness Measuring Instruments

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STANDARD METHODS FOR CHECKING SHAFTS & BEARINGS (CONTD.)

Micrometer Gauge, Micrometer for inner Diameters

A gauge (a.k.a. micrometer gauge or only micrometer) is a length measuring device, which is suited for measuring the diameter of e. g. a shaft or a bearing exactly.

Different micrometers are needed to measure the inner and outer diameter.

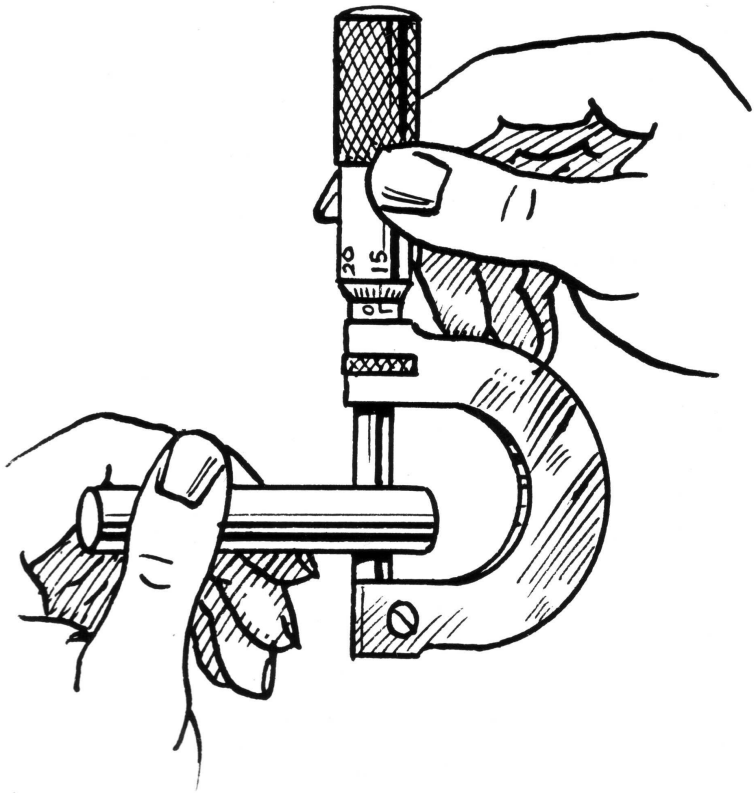
Testing Methods

The gauge is composed of a constant and a with a fine thread moveable measuring surface, which are connected by a bow. The part that has to be measured is located in between the two measuring surfaces and the thread is turned with a adjusting screw (mostly knurled) so far until both surfaces have contact with the object.

The length of the part can be read on a scale parallel to the moving direction in full pitches, mostly full or half milimeters; a second scale located around the adjustment screw is used to read the length which only causes a fraction of the pitch. The fine scale is commonly given in a hundredth or a thousandth of a millimeter. To prevent a false measuring caused by different measuring forces (deformation of the measured object), the adjustment screw is turned by a friction clutch.

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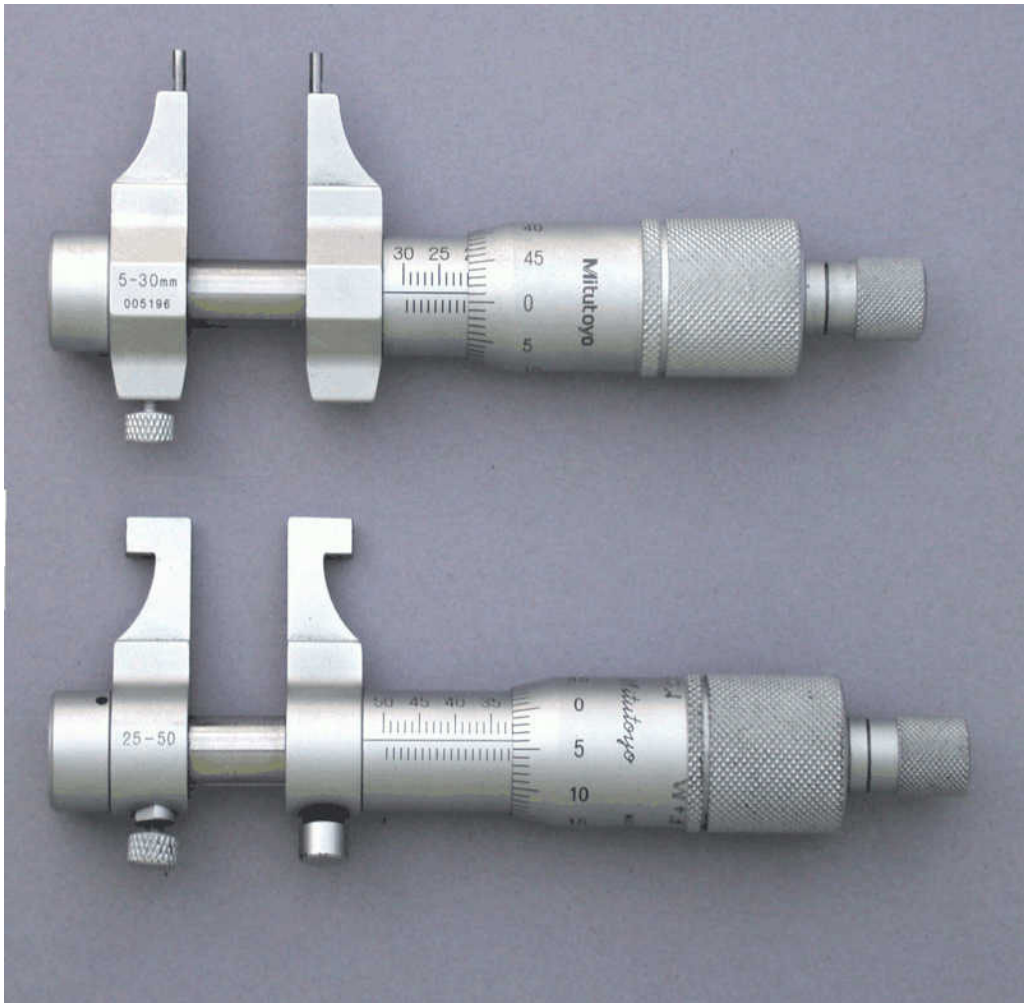


Figure 8 Micrometer Gauge

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