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Radatox™

FOR SPACE APPLICATIONS

Atomic Oxygen (ATOX) resistant Interconnect solutions

axon' cable & interconnect

A flexible, resistant & lightweight solution

Solutions exist on the market to protect organic materials including wire and cable insulations against ATOX.
This is typically achieved by wrapping, coating or insulating wires in aluminium trays or conduits or by routing cables to areas that are protected from atomic oxygen.
But these solutions add mass to the system and decrease flexibility, both of which can be avoided by using Radatox™ insulated wires.

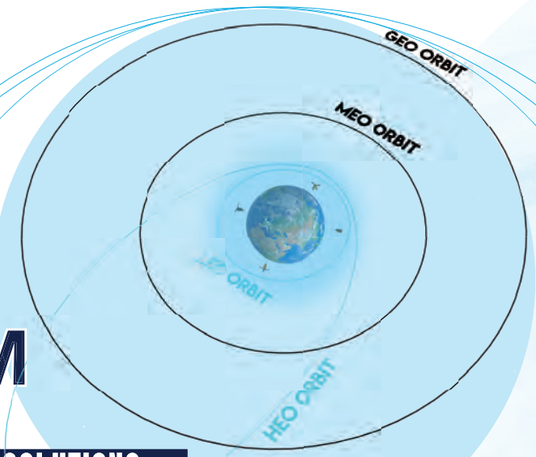
Radatox™ insulated wires and cables have undergone tests including Atomic Oxygen erosion and ageing in space-like simulated conditions (radiation, UV and thermal cycling) led by independent laboratories including ESA ESTEC's TEC-QEE lab.

Radatox™ based pressure sensitive tapes (PST) survive the harsh, on-ground evaluation test plan without any noticeable cracking or degradation of properties after 200 Mrad irradiation followed by UV exposure up to 6000 ESH and finally 100 thermal cycles in vacuum between [-150 +150]°C. Thermo-optical properties have also been measured at each of the ageing stages.

Materials used on spacecraft exteriors are exposed to a variety of environmental threats that can cause significant degradation. In Low Earth orbit ***(LEO),*** *these threats include radiation, ultraviolet (UV) radiation, thermal cycling, micrometeoroids, orbital debris impact, and especially atomic oxygen* ***(ATOX).*** *In order to limit the effects of ATOX which erodes and damages materials including polymer insulated wires and cables, Axon' Cable has developed a new electrical insulation system called Radatox™.*

Radatox™

INTERCONNECT SOLUTIONS



- **10 times more resistant to ATOX compared to typical perfluoropolymers (FEP, PFA, PTFE) which are highly sensitive to the combined effects of ATOX, UV, radiation and thermal cycling, limiting their use for long lifetime missions.**
- **100 times more ATOX-resistant than polyimides such as Kapton® (1)**
  (Radatox™ ATOX erosion yield : < $2x10^{-26}$ cm^3/atom).
- **Intrinsically bulk resistant to ATOX.**
  Alternative products based on protective coatings such as aluminized SiOx, ITO or FEP coated polyimides can offer improved protection, but the whole ATOX resistance can be compromised by the presence of microscopic pinholes or defects in these thin coatings from micro-meteroids or even during manufacturing or handling stages.
- **Radiation resistant (≥ 200Mrad).**
- **40% mass saving compared to solutions such as FEP, PFA or PTFE.**
- **Twice as flexible as polyimide tapes with similar thickness.**
- **Easy to strip.**
- **ITAR-free.**
- **Proven by independent laboratories to have superior ATOX performance.**

ATOMIC OXYGEN: a real threat for spacecraft

In space, solar radiation has enough energy to break apart oxygen (O_2) molecules and create atomic oxygen (O). This very abundant particle, particularly present at altitudes from 180 km to 650 km, erodes and damages many materials including most polymers and even some metals including silver.
The lower the altitude, the higher the ATOX density and its effects. Multi-Layer Insulation (MLI) blankets, solar panels and wires and cables located on spacecraft exteriors are all susceptible to this threat. ATOX erosion limits the service life of the components and therefore of the mission. Protection against atomic oxygen is, therefore, a key challenge for the space industry.

How ATOX damages materials

A spacecraft in LEO orbits Earth at a velocity of about 8 km/sec (nearly 30,000 km/hr). At such high speed, the collision with atomic oxygen atoms results in erosion by thermo-oxidation due to the high impact energies involved. Eroded particles can further condensate and contaminate functional surfaces of the satellites including optics.

LEO Satellites are not the only ones exposed to this threat. Any satellite designed to fly at any time in low orbits is concerned. This includes missions in Polar orbits **(POL)**, Highly Elliptical Orbits **(HEO)**, and Geostationary Transfer Orbits **(GTO)**.

With the new generation of **GEO** satellites equipped with electrical propulsion for Electrical Orbit Raising (EOR) from LEO to final GEO altitude, combined radiation and ATOX levels are a real challenge. Very Low Earth Orbits (**VLEO**) missions with altitudes below 350km are also concerned by this problem as the ATOX density increases.

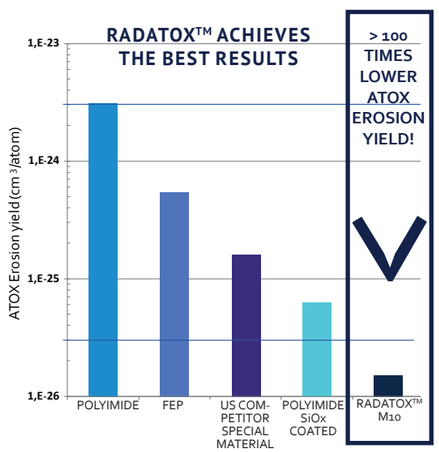
Applications & Products

New **Radatox™** solutions are already available for round wires and cables. Flat Flexible Cable (FFC) prototypes with **Radatox™** protection have also been developed.

Principal potential applications for **Radatox™** insulation include wires and cables, antennae, solar array cabling, adhesive tapes and a potential further application in MLI Thin films (≥25µm) and Pressure Sensitive Tapes (PST). (**Radatox™** combined with low outgassing space grade adhesives).

ALTERNATIVE ATOX RESISTANT SOLUTIONS

Radatox™ is an optimized, mass saving solution for spacecraft operating in LEO orbits, particularly those below 600 km. But for missions for which mass saving and material erosion are less critical, Axon' Cable also offers ESA qualified wires and cables (**ESCC 3901/018 and ESCC 3901/024**) which already present some resistance to ATOX.
This mainly concerns satellites in higher altitudes where ATOX density is lower or for shorter mission lifetimes (less than 5 years).



ATOX EROSION EXPERIMENTS TEST RESULTS AT ESA ESTEC LABORATORY

MATERIALS COMPARISON: RADATOX™ AT THE FOREFRONT

TYPICAL LEO MISSION EXAMPLES			ESTIMATED END OF LIFE ATOX EROSION DEPTH		
ORBIT	LIFETIME	ATOX FLUENCE	POLYIMIDE TAPE	FEP	RADATOX ™ -M10
km	years	(ATOM/cm²)	µm	µm	µm
400	5	$1.07x10^{22}$	≈ 320	≈ 21	≈ 1.6
500	10	$8.82x10^{21}$	≈ 265	≈ 18	≈ 1.3
600	15	$3.5x10^{21}$	≈ 106	≈ 7	≈ 0.5

(1) KAPTON® IS A REGISTERED TRADEMARK OF DUPONT DE NEMOURS