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**PPPL, Tokamak Physics Experiment**

**To:** Distribution                      **Date:** 23 August 1993

RBF.

**From:** R.B. Fleming                      **Subject:** *Revised Classification of Materials  
for Use Inside the TFTR Vacuum*

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The Vacuum Materials Committee has recommended the addition of several materials to the Classification *Of Materials for Use Inside the TFTR Vacuum* since the last revision of March 1993. The revised list is attached.

Also enclosed is a description of the VMC functions and resources. I wrote this up at the suggestion of Rich Hawryluk, and sent it with the wide distribution last March. If you have any suggestions for improvements, please let me know.

Since a *Classification* was sent to the wide distribution last March, and since the three changes listed below aren't especially significant, I don't plan to make a wide distribution of this revision.

With the departure of Mike Ulrickson from the lab, we lack a TPX representative on the VMC. Perhaps Jim Sinnis could suggest a replacement.

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Following are the changes incorporated in this revision of the Classification.

- Added to Category III: **TFTR-101**, beryllium-copper snap rings for use in bumper limiter T-bar retainers.
- Added to Category III: **TFTR-102**, nickel foils, about 1  $\mu\text{m}$  thick, used as sample exposure alpha collectors inside a probe head attached to the Bay D vertical probe.

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**DISTRIBUTION:**

**Vacuum Materials Committee**

**Others**

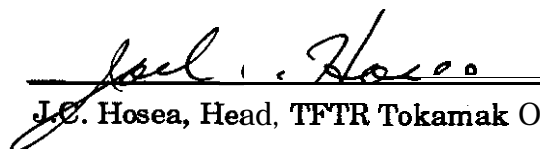
R.B. Fleming	New Guggenheim	J.C. Hosea	Csik, LOB
G.J. Gettelfinger	Csik, S206	D.J. Kungl	C-site, Eng. Wing
G.W. Labik	C-site, Eng. Wing	N.R. Sauthoff	C-Site, C223
P.H. La Marche	Csik, LOS	J.C. Sinnis	New Gugg.
D.K. Owens	C-site, LOS	C.S. Such	Csik, LOB
R.W. Walls	C-site, Eng. Wing	K.M. Young	C-site, LOB

- Added to Category III: **TFTR-103**, RS17 paint, manufactured by Micro-Circuits Company, es a blackening agent within the collimator of the Alpha Charge Exchange diagnostic. While accepted for this specific (*one* time only) use, this material is not recommended for any other **TFTR** application.
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Following are open items or data needed:

- ✓ Tests are needed to determine if a vacuum bake is required after the air bake for **Nextel-312 (TFTR-094)**. If a mass **spec** test shows that an air bake is adequate, the vacuum bake requirement will be eliminated.
  - ✓ Outgassing tests are also needed to determine if the **bakeout** requirement of **TFTR -072 ("TV-Tube Koat")** as a blackening agent of stainless steel (Category II, Location I), should be retained.
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The above change; are approved by

 8/28/93  
\_\_\_\_\_  
J.C. Hosea, Head, **TFTR Tokamak** Operations Division

# Functions of the Vacuum Materials Committee

August 1993

The Vacuum Materials Committee serves as a clearing house and coordinator for materials used in vacuum systems. Its primary purpose is to help in the selection of materials and designs relative to vacuum performance.

The VMC serves all machines at PPPL, **specifically TFTR**, PBX, and TPX. Functions **of** the VMC are:

- Approve materials for use in the vacuum and maintain lists of approved materials specific to each of three machines.
- Provide recommendations on the use of special materials in specific locations in the vacuum.
- Review, recommend, and approve the materials and configuration of vacuum **seals**.
- Review, recommend, and approve design configurations, components, and surface preparation procedures that affect outgassing, base **pressure**, pump down rate, and contamination within the vacuum envelope.
- Maintain and make available a **file** of outgassing data.
- Perform **outgassing** tests on materials for which there are insufficient **outgassing data**. **Tests** on samples up to **6.3 cm** diameter can be run at temperatures up to about 600°C.
- Offer advice on vacuum welding design and techniques.

Requests for approval of materials are made on a VMC Approval Request Form (copy attached).

To avail yourself of any of the services or resources listed above, please call the VMC Chairman, Bob Fleming (extension **2152**), or talk with any other member of the **VMC** (see list below).

## ***Vacuum Materials Committee***

R.B. Fleming  
G.J. Gettelfinger  
G.W. Labik

New Guggenheim  
C-site, S206  
C-site, Eng. Wing

P.H. La Marche  
D.K. Owens  
R.W. Walls

C-site, LOS  
C-site, LOB  
C-site Eng. Wing

# Vacuum Materials Committee Approval Request Form

Princeton University, Plasma Physics Laboratory

Date	VMC log number	
Request is for: <input type="checkbox"/> TFTR <input type="checkbox"/> PBX <input type="checkbox"/> Other:		
<b>Request Section</b>		
Item	Supplier	
Item description .		
Location (where used), bay number, etc.		
Application		
Nearest standard material		
Reason why standard material <b>cannot</b> be used		
Is this material shielded from direct view of the plasma? <input type="checkbox"/> Yes <input type="checkbox"/> No		
Number of items used	Total volume	Total area exposed to <b>vacuum</b>
Vacuum exposure	Magnetic <b>field</b>	Radiation exposure
Maximum operating temperature of the material in the machine during: <b>Bakeout:</b> °C;    High power pulsing:            °C;    Discharge cleaning:            °C .		
<b>Pre-installation</b> processing — examples: cleaning, polishing, machining, <b>bakeout</b> (air <b>or</b> vacuum, <b>temperature</b> , time at <b>temperature</b> ). Cite a procedure if one is applicable.		
Are <b>outgassing</b> test results available? <input type="checkbox"/> Yes <input type="checkbox"/> No (If yes, please send copy of report to the VMC)		
Initiated by	Location	Phone
<b>Approval Section</b>		
<input type="checkbox"/> Approved		<input type="checkbox"/> Rejected (basis)
Category:	Location	
Please send completed form to R.B. Fleming, B-site, New Guggenheim (Phone extension 2152).		

# CLASSIFICATION OF MATERIALS FOR USE INSIDE THE TFTR VACUUM

Retied August, 1993

## Category I Materials (Approved)

- No # Vacuum grade aluminum (no anodize).
- No # Austenitic stainless steel.
- No # Glass.
- No # Alumina, at least 85% pure, minimum density 3.48 g/cc, no glaze on vacuum side.
- No # Macor machinable glass.
- No # Quartz.
- No # Inconel.
- TFTR-025 Inorganic bonded mica, limited to Mica Mat 78300, manufactured by Insulating Materials Incorporated. To be used only in locations where it will be baked at the same temperature as the vacuum vessel; must be shielded from the plasma (for electrical insulation reasons).
- TFTR-027 Graphite, POCO graphite grade AXF-5Q or equivalent; must meet all requirements of GA Technical Materials Specification 0.9100.2TS, and all processing requirements of PPPL Specification TFM-123-D3B3-C646, and any subsequent applicable materials or processing specifications.
- TFTR-073 Coarse weave 4-D carbon-carbon composite, made by FMI under Contract S-03131-F. The material must be vacuum pre-baked according to "PPPL Specification for Bakeout of Graphite Tiles for use in TFTR," CVO OPR-2995, Rev. 0, dated May 4, 1987, and any subsequent applicable specifications.
- TFTR-081 Nitrided surfaces of stainless steel or Inconel-type alloys, applied by high temperature salt bath, gas nitriding, or ion nitriding, for surfaces not directly facing the plasma.
- TFTR-082 Carbon-carbon composite, provided the density is a minimum of 1.6 g/cc, and the final heat treatment (graphitization) temperature is a minimum of 2400°C. The material must be processed according to TFTR Specification OPR-SPEC-RFL-19, Rev. 0, dated 27 July 1990, and any subsequent applicable specifications.

## Category II Materials (Approved for use in only certain locations)

Approval of a material for a certain location implies approval for all locations with a higher number (example: approval for Location II implies approval also for Locations III and IV).

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### CATEGORY II MATERIALS, LOCATION I (Main Torus)

- TFTR-019** Thermocouple wire XC-E-20(Chromel-Constantan covered with Nextel-312 fibrous insulation and braided Inconel jacket) for surface pumping panels, bellow covers, moveable limiters, and internal vacuum vessel wall. See bakeout requirement of TFTR-094, below.
- TFTR-066** "Edick Number 33" aluminate coated wire for winding small Mirnov coils at each bay. This material must be shielded from the plasma.
- TFTR-0613** Silver thread lubricant when applied to the *external thread (bolt thread) only*, according to the following pretreatment and plating procedures.  
**Pretreatment:** (1) For precipitation hardenable Inconels: precipitation heat treat, then acid pickle in nitric hydrofluoric solution (2) For other alloys: *degrease*, then apply normal vacuum preparation according to TFTR standards. **Plating:** Silver plate to a thickness of 0.0002 inches according to AMS 2410. Specified dimensions and tolerances must be maintained after pretreatment and plating. Limited to bakeout temperatures of 250°C (until further testing). Silver must be shielded from the plasma.
- TFTR-069** Silver jacketing forming the outer layer of Helicoflex Model HND 208A seals, manufactured by Cefilac, used as vacuum seals for lateral access port covers and racetrack port covers (reference MDRAC drawings 6426.5087 and 5086).
- TFTR-070** Copper used in Varian Conflat seals for circular ports on the vacuum vessel.
- TFTR-071** "Vicor" mirror with aluminized coating and a silicon dioxide overcoat, for the beam emission spectroscopy diagnostic at the Bay J midplane.
- TFTR-072** "TV-Tube Koat" for blackening the surfaces of the *mirror box of the beam emission spectroscopy diagnostic at the Bay J midplane*. Prior to installation, any part coated with TV-Tube Koat must be vacuum baked at a minimum of 250°C for a minimum of 8 hours.
- TFTR-075** Metal oxide varistor, by GE Semiconductor Products Department, a zinc oxide sintered disc with silver thin film contacts and plastic encapsulation removed, for the CESEP probe vacuum envelope at Bay D (not exposed to plasma). The zinc oxide is coated with EPC-TEK 377.
- TFTR-076** EPC-TEK 377, a two-component, 100% solids epoxy, for the CESEP probe vacuum envelope at Bay D (not exposed to plasma).
- TFTR-078** Boron/carbon mixture (hot-pressed mixture of 50% boron and 50% carbon) on leading edge of Material Ablation Probe head mounted on Bay D CESEP probe (for experimental attempt to coat the limiter with boron).
- TFTR-085** Carbon coating as a high temperature optical blackening agent on stainless steel, for use in the lost alpha probes.

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**CATEGORY II MATERIALS (continued)**

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- TFTR-087** Nitriding of stainless steel bolts and parts of the shutter for the illumination pmbe.
- TFTR-094** Nextel-312 electrical insulation. Installation must be preceded by a 4-hour air bakeout at 500°C and a 4-hour vacuum bake at 500°C. Adequate ventilation is required during the air bake to avoid hazardous vapors that are produced when Nextel is first heated. The stainless steel or Inconel overbraid must be cleaned separately and prebaked with the Nextel.
- TFTR-095** Boron-impregnated carbon felt, Fiber Materials, Inc., limited to the GH grade, processed at a minimum of 2300°C, and 99.7% pure. Must satisfy OPR-SPEC RFL-19, Rev. 0, dated 27 July 1990, and any subsequent applicable specifications. Under that specification, the vacuum bakeout temperature and time are 800°C for 12 hours. For this material to be considered mechanically acceptable, a means should be developed to prevent the release of boron particles in a disruption
- TFTR-096** CEFIR B/STW-20-BX, a ceramic fiber braid with an outer braid of stainless steel, manufactured by Thermo Electric Company, Inc. to cover copper wire. The material must be processed according to OP-W-175, and subsequently baked out in air at a minimum of 400°C for at least one hour.
- TFTR-099** Alomega or Alumel, nickel alloy thermocouple wire.
- TFTR-100** Pure graphite powder as a thread lubricant for bolts in the vacuum vessel. The powder is mixed with alcohol, brushed on the threads, and the bolts are screwed in wet.

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**CATEGORY II MATERIALS, LOCATION II (High Conductance Appendage Vacuum Systems or Ducts [greater than 1 liter/second])**

- TFTR-074** Carbon-graphite brush, grade 605, MoS<sub>2</sub> treated carburized molded block with a flame-sprayed copper pad for electrical contact, made by Stackpole Corp., mounted below the ceiling of the test cell basement, for the CESEP probe vacuum envelope at Bay D.

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**CATEGORY II MATERIALS, LOCATION III (Low Conductance, Appendage Vacuum Systems or Ducts [less than 1 liter/second])**

No items have yet been entered into this category and location

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**CATEGORY II MATERIALS, LOCATION IV (Vacuum Pumping Components)**

No items have yet been entered into this category and location.

**CATEGORY II MATERIALS (continued)**

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**CATEGORY II MATERIALS. NOT YET SUBDIVIDED BY LOCATION**

No #	Viton
No #	Titanium
TFTR-009	Zirconium-copper alloy (0.13-0.20% zirconium).
TFTR-001 & - 0 1 0	Nelson studs (with aluminum flux).
TFTR-014	Silicon carbide, for microwave calibration source.
TFTR-015	Kanthal A-1 alloy, flame sprayed on 304L stainless steel, for microwave calibration source.
TFTR-024	Polyimide, Vespel SP-3 for guides in the impurity injector.
TFTR-026	Ceramabond 503, an alumina base adhesive, to secure a quartz lamp to a Macor base in the TVTS calibration and alignment probe at Bay C.
TFTR-028	OFHC copper.
TFTR-031	Carbon steel for bearings and ball screw in maintenance manipulator.
TFTR-035	Epoxy and Kapton, for attaching platinum resistance sensors to substrates in tangential bolometers at the midplanes of Bay S and N.
TFTR-038	Vespel, SP-1 (brown), for holders of lenses and pmbe shaft in the prototype escaping alpha pmbe at the bottom of Bay P.
TFTR-039	Bronze bearing cages, 0.5% zinc, for the maintenance manipulator.
TFTR-040	Epoxy, EPO-TEK 377, for termination of fiber optic cables for escaping alpha diagnostic, Bays E and F. Must be vacuum pre-baked at 150 °C.
TFTR042	Braycote 601, a perfluorinated polyether-base grease, for the following three components of the maintenance manipulator: (1) 6.3-m long roller spindle, (2) right-angle gear box for carriage drive, and (3) link bearings and other ball and roller bearings within the maintenance arm.
TFTR-044	Vespel polyimide, SP-01, manufactured by Polymicro Technologies, as coating on quartz fibers for lost alpha diagnostic in conduit at bottom of the vessel at Bay E.
TFTR-045	Invar, a nickel-iron alloy, to compensate for thermal expansion in camera housing of maintenance manipulator, Bay R.
TFTR-046	Vespel, SP-1, by DuPont, for lens holding rings in escaping alpha diagnostic at bottom of Bays E-F and Bay E.



CATEGORY II MATERIALS (continued)

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- TFTR-047 Fiber optic cable with polyimide buffer, by Polymicro Technologies, for escaping alpha toroidal array at bottom of Bays E-F and Bay E.
- TFTR-061 Thermocouple wire, Omega 6-6-E-30 with glass braid duplex insulation, by Omega, in the triton midplane probe at Bay E.
- TFTR-062 Vespel SP-1 (brown), by DuPont, as fiber bundle terminator in the triton midplane probe at Bay E.
- TFTR-063 Epo-Tek 390, polyimide based epoxy by Epoxy Technology, Inc., as a binder for the ends of the fiber optic bundle in the triton midplane probe at Bay E.
- TFTR064 Polyimide, as the quartz fiber optic jacket in the triton midplane probe at Bay E.
- TFTR065 "Silverflex" fiberglass sleeving, by Suflex, for the fiber-optic bundle in the triton midplane probe at Bay E.
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**Category III Materials (new or innovative materials to be approved on a case by case basis)**

- TFTR012 Braycote 3L-38-RP grease, and Brayco 815Z oil, limited to bearings in sample exposure probe mechanisms at bays D and N.
- TFTR-016 Flame sprayed alumina, for rails of bellows cover plate assemblies.
- TFTR-017 Fiberglass wire insulation, for electron beam at bay F, prior to ohmic heating plasma phase.
- TFTR-018 Bearing coating by Hohman Plating & Mfg., (MoS<sub>2</sub>/10% Ni), for short probes at bays A, E, and N.
- TFTR-020 Molybdenum disulfide, in roller bearings of moveable limiters.
- No # Dye penetrant, for checking welds in initial protective plates, followed by cleaning and vacuum bake at 250 C (ref. minutes of 19th meeting).
- TFTR021 Neo-Lube, on screw threads in Michelson Interferometer Periscope at Bay F.
- TFTR-023 Dye penetrant, for checking welds in bumper limiters and protective plates, followed by cleaning and vacuum bake at 620°C.
- TFTR-030 Molybdenum disulfide, applied by chemical deposition in an autoclave process, on bearing surfaces of maintenance manipulator.
- TFTR-032 Nitrided surfaces of stainless steel or Inconel-type alloys, applied by gas nitriding or ion nitriding, for rails of maintenance manipulators.

### Category III Materials (continued)

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- TFTR-033** Carbon-carbon composite, as limiters for RF antennas at bays K/L and N/O, meeting all requirements of Physics Design Specification PSD-0686-IC, dated 8 July 1936. \*
- TFTR-034** Carbon-carbon composite, designated "K-Karb" by Kaiser Aerotech, for the head of the prototype escaping alpha probe at the bottom of Bay P.
- TFTR-036** TRA-DUCT 2992, a conductive silver paste epoxy adhesive manufactured by TRA-CON, inc., for electrically and thermally bonding thermocouples to neutral beam calorimeters.
- TFTR-043** TiCuSil braze foil, manufactured by Wesgo, for brazing graphite to the Faraday shield tubes on the RF antenna.
- TFTR-048** Carbon/carbon composite, by B.F. Goodrich, (same material as RF limiters) as armor plates for escaping alpha diagnostic at bottom of Bays E-F and Bay E.
- TFTR-049** Silver-plated monel RF shield gasket, by Tecknit, as an RFI shield between demountable surfaces in the tangential array bolometer assembly.
- TFTR-060** Silver plating, by New Brunswick Plating, on inner surfaces of ICRF antenna box at Bay M midplane.
- TFTR-051** Titanium carbide/titanium nitride coating of the Faraday shield rods at Bay M (exposed to plasma).
- TFTR-062** Microbraze, used to assemble parts of the Bay M ICRF antenna (not exposed to plasma).
- TFTR-053** Molybdenum, for brazing graphite in the ICRF antennas, Bays L and M (not exposed to plasma).
- TFTR054** Dye penetrants for testing braze joints in Faraday shield water cooling tubes for the RF antennas at Bay L. Must use dyes soluble in water, alcohol, or acetone; dyes must not contain heavy metals (z must be less than 20); PPPL approved cleaning procedure must be used after the dye testing.
- TFTR-055** Pd-MOS diode with gold overlayer; on Bay E midplane short probe.
- TFTR-056** Surface blackening of 304 stainless, sodium dichromate solution treatment applied by Bristol Steel Treating Company, to various parts requiring a non-reflective surface.
- TFTR-057** TV-Tube Koat, by GL Electronics, a black coating for the horizontal VB viewing dump on the vertical side wall of the NB 5 nozzle.
- TFTR-058** Carbon-carbon composite, 4-D weave, by F.M.I., used as armor for probe head of the triton midplane probe at Bay E.
- TFTR-059** Zinc sulfide/silver phosphor for the scintillator in the triton midplane probe at Bay E.

### Category III Materials (continued)

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- TFTR-060 Silicon wafers for triton collecting on the probe head armor in the triton midplane probe at Bay E.
- TFTR-067 Braycote 601 for use as a thread lubricant for bolts holding the ion dump plate supports to the batch cover at the top rear of the neutral beam box.
- TFTR-083 Molybdenum used as support plates for caps in the lost alpha probes.
- TFTR-084 TiCuSil braze foil, manufactured by Wesgo, for brazing Carbone 5820 caps to moly plates on the lost alpha probes.
- TFTR-088 Nickel wire as power wiring for the bulbs of the vacuum vessel illumination probes.
- TFTR-089 Tungsten-halogen lamp bulbs (typically Sylvania "FAD" lamps) for the vacuum vessel illumination probes. Prior to installation, must be baked in vacuum for at least 4 hours.
- TFTR-090 "Incusil-15" hydrogen braze for brazing nickel wire to copper feedthroughs for the vacuum vessel illumination probes.
- TFTR-091 Fiberglass wire insulation for use in the vacuum vessel illumination pmbe (the single *prototype* unit only).
- TFTR092 Sylvania Type S2/12 tungsten lamp holders for use in the vacuum vessel illumination probes.
- TFTR-093 Monel lugs for electrical connections between nickel wire and lamp holders for the vacuum vessel illumination probes.
- TFTR097 Brass rollers for neutral beam calorimeter guides. Since brass is normally to be avoided in high vacuums, this approval is based on the fact that the rollers are well shielded from the beams, and that *they* will not exceed 0°C at any time during operation.
- TFTR098 Polyimide, Vespel SP-22, as bearing bushings within the brass rollers of TFTR-097.
- TFTR-101 Beryllium-copper snap rings for use in bumper limiter T-bar retainers.
- TFTR-102 Nickel foils, about 1  $\mu\text{m}$  thick, used as sample exposure alpha collectors inside a probe head attached to the Bay D vertical probe.
- TFTR-103 RS17 paint, manufactured by Micro-Circuits Company, as a blackening agent within the collimator of the Alpha Charge Exchange diagnostic. While accepted for this specific (*one time only*) use, this material is not recommended for any other TFTR application.