winter presentation and a forthcoming report by the National Academy of Sciences. Most experts agree that this dispute can only be resolved by experience. A final and clearly legitimate complaint is that all of the models developed thus far assume no geographical overlap between nuclear detonations. In practice, each side would explode at least two and probably more warheads on a given target, just for insurance. This analytical defect may be eliminated in forthcoming studies by Livermore. The entire issue is also scheduled for a thorough review by a newly formed Defense Science Board nuclear winter task force.

Zraket believes that the discovery of nuclear winter has a number of important implications beyond its potential use for propaganda and nuclear targeting revisions. "Assuming that it withstands additional scrutiny, nuclear winter suggests that it is not possible to build a command, control and communications network for a protracted war involving large numbers of nuclear weapons—as some have urged. If you feel—as some do—that a nuclear war can successfully be fought for months, then this should dissuade you. It will reinforce the existing belief that a first strike makes no sense, because it may be suicidal. And it renders the notion of a real civil defense program, which is already in disrepute, even more disreputable."

Zraket, of course, does not have his finger on the nuclear button. The extent to which these views are shared by those who do should become evident in March 1985, with the release of the report that Congress has now ordered.

—R. JEFFREY SMITH

Static at EPA Over Broadcast Transmitters

Some officials push for tough restrictions, contending low-level electromagnetic fields pose potential health risks, but others are not convinced

For years, radio and television transmitting towers have sprouted up across the nation, virtually unrestricted in their power to broadcast the latest newscast or ball game. But now the Environmental Protection Agency (EPA) is considering a proposal to limit the power of these transmitters. The proposed curbs stem from concern by some EPA authorities that exposure to the radiation created by the towers may pose health risks to humans.

For now, the proposal is on hold because of vexing scientific and policy questions. The potential hazards of low-level, nonionizing radiation to humans are the subject of intense debate among researchers. At present, EPA officials are at odds with each other about whether to regulate at all, and, if so, at what levels of emission.

The broadcasting industry is watching the regulatory developments with interest. If tough restrictions are adopted, compliance could cost broadcasting companies millions of dollars as antennas are redesigned or relocated. David E. Jones, Jr., director of EPA's office of radiation programs, estimates that as many as 1000 of the nation's 4500 frequency-modulation (FM) towers might be affected by the proposed limitations, especially those in urban areas.

Recent animal studies have shown that weak electromagnetic fields can produce subtle changes in the nervous and immune systems, in blood, and in behavior. But the medical significance of these changes to humans is hotly disputed because of uncertainty about the relevance of the animal models to humans, and the dearth of epidemiological data.

Sources of nonionizing radiation range from low-frequency, low-power appliances, such as personal radios, to high-frequency, high-powered equipment, such as microwave radar systems. Since radiation diminishes dramatically with distance from a source, most people are exposed to amounts of nonionizing radiation that are considered harmless. But individuals who live or work within a radius of about 150 feet of the 1000 FM transmission towers believed to be trouble spots are of particular concern, according to Richard A. Tell, chief of EPA's nonionizing radiation branch.

Industry currently follows voluntary guidelines for emission and exposure set in 1982 by the American National Standards Institute. This spring, however, the National Council on Radiation Protection and Measurements, a private corporation chartered by Congress, approved an exposure guideline for the general population that is five times more stringent than the institute's guidelines. A few states and local communities have approved or are considering regulations that are more strict than the voluntary guideline.

This has led to a regulatory patchwork and, as a result, the broadcasting industry has been urging the federal government to develop a national standard. The industry obviously did not expect the EPA staff to propose such a tough plan.

The current voluntary guideline recommends an emission limit of 1000 microwatts per square centimeter ($\mu W/cm^2$) and an exposure level of 0.4 watt per kilogram (W/kg). Exposure at 4 W/kg is considered adverse. According to EPA documents, the agency's office of radiation programs has recommended emission restrictions ten times more stringent than the voluntary guidelines and would limit emissions from FM towers to 100 $\mu W/cm^2$ and exposure to 0.04 watt per kilogram (W/kg). This is more stringent than any existing state or local standard.

The radiation office based its proposal on an extensive survey of the scientific literature. The findings, recently released in a 500-page report, were judged by an EPA science advisory board comprised of outside scientists to be a fair and adequate review of published studies and a basis to develop federal regulations. The report asserts that, based on recent animal experiments, biological effects can occur at an absorption level lower than 4 W/kg, the threshold at which adverse effects previously have been observed. According to the report, several findings were significant:

- Tests showed that absorption of radio-frequency radiation of less than 4 W/kg caused a rise in animal body temperature. The elevation was associated with alterations in the blood, immune, and endocrine systems. In guinea pigs and rabbits, low absorption levels were linked to an increase in white blood cells. In several studies, rats tested at similar levels showed increases and decreases in various hormone concentrations on the blood.
- Data from one laboratory "raised the possibility" that radio-frequency radiation at 2 to 3 W/kg can act as a cancer promoter or cocarcinogen in mice, the EPA report says. The findings, however,

require confirmation and testing in additional animal models, said Barbara Chang, a member of the advisory board and an oncologist at the Medical College of Georgia.

• Experiments showed that 3 W/kg of radiation, in combination with increases in body or ambient air temperature, can influence biological changes. In one study, scientists studied the learned behavior of laboratory rats at room temperature and observed that the animals responded more slowly than normal. When the ambient temperature was raised, the rats' behavior changed at an even lower dosage, 1 and 2 W/kg.

The observation is provocative to EPA scientists because, in their opinion, it could mean that people stressed by heat and high humidity during the summer may be more susceptible to possible effects of radio-frequency radiation—especially infants, the elderly, and individuals with cardiovascular problems. Although there are no human data to support or rebut this theory, primate studies have shown that exposure to radio-frequency radiation can cause a rise in body temperature.

Some researchers contend that other sources of nonionizing radiation may pose potential hazards to humans. Scientists have assumed that the telltale sign of exposure to nonionizing radiation is heating. But during the past few years, a handful of researchers have demonstrated that electromagnetic fields much weaker than those created by radio and television transmitters can cause biological changes without measurable changes in heat.

In this camp is W. Ross Adey, associate chief of staff for research at the Veterans Administration Hospital, Loma Linda, California. Adey and others have shown that electromagnetic sources modulated at extremely low frequencies can change the flux of calcium ions between animal brain cells in vitro. Broadcasting frequencies are not deeply modulated, so the relevance of Adey's findings to the proposed limits is controversial. The results of Adey and others have raised numerous questions about the potential effects of exposure to sources that generate weaker electromagnetic fields than broadcasting transmitters, such as microwave radiation, large power lines, and ELF (extremely low-frequency) sources.

The science advisory board made no recommendation concerning potential regulation and suggested that the health effects be characterized as significant, not adverse, in EPA's report. Adey, for one, strongly criticized the agency study, contending that the agency has not paid sufficient attention to weak field effects. But he says that EPA's staff proposal to restrict transmitters' power to 100 $\mu W/cm^2$ is low enough to take care of his concerns. "There has been no evidence of adverse effects at 100 μW in the laboratory," he said.

EPA officials outside the radiation office, particularly in the Office of Policy, Planning and Evaluation, are not yet convinced that any guidance level should be set, however. A memorandum listing several options, ranging from no regulation at all to the 100-μW level, is currently circulating in the agency.

"There's a lot of uncertainty about the effects of low-level exposure," one EPA official says. "Should the federal government be telling the public there's an imminent hazard when there's not? By implication, [if a standard is set] that's what we're saying and I'm not sure that honestly reflects the science." The official also challenges the conservatism represented in the 100-μW limit. The radiation office incorporated a safety margin of 100 in the proposal, which is the same margin used to weigh the risks of carcinogens. While cancer may often result in death, the effects of heat stress from radio-frequency radiation are much less well defined, he says.

The National Association of Broadcasters favors a regulation that simply codifies the present voluntary standard. Thomas B. Keller, NAB's senior vice president of science and technology, said, "We're all for a standard, but not one that's 100 to 200 μW." Keller says that if a low-level standard is imposed, the industry as a whole would not suffer terribly. But for individual stations, the proposed rule could be "disastrous."

Given the various gaps in data, some agency officials are pondering whether EPA's time and effort is better spent working on known problems such as air pollutants. "We're a long way away from a resolution," the EPA official says.

But Richard Tell of the radiation office remarks, "Some people think we've gone overboard but we don't think we have. The attitude of the agency is that there's no problem because we can't point to one excess twitching of a small finger or one extra cold. I don't think you need a definite [health] problem to regulate."—**MARJORIE SUN**

Hot Spots on Honolulu High-rises

No matter what the Environmental Protection Agency (EPA) decides to do about a proposed 100-microwatt limit on broadcasting transmitters, one city in particular will likely want to change the way the towers are set up around town. According to agency officials, Honolulu has the dubious distinction of having the biggest cluster of powerful radio and television transmitters of any major American city.

More than a dozen big transmitting towers are located in downtown Honolulu. City zoning ordinances bar broadcasting towers from the surrounding hillsides, so radio and TV stations have erected them atop the high-rise buildings in downtown Honolulu. The problem is that the transmission towers are too close to other tall buildings and people.

Richard A. Tell, a scientist at the Environmental Protection Agency (EPA) last month completed a field study of radio-frequency radiation in Honolulu and found a variety of "hot spots." In outdoor locations that were accessible to the public, he measured emission levels that exceed the proposed limit of 100 microwatts per square centimeter. Tell said, however, that most, if not all, readings taken indoors were less than 100 μW. He declined to elaborate on his findings until an agency report is finished.

The Hawaii health department and Honolulu residents have long been concerned about the actual emission levels and their potential health effects. At their request, EPA in 1975 estimated the emission levels using mathematical models. Tell, who carried out the calculations, reported that the emission levels were very high. Atop the Ala Moana Hotel, for example, is a 76-foot, 100-kilowatt FM transmitting tower. According to Tell's 1975 report, the roof of the adjacent building could receive 400 $\mu W/cm^2$. A television and FM transmitter, operating at 616 kilowatts, had an emission level of 1000 $\mu W/cm^2$ at the base of the tower. At the time, the radiation levels did not exceed the existing standards. Since then, as more scientific data have become available, the guideline levels have dropped.—**M.S.**