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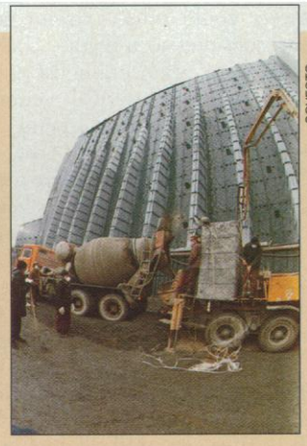
LETTERS

Fallout

The exact nature of the damage done—and the danger still present—at the site of the Chernobyl nuclear power plant accident is the concern of several readers (right, the "sarcophagus" under construction over the damaged reactor). The challenge of defining scientific misconduct and handling misconduct cases is discussed. The work of scientists at federal research and regulatory agencies is praised. Partners who are helping to create, on the World Wide Web, a taxonomic catalog of North American plant and animal species are acknowledged. And the difficulty faced by women and minorities who try to change, not just succeed at, the "rules" of a scientific career is noted.



What Happened at Chernobyl?

I would like to clarify two points in Richard Stone's otherwise fine article "The explosions that shook the world" (Special News Report, 19 Apr., p. 352).

First, I do not think (as the article notes) that a lot of fuel material from the core ended up "in the surrounding countryside." In fact, my analysis agrees fully with the conclusions of Edward Pazukhin that most of the fuel is located in the lower regions of the reactor building. Part of the confusion may stem from the fact that approximately 18,500 "bricks" of graphite moderator surrounded the fuel-containing part of the core. Hence, a significant portion of the ejected material would not have contained fuel (*1*).

Second, the conclusions I reach in general agree quite well with those of Pazukhin. He approached the problem through an excellent analysis of the chemical and thermodynamic properties of the core "lava" and by conducting a heat balance (*2*). I, on the other hand, used the results of radiochemical analyses of the lava to conduct a source-term release dynamics analysis. We only disagree on the amount of time it took for the core to melt through the reactor's "Lower Biological Shield" (lid); but more robust modeling should help to reconcile our differences.

Finally, a peer review of Purvis's work was conducted on 2 February 1996 at the Kurchatov Institute, with Russian, Ukrainian, and German specialists present. Their main conclusion was, "All participants noted the great number of technical inaccuracies and mistakes in the work reviewed as well as insufficient argumentation, from the scientific point of view, to support its basic points."

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2. E. Pazukhin, *Radiochemistry (Moscow)* **36**, 97 (December 1995).

The "low-power safety test" at Chernobyl was not a safety test but a piece of nonsense ordered by a chief engineer to test his standby diesel generators. It is significant that it took 2½ days to disable automatic plant controls that would have shut the machine off safely. By comparison, it took only 1/2 hour of operator errors to melt down the Western-style reactor at Three Mile Island. The saving grace in Pennsylvania was not a safer reactor design but the fact that Western reactors are housed within a containment shell.

The RMBK reactors still in operation are indeed not safe, but their design is not at fault. One fault, which will prove important in the long run, is a lack of administrative checks and balances in Ukraine: there is no independent control agency and no inspector on site with adequate authority over plant operations and maintenence. The other, and most urgent, fault is the lack of money to keep the power plants properly staffed and repaired. Consumers of electricity still do not pay what it costs to produce and deliver the energy. In the course of switching from

communist dictatorship to free elections, the government has lost the power to subsidize a pet technology regardless of cost, but the elected legislators have not gained the political clout to upset voters accustomed to cheap electricity. Western powers could offer Ukraine advice and even subsidies to integrate existing power plants into an economically viable and well-managed electrical generation system. If, instead, they spend even more money on shutting off the remaining RMBK reactors, they will be merely piling up waste on top of mismanagement.

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The neutron absorber dumped into various sarcophagus rooms at Chernobyl is *gadolinium* nitrate, not *gallium* nitrate. Similarly other references to "gallium" in the article should read "gadolinium."

Gallium, a semiconductor, has a low neutron absorption cross-section. In contrast, gadolinium is an efficient neutron absorber; for example, the second shutdown system in Canadian CANDU nuclear reactors uses injected gadolinium nitrate.

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Stone's description of the status of the Chernobyl 4 rubble is disturbing. The action to reduce the 60-fold neutron rate increase in 1990 using the neutron poison gadolinium succeeded so that the reactivity at that time came under the control of the gadolinium. Gadolinium has been added periodically since, and more water has entered the system over the past 5 years through the leaking sarcophagus. The choice of gadolinium for reducing the reactivity was unfortunate because this poison imparts positive feedback owing to its rapidly decreasing neutron absorption cross-section with increasing energy. Any future recriticality with the rubble under the influence of gadolinium-induced positive feedback could result in uncontrolled energy release.

After the system was controlled by the gadolinium, subsequent water intrusion might have created an overmoderated condition for the rubble. An overmoderated system exhibits positive feedback, because fission heat decreases the water content by expansion or vaporization. The predominant effect of decreased water with overmoderation is to decrease the neutron absorption in water rather than to decrease the moderation of the neutrons. The planned removal of the water possibly could result in criticality with positive feedback (*1*) if the rubble is now overmoderated.

With positive feedback conditions now established through the use of gadolinium and possibly also via the additional water, reestablishing negative feedback, if possible, should be the first priority before disturbing the rubble or the water it contains. A helpful first step would be to override the gadolinium now in the system with cadmium, which has negative feedback properties. The rubble status with respect to overmoderation should be well understood before water removal begins.

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