



ADVANCED LIGO VACUUM REQUIREMENTS

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ADVANCED LIGO VACUUM REQUIREMENTS

- LIGO Vacuum Compatible Materials List - LIGO-**E960050**-A lists the materials allowed in the LIGO vacuum chambers.
- LIGO Vacuum Compatibility, Cleaning Methods and Qualification Procedures, LIGO-**E960022**-B lists procedures and standards for material qualification.



E960050 Vacuum Materials

- Document dated 7/96, needs updating.
- Contains:
 - » Problems associated with materials in vacuum system
 - » Approved materials
 - » Presently used materials
 - » Explicitly rejected materials



E960050 Vacuum Materials Problems with Materials

- Outgassing that increases the gas load which either compromises the IFO phase noise budget or forces higher pumping capacity.
 - » Heavy hydrocarbons: larger phase noise sensitivity and optical contamination
- Outgassing as a source of contamination on the optics: increased optical losses and failure due to heating.



E960050 Vacuum Materials Approved Materials

- aluminum & alloys
- beryllium copper
- copper-nickel alloys
- copper (OFHC)
- electroless nickel
- gold
- indium
- molybdenum
- niobium
- phosphor bronze
- platinum
- silver/ silver solder
- 304 & 316 stainless steels
- titanium
- tungsten
- Fired non-permeable ceramics (e.g.alumina, beryllia)
- Boron Nitride (machinable)
- Macor, Corning's machinable ceramic
- Glazed Ceramics (e.g.porcelain)
- BT Baffle Clayless Black Enamel
- ADP, calcite, diamond, germanium and KDP crystalline materials
- quartz
- sapphire
- silicon dioxide and tantalum pentoxide
- fused quartz
- Pyrex glass
- glass



E960050 Vacuum Materials

Presently used materials

- carbon steel suspension wire
- carbon steel balls
- carbon steel race ways
- Sm-Co and NEO-35 magnets
- PZT piezoelectric ceramics
- Vac-Seal and Torr-Seal epoxies
- non-OFHC copper
- standard tin/lead solder
- Viton
- Glass and ceramic type vacuum connectors
- DuPont Krytox high vacuum grease - may be removed
- molybdenum disulphide dry lubricant
- Kapton/polyimide wire insulation
- PFA 440HP Teflon-like material



E960050 Vacuum Materials Explicitly Rejected Materials

- Alkali metals
- Cadmium and zinc plating on metal parts
 - » cad and zinc have prohibitively high vapour pressures. Crystalline whiskers grow on cad, can cause short circuits
- Delrin or similar polyacetal resins
 - » outgassing products known to contaminate mirrors
- Oilite™ or other lubricant-impregnated bearings
- Oriel MotorMike actuators filled with hydrocarbon oil
- Palladium
- RTV Type 615
- Soldering flux
- Tellurium



Processes

- After cleaning and pickling, no grinding with abrasive wheels, cloth or stones is permitted. No iron, carbon steel or other contaminants (such as grease, chloride compounds, oil, hydrocarbons) are to come in contact with the material, except for machining bits.
- When machining, water soluble lubricants must be used. Machining fluid shall be free of sulfur, chlorine and silicone.
- All materials shall be wrapped and covered at all times the material is not undergoing processing to minimize exposure to contaminants.
- Once cleaned and baked (instructions in E960022), the preferred wrapping material is UHV foil and Ameristat™.
- All blind holes and trapped volumes shall be explicitly vented to avoid virtual leaks; provisions for cleaning such volumes adequately (e.g. by solvent flushing) shall also be considered in the design process.



Processes & Materials

- Currently an anodizing process for aluminum is going through the qualification process. We are qualifying MIL-A-8625, Type III. It is a hard sulfuric acid coating.
- Currently qualifying PEEK



Welding

- No requirements for welding filler material, unless non-magnetic material is required.
- No limitations (for vacuum qualification) on the extent of the heat effected zone.
- In order to avoid virtual leaks:
 - » full-penetration welds should be used, or
 - » continuous interior weld seam with no outer weld, or
 - » if required for structural reasons, continuous weld seam on the interior and a stitch weld on the exterior
 - » don't trap any volumes, including gaps between surfaces.
- The welds should not be subsequently ground.
- An inert gas (e.g. argon) must be used in all welding. Before welding the surfaces should be cleaned according to the UHV cleaning procedure.



Part identification

- Marking the finished materials with marking fluids, die stamps and/or electro-etching is not permitted.
- A vibratory tool with a minimum tip radius of 0.005" is acceptable for marking on surfaces which are not hidden from view
- Engraving is permitted, as is laser marking and acid etching



E960022 Vacuum Procedures

- LIGO Vacuum Review Board
- Vacuum compatible material usage in LIGO
- Cleaning & preparation of materials procedures
- Handling and storage procedures
- Qualification and screening tests for materials and components
- Cleaning & baking procedures for approved materials
- Cleaning & baking procedures for approved sub-assemblies
- Forms



E960022 Vacuum Procedures

- Vacuum Review Board
 - » must approve tested materials and parts before going into the LIGO chambers
 - » will recommend the disposition of issues where policy and schedule are in conflict
 - » Chair - Albert Lazzarini, Caltech
 - » Guru - Rai Weiss, MIT



E960022 Vacuum Procedures

- Vacuum compatible materials usage in LIGO
 - » Material approval process
 - if material can't handle the outlined cleaning and baking process, a waiver may be submitted to the Review Board
 - » Component qualification



E960022 Vacuum Procedures

- Cleaning & Preparation of Materials Procedures
 - » Commercially produced components
 - » Internally produced (fabricated) components



E960022 Vacuum Procedures

- Handling & Storage Procedures
 - » Class A - in-vacuum use
 - » Class B - outside-vacuum use such as assembly fixtures and tools
 - » Wrapping and storage procedures including UHV foil and anti-static bags with labels
 - » Procedures for work areas (e.g. optics labs)



E960022 Vacuum Procedures

- Qualification and screening tests for materials and components
 - » initial material qualification > material effect on optical surfaces and IFO excess phase noise caused by forward scattering; 2 mirror resonant cavity with resonant optical power for optical effects and RGA scan
 - » QA screening of all materials going into the IFO > cleaning and baking all parts; review of RGA scan



E960022 Vacuum Procedures

- Appendix A: Cleaning and baking procedures for approved and provisionally approved materials
 - » metals
 - » ceramics and glasses
 - » LIGO optical components
 - » Viton-Fluorel
 - » Teflon and PFA 440HP
 - » NEO-35 permanent magnets



E960022 Vacuum Procedures

- Appendix A: Cleaning and baking procedures for approved and provisionally approved materials
 - » silicone rubber
 - » lead/tin solder
 - » Vac-Seal
 - » Sn-Co permanent magnets
 - » PZT piezoelectric ceramics
 - » Ryton
 - » Hygroscopic crystalline optics
 - » PEEK connectors/Kapton cabling/wire harnesses



E960022 Vacuum Procedures

- Appendix A: Cleaning and baking procedures for approved and provisionally approved materials
 - » Cleaning and baking of Class B materials
 - » Cleaning and baking of Class B brass



E960022 Vacuum Procedures

- Appendix B: Cleaning and baking procedures for approved sub-assemblies
 - » LOS structure
 - » commercial stages
 - » electronic components
 - » OSEM (sensor/actuator) heads: hot bake and 2nd bake
 - » OSEM pigtails
 - » viewports



E960022 Vacuum Procedures

- Forms
 - » Parts cleaning request
 - » LIGO vacuum bake oven procedure and check list