On the issue of nuclear nonproliferation, Mathews feels that a great deal of progress has been made. The Nuclear Non-Proliferation Act of 1978 was the result of a year's hard work with Congress, and passed both houses with large majorities. The act set out a rational framework in which the nuclear power industry could make exports in a way that would reduce the risk of other nations using nuclear power facilities and materials as a means for obtaining nuclear weapons.

Perhaps the least tractable issue Mathews handled was that of foreign military sales. Carter announced in May 1977 that the United States accounted for more than half of the world's $20-billion-a-year arms sales, and that in 1978 it would account for less. In 1978 American arms merchants enjoyed a better year than ever, and an atmosphere of widespread skepticism has enveloped the Administration's policy on arms restraint ever since. Members of NATO and other allied countries are excluded from the policy and have generally increased their purchases. Mathews claims that sales to those regions of the world where rising arms inventories posed a particular danger have in fact decreased by a target 8 percent in each of the last 2 years. The Administration's claims of success have been derided in some quarters as creative bookkeeping: to keep within the 8 percent ceiling, the cost of some arms sales has been attributed to future years. "There has been some criticism of phony accounting. It may look phony but it isn't," says Mathews.

Mathews puts her heart into the causes she has been working for. She describes as "really an outrage" the difficulty the White House is meeting in getting Congress to kill the Clinch River breeder reactor, foresworn by Carter in 1977 as part of his nonproliferation initiative. Another frustration has been trying to have the Senate ratify the treaty against genocide: "It will be 30 years this month that it was first sent to the Senate. The failure to ratify is a real blot on the United States."

Mathews says she is leaving the National Security Council because she wants to get into resource management and materials policy: "I think these are really key issues. Another reason is that I really wanted to deal with issues in depth. My personal view is that no one in government contemplates—it just isn't possible. The time to do contemplative thinking is outside government."

She is joining the editorial board of the *Washington Post* to write about science and resource issues.

Mathews is one of at least seven National Security Council aides who have recently decided to leave. Among the reasons suggested for the exodus are the exhausting pace of work and "mid-term blues"—the realization that at this point in the Administration's life the possibility for new initiatives is sharply diminished.—NICHOLAS WADE

Uncontrolled SO_2 Emissions Bring Acid Rain

EPA announces scrubber requirements for new power plants but little is done to stop pollution from old plants

Air pollution has posed a troublesome issue for Congress, the U.S. Environmental Protection Agency (EPA), and the states because solutions worked out by traditional political and economic trade-offs and compromises can easily turn out not to make sense environmentally. The way Congress and EPA have moved to bring about sharp reductions in sulfur dioxide emissions from new coal-fired power plants without also moving effectively to control such emissions from existing plants is a case in point.

On 25 May, EPA Administrator Douglas M. Costle, in one of his most important actions to date, announced final federal standards to reduce SO_2 emissions from new plants to half what would have been allowed under the preexisting standards. Although not as stringent as what the environmental groups had wanted, these "new source performance standards" (NSPS) go far beyond what electric utilities and the National Coal Association have said is acceptable. They represent a major environmental safeguard with respect to the some 350 coal-burning plants expected to be built between now and 1995. Utilities will have to invest several billions of dollars in scrubbers and remove from 70 to 90 percent of the SO_2 from stack gases, with the degree of control to depend upon whether low- or high-sulfur coal is burned.

However, in announcing the NSPS (which set tighter limits for particulates and nitrogen dioxide as well as SO_2), Costle acknowledged that total annual sulfur emissions from power plants will increase by nearly 2 million tons over the next decade and a half. In part this will be due to the threefold increase in the burning of coal expected during this period as new plants come on line. But, principally, it will be due to the fact that the emission standards for the coal-fired plants already in existence today are lax to the point that for many of them SO_2 emissions go entirely uncontrolled.

In 1975 sulfur emissions from fossil-fuel plants totaled some 18.6 million tons. Without the NSPS, total annual SO_2 emissions would be expected to rise to 23.8 million tons by 1995; even with the NSPS, according to EPA modeling studies, these emissions will increase to 20.5 million tons, with about 75 percent of the total attributable to old plants not covered by the new standards.

Sulfur dioxide and the fine sulfate mist into which SO_2 is readily transformed are the principal precursors of acid rain, which is believed to have destroyed fish life in hundreds of lakes in the Adirondack Mountains of upstate New York and now to threaten fish life in thousands of lakes in Canada. Another worry is that acid rain, a phenomenon widely noted as early as the Stockholm environmental conference of 1972, may reduce forest yields and poison soils.

The acid rain problem, together with that of the loss of visibility from the hazy air that now hangs over much of the eastern half of the United States, comes largely from the transport of SO_2 and sulfates over distances of hundreds of miles, from one region to another. Viewed in these terms, individual stack plumes with sulfur concentrations considered too dilute to represent a direct public health or environmental threat lo-

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that type of obligation-free donation. Why should they start now? Some also critique the often contentious tone of the *White Paper*. The report, for example, hits the Smithsonian's National Air and Space Museum as "a temple to the glories of aviation and the inventiveness of the aerospace industry." But what else could it be? "The museum," says Lawrence Taylor, coordinator for public information at the Smithsonian, "is filled with actual airplanes, rockets, satellites, and other aerospace hardware that has been donated to the Smithsonian. What's so criminal about that?" At the Chicago Museum of Science and Industry, the director, Victor Danilov, calls the CSPI report "a very naïve and impractical view of the real world. It is geared to show that we're in cahoots with big business and that it is a bad relationship. But it's just the opposite. If it were not for business and industry, you wouldn't have so many science museums in this country."

Yet even at the Chicago museum, which has more industry-sponsored exhibits than any other U.S. museum, the corporate line is not necessarily the last word. In March, for instance, more than 200 demonstrators picketed and leafletted in front of the museum, demanding that the pronuclear "Electricity and Our Future" exhibit be given the boot. And now the CSPI *White Paper* has added fuel to the fire. The complaints have apparently made their mark. The exhibit is going to be revised, Danilov recently told *Science*, "to present a more comprehensive story."

Rubber Bible Turns 60

The bible of laboratory scientists is going into its 60th edition this July. At 2500 pages and 6.5 pounds, the *CRC Handbook of Chemistry and Physics* is no small collection of tables, physical constants, and esoteric facts. It has simplified life for generations of scientists. For all its substance and renown, however, there has always been an air of mystery about the book. What does the CRC stand for? A look at the fine print on the back side of the title page only deepens the mystery. Why is an organization known as the Chemical Rubber Company turning out a scientific reference work? A call to CRC Press on the occasion of the book's 60th anniversary produced a surprising, if not earthshaking, story. In short, what is now a scientific bible started out as a huckster's come-on.

Around the turn of the century, an engineering student at the Case School of Applied Science (now part of Case Western Reserve University) started a part-time enterprise to help finance his college education. Arthur Friedman made rubber-coated aprons for chemistry classes and called his one-man effort the Chemical Rubber Company. Starting in the late summer, he would make the aprons in a small hot loft and peddle them to high-school teachers around Cleveland, Ohio, in time for the start of their fall classes. Business boomed, but not enough for the upstart entrepreneur. By the time he graduated from Case in 1907 with a degree in mechanical engineering, Friedman was giving away, with group orders of aprons, a small booklet that contained handy formulas, logarithms, and a periodic table for the use of chemistry students. "We don't know the exact conditions," says Earl Starkoff, general manager at CRC Press, "but we think that if a high school ordered something like 10 aprons, then the person placing the order would get a booklet for free."

Demand for the booklet grew, and Friedman kept going back to his old professors at Case for more tables and formulas. By 1913, he brought out a copyrighted, hardbound edition of 116 pages—still as a come-on to be given away with large orders of aprons. But not for long. Sales took off, and Friedman saw the light. Starting in 1914, the *Handbook of Chemistry and Physics* was sold on its own. Things have been booming ever since. Though the last rubber-coated apron was squeezed out in 1943, the *CRC Handbook* continues to prosper, the 1978 edition going out to more than 100,000 scientists and libraries. "It reached international distribution in the early 1920's," recalls Bernard Starkoff, president of CRC Press and son-in-law to the late Arthur Friedman. "Whole generations of scientists over in England grew up calling it the rubber bible. It is still called the rubber bible over there."

William J. Broad

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cally are contributing to interregional pollution problems that are truly alarming.

The pollution from the heavily industrialized Ohio River basin alone is enough to constitute a serious national problem. With its scores of large coal-burning power plants (not to mention countless industrial boilers), this basin is generating hazy, polluted air masses that are regularly being transported, depending on the wind, northeastward across Pennsylvania and New York into New England, northwestward across Illinois into Wisconsin and Minnesota, or due north into Ontario.

Accordingly, groups such as the Environmental Defense Fund (EDF) are now beginning to see the interregional transport of SO_2 and sulfate—and the lax regulation of existing power plants—as a key issue in air pollution control. Costle and other officials at EPA also are expressing concern. "If I could get a good legal handle on it, I would like to tighten up standards for existing plants," Costle told *Science* recently.

But there is reason to question whether such a handle is lacking. Some middle-level officials at EPA, frustrated at the failure to deal more effectively with the massive discharge of SO_2 from existing plants, say that it probably is not, although they concede that Congress has not made it easy for the agency to cope with the problem.

Congress first made a sharp distinction between existing and new power plants in writing the Clean Air Act of 1970. A specific requirement for scrubbers was not imposed then for any plants, but new plants were to limit their emissions to 1.2 pounds of SO_2 per million Btu. For existing plants, there was, and is, no flat, across-the-board ceiling on emissions.

Instead, control of their emissions was left largely to the states, which were directed to prepare state implementation plans (SIP's) based on two kinds of ambient air standards to be promulgated by EPA, primary standards intended to prevent harm to human health, and secondary standards intended to reduce harm to the environment.

The SIP's work this way. If, for instance, an SO_2 level of 365 micrograms per cubic meter (averaged over 24 hours) is considered the maximum allowable from the standpoint of protecting public health—this is, in fact, EPA's primary ambient air standard for SO_2—then stack emissions which cause concentrations greater than that are not supposed to be permitted. Pollutant dispersal and

diffusion models are used to determine the plume concentrations.

The modeling is a "soft spot" in the SIP system, says one EPA scientist. For instance, data on wind direction are typically taken from measurements made near ground level, where the wind is usually more variable than at stack height; such data biases the results of the model so as to show a greater dispersal of pollutants than may actually have taken place.

"For a plant situated on flat terrain, the model may be accurate within a factor of 2," says this EPA source. "But for one on complex terrain, you are fortunate if it comes within an order of magnitude."

In any case, at a distance of 20 to 30 kilometers from any particular power plant, the concentration of SO_2 in the plume is so dilute (measuring only a few micrograms) as to fall outside the sensitivity of the model, which is designed to measure only local effects. Yet the cumulative buildup of a few micrograms of SO_2 from each of a large number of plants, as regularly occurs along the Ohio River, ultimately results in polluted air masses that will be visited upon other regions by the wind. Indeed, in the Huntington-Wheeling area, far up the Ohio River and downwind from innumerable stacks in the lower basin, the annual average background level for SO_2 is at or above 80 micrograms, the maximum allowed on a yearly basis under EPA's primary standard.

Why did Congress, in the 1970 Clean Air Act and again in the 1977 amendments to that act, look to so tortuous and uncertain a regulatory scheme to control SO_2 emissions from existing plants? And why were fixed emission limits, or even a requirement for scrubbers, not imposed for all or at least most power plants, new and old?

The answer seems to lie in the heavy pressure Congress has been under not to burden the utilities and their ratepayers with additional costs of regulation. Because of this, Congress has kept the yoke light by sanctioning a scheme that is both flexible and, in many cases, extremely permissive. A particularly striking example of such permissiveness can be found at the Ohio Edison Company's Burger plant on the Ohio–West Virginia border; this plant emits up to 12 pounds of SO_2 per million Btu's, or ten times the amount that would be allowed if its emissions were subject to the NSPS.

Weak as the 1970 and 1977 acts are from the standpoint of control of SO_2 and other pollutants from existing plants, these statutes are not so weak that nothing more can be done. In the view of some at EPA, substantial reductions in sulfur emissions from these sources can be achieved without any strengthening of present law—provided there is the political will to take on the task.

EPA is currently reviewing the SIP's as required by the 1977 act, and it also has under way a review of its SO_2 ambient air standards. For some years now, EPA and the Department of Energy have been developing models for calculating sulfur and sulfate concentrations hundreds of miles downwind from power plants and other SO_2-emitting sources. But not much effort has been made to validate these models even though they could be the very tools needed for the preparation and enforcement of a sulfate standard. They are said to produce results at least as good as, and perhaps better than, the models used over the last decade to fix the emission limits for compliance with primary and secondary ambient air standards in the vicinity of power plants. (This is not to say such standards are always complied with. They are violated in parts of 23 states. In industrial areas along the Ohio River not even the primary standards are met.)

Major reductions in sulfur emissions are said to be achievable without requiring installation of scrubbers at existing plants. For instance, SIP's could be revised to have utilities rely more on their new scrubber-equipped plants for base load generation than they do on plants not covered by the NSPS. As the SIP's are now written, utilities are free to place their scrubberless plants first in the "dispatch order," and this is often done because they are cheaper to operate. Although model studies have not yet been done to assess how much SO_2 emissions from existing plants could be reduced from such a change in the dispatch order, it might be by as much as 50 percent, some sources say.

Another possibility would be to require the washing of high-sulfur coal if it is to be burned in plants without scrubbers and thus reduce SO_2 emissions by some 20 to 40 percent. So lenient are the present SIP's, most of the high-sulfur coal produced by surface mining in the East is not now being washed.

A third but less certain possibility would be to use solvent-refined coal (SRC) if the technology for producing it commercially as a liquid or solid fuel proves to be feasible over the next few years. The Gulf Oil Corporation, now seeking government support for the demonstration of its SRC-II (liquid fuel) process, believes that a 1.5- to 2-million-barrel-a-day market for SRC at $20 to $22 a barrel already exists in the eastern United States.

(However this may be, promulgation by EPA of a sulfate standard to require sharp reductions in stack emissions of SO_2 would clearly strengthen the market potential for such a fuel. A Gulf spokesman, who acknowledges that proving out the complex SRC-II technology is "no piece of cake," says that it is designed to achieve 92 to 94 percent sulfur removal.)

Then, there seems no convincing reason why installation of scrubbers could not be required for at least some plants not covered by the NSPS; among them are many that are less than 15 years old and some are relatively new. Plants commonly remain in service for more than 40 years, and, while in the case of some existing plants there are compelling physical or economic reasons for not installing scrubbers, this is by no means true of them all.

If the SO_2 transport and acid rain problems are ever to be vigorously addressed by EPA, Congress may have to help Costle and others at the agency screw up their nerve. As chairman of the Regulatory Council created by President Carter last year to keep regulation from becoming unduly costly and burdensome, Costle is probably under more pressure from White House agencies such as the Council on Wage and Price Stabilization and the Council of Economic Advisers to avoid costly new regulatory initiatives than he is from environmentalists to undertake them.

There has been some interest in Congress in the problems of acid rain and the interregional transport of SO_2 and sulfates, but up to now it seems to have remained at a fairly low level. The Senate Environmental Pollution Subcommittee chaired by Senator Edmund S. Muskie of Maine has plans to conduct hearings on acid rain, but these hearings have been deferred repeatedly and are not likely to be held before next fall, if then.

Yet a congressional initiative of this kind may be necessary if anything much is going to happen at EPA, which often seems to fit the classic definition of the regulatory agency that regulates only when the pressures to do so are greater than those that favor retrenchment and inaction. In any case, the problem represented by the lax regulation of existing power plants and the massive sulfur emissions that these plants produce is clearly one of some urgency. Should the acid rain phenomenon grow worse because of regulatory inattention and timidity, the result will not be merely an environmental affront but an outrage.

—LUTHER J. CARTER