HS 3 SELECTION OF RADIATION RESISTANT MATERIALS
USED IN ACCELERATOR ENGINEERING

Materials and components which are installed in the primary proton beam areas of the CERN high-energy accelerators are exposed to annual radiation dose levels ranging from $10^2$ to $10^6$ Gy (1 Gy = 1 J/kg = 100 rad absorbed dose). In order to predict their life time in a radiation environment, a wide variety of organic, inorganic and metallic materials have been subjected to radiation damage tests. These studies have also led to a selection of radiation resistant materials.

Magnet coil insulations

Magnet coil insulations used at CERN are almost exclusively based on an epoxy resin of the type diepoxypropylether-bisphenol A with an anhydrid hardener and an amine type accelerator. Mechanical degradation of the base resin becomes serious at doses above $2-3 \cdot 10^7$ Gy. Impregnated glass tape or Mica may increase the radiation resistance by a factor of 10 (up to a few $10^8$ Gy). (For reference see CERN reports 70-5 and 70-10.)

Cable insulating materials

Cable insulating materials on the basis of common thermoplastics or elastomers (like polyethylene, polyvinyl chloride, ethylene propylene rubber, etc.) can in general be used in radiation areas up to $1-3 \cdot 10^6$ Gy. For higher doses up to $1 \cdot 10^8$ Gy special radiation resistant control and power cables insulated with Kapton (polyimide Du Pont) and glass tape are available. (For reference see CERN report 75-3.)

Electronic components

Electronic components are very sensitive to nuclear radiation. Degradation may start at doses as low as $10^2$ Gy, and at $10^4$ Gy practically no active semiconductor devices are fully operational. (For reference see CERN reports 75-4 and 75-18.)

Glass

Glass for windows, TV cameras, etc., may show darkening at doses above $10^6$ Gy. Special radiation resistant cerium doped glass is available where the reduction in light transmission is less than 20% at doses above $5 \cdot 10^7$ Gy.

O-rings and seals

O-rings and seals are metallic wherever this is possible. If organic materials are necessary, special O-rings based on ethylene, propylene or polyurethene rubber, which are radiation resistant up to $1 \cdot 10^7$ Gy, can be used.
Oils and greases

Oils and greases have to be carefully selected when they have to be used in a radiation environment. Base oils of phosphates, chlorofluorocarbons and fluorinated compounds show poor radiation resistance ($10^6 \text{ to } 15^5 \text{ Gy}$). Mineral base oils and alkyl aromatics show good radiation resistance (up to $10^7 \text{ Gy}$). (For reference see CERN report 70-5.)

Paints

Paints based on epoxy and polyurethane resins are available which are resistant to radiation up to $10^6 \text{ Gy}$. This is of importance to reduce corrosion and contamination. (For reference see Kerntechnik 1977, 5, 209.)

Inorganic materials

Inorganic materials, such as oxides, concrete and ceramics, are very resistant to radiation and show, at doses that could occur near high-energy accelerators, practically no degradation ($10^9 \text{ Gy}$).

Metallic materials

Parameters that are of interest for application at CERN are the resistivity in copper and permeability in steel. Changes may occur at doses above $10^8 \text{ Gy}$. (For reference see Nucl. Instr. Meth. 1976, 136, 575.)