Vacuum Cabling and Feedthroughs Requirements

- Vibration Isolation (ref. Seismic Isolation DRD)

  —Cabling shall be firmly clamped to each successive stage of the seismic isolation to prevent this cabling from conducting vibration around the isolation system.

  —In the case of multiconductor cables, each wire must be firmly fixed in place so that its effective mass at the clamped area is comparable to the mass of the stage to which it is clamped.

  —The strain rate (stiffness of the cable) for free lengths of cable[1] clamped to isolation stages must be less than 10 N/m.

  —The mass of the free lengths of cable must be less than $3 \bullet Q$ kg, where Q is the mechanical quality for oscillation of the free cable length.

1. "Free length" indicates the length of cable that is between clamps connecting two stages or connecting the lowest stage to any non-isolated surface.

Vacuum Cabling and Feedthroughs Requirements

—Free lengths of cable must be placed so that they cannot possible touch other surfaces except where they are clamped.

—Cabling must not "crackle" when vibrated under operating conditions[1]. This may be ensured either by choice of material or by the method in which the material is mounted.

1. "Crackle" refers to the sound made by upconversion when a low-frequency (inaudible) motion of the cable is made. (Thin plastic wrap often crackles when subjected to large slow flexing.)

Vacuum Cabling and Feedthroughs Requirements

- Vacuum Compatibility

  ››Cabling must satisfy the requirements for vacuum compatibility listed in *LIGO Vacuum Compatibility, Cleaning Methods and Procedures* (LIGO-E960022-00-D)

  ››All materials used in the system shall be able to meet all performance requirements after being subjected to a vacuum equipment bake out. The table below summarizes the expected environment during a bake out.

Table 1: Vacuum Equipment Bake Out Characteristics

Temperature	*Duration*	*Frequency*
+170 C, max.	1000 Hours	1 cycle per year

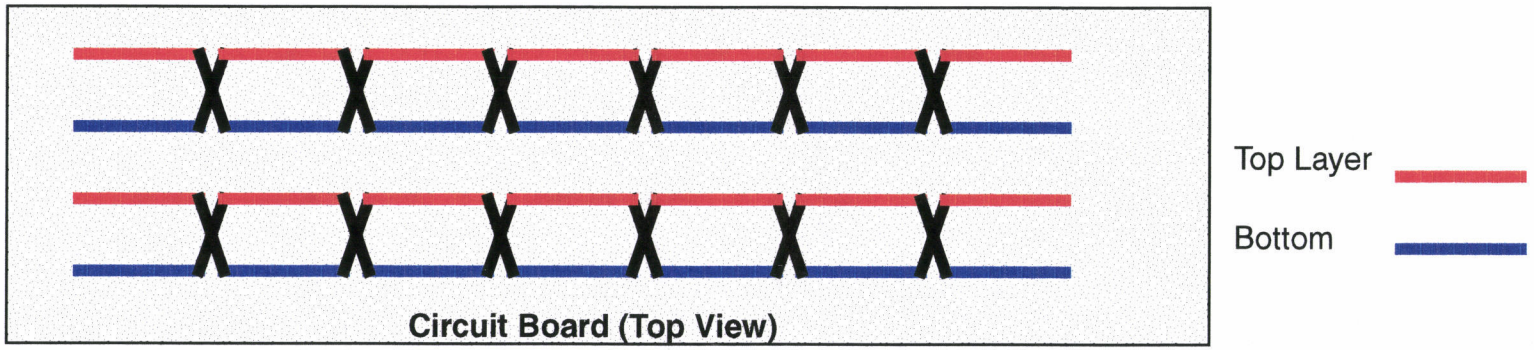
  ››A list of the currently approved materials for use inside the LIGO vacuum envelope can be found in *LIGO Vacuum Compatible Materials List* (LIGO E960050-A-E).

Vacuum Feedthroughs

- Multiconductor feedthroughs will be Ceramaseal part number 14444-02-W. Connectors will be e-beam or laser welded to conflat flanges per manufacturer's instructions.
- At this time there is no requirement to provide coaxial/triaxial vacuum feedthroughs or cabling. In the event that future requirements arise, the connectors of choice for coaxial systems will be BNC and SMA. These connectors will be purchased commercially and e-beam welded to conflat flanges in a manner similar to that used for the multi-conductor feedthroughs.

Vacuum Cabling and Connectors

- Internal vacuum cabling prototypes being procured from Flex-Link
- Multi conductor twisted pair (6 twists per inch) will be fabricated as multi-layer flexible circuit boards.



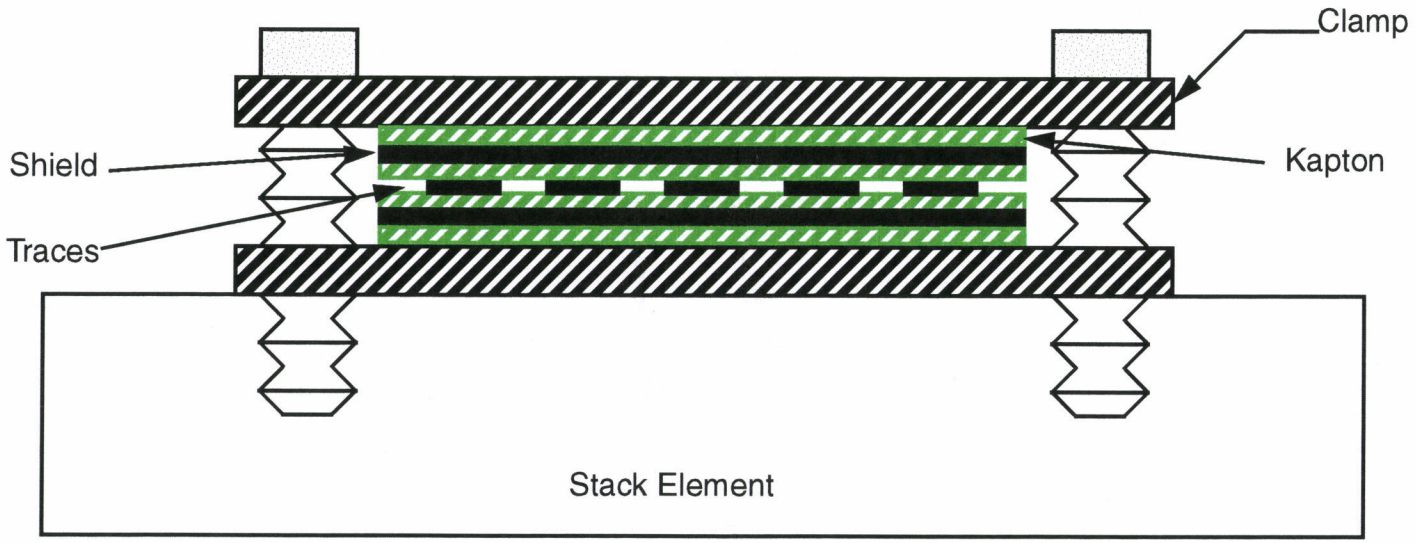
- In the event that it is needed, coaxial cabling can fabricated or purchased directly from companies such as ISI

Vacuum Cabling and Connectors

- Internal connectors will be all metal and ceramic construction. (Ceramaseal 14444-02-W mounted on bracket on optics platform).

Cable Fasteners and Harnesses

- Cables will be fastened to the stack elements via mounting screws
- The cable will be firmly clamped at each location.



Action Items from DRR

- Concern: Possible "crackling" of kapton wiring.

  ››Response: Prototype cables have been procured and will be tested. Initial testing with samples indicates that crackling only occurs if the cable is twisted. Testing will be difficult without a seismic isolation test stand, but we should be able to test as part of the 40 meter installation.

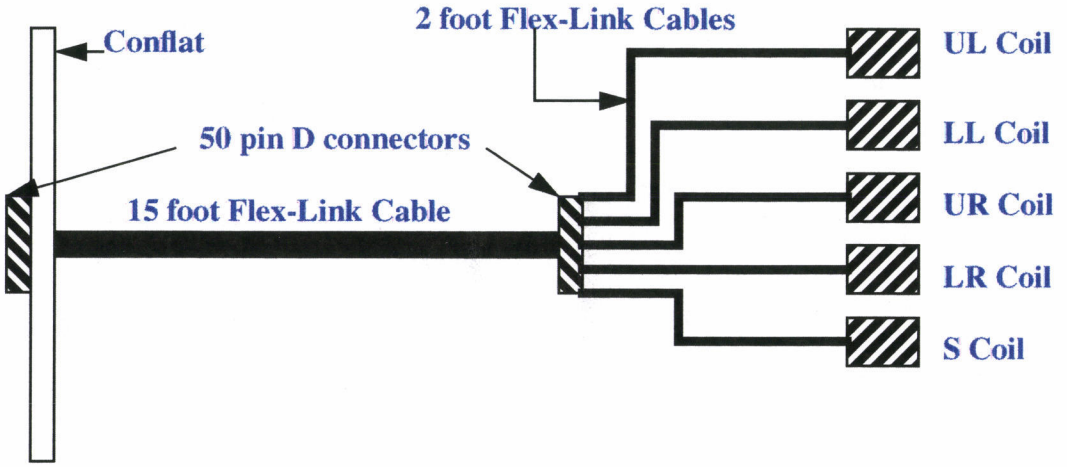
- Concern: Kapton cabling needs further contamination and outgassing R&D.

  ››Response: Initial samples were tested and made the vacuum materials list. CDS is waiting for further testing.

- Concern: Option to delete internal connector on vac. feedthrough may impair serviceability.

  ››Response: Feedthrough and long "stack" cable will be fab'd as a unit. Connectors will be used to get to coils (see next figure).

Vacuum Cabling Block Diagram



- Conflat, feedthrough and 15 foot cable will be fab'd as a unit. 50 pin D connector will be mounted on optics platform for connection. 2 foot cable and coils will be fab'd as a unit.
- Service of 15 foot cable is unlikely. Service of 2 foot cable and/or coil is accomplished by disconnecting and removing.

Twisted Pair Cable Rejection Example

- Length of cable= $l = 5 meters$
- twists = n = 6 twists/inch = 235 twists/meter
- freq = 10 kHz

$$\lambda = 22500 meters$$

$$n \times \lambda = 5.3 x 10^{6} twists$$

- From figure 7.7 of EMI Control Methodology and Procedures:

$$TotalRejection = 60 dB$$