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Reaffirmed 2013-01
Superseding AIR1418

Flexure Fatigue Strength of Tube Fitting Joints

RATIONALE

AIR1418A has been reaffirmed to comply with the SAE five-year review policy.

1. SCOPE:

This SAE Aerospace Information Report (AIR) presents flexure fatigue strength of tube fitting joints in the form of graphs showing applied deflection D and total calculated axial stress S versus number of cycles to failure N . The graphs have been prepared from data obtained by actual testing conducted in accordance with ARP1185.

1.1 Purpose:

The accompanying D/N (deflection versus cycles) and S/N (stress versus cycles) curves for tube fitting joints are presented over the widest practical range to enable a designer to choose the optimum design for a particular application. Requirements may vary from missile applications with a very short cycle life to a commercial airplane application with a very long cycle life. S/N curves can predict a life for projected designs where given stresses are forecast. D/N curves can compare similar fittings used on different tubing with widely varying levels of elasticity. The curves may also be used as the base line for qualification testing of alternate fitting joint designs.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

ARP1185 Flexure Testing of Hydraulic Tube Fitting Joints

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on this Technical Report, please visit
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3. INFORMATION:

The curve on the graph represents a minimum fatigue strength boundary. The apparent axial stress has been calculated using Equation 1:

$$S = e_{\max} \cdot E + \frac{P d_o^2}{d_o^2 - d_i^2} \quad (\text{Eq. 1})$$

where:

- S = Maximum apparent total axial stress
- $e_{\max}$ = Maximum measured axial unit bending strain
- E = Modulus of elasticity for the tube material
- P = Internal pressure
- d_o = Tube outside diameter
- d_i = Tube inside diameter

The deflection has been calculated using Equation 2:

$$D = \frac{D_i L^2}{L_i^2} \quad (\text{Eq. 2})$$

where:

- D = Double amplitude deflection at L
- L = Length of tube per ARP1185
- L_i = Measured length of tube
- D_i = Measured double amplitude deflection at L_i

All measured and calculated data used in preparing the graphs is presented in Appendix A.

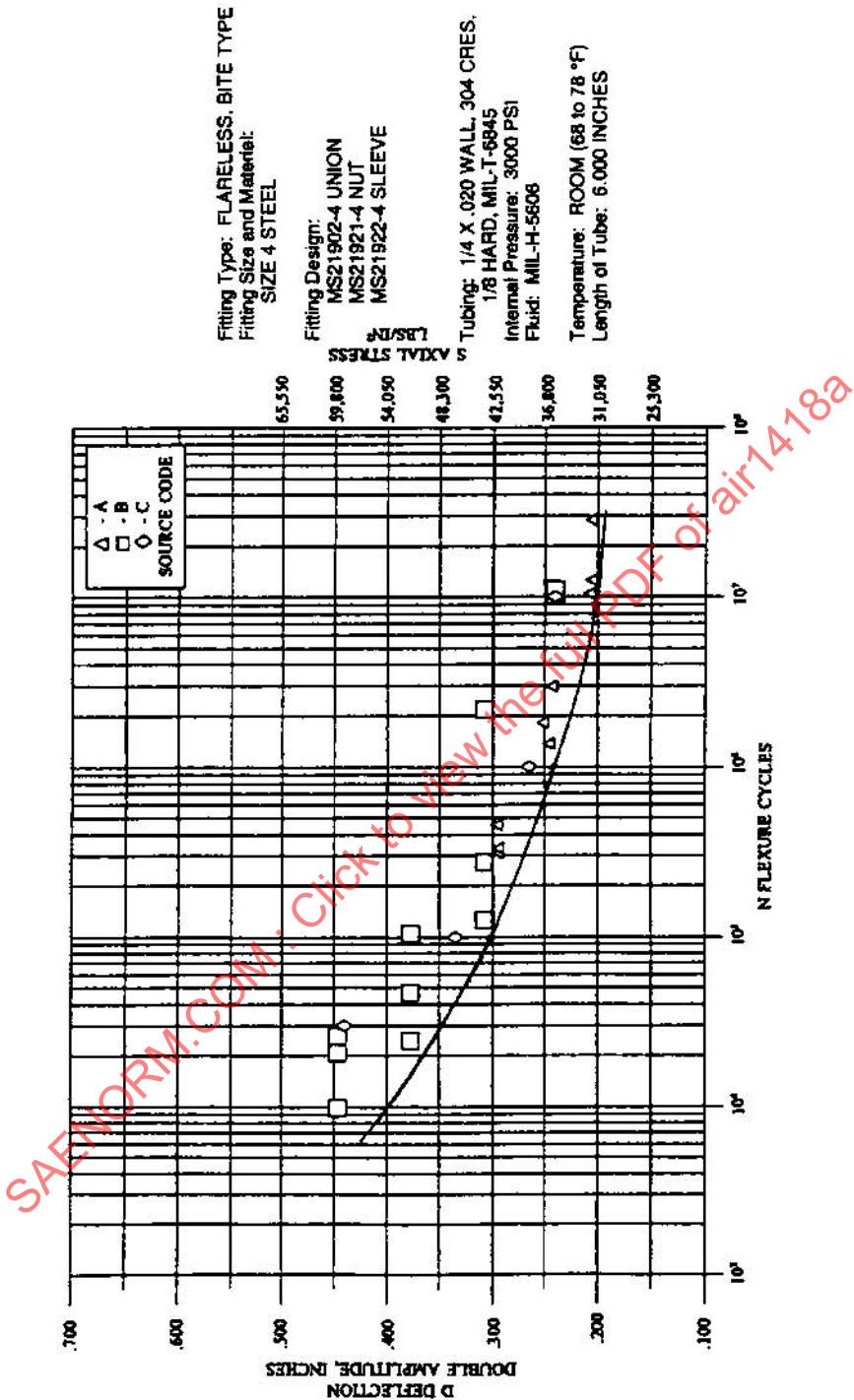


FIGURE 1

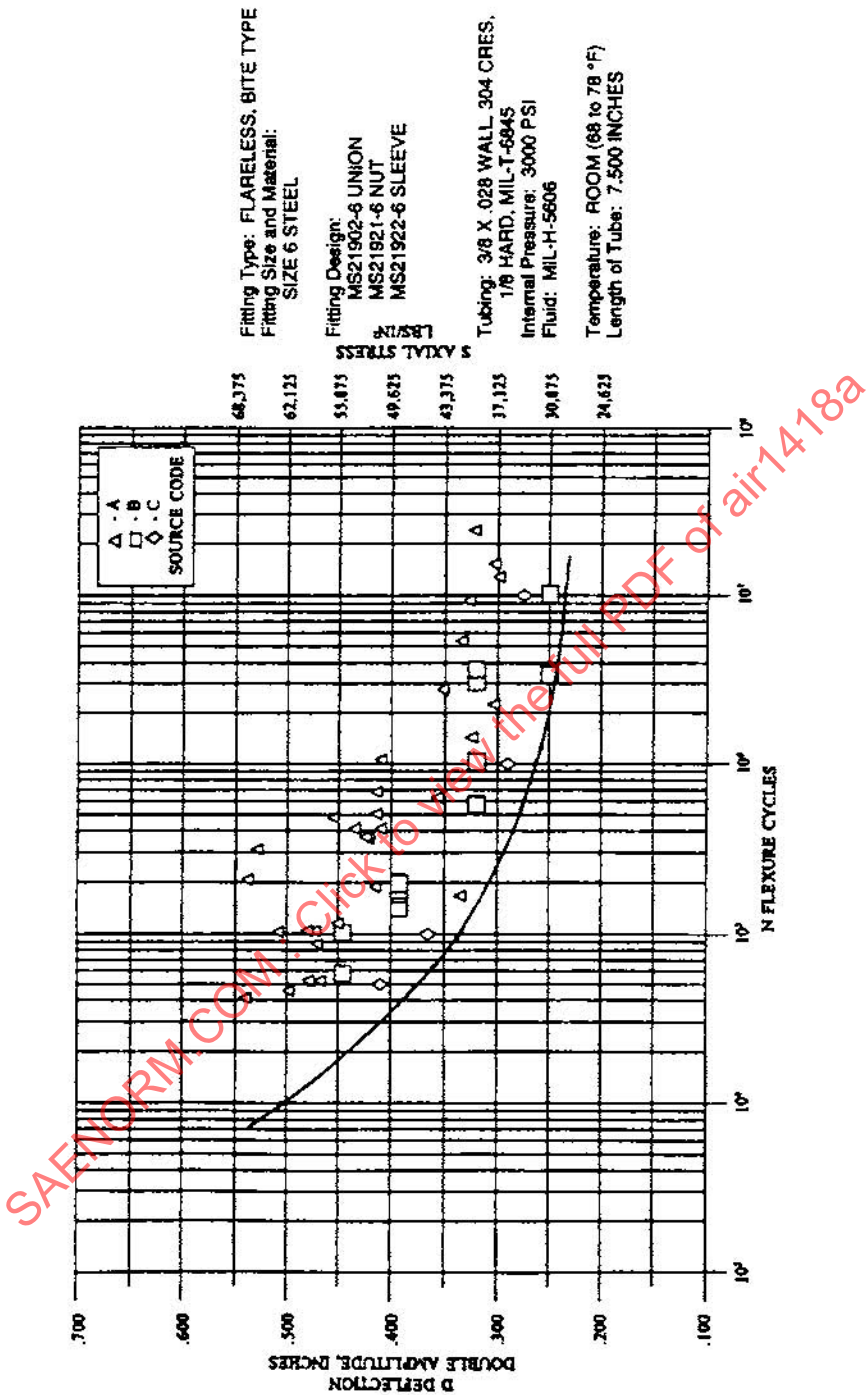


FIGURE 2

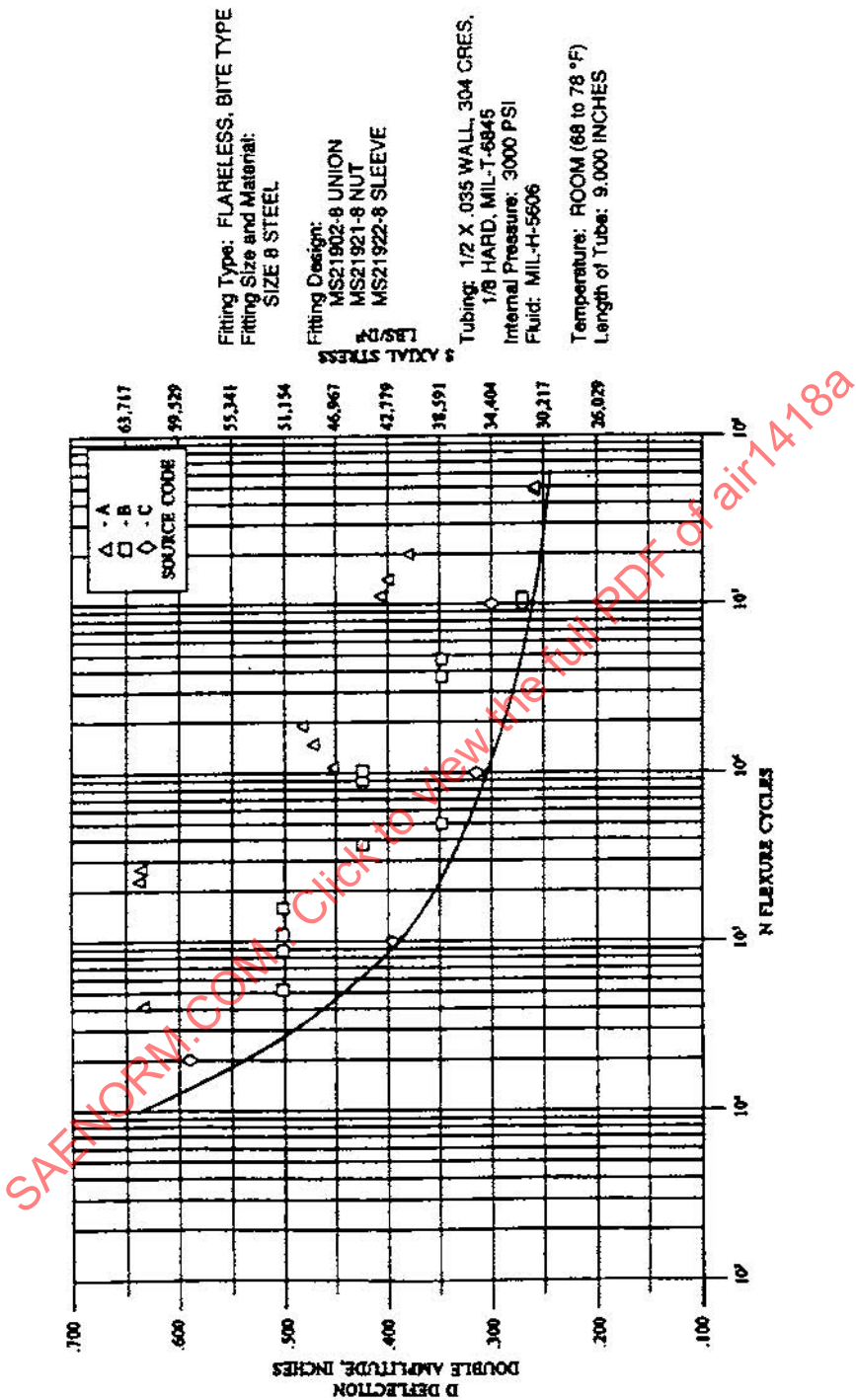


FIGURE 3

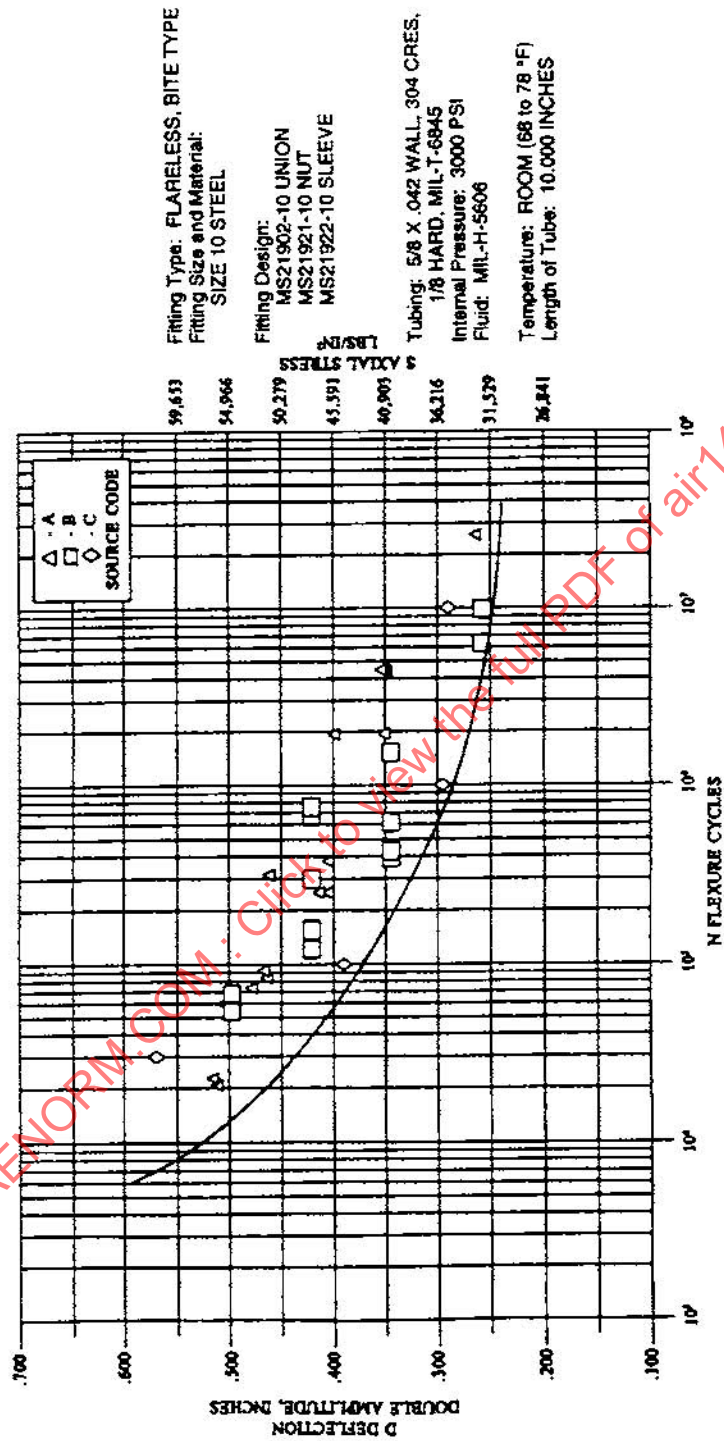


FIGURE 4

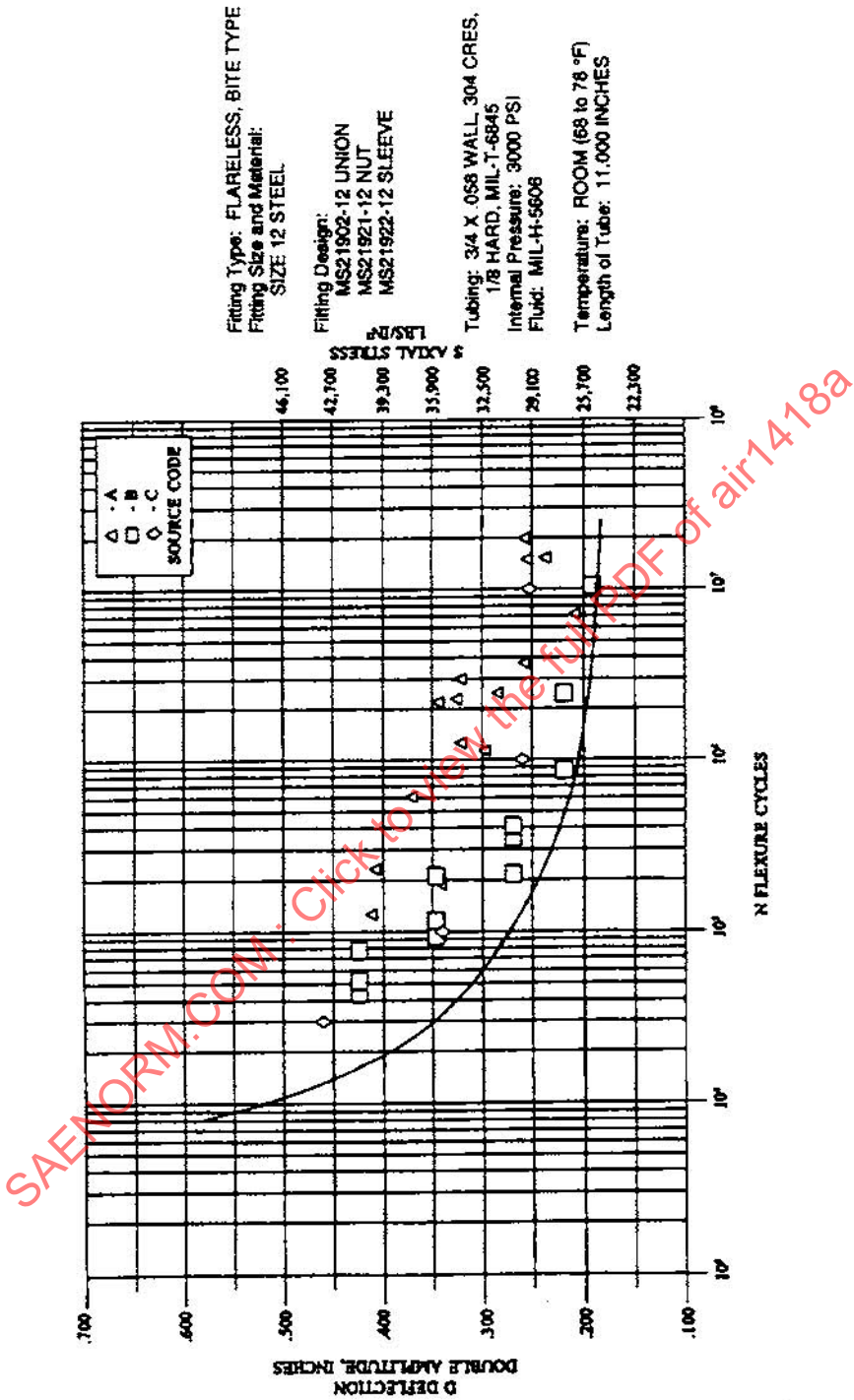


FIGURE 5

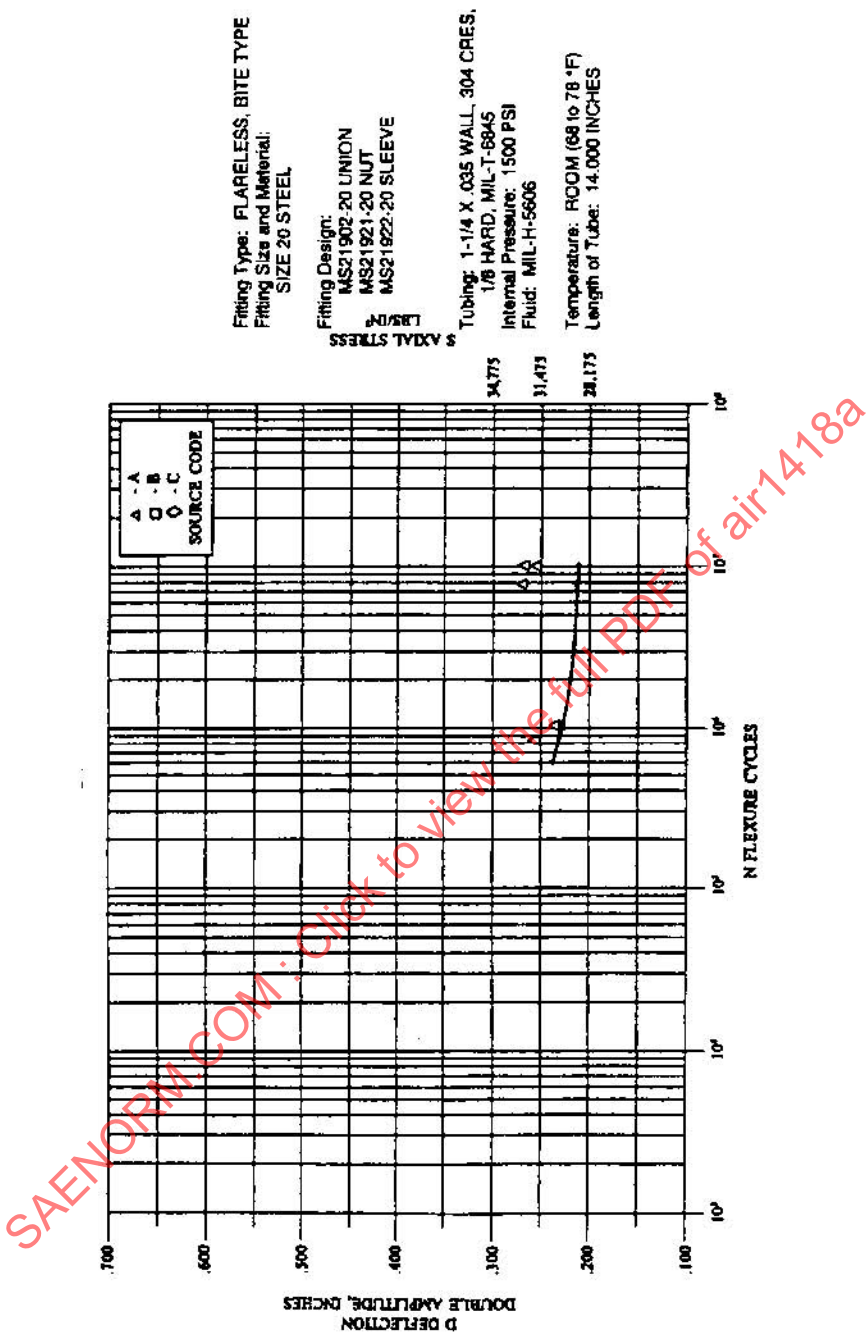


FIGURE 7

APPENDIX A

TABLE A1

Figure No.	Source Code	Sample No.	L, in.	D, in.	L, in.	D, in.	$\sigma \cdot 10^4$				E, 10^6 lb/in ²	P, psi	d ₀ , in.	d ₁ , in.	I, in.	μ	σ_{max} , E, lb/in ²	$\frac{P \sigma_1^2}{d_0^2 - d_1^2}$, lb/in ²	S, lb/in ²	N, Cycles
							Gage #1	Gage #2	Gage #3	Gage #4										
1	A	122-1	7.312	.308	870	835	855	845		28	3000	2523	2141	.0191	.30	24,360	7717	32,077	10,391,400	
		122-2	7.312	.308	843	843	825	870								24,360	32,077	28,152,000		
		122-3	7.312	.308	845	865	850	850								24,220	31,937	12,462,100		
		122-5	7.375	.387	1011	1008	1015	1000								28,420	36,137	2,960,800		
		122-6	7.312	.375	1010	1000	1006	1007								28,840	36,557	1,821,600		
		122-7	7.312	.365	1005	990	995	980								28,140	35,857	1,366,200		
		122-10	7.375	.445	1180	1225	1210	1225								34,300	42,017	310,500		
		122-11	7.250	.430	1185	1185	1200	1220								34,180	41,877	331,200		
		122-12	7.312	.440	1185	1210	1205	1200								33,880	41,597	455,400		
					448	448													9,900	
					446	446													21,000	
					377	377													26,000	
2	A				377	377													24,500	
					308	308													47,000	
					308	308													105,000	
					240	240													126,000	
					240	240													275,000	
					440	440													2,170,000	
					335	335													10,300,000	
					265	265													11,000,000	
					240	240													30,000	
					327	327													100,000	
					323	323													1,000,000	
		122-1	6.562	.250	1214	1226	1184	1210		28	3000	.375	.319	.028	.30	34,328	7854	42,182	9,315,000	
122-2	6.625	.252	1195	1210	1200	1280								35,840	43,894	43,894	24,012,000			
122-3	6.750	.242	1195	1215	1175	1220								34,160	42,014	42,014	12,834,000			
122-4	6.825	.261	1215	1260	1220	1250								33,280	43,134	43,134	5,362,000			
122-5	6.562	.333	1420	1470	1470	1720								48,160	56,914	56,914	414,000			
122-6	6.825	.320	1410	1540	1685	1580								47,320	55,174	55,174	414,000			
122-7	6.562	.323	1550	1610	1580	1650								48,200	54,054	54,054	362,250			
122-9	6.562	.413	1852	2165	1782	2080								60,820	86,474	86,474	41,400			
122-10	8.375	.387	1875	1885	1905	1930								55,580	83,434	83,434	103,500			
122-11	6.500	.404	1585	2025	1860	2150								56,000	68,054	68,054	207,000			
122-12	6.562	.406	1835	2000	1860	1975								56,000	83,404	83,404	310,500			
150-1	7.387	.454	1645	1645	1645	1740								48,300	56,574	56,574	105,000			
150-2	7.395	.460	1790	1650	1850	1725								51,240	58,094	58,094	52,500			
150-3	7.364	.462	1470	1465	1440	1600								41,180	49,914	49,914	1,060,500			
150-4	7.412	.400	1470	1465	1440	1600								44,800	52,654	52,654	189,000			
150-5	7.476	.412	1415	1425	1385	1600								44,800	52,654	52,654	463,000			
150-6	7.409	.445	1525	1540	1580	1800								42,000	49,854	49,854	662,500			
150-9	7.375	.400	1414	1495	1485	1485								38,400	44,254	44,254	2,761,500			
150-10	7.375	.340	1297	1300	1290	1295								38,400						

Figure No.	Source Code	Sample No.	L in	D in	L in	D in	e 10 ⁴		E · 10 ⁴ B/in ²	P psi	d _h in	d in	l in	μ	e _{max} - E B/in ²	Pd ² / (σ ₀ - σ ₁) ² B/in ²	S B/in ²	N Cycles
							Gage #1	Gage #2										
2	A	150-11	7.375	.455	7.500	.471	1700	1685	28	3000	.375	.319	.028	.30	47,600	7854	55,454	87,500
		150-15	7.500	.498		488	1757	1802							50,540		59,394	45,500
		150-17	7.500	.325		325	1200	1205							33,740		41,594	1,438,500
		150-19	7.500	.304		304	1095	1100							30,800		38,854	15,246,000
		150-7	7.374	.411		425	1475	1480							41,580	7580	49,170	387,500
		150-8	7.389	.435		451	1525	1550							48,200		53,780	115,500
		150-12	7.375	.400		414	1500	1495							42,084		49,674	504,000
		150-13	7.375	.465		481	1705	1705							47,740		55,300	105,000
		150-14	7.375	.345		357	1300	1300							33,400		38,880	630,000
		150-18	7.500	.335		335	1200	1205							33,740		41,330	188,000
		150-20	7.500	.304		304	1095	1097							30,884		38,474	2,247,000
		3	A	122-1	6.375	.190	9.000	.275	778	790	29	3000	.500	.430	.035	.30	22,400	8521
122-3	6.375			.130		259	770	800							22,400		30,921	49,110,750
122-4	6.312			.200		407	1158	1160							33,940		41,581	1,178,000
122-5	6.582			.202		390	1080	1215							34,020		42,541	19,924,100
122-6	6.281			.195		400	1155	1165							32,620		41,141	14,098,700
122-7	6.344			.240		463	1393	1470							41,160		48,681	1,893,700
122-8	6.436			.232		453	1320	1430							40,040		48,581	1,074,400
122-9	6.375			.237		472	1385	1440							40,320		48,841	1,469,700
122-10	6.375			.318		634	1750	1800							53,200		81,721	41,400
122-11	6.375			.319		636	1790	1780							52,780		61,301	260,100
122-12	6.375			.320		638	1795	1790							52,920		61,441	227,700

TABLE A1 (Continued)

Figure No.	Source Code	Sample No.	L, in	D, in	L, in	D, in	e 10 ⁴				E 10 ⁴ lb/in ²	p psi	d ₀ in	d in	t in	μ	ε _{max} E lb/in ²	$\frac{p d^2}{\sigma_0^2 - \sigma_1^2}$ lb/in ²	S lb/in ²	N Cycles
							Gage #1	Gage #2	+	-										
3	B	138-1	9.000	424	1155	1150	1155	1150	1150	28	3000	8280	54.15	.0432	.30	32,340	8696	41,036	910,000	
			9.000	424	1155	1150	1155	1150	1150	28	3000	8280	54.15	.0432	.30	32,340	8696	41,036	1,030,000	
			9.000	424	1155	1150	1155	1150	1150	28	3000	8280	54.15	.0432	.30	32,340	8696	41,036	500,000	
			9.000	424	1155	1150	1155	1150	1150	28	3000	8280	54.15	.0432	.30	32,340	8696	41,036	3,700,000	
			9.000	424	1155	1150	1155	1150	1150	28	3000	8280	54.15	.0432	.30	32,340	8696	41,036	4,700,000	
			9.000	424	1155	1150	1155	1150	1150	28	3000	8280	54.15	.0432	.30	32,340	8696	41,036	10,100,000	
			9.000	424	1155	1150	1155	1150	1150	28	3000	8280	54.15	.0432	.30	32,340	8696	41,036	10,800,000	
			9.000	424	1155	1150	1155	1150	1150	28	3000	8280	54.15	.0432	.30	32,340	8696	41,036	20,000	
			9.000	424	1155	1150	1155	1150	1150	28	3000	8280	54.15	.0432	.30	32,340	8696	41,036	100,000	
			9.000	424	1155	1150	1155	1150	1150	28	3000	8280	54.15	.0432	.30	32,340	8696	41,036	1,000,000	
			9.000	424	1155	1150	1155	1150	1150	28	3000	8280	54.15	.0432	.30	32,340	8696	41,036	1,953,000	
			9.000	424	1155	1150	1155	1150	1150	28	3000	8280	54.15	.0432	.30	32,340	8696	41,036	4,410,000	
			9.000	424	1155	1150	1155	1150	1150	28	3000	8280	54.15	.0432	.30	32,340	8696	41,036	4,431,000	
			9.000	424	1155	1150	1155	1150	1150	28	3000	8280	54.15	.0432	.30	32,340	8696	41,036	252,000	
			9.000	424	1155	1150	1155	1150	1150	28	3000	8280	54.15	.0432	.30	32,340	8696	41,036	1,832,000	
			9.000	424	1155	1150	1155	1150	1150	28	3000	8280	54.15	.0432	.30	32,340	8696	41,036	378,000	
			9.000	424	1155	1150	1155	1150	1150	28	3000	8280	54.15	.0432	.30	32,340	8696	41,036	92,500	
			9.000	424	1155	1150	1155	1150	1150	28	3000	8280	54.15	.0432	.30	32,340	8696	41,036	21,000	
			9.000	424	1155	1150	1155	1150	1150	28	3000	8280	54.15	.0432	.30	32,340	8696	41,036	22,750	
4	B	138-2	10.000	487	1650	1650	1650	1650	1650	25	4700	10,000	62.15	.0432	.30	47,460	55,876	55,876	25,883,000	
			10.000	487	1650	1650	1650	1650	1650	25	4700	10,000	62.15	.0432	.30	47,460	55,876	55,876	4,473,000	
			10.000	487	1650	1650	1650	1650	1650	25	4700	10,000	62.15	.0432	.30	47,460	55,876	55,876	252,000	
			10.000	487	1650	1650	1650	1650	1650	25	4700	10,000	62.15	.0432	.30	47,460	55,876	55,876	315,000	
			10.000	487	1650	1650	1650	1650	1650	25	4700	10,000	62.15	.0432	.30	47,460	55,876	55,876	84,000	
			10.000	487	1650	1650	1650	1650	1650	25	4700	10,000	62.15	.0432	.30	47,460	55,876	55,876	73,500	
			10.000	487	1650	1650	1650	1650	1650	25	4700	10,000	62.15	.0432	.30	47,460	55,876	55,876	59,500	
			10.000	487	1650	1650	1650	1650	1650	25	4700	10,000	62.15	.0432	.30	47,460	55,876	55,876	54,000	
			10.000	487	1650	1650	1650	1650	1650	25	4700	10,000	62.15	.0432	.30	47,460	55,876	55,876	68,000	
			10.000	487	1650	1650	1650	1650	1650	25	4700	10,000	62.15	.0432	.30	47,460	55,876	55,876	122,000	
			10.000	487	1650	1650	1650	1650	1650	25	4700	10,000	62.15	.0432	.30	47,460	55,876	55,876	158,000	
			10.000	487	1650	1650	1650	1650	1650	25	4700	10,000	62.15	.0432	.30	47,460	55,876	55,876	300,000	
			10.000	487	1650	1650	1650	1650	1650	25	4700	10,000	62.15	.0432	.30	47,460	55,876	55,876	870,000	
			10.000	487	1650	1650	1650	1650	1650	25	4700	10,000	62.15	.0432	.30	47,460	55,876	55,876	755,000	
			10.000	487	1650	1650	1650	1650	1650	25	4700	10,000	62.15	.0432	.30	47,460	55,876	55,876	395,000	
			10.000	487	1650	1650	1650	1650	1650	25	4700	10,000	62.15	.0432	.30	47,460	55,876	55,876	430,000	
			10.000	487	1650	1650	1650	1650	1650	25	4700	10,000	62.15	.0432	.30	47,460	55,876	55,876	815,000	
			10.000	487	1650	1650	1650	1650	1650	25	4700	10,000	62.15	.0432	.30	47,460	55,876	55,876	1,530,000	
			10.000	487	1650	1650	1650	1650	1650	25	4700	10,000	62.15	.0432	.30	47,460	55,876	55,876	6,300,000	
10.000	487	1650	1650	1650	1650	1650	25	4700	10,000	62.15	.0432	.30	47,460	55,876	55,876	9,800,000				
10.000	487	1650	1650	1650	1650	1650	25	4700	10,000	62.15	.0432	.30	47,460	55,876	55,876	30,000				
10.000	487	1650	1650	1650	1650	1650	25	4700	10,000	62.15	.0432	.30	47,460	55,876	55,876	100,000				
10.000	487	1650	1650	1650	1650	1650	25	4700	10,000	62.15	.0432	.30	47,460	55,876	55,876	1,000,000				
10.000	487	1650	1650	1650	1650	1650	25	4700	10,000	62.15	.0432	.30	47,460	55,876	55,876	10,000,000				