The Engineering Society For Advancing Mobility Land Sea Air and Space ®

400 COMMONWEALTH DRIVE, WARRENDALE, PA 15096

AEROSPACE INFORMATION REPORT

AIR4092

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INVESTIGATION OF PTFE "MELT" PHENOMENON FOR HIGH PRESSURE HOSES

INDEX

APPENDIX

1. ABSTRACT:

The lightweight, high pressure hose with high density braid is susceptible to PTFE innercore melt from induced and applied axial vibration starting at double amplitudes of about 0.180 and frequency of 20 Hz. The use of an integral silicone firesleeve helps to "dampen" out these vibrations, and it increases the threshold for damage to about 0.300 double amplitude. The use of heavy duty, spiral wrapped, high pressure hose, as a practical thing, eliminates the PTFE "melt" phenomenon. This heavy duty hose does have an axial displacement damage threshold of about 0.750 double amplitude, but the mode of failure is mechanical wire breakage not PTFE "melt". There were no failures of the spiral wrapped hose below 0.750 double displacement.

The problem is international, and there have been failures on commercial and military aircraft using AS1339 (AS115...etc) assemblies with bare hose and hose with integral firesleeve. There are no failure reports for AS604 hose (AS621...etc.) assemblies.

There have been no additional failure reports since 1984, primarily due to SAE G-3 activity to alert the aerospace community.

2. HISTORY:

Starting in 1978, Titeflex began receiving reports from the field that in certain main pump and auxiliary pump applications, the PTFE, high pressure product lines with high density, lightweight braid construction were failing after as little as 7 h of service due to melting of the PTFE liner which, among other symptoms, showed PTFE extrusion ("porcupining") through the braid.

From 1978 - 1983, multiple failures were reported and confirmed for hoses on pumps in hose sizes -6, -8, and -10.

These included confirmed reports from:

DeHavilland
Canadair
Boeing Vertol
SNIAS (Air Bus)

Other unconfirmed reports of similar failures were received from:

U.S. Air Force
S.A.S.
MacDonnell/Douglas

Failures reported involved hoses made by all of the suppliers of the high density braid, lightweight, high pressure hose. In some cases, where Titeflex high density, braided hoses failed, Titeflex had been using heavy duty spiral-wrapped hose for many years without difficulty. The substitution to high density/lightweight hose was made to save weight. Immediately after the substitution was made, the failures began. When the heavy duty, spiral-wrapped hose was reinstalled, the problem disappeared. In all cases where the problem has occurred, Titeflex has recommended the installation of

2. HISTORY (Cont'd.):

the heavy duty spiral-wrapped hose. There has never been a "melt Teflon" failure using the heavy duty hose.

The second manufacturer of this lightweight construction experienced the "melt PTFE" failures in frequencies and serverity equivalent to the Titeflex experience. Reports from that source indicated that the application of a heavy integral, elastomeric sleeve provided sufficient "dampening" to prevent the problem from occurring.

In the period since January 1983 - January 1984, there have been no further confirmed failures due to PTFE "melt".

Note: After this report was made (early 1984), there was a field failure using hose with integral firesleeve. No failure reports were received after 1984.

Early in 1982, the SAE G-3D Hose Subcommittee established project G-3D82-1 to monitor this melt failure phenomenon and to establish corrective action. After due consideration in March 1987, G-3D established project G-3D87-2 to prepare an AIR4092, Lightweight Hose in Pump Applications, to be referenced in AS115....etc. to assure that future users are advised of the potential problem.

3. TEST PROCEDURE:

Prelude: Before establishing the given test procedure, Titeflex did extensive testing to develop a test specimen and installation geometry, together with operating criteria, that would:

a. Generate the "melt" mode of failure in lightweight, high pressure hose.

b. Use a test specimen that could reasonably be representative of service conditions.

Test Specimens:

1. 18 in long, "230" Series, -8 size assemblies using straight to straight flared fittings. This is the lightweight, high pressure hose (see Fig. 1). Conforms to AS1339 and AS115 (bare hose) and MIL-H-38360.

2. 18 in long assembly is identical to sample 1, except it has an integral silicone firesleeve (see Fig. 2). Conforms to AS1339 and AS115 (integral firesleeve) 15 min and MIL-H-38360.

3. 18 in long assembly, "660" Series, -8 size assemblies using straight to straight flared fitting. This is the heavy duty spiral-wrapped, high pressure hose (see Fig. 3). Conforms to AS 604 and AS 621 (bare hose) and MIL-H-38360.

Note: The -8 size was selected because failures occurred in -6, -8, and -10 sizes only. The -8, therefore, was most representative of the failed assemblies.

4. PURPOSE OF TEST PROGRAM:

To reproduce the "melt Teflon" failure mode for high pressure, PTFE assemblies using high density braid reinforcement and to examine the effectiveness of spiral wraps or integral sleeve elastomeric dampeners, or both, to reduce or eliminate the "melt Teflon" phenomenon.

5. TEST EQUIPMENT AND SET UP (see Fig. 4):

The specimens were installed in a vertical attitude and essentially in a straight position. The bottom fitting was attached to the top of an MB shaker table. The top fitting was attached to a fixed terminal with a pressure supply. The hose was filled with water at 3000 lbf/in^2 throughout the test.

The shaker table was oscillated up and down at various frequencies and amplitudes to establish thresholds of sensitivity for the PTFE "melt" characteristic in each type of hose.

6. TEST RESULTS:

Chart #1 documents the test results. Frequency, so long as it exceeded 20 Hz, did not appear to be a principal contributing factor in the "melt" phenomenon, nor did the "G" load acceleration highlight the susceptibility to the PTFE "melt" phenomenon. Amplitude was very significant and, together with the minimum frequency requirement, served as the principal variable to induce the PTFE "melt" phenomenon.

Examination of the hoses after failure indicated the following:

1. Bare "230" series, lightweight hose assembly showed heavy Teflon extrusion of PTFE through the braid and some broken braid externally and major deterioration of the innercore internally (see Figs. 5 and 6).

2. The "230" series, lightweight hose with integral firesleeve showed light extrusion of PTFE through the braid and some broken braid externally and major deterioration of the innercore internally (see Figs. 7 and 8).

3. The "660" series showed no extrusion of PTFE through the braid but did have broken wires externally, and it showed deformation of the innercore but no heat deterioration of the PTFE internally (see Figs. 9 and 10).

7. CONCLUSIONS:

The PTFE "melt" phenomenon is a characteristic associated with the high density braid of the lightweight, high pressure hose. We were not able to create this "melt" phenomenon when the hose was vibrated at right angles to the axis even at prolonged 50 g vibration levels of high amplitude. We were able to generate the "melt" phenomenon when the vibration had an axial component and the hose gave significant resistance to the axial force. This condition will occur when there is only a small bend or no bend in the hose. Based on these tests, the threshold for damage at 20 Hz or greater is as follows:

a. Bare lightweight hose - 0.180 Double Amplitude

b. Lightweight hose w/integral firesleeve - 0.320 Double Amplitude

c. Bare heavy duty hose - 0.750 Double Amplitude

Note: In the case of the heavy duty hose, the failure mode was broken wires. There was no evidence of innercore melt.

8. RECOMMENDATION:

For hose assembly applications where the hose can be subjected to applied or induced vibration with high displacements along the axis of the hose, use the heavy duty spiral-wrapped type of hose. One typically critical application is the pump discharge hose for main and auxiliary pumps on aircraft. When the application requires an integral firesleeve to meet fire resistance of TSO or AS specifications, consideration can be given to the use of the lightweight hose and firesleeve combination as the most cost effective solution, provided the axial component of the vibration to be experienced does not exceed 0.200 double amplitude for an 18-in length of hose.

PREPARED BY SUBCOMMITTEE G-3D, AEROSPACE HOSE,
OF COMMITTEE G-3, AEROSPACE FITTINGS, HOSE & TUBING ASSEMBLIES

CHART 1

G LOAD	FREQ (Hz)	DISP (IN DA)	"230"	"RM 230"	"660"
5	40	0.060	No Test	No Test	70 min - o.k.
	60	0.027	60 min - o.k.	No Test	60 min - o.k.
	120	0.0065	No Test	No Test	60 min - o.k.
10	40	0.122	60 min - o.k.	No Test	65 min - o.k.
16	21.3	0.75	19 min - leak	24 min - failure	2 h 24 min
	21.3	0.75	20 min - leak	15 min - failure	4 h 8 min
25	40	0.3	17 min - leak	90 min - o.k.	60 min - o.k.
	60	0.125	No Test	No Test	60 min - o.k.
	120	0.034	60 min - o.k.	60 min - o.k.	60 min - o.k.
	500	0.0018	No Test	No Test	60 min - o.k.
	1000	0.00045	No Test	No Test	60 min - o.k.
30	40	0.35	25 min - leak	90 min - o.k.	60 min - o.k.
32	40	0.36	15 min - leak	60 min - o.k.	No Test
	50	0.25	35 min - leak	90 min - o.k.	60 min - o.k.
	60	0.189	40 min - leak	90 min - o.k.	60 min - o.k.
35	70	0.140	120 min - o.k.	60 min - o.k.	No Test
36	40	0.43	14 min - leak	57 min - failure	70 min - o.k.
40	50	0.32	17 min - leak	25 min - leak	60 min - o.k.
	120	0.05	70 min - o.k.	No Test	No Test
48	60	0.26	60 min - leak	65 min - o.k.	60 min - o.k.
50	60	0.27	20 min - leak	90 min - o.k.	60 min - o.k.
	70	0.20	25 min - leak	65 min - o.k.	60 min - o.k.
	500	0.0035	No Test	No Test	60 min - o.k.
	1000	0.0008	No Test	No Test	60 min - o.k.
55	120	0.07	70 min - o.k.	No Test	No Test

Note: "No Test" - This signifies that testing was not performed at this specific vibration level because previous testing at more severe vibration levels resulted in no failure.

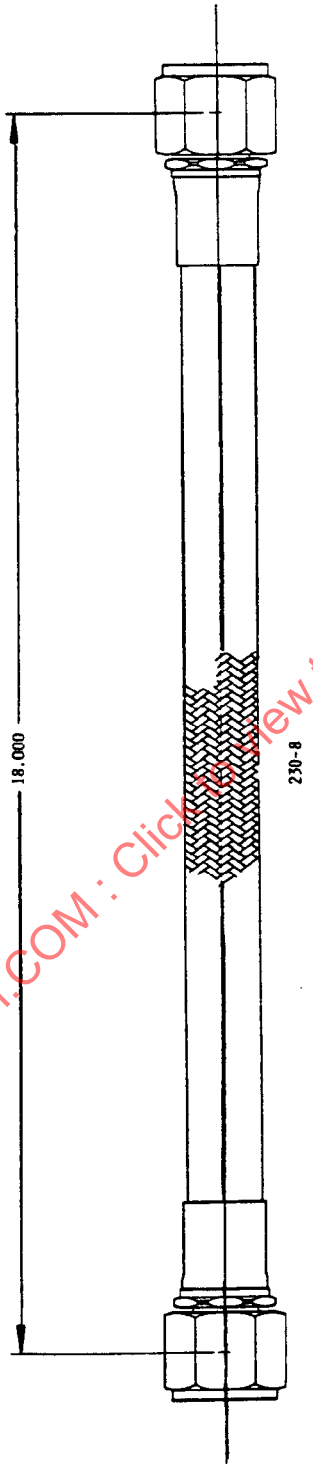


FIGURE 1

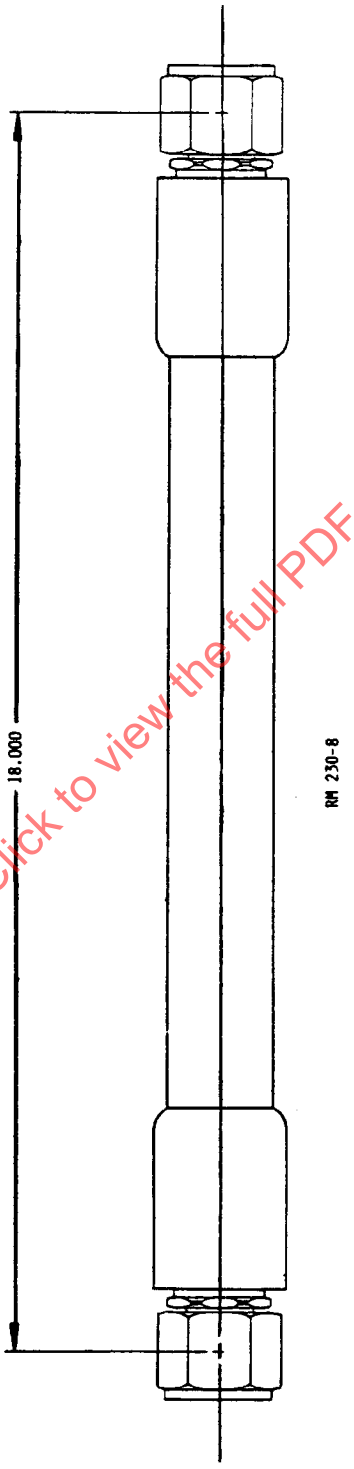


FIGURE 2

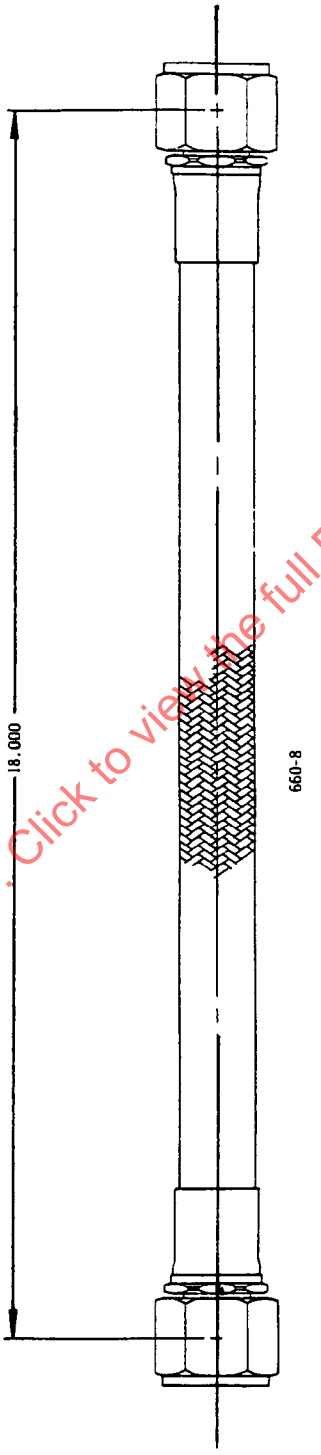


FIGURE 3

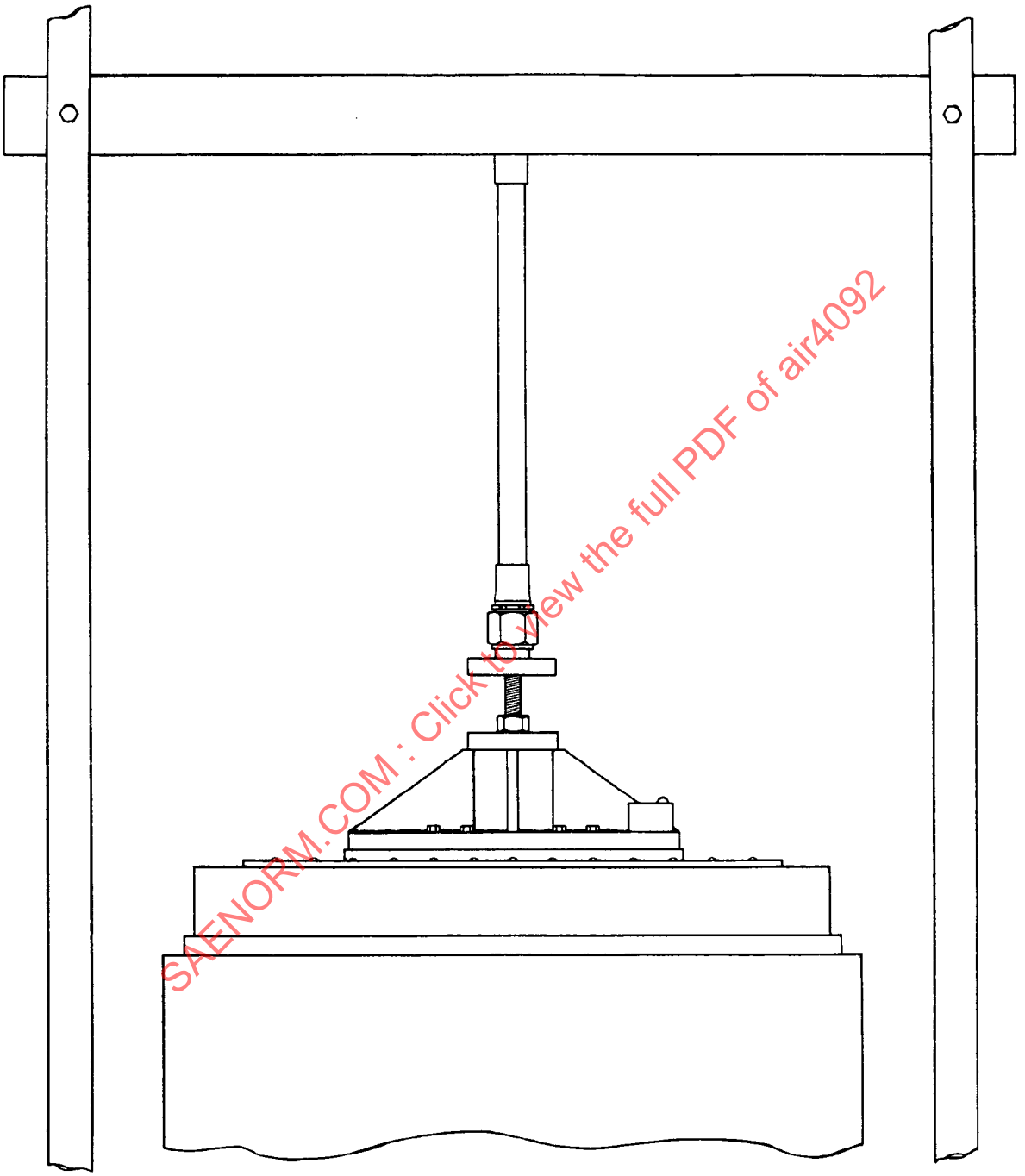
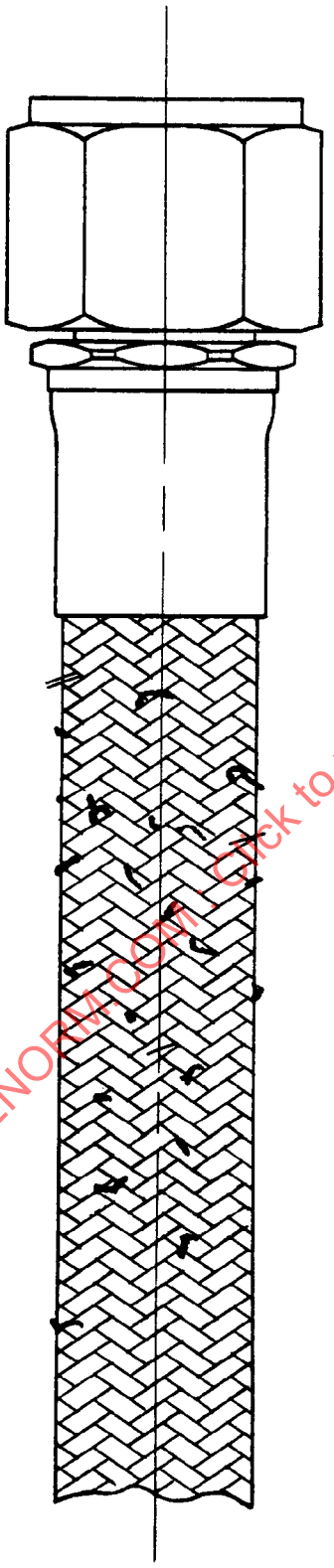


FIGURE 4



230-8
21.3 Hz 16 g
FAILURE 20 MIN

FIGURE 5

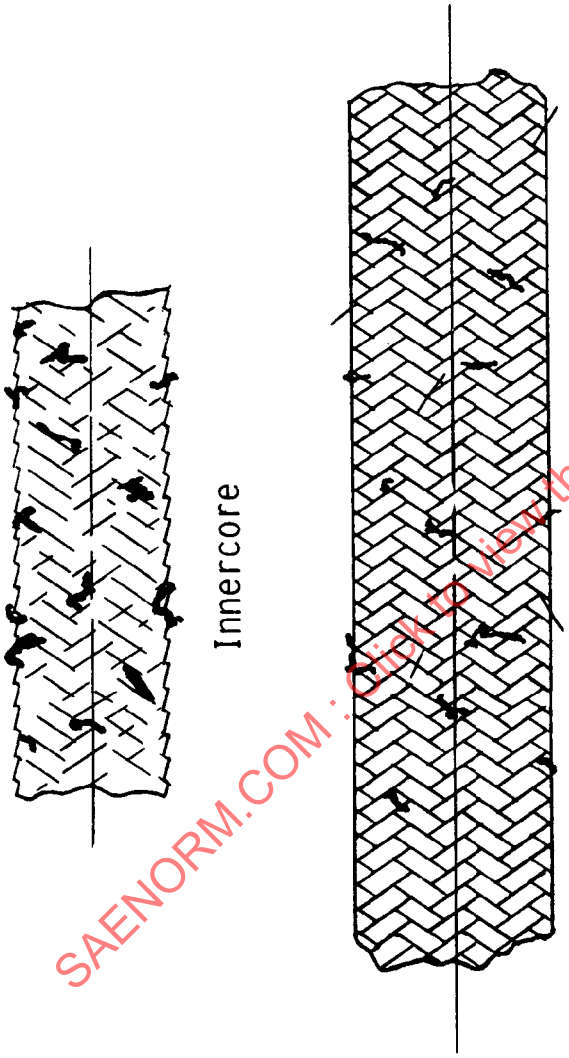


FIGURE 6