# X-ray Proofing

**To save himself, a physician enters the rag trade** By STEVEN ASHLEY

**If necessity is the mother of invention,** then self-preservation is surely one of the family matriarchs. A case in point is the brainchild of Ronald F. DeMeo, a Florida-based anesthesiologist who regularly takes x-rays of his patients when treating chronic back and neck pain.

Concerned about the cumulative damage x-rays might be wreaking on his own body, DeMeo began searching years ago for a better way to protect himself—beyond the standard practice of donning a heavy lead medical vest or apron, gloves, a thyroid shield or lead-glass goggles or of having to leave the room frequently during x-ray imaging to keep a safe distance away from the radiation source.

NEW HAZMAT COUTURE is both radiation-resistant and comfortable to wear over extended periods.

RADIATION SHIELD TECHNOLOGIES

After eight years of collaborative research, the physician-entrepreneur has developed a unique polymer composite–based fabric he calls Demron. It not only blocks x-rays and nuclear emissions (gamma rays, alpha particles and beta particles) as effectively as current standard lead-based apparel does, it is also significantly more flexible and wearable. Widely used lightweight plastic protective outerwear does not impede the passage of x-rays and gamma rays at all.

In addition, the new fabric seems to be impermeable to deadly chemical and biological warfare agents, so it can be used in jumpsuits for hazardous-materials emergency workers and "first responders" to disaster scenes. Experts at the U.S. Department of Defense are currently evaluating Demron's effectiveness when used in nuclear-biological-chemical suits against common chemical warfare agents such as mustard gas, VX nerve gas and sarin. A typical Demron full-body hazmat suit costs about $600. The new material could also be fashioned into radiation-proof tents, linings for aircraft and spacecraft, covers for sensitive equipment, and medical shielding garments.

Anxious about the steady rise of his own total radiation dosage, DeMeo sought to reduce exposure for himself and his staff. "I entered the radiation-shielding business for reasons of self-preservation—to allow me to live longer," he recalls.

For those who come into contact regularly with x-rays or nuclear material, limiting one's dosage is difficult. "Most practitioners, for example, work in different hospital facilities, each of which use different dosimeter badge sets," DeMeo notes. "Hardly anybody does the math and adds up all the separately measured doses." Complicating the situation is an abiding problem: regulations forbid medical and radiation workers from continuing in their jobs if they have exceeded safe cumulative dosage levels. "People often don't want to know what their total dose is because they don't want to be forced to stop working," he says.

And few want to work wearing awkward lead aprons and vests (costing between $85 and $600), which are typically constructed of weighty, cumbrous sheets of powdered lead in a polymeric matrix.

Although the radiation-safety experts DeMeo consulted were skeptical, he began funding research projects in which he hired chemists and materials experts to search for lightweight, flexible substances that can stop x-rays. Eventually the physician formed a company in Miami, Radiation Shield Technologies (RST), to develop and market his products. Now the firm's chief executive officer, DeMeo continues his medical practice as well.

At first the small research group studied metal shielding, but that turned out to be just one of numerous dead ends. Lead is toxic, heavy and bulky, so that was out. Says DeMeo: "Copper and aluminum showed some [shielding] response, but nothing overly useful. Later we worked on embedding metal particles in fabric and obtained a few patents in that area. Then we got involved with trying to find polymers that attenuate radiation."

After considerable fruitless effort, the RST team came up with a polymer composite of polyurethane and polyvinylchloride that incorporates a variety of organic and inorganic salt particles that block radiation. Constituents of these salts have high atomic numbers (the number of protons in an atom of a particular element), so they tend to arrest radiation more effectively. "Our material looks and behaves like a heavy, dense rubber," DeMeo says.

Demron works in two ways, depending on the type of radiation. When x-rays or gamma rays meet these dispersed salt particles, DeMeo explains, they are either absorbed (via the photoelectric effect) and their energy dissipated through the generation of heat, or they are scattered at an altered energy level (via the Compton effect) and then absorbed or deflected by surrounding particles. This cascade of absorption and scattering stops harmful radiation from penetrating to body tissues. When alpha and beta particles strike Demron, intervening electrons in the salt atoms deflect and slow them down, whereupon they are absorbed into the material.

Because x-ray machines produce a spectrum of photons and common radionuclides emit particles with a range of energies, the radiation-blocking agents in the Demron fabric must be tailored to these various energies, a technique called spectral hardening. "Each attenuation material we've included has an energy level it's good at absorbing or scattering," DeMeo says. "It's something like installing soundproofing. A one-inch-thick panel of wood stops certain sound frequencies, but a similar-size sandwich comprising a quarter-inch-thick piece and a three-quarter-inch piece stops more frequencies."

The polymer composite can be made in two forms: as thin film sheets or as injection-molded shapes. RST's initial Demron offering is produced by laminating the film between two layers of fabric—one woven, the other nonwoven. The resulting material is about 0.43 millimeter thick and has a density of about 0.7 gram per square inch.

Though nearly as dense as the material in lead-based shielding vestments, Demron readily bends, creases and folds. The thin, compliant fabric has proved itself

**Toxic-site cleanup crews wore Demron hazmat suits for hours, even doing calisthenics in them.**

against both x-rays and nuclear emissions in tests at Lawrence Livermore National Laboratory, the Neely Nuclear Research Center at the Georgia Institute of Technology, and the department of radiology at Columbia University's College of Physicians and Surgeons. It is not yet clear, however, whether Demron degrades when subjected to extended radiation exposure. The material is impermeable to air and fluids and can withstand at least eight hours of exposure to corrosive chlorine and ammonia gas.

Because it allows radiant heat loss, Demron feels cool to the touch and releases internal heat to the surrounding air. Therefore, "it can be used to cover 100 percent of your body surface area," DeMeo says. Last summer, toxic-site cleanup crews tested prototype Demron suits to see whether they would be comfortable when worn for long periods. "The ergonomic evaluation went well," he reports. "The crews could wear it for hours at a time, even do calisthenics in it. Current nuclear-biological-chemical suits are walking saunas. Troops wearing them could die of heatstroke in the desert."

In October 2002 RST contracted with a clothing manufacturer to make jumpsuits for first responders and cleanup workers. DeMeo is next considering producing injection-molded gloves as well as customized protective covers for equipment.

Orders for Demron hazmat outfits are backing up, he says: "We've had a fairly tremendous response to our product introduction." Thus far Demron has gone a long way toward proving that a thin, highly flexible and wearable radiation shield is not a technical impossibility after all. SA