TO: DISTRIBUTION
FROM: C NEUMEYER
SUBJECT: TF CREEPAGE BREAKDOWN TESTS

References:

[1] 13-030512-CLN-01, " TF Inner Leg Ground Insulation Criteria"

The reference memo indicated the need to quantify the creepage breakdown characteristics of two limiting creepage paths in the TF hub assembly. This memo provides results of breakdown testing. It appears that these elements of the TF insulation system can withstand a DC hipot of 7kV, under nominal (clean) conditions. Other elements still need verification.

Creepage Paths

There are two creepage path situations associated with the flags as depicted in figures 1 and 2 below. There will be others associated with the water tubes in the bulkhead. Creepage paths #1 and #2 shown in the figure below exist between the flag conductor and the flag box. Creepage path #2 will actually be extended out to the end of the flag, an additional inch beyond what is shown in figure 1, by insulating the end of the tee.

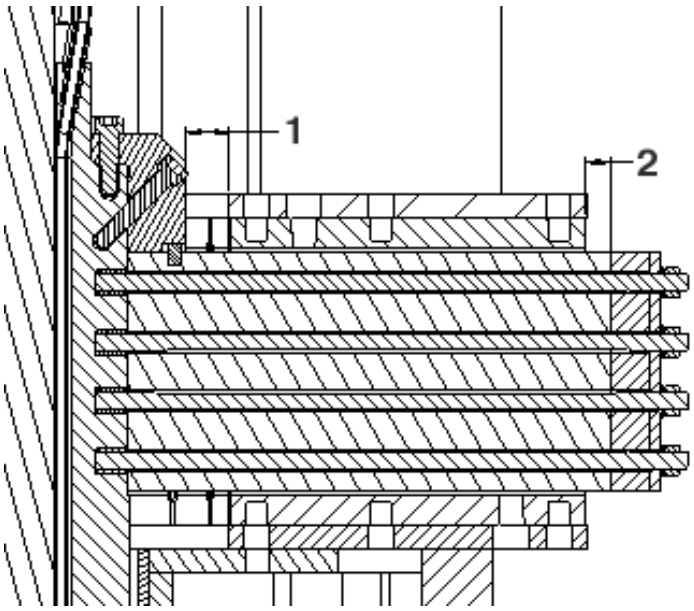

Fig. 1

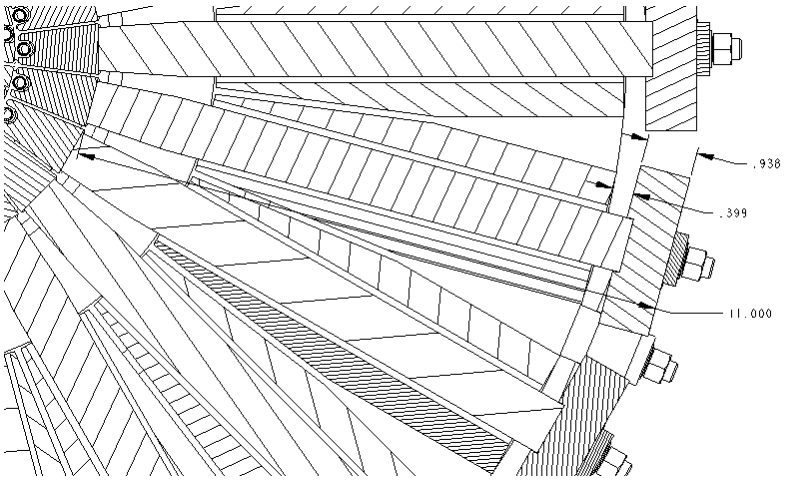

Fig. 2

Mock ups were tested by E. Baker to simulate the creepage configurations as shown in figures 3 and 4.

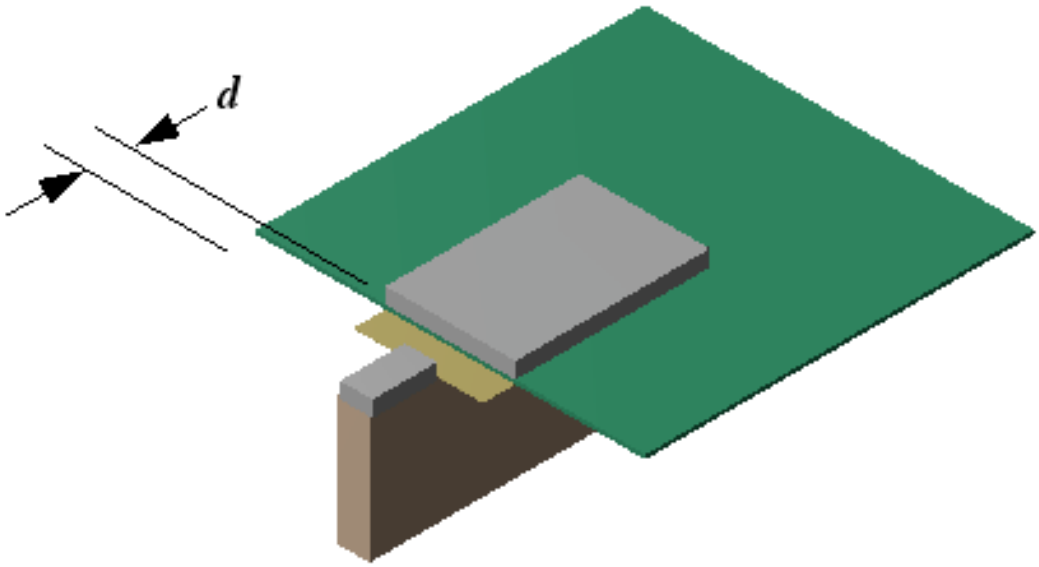

Fig. 3 – Mock-up of creepage path #1

A 1”x4”x6” Cu block was used to simulate the flag, a 12”x12”x0.125” G10 sheet to simulate the potting, a 4” x 6” Kapton sheet to simulate the Kapton flag insulation, a 0.5”x4”x6” Cu block to simulate the flag box, and an additional Cu block to simulate the shear shoe.

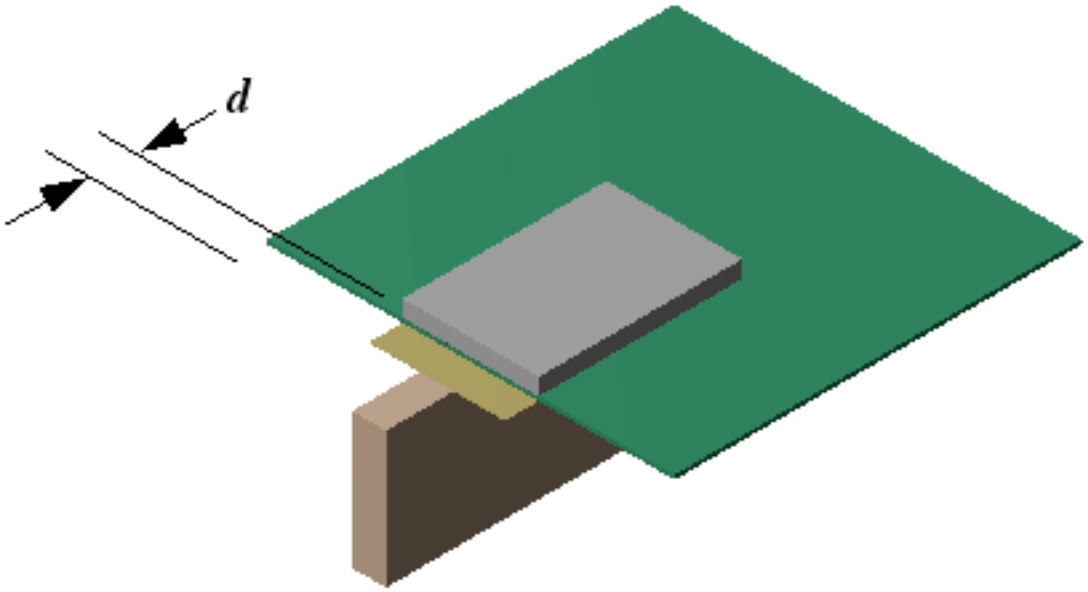

Fig. 4 – Mock-up of creepage path #2

Three trials were made for each configuration. Ambient temperature ranged from 69.3 ºF to 70.9ºF, and humidity from 54.1 to 57.5%. (Note: in the test cell, the HVAC system controls temperature to around 68 ºF, and dew point to around 45 ºF, so the corresponding relative humidity of 33% is considerably less than the conditions reported herein, which is conservative). Voltage was applied at a rate of 1kV/sec.

The following table provides the results in terms of the voltage level at which the inception of audible/visible partial discharges commenced, and at which a sustained breakdown occurred. Also indicated is the theoretical formula for breakdown in air under worst case electrode geometry conditions (Vbreakdown = 8.485*(d*2.54)^0.823), V in kV, d in inches).

The following tables and figures summarize the result for the two creepage paths.

Table 1: Creepage Configuration #1

Gap (in)	Trial #1 Inception (kV)	Trial #1 Breakdown (kV)	Trial #2 Inception (kV)	Trial #2 Breakdown (kV)	Trial #3 Inception (kV)	Trial #3 Breakdown (kV)	Theory (kV)
0.2	11	11	10	11	12	12	4.9
0.3	11.5	14	11	15	13	15	6.8
0.4	13.5	18	15	15	16	16	8.6
0.5	12.5	17	13	15.5	12	14	10.3
0.6	13.5	16	13.5	16	13.5	15	12.0
0.7	13	15	11	17	13	15.5	13.6
0.8	13.5	15	15	17	10	18	15.2
0.9	11	18	16.5	16.5	18	18	16.8
1	14	20.5	13.5	19	17	19.5	18.3

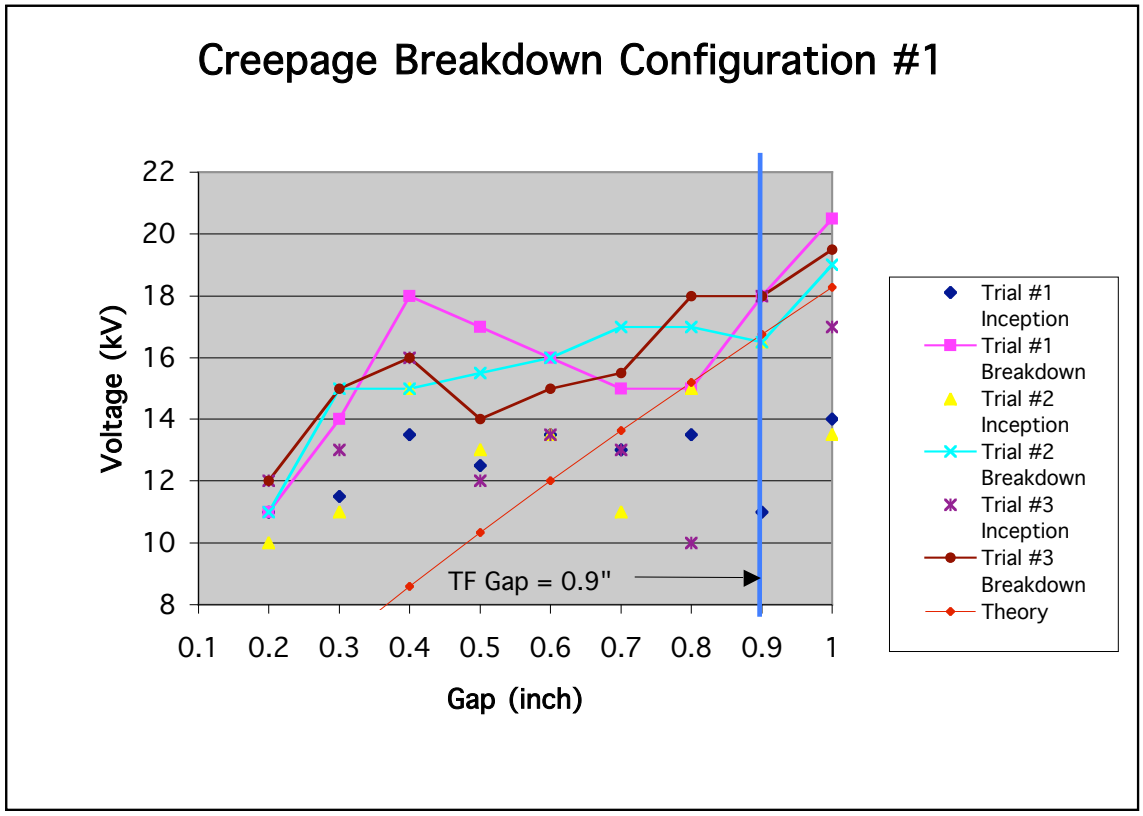

Fig. 5: Creepage Configuration #1

Table 2: Creepage Configuration #2

Gap (in)	Trial #1 Inception (kV)	Trial #1 Breakdown (kV)	Trial #2 Inception (kV)	Trial #2 Breakdown (kV)	Trial #3 Inception (kV)	Trial #3 Breakdown (kV)	Theory (kV)
0.2	10	13	11	14	11	14	4.9
0.3	11	14	13	13.5	11	14	6.8
0.4	10.5	13	13	16	13	16	8.6
0.5	11	17.5	12	15	14	17	10.3
0.6	16	17	14	17	16	19	12.0
0.7	13	17	16	17	13	16	13.6
0.8	16	18	15.5	18.5	14.5	18	15.2
0.9	16	17	16	17.5	11	19	16.8
1	16.5	18.5	11	18	14	18	18.3

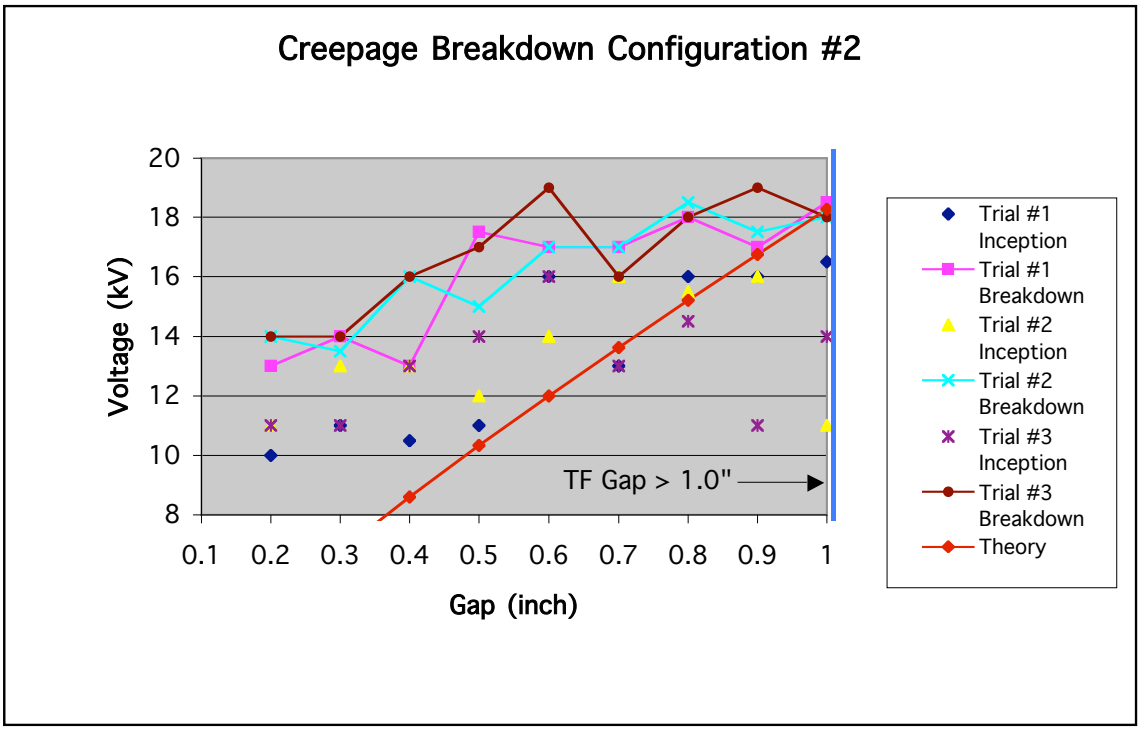

Fig. 6: Creepage Configuration #2

The following tables summarizes the results…

Path	#1	#2	
Path Length	0.90	1.40	in
Discharge Inception Voltage	>11	>11	kV
Breakdown Voltage	>16.5	>18	
Hipot	7	7	kV
Safety Margin over Inception	1.6	1.6	kV
Safety Margin over Breakdown	2.4	2.6	

These safety margins are adequate, in the opinion of the writer.

cc:

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