Before SHINE . . .

The September issue of *Nuclear News* contained an article in the Isotopes & Radiation section (page 40) about SHINE Medical Technologies. The article announced the groundbreaking celebration and the company's general plans for future operations at the Janesville, Wis., site. The initial activity will be the production of molybdenum-99, which is widely used in diagnostic nuclear medicine procedures. This endeavor is described in the article as "the first fully integrated, full-size Mo-99 production system."

I believe that it is worth pointing out that the first fully integrated, full-size Mo-99 production system was established in the 1960s at the research reactor and radioisotope processing facility located in Sterling Forest, in the town of Tuxedo, N.Y. This facility was originally owned by Union Carbide Corporation, Medical Products Division, later to become Cintichem Inc., a subsidiary of Medi-Physics/Hoffmann La-Roche. The initial production of Mo-99 was by n-*y* reaction with Mo-98. A vast improvement in the quality of this product was developed at this facility in 1969 by separating Mo-99 from the fission products of uranium-235. This was a fully integrated process (target production–target irradiation in a 5-MW research reactor, Mo-99 separation in a radiochemical processing facility, and eventually Mo-99/Tc-99m generator production) that provided about half of the world demand for this product for more than 20 years.

I am sending you this comment because, as the erstwhile plant manager of that facility, I believe it is appropriate to recognize the expertise and ingenuity of the team that developed the technology, and the diligence and perseverance of those who operated the plant practically 24/7 to provide this vital radioisotope reliably to the nuclear medicine community throughout all those years.

James McGovern
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Reply

Our apologies to Mr. McGovern and those who operated the Tuxedo, N.Y., Mo-99 production facility. He is, of course, correct. The wording in the article should have read, "the first fully integrated, full-size SHINE production system" (*not* "Mo-99 production system").—*Ed.*

Entrenched in tradition

I was gratified to see that the first item on the agenda for Andy Klein's Nuclear Grand Challenges is to work toward revising the basis for radiation dose limits. I was also glad to see the article on

the subject by Jerry Cuttler and William Hannum (*NN*, Sept. 2017, p. 34). Nothing has been more entrenched in nuclear tradition than the outdated and actually incorrect linear no-threshold hypothesis (LNT). Many of us have sat on ALARA review committees at our plants where we spent way too much time trying to decide how to shave 50 or 100 mrem off of an outage or on-line job. We knew that as far as any benefit versus risk, there was little to none, and we could have been back at our workstations doing things to really help the plant perform better.

The overreliance on this incorrect and antiquated approach has also led to a lot of extra expenses—temporary lead shielding being carried around and hefted into position, engineering reviews to ensure that the shielding weight did not affect structural attributes of piping and valves, and in some cases, even the actual postponement of work to other times. Then there is the inevitable time spent in flushing "hot spots," requiring specific procedures, valve lineups, etc. This does not include the expense of actually procuring materials from numerous vendors. It has been a very costly journey and will remain so until both the regulator and the Institute of Nuclear Power Operations realize the errors in thought processes.

The key to keeping doses down, of course, is managing the source term, and plants and fuel vendors have made amazing progress in reducing the number of fuel rod leaks and in managing them effectively when they do occur.

This effort will also be consistent with the current risk-informed management of nuclear power stations. For far too long, it has been considered a sacrosanct tradition that zero dose—while not achievable in reality—is a goal that must be striven for under the guise of so-called excellence. Jobs and evolutions in the radiologically controlled areas of the plants, like any other job, should be planned and done as efficiently as possible—just like work on a feed pump in the turbine building. That is just good business, but for decades we have forced upon them the additional burden of ALARA so that we could publish and brag in periodicals about completing our outage with "lowest dose ever." INPO actually calls its goals *radiation protection* goals! Of course, they never were. The very use of that terminology further entrenched the erroneous concept of the LNT. *Radiation exposure management* goals would have been better, but not quite as attention getting as radiation protection.

I hope this effort bears fruit because there are many of us who tried to advocate for it long before ANS made it a Grand Challenge. The LNT is bad science that has resulted in more expense over the years than any benefit achieved. The late Theodore Rockwell tried years ago, through personal efforts and at his own expense, to lobby for change, but the opposition was so formidable he finally had to yield.

So, thanks to ANS for its efforts. Maybe people in positions of responsibility in our industry will listen this time.

Dennis Mosebey
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LETTERS TO THE EDITOR on any aspect of the contents of *Nuclear News*—or on related nuclear industry issues—are welcome. Letters (which should not exceed 700 words and may be subject to editing for length/clarity) should be addressed to:

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Letter should include the writer's full name, address, and daytime phone and fax numbers.

Intensive, not extensive

The recent article by Jerry M. Cuttler and William H. Hannum (*NN*, Sept. 2017, p. 34) about the linear no-threshold (LNT) model shows that not only is the no-threshold aspect wrong, but that low-dose radiation has beneficial effects.

Perhaps because I am not an expert in the biological effects of radiation, I have never seen a discussion of the *intensive* (versus *extensive*) nature of exposure. Please forgive me if I go over a principle that is perhaps so well-known and so fundamentally obvious to experts that it should require no elaboration.

In thermodynamics, there are *extensive* variables—additive quantities such as internal energy, enthalpy, and entropy. There are also *intensive* variables, such as pressure and temperature, that are not additive. We do not add the temperature on one side of the room to the temperature on the other side of the room to obtain a total temperature.

Radiation doses are reckoned in units of energy per unit mass—1 gray is 1 joule per kilogram. This definition is strikingly similar to the concept of temperature as the energy per molecule and suggests that radiation dose is an intensive variable.

We can go further by considering a radiation exposure of 1 J dissipated in 1 kg of leg muscle, amounting to 1 Gy. If we imagine that mass as two ½-kg masses, each receiving ½ J, each ½ kg has a 1-Gy exposure (½ J divided by ½ kg). If exposure were an additive quantity, we could add the two 1-Gy exposures to get 2 Gy. But why stop there? We could mentally separate the 1 kg muscle into 1-g sections, each getting 1 millijoule ([0.001J]/[0.001 kg] = 1 Gy), and add them all up to get a very lethal and utterly nonsensical 1,000-Gy "total" exposure.

In other words, exposure is an *intensive* variable. It is not additive. *Cumulative dose* and *population dose*, both obtained by the addition of nonadditive quantities, and both apparently in common use, are nonphysical statistics. In particular, they are not doses any more than a sum of temperatures is a total temperature.

High, near-lethal exposures are extremely rare. Therefore, for almost all cases, the LNT is based entirely on the notion that exposure is an additive quantity. It is not.

The only case in which the LNT *might* hold is for one-off events, such as the atomic bomb survivors. In this case, there is no summation of doses, so the intensive nature of dose is irrelevant. For example, in Cuttler and Hannum's Fig. 1, the effect (leukemia cases per million exposed people) is plotted against the single dose that people received. The authors show that even here the LNT does not apply.

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Join the debate

I wish to commend the authors of the excellent article, "Current radiation protection limits: An urgent need for change," that appeared in the September 2017 issue of *Nuclear News* (page 34). My library still contains *Health Physics Journal* articles and letters battling over the scientifically indefensible linear no-threshold (LNT) basis for current dose limits.

Every field of endeavor has risks, which actuaries quantify and stakeholders use to put a price on the mitigation of those risks. We put a price on health and life every day, deciding how many quality inspectors, police officers, firefighters, and nurses we employ. It extends even to your door locks and shower floor. If LNT were widely used, nobody would be able to cross the street—unless, of course, vehicles were banned.

I encourage everyone to read the Cuttler and Hannum article with a critical eye. Look carefully at the actual data, and be prepared to join the debate. Kudos to *Nuclear News* and ANS for fostering this dialog!

We have a huge volume of "spent" fuel that can be recycled, and even more slightly radioactive waste that doesn't need to go to Nevada or any other repository if we are simply led by science, not non-science.

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