NUCLEUS
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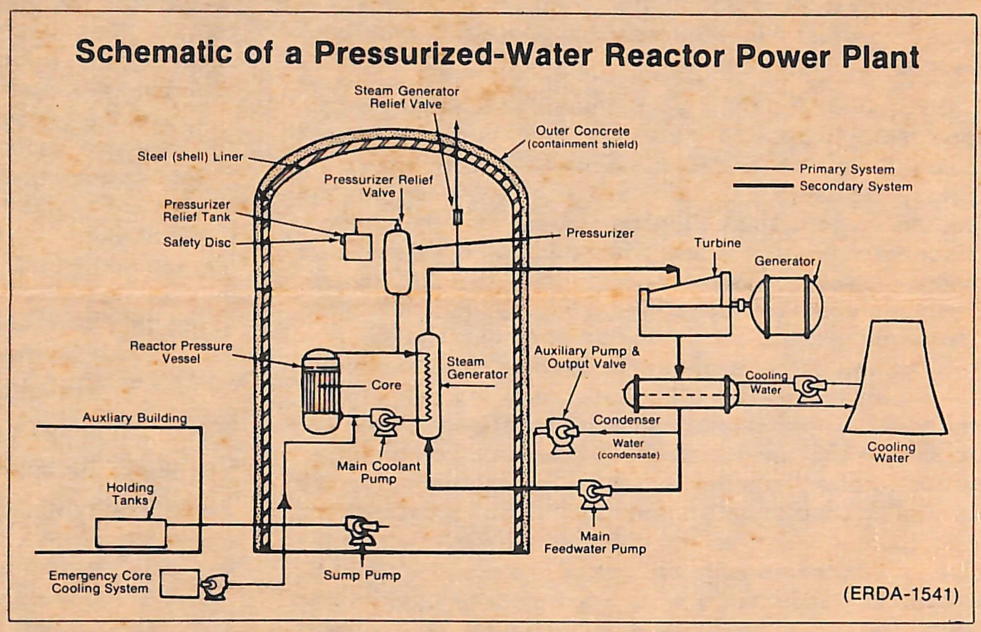
To the Brink of the Abyss: The First Hours of Three Mile Island



The accident at the Three Mile Island-2 (TMI) Nuclear Generating Plant near Harrisburg, Pennsylvania, began with a rather mundane event: a pump failure. Pump trips, as such breakdowns are called, are common occurrences at most generating plants, but usually they do not initiate a series of life-threatening events like those which developed at TMI. Under most circumstances, the plant—whether nuclear or not—can be shutdown until the malfunction is repaired with no consequence to the surrounding population. At TMI, a cascading series of operator actions, equipment failures and design defects caused what should have been a minor problem to balloon into the most serious accident ever to befall a nuclear plant. Fortunately, no one was immediately killed as a result of the near-meltdown at TMI, but this may have been only a matter of good luck. The long-term consequences are still unknown. Nevertheless, a recounting of the first few hours of the TMI accident underlines just how fortunate the residents of central Pennsylvania actually were, for it certainly wasn't technical skill that kept this so-called "incident" from becoming a catastrophe.

4:00 AM

The accident was initiated by the trip of a feedwater pump (See diagram above) which sends water through the steam generators and thence to the generating turbine. The failure was apparently caused by a technician working on the feedwater system. As a result of the pump stopping, the turbine automatically shut down. This stopped the flow of steam out of the steam generators and increasing pressure opened the steam generator relief valves discharging steam to the atmosphere outside the reactor building. Rising pressure in the reactor's primary coolant loop—the one that cools the reactor—caused a relief valve in the reactor pressurizer to open, releasing a blast of steam to a tank inside the reactor building. The

See **Three Mile Island**, *page 6*

EDITORIAL

Reactor Safety—What Must Be Done?

This issue's editorial has been drawn from testimony of Daniel F. Ford, Henry W. Kendall and Robert D. Pollard on behalf of UCS submitted to the House Interior and Insular Affairs Committee on February 26, 1979.

On January 19, 1979, the U.S. Nuclear Regulatory Commission (NRC) repudiated the central findings of the *Reactor Safety Study*, the so-called Rasmussen Report, which the agency had issued in October 1975. This celebrated study had become the official bible supporting the claim that the country's six dozen commercial nuclear power plants were safe enough to operate. Official acknowledgement that the Rasmussen Report's findings are technically indefensible has profound implications for the future of the U.S. nuclear power program . . .

Withdrawal of the Rasmussen Report does more than tarnish the general image of the U.S. nuclear power program; it leaves the country with no objective, scientific basis for concluding that nuclear power plants are safe enough to operate. The mere *belief* in nuclear safety, however confidently and frequently stated by nuclear proponents, does not amount to reliable proof of safety. The country cannot accept claims of nuclear safety at the nuclear proponent's valuation. Instead of speculative technical propositions about safety, unambiguous scientific evidence is demanded if we are to have large nuclear power plants operating in our midst . . .

The rise and fall of the Rasmussen Report raises troubling questions about the safety of the six dozen operating nuclear power plants in the U.S. On what basis are they being allowed to operate? NRC maintains that its regulations provide a "defense in depth" approach to nuclear safety, i.e., multiple levels of protection against the accidental escape of radioactivity. On a philosophical level, the logic of "defense in depth" is impeccable. The real question, however, is how well the philosophy is actually applied. A careful review of NRC internal files shows that the agency is aware of major gaps in nuclear power plant defenses against catastrophic accidents. Agency files show that there are major uncorrected safety problems which compromise plant safety, that there are extensive quality assurance deficiencies which affect the reliability of reactor safety equipment, and that there are repeated, flagrant violations of basic Federal safety standards by the utility companies operating nuclear power plants. NRC has adopted a relaxed and tolerant attitude, forgiving these deficiencies and allowing continued plant operations. NRC, moreover, has used the Rasmussen Report's probability estimates [that allege to demonstrate that the risks to individuals from reactor operation are wholly negligible] to rationalize the operation of plants with defective safety equipment.

[T]here are many safety related defects in plants known to the NRC which have the potentiality of aggravating abnormal occurrences perhaps to catastrophic proportions. These include many unresolved safety problems of a generic nature.

Some examples of such generic safety issues from the list of those identified by NRC as "top priority" include: Main line steam breaks; pressure transient protection; designs to control sabotage; adequacy of safety related DC power supplies; turbine and tornado missiles; adequacy of offsite power systems; instruments for monitoring radiation and process variables during accidents; short and long-term seismic design criteria; steam generator tube integrity; RPV [reactor pressure vessel] transient over-pressure protection; steam effects on BWR [Boiling Water Reactor] core spray distribution; BWR nozzle cracking; anticipated reactor operating transients without SCRAM; asymmetric blowdown loads on RPVs.

Many of the items on this list are individually quite serious. For some the delineation is not complete. In many cases research has not been finished. For most, solutions are not at hand and so the question of retrofitting existing plants with new safety equipment to control the attendant risks remains open.

In the face of this disturbing evidence, the official claims about nuclear power plant safety have to be regarded at best as unproven speculations. Operating nuclear plants in populated areas with known safety defects and only speculative safety assurances can hardly be reckoned a responsible or prudent policy.

Conclusions and Recommendations

It is urgently required that Congress take prompt action to resolve the country's nuclear safety problem. Repudiation of the Rasmussen Report together with the disturbing evidence of widespread nuclear safety deficiencies underscores the need for action. Congress cannot itself develop the technical solutions required; what Congress must focus on are the institutional and management problems that have allowed these problems to develop. Chief among these problems is the fact that the Nuclear Regulatory Commission is not doing its job . . .

How one goes about the reshaping of a non-performing regulatory bureaucracy is a difficult question. It is obvious that the regulatory problems that exist have their roots in the promotional policies laid down by the Atomic Energy Commis-

See **Reactor Safety**, *page 9*

From the "Nugget File"

September 1975: Southport, North Carolina

During a test of the control rods for the Brunswick Unit 2 reactor, it was found that when the control switches were released the rod continued to move to a more fully withdrawn position. The rod was then fully inserted by the operator but again moved to a withdrawn position causing reactor power to increase approximately 10 MWe. This was repeated approximately five times. The cause was attributed to "foreign material" in the control rod mechanism and failure of a directional control valve.

Since failure of *one* control rod to insert when required was considered in plant safety analysis, Carolina Power and Light Company felt that although the above circumstances were highly unusual, they were not a compromise of reactor safety systems. The effects of two or more control rods failing in this manner were not discussed.

Nucleus is published quarterly and distributed free to Union of Concerned Scientists sponsors. For additional information, write Union of Concerned Scientists, 1208 Massachusetts Avenue, Cambridge, Mass. 02138. Ronnie Lipschutz, Editor.

NRC Repudiates Reactor Safety Study; UCS Calls for Immediate Shutdown of 16 Reactors

This past January, the Nuclear Regulatory Commission (NRC) formally repudiated significant portions of the Reactor Safety Study (RSS)—also known as WASH-1400 or the "Rasmussen Report"—used since 1975 in support of general claims about nuclear safety and in specific instances in support of reactor licensing. The RSS is best known, perhaps, for its assertion that the chance of a major nuclear power plant accident is akin to that of a meteorite striking a city—about one in a million. The unprecedented action by the Commission came four soul-searching months after the release of a stinging critique of the RSS by the "Risk Assessment Review Group," headed by Prof. Harold Lewis of the University of California at Santa Barbara (See *Nucleus* 1, #2, Nov. 1978).

In a policy statement on January 18th, the NRC withdrew its support for the Executive Summary of the RSS, the most widely circulated portion of the 18-volume $4 million study, agreed that the review process followed in publishing WASH-1400 was inadequate, and stated that it "does not regard as reliable the Reactor Safety Study's numerical estimate of the overall risk of a reactor accident," echoing the report of the Review Group which found the error bounds on the absolute probabilities of accident sequences in the RSS to be greatly understated.

The Commission directed that all known recipients of the RSS receive a copy of the Review Group critique and the Commission's policy statement, and ordered the NRC staff to prepare "detailed procedures to ensure the proper and effective use of risk assessment theory, methods, data development and statistical analyses by the staff by June 30, 1979."

The NRC's repudiation of the RSS—and the recent near-meltdown at the Three Mile Island-2 Nuclear Plant—has breathed new life into the debate over the risks of nuclear power reactors. Not the least of the questions raised by this action is whether any operating plants were licensed on the basis of RSS probability estimates. According to the NRC staff, the study was not used extensively in support of major licensing and regulatory decisions; however, internal NRC documents obtained by UCS through Freedom of Information Act requests strongly suggest otherwise. In fact, a number of plants were allowed to continue operating because the RSS calculated a small probability that their safety defects could lead to a catastrophic accident. In a press conference on January 26, 1979, UCS called for the immediate shutdown of 16 such nuclear plants because the NRC's rejection of the RSS probability estimates left no technical basis for justifying continued operation of the plants in the face of three serious safety hazards. The three defects are:

1. Safety system electrical cables will fail in fire: The NRC has determined that in at least 12 operating plants a fire could destroy all cables controlling the multiple safety systems intended to prevent a reactor core meltdown. The Commission decided to allow these plants to continue to operate—at least until the end of 1980 in some instances—because the RSS said that the probability of a serious fire is small. UCS specifically challenges this assertion because it appears that fires may in fact be among the dominant accident modes.

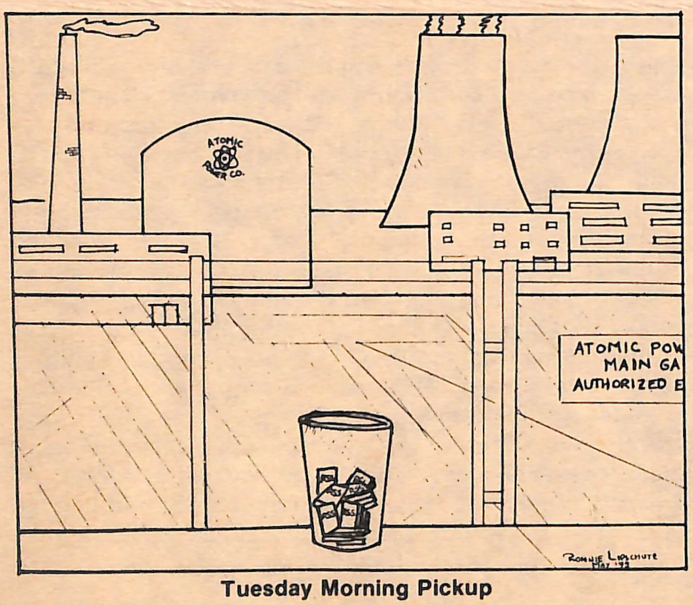
2. Safety system equipment cannot withstand the accident it is designed to control: Six plants have been licensed on the basis of an electrical equipment standard described by Dr. Stephen Hanauer, a senior NRC official, as "worthless." This safety-related equipment has been found to be unable to withstand the high-temperature, high-radiation conditions that could develop in the course of a serious accident. Again, on the basis of RSS estimates, the NRC maintains that "the likelihood of a major accident requiring the performance of this equipment is very low."

3. No protection is required for certain catastrophic accidents: For years, the NRC has labelled as "Class 9" certain accidents whose probability of occurrence were *deemed* so low as to be "incredible"—on the basis of judgement and RSS estimates; an example of a Class 9 accident would be a crack in a reactor pressure vessel. These accidents can have catastrophic consequences but, because they are thought to be of very low probability, there is no requirement for protection against the consequences of such an accident. This is in direct contrast to the safety philosophy in West Germany, where all protection

See **Reactor Safety Study**, *page 8*

In opening the Hearing on the Review of the Reactor Safety Study (See Editorial, Page 2), Congressman Morris Udall said:

> *I would . . . like to commend the Union of Concerned Scientists for their persistence in pointing out problems that might otherwise be swept under the rug. If it had not been for the UCS and their colleagues, I believe the Reactor Safety Study would have remained the primary reference used by those who wished to provide assurance that nuclear power was safe.*



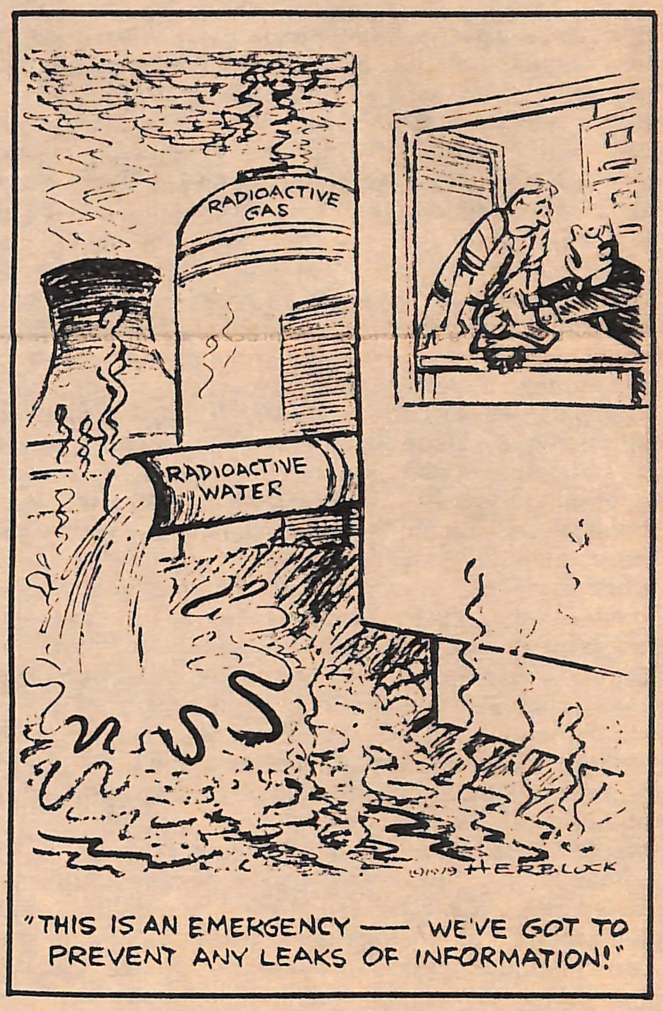
Tuesday Morning Pickup

Nuclear Power:
Will the Lights Go Out If We Do Without?

According to the conventional wisdom as espoused by the Nation's electric utilities, without nuclear power the United States would rapidly face the threat of electrical brownouts and blackouts during periods of peak electricity demand. Furthermore, claim the utilities, nuclear power presently provides an economic replacement for large quantities of expensive foreign oil and will supplant even greater quantities in the future. Actually, neither of these assertions has much basis in fact, for nuclear power is not nearly so critical to our current energy needs as is commonly thought. At the present time, nuclear power plays a relatively small role in the United States both in terms of electrical generating capacity and overall energy consumption. The country can adapt relatively well to the nuclear power plant shutdowns, some temporary, some permanent, that UCS has been urging to allow critically important repairs and design alterations needed to improve their levels of safety.

The 72 operating nuclear plants in this country presently account for about 10% of total electrical generating capacity and provide roughly 13% of all electrical consumption. Even so, were all 72 plants to be brought off line simultaneously in order to correct safety deficiencies, there would still remain more than enough generating capacity to take up the slack, for the United States is currently endowed with a substantial excess of electrical generating capacity. The Federal Power Commission generally recommends an excess of about 20% over peak demand, a quantity known as the "reserve margin." In 1978, however, the national reserve margin was about 33% on the summer day of heaviest electricity use, and in some areas of the country, even more. Excessive reserve capability normally leads to higher electricity costs, for the cost of all generating equipment is figured into the rates paid by consumers, whether or not the equipment is being fully utilized. Thus, if all 72 plants were shut down, the reserve margin would still be in excess of the necessary 20%. However, in the New England region and states such as South Carolina and Illinois, where nuclear power provides one-third or more of the electricity consumed, abrupt shutoffs of all nuclear plants could not occur without disruptive effects. In those areas, phased and temporary shutdowns —starting with those plants posing the most severe safety risks— would be necessary to avoid dislocations of service. In fact, the correction of many of the safety defects and installation of most of the additionally needed safety devices could—according to the Advisory Committee on Reactor Safety—take place when reactors are scheduled to be closed down for refueling, thus avoiding any unanticipated loss of electrical generating capacity.

If it were ultimately deemed prudent to reduce our dependence on nuclear power, the phase-out period for regions with a heavy nuclear dependence would have to be closely coordinated with the implementation of energy conservation measures and the introduction of alternate electric generation technologies. In the event of permanent plant shutdowns, it remains to be determined whether financial responsibility for defraying the cost of the "scrapped" investment will be shouldered by the utility stockholders—who reap the benefit of profits—or by the customers themselves.



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Do We Need It?

Nuclear power will be able to make, at best, only a modest, easily replaceable contribution to future domestic and global energy requirements. This is the surprising conclusion of *Energy: The Easy Path*,* a recent report by Vince Taylor to the United States Arms Control and Disarmament Agency. Nuclear power is a practical source only of *electricity*, Taylor argues, a special, very expensive form of energy used only where its unique properties justify its premium price. As a result, industrial nations consume only 10-15% of their end-use energy in the form of electricity. Only about one-tenth of their oil is used for electrical generation. The very high cost of nuclear electricity from new plants—about $100 for the heat equivalent of a barrel of oil—rules out the possibility that it will soon replace gas and oil now consumed directly. The minor role of electricity in overall energy consumption severely limits the future of nuclear power. Even if no additional regulatory restraints are imposed in the

* Available from UCS. See back page of *Nucleus*.

wake of Three Mile Island, Taylor estimates that purely economic considerations will limit nuclear power to about 10% of total primary energy supply in the year 2000. This contribution would suffice to delay the onset of oil shortages widely predicted for the turn of the century (and used to justify the necessity of nuclear power) by less than five years.

By contrast, in Taylor's view, improvements in the *productivity of energy* have the potential to completely avert future energy shortages: "Simple measures, such as improving the design of new buildings and reducing heat losses from existing ones, improving auto mileage, installing industrial heat recuperators, and co-generating electricity and process steam, could provide major reductions in energy consumption without depriving anyone of desired energy services. This is true not only for the United States but for other countries thought to be much more efficient users of energy. Because of the large potential for improving energy productivity, neither the limits to oil nor the possibility that nuclear power may be judged unacceptably dangerous need be cause for serious concern. Detailed analyses show that productivity improvements alone could extend the lifetime of conventional fuels sufficiently to permit them to continue as the dominant sources of world energy until well beyond 2025—providing time for an unhurried, gradual transition to renewable resources."

The Easy Path also concludes that pursuing an energy strategy based on improving energy productivity would not involve a heavy economic burden. Because nations currently expend only about 5% of their total incomes on energy resources, they could make large, apparently costly improvements in energy productivity without noticeably affecting overall prosperity. Only a small fraction of growth in economic output would be needed to improve energy productivity sufficiently to avoid future energy shortages. And, because nuclear power could provide only a minor fraction of future energy requirements, the added cost of foregoing it and obtaining equivalent oil savings through added productivity improvements would be very small—less than 1% of national income by the year 2000.

* * *

Dr. Vince Taylor has joined UCS as a consultant on energy economics and policy. He received a B.S. in physics from Caltech and a Ph.D. in economics from MIT. In the past, he has worked for the Rand Corporation and also for Pan Heuristics, a Los Angeles consulting firm. In the latter position, he produced a number of highly respected studies for the Arms Control and Disarmament Agency. At a time when rapidly rising uranium prices were being used to argue for the urgency of developing plutonium fuels and breeder reactors, his analyses documented the view, now widely accepted, that relatively low-cost uranium was sufficiently abundant to make the breeder unnecessary and unwise.

About his latest study, Dr. Taylor comments: "Apparently, because *The Easy Path* argues against present U.S. policy—which emphasizes the importance of nuclear power, while arguing against the breeder—both the Arms Control and Disarmament Agency and my former employer, Pan Heuristics, disclaim responsibility, even though they paid for most of it."

Is SALT II Worth Fighting For?

Is the pending Strategic Arms Limitation Treaty (SALT II) worth supporting? While the Union of Concerned Scientists strongly supports the new Treaty as a vital step in nuclear arms control, UCS also recognizes that many concerned individuals, impressed with the urgent need to curb the nuclear arms race, have come to harbor serious misgivings about SALT II. These critics have two complaints which deserve careful thought:

1. "The Treaty doesn't go far enough": After six years of negotiations, the resulting document would not require the United States to dismantle a single weapon, would not permanently ban new weapons like the cruise missile or mobile missiles, and would not prevent the stockpiling of thousands more nuclear warheads by both sides.

2. "The Treaty provides a cover for development and adoption of new weapons systems": President Carter appears to be promising undecided Senators the M-X mobile missile (a successor to the current generation of land-based missiles) and higher defense budgets in exchange for their support for the Treaty. He also has appointed a military man, General George Seignious, to head the U.S. Arms Control and Disarmament Agency.

Those disenchanted with this kind of SALT deal have suggested two alternatives: renegotiate to obtain a better treaty and/or take unilateral disarmament steps. Could either strategy work in the current situation?

In all likelihood, no. Ratification of even the existing Treaty is in doubt. Many Senators are concerned that the Treaty would give the Soviet Union a strategic advantage. To satisfy these legislators, whose support is crucial to the passage of SALT II, any renegotiated treaty—especially one that involved reduction in nuclear armaments by the United States—would probably have to be so tilted in our favor that it would be unacceptable to the Soviets. If negotiations foundered, a vastly widened and accelerated arms race could result.

With respect to unilateral nuclear arms reductions, even small ones, the hard reality of present public opinion in this country makes such steps politically impossible. A 1978 poll found that 48% of the public felt the United States should have military superiority over the Soviet Union, while an additional 42% said we should maintain equality. A majority was willing, even if it meant more taxes, to spend an extra $10 billion per year on defense to achieve these conditions. The poll indicates a serious public misunderstanding of military logic in the nuclear age: when each country already can destroy the other, even after being attacked first, it is impossible to produce any kind of meaningful military superiority (or global security) by building more nuclear weapons.

Which brings us back to SALT II. Although this imperfect treaty—and the military "sweeteners" highly likely to accompany it—would represent a continuation in nuclear weapons construction, it would nonetheless prevent an even worse spiral in the arms race. In the absence of any treaty, military planners, political leaders, and citizens in both countries would very likely revert to traditional "absolute worst case" thinking, creating an exceedingly vicious cycle of expanding armaments

See **SALT II**, *page 9*

Three Mile Island

continued from page 1

pressure began to drop. The pressurizer relief valve should have reclosed but didn't. A few seconds later, the reactor shut itself down and the fission chain reaction in the core slowed to a halt. About 30 seconds after the main feedwater pump trip, three auxiliary feedwater pumps kicked on. Any one of these pumps keeps water supplied to the steam generators, thus ensuring that the reactor does not overheat. But two valves controlling water from all three pumps were closed, apparently closed after maintenance and testing some weeks earlier (and in violation of the plant operating license.) Because of this, the steam generators boiled dry, and thus there was no other way to cool the reactor. The rising temperature combined with the stuck open pressurizer relief valve caused some of the water in the reactor core to boil, producing steam and causing "core voiding," that is, areas in which the hot uranium fuel was not covered with water.

4:02 AM
The pressurizer relief valve remained open, allowing pressure in the primary loop to drop from the standard 2250 pounds per square inch (psi) to 1600 psi. This decreasing pressure caused the High Pressure Emergency Core Coolant Injection System (ECCS) to come on. Several minutes later, the plant operators noted that the device which records water level in the pressurizer was going off scale. Believing that this indicated an adequate water level in the reactor core, and that rising water in the pressurizer would result in water exiting the pressurizer, the operator *manually* shut off one of the ECCS pumps. In fact, the water remaining in the reactor was flashing to steam and the water level was *dropping*. As pressurizer level continued to rise, the second ECCS was shut off by the operator.

4:08 AM
About 8 minutes after the auxiliary pumps engaged, an observant engineer noticed that the output valves were shut. These were opened, the reactor cooling water temperature decreased, pressurizer level came back on scale and the ECCS was turned back on.

4:15 AM
Steam was still pouring from the relief valve into the relief tank. A safety disc on the tank ruptured, spilling radioactive water onto the floor of the containment building. The containment was not yet sealed off and, in fact, was not isolated until some five hours later. As a result, when the water depth reached about two feet, sump pumps, responding to "normal" condensation in the building, automatically engaged and began to pump the contaminated water into holding tanks in an adjacent auxiliary building. These tanks overflowed, spilling the highly radioactive water onto the building floor. Radioactive gases escaped from the building, forming a radioactive plume later detected as far as 20 miles from the plant.

5:15 AM
Until 5:00 AM, the situation appeared to be stabilizing, but at 5:15, the plant operators shut off two of the four main reactor coolant pumps which were sending water through the core. This may have been done because steam formation in the cooling loop caused the pumps to lose suction and begin vibrating. Twenty-five minutes later, the remaining two pumps were also shut down for the same reasons.

5:45 AM
Immediately after the reactor coolant pumps were stopped, the reactor core began to heat up very rapidly. Temperature sensing devices above the core read 620 degrees Farenheit, but climbed past 700 degrees within 15 minutes. Subsequent core temperatures could not be determined because the device recording this information only prints out numerical values within the normal operating range of the reactor. Above and below normal temperatures, it prints question marks. By 6:00 AM, it was printing a string of question marks.

6:10 AM
The stuck pressurizer relief valve was finally discovered and closed. During the next 12 hours, no cooling water circulated through the reactor. Pressures within the core oscillated wildly as the operators attempted to reassert control; temperatures continued to climb. Bulk boiling of water remaining in the reactor pressure vessel left much of the core uncovered for significant periods of time, and, for a period of several hours, the core was cooled only by steam. When core temperatures climbed past 1600 degrees Farenheit—and no one can say for sure when this was—the fuel rods began to swell and crack, releasing radioactive fission product gases into the cooling water. Radioactivity was first detected in the containment building at about 7:30 AM, so it seems that significant core damage began earlier. Above 2000 degrees the zirconium alloy fuel cladding holding the uranium fuel pellets began to chemically react with the remaining cooling water, producing large quantities of hydrogen gas. (Hydrogen is ordinarily produced by the decomposition of water by radiation but in much smaller quantities.) At 3300 degrees, the zirconium alloy began to melt, increasing the rate of hydrogen production. This was the source of the hydrogen bubble that was to prove so troublesome two days later. It is believed that core temperatures reached 3600 degrees before cooling water was restored to the reactor core. (Bulk fuel melting would begin at 5000 degrees.)

11:30 AM
The operators decided to "go for broke." They attempted to blowdown the reactor, that is, they tried to lower the pressure in the primary loop from 1000 psi to 400 psi so that the low-pressure residual heat removal system could be turned on. This system would provide much more effective cooling of the core than the high pressure cooling systems. The blowdown procedure was continued throughout the afternoon.

2:30 PM
A hydrogen explosion rocked the containment building. Apparently, hydrogen gas was escaping into the containment dome. The explosion stressed the dome to about half of the maximum pressure it was able to stand. (The TMI containment dome is much stronger than that of most reactors because of the plant's proximity to the Harrisburg Airport.)

5:30 PM
The attempt to blowdown the reactor was reluctantly abandoned. The operators feared that by continuing to decrease the pressure, steam binding might prevent any cooling of the core whatsoever. At 5:30 PM, one of the main reactor coolant

pumps was restarted, albeit with great caution out of fear that the pump might vibrate and tear itself loose from the loop. Gingerly, the operators jogged the pump for 10 seconds and held their breath. When nothing happened, they turned it back on. During the next three hours, water pressure rose and the core temperature gradually dropped. But, although the initial crisis was over, there were many problems—some of them extremely dangerous—yet to be overcome.

For the next several weeks, the TMI reactor was cooled by allowing the primary coolant to circulate through the undamaged steam generator and allowing water in the secondary loop to boil. This procedure was continued while scientists and engineers from the Nuclear Regulatory Commission and Babcock and Wilcox, manufacturers of the plant, tried to determine how to bring the reactor to a "cold shutdown" where it would be cooled at atmospheric pressure.

Even with a cold shutdown, the problems at TMI will be far from over. It may take months or years before the levels of radioactivity inside the reactor's containment die down to levels which will allow a post-mortem of the reactor. Large amounts of radioactive gases, liquids, and solids will have to be carted away for disposal. The entire core will have to be removed. Indeed, it is not known whether TMI-2 will ever operate again.

Clearly, the TMI accident was quite serious, much more so than some nuclear apologists would now have us believe. On the basis of what is known about the first hours of the accident, it is possible to come to some rather devastating conclusions about the quality of nuclear reactor safety:

1. TMI-2 came perilously close to a meltdown—Had the reactor been in operation at full power for a year rather than several months—it was brought on-line on December 30, 1978—a massive core meltdown would have occurred during the early hours of the accident. It was only because the inventory of hot fission products was not very great that the core did not heat up much more rapidly. Even so, as many as 50% of the fuel rods in the core may have suffered some damage.

2. The emergency systems were unable to deal with the accident—The successful operation of the emergency core cooling systems depends upon having a Loss-of-Coolant Accident. In the absence of such an accident, and given the situation which developed at TMI, there was no way to bring the low pressure cooling systems, which can rapidly bring the core to a cold shutdown, into operation.

3. The plant was saved by non-safety related equipment-The systems actually used to cool the reactor were those very systems assumed to *fail* in the event of a serious accident. Had the main reactor coolant pumps broken down during the course of the accident, for example, all ability to cool the reactor would have been lost.

4. The plant was not designed to handle the series of events which occurred at TMI—As in the past, events unanticipated by reactor designers and safety experts combined to create a dangerous situation. Ultimately, the plant operators were forced to improvise in order to prevent a core meltdown.

The next issue of Nucleus *will delve more deeply into the causes and consequences of the near-disaster at Three Mile Island.*

UCS urges you to clip and send the coupons below to President Carter and the Honorable Thomas P. O'Neill

President Jimmy Carter
THE WHITE HOUSE
Washington, D.C. 20500

Dear President Carter:
I'm a concerned citizen and I want to know why your administration has ignored the warnings of the Union of Concerned Scientists. I want to know why Energy Secretary Schlesinger is making the recommendation to speed up nuclear plant construction in the face of glaring evidence of critical safety problems. Please let me hear from you promptly.

Name:_____
Street:_____
City or Town:_____
State:_____ Zip:_____

The Honorable Thomas P. O'Neill
SPEAKER OF THE HOUSE
U.S. House of Representatives
Washington, D.C. 20515

Dear Mr. Speaker:
I urgently request a thorough congressional investigation of the nuclear safety questions raised by the Union of Concerned Scientists and by the accident at the Three Mile Island Nuclear Power Plant.

Name:_____
Street:_____
City or Town:_____
State:_____ Zip:_____

NEW PUBLICATIONS:

The Nugget File

Excerpts from the Government's special file on nuclear power plant accidents and safety defects, obtained by the Union of Concerned Scientists under the Freedom of Information Act. Comments and editing by Robert Pollard. January 1979. $4.95.

Looking But Not Seeing

—The Federal Nuclear Power Plant Inspection System

This report examines the Federal Nuclear Power Plant Inspection Program. UCS evaluation of whether the NRC inspection and enforcement efforts are effectively protecting the public from the risks of nuclear power plant accidents. Lawrence S. Tye. December 1978. $3.50.

Energy: The Easy Path

A study prepared for the U.S. Arms Control and Disarmament Agency which concludes that nuclear power cannot make a substantial impact on energy needs over the next several decades and is therefore unnecessary. Vince Taylor. January 1979. $3.95.

Prices include bookrate postage and handling. Add $2.00 if first class postage is desired. All orders must be prepaid.

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For Your Information

Low-Level Radiation Study Released

In 1978 an Interagency Task Force on the Health Effects of Ionizing Radiation was organized at the direction of President Carter. The draft working papers of the Task Force were released for public comment in late February by Secretary of Health, Education and Welfare Joseph Califano. In doing so, he noted that the issue of low-level ionizing radiation hazards now merit greater attention than in the past, in part because recent studies, although not conclusive, suggest that low-level radiation may cause a higher incidence of leukemia than previously thought.

The task force found that most radiation exposure—about 51% of the total—came from natural background, about which nothing could be done. Exposure from medical and dental x-rays *accounted for almost 43% of the total annual population dose.* Other sources and percentages were: Nuclear weapons fallout, 3.3%; technically enhanced radiation sources, 2.5%; nuclear energy, 0.14%; and consumer products, such as smoke detectors, 0.02%. The task force concluded, as a result, that elimination of unnecessary medical and dental x-rays was the best way to cut down on exposure of the population, and urged patients to see that unnecessary x-rays are kept to a minimum. (The report is available from HEW, Room 712-E, HHH Bldg., 200 Independence Ave., SW, Washington, DC 20201. Or call: (202) 245-6318/6733.)

Reactor Safety Study, *continued from page 3*

within the state of the art must be provided without regard to the probability of an accident.

Because the NRC repudiated the quantitative probabilities set forth in the RSS which provided the basis for licensing of these 16 reactors, UCS called on the Commission to reassess all operating plants in order to determine which accident scenarios had not been examined in licensing and decide what additional reactor safety features are necessary to adequately protect the health and safety of the public.

NRC Shuts Down Five Plants Because of Earthquake Hazard, But Are Fires a Greater Hazard than Earthquakes?

Predictably, the NRC ignored UCS' call for the shutdown of the 16 suspect nuclear plants. However, on March 13, 1979, the Commission surprised the country and stunned the nuclear industry by ordering the shutdown of five nuclear plants in the eastern United States because a deficient calculation had been used in determining the ability of the plants to withstand earthquakes greater than a certain magnitude.

The error occurred when Stone and Webster, the Boston-based engineering firm which designed the plants, subtracted rather than added two mathematical terms in a calculation intended to determine the strength needed by coolant piping in order to withstand an earthquake of a given severity. This led to design strengths between three and six times too small. Failure of these coolant lines could lead to a loss of coolant accident and core meltdown. Stone and Webster was quick to deny making an "error," arguing that the plants could withstand any earthquake likely to occur. Others attacked the NRC for precipitate action, apparently more concerned about the health of the industry than the health of the public, and ridiculed the assumption that serious earthquakes can occur in the Eastern United States. In fact, serious earthquakes rocked New England in 1663, 1755, and 1925. In 1929, a severe earthquake occurred in Attica, N.Y., located only 100 miles from one of the affected plants. According to a recent article in *Science* (3/30/79), the NRC estimated that an earthquake which could affect the shutdown plants had a probability of occurring of between 0.2% and 1% per plant-year. For the four affected sites (two of the plants are located at the same site), there is, over a five-year period, an upper bound probability of 20% that a *serious earthquake could occur, with severe consequences.* Over the operating life of the five plants, such an event is virtually certain to occur.*

It also appears that the NRC already knew of the incorrect calculations as long as five years ago. In December 1974, the Commission issued a Regulatory Guide stipulating that a correct analysis method be used in the evaluation of reactor construction permits issued after that date. The NRC did not, however, address the question of what to do about plants already operating or under construction which incorporated the inadequate design.

By this time, the perceptive observer might be asking: If the NRC will shut down plants on the basis of earthquake hazards which have not physically affected any operating plant, what about the problem of serious fires, which have occurred at several reactors? This question was addressed in a letter which UCS sent to the NRC Commissioners:

* Ironically, a minor earthquake more recently hit New England, near the Maine Yankee Plant; one of the five affected.

> What is the probability of these types of common mode failures [caused by fire and earthquakes]? In the operating experience of the commercial nuclear power program there have already been a number of serious electrical cable fires. The fires at San Onofre, Peach Bottom and Browns Ferry come immediately to mind. One can reasonably conclude, therefore, that the probability of serious electrical cable fires is approximately once in every hundred [plant] years of operation, i.e., at the one percent [per plant-year] level. On the other hand, there has never been a serious earthquake affecting a nuclear power plant in the United States; one can conclude here that we are dealing with a probability somewhat less than the one percent level. By any reasonable standard of reckoning, the relative risk of catastrophic accidents from serious electrical cable fires is demonstrably higher than the risk from earthquakes.

In fact, even the Atomic Energy Commission was appreciative of this risk, having convened in 1973 a special *ad hoc* working group on fire protection. That group was told by D.E. Patterson, of the AEC Division of Operational Safety, *that the probability of* a catastrophic fire was apparently much higher than the probability of other events for which special preventative measures were required. According to Patterson, "the recurrence interval for very costly fires (greater than $100 million) appear to be once each hundred years [of operating experience]."

In 1977, UCS submitted to the NRC a Petition for Emergency and Remedial Action showing that 51 currently operating nuclear plants have electrical cable systems whose destruction by fire could incapacitate all of the safety apparatus required for the safe shutdown of the facility. In April 1978 the petition was denied. UCS subsequently appealed the decision, but, until now, the Commission has taken no further action. The events of the past few months—in particular the accident at Three Mile Island—suggest that the high probability of serious cable fires, combined with the potentially catastrophic consequences, presents a serious safety hazard requiring immediate action by the NRC.

SALT II, *continued from page 5*

and an increasingly fragile nuclear standoff. The logic on both sides would go something like this: "Since *they* are no longer limited by treaty, *they* will eventually produce more and better weapons (including new land-based missiles, mobile missiles, cruise missiles, nuclear bombers *and* the warheads to accompany them) which *we* must begin *now* to match or exceed!" Without the degree of certainty provided by treaty restrictions, the fears that help to drive the arms race would multiply.

The resulting nuclear build-ups would require higher defense budgets (and resulting inflation) and would almost certainly increase Soviet-American tensions and other countries' desires for nuclear weapons. Ultimately, previous arms control treaties like the Anti-Ballistic Missile Treaty, which now bans rings of defensive missiles around every city, could be scrapped.

SALT II, although far from achieving the full measure of what is needed, would help us avoid this situation and provide a chance to do better. The Treaty would require the Soviets to *dismantle* 250 missiles and/or bombers. It would restrict each side to a single new type of land-based missile and would limit the number of warheads placed atop any missile. The accompanying short-term Protocol (which might or might not be extended) would ban mobile missiles and restrict the ground and sea-launched varieties of cruise missiles. These provisions would set extremely important precedents.

The Treaty package also includes a Statement of Principles for future SALT III negotiations. The Statement is expected to call for significant weapons reductions, tighter controls on new weapons technology, and limits on nuclear weapons in Europe. The SALT III talks could begin soon after ratification of the SALT II Treaty.

Thus SALT II would set an important psychological climate of control in contrast to expectations of unbridled competition. It could open the door to a Comprehensive Test Ban Treaty which would prohibit—albeit probably with some small loopholes—all test explosions of nuclear weapons. This would be a major symbolic turnaround in the arms race, since test explosions are needed to develop new kinds of nuclear weapons such as the neutron bomb, and would dramatically increase hopes for preventing the further spread of nuclear weapons. Successful Test Ban and SALT III treaties would represent gains of the greatest importance and could set the stage for steps leading to important reductions in nuclear armaments.

One distinguished scientist has told us that, in his opinion, *disarmament is certain. What is uncertain* is whether it will come before (and help avoid) World War III or come after. A successful SALT II Treaty, providing direction and impulse towards the ultimate goal of significant nuclear arms control and nuclear disarmament can help insure that disarmament will *not* come after the war.

Reactor Safety, *continued from page 2*

sion . . . Congress took what it considered to be a drastic action when it abolished the AEC and set up the new Nuclear Regulatory Commission. NRC, however, did not bring about basic reforms, but adopted all of the regulations, rules and policies and criteria of the old AEC as one of its first official acts of business . . .

Congress must now take much more decisive action if it wants to establish some proper regulatory control over nuclear power . . . We recommend, as a relatively simple starting point for further regulatory reform, that Congress amend NRC's currently proposed budget to provide for the establishment of several *ad hoc* independent technical review groups. Work should begin immediately to review some of the outstanding generic safety issues, quality assurance lapses and other safety policy questions that we have discussed . . .

Secondly, Congress itself must make a more concerted effort to get its own independent technical advice so that it can more effectively oversee the NRC. Congress should not wait for NRC to identify issues needing attention or for outside critics to raise such issues, but should have its own capability in this area.

Finally, as a long-term reform that may supplant the interim *ad hoc* review process that we recommend, Congress should consider the establishment of a new independent agency, akin to the National Transportation Safety Board, that would monitor nuclear safety issues and the development of NRC policy. One of the most disturbing things we have seen about the nuclear program is the fact that only rarely is there any systematic follow-up effort in the aftermath of reported accidents and deficiencies at individual nucler plants. Rather than learning from experience, safety records indicate that the nuclear program frequently re-experiences the same types of defects time and time again because appropriate investigation and corrective action is not taken. A permanent body that carefully investigates the causes of accidents and recommends specific corrective action would serve a major purpose in helping to assure safe nuclear power plant operation.

Capitol Eye

The Fallout From Three Mile Island

"Confidence in nuclear energy has been shattered" in the wake of the traumatic accident at the Three Mile Island Nuclear Generating Plant, according to Rep. Morris Udall (D-AZ), Chairman of the House Interior Committee and the Energy and Environment Subcommittee. The powerful House leader added that the United States had not gone so far into the "nuclear swamp" that it could not retreat.

For the first time in the 25 years since the establishment of the civilian nuclear program, the Three Mile Island accident is forcing Congress to take a long, hard look at nuclear power. Udall's subcommittee, the key House body with primary nuclear jurisdiction, will conduct a 12 to 24 month comprehensive inquiry into the future role of nuclear power in the United States energy picture. The subcommittee's Senate counterpart, the Nuclear Regulation Subcommittee, also plans a lengthy investigation into the accident's implications for nuclear power development.

The two investigations are considered a radical departure for Congress which for nearly three decades had rarely wavered in its almost religious promotion of nuclear energy as a national goal. However, neither investigation intends to address the immediate action necessary to repair known safety defects in the 71 still-operating nuclear plants. These reactors, plus an additional 92 under construction, are affected by one or more unresolved generic safety defects. In effect, the committee investigations will "side-step" the urgent reactor safety issues highlighted by the Three Mile Island debacle.

Nonetheless, the plans for exhaustive congressional investigations do accomplish at least one positive end by forcing postponement of the efforts of the nuclear industry and the Carter Administration to speed up the licensing of nuclear plants and hastily resolve the radioactive waste problem. Before Three Mile Island, legislative proposals to accomplish these goals, pushed hard by atomic industry lobbying, had a reasonable chance of passage in the 96th Congress. For the immediate future, however, the proposals have been frozen by the impending Congressional investigations.

UCS has targeted the 164 reactors operating or under construction as potential threats to the public safety. All of these plants are governed by the same lax regulatory system which permitted the Three Mile Island accident to occur. It is unlikely that the Congressional investigations will even seek to impose substantive safety reforms on these 164 nuclear plants, and, in any event, the investigations will take months or years to complete.

There are, however, efforts being made in Congress to address the safety question. One positive step in this direction is the Nuclear Power Plant Safety Review Act of 1979 (S. 926), introduced by Senator George McGovern (D-SD), Rep. Ed Markey (D-MA) and others. This legislation would temporarily halt the issuance of 92 operating licenses and 37 construction permits pending congressional review of a three-year study of reactor safety defects such as those that contributed to the Three Mile Island accident. This moderate legislation argues that reactor safety questions should be answered *before*, rather than *after*, the United States doubles its commitment to nuclear power. Nuclear proponents in and out of the Carter Administration will do their best to stop this Act. UCS sponsors should express their opinions on this important legislation by contacting their Senators and Representatives.

For an update on other nuclear legislation concerning radioactive waste, repeal of the Price-Anderson Act, or the breeder reactor, please write to:

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Life Imitates Art Department

If you haven't already done so, see "The China Syndrome." *Nucleus'* highly regarded film critic, Daniel F. Ford, found it a "tense, gripping drama" and praised it for its technical accuracy. The film, about an accident at a nuclear power plant in California, stars Jane Fonda, Jack Lemmon and Michael Douglas. In the aftermath of Three Mile Island, it is hauntingly prophetic.

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