Hans Jostlein 8/4/2009

50 kV feedthrough Design dated August 4, 2009

Abstract

This is a brief report on the proposed design for the 50 kV (and the 20 kV) feedthroughs for the 20 kg dark matter detector. The feedthrough uses the double O-ring seal without cryo-compression. It follows the general design proposed earlier by Tristen Hohman (and reproduced below) .

Changes:

a. We propose a continuous insulator element to avoid any possible discharge pathways to the threaded section

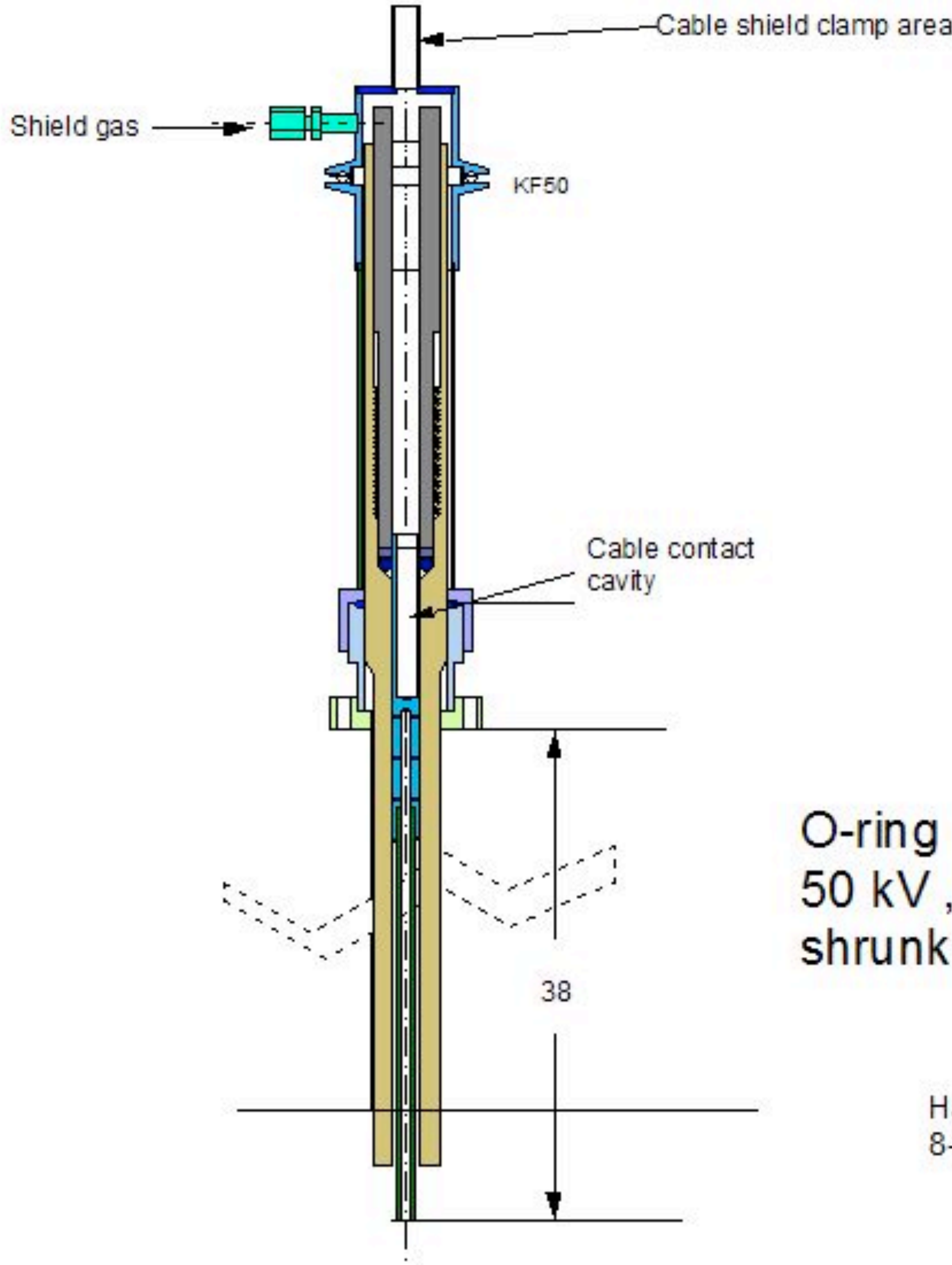
b. We propose to make the threaded compressor for the inner O-ring from ULTEM (rather than PE). ULTEM has a very high dielectric strength, high modulus, high dimensional stability, and machines well (ee the materials table below) . ULTEM would make a good insulator material for the feedthrough, were it not for its modest water absorption (where PE has zero water absorption). Please note that ULTEM might make a good substitute for the Nylon hardware currently considered. ULTEM has 10 time less water absorption than Nylon (See info on Nylon below).

c. For the electrical connection I am showing the solution where the connection with its sharp points resides inside a “Farady cage” type cavity where the electrostatic field is zero. The cable dielectric (diameter 0.370”) enters into this cavity, while the outer mesh and plastic jacket are stretched over the top pipe stub and secured with a clamp.

d. I have found a vendor who can supply the 1.25” ID x 0.006 wall electrostatic shield pipe below the 2 ¾” mounting flange

Near Term Plans

I hope the group will review this proposal soon, ideally this week. Depending on the outcome of the review I propose to purchase the few items needed to make a prototype and to test it for vacuum integrity and HV performance in LAr



O-ring Feed, 50 kV , 1 1/2", shrunk

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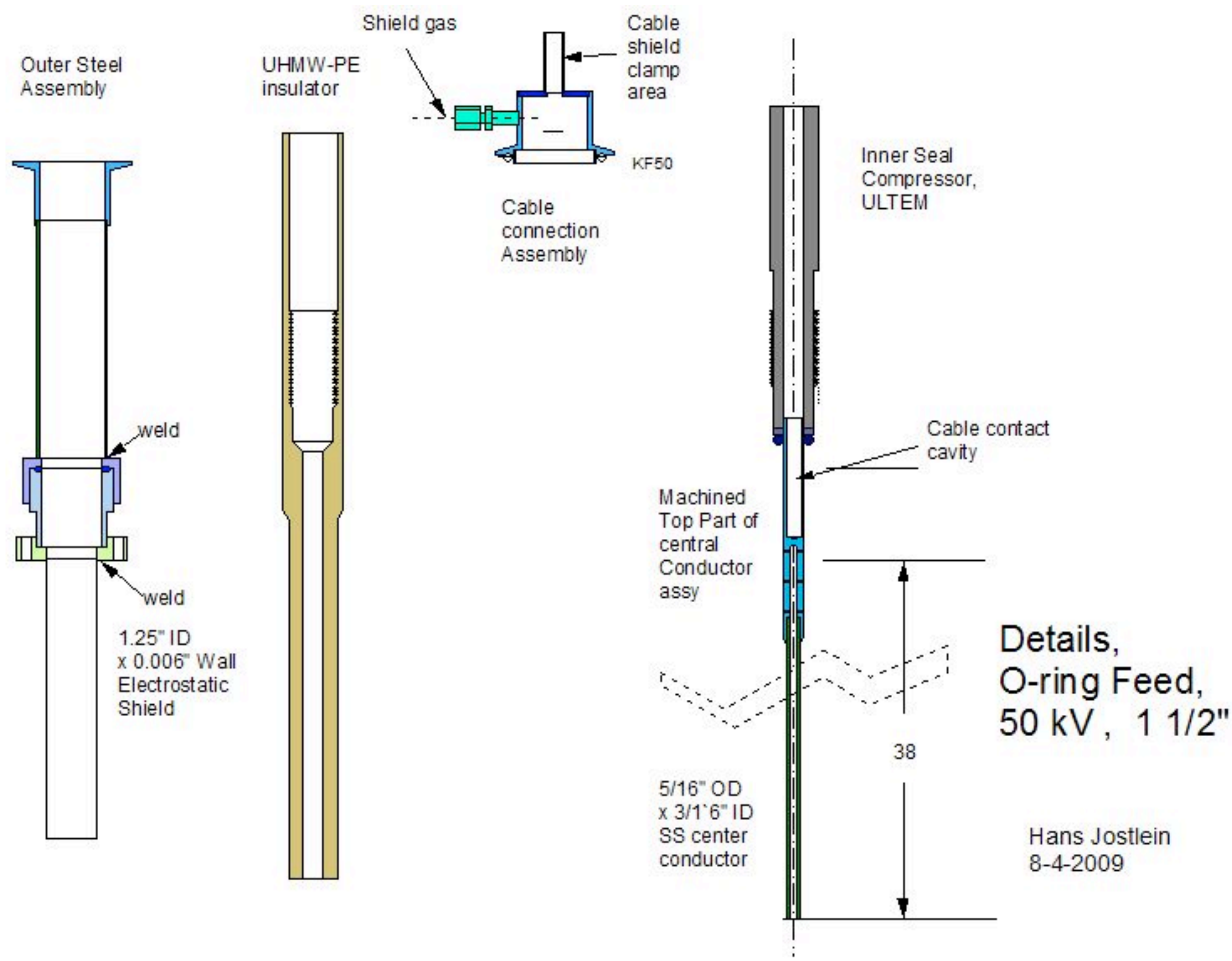
Outer Steel Assembly
UHMW-PE insulator
Shield gas
Cable shield clamp area
KF50
Cable connection Assembly
Inner Seal Compressor, ULTEM
weld
weld
1.25" ID x 0.006" Wall Electrostatic Shield
Cable contact cavity
Machined Top Part of central Conductor assy
38
5/16" OD x 3/1`6" ID SS center conductor
Details, O-ring Feed, 50 kV , 1 1/2"
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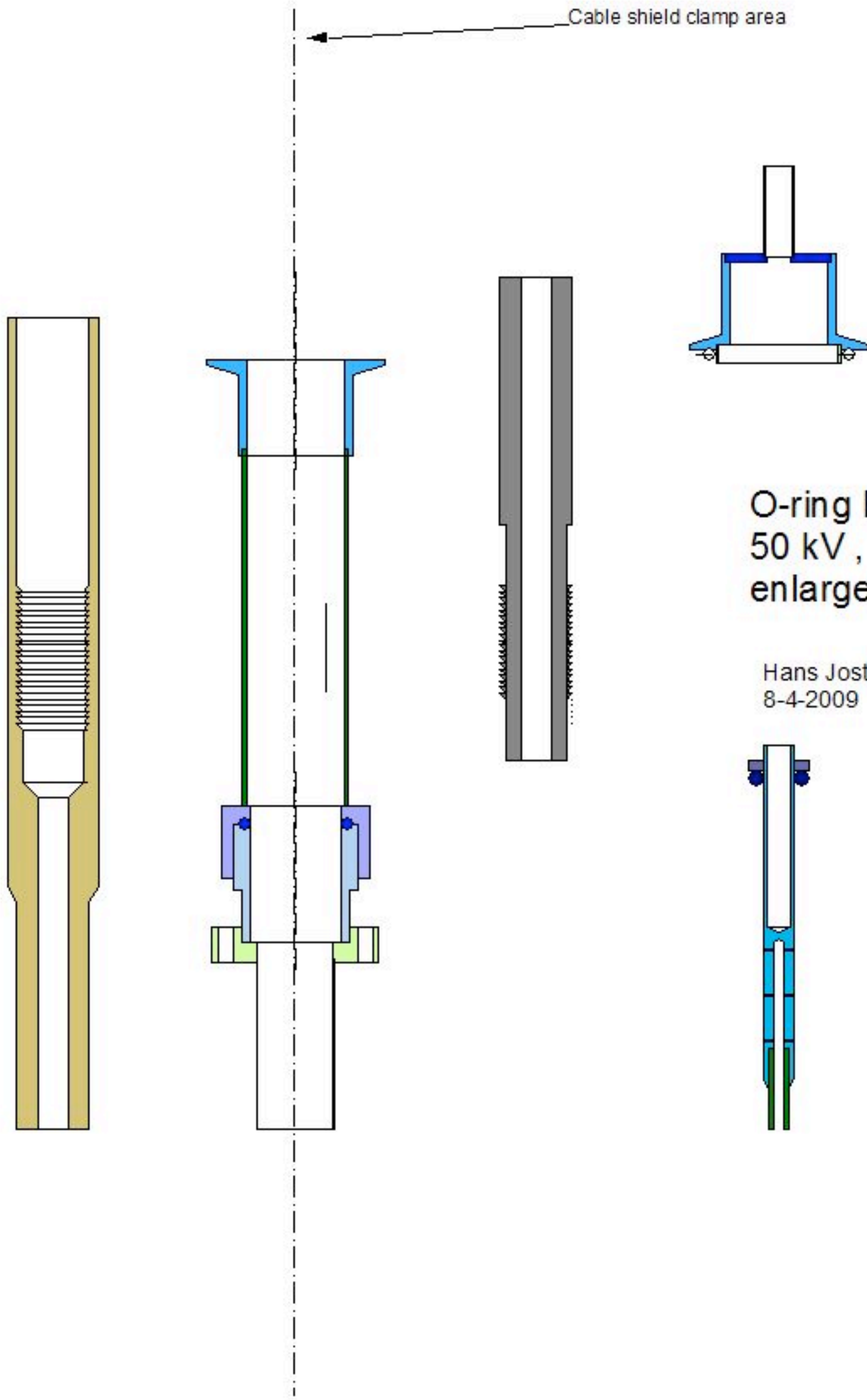

O-ring Feed,
50 kV, 1 1/2",
enlarged

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8-4-2009

Plastic Properties

Plastic Properties							
	Ultem	Udel	Poly-	UHMW	Radel	Nylon	Plexi
	Poly ether	Poly-	carbona te	Poly-	Poly phenyl		glass
	imide	sulfon e		ethylen e	sulfone		
Dielectric strength [V/mil]	800	465	380	900	400		
density [g/ml]	1.28	1.24	1.2	0.93	1.37	1.06 to 1.14	1.19
Water absorption (24 hours)	0.25	0.3		0	0.54	0.7 - 2.9	0.3
Tenile strength [ksi]	16.5	10.2	9.5	3.1	12.2	9.4 to 14	10.5
Modulus [ksi]	475	360	345	125	385	400	430
Elongation at break [%]	80	30	100	infinite	6.5	7 to 150	5
Rockwell hardness	125	128			127	R88 to R114	M96
Thermal expansion [1/F]	3.10E-05	3.10E-05		1.10E-04	2.70E-05	4.00E-05	
Thermal conductivity [BTU/in ft^2 hr]	0.9		1.3	2.92	1.13		

Nylon Properties

PROPERTIES	A.S.T.M Test Method	NYLON	NYLO N	NYLON	NYLON
		TYPE 6	TYPE 66	TYPE 612	CAST TYPE 6
Specific Gravity	D792	1.12 - 1.14	1.14 - 1.1	1.06	1.15
Water Absorption Method A	D570	2.9	1.24	0.25	-=-
Tensile strength at yield, 1000 psi	D638	9.4	12	8.8	11 - 14
Elongation at yield, %	D638	25	>150	7	10
Elastic Modulus in Tension, 10~5 psi	D638	-=-	4.4	-=-	3.5 - 4.5
Flexural Strength at yield, 1000 psi	D790	NO YIELD	16	NO YIELD	16 - 17.5
Elastic modulus in flexure, 10~5 psi	D790	1.50	4.1	2.95	-=-
Rockwell Hardness (Method A)	D785	R104	88	R114	R112
Izod impact strength, ft-lb/in. notch 1/8 in. speciman	D256	2.2	1.2	1.5	-=-

Deform. under load(2000 psi; 122f), %	D621	-=-	0.8	1.6	0.5 - 1.0
Deflection temperature, F at 66 psi fiber stress	D648	340	450	356	400
Max recommended service Temp., F continuous use	-=-	175	270	290	200 - 225
Coeff. of Linear Thermal Expansion, F	D696	4 x 10~5	4.5 x 10~5	5 x 10~5	5.0 x 10~5
Underwriters' Lab Rating (Subj. 94)	-=-	HB	V - 2	V - 2	-=-
Dielectric strength, v/mil, short time	D149	-=-	555	650	500
Dielectric constant at 60 Hertz	D150	7.2	4.0	4.0	3.7
Dielectric constant at 1 MegaHertz	D150	3.7	3.5	3.5	3.7
Dissipation factor, at 60 Hertz	D150	-=-	0.02	.02	-=-
Dissipation factor, at 1 MegaHertz	D150	0.12	0.03	0.2	-=-
Volume resistivity, ohm-cm	D257	10~12	10~15	10~15	-=-
Arc resistance (SS Electrode), sec.	D495	-=-	123	-=-	-=-

Table 6.1 Absorption of Moisture by Nylons by Weight % at 50% R.H. and Saturation @ 23øC (Ref 16)

Type of Nylon	Equilibrium @ 50% R.H.	Equilibrium @ Saturation
6	2.7	9.5
6/6	2.5	8.0
6/10	1.5	3.5
6/12	1.3	3.0
11	0.8	1.9
12	0.7	1.4

Water molecules produce polar bonds with the amide groups in the nylon molecules. Although small, water molecules take up space and displace the nylon molecules. This results in the nylon molecular matrix swelling. Dimensional changes of 0.7% can result in nylon parts from the "as-molded" state to equilibrium at 50% R.H. environments. This change occurs in approximately 150 days for a 0.0 60 inch (1.5 mm) thick part. (Ref 17) Molecular mobility is increased through the absorption of water. The increase in spacing between nylon molecules lowers the secondary forces allowing easier translational motion. This is the major reasons for the change in physical properties discussed above. There is less resistence to applied stress from the decrease in intermolecular friction. The change in molecular mobility is significant enough that molded nylon parts can relieve molded in stresses as they absorb moisture. Pretty neat 'eh?

The absorption of moisture by nylon is a completely reversible physical reaction. Drying in an oven will drive off all but a small percentage of the water molecules which can only be removed through dissolution of the nylon molecular matrix. The rate of absorption/desorption varies with type of nylon as well as temperature and relative humidity. Addition of fillers reduces the effect of moisture both due to volume reduction of the ammount of nylon polymer in the mixture, and by sharing the attraction of the molecules somewhat reducing polarity and the available space for moisture molecules. Reinforcements reduce the effects more than fillers due to nylons strong affinity for reinforcement. In addition to the mechanisms which take place with fillers, the adhesion of the nylon molecular matrix to dimensionally stable reinforcements is stronger than than polar bonding of the water molecules and it dominates.