Section III: Exhibits

- Exhibit 1 — Rivet identification and part number breakdown
- Exhibit 2 — Aircraft rivet identification
- Exhibit 3 — Aircraft rivet identification (continued)
- Exhibit 4 — Rivet requirement chart for bare and clad alloys
- Exhibit 5 — Rivet requirement chart for ALCLAD alloys
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- Exhibit 7 — Recommended radii for 90º bends in aluminum alloys
- Exhibit 8 — Minimum Bend Radius for Aluminum Alloys
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- Exhibit 19 — Minimum bend radii for MIL-H-8794 and MIL-H-8788 hose
- Exhibit 20 — Minimum bend radii for Teflon hose
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- Exhibit 23 — Minimum Equipment List Page
- Exhibit 24 — IAR Bend Allowance
- Exhibit 25 — IAR Circumference Formula

EXHIBIT 1

Rivet identification and part number breakdown.

RIVET IDENTIFICATION
The material can be identified by the head marking

Rivet	Material Code	Head Marking	Material
	A	Plain (Dyed)	1100
	AD	Dimpled	2117
	D	Raised Dot	2017T
	DD	Two Raised Dashes	2024
	B	Raised Cross (Dyed)	5056
	E	Raised Circle	7050
	M	Two Dots	Monel

PART NUMBER BREAKDOWN

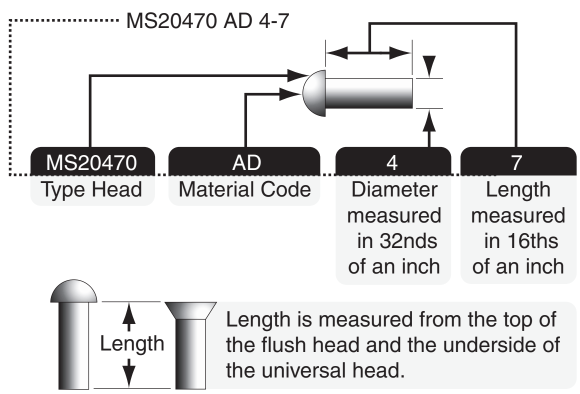
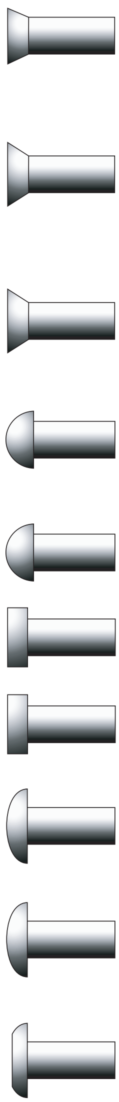


EXHIBIT 2

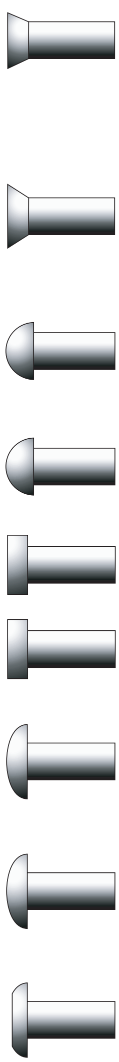
Aircraft rivet identification.



Material	1100	2117T	2017T	2017T-HD	2024T	50567	7075-T73
Head Marking	Plain	Dimpled	Raised Dot	Raised Dot	Raised Double Dash	Raised Cross	Three Raised Dashes
AN Material Code	A	AD	D	D	DD	B	
AN425 78 ▪ Counter-Sunk Head	X	X	X	X	X		X
AN426 100 ▪ Counter-Sunk Head MS20426	X	X	X	X	X	X	X
AN427 100 ▪ **Counter-Sunk Head MS20427**							
AN430 Round Head MS20470	X	X	X	X	X	X	X
AN435 Round Head MS20613 MS20615							
AN441 Flat Head							
AN441 Flat Head MS20470	X	X	X	X	X	X	X
AN 455 Brazier Head MS20470	X	X	X	X	X	X	X
AN 456 Brazier Head MS20470	X	X	X	X	X	X	X
AN 470 Universal Head MS20470	X	X	X	X	X	X	X
Heat Treat Before Using	No	No	Yes	No	Yes	No	No
Shear Strength psi	10000	30000	34000	38000	41000	27000	
Bearing Strength psi	25000	100000	113000	126000	136000	90000	

EXHIBIT 3

Aircraft rivet identification. (continued)



Material	Carbon Steel	Corrosion-Resistant Steel	Copper	Monel	Monel Nickel-Copper Alloy	Brass	Titanium
Head Marking	Recessed Triangle	Recessed Dash	Plain	Plain	Recessed Double Dots	Plain	Recessed Large and Small Dot
AN Material Code		F	C	M	C		
AN425 78 ▪ Counter-Sunk Head							
AN426							MS 20426
AN427 100 ▪ Counter-Sunk Head MS20427	X	X	X	X			
AN430 Round Head MS20470							
AN435 Round Head MS20613 MS20615	X MS20613	X MS20613	X		X MS20615	X MS20615	
AN441 Flat Head	X		X	X			X
AN442 Flat Head MS20470							
AN 455 Brazier Head MS20470							
AN 456 Brazier Head MS20470							
AN 470 Universal Head MS20470							
Heat Treat Before Using	No	No	No	No	No	No	No
Shear Strength psi	35000	65000	23000	49000	49000		95000
Bearing Strength psi	90000	90000					

EXHIBIT 4

Number of rivets required for splices (single-lap joint) in bare 2014-T6, 2024-T3, 2024-T36, and 7075-T6 sheet, clad 2014-T6, 2024-T3, 2024-T36, and 7075-T6 sheet, 2024-T4, and 7075-T6 plate, bar, rod, tube, and extrusions, 2014-T6 extrusions.

Thickness "t" in inches	No. of 2117-T4 (AD) protruding head rivets required per inch of width "W" Rivet size					No. of Bolts
	3/32	1/8	5/32	3/16	1/4	AN-3
.016	6.5	4.9	- -	- -	- -	- -
.020	6.9	4.9	3.9	- -	- -	- -
.025	8.6	4.9	3.9	- -	- -	- -
.032	11.1	6.2	3.9	3.3	- -	- -
.036	12.5	7.0	4.5	3.3	2.4	- -
.040	13.8	7.7	5.0	3.5	2.4	3.3
.051	- -	9.8	6.4	4.5	2.5	3.3
.064	- -	12.3	8.1	5.6	3.1	3.3
.081	- -	- -	10.2	7.1	3.9	3.3
.091	- -	- -	11.4	7.9	4.4	3.3
.102	- -	- -	12.8	8.9	4.9	3.4
.128	- -	- -	- -	11.2	6.2	3.2

NOTES:

a. For stringers in the upper surface of a wing, or in a fuselage, 80 percent of the number of rivets shown in the table may be used.

b. For intermediate frames, 60 percent of the number shown may be used.

c. For single lap sheet joints, 75 percent of the number shown may be used.

ENGINEERING NOTES:

a. The load per inch of width of material was calculated by assuming a strip 1 inch wide in tension.

b. Number of rivets required was calculated for 2117-T4 (AD) rivets, based on a rivet allowable shear stress equal to 40 percent of the sheet allowable tensile stress, and a sheet allowable bearing stress equal to 160 percent of the sheet allowable tensile stress, using nominal bolt diameters for rivets.

c. Combinations of sheet thickness and rivet size above the underlined numbers are critical in (i.e., will fail by) bearing on the sheet; those below are critical in shearing of the rivets.

d. The number of AN-3 bolts required below the underlined number was calculated based on a sheet allowable tensile stress of 70,000 psi and a bolt allowable single shear load of 2,126 pounds.

EXHIBIT 5

Number of rivets required for splices (single-lap joint) in 2017, 1017 ALCLAD, 2024 T3 ALCLAD sheet, plate, bar, rod, tube, and extrusions.

Thickness "t" in inches	No. of 2117-T4 (AD) protruding head rivets required per inch of width "W" Rivet size					No. of Bolts
	3/32	**1/8**	**5/32**	**3/16**	**1/4**	**AN-3**
.016	6.5	4.9	- -	- -	- -	- -
.020	6.5	4.9	3.9	- -	- -	- -
.025	6.9	4.9	3.9	- -	- -	- -
.032	8.9	4.9	3.9	3.3	- -	- -
.036	10.0	5.6	3.9	3.3	2.4	- -
.040	11.1	6.2	4.0	3.3	2.4	- -
.051	- -	7.9	5.1	3.6	2.4	3.3
.064	- -	9.9	6.5	4.5	2.5	3.3
.081	- -	12.5	8.1	5.7	3.1	3.3
.091	- -	- -	9.1	6.3	3.5	3.3
.102	- -	- -	10.3	7.1	3.9	3.3
.128	- -	- -	12.9	8.9	4.9	3.3

NOTES:

a. For stringers in the upper surface of a wing, or in a fuselage, 80 percent of the number of rivets shown in the table may be used.

b. For intermediate frames, 60 percent of the number shown may be used.

c. For single lap sheet joints, 75 percent of the number shown may be used.

ENGINEERING NOTES:

a. The load per inch of width of material was calculated by assuming a strip 1 inch wide in tension.

b. Number of rivets required was calculated for 2117-T4 (AD) rivets, based on a rivet allowable shear stress equal to percent of the sheet allowable tensile stress, and a sheet allowable bearing stress equal to 160 percent of the sheet allowable tensile stress, using nominal hole diameters for rivets.

c. Combinations of sheet thickness and rivet size above the underlined numbers are critical in (i.e., will fail by) bearing on the sheet; those below are critical in shearing of the rivets.

d. The number of AN-3 bolts required below the underlined number was calculated based on a sheet allowable tensile stress of 55,000 psi and a bolt allowable single shear load of 2,126 pounds.

EXHIBIT 6

Number of rivets required for splices (single-lap joint) in 5052 (all hardnesses) sheet.

Thickness "t" in inches	No. of 2117-T4 (AD) protruding head rivets required per inch of width "W" Rivet size					No. of Bolts
	3/32	1/8	5/32	3/16	1/4	AN-3
.016	6.3	4.7		- -	- -	- -
.020	6.3	4.7	3.8	- -	- -	- -
.025	6.3	4.7	3.8	- -	- -	- -
.032	<u>6.3</u>	4.7	3.8	3.2	- -	- -
.036	7.1	4.7	3.8	3.2	2.4	- -
.040	7.9	<u>4.7</u>	3.8	3.2	2.4	- -
.051	10.1	5.6	<u>3.8</u>	3.2	2.4	- -
.064	12.7	7.0	4.6	3.2	2.4	- -
.081	- -	8.9	5.8	4.0	<u>2.4</u>	3.2
.091	- -	10.0	6.5	4.5	2.5	3.2
.102	- -	11.2	7.3	5.1	2.8	3.2
.128	- -	- -	9.2	6.4	3.5	3.2

NOTES:

a. For stringers in the upper surface of a wing, or in a fuselage, 80 percent of the number of rivets shown in the table may be used.

b. For intermediate frames, 60 percent of the number shown may be used.

c. For single lap sheet joints, 75 percent of the number shown may be used.

ENGINEERING NOTES:

a. The load per inch of width of material was calculated by assuming a strip 1 inch wide in tension.

b. Number of rivets required was calculated for 2117-T4 (AD) rivets, based on a rivet allowable shear stress equal to 70 percent of the sheet allowable tensile stress, and a sheet allowable bearing stress equal to 160 percent of the sheet allowable tensile stress, using nominal hole diameters for rivets.

c. Combinations of sheet thickness and rivet size above the underlined numbers are critical in (i.e., will fail by) bearing on the sheet, those below are critical in shearing of the rivets.

EXHIBIT 7

Recommended radii for 90° bends in aluminum alloys

Alloy and	Approximate sheet thickness (t) (inch)					
temper	0.016	0.032	0.064	0.128	0.182	0.258
2024-0[1]	0	0-1t	0-1t	0-1t	0-1t0-1t	0-1t
2024-T3[1,2]	1½t-3t	2t-4t	3t-5t	4t-6t	4t-6t	5t-7t
2024-T6[1]	2t-4t	3t-5t	3t-5t	4t-6t	5t-7t	6t-10t
5052-0	0	0	0-1t	0-1t	0-1t	0-1t
5052-H32	0	0	½t-1t	½t-1½t	½t-1½t	½t-1½t
5052-H34	0	0	½t-1½t	1½t-2½t	1½t-2½t	2t-3t
5052-H36	0-1t	½t-1½t	1t-2t	1½t-3t	2t-4t	2t-4t
5052-H38	½t-1½t	1t-2t	1½t-3t	2t-4t	3t-5t	4t-6t
6061-0	0	0-1t	0-1t	0-1t	0-1t	0-1t
6061-T4	0-1t	0-1t	½t-1½t	1t-2t	1½t-3t	2½t-4t
6061-T6	0-1t	½t-1½t	1t-2t	1½t-3t	2t-4t	3t-4t
7075-0	0	0-1t	0-1t	½t-1½t	1t-2t	1½t-3t
7075-T6[1]	2t-4t	3t-5t	4t-6t	5t-7t	5t-7t	6t-10t

[1] Alclad sheet may be bent over slight smaller radii than the corresponding tempers of uncoated alloy.

[2] Immediately after quenching this alloy may be formed over appreciably smaller radii.

EXHIBIT 8

Minimum Bend Radius for Aluminum Alloys								
Alloy	**Thickness**							
	0.020	**0.025**	**0.032**	**0.040**	**0.051**	**0.064**	**0.072**	**0.081**
2024-O	1/32	1/16	1/16	1/16	1/16	3/32	1/8	1/8
2024-T4	1/16	1/16	3/32	3/32	1/8	5/32	7/32	1/4
5052-O	1/32	1/32	1/16	1/16	1/16	1/16	1/8	1/8
5052-H34	1/32	1/16	1/16	1/16	3/32	3/32	1/8	1/8
6061-O	1/32	1/32	1/32	1/16	1/16	1/16	3/32	3/32
6061-T4	1/32	1/32	1/32	1/16	1/16	3/32	5/32	5/32
6061-T6	1/16	1/16	1/16	3/32	3/32	1/8	3/16	3/16
7075-O	1/16	1/16	1/16	1/16	3/32	3/32	5/32	3/16
7075-W	3/32	3/32	1/8	5/32	3/16	1/4	9/32	3/16
7075-T6	1/6	1/8	1/8	3/16	1/4	5/16	3/8	7/16

EXHIBIT 9

Band allowance chart

THICKNESS \ RADIUS	1/32 .031	1/16 .063	3/32 .094	1/8 .125	5/32 .156	3/16 .188	7/32 .219	1/4 .250	9/32 .281	5/16 .313	11/32 .344	3/8 .375	7/16 .438	1/2 .500
.020	.062 .000693	.113 .001251	.161 .001792	.210 .002333	.259 .002874	.309 .003433	.358 .003974	.406 .004515	.455 .005056	.505 .005614	.554 .006155	.603 .006695	.702 .007795	.799 .008877
.025	.066 .000736	.116 .001294	.165 .001835	.214 .002376	.263 .002917	.313 .003476	.362 .004017	.410 .004558	.459 .005098	.509 .005657	.558 .006198	.607 .006739	.705 .007838	.803 .008920
.028	.068 .000759	.119 .001318	.167 .001859	.216 .002400	.265 .002941	.315 .003499	.364 .004040	.412 .004581	.461 .005122	.511 .005680	.560 .006221	.609 .006762	.708 .007853	.804 .007862
.032	.071 .000787	.121 .001345	.170 .001886	.218 .002427	.267 .002968	.317 .003526	.366 .004067	.415 .004608	.463 .005149	.514 .005708	.562 .006249	.611 .006789	.710 .007889	.807 .008971
.038	.075 .000837	.126 .001396	.174 .001937	.223 .002478	.272 .003019	.322 .003577	.371 .004118	.419 .004659	.468 .005200	.518 .005758	.567 .006299	.616 .006840	.715 .007940	.812 .009021
.040	.077 .00853	.127 .001411	.176 .001952	.224 .002493	.273 .003034	.323 .003593	.372 .004134	.421 .004675	.469 .005215	.520 .005774	.568 .006315	.617 .006856	.716 .007955	.813 .009037
.051		.134 .001413	.183 .002034	.232 .002575	.280 .003116	.331 .003675	.379 .004215	.428 .004756	.477 .005297	.527 .005855	.576 .006397	.624 .006934	.723 .008037	.821 .009119
.064		.144 .001595	.192 .002136	.241 .002676	.290 .003218	.340 .003776	.389 .004317	.437 .004858	.486 .005399	.536 .005957	.585 .006498	.634 .007039	.732 .008138	.830 .009220
.072			.196 .002202	.247 .002743	.296 .003284	.346 .003842	.385 .004283	.443 .004924	.492 .005465	.542 .006023	.591 .006564	.639 .007105	.738 .008205	.836 .009287
.078			.202 .002247	.251 .002787	.300 .003327	.350 .003885	.399 .004426	.447 .004963	.496 .005512	.546 .006070	.595 .006611	.644 .007152	.742 .008243	.840 .009333
.081			.204 .002270	.253 .002811	.302 .003351	.352 .003909	.401 .004449	.449 .004969	.498 .005535	.548 .006094	.598 .006635	.646 .007176	.744 .008266	.842 .009357
.091			.212 .002350	.260 .002891	.309 .003432	.359 .003990	.408 .004531	.456 .005072	.505 .005613	.555 .006172	.604 .006713	.653 .007254	.752 .008353	.849 .009435
.094			.214 .002374	.262 .002914	.311 .003455	.361 .004014	.410 .004555	.459 .005096	.507 .005637	.588 .006195	.606 .006736	.655 .007277	.754 .008376	.851 .009458
.102				.268 .002977	.317 .003518	.367 .004076	.416 .004617	.464 .005158	.513 .005699	.563 .006257	.612 .006798	.661 .007339	.760 .008439	.857 .009521
.109				.273 .003031	.321 .003572	.372 .004131	.420 .004672	.469 .005213	.518 .005754	.568 .006312	.617 .006853	.665 .008394	.764 .008493	.862 .009575
.125				.284 .003156	.333 .003697	.383 .004256	.432 .004797	.480 .005338	.529 .005678	.579 .006437	.628 .006978	.677 .007519	.776 .008618	.873 .009700
.156					.355 .003939	.405 .004497	.453 .005038	.502 .005579	.551 .006120	.601 .006679	.650 .007220	.698 .007761	.797 .008860	.895 .009942
.188						.417 .004747	.476 .005288	.525 .005829	.573 .006370	.624 .006928	.672 .007469	.721 .008010	.820 .009109	.917 .010191
.250								.568 .006313	.617 .06853	.667 .007412	.716 .007953	.764 .008494	.863 .009593	.961 .010675

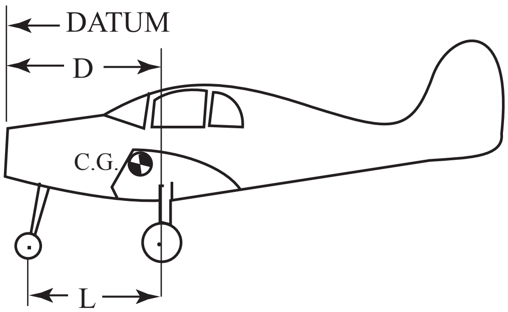
EXHIBIT 10

K-chart for determining setback for bends other than 90°

Deg.	K	Deg.	K	Deg.	K	Deg.	K	Deg.	K
1	0.0087	37	0.3346	73	0.7399	109	1.401	145	3.171
2	0.0174	38	0.3443	74	0.7535	110	1.428	146	3.270
3	0.0261	39	0.3541	75	0.7673	111	1.455	147	3.375
4	0.0349	40	0.3639	76	0.7812	112	1.482	148	3.487
5	0.0436	41	0.3738	77	0.7954	113	1.510	149	3.605
6	0.0524	42	0.3838	78	0.8097	114	1.539	150	3.732
7	0.0611	43	0.3939	79	0.8243	115	1.569	151	3.866
8	0.0699	44	0.4040	80	0.8391	116	1.600	152	4.010
9	0.0787	45	0.4142	81	0.8540	117	1.631	153	4.165
10	0.0874	46	0.4244	82	0.8692	118	1.664	154	4.331
11	0.0963	47	0.4348	83	0.8847	119	1.697	155	4.510
12	0.1051	48	0.4452	84	0.9004	120	1.732	156	4.704
13	0.1139	49	0.4557	85	0.9163	121	1.767	157	4.915
14	0.1228	50	0.4663	86	0.9324	122	1.804	158	5.144
15	0.1316	51	0.4769	87	0.9489	123	1.841	159	5.399
16	0.1405	52	0.4877	88	0.9656	124	1.880	160	5.671
17	0.1494	53	0.4985	89	0.9827	125	1.921	161	5.975
18	0.1583	54	0.5095	90	1.000	126	1.962	162	6.313
19	0.1673	55	0.5205	91	1.017	127	2.005	163	6.691
20	0.1763	56	0.5317	92	1.035	128	2.050	164	7.115
21	0.1853	57	0.5429	93	1.053	129	2.096	165	7.595
22	0.1943	58	0.5543	94	1.072	130	2.144	166	8.144
23	0.2034	59	0.5657	95	1.091	131	2.194	167	8.776
24	0.2125	60	0.5773	96	1.110	132	2.246	168	9.514
25	0.2216	61	0.5890	97	1.130	133	2.299	169	10.38
26	0.2308	62	0.6008	98	1.150	134	2.355	170	11.43
27	0.2400	63	0.6128	99	1.170	135	2.414	171	12.70
28	0.2493	64	0.6248	100	1.191	136	2.475	172	14.30
29	0.2586	65	0.6370	101	1.213	137	2.538	173	16.35
30	0.2679	66	0.6494	102	1.234	138	2.605	174	19.08
31	0.2773	67	0.6618	103	1.257	139	2.674	175	22.90
32	0.2867	68	0.6745	104	1.279	140	2.747	176	26.63
33	0.2962	69	0.6872	105	1.303	141	2.823	177	38.18
34	0.3057	70	0.7002	106	1.327	142	2.904	178	57.29
35	0.3153	71	0.7132	107	1.351	143	2.988	179	114.59
36	0.3249	72	0.7265	108	1.376	144	3.077	180	Inf.

EXHIBIT 11

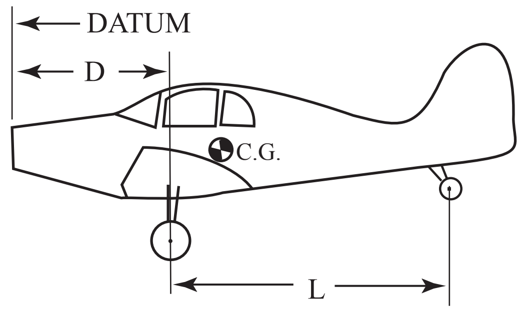
Empty weight center-of-gravity formulas.



NOSE WHEEL TYPE AIRCRAFT

DATUM LOCATED FORWARD OF THE MAIN WHEELS

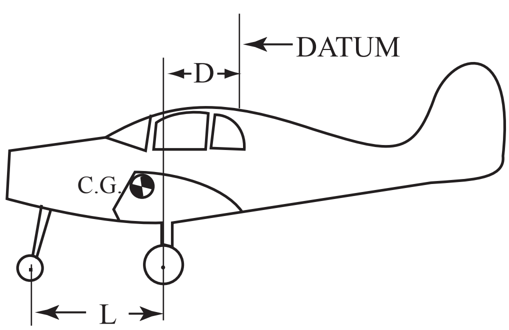
$$C.G. = D \left(\frac{F \times L}{W}\right)$$



TAIL WHEEL TYPE AIRCRAFT

DATUM LOCATED FORWARD OF THE MAIN WHEELS

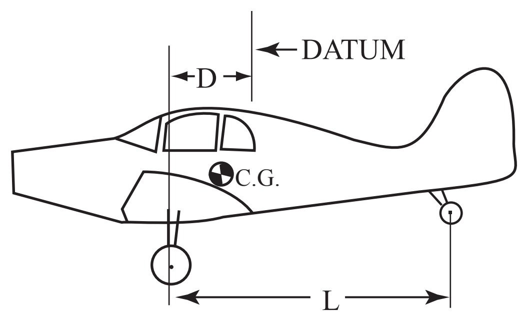
$$C.G. = D + \left(\frac{R \times L}{W}\right)$$



NOSE WHEEL TYPE AIRCRAFT

DATUM LOCATED FORWARD OF THE MAIN WHEELS

$$C.G. = -\left(D + \frac{F \times L}{W}\right)$$



TAIL WHEEL TYPE AIRCRAFT

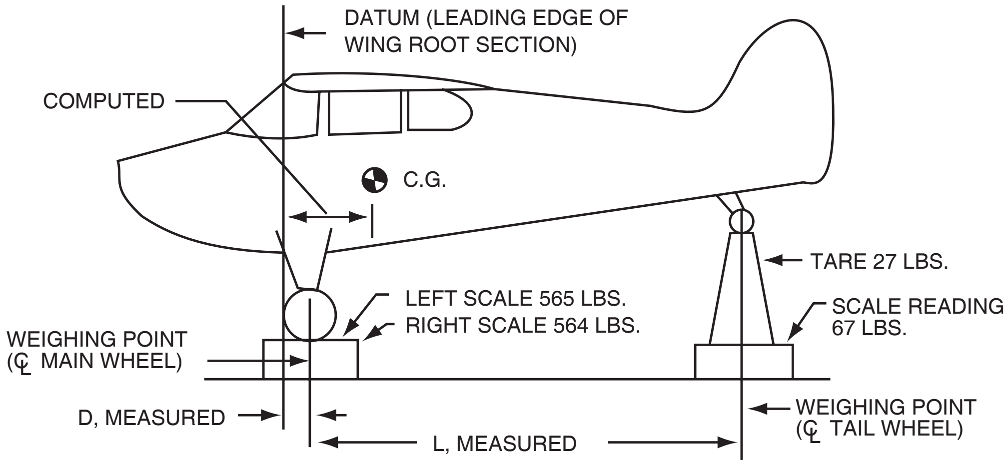
DATUM LOCATED FORWARD OF THE MAIN WHEELS

$$C.G. = -D + \left(\frac{R \times L}{W}\right)$$

CG = Distance from datum to center of gravity of the aircraft.
W = The weight of the aircraft at the time of weighing.
D = The horizontal distance measured from the datum to the main wheel weighing point.
L = The horizontal distance measured from the main wheel weighing point to the nose or tail weighing point.
F = The weight at the nose weighing point.
R = The weight at the tail weighing point.

EXHIBIT 12

Empty weight and empty center of gravity—tail-wheel type aircraft.



TO FIND: EMPTY WEIGHT AND EMPTY WEIGHT CENTER OF GRAVITY

Datum is the leading edge of the wing (from aircraft specification)

(D) Actual measured horizontal distance from the main wheel weighing point ℄ main wheel) to the Datum - 3"

(L) Actual measured horizontal distance from the rear wheel weighing point (℄ rear wheel) to the main wheel weighing point - 222"

SOLVING: EMPTY WEIGHT

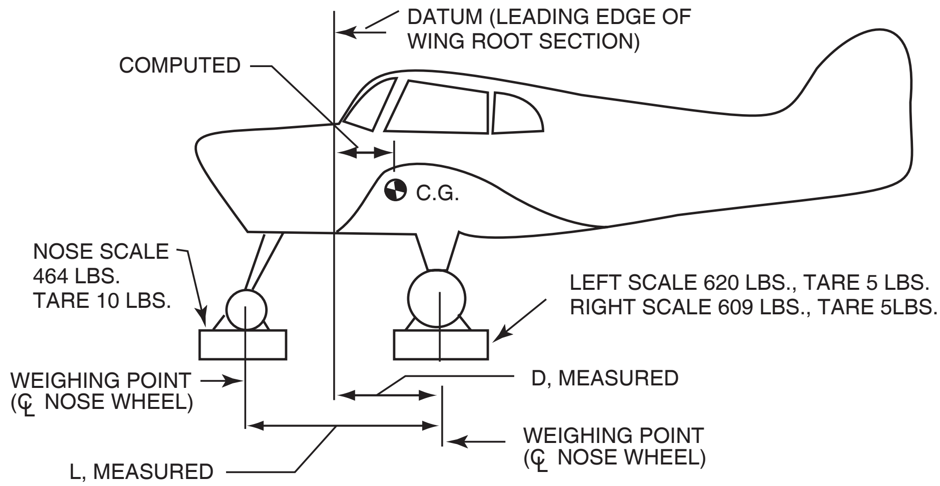
Weighing Point	Scale Reading #	Tare #	Net Weight #
Right	564	0	564
Left	565	0	565
Rear	567	7	40
Empty Weight (W)			1169

SOLVING: EMPTY WEIGHT CENTER OF GRAVITY

Formula: $\text{C.G.} = D + \frac{R \times L}{W} = 3" + \frac{40 \times 222}{1169} = 3" + 7.6" = 10.6"$

EXHIBIT 13

Empty weight and empty center of gravity—nose-wheel type aircraft



TO FIND: EMPTY WEIGHT AND EMPTY WEIGHT CENTER OF GRAVITY

Datum is the leading edge of the wing (from aircraft specification)

(D) Actual measured horizontal distance from the main wheel weighing point ℄ main wheel) to the Datum -- 34.0"

(L) Actual measured horizontal distance from the rear wheel weighing point (℄ rear wheel) to the main wheel weighing point -- 67.8"

SOLVING: EMPTY WEIGHT

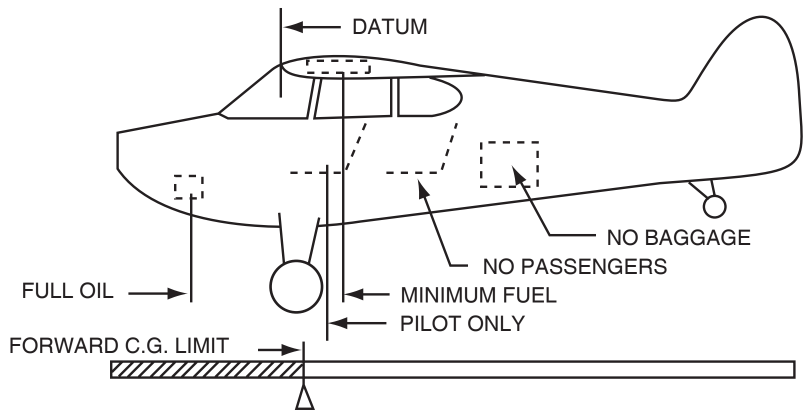
Weighing Point	Scale Reading #	Tare #	Net Weight
Right	609	5	604
Left	620	5	615
Front	464	10	454
Empty Weight (W)			1673

SOLVING: EMPTY WEIGHT CENTER OF GRAVITY

Formula: $\text{C.G.} = D - \frac{F \times L}{W} = 34" - \frac{454 \times 67.8}{1673} = 34" - 18.3" = 15.7"$

EXHIBIT 14

Example of check of most forward weight and balance extreme



TO CHECK: MOST FORWARD WEIGHT AND BALANCE EXTREME.

GIVEN: Actual empty weight of the airplane ---------------- 1169#
Empty weight center of gravity ----------------- +10.6"
*Maximum weight -------------------------- 2100#
*Forward C.G. limit ------------------------- + 8.5"
*Oil, capacity 9 qts. ----------------------------17# at -49
*Pilot in farthest forward seat equipped with controls (unless otherwise placarded) ---------------170# at + 16"
*Since the fuel tank is located to the rear of the forward C.G. limit, minimum fuel should be included. $\frac{\text{METO HP}}{12} = \frac{160}{12} =$ 13.75 GAL. x 6# --------83# at + 22"

*Information should be obtained from the aircraft specification.

Note: Any items or passengers must be used if they are located ahead of the forward C.G. limit.
Full fuel must be used if the tank is located ahead of the forward C.G. limit.

CHECK OF FORWARD WEIGHT AND BALANCE EXTREME

	Weight (#)	x Arm (") =	Moment ("#)
Aircraft Empty	+ 1169	+ 10.6	+ 12391
Oil	+ 17	- 49	- 833
Pilot	+ 170	+ 16	+ 2720
Fuel	+ 83	+ 22	+ 1826
Total	+ 1439 (TW)		+ 16104 (TM)

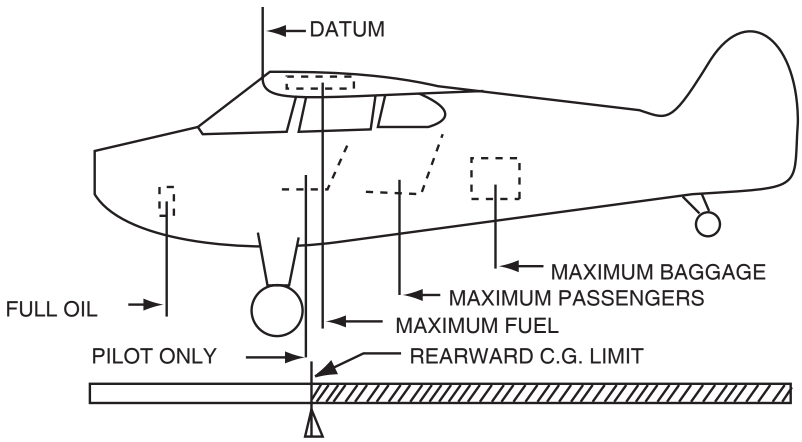
Divide the TM (Total Moment) by the TW (Total Weight) to obtain the forward weight and balance extreme.

$$\frac{TM}{TW} = \frac{16104}{1439} = +11.2"$$

Since the forward C.G. limit and the maximum weight are not exceeded, the forward weight and balance extreme condition is satisfactory.

EXHIBIT 15

Example of check of most rearward weight and balance extreme



TO CHECK: MOST REARWARD WEIGHT AND BALANCE EXTREME.

GIVEN: Actual empty weight of the airplane ---------------- 1169#
Empty weight center of gravity------------ +10.6"
*Maximum weight ------------------------ 2100#
*Rearward C.G. limit ------------------------ 21.9"
*Oil, capacity 9 qts. --------------------- 17# at -49
* Baggage, placarded do not exceed 100 lbs. ----------- 100# at 75.5"
*Two passengers in rear seats, 170 x 2 --------------- 340# at +48
*Pilot in most rearward seat equipped with
controls (unless otherwise placarded) ---------------170# at + 16"
*Since the fuel tank is located aft of the
rearward C.G. limit full fuel must be used ------------ 240# at + 22"

*Information should be obtained from the aircraft specification.

Note: If fuel tanks are located ahead of the rearward C.G. limit minimum fuel should be used.

CHECK OF REARWARD WEIGHT AND BALANCE EXTREME

	Weight (#)	x Arm (") =	Moment ("#)
Aircraft Empty	+ 1169	+ 10.6	+ 12391
Oil	+ 17	- 49	- 833
Pilot (1)	+ 170	+ 16	+ 2720
Passengers (2)	+ 340	+ 48	+ 16320
Fuel (40 gals.)	+ 240	+ 22	+ 5280
Baggage	+ 100	+ 75.5	+ 7550
Total	+ 2036 (TW)		+ 43428 (TM)

Divide the TM (Total Moment) by the TW (Total Weight) to obtain the forward weight and balance extreme.

$$\frac{TM}{TW} = \frac{43428}{2036} = +\ 21.3''$$

Since the rearward C.G. limit and the maximum weight are not exceeded, the rearward weight and balance extreme condition is satisfactory.

EXHIBIT 16

Chapter 1. STRUCTURAL DATA

1. GENERAL. The minimum airworthiness requirements are those under which the aircraft was type certificated. Addition or removal of equipment involving changes in weight could affect the structural integrity, weight, balance, flight characteristics, or performance of an aircraft.

2. STATIC LOADS. Utilize equipment supporting structure and attachments that are capable of withstanding the additional inertia forces ("g." load factors) imposed by weight of equipment installed. Load factors are defined as follws:

a. Limit load factors are the maximum load factors which may be expected during service (the manuevering, gust, or ground load factors established by the manufacturer for type certification).

b. Ultimate Load Factors are the limit load factors multiplied by a prescribed factor of safety. Certain loads, such as the minimum ultimate inertia forces prescribed for emergency landing conditions, are given directly in terms of ultimate loads.

c. Static Test Load Factors are the ultimate load factors multiplied by prescribed casting, fitting, bearing, and/or other special factors. Where no special factors apply, the static test load factors are equal to the ul;timate load factors.

d. Critical Static Test Load factors are the greater of the manuevering, gust, ground and inertia load static test load factors for each direction (up, down, side, fore, and aft).

Static tests using the following load factors are acceptable for euipment installations:

Direction of Force Applied	*Normal Utility FAR 23 (CAR3)*	*Acrobatic FAR 23 (CAR3)*	*Transport FAR 25 (CAR 4b)*	*Rotorcraft FAR 27, 29 (CAR 6, 7)*
Sideward	1.5g	1.5g	1.5g	2.0G
Upward	3.0g	4.5g	**	1.5g
Forward*	9.0g	9.0g	9.0g	4.0g
Downward	6.6g	9.0g	**	4.0g

* When equipment mounting is loacted externally to one side, or forward of occupants, a forward load factor of 2.0g is sufficient.

** Due to differences among various aircraft designs in flight and ground load factors, contact the aircraft manufacturer for the loaf factors required for a given model and location. in lieu of specific information, the factors used for FAR 23 utility category are acceptable for aircraft with never exceed speed of 250 knots or less and the factors used for FAR 23 acrobatic category for all other transport aircraft..

The following is an example of determining the static test loads for a 7-pound piece of equipment to be installed in a utility category aircraft (FAR Part 23).

When an additional load is to be added to structure already supporting previously installed equipment, determine the capability of the structure to support the total load (previous load plus added load).

Load factors (From the above table)		*Static Test Loads* (Load factor x 7 pounds)
Sideward	1.5g	10.5 pounds
Upward	3.0g	21.0 pounds
Downward	6.6g	46.2 pounds
Forward	9.0g	63.0 pounds

3. STATIC TESTS.
Caution: The aircraft and/or equipment can be damaged in applying static loads, particularly if careless or improper procedure is used.

It is recommended, whenever practicable, that staic testing be conducted on a duplicate installation in a jig or mockup which simulates the related aircraft structure. Static test loads may exceed the yiled limits of the assemblies being substantiated and can result in partially sheared fasteners, elongated holes, or other damage which may not be visible unless the structure is disassembled. If the structure is materially weakened during testing, it may fail at a later date.

Riveted sheet metal and composite laminate construction methods especially do not lend themselves to easy detection of such damage. To conduct static tests:

a. Determine the weight and center of gravity position of the equipment item.

b. Make actual or simulated installation of attachment in the aircraft or preferably on a jig using the applicable static test load factors.

c. Determine the critical ultimate load factors for the up, down side, fore, and aft directions. A hypothetical example which follows steps (1) through (4) below is shown in figure 1.1.

(1) Convert the gust, maneuvering, and ground load factors obtained from the manufacturer or FAA engineering to ultimate load factors. Unless otherwise specified in the airworthiness standards

applicable to the aircraft. ultimate load factors are limit load factors multiplied by a 1.5 safety factor. (See columns 1, 2, and 3 for items A, B, and C of fig. 1.1.)

(2) Determine the ultimate inertia load forces for the emergency landing conditions as prescribed in the applicable airworthiness standards. (See items D and E, column 3, of fig. 1.1.)

(3) Determine what additional load factors are applicable to the specific seat, litter, berth or cargo tiedown device installation. The ultimate load factors are then multiplied by these factors to obtain the static test factors. (To simplify this example, only the seat, litter, berth, and safety belt attachment factor of 1.33 was assumed to be applicable. See Item E, column 4, of fig. 1.1.)

(4) Select the highest static test load factors obtained in Steps 1, 2, and/or 3 for each direction (up, down, side, fore, and aft). These factors are the critical static test load factors used to compute the static test load. (See column 6 of fig. 1.1.)

d. Apply load at center of gravity position (of equipment item or dummy) by any suitable means that will demonstrate that the attachment and structure are capable of supporting the required loads.

When no damage or permanent deformation occurs after 3 seconds of applied static load. The structure and attachments are acceptable. Should permanent deformation occur after 3 seconds, repair or replace the deformed structure to return it to its normal configuration and strength. Additional load testing is not necessary.

4. MATERIALS. Use materials conforming to an accepted standard such as AN, NAS, TSO, or MIL–SPEC.

5. FABRICATION. When a fabrication process which requires close control is used. Employ methods which produce consistently sound structure that is compatible with the aircraft structure.

6. FASTENERS. Use hardware conforming to an accepted standard such as AN, NAS, TSO, or MIL–SPEC. Attach equipment so as to prevent loosening in service due to vibration.

7.PROTECTION AGAINST DETERIORATION. Provide protection against deterioration or loss of strength due to corrosion, abrasion, electrolytic action, or other causes.

8. PROVISIONS FOR INSPECTION. Provide adequate provisions to permit close examination of equipment or adjacent parts of the aircraft that regularly require inspection, adjustment, lubrication, etc.

9. EFFECTS ON WEIGHT AND BALANCE. Assure that the altered aircraft can be operated within the weight and center of gravity ranges listed in the FAA Type Certificate (T.C.) Data Sheet or Aircraft Listing. Determine that the altered aircraft will not exceed maximum gross weight. (If applicable, correct the loading schedule to reflect the current loading procedure.) Consult Advisory Circular 43.13–1A, "Acceptable Methods, Techniques, and Practices—Aircraft Inspection and Repair" for Weight and Balance Computation Procedures.

10. EFFECTS ON SAFE OPERATION. Install equipment in a manner that will not interfere with or adversely affect the safe operation of the aircraft (controls, navigation equipment operation, etc.).

11. CONTROLS AND INDICATORS. Locate and identify equipment controls and indicators so they can be operated and read from the appropriate crewmember position.

12. PLACARDING. Label equipment requiring identification and, if necessary, placard operational instructions. Amend weight and balance information as required.

13.–20. [RESERVED]

EXHIBIT 16 (continued)

Utility Category Aircraft (FAR 23)

TYPE OF LOAD	LOAD FACTORS: Direction	1 Limit	2 X Safety	3 = Ultimate	4 X Special	5 = Static Test	6 Critical Static Test
A. Maneuvering	Fwd	(None)					
	Down	6.2 g	1.5	9.30 g		9.3 g	9.3 g
	Side	(None)					
	Up	-3.8 g	1.5	-5.7 g		-5.7 g	5.7 g
	Aft	1.0 g	1.5	1.5 g		1.5 g	
B. Gust (= 30FPS @ KVc)	Fwd	(None)					
	Down	6.0 g	1.5	9.0 g		9.0 g	
*For locations aft of fuelage Sta. 73.85	Down*	6.4 g	1.5	9.6 g		9.6 g	*9.6 g
	Side	1.6 g	1.5	2.4 g		2.4 g	2.4 g
	Up	-2.8 g	1.5	-4.2 g		-4.2 g	
	Aft	(None)					
C. Ground	Fwd	6.6 g	1.5	9.9 g		9.9 g	9.9 g
	Down	4.0 g	1.5	6.0 g		6.0 g	
D. Ultuimate Inertia Forces for Emergency Landing Condition (FAR 23.561).	Fwd	Already Prescribed as Ultimate “	“	9.0 g			
**For Separate cargo compartments.	Fwd**	“	“	4.5 g			**4.5 g
	Down	“	“	(None)			
	Side	“	“	1.5 g		1.5 g	
	Up	“	“	-3.0 g		-3.0 g	
	Aft	“	“	(None)			
E. Ultimate Inertia Forces for Emergency Landing Condition For Seat, Litter, & Berth Attachment to Aircraft Structure (FAR 23.785).a	Fwd	“	“	9.0 g	1.33	12.0 g	12.0 g
	Down	“	“	(None)			
	Side	“	“	1.5 g	1.33	2.0 g	
	Up	“	“	-3.0 g	1.33	-4.0 g	
	Aft	“	“	(None)			

* Asterisks denote special load conditions for the situation shown.

EXHIBIT 17

Turnbuckle safetying guide

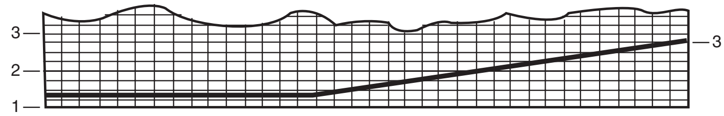
Cable size	Type of Wrap	Diameter of safety wire	Material (annealed condition)
1/16	Single	0.040	Copper, brass.[1]
3/32	Single	0.040	Copper, brass.[1]
1/8	Single	0.040	Stainless steel, Monel and "K" Monel.
1/8	Double	0.040	Copper, brass.[1]
1/8	Single	0.057 min	Copper, brass.[1]
5/32 and greater	Double	0.040	Stainless steel, Monel and "K" Monel.[1]
5/32 and greater	Single	0.057 min	Stainless steel, Monel and "K" Monel.[1]
5/32 and greater	Double	0.051[2]	Copper, brass.[1]
[1] Galvanized or tinned steel, or soft iron wires are also acceptable.			
[2] The safety wire holes in 5/32-inch diameter and larger turnbuckle terminals for swagging may be drilled sufficiently to accommodate the double 0.051-inch diamter copper or brass wires when used.			

EXHIBIT 18

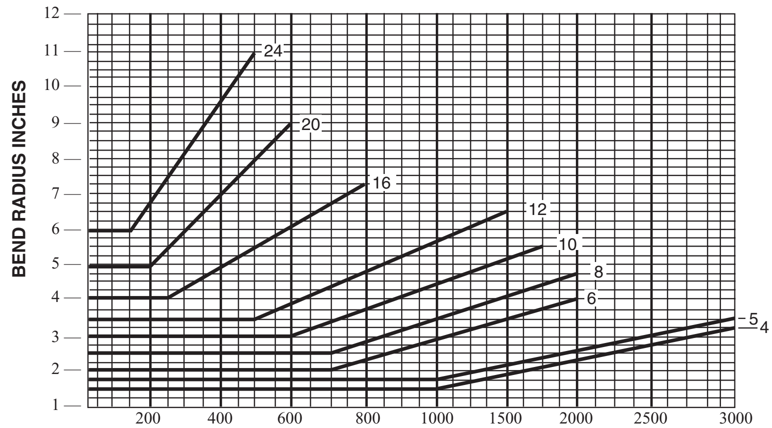
Straight-shank terminal dimensions (cross reference AN to MS: AN-666 to MS 21259, AN-667 to MS 20667, AN-668 to MS 20668, AN-669 to MS 21260)

Straight-shank terminal dimensions (cross reference AN to MS: AN-666 to MS 21259, AN-667 to MS 20667, AN-668 to MS 20668, AN-669 to MS 21260							
Cable size (inches)	Wire strands	Before Swaging				After swaging	
		Outside diameter	Bore diameter	Bore length	Swaging length	Minimum breaking strength (pounds)	Shank diameter*
1/16	7 x 7	0.160	0.078	1.042	0.969	480	0.138
3/32	7 x 7	.218	.109	1.261	1.188	920	.190
1/8	7 x 19	.250	.141	1.511	1.438	2,000	.219
5/32	7 x 19	.297	.172	1.761	1.688	2,800	.250
3/16	7 x 19	.359	.203	2.011	1.938	4,200	.313
7/32	7 x 19	.427	.234	2.261	2.188	5,600	.375
1/4	7 x 19	.494	.265	2.511	2.438	7,000	.438
9/32	7 x 19	.563	.297	2.761	2.688	8,000	.500
5/16	7 x 19	.635	.328	3.011	2.938	9,800	.563
3/8	7 x 19	.703	.390	3.510	3.438	14,400	.625
* Use gauges in kit for checking diameters.							

EXHIBIT 19



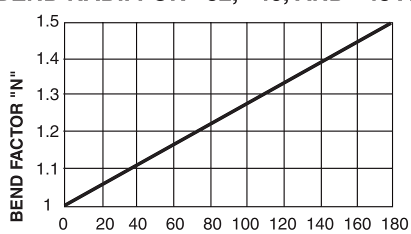
INSIDE BEND RADII V.S. OPERATING PRESSURE MIL-H-8794 HOSE WITH NO FLEXING



OPERATING PRESSURE — POUNDS/SQ. IN. (–3 TO –24 INCLUSIVE)

MINIMUM BEND RADII FOR –32, –40, AND –48 AT ALL PRESSURES ARE AS FOLLOWS:

–32	**13.25"**
–40	**24"**
–48	**33"**

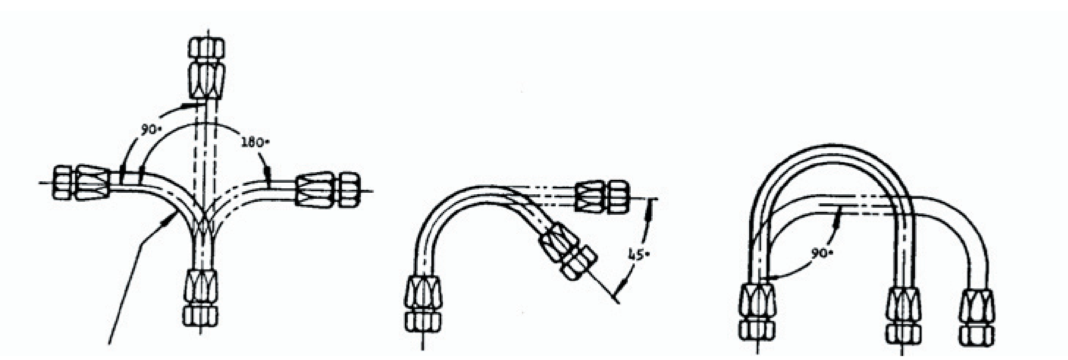


TOTAL FLEXING RANGE OF INSTALLED HOSE (DEGREES)

MIL-H-8788 HOSE WITH NO FLEXING	
DASH NO.	BEND RADII
4	3.000
5	3.375
6	5.000
8	5.750
10	6.500
12	7.750
16	9.625

MINIMUM BEND RADIUS OF HOSE UNDER FLEXING CONDITIONS = "N" X NO FLEXING BEND RADIUS OF EITHER MIL-H-8794 OR MIL-H-8788 HOSE.

EXAMPLE: FOR MIL-H-8794 HOSE –12 SIZE AT 1500 PSI AND HAVING A FLEXING RANGE OF 60° MINIMUM BEND RADIUS = 1.16 X 6.5 = 7 $^{1}/_{2}$ INCHES (MEASURED AT INSIDE OF BEND).



MINIMUM BEND RADII MEASURED AT INSIDE OF BEND
DIMENSIONS IN INCHES.

EXHIBIT 20

Minimum Bend Radii-Teflon Hose

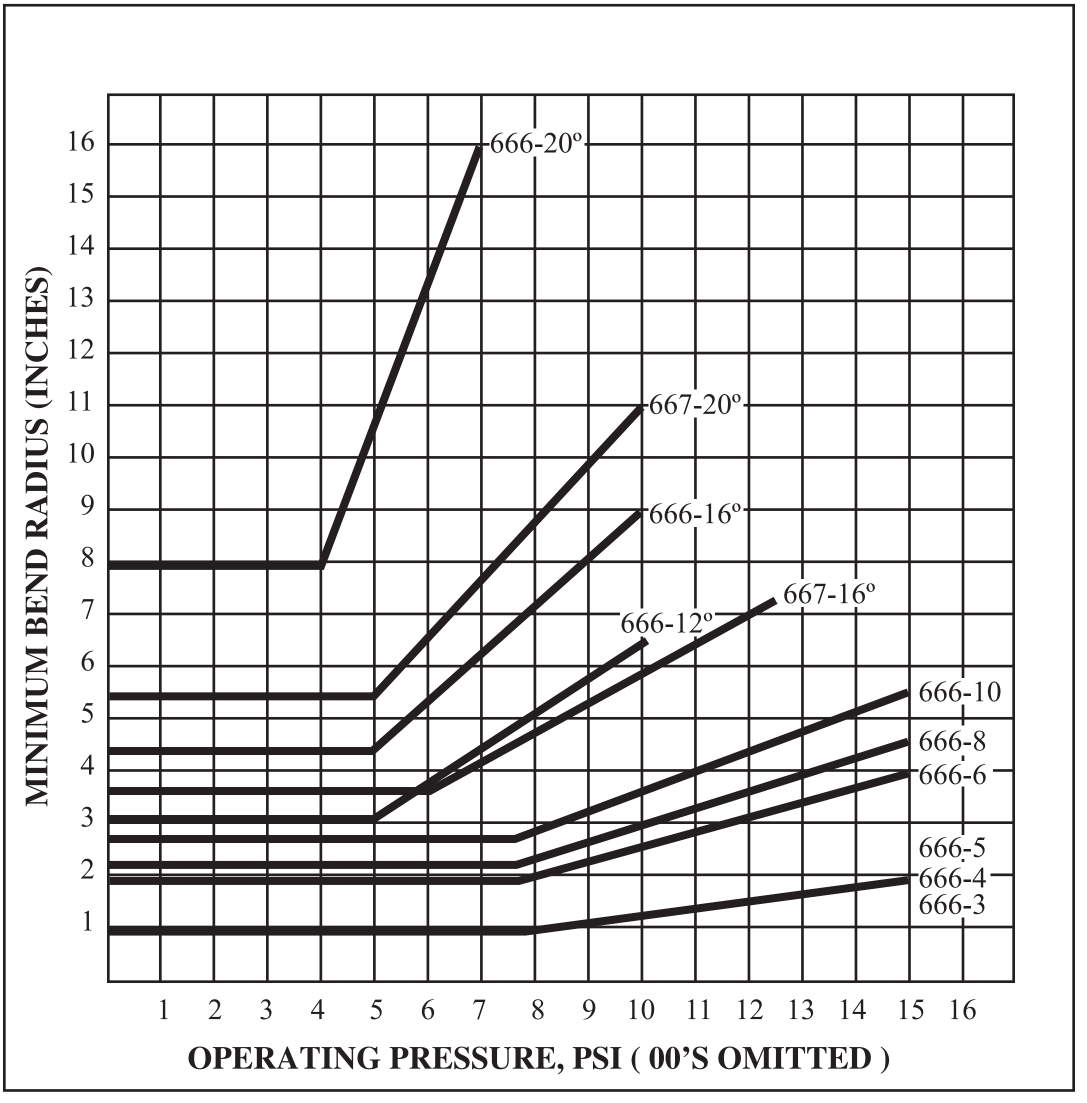


EXHIBIT 21

Chapter 11. Adding or Relocating Instruments

211. GENERAL. This chapter contains structural and design information to be considered when aircraft alterations involving the addition and relocation of instruments are being made.

212. PREPARATION. First determine what regulation, (CAR 3, 4b, FAR 23, 25, etc.) is the basis for the aircraft type certificate. That regulation establishes the structural and performance requirements to be considered when instruments are to be added or relocated.

a. ***Structure.*** Chapter 1 of this handbook provides information by which structural integrity may be determined. Chapter 2, paragraph 23a through f provides information pertinent to instrument panel installation.

b. ***Location.*** Consult the applicable regulation for the specific requirements for instrument location and arrangement.

(1) In the absence of specific requirements, installation of IFR flight instruments in a "T" arrangement is recommended. Locate the aircraft attitude indicator at top center, airspeed indicator to the left, altimeter to the right and directional indicator directly below, thus forming the letter "T." When a radio altimeter is used, the indicator may be placed on the immediate right of the attitude indicator with the pressure altimeter to the right of the radio altimeter indicator.

213. INSTALLATION. Mount all instruments so they are visible to the crewmember primarily responsible for their use. Mount self-contained gyroscopic instruments so that the sensitive axis is parallel to the aircraft longitudinal axis.

a. ***Structure.*** When making structural changes such as adding holes in the instrument panel to mount instruments, refer to chapter 2, paragraph 23a through f of this handbook. Refer to the aircraft manufacturer's instructions and Advisory Circular 43.13–1A, "Acceptable Methods, Techniques. and Practices—Aircraft Inspection and Repair," chapter 2, section 3, for methods and techniques of retaining structural integrity.

b. ***Plumbing.*** Refer to the manufacturers instructions for fabrication, routing and installation of instrument system lines. Advisory Circular 43.13–1A provides information regarding the installation and fabrication of aircraft plumbing.

c. **Vacuum Source.** Minimum requirements for installation and performance of instrument vacuum systems are covered in the applicable FAR Airworthiness Standards under "Instruments: Installation."

(1) In the absence of specific requirements for vacuum pump installation, refer to FAR Part 25, section 25.1433 for guidance. It is desirable to install a "T" fitting between the pump and relief valve to facilitate ground checking and adjustment of the system.

(2) When a venturi tube power source is used, it should not be taken for granted that a venturi will produce sufficient vacuum to properly operate one or more instruments. Many of the venturi tubes available for aircraft have a flow rate of approximately 2.3 cubic feet per minute at 3.75 inches of mercury (in. Hg) vacuum. Therefore, it is essential that the vacuum load requirements be carefully evaluated.

(3) Vacuum loads may be calculated as follows:

(a) Gyroscopic instruments require optimum value of airflow to produce their rated rotor speed. For instance, a bank and pitch indicator requires approximately 2.30 cubic feet per minute for its operation and a resistance or pressure drop of 4.00 in. Hg. Therefore, operating an instrument requiring 4.00 in. Hg from one venturi would be marginal. Similarly, the directional gyro indicator consumes approximately 1.30 cubic feet per minute and a pressure drop of 4.00 in. Hg. The turn and bank indicator has a flow requirement of 0.50 cubic feet per minute and reaches this flow at a pressure drop of 2.00 in. Hg. The above instruments are listed in Tables 11.1 and 11.3. Optimum values are shown in Table 11.3. It should be noted that the negative pressure air soruce must not only deliver the optimum air source of vacuum to the instruments, but must also have sufficient volume capacity to accommodate the total flow requirements of the various instruments which it serves

Table 11.1—Instrument air consumption.

	Air consumption at sea level	
Instrument	*Differential drop in. Hg suction (Optimum)*	*Cubic feet/per minute*
AUTOMATIC PILOT SYSTEM (Types A-2, A-3, & A-3A)		
Directional gyro control unit across mount assembly	5.00	2.15*
Bank & climb gyro control unit across mount assembly	5.00	3.85*
Total	------	6.00*
AUTOMATIC PILOT SYSTEM (Type A-4)		
Directional gyro control unit	5.00	3.50*
Bank & climb gyro control unit	5.00	5.00*
Total	------	8.50*
Bank & Pitch indicator	4.00	2.30
Directional gyro indicator	4.00	1.30
Turn & bank indicator	2.00	.50
* NOTE.—Includes air required for operation of pneumatic relays.		

(b) To calculate the flow requirements of a simple vacuum system, assume four right-angle elbows and 20 feet of line (1/2 O.D. x .042) tubing.

1 Assume the flow requirements for:

Turn & bank indicator	.50 CFM
Directional gyro indicator	1.30 CFM
Bank & pitch indicator	2.30 CFM
Total flow required	4.10 CFM

2 The pressure drop for one 90° 1/2-inch O.D. x .042 elbow is equivalent to 0.62 feet of straight tubing, figure 11.1. Therefore, the pressure drop of four 90° elbows is equivalent to 2.48 feet of tubing.

Table 11.2—Equivalent straight tube line drops for 90° elbow.

Tubing size		Pressure drop in a 90° elbox in terms of length of straight tube equivalent to a 90° elbow
O.D. inch	*Wall thickness inch*	*Feet*
1/4 x	.035	0.28
3/8 x	.035	0.46
1/2 x	.042	0.62
5/8 x	.042	0.81
3/4 x	.049	0.98
1 x	.049	1.35

3 Determine the pressure drop through 22.48 feet (20 feet + 2.48 equivalent feet) of 1/2O.D. X .042 tubing at 4.10 CFM flow. From figure 11.1, pressure drop per each 10-foot length = 0.68 in. Hg. Divide 22.48 feet of tubing by 10 to obtain the number of 10-foot sections, i.e., 22.48 ÷ 10 = 2.248. Multiply the number of sections by 0.68 in. Hg to obtain the pressure drop through the system. (0.68 X 2.248 = 1.53 in. Hg)

	Suction in inches of mercury		
Instrument	*Minimum*	*Optimum*	*Maximum*
AUTOMATIC PILOT SYSTEM (Types A-2, A-3, & A-3A)			
Directional gyro control unit across mount assembly	4.75	5.00	5.25
Bank & climb gyro control unit across mount assembly	4.75	5.00	5.25
Gauge reading (differential gauge in B & C control unit)	3.75	4.00	4.25
AUTOMATIC PILOT SYSTEM (Type A-4)			
Directional gyro control unit	3.75	5.00	5.00
Bank & climb gyro control unit	3.75	5.00	5.00
Bank & Pitch indicator	3.75	4.00	5.00
Directional gyro indicator	3.75	4.00	5.00
Turn & bank indicator	1.80	2.00	2.20

4 The pump must therefore be capable of producing a minimum pressure differential of 5.53 in. Hg, i.e., 4.00 in. Hg for maximum instrument usage + 1.53 in. Hg (determined) at a flow of 4.10 cubic feet per minute.

d. Filter. Filters are used to prevent dust, lint and other foreign matter from entering the instrument and vacuum system. Filters may be located at the instrument intake port or at the manifold intake port when instruments are interconnected. Determine that the capacity of the filter is as great or greater than the capacity of the vacuum system. Assure that there is no pressure drop across the filter media.

e. Electrical Supply for Instruments. Guidelines for the installation of instrument electrical wiring and power source are provided in Advisory Circular 43.13-1A, chapter 11, sections 2 and 3, and Chapter 16, section 3.

NOTE: Strict conformance to the shielding specifications supplied by compass manufacturers is recommended in all installations to eliminate any possibility of spurious signals.

f. Instrument Lighting. Instrument lighting must be installed in accordance with the regulations that are applicable to the aircraft type certification requirements. If in some instances the reflection of the lights is unsatisfactory, provide a shield or a means for controlling the intensity of illumination.

g. Magnetic Headings. Calibrate magnetic instruments with the powerplants operating. After this initial calibration, switch all nav/com and electrical equipment, such as windshield wipers and defrosters, "on" to determine if any electrical system interference affects the instrument calibration. If the calibration is affected, prepare an instrument placard identifying the compass headings with the equipment "on" and also with the equipment "off." Placard in accordance with par. 214f of this chapter.

214. TESTING, MARKING, AND PLACARDING.

a. Testing the Venturi Tube-Powered Systems. At normal inflight cruise speed, check the venturi tube-powered system to assure that the required vacuum pressure is being supplied.

b. Testing the Vacuum Air Pump Powered System. When the system is powered by vacuum air pumps, check the system while the pumps are operating at their rated r.p.m. and measure the vacum available to the instruments.

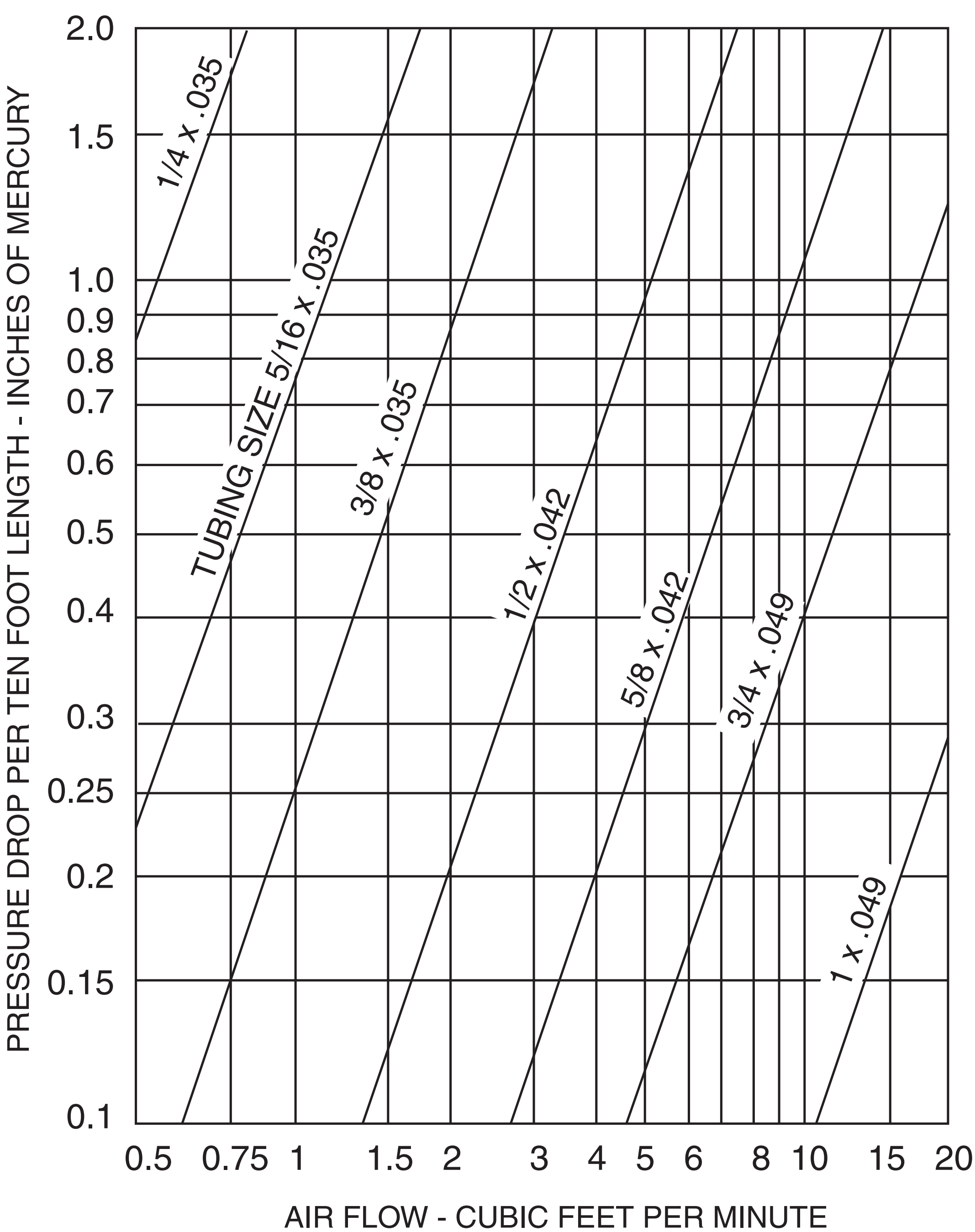
c. Testing of Altimeters and Static Systems. When checking the operation of an altimeter static system to determine that the system is free of any contaminating materials, be sure to disconnect the plumbing from all air operated instruments before purging the lines with dry air or nitrogen since the pressure necessary for purging may damage any connected instrument. Static system test procedures are provided in FAR 43, Appendix E.

d. Testing electrical supply (instruments). Check the voltage at the instrument terminals and determine that it is equal to the manufacturer's recommended values.

e. Fuel, Oil, and Hydraulic (Instrument Supply). Measure the fluid pressure at the instrument end of the line to determine whether it is equivalent to that at the pressure source.

f. Instrument Markings and Placards. When additional instruments are installed they must be appropriately marked. Refer to the applicable CAR/FAR under "Markings and Placards" for specific instrument marking and placard requirements.

215. - 240. [RESERVED]



PRESSURE DROP DATA FOR SMOOTH TUBING

EXHIBIT 22

ELECTRICAL WIRE RATING

DC wire and circuit protector chart.

Wire AN gauge copper	Circuit breaker amp.	Fuse amp.
22	5	5
20	7.5	5
18	10	10
16	15	10
14	20	15
12	30	20
10	40	30
8	50	50
6	80	70
4	100	70
2	125	100
1		150
0		150

Basis of chart:
(1) Wire bundles in 135 °F. ambient and altitudes up to 30,000 feet.
(2) Wire bundles of 15 or more wires, with wires carrying no more than 20 percent of the total current carrying capacity of the bundle as given in Specification MIL-W-5088 (ASG).
(3) Protectors in 75 to 85 °F. ambient.
(4) Copper wire Specification MIL-W-5088.
(5) Circuit breakers to Specification MIL-C-5809 or equivalent.
(6) Fuses to Specification MIL-F-15160 or equivalent.

Table 11-6. Tabulation chart (allowable voltage drop between bus and utilization equipment ground).

Nominal system voltage	Allowable voltage drop continuous operation	Intermittent operation
14	0.5	1
28	1	2
115	4	8
200	7	14

Tables 11-7 and 11-8 show formulas that may be used to determine electrical resistance in wires and some typical examples.

a. Resistance Calculation Methods. Figures 11-2 and 11-3 provide a convenient means of calculating maximum wire length for the given circuit current.

(1) Values in tables 11-7 and 11-8 are for tin-plated copper conductor wires. Because the resistance of tin-plated wire is slightly higher than that of nickel or silver-plated wire, maximum run lengths determined from these charts will be slightly less than the allowable limits for nickel or silver-plated copper wire and are therefore safe to use. Figures 11-2 and 11-3 can be used to derive slightly longer maximum run lengths for silver or nickel-plated wires by multiplying the maximum run length by the ratio of resistance of tin-plated wire, divided by the resistance of silver or nickel-plated wire.

TABLE 11-7. Examples of determining required tin-plated copper wire size and checking voltage drop using figure 11-2

Voltage drop	Run Lengths (Feet)	Circuit Current (Amps)	Wire Size From Chart	Check-calculated voltage drop (VD)= (Resistance/Ft) (Length) (Current)
1	107	20	No. 6	VD= (.00044 ohms/ft) (107)(20)= 0.942
0.5	90	20	No. 4	VD= (.00028 ohms/ft) (90)(20)= 0.504
4	88	20	No. 12	VD= (.00202 ohms/ft) (88)(20)= 3.60
7	100	20	No. 14	VD= (.00306 ohms/ft) (100)(20)= 6.12

TABLE 11-8. Examples of determining maximum tin-plated copper wire length and checking voltage drop using figure 11-2.

Maximum Voltage drop	Wire Size	Circuit Current (Amps)	Maximum Wire Run Length (Feet)	Check-calculated voltage drop (VD)= (Resistance/Ft) (Length) (Current)
1	No. 10	20	39	VD= (.00126 ohms/ft) (39)(20)= .98
0.5	----		19.5	VD= (.00126 ohms/ft) (19.5)(20)= .366
4	----		156	VD= (.00126 ohms/ft) (156)(20)= 3.93
7	----		273	VD= (.00126 ohms/ft) (273)(20)= 6.88

(2) As an alternative method or a means of checking results from figure 11-2, continuous flow resistance for a given wire size can be read from table 11-9 and multiplied by the wire run length and the circuit current. For intermittent flow, use figure 11-3.

(3) Voltage drop calculations for aluminum wires can be accomplished by multiplying the resistance for a given wire size, defined in table 11-10, by the wire run length and circuit current.

(4) When the estimated or measured conductor temperature (T2) exceeds 20 °C, such as in areas having elevated ambient temperatures or in fully loaded power-feed wires, the maximum allowable run length (L2), must be shortened from L1 (the 20 °C value) using the following formula for copper conductor wire:

$$L_2 = \frac{(254.5\ °C)(L_1)}{(234.5\ °C)+(T_2)}$$

For aluminum conductor wire, the formula is:

$$L_2 = \frac{(258.1\ °C)(L_1)}{(238.1\ °C)+(T_2)}$$

These formulas use the reciprocal of each material's resistively temperature coefficient to take into account increased conductor resistance resulting from operation at elevated temperatures.

(5) To determine T2 for wires carrying a high percentage of their current carrying capability at elevated temperatures, laboratory testing using a load bank and a high-temperature chamber is recommended. Such tests should be run at anticipated worse case ambient temperature and maximum current-loading combinations.

(6) Approximate T2 can be estimated using the following formula:

$$T_2 = T_1 + (T_R - T_1)(\sqrt{I_2 / I_{max}})$$

Where:

T_1 = Ambient Temperature
T_2 = Estimated Conductor Temperature
T_R = Conductor Temperature Rating
I_2 = Circuit Current (A=Amps)
I_{max} = Maximum Allowable Current

(A=Amps) at T_R

This formula is quite conservative and will typically yield somewhat higher estimated temperatures than are likely to be encountered under actual operating conditions.

Note: Aluminum wire-From Table 11-9 and 11-10 note that the conductor resistance of aluminum wire and that of copper wire (two numbers higher) are similar. Accordingly, the electric wire current in Table 11-9 can be used when it is desired to substitute aluminum wire and the proper size can be selected by reducing the copper wire size by two numbers and referring to Table 11-10. The use of aluminum wire size smaller than No. 8 is not recommended.

TABLE 11-9. Current carrying capacity and resistance of copper wire**.**

Wire Size	Continuous duty current (amps)-Wires in bundles, groups, harnesses, or conduits. (See Note #1)			Max. resistance ohms/1000ft@20 °C tin plated conductor (See Note #2)	Nominal conductor area -
	Wire Conductor Temperature Rating				
	105 °C	150 °C	200 °C		
24	2.5	4	5	28.40	475
22	3	5	6	16.20	755
20	4	7	9	9.88	1,216
18	6	9	12	6.23	1,900
16	7	11	14	4.81	2,426
14	10	14	18	3.06	3,831
12	13	19	25	2.02	5,874
10	17	26	32	1.26	9,354
8	38	57	71	0.70	16,983
6	50	76	97	0.44	26,818
4	68	103	133	0.28	42,615
2	95	141	179	0.18	66,500
1	113	166	210	0.15	81,700
0	128	192	243	0.12	104,500
00	147	222	285	0.09	133,000
000	172	262	335	0.07	166,500
0000	204	310	395	0.06	210,900

Note #1: Rating is for 70°C ambient, 33 or more wires in the bundle for sizes 24 through 10, and 9 wires for size 8 and larger, with no more than 20 percent of harness current carrying capacity being used, at an operating altitude of 60,000 feet. For rating of wires under other conditions or configurations see paragraph 11-69.

Note #2: For resistance of silver or nickel-plated conductors see wire specifications.

TABLE 11-10. Current carrying capacity and resistance of aluminum wire.

Wire Size	Continuous duty current (amps) Wires in bundles, groups or harnesses or conduits (See table 11-9 Note #1)		Max. resistance ohms/1000ft
Wire conductor temperature rating			@ 20 °C
	105 °C	150 °C	
8	30	45	1.093
6	40	61	0.641
4	54	82	0.427
2	76	113	0.268
1	90	133	0.214
0	102	153	0.169
00	117	178	0.133
000	138	209	0.109
0000	163	248	0.085
Note: Observe design practices described in paragraph 11-67 for aluminum conductor			

11-67. METHODS FOR DETERMINING CURRENT CARRYING CAPACITY OF WIRES. This paragraph contains methods for determining the current carrying capacity of electrical wire, both as a single wire in free air and when bundled into a harness. It presents derating factors for altitude correction and examples showing how to use the graphical and tabular data provided for this purpose. In some instances, the wire may be capable of carrying more current than is recommended for the contacts of the related connector. In this instance, it is the contact rating that dictates the maximum current to be carried by a wire. Wires of larger gauge may need to be used to fit within the crimp range of connector contacts that are adequately rated for the current being carried. Figure 11-5 gives a family of curves whereby the bundle derating factor may be obtained.

a. **Effects of Heat Aging on Wire Insulation.** Since electrical wire may be installed in areas where inspection is infrequent over extended periods of time, it is necessary to give special consideration to heat-aging characteristics in the selection of wire. Resistance to heat is of primary importance in the selection of wire for aircraft use, as it is the basic factor in wire rating. Where wire may be required to operate at higher temperatures due either to high ambient temperatures, high-current loading, or a combination of the two, selection should be made on the basis of satisfactory performance under the most severe operating conditions.

b. **Maximum Operating Temperature.** The current that causes a temperature steady state condition equal to the rated temperature of the wire should not be exceeded. Rated temperature of the wire may be based upon the ability of either the conductor or the insulation to withstand continuous operation without degradation.

c. **Single Wire in Free Air.** Determining a wiring system's current carrying capacity begins with determining the maximum current that a given-sized wire can carry without exceeding the allowable temperature difference (wire rating minus ambient °C). The curves are based upon a single copper wire in free air. (See figures 11-4a and 11-4b.)

d. **Wires in a Harness.** When wires are bundled into harnesses, the current derived for a single wire must be reduced as shown in figure 11-5. The amount of current derating is a function of the number of wires in the bundle and the percentage of the total wire bundle capacity that is being used.

e. **Harness at Altitude.** Since heat loss from the bundle is reduced with increased altitude, the amount of current should be de-rated. Figure 11-6 gives a curve whereby the altitude-derating factor may be obtained.

f. **Aluminum Conductor Wire.** When aluminum conductor wire is used, sizes should be selected on the basis of current ratings shown in table 11-10. The use of sizes smaller than #8 is discouraged (Ref. AS50881A). Aluminum wire should not be attached to engine mounted accessories or used in areas having corrosive fumes, severe vibration, mechanical stresses, or where there is a need for frequent disconnection. Use of aluminum wire is also discouraged for runs of less than 3 feet (AS50991A). Termination hardware should be of the type specifically designed for use with aluminum conductor wiring.

11-4. INSTRUCTIONS FOR USE OF ELECTRICAL WIRE CHART.

a. **Correct Size.** To select the correct size of electrical wire, two major requirements must be met:

(1) The wire size should be sufficient to prevent an excessive voltage drop while carrying the required current over the required distance. (See table 11-6, Tabulation Chart, for allowable voltage drops.)

(2) The size should be sufficient to prevent overheating of the wire carrying the required current. (See paragraph 11-69 for allowable current carrying calculation methods.)

b. Two Requirements. To meet the two requirements (see paragraph 11-66b) in selecting the correct wire size using figure 11-2 or figure 11-3, the following must be known:

(1) The wire length in feet.

(2) The number of amperes of current to be carried.

(3) The allowable voltage drop permitted.

(4) The required continuous or intermittent current.

(5) The estimated or measured conductor temperature.

(6) Is the wire to be installed in conduit and/or bundle?

(7) Is the wire to be installed as a single wire in free air?

c. Example No. 1. Find the wire size in figure 11-2 using the following known information.

(1) The wire run is 50 feet long, including the ground wire.

(2) Current load is 20 amps.

(3) The voltage source is 28 volts from bus to equipment.

(4) The circuit has continuous operation.

(5) Estimated conductor temperature is 20 °C or less.

The scale on the left of the chart represents maximum wire length in feet to prevent an excessive voltage drop for a specified voltage source system (e.g., 14V, 28V, 115V, 200V). This voltage is identified at the top of scale and the corresponding voltage drop limit for continuous operation at the bottom. The scale (slant lines) on top of the chart represents amperes. The scale at the bottom of the chart represents wire gauge.

STEP 1: From the left scale find the wire length, 50 feet under the 28V source column.

STEP 2: Follow the corresponding horizontal line to the right until it intersects the slanted line for the 20-amp load.

STEP 3: At this point, drop vertically to the bottom of the chart. The value falls between No. 8 and No. 10. Select the next larger size wire to the right, in this case No. 8. This is the smallest size wire that can be used without exceeding the voltage drop limit expressed at the bottom of the left scale. This example is plotted on the wire chart, figure 11-2. Use figure 11-2 for continuous flow and figure 11-3 for intermittent flow.

b. Procedures in Example No. 1 paragraph 11-68c, can be used to find the wire size for any continuous or intermittent operation (maximum two minutes). Voltage (e.g. 14 volts, 28 volts, 115 volts, 200 volts) as indicated on the left scale of the wire chart in figure 11-2 and 11-3.

c. Example No. 2. Using figure 11-2, find the wire size required to meet the allowable voltage drop in table 11-6 for a wire carrying current at an elevated conductor temperature using the following information:

(1) The wire run is 15.5 feet long, including the ground wire.

(2) Circuit current (I2) is 20 amps, continuous.

(3) The voltage source is 28 volts.

(4) The wire type used has a 200 °C conductor rating and it is intended to use this thermal rating to minimize the wire gauge. Assume that the method described in paragraph 11-66d(6) was used and the minimum wire size to carry the required current is #14.

(5) Ambient temperature is 50 °C under hottest operating conditions.

d. Procedures in example No. 2.

STEP 1: Assuming that the recommended load bank testing described in paragraph 11-66d(5) is unable to be conducted, then the estimated calculation methods outlined in paragraph 11-66d(6) may be used to determine the estimated maximum current (Imax). The #14 gauge wire mentioned above can carry the required current at 50 °C ambient (allowing for altitude and bundle derating).

(1) Use figure 11-4a to calculate the Imax a #14 gauge wire can carry.

Where:

T_2 = estimated conductor temperature

T_1 = 50 °C ambient temperature

T_R = 200 °C maximum conductor rated temperature

(2) Find the temperature differences (T_R-T_1) = (200 °C-50 °C) = 150 °C.

(3) Follow the 150 °C corresponding horizontal line to intersect with #14 wire size, drop vertically and read 47 Amps at bottom of chart (current amperes).

(4) Use figure 11-5, left side of chart reads 0.91 for 20,000 feet, multiple 0.91 x 47 Amps = 42.77 A mps.

(5) Use figure 11-6, find the derate factor for 8 wires in a bundle at 60 percent. First find the number of wires in the bundle (8) at bottom of graph and intersect with the 60 percent curve meet. Read derating factor, (left side of graph) which is 0.6. Multiply 0.6 x 42.77 Amps = 26 Amps.

I_{max} = 26 amps (this is the maximum current the #14 gauge wire could carry at 50°C ambient

L_1=15.5 feet maximum run length for size #14 wire carrying 20 amps from figure 11-2

STEP 2: From paragraph 11-66d (5) and (6), determine the T_2 and the resultant maximum wire length when the increased resistance of the higher temperature conductor is taken into account.

$$T_2 = T_1 + (T_R - T_1)\,(\sqrt{I_2}\,/I_{max})$$

$$T_2 = 50\ °C = (200\ °C - 50\ °C)\,(\sqrt{20A/26A})$$
$$= 50\ °C+(150\ °C)(.877)$$
$$T_2 = 182\ °C$$

$$L_2 = \frac{(254.5\ °C)(L_1)}{(234.5\ °C) + (T_2)} =$$

$$L_2 = \frac{(254.5\ °C)(15.5\ Ft)}{(234.5\ °C) + (182\ °C\ )}$$

$$L_2 = 9.5\ ft$$

The size #14 wire selected using the methods outlined in paragraph 11-66d is too small to meet the voltage drop limits from figure 11-2 for a 15.5 feet long wire run.

STEP 3: Select the next larger wire (size #12) and repeat the calculations as follows:

L_1=24 feet maximum run length for 12 gauge wire carrying 20 amps from figure 11-2.

I_{max} = 37 amps (this is the maximum current the size #12 wire can carry at 50 °C ambient. Use calculation methods outlined in paragraph 11-69 and figure 11-4a.

$T_2 = 50\ °C + (200\ °C - 50\ °C)\ (\sqrt{20A/37A}) =$
$50\ °C+(150\ °C)(-540) = 131\ °C$

$$L_2 = \frac{(254.5\ °C)(L_1)}{(234.5\ °C) + (T_2)} =$$

$$L_2 = \frac{(254.5\ °C)(24\ Ft)}{(234.5\ °C) + (131\ °C\ )} = \frac{6108}{366}$$

$$L_2 = \frac{(254.5\ °C)(24\ Ft)}{366} = 16.7\ ft$$

The resultant maximum wire length, after adjusting downward for the added resistance associated with running the wire at a higher temperature, is 15.4 feet, which will meet the original 15.5 foot wire run length requirement without exceeding the voltage drop limit expressed in figure 11-2.

11-5. COMPUTING CURRENT CARRY- ING CAPACITY.

a. Example 1. Assume a harness (open or braided), consisting of 10 wires, size #20, 200 °C rated copper and 25 wires, size #22, 200 °C rated copper, will be installed in an area where the ambient temperature is 60 °C and the vehicle is capable of operating at a 60,000-foot altitude. Circuit analysis reveals that 7 of the 35 wires in the bundle (7/35 = 20 percent) will be carrying power currents nearly at or up to capacity.

STEP 1: Refer to the "single wire in free air" curves in figure 11-4a. Determine the change of temperature of the wire to determine free air ratings. Since the wire will be in an ambient of 60 ºC and rated at 200° C, the change of to temperature is 200 °C - 60 °C = 140 °C. Follow the 140 °C temperature difference horizontally until it intersects with wire size line on figure 11-4a. The free air rating for size #20 is 21.5 amps, and the free air rating for size #22 is 16.2 amps.

STEP 2: Refer to the "bundle derating curves" in figure 11-5, the 20 percent curve is selected since circuit analysis indicate that 20 percent or less of the wire in the harness would be carrying power currents and less than 20 percent of the bundle capacity would be used. Find 35 (on the abscissa) since there are 35 wires in the bundle and determine a derating factor of 0.52 (on the ordinate) from the 20 percent curve.

STEP 3: Derate the size #22 free air rating by multiplying 16.2 by 0.52 to get 8.4 amps in-harness rating. Derate the size #20 free airrating by multiplying 21.5 by 0.52 to get 11.2 amps in-harness rating.

STEP 4: Refer to the "altitude derating curve" of figure 11-6, look for 60,000 feet (on the abscissa) since that is the altitude at which the vehicle will be operating. Note that the wire must be derated by a factor of 0.79 (found on the ordinate). Derate the size
#22 harness rating by multiplying 8.4 amps by 0.79 to get 6.6 amps. Derate the size #20 harness rating by multiplying 11.2 amps by 0.79 to get 8.8 amps.

STEP 5: To find the total harness capacity, multiply the total number of size #22 wires by the derated capacity (25 x 6.6 = 165.0 amps) and add to that the number of size #20 wires multiplied by the derated capacity (10 x 8.8 = 88 amps) and multiply the sum by the 20 percent harness capacity factor. Thus, the total harness capacity is (165.0 + 88.0) x 0.20 = 50.6 amps. It has been determined that the total harness current should not exceed 50.6 A, size #22 wire should not carry more than 6.6 amps and size #20 wire should not carry more than 8.8 amps.

STEP 6: Determine the actual circuit current for each wire in the bundle and for the whole bundle. If the values calculated in step #5 are exceeded, select the next larger size wire and repeat the calculations.

b. Example 2. Assume a harness (open or braided), consisting of 12, size #12, 200 °C rated copper wires, will be operated in an ambient of 25 °C at sea level and 60 °C at a 20,000-foot altitude. All 12 wires will be operated at or near their maximum capacity.

STEP 1: Refer to the "single wire in free air" curve in figure 11-4a, determine the temperature difference of the wire to determine free air ratings. Since the wire will be in ambient of 25 °C and 60 °C and is rated at 200 °C, the temperature differences are 200 °C-25 °C = 175 °C and 200 °C-60 °C = 140 °C respectively. Follow the 175 °C and the 140 °C temperature difference lines on figure 11-4a until each intersects wire size line, the free air ratings of size #12 are 68 amps and 61 amps, respectively.

STEP 2: Refer to the "bundling derating curves" in figure 11-5, the 100 percent curve is selected because we know all 12 wires will be carrying full load. Find 12 (on the abscissa) since there are 12 wires in the bundle and determine a derating factor of 0.43 (on the ordinate) from the 100 percent curve.

STEP 3: Derate the size #12 free air ratings by multiplying 68 amps and 61 amps by 0.43 to get 29.2 amps and 26.2 amps, respectively.

STEP 4: Refer to the "altitude derating curve" of figure 11-6, look for sea level and 20,000 feet (on the abscissa) since these are the conditions at which the load will be carried. The wire must be derated by a factor of 1.0 and 0.91, respectively.

STEP 5: Derate the size #12 in a bundle ratings by multiplying 29.2 amps at sea level and 26.6 amps at 20,000 feet by 1.0 and 0.91, respectively, to obtained 29.2 amps and 23.8 amps. The total bundle capacity at sea level and 25 °C ambient is 29.2x12=350.4 amps. At 20,000 feet and 60 °C ambient the bundle capacity is 23.8x12=285.6 amps. Each size #12 wire can carry 29.2 amps at sea level, 25 °C ambient or 23.8 amps at 20,000 feet, and 60 °C ambient.

STEP 6: Determine the actual circuit current for each wire in the bundle and for the bundle. If the values calculated in Step #5 are exceeded, select the next larger size wire and repeat the calculations.

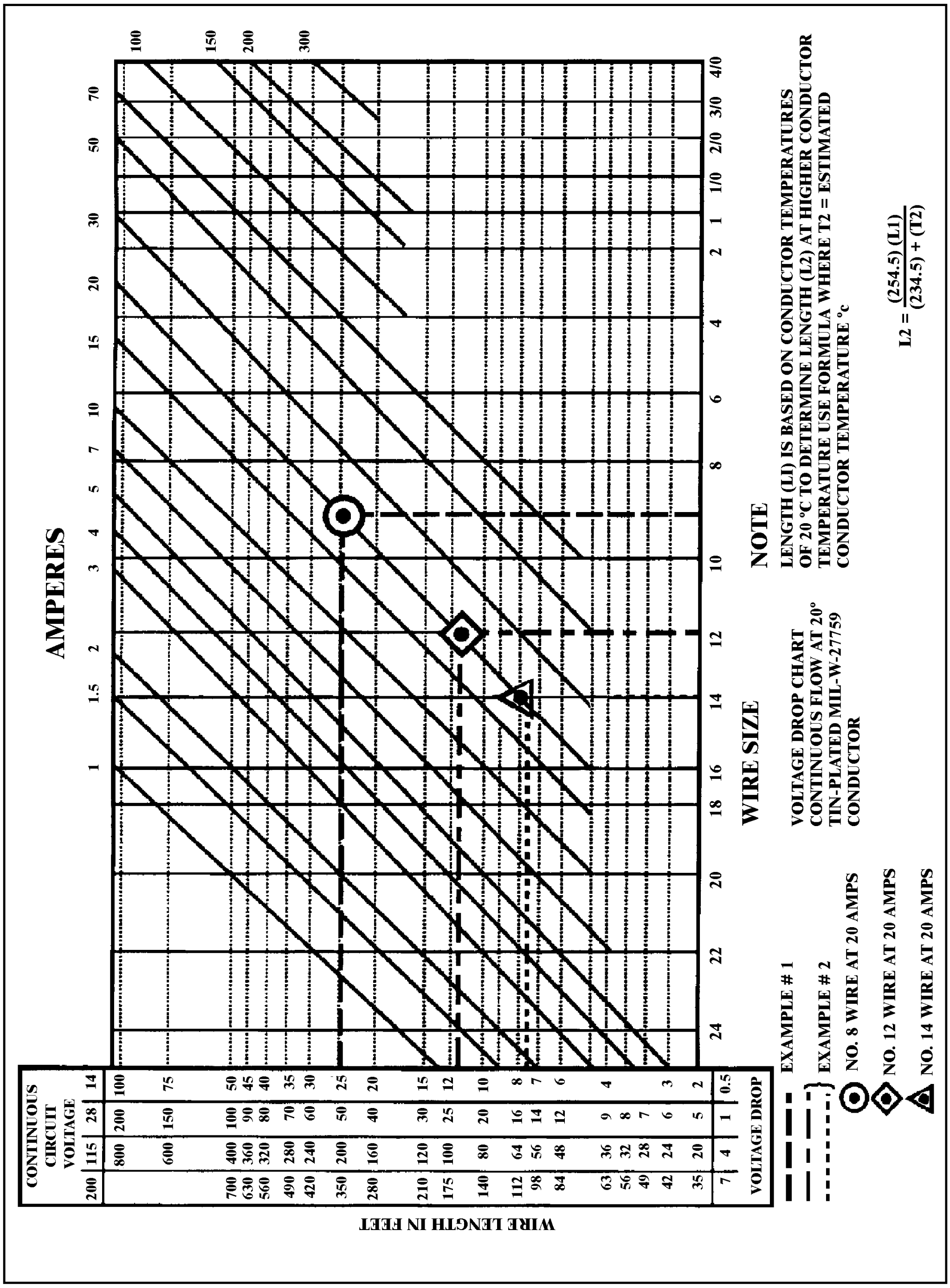


FIGURE 11-2. Conductor chart, continuous flow.

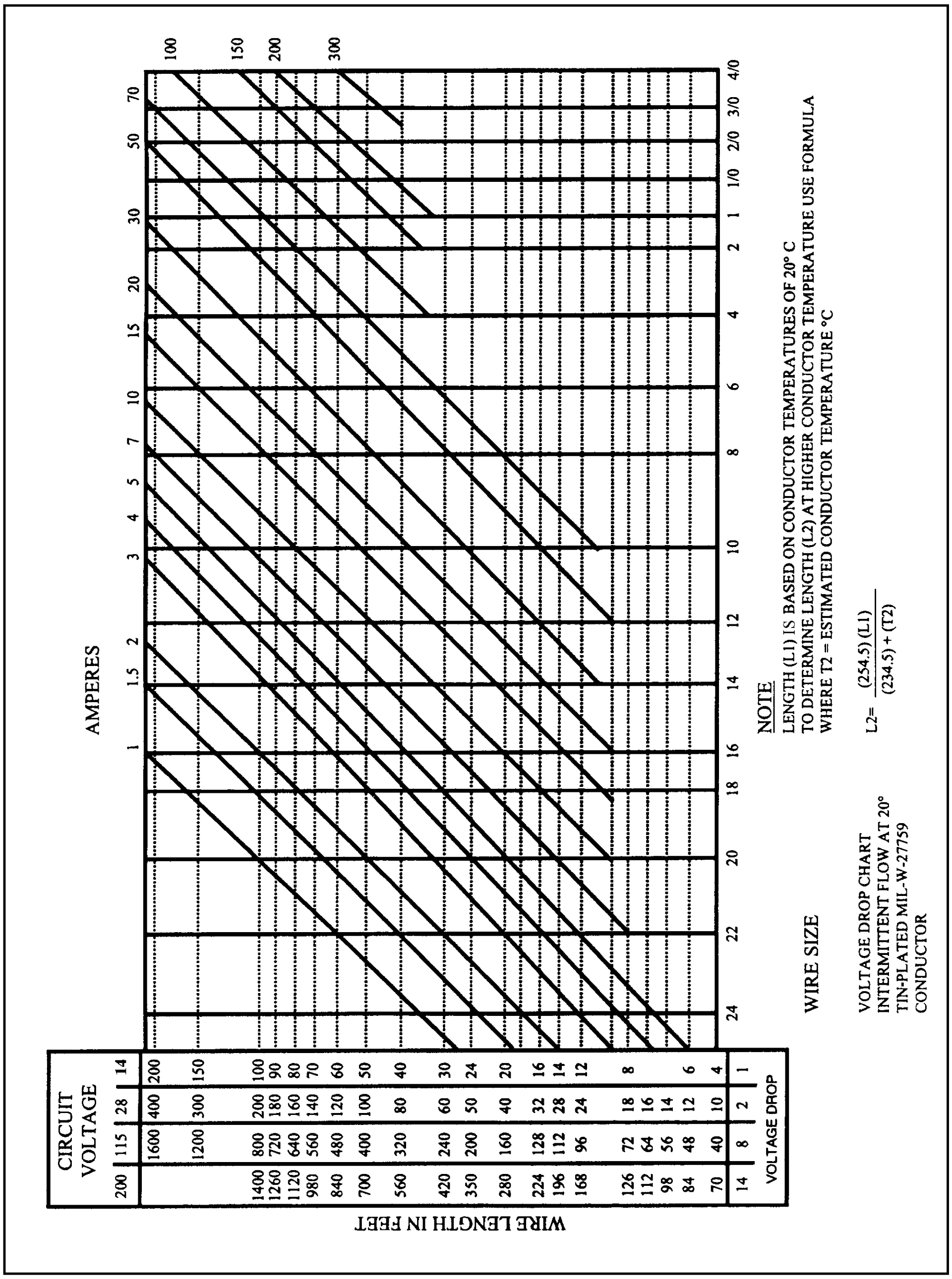


FIGURE 11-3. Conductor chart, intermittent flow.

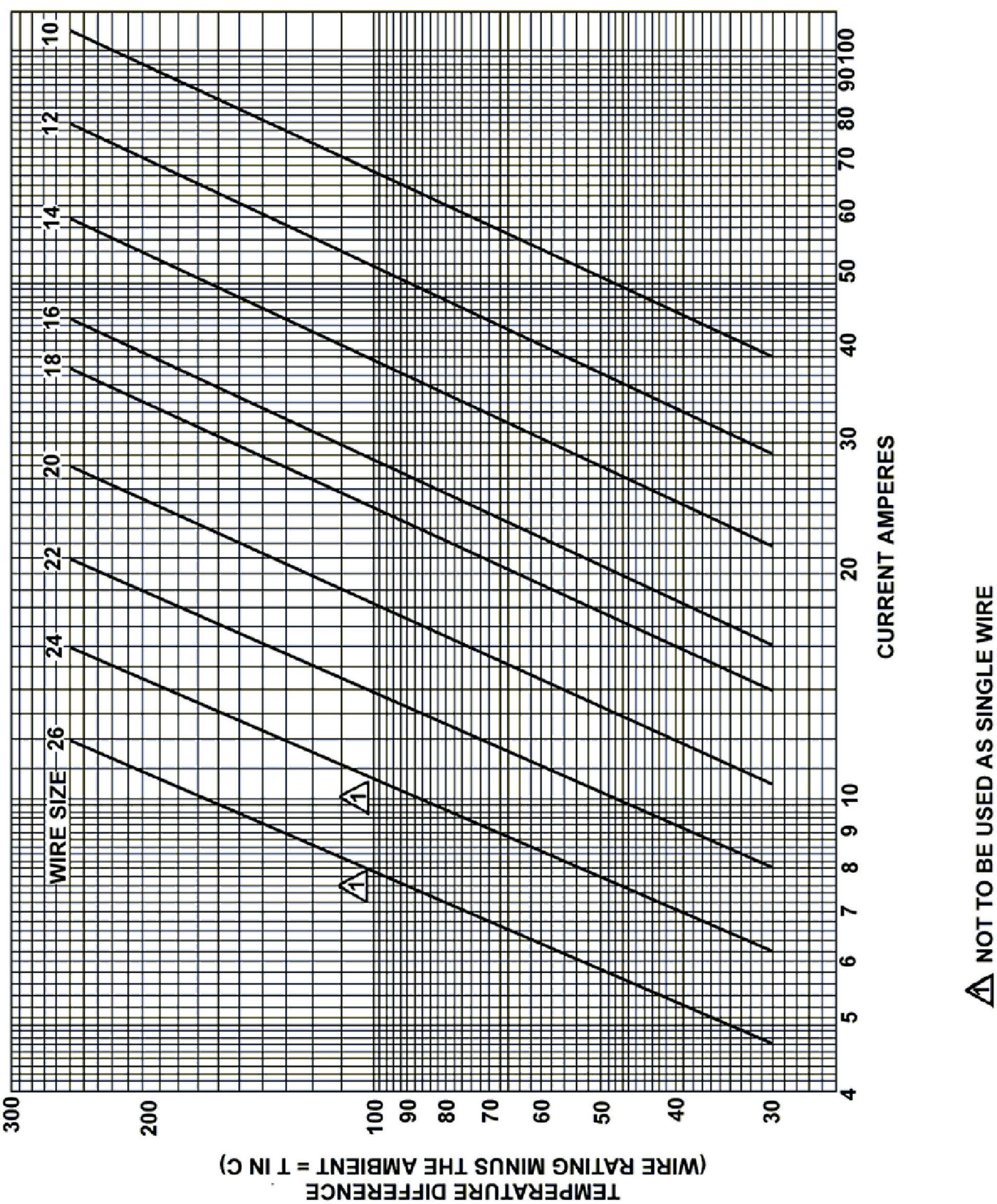


Figure 11-4a. Single copper wire in free air.

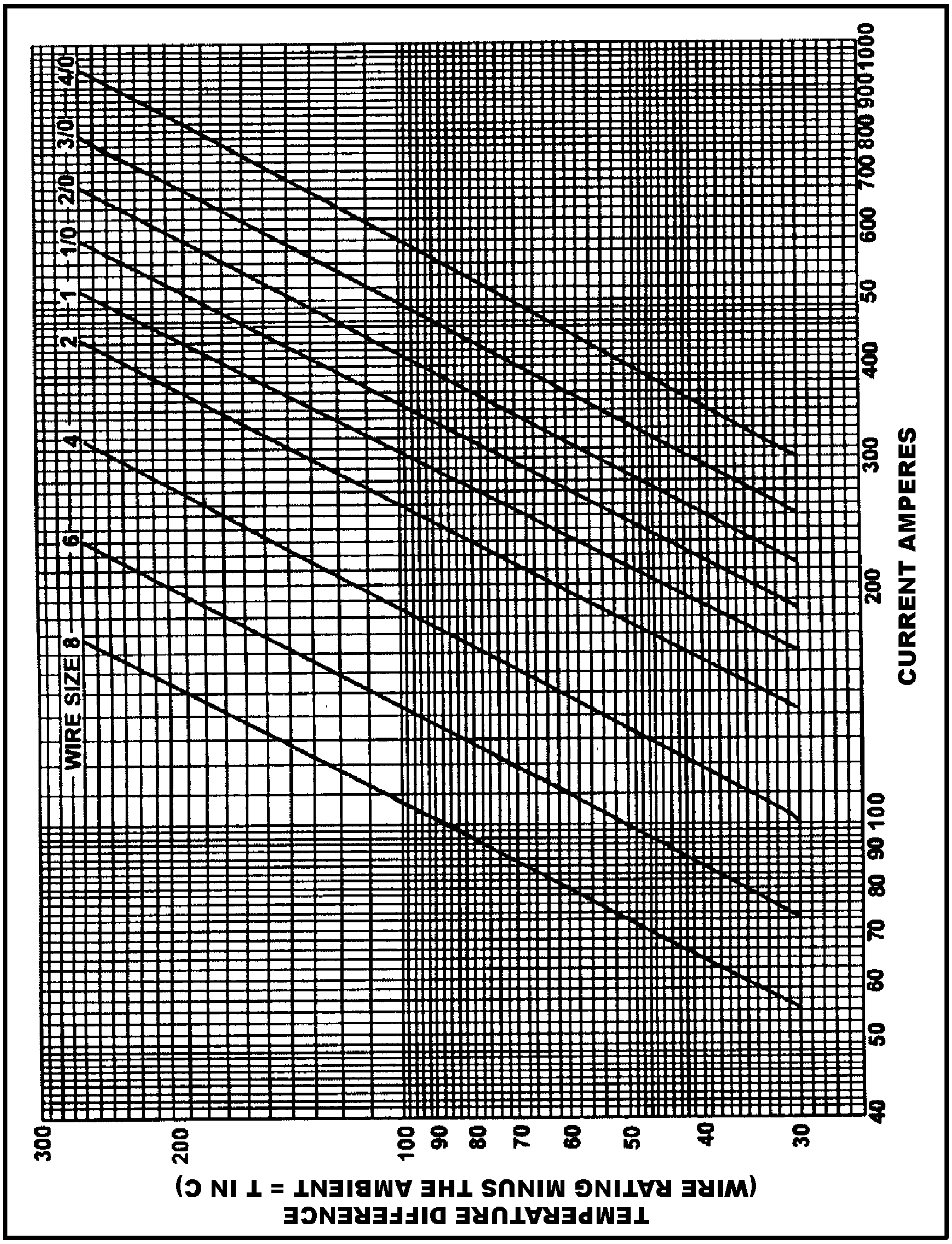


FIGURE 11-4b. Single copper wire in free air.

EXHIBIT 22 (continued)

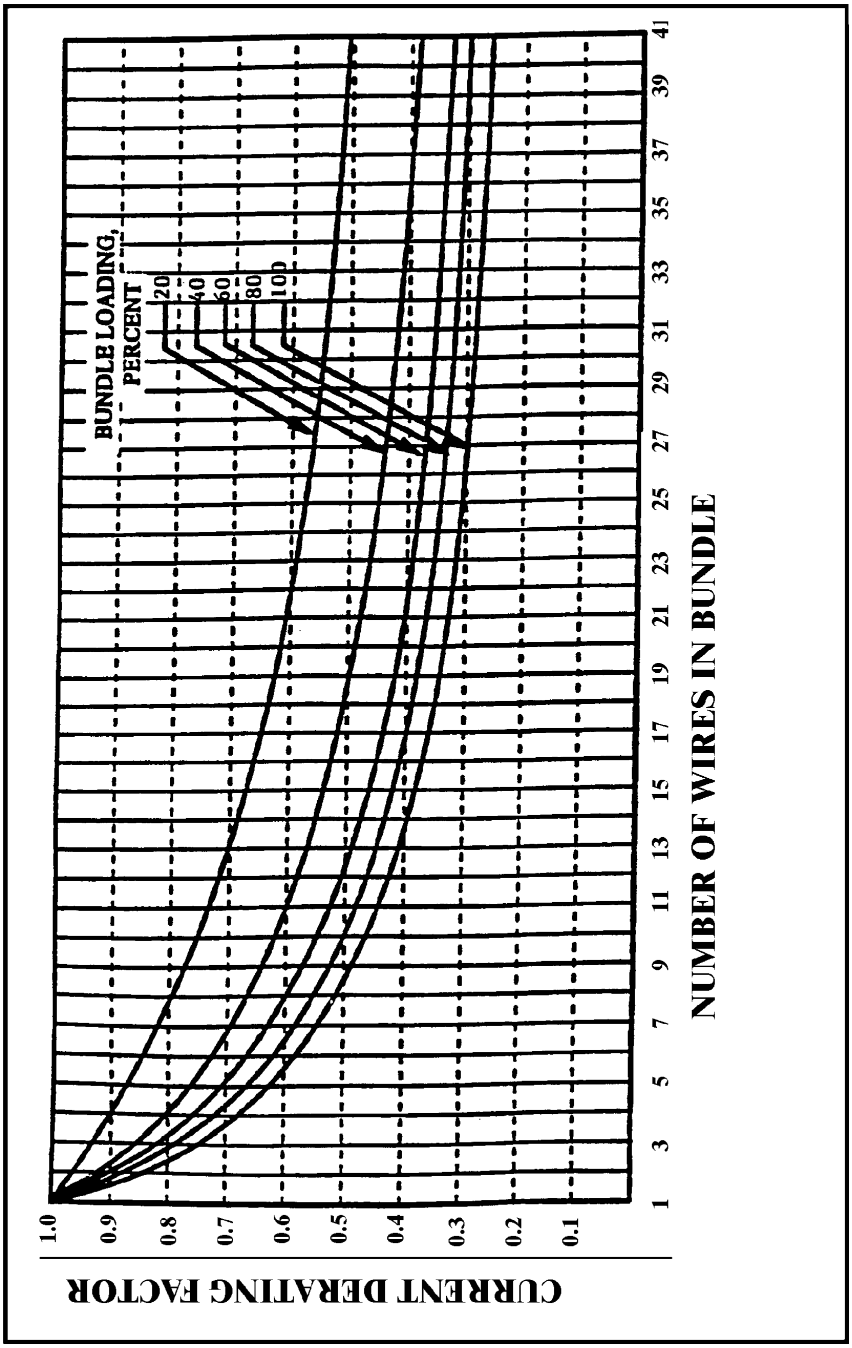


Figure 11-5. Bundle derating curves.

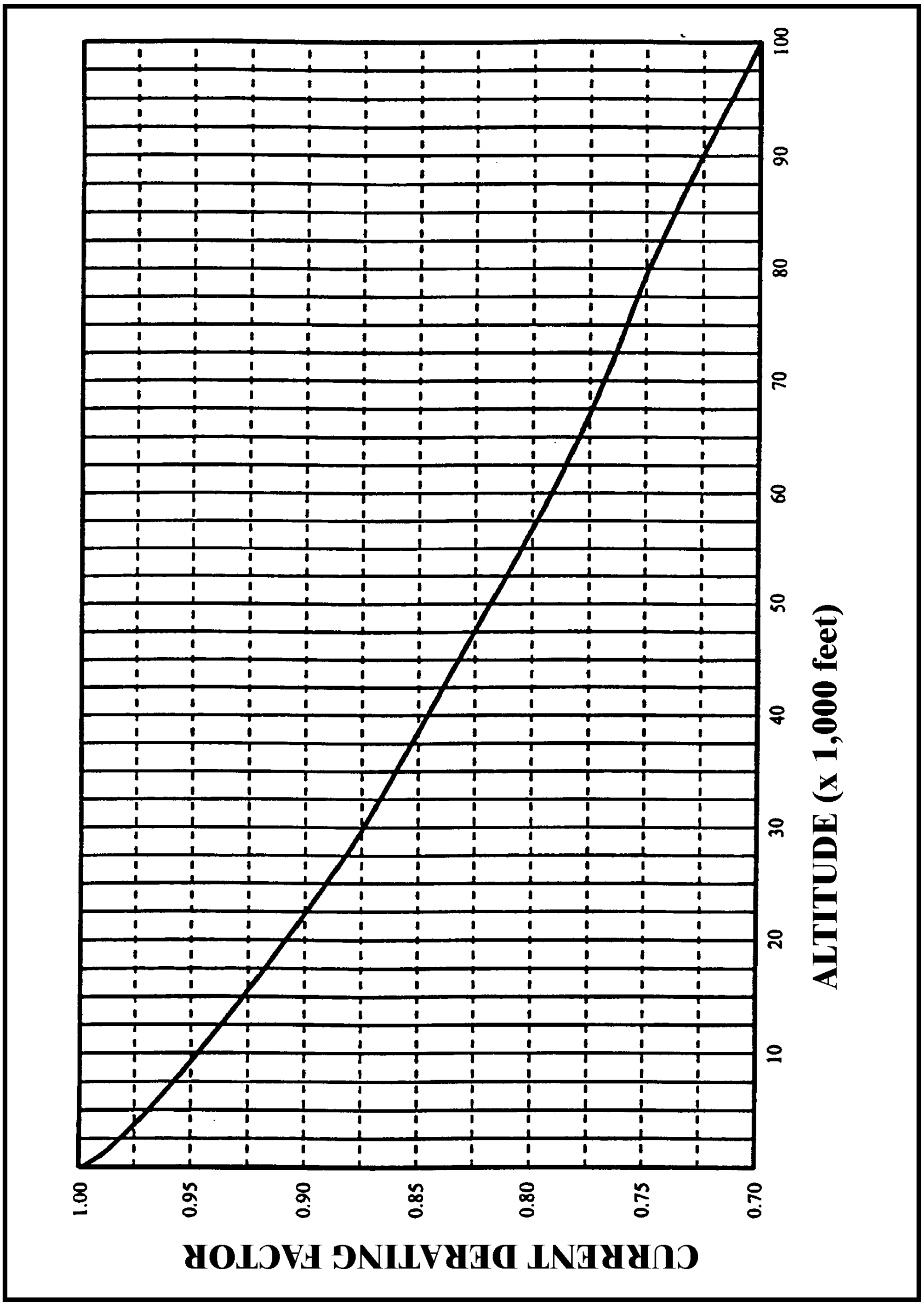


FIGURE 11-6. Altitude derating curve.

11-70. – 11-75. [RESERVED

EXHIBIT 23

Minimum Equipment List Page

MINIMUM EQUIPMENT LIST

AIRCRAFT: CESSNA – (TURBOPROP) 421 C STC SA1361SO	REVISION NO: 2	PAGE: 25-1

SYSTEM & SEQUENCE NUMBERS	ITEM	1.	2. NUMBER INSTALLED	3. NUMBER REQUIRED FOR DISPATCH	4. REMARKS OR EXCEPTIONS
25	EQUIPMENT/FURNISHINGS				
1.	Cockpit Shoulder Harness	B	2.	1	*One may be inoperative. The aircraft may continue the flight or series of flights, but shall not depart an airport where repair or replacement can be made.
2.	Passenger Seats	C	–	0	* (M) All may be inoperative provided: a) Affected seat does not block emergency agress to the aisle or exit, and b) Affected seat is blocked and placarded "DO NOT OCCUPY." NOTE: 1. A seat with an inoperative seatbelt or shoulder harness is considered to be inoperative. 2. A seat with an inoperative recline mechanism is considered to be inoperative if the seat back cannot be secured in the upright position.
3.	Floatation Devices	C	–	–	As required by FAR.
4.	ELT	C	1	0	*May be inoperative for published scheduled flights in scheduled air carrier service. Must be operative for all other flights.

EXHIBIT 24

$$\textbf{Bend Allowance} = 2\pi\,\frac{(R + 1/2T)}{4}$$

(use lowest value for radii)

EXHIBIT 25

$$c = 2\pi \sqrt{\frac{a^2 + b^2}{2}}$$

Circumference Formula

END OF SECTION 3