last year by George Miller, Livermore's acting associate director for defense programs, who told *Science* that "on the order of a couple of dozen U.S.tests" are performed annually.) This total can be compared to that for the previous 5-year period, when 73 tests were announced and 3 others were detected by seismologists. Assuming that one or two additional unannounced tests remained undetected, the total from 1975 to 1979 is 77 to 78 tests, or an average of 15 each year. A portion of the increase in testing since 1980 can be ascribed to Britain, which conducted four tests in Nevada in the late 1970's, and eight between 1980 and 1984. When these are subtracted, it appears that annual U.S. testing has increased between 11 and 33 percent.

Robinson says that part of the increase was authorized by President Jimmy Carter. "Two weeks after his defeat in the 1980 election, Carter approved a schedule that would allow us to do more weapons physics tests," Robinson says. "It had been sitting on his desk for about 3 years." But others say that much of the increase occurred in 1984 and 1985, due to expansion of the "Star Wars" effort and the fact that a variety of strategic weapons entered the final stage of development. ■ **R. JEFFREY SMITH**

Rancho Seco Reactor Suffers Another Mishap

An "unusual event" at the Rancho Seco nuclear reactor 25 miles from Sacramento lasted only 4 hours, from 4:30 a.m. to 8:41 a.m. on 26 December, but it triggered a special inquiry by the Nuclear Regulatory Commission (NRC). According to a preliminary NRC report dated 5 January, all power to the plant's computerized control system was lost for 26 minutes. A pump burned out, spilling 450 gallons of radioactive water onto the floor of an auxiliary building, some of which escaped to the atmosphere as radioactive steam. A spokesman for the owner, the Sacramento Municipal Utility District, says that a person standing at the edge of the site boundary would have received no more than 0.2 millirem of extra radiation, a trivial amount. Two workers received small exposures to excess radiation.

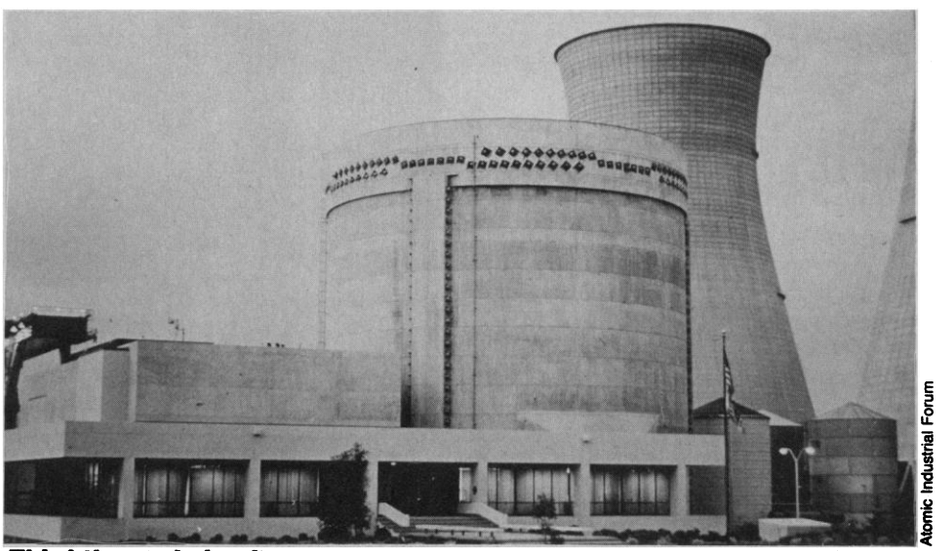
Despite the happy outcome, the incident aroused concern for two reasons. The chronicle of the 4-hour crisis indicates that the control room was thrown into confusion and that operators had only a tentative grasp of what was going on inside the plant when the electrical power was out.

Second, the steel reactor vessel was put through a kind of stress it is not supposed to endure. It was overheated, then rapidly cooled at high pressure, exposing it to the hazard known as "pressurized thermal shock." The NRC has been concerned for several years about the possibility that welds between the steel plates might crack under stresses such as these. Last July the Commission issued a rule asking utilities to guard against this risk. Rancho Seco has already had two cooldown events, a major one in 1978 and a minor one on 2 October 1985.

Judging by the NRC report, the environment in the control room was chaotic after the power went out. (The investigators have not yet discovered why the power failed.) Many indicators and controls are programmed to go to mid-value when power is lost. When this happened at Rancho Seco, water flow to the reactor decreased, leading to an increase in pressure and heat. Other systems went faster at mid-value. Within seconds, the reactor automatically shut down because of the pressure buildup. At this point "many fire alarms," a spray actuation alarm, a seismic alarm, and a high-temperature alarm for the spent fuel pool went off.

The operators made several false starts in attempting to bring the system under control. They attempted to close some valves using hand cranks, and when a couple of them apparently got stuck, they resorted to a wrench. It, too, proved inadequate to the task. Meanwhile, the emergency heating and cooling system sprang into action, "significantly" increasing the noise in the control room. Nine minutes later, someone shut this emergency system off to maintain sanity. A senior operator, possibly exhausted from his work on the hand cranks, collapsed on the floor and was taken away by ambulance. He left the hospital a few hours later reporting no ill effects. Finally, at 4:40 am, an operator noticed that the power could be restored by resetting some main switches, which he did, bringing the controls back to life. Nevertheless, it took several hours to bring the whole plant back to normal.

Brad Thomas, a spokesman for the plant owner, says that the rapid cooldown of the reactor exceeded the guidelines for cooldown stress drawn up by the manufacturer, Babcock & Wilcox. However, an "owners' group" met in mid-January, examined the record, and announced that the incident had no general implications for this type of reactor. They did agree, however, that Rancho Seco will need to take steps to ensure that loss of control power does not lead to a rapid cooldown again.



Atomic Industrial Forum

Third thermal shock

Rancho Seco has now had three mishaps resulting in excessively rapid cooldown.

An NRC official in California says a more extensive report will be published in February. The government's chief concern is that Rancho Seco seems to be able to get into trouble quite rapidly on its own, without any coaxing from operators. "We think it may be necessary to modify the control system design to make the plant more forgiving," the NRC official says. "We'd like to see a system where the operators don't have to take any actions for 10 to 20 minutes" into a crisis. In this recent case, the operators prevented the cooldown from becoming more severe by taking quick preventive steps, even though in retrospect, it is clear they could have stopped the cooldown even sooner than they did.

The NRC has not decided yet whether the incident has general implications, and no time has been set for restarting the plant. ■ **ELIOT MARSHALL**