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January 5, 1972

Hon. Arthur W. Murphy, Chairman
Atomic Safety and Licensing Board
Columbia University School of Law
Box 38, 435 West 116th Street
New York, N.Y. 10027

Re: In the Matter of Consumers Power Company, Midland Plant, Units 1 & 2
Docket Nos. 50-329 and 50-330

Dear Professor Murphy:

In behalf of Mapleton intervenors, we serve herein, as the testimony of Robert L. Whitelaw, Professor of Mechanical & Nuclear Engineering, his letter to Irving Like dated December 28, 1971, with attachments dated September 30, 1971 and pp. 363-375 of the May 1969 issue of I.E.E.E. Transactions.

Respectfully submitted
REILLY, LIKE & SCHNEIDER

Irving Like

IL:mc
Encs.

copy to:
ASLB members
Secretary
All counsel of record

COLLEGE OF ENGINEERING

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Blacksburg, Virginia 24061

DEPARTMENT OF MECHANICAL ENGINEERING

December 28, 1971

Mr. Irving Like
200 W. Main Street
Babylon, New York 11702

Re: Safety of Midland Nuclear Powerplants #1 and #2

Dear Mr. Like:

Under separate cover, dated September 30, 1971, I have submitted a prepared list of ten questions which I believe are pertinent to the immediate safety of nuclear powerplants and to the long term public interest in their development.

The first seven questions deal with a particular category of nuclear plant safety in which I believe I have established both competence and extensive experience, by virtue of twenty-three years' experience in responsible engineering design and development of powerplant pressure vessels and heat exchangers, including twenty years' experience and special postgraduate studies in nuclear technology.

This category of nuclear safety pertains to the integrity attainable in the design and assembly of a complex system of high pressure pipes, fittings, and large pressure vessels such that every conceivable leak involving radioactive material can be contained, and in particular, that no explosive failure anywhere in the system can result in flying parts that can destroy a containment system designed on the assumption that no such explosive ruptures will ever occur.

There is no question that American technology, since the early days of steam power, has attained a record of pressure vessel safety that is the envy of the engineering world. Nevertheless, explosive pressure vessel ruptures still occasionally occur with devastating results, and while no actual reactor vessel has yet exploded, the facts of the matter appear to be that

(1) no nuclear equipment manufacturer is yet prepared to give an ironclad guarantee that a pressure vessel he sells will never rupture either explosively or non-explosively, or that if it does, he will pay all consequential damages; and

(2) many nuclear powerplants designed today, possibly including the Midland plants, are not designed to maintain radioactive containment in the face of explosive rupture of vessels in the primary system.

While there are other nuclear plant safety problems of equal concern to the public, in most cases adequate precautions, procedures, interlocks, etc. are being demonstrated to the A.E.C. by the designers and operators. Hence the safety problem posed by the two items listed above, in my judgment, constitutes the greatest hazard or "maximum credible accident" which every operating plant must be able to withstand and against which the public needs protection.

Questions #8 and #10 represent matters which the nuclear power industry as a whole, and the A.E.C. in particular, should be compelled to face, for the simple reason that if they are not answered, and soon, the projected proliferation of nuclear powerplants throughout the land makes very little sense, and may well leave our children an inheritance of unmanageable radioactive wastes and hundreds of obsolete nuclear plants far beyond what was really necessary,

The substance of these concerns was first raised by the well-known consulting engineer, Mr. A. J. Ackerman, in his noteworthy paper "Atomic Power - Who Looks After Public Safety?" and in my comments on this paper.

The paper, and my comments on it, were published in the May, 1969, issue of I.E.E.E. Transactions, pp. 363-375, of which I attach a copy.

Yours very truly,

Robert L. Whitelaw

Robert L. Whitelaw
Professor of
Mechanical and Nuclear Engineering

RLW/mf1

Enclosure

September 30/71

Questions Concerning Midland Nuclear Powerplant, Units #1 and #2

By: R. L. Whitelaw, Prof. of Nuclear & Mech. Eng., V.P.I.&S.U.

1. What is the probability of an explosive rupture of the reactor vessel or of large elements of the primary loop, resulting in flying parts at high velocity and momentum? i.e. can it be shown that such a failure has never happened in the history of high pressure vessels, or is extremely unlikely today?
2. What is the probability of a failure in the reactor vessel head bolts, or in the control rod head nozzles or retention bolts that would result in the entire head or a control rod drive being ejected upward at high velocity? Has such a failure ever happened yet?
3. Is there a conceivable combination of events or combination of failures in the control rod drive system that could permit the reactor pressure to drive a rod upwards at high velocity sufficient to rupture and keep on going?
4. What is the probability that any of the flying parts in any of the three failures above would rupture either a) the wall of the containment vessel, or b) one of the vulnerable points in the containment, such as a penetration bellows?
5. During the expected operating life of the reactor vessel, will the embrittlement of its steel due to radiation increase the probability of the failures above? If so, by how much? What is this operating life? What is the latest embrittlement (NDT) data to support this conclusion?
6. Is it possible for the safety injection system to subject the reactor vessel to thermal shock, so that it would be unsafe to operate again? What is the maximum local cooling rate the steel might experience in this event?
7. An explosive rupture of the steam turbine high pressure or cross-over piping or casings can occur, as it has in other power stations. It can

cause or be associated with a generator failure and consequent hydrogen fire. Can such an explosion and fire in any way result in a rupture of the containment vessel? Or could such a sequence be a logical consequence of a non-explosive primary system failure inside the containment vessel?

8. Does this unit promise a significant gain in U238 conversion over previous reactors of this type. If not, is it to our long-term advantage to multiply non-breeding reactors, without a significant gain in conversion ratio from one generation to the next?

9. Is it compatible with the long-term water supply plans of this area to add nuclear plants on the Tittabawassee River? Any water purification and reuse downstream would be jeopardized by a nuclear plant upstream.

10. Since nuclear fission, as presently employed in non-breeding low efficiency water reactors, is by no means the long-term answer to the nation's electric power needs, has the operating company put significant study, research, and development into better long-term means, such as Drilled Geothermal Power. If not, what not? And if such a better means of generating power (with no radioactive wastes, nor hazards, and an almost inexhaustible source of energy right under our feet) is almost sure to come, should not the Consumers Power Company be supporting research and development on it, and scheduling an installation on its system as soon as it can be made feasible?

Atomic Power—Who Looks After Public Safety?

ADOLPH J. ACKERMAN, Senior Member, IEEE
1250 Sherman Avenue
Madison, Wis. 53703

Editor's Note: This paper marks a departure from our usual practice of publishing communications as correspondence. The discussions prepared for the ASME Meeting follow directly after the text.

Although this paper deals mainly with the use of atomic power in generating stations, it is included because G-AES is concerned with power generation in space and possibly, someday, the nuclear-engined airplane.

Abstract

In this new technology the history to date adds up to a very small record of operating experiences, along with a variety of deficiencies and failures. At this stage the development of atomic power suffers from a surge of over-optimistic promotion plus a general breakdown in engineering responsibility and control of safety that could culminate in a national catastrophe.

Manuscript received November 25, 1968.

This paper was presented at the Winter Annual Meeting of the American Society of Mechanical Engineers, New York, N. Y., December 1-5, 1968.

Introduction

In reviewing the emerging technology of atomic power, this paper is primarily concerned with questions of basic policy and public safety, and with the deficiencies in these areas. There is an urgent need for rectifying current trends in the power industry, and this calls for renewed emphasis on the obligations of local utility managements and their Chief Engineers who have the ultimate responsibility for public safety. The adoption of higher standards of safety for the protection of the public is of utmost importance; furthermore, this is a valid and feasible objective.

This review is directed primarily to the "decision-makers" and "policy-makers"—past and present—and no reflection is intended on the people currently employed in this new technology. Obviously, the sincerity and dedicated efforts of all these people are not in question, but the policies under which they have been obliged to work are very much in question.

The objective here is to promote a higher level of integrity in atomic power policy, both in industry and government, and higher standards of engineering in which the ultimate responsibility for public safety is clearly identified.

Such a review is not only in keeping with our professional right of analysis and discussion; it is, in fact, a professional *duty*—and responsive to the purpose for which our professional societies have been established. It is also responsive to the philosophy of Cicero: "The safety of the people shall be the highest law."

In the new and unprecedented science of atomic energy, unfortunately, the philosophy of engineering responsibility has been allowed to fall by the wayside, or it has been deliberately dismissed. This is a matter of such importance that a conclusive exposition could fill a book; hence, a brief review such as this can only sound an alert on current deficiencies.

This initiative, of necessity, is a highly personalized responsibility, reflecting professional experiences and judgments which extend beyond conventional technical analyses and conclusions derived from statistics. In essence, this review reflects a decade of continuing analysis of the social, economic, and political experiences in this new technology of atomic power. There is only one objective—to serve the best interests of the public and of the engineering profession.

I. Responsibility for Public Safety

The public health and safety are, first and foremost, the responsibilities of professional men. The distinctive marks of a professional man include a motive of service to meet a social duty, the ability to carry high individual responsibility, and a commitment to uphold the ethics of his profession. The application of science and technology is a

difficult and personalized *art* in which the engineer in charge commits himself to serving the public interest above all others, and he carries this responsibility in his conscience. On him rests the ultimate responsibility for public safety.

In 1939 Thaddeus Merriman, the former Chief Engineer of the Board of Water Supply for the City of New York, declared [1]:

> The engineer's duty does not lie only in saving a maximum of his client's money. It demands absolutely that the public be afforded a maximum of safety. If the client is unwilling or unable to pay for that maximum then he should not have his project. And what is true in the case of a private client is just as importantly true when the engineer acts for public authority—he must still protect the public—no one else can perform that function.

And "responsibility" has been clearly defined by Admiral Hyman G. Rickover [2]:

> Responsibility is a unique concept: it can only reside and inhere in a single individual. . . . If responsibility is rightfully yours, no evasion, or ignorance or passing the blame can shift the burden to someone else. Unless you can point your finger at *the man* who was responsible when something goes wrong, then you have never had anyone really responsible. . . .
>
> Service ceases to be professional if it has in any way been dictated by the client or employer. The role of the professional man in society is to lend his special knowledge, his well-trained intellect, and his dispassionate habit of visualizing problems in terms of fundamental principles to whatever specific task is entrusted to him. Professional independence is not a special privilege but rather an inner necessity for the true professional man, and a safeguard for his employers and the general public. Without it, he negates everything that makes him a professional person and he becomes at best a routine technician or hired hand, at worst a hack.

This concept of an engineer's responsibility together with the confidence of the public in the engineering profession comprise a rich heritage which stand as the primary bulwark for the protection of the public in the application of science and technology. Political interference or arbitrary executive displacement of a Chief Engineer's responsibilities would clearly be a violation of public trust. The public has a right to expect absolute intellectual honesty in matters of public health and safety. Herbert Hoover has stated most precisely that "technology without intellectual honesty will not work."

Abdication of Professional Responsibility

Regrettably, however, this concept of responsibility is not being perpetuated in the new postwar technologies, and the engineering profession is allowing itself to be subordinated to governmental authority. During the past decades we have seen many proposals for impressive scientific and engineering projects, but they are being promoted under political domination, completely devoid of financial responsibility, and under deliberate censorship of any opposition.

Notwithstanding the magnitude of such projects, there are relatively few "experts" employed in this type of planning. Unfortunately, most of them tend to ignore the harmful implications. In addition, many politicians are eager to make long-term commitments, supposedly for plausible objectives—but also to maintain their political positions. They encroach on engineering independence and responsibilities, they dominate the establishing of debased planning policies for monumental projects, and they insist upon open-ended financial commitments and the use of arbitrary "legal" strategies. The net result is a breakdown in the areas of professional responsibilities, ethical standards, the rule of law, public safety, financial controls, and the accounting for public funds.

This debased planning technique is emerging currently on a large scale and on a nationwide basis. The most terrifying example is to be found in the development of atomic power, where the traditional professional disciplines and responsibilities of the independent engineer have been completely disrupted.

To understand how this came about, we need to go back to 1957 when Congress was persuaded to adopt a revolutionary change in insurance practices through the enactment of the Third Party Liability (Price-Anderson) Act. Under this act, in the event of a failure or accident in an atomic power plant, the major part of the cost of the destruction in life and property will be transferred to the victims and to the taxpayers of the nation. This legislation must be regarded as a great historical tragedy for two reasons: 1) it has destroyed the traditional concepts of *responsibility* and *corporate liability*, and 2) it has led to the exploitation of public confidence in the engineering profession and in the American system of private enterprise. (The history of this revolutionary change has been examined in greater detail elsewhere [3].) In essence this new law relieves the utilities and insurance companies of a huge financial risk against damages which could exceed 5 to 7 billion dollars. Private insurance companies are carrying only one percent of the peril, and the law authorizes payments of another ten percent of the estimated peril, a maximum of $500 000 000 from the public treasury, on any one failure of an atomic reactor.

U. S. Congress Ignored Warning

When this legislation was being considered in 1957 by the Joint Committee on Atomic Energy (JCAE), and in the U. S. Congress, Representative Chet Holifield, as the lone dissenting member of this 18-member committee, declared himself opposed to the Price-Anderson Act in these words [4]:

> It would provide another government subsidy to atomic power development without any commensurate benefits to taxpayers and power consumers. It would place upon the federal government an enormous potential liability that could reach several hundred billion dollars. . . .

> This bill is put forth by its proponents as a bill for the protection of the public. This amounts to making a virtue out of a subsidy. The bill is protective of large utilities, industrial companies, and insurance companies which are not willing to adhere to the tenets of free enterprise. . . .
>
> This bill is not a minor technical amendment to the Atomic Energy Act. It is a major piece of legislation. It goes far beyond anything I know in committing the federal government to future liabilities without any clear understanding or basis in experience as to the nature or the magnitude of those liabilities.

Later, during the debate in the House of Representatives, Holifield declared [5]:

> . . . You Members of Congress are taking upon your shoulders the personal responsibility for writing an indemnity bill which will give these people the coverage that they want *financially* and you will have upon your hearts and upon your minds and upon your souls the responsibility in case there is a blowup in this field.

Unfortunately this historic warning was ignored. The lobbying for this bill apparently had been managed so skillfully that the Act was passed by both Houses of Congress without even recording the voting.

High-Pressure Propaganda

Once the Price-Anderson Act had passed, it brought with it a new concept (or "fourth dimen[illegible]onic power development—*the perversion of* [illegible], and the widespread application of "emotio[illegible]ngineering." As a consequence an aggressive promotional effort was launched, ostensibly to accelerate the development of atomic power. Advertisements deteriorated into unsupportable claims of low cost, safety, and abundance of electricity for everyone, and into emotional propaganda. Engineering conferences invariably featured the wonders of this great new energy resource, and professional papers forecasting a new utopia were given special recognition. Against the traditional professional disciplines and moderating influences of responsible engineers and fully responsible insurance companies, the new atomic scientist-administrators argued [6], "This simultaneous pursuit of programs of research, development and construction has become standard in the fast-moving field of atomic energy."

A few years later a new warning was heard when engineer Abel Wolman, Hon. M.ASCE, testified in 1960 before a Congressional Committee [7]:

> It is only with research for criteria for radiation limits that one finds that it should be permissible to kill people to attain benefits to society. This has undoubtedly been in the minds of all criteria makers, but rarely has it reached the frank and stark pronouncements of recent years. . . . An agreed acceptance of a number of consequent disabilities is not an appealing basis for the development, say, of nuclear power. *Industry will do better than rest upon such an affront to man.*
>
> (Emphasis added)

These words should have touched everyone's conscience. But, unfortunately, this responsible warning has remained unheeded to this day.

Only on rare occasions were appeals heard for a more deliberate approach in developing "engineered factors of safety" and economic principles of application. Reports and professional papers were difficult to find on operating problems and on deficiencies or failures experienced in the first group of atomic power plants, although the art of engineering is advanced through the lessons learned from failures. However, over the years, and generally under special circumstances, a few significant statements saw the light of day, such as "We Are Being *Misled* on Nuclear Power" by a former member of the AEC's General Advisory Committee [8] and my own paper [3].

Furthermore, with Hiroshima and Nagasaki still very much in the public mind, some local groups of citizens banded together and registered violent opposition to the building of atomic power plants in populated areas. This resulted in several important projects being canceled as, for example, in Queens, N. Y., and Bodega Bay, Calif.

Despite all the deficiencies and confusing concepts that inevitably appeared during the first decades of this new technology, the engineering profession (through its official societies) has made very little effort to oppose unsound policy trends or to bring about a sound reorientation in professional responsibility.

The Problem of Public Safety is Taken to Court

The first court action in defense of public health and safety was filed in 1956, not by the engineering profession, but by a labor union, which opposed the construction of the Enrico Fermi Atomic Power Plant near Detroit. After this case reached the U. S. Court of Appeals it handed down a decision in June 1960 [9]:

> In our opinion the [Atomic Energy] Commission's findings regarding safety of operation are not sufficient. . . . We think it clear from the Congressional concern for safety that Congress intended no reactor should, without compelling reasons, be located where it will expose so large a population to the possibility of a nuclear disaster. . . . Because we think the safety findings insufficient, we must set aside the Commission's grant of a construction permit. . . .

The case was carried to the Supreme Court of the United States on appeal in the fall of 1960 [10]. This provided an opportunity for contributing an *amicus curiae* brief to the Court [11], in which the professional and legal responsibilities of engineers were defined and recommendations were offered for returning to the traditional practices of engineering and construction under the rule of law.

Unfortunately, the Court held that since only a *construction* permit had been granted there could be no legal issue over *operating* safety until the plant had been constructed and an *operating* permit was under considera-

tion. Against this the minority opinion of the Court declared [3]:

> The legislative history makes clear that the time when the issue of "safety" must be resolved is before the Commission issues a construction permit. The construction given the Act by the Commission (and today approved) is, with all deference, a lighthearted approach to the most awesome, the most deadly, the most dangerous process that man has ever conceived.

The net effect of the Court's decision on atomic power development has been to disrupt a traditional safeguard for prospective investors and to weaken the ethical disciplines of the engineering profession in the areas of economics, finance, and public safety.

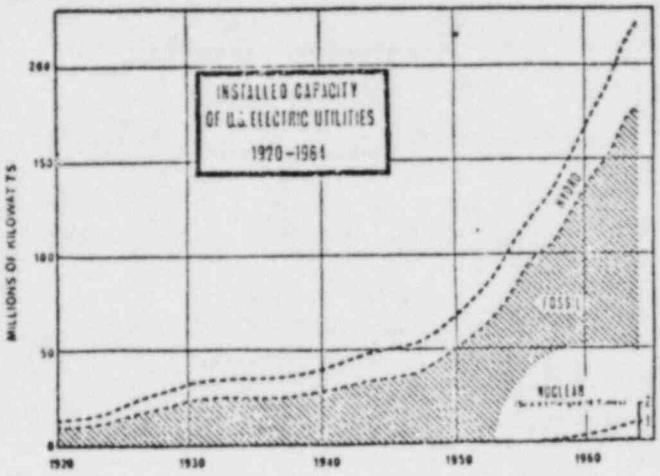


Fig. 1. Installed capacity and annual energy production by U. S electric utilities, 1920–1964 [12, p. 740]. (Note that the scale for nuclear power generation is enlarged 10 times for visibility.)

II. Responsibilities of Management

The problems of corporate liability in the event of a catastrophic failure of an atomic power plant continued to plague a number of responsible utility managements and their Boards of Directors. The chief reasons for their concern were 1) the continuing refusal by the insurance companies to write the same kind of comprehensive Third Party Liability Insurance as is available for fossil-fueled steam plants; 2) the absence of an adequate record of successful operating experience from which sound judgment could be drawn for major commitments into the future; 3) a high degree of public concern about the peril of radioactive fallout, as reflected in the active opposition to several atomic power projects; and 4) the fact that the Price-Anderson Act was operable for only a limited period of ten years and was due to expire in 1967.

As recent as June, 1967, there were only four public utility atomic power plants in operation in the U. S. with capacities exceeding 75 000 kW, and only one of these had a rating as high as 265 000 kW. All of them, including seven smaller plants, were considered largely experimental. The total capacity of nuclear generation, including the smaller units, came to about 1 000 000 kW, or less than half a percent of the total electrical capacity in the United States of about 230 000 000 kW (Fig. 1). (The deficiencies in these atomic power developments, and the unsatisfactory operating experiences, have been critically reviewed elsewhere [12], [13].

Responsibilities of Boards of Directors

Our great American system of free enterprise is founded on the *integrity* of each company or corporation, and on their *willingness to assume full responsibility* for their acts. At that level, obviously, only the Board of Directors can supply the answers to questions of corporate policy. Granted that there are many fine directors of high integrity serving on the Boards of the great power and manufacturing companies, it is, nevertheless, distressing to see how few have publicly challenged the revolutionary changes of policy in the power industry, and the ethical issues inherent in the application of nuclear science. The majority appear to be unaware of the new and subtle influences that are undermining the welfare of their own companies, as well as the public safety. Some of them seem to rely on someone else's opinion, or on the fact that "everybody's doing it." A more cynical comment is sometimes heard that "Directors don't direct."

At a recent hearing before an Atomic Safety and Licensing Board these deficiencies in corporate management were identified in the following testimony [14]:

> The introduction of a major peril, with a potentiality for destruction greater than was experienced at Hiroshima, is a tremendous responsibility. *This is, first of all, a responsibility resting on the individual Directors of the power company*—and on the Directors of the participating power companies. Commissioner James T. Ramey of the U. S. Atomic Energy Commission has declared: "It must never be forgotten, however, that responsibility for safety of the plant rests with the owner or operator. The regulatory groups, no matter how thoroughly they carry out their function, cannot provide complete assurance that public health and safety will be adequately protected in a power reactor project. . . ." (AEC Authorizing Legislation—1963, p. 1288.)
>
> The proposed atomic power plant represents a revolutionary departure from traditional corporate responsibility and from the traditional confidence reposed in utility Directors by an uninformed public. There is little indication that utility Directors have examined the personal and ethical responsibilities involved in introducing such a peril. It is respectfully suggested that each Director be given an opportunity to re-examine his responsibilities and publicly declare his position as part of this hearing record.

Very few utility directors apparently have been given the opportunity to balance their judgment through a careful study of the *failures* and *adverse experiences* in atomic power development, and the lessons to be learned from them. These experiences include the public protests which led to calling off plans for the 1 000 000-kW Ravenswood plant in New York and the 325 000-kW Bodega Bay plant near San Francisco in 1964; the deferment of the 462 000-kW Malibu plant near Los Angeles in 1966; the abandonment of the 150 000-kW Enrico Fermi reactor near Detroit in 1965 and the decision of the Detroit Edison Company directors to enlarge their system until 1972 with a coal-burning steam plant; the closing down of the Oak Ridge plant in 1966 after 557 000 000 had been spent on it; the dismantling of the Hallam, Neb., plant in 1966 after an expenditure of 555 000 000; the interminable operating difficulties with smaller plants in La Crosse, Wis., Elk River, Minn., and Puerto Rico; the discovery late in 1967 of more than a hundred cracks in the Oyster Creek pressure vessel; and the disapproval by the AEC in 1967 of the 2 000 000-kW plant in Burlington, N. J., "because of its proximity to major population centers."

Furthermore, Directors could to advantage examine the complete lack of operating experiences in large-sized reactors, the lack of integrity in the massive promotional campaigns, the efforts to brainwash the public, the problem of radioactive waste disposal, and several other technical problems of equal importance.

There are some fundamental defects also in basic economics in comparing the cost of electricity produced from atomic reactors with the cost of electricity produced from fossil fuels. Comparative costs in terms of "mills per kWh" are being relied upon by Directors for making huge financial and long-range policy commitments, despite the fallacies to be found on the subject of "cost of atomic energy." We would do well to remind ourselves of the notable opinion expressed by a former AEC Director of Reactor Development who declared [15]:

> Figures in the literature on estimated cost of atomic energy vary by at least a factor of 10. I am not going to try at this time to give you more accurate cost figures for three very good reasons:
>
> 1) They do not exist even with the Atomic Energy Commission.
> 2) If they did exist, they could not be released for security reasons.
> 3) If they did exist and if they could be released, I wouldn't believe them anyway.

III. New Congressional Hearings

In June 1965 the Joint Committee on Atomic Energy held new hearings in the nation's Capitol on the question of extending the Price-Anderson Act for another ten years. A total of 35 witnesses were heard, of which 30 advocated extension of the Act and 5 opposed such extension (4 from the coal industry and 1 independent consulting engineer) [16].

The promotional efforts and "emotional engineering" in support of this legislation were something remarkable to behold. The preparatory work by most witnesses was extensive, and a solid front was presented by the spokesmen for the electrical industry.

These hearings brought forth some strange testimony. For example, two witnesses who advocated the extension of the Price-Anderson Act inadvertently exposed some important factors that impinge directly on business ethics.

The first one, a reactor manufacturer, was asked what effect it would have on his company's activities in the nuclear field if the Price-Anderson Act were not extended. He replied [16, p. 95]. " . . . Of course, my opinion would be that that probably would deter us from taking on further work—a conservative approach by the Board of Directors. . . ."

The second one, a spokesman for the Nuclear Energy Liability Insurance Association, was asked what the impact would be on the insurance industry and the nuclear liability policies they issue if Price-Anderson were allowed to expire. He responded [16, p. 196], "It would be my guess that the system of economic channeling that Price-Anderson more or less stimulates might very well break down . . . and it would depend largely *on the financial responsibility and integrity of each nuclear operator*" (emphasis added).

Testimony by Concerned Citizens

Such hearings also provide an opportunity for interested citizens to contribute important information; and when the official reports on such hearings are published, they are available to all citizens for detailed study. Obviously, anyone who speaks out in dissent against popular ideas assumes a special burden in volunteering to testify. And, depending on the adequacy or inadequacy of the judgment developed from these hearings, the future of our nation and its people is committed accordingly.

The fact remains, however, that the public is confronted with a highly sophisticated new technology, and the controversial issues (such as the "safety factors" in atomic power plants) despite their importance are understood by very few people. This was confirmed by the general lack of public interest and concern in the announcement of August 31, 1965: "The Senate proceeded to consider bill (S. 2042), 'Extending and Amending the Price-Anderson Indemnity Provisions of the Atomic Energy Act of 1954' and passed it"—without a record of the voting [17].

JCAE Hearings of September 1967

The most recent opportunity for reexamining basic issues was at the JCAE Hearings in the U. S. Capitol on September 12-14, 1967. The hearings provided a review of current procedures [18] and comments were invited on

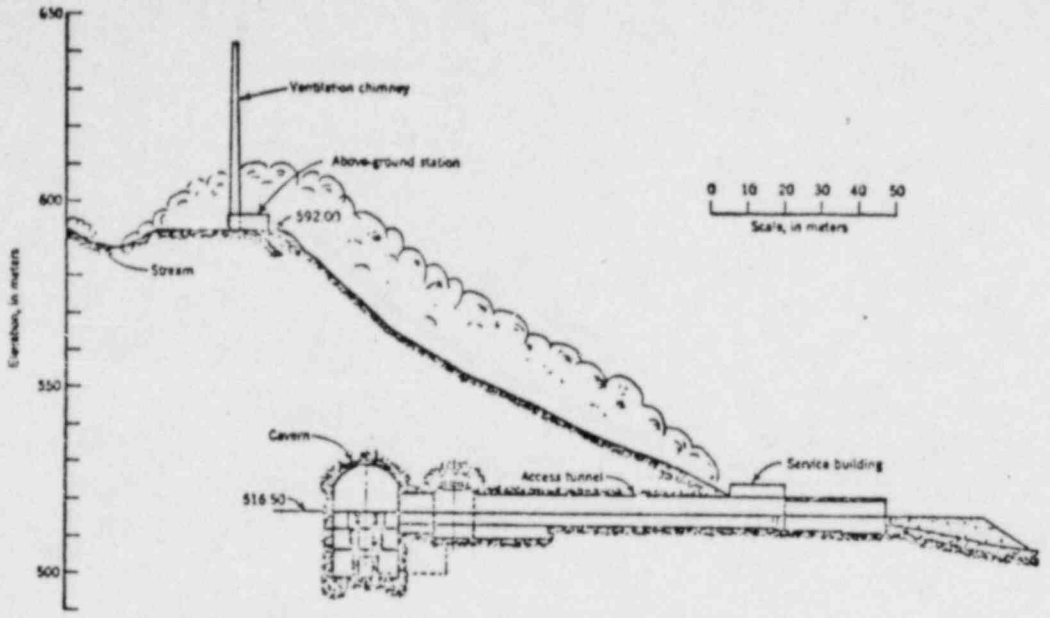
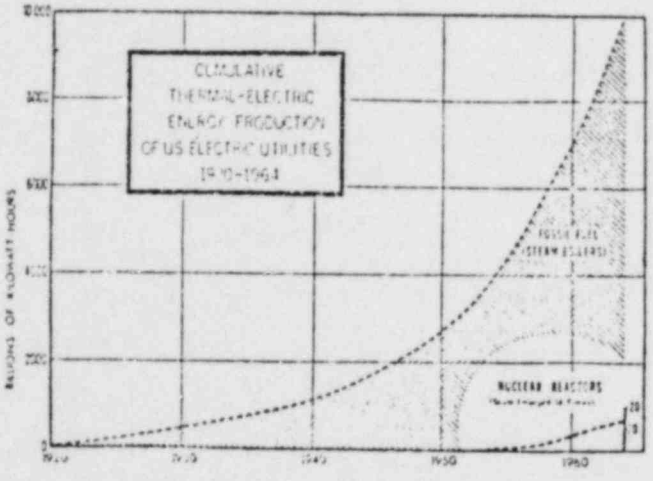


Fig. 3. Underground setting for atomic power plant, Lucens, Switzerland [3, p. 68]. In this design the atomic power plant is located completely underground in solid rock, a well-recognized technique employed for the economic development of hydroelectric power in many parts of the world.

Fig. 2. Cumulative thermal-electric energy production of U. S. electric utilities, 1920–1964 [12, p. 747]. (Note that the scale for nuclear power generation is enlarged 50 times for visibility.)



twelve questions. The proponents of atomic power were there en masse and painted a rosy picture for the future. By contrast, the author's testimony, in essence, covered the following points [18].

1) The AEC's regulatory program (at this stage) cannot be expected to provide reasonable assurance that the public health and safety is not endangered by the operation of nuclear reactors. In this new technology the operating experience is exceedingly small (Fig. 2) in relationship to the magnitude of the peril to the public; in the half-dozen small reactors currently in utility service, the operations have been under constant surveillance by scientists and physicists who have had superior training. However, as in the case of the historical development of steam boilers, *major failures in atomic power plants* eventually will provide important lessons and serve as a guide for future developments.

2) The nuclear industry undoubtedly is taking many important steps in the development of this new technology. But it has not adopted the design and siting criteria which would guarantee complete safety to the public living in the surrounding region. (The feasibility of such siting has been demonstrated by the underground testing of atomic bombs.)

3) A further separation of the AEC's regulatory responsibilities is called for at this time, provided it leaves the ultimate responsibility for public safety with the utility companies, their Chief Engineers, and their insurance companies.

4) The regulatory process would become more efficient if the Price-Anderson Act were repealed and if regulation were based on placing *full* responsibility for public safety on the Directors of the utilities, and on their designated Chief Engineers of the projects.

5) A change is definitely called for in the AEC's policies on siting of nuclear reactors for all regions, whether heavily or sparsely inhabited. It is recommended that the AEC require all atomic power plants to be located "underground." This means, in caverns excavated in solid rock hillsides, as in the case of many hydroelectric projects (Fig. 3). (Such plants could be designed to justify 100 percent commercial insurance protection for third parties, without reliance on the Price-Anderson Act.)

6) It is not feasible to evaluate the . . . reactor safety systems . . . as long as sabotage can release a major radioactive fallout with widespread destruction.

7) Members of the public . . . have very little opportunity to become aware of the problems of public safety. For example, where has an owner of an atomic power plant explained to homeowners that under their insurance policies on their homes they are not covered against nuclear reactions or fallout. . . .

8) In summary, the following recommendations for Congressional consideration were offered:

a) that Congress repeal the Price-Anderson Act;
b) that the insurance companies remove the nuclear exclusion provisions from all homeowners' insurance policies;
c) that full responsibility for public safety be placed on the Directors of the utility company or power agency operating an atomic power plant;
d) that the power company's own Chief Engineer for the project be publicly identified as having the full responsibility for directing the design and construction of an atomic power plant—with the overriding duty to protect the public interest and safety;
e) that atomic power plants be located underground in solid rock.

Lack of Responsible Criticism in JCAE Hearings

The author's testimony reviewed in particular "The Duty to Dissent" and his concern that the Joint Committee, while dealing with one of the most important responsibilities in the history of the world, is being denied the full benefits of "the loyal opposition." In a supplementary communication to the Committee this issue was identified in greater detail, from which the following is summarized [18, pp. 791–794].

The former editor of the official journal of the IEEE has recently reviewed the obstacles confronting an engineer when his conscience dictates that he must record a dissenting opinion where the public interest is at stake. He declared editorially [19]:

> Is it true . . . that editorial space for presentation of an unpopular viewpoint is virtually impossible to obtain in a reputable technical journal? Alas, it is true. . . . Dissenting opinions are likely to be unpopular. . . . Many claim that it is disloyal to protest. Sometimes the penalty—disapproval, loss of status, even vilification—can be severe. The penalty for neglect of this duty, however, can be much more severe. . . .

The responsibilities resting on the Joint Committee on Atomic Energy are tremendous, and the Committee has shown a willingness to hear a diversity of ideas, including forthright criticism and opposition. However, there was a notable lack of critical testimony as may be illustrated by several incidents.

1) A spokesman, claiming to represent "178 investor-owned electric power companies serving more than three-quarters of our nation's rs of electricity," introduced a statement bearing the names of 17 utility executives. Unfortunately, however, some of their declarations were contrary to the disciplines and ethical commitments of the engineering and legal professions. The long-term effect of such high-level initiative is to silence all engineers and lawyers in the private utility industry unless they are prepared to jeopardize their future by challenging the policy commitments introduced by these few but influential executives. As a consequence the process of critical analysis is suppressed on the most important and controversial issue ever to confront that industry.

2) A representative of one of the nation's leading manufacturers of nuclear reactors testified: "We simply could not afford to jeopardize our very substantial investment in this industry, and perhaps in other businesses, by assuming safety risks. I have no doubt at all that the entire industry holds this view." In a matter as important and as controversial as the question of public safety this declaration tends to silence professional engineers and lawyers employed in that industry who should be speaking out against such an "affront to man." This testimony was reminiscent of the notable opinion handed down by Federal District Judge J. Cullen Ganey in 1961 in the Price-Fixing Case [20]:

> What is really at stake here is the survival of the kind of economy under which this country has grown great, the free enterprise system. . . . The conduct of these corporations and individuals has flagrantly mocked the image of the economic system of free enterprise which we profess to the country, and it has destroyed the model which we offer today as a free world alternative to state control, to socialism, and eventual dictatorship.

3) The Chairman of JCAE referred to the fact that "in the Turkey Point licensing proceedings there was considerable discussion of the need for an applicant to make specific provision in design for sabotage or other enemy action." He asked a leading public utility executive [18, p. 779]: "Do you believe consideration should be given in such matters of design of nuclear power plants?" There was no open and forthright answer to this question, although it is one of the most important questions on public safety ever posed in the history of our country. Furthermore, no proposal was offered by this executive to consult the engineering profession which has the ultimate responsibility for public safety.

4) The Chairman also remarked that the Atomic Energy Commission had decided that protection against sabotage was not to be an issue in the Turkey Point licensing procedure. It is interesting to note that this particular rule, applicable to all atomic power plants, was published earlier in 1967 in the Federal Register where it apparently attracted very little attention (February 11 and April 5, 1967). This terrifying rule did not have the benefit of open analysis and debate within the engineering and legal professions. According to the AEC's public document file, only three comments were received, one from a reactor manufacturer concurring in the order, and two in opposi-

tion—one from an independent consulting engineer [21] and one from an independent attorney [22]. (The current rule on the sabotage peril, as an open invitation to catastrophe, is of such great importance that it calls for a separate story.)

IV. New Program of Atomic Power Development

Extending the Price-Anderson Act for another ten years has had the net effect of greatly enlarging the "fourth dimension" in atomic power development—*the perversion of responsibility* and the *abandonment of primary concern for public safety* by various Boards of Directors who decided to join the bandwagon rush into atomic power.

Furthermore, it has opened the door for a new campaign of emotional engineering at all levels. For example, in an effort to brainwash the worried public the management of a national magazine of the "family type" was persuaded to publish a propaganda article on the "New Age" of atomic power, authored by a free-lance writer—a type of article no responsible executive or independent engineer would write. To give the article more "character," it was first "planted" in the official magazine of an international service club of business and professional men, and then "reprinted" for the nation's families.

The latest effort to brainwash the public was a so-called "public opinion" poll in California which reported, "Seventy-three percent agreed that nuclear plants are necessary for additional electricity for California's growth . . . and 64 percent agreed that opponents of nuclear plants spread false rumors and try to scare people." However, apparently none of those interviewed were told that the insurance companies (under a standard "nuclear exclusion clause" in the fine print) specifically deny homeowners compensation in the event of damage from the failure of a nearby nuclear plant.

The more aggressive reactor manufacturers stepped up their sales initiative with offerings of "turn-key contracts" for atomic power plants of unprecedented size; this included all costs of engineering, construction and installation of equipment under an AEC *construction permit*, without knowing in advance whether AEC would ever grant an *operating permit* when the plant is completed. The engineering firms on these projects, in effect, became subcontractors or drafting services and gave up their professional independence and freedom to challenge the merits of such projects. The net effect of all this has been a breakdown in professional disciplines and ethics in this new technology, and a voluntary retreat from the obligation to serve the public safety and interest above all others.

Claims that prospective generating costs from atomic power plants in the years ahead will be lower than from coal- or oil-fired steam plants were disseminated with an abandon reminiscent of the "30-inch yardstick costs" of earlier days. It is nothing short of frightening that in the brief period of 18 months of 1966–1967 a total of 97 large atomic generating units, aggregating 78 000 000 kW, were ordered or projected for installation during the period 1969–1975. Most of these units have ratings of 800 000 to 1 000 000 kW, far beyond any reactor in commercial operation today [23].

This situation has become so serious that the JCAE issued House of Representatives Report 1266 on April 1, 1968, in which it expressed concern about "the bandwagon rush" into atomic power, and warned a portion of the utility industry that it "lacks a full appreciation of the job confronting the utilities at this time."

Need for Return to Fundamentals

In this overpowering new science the experiences of the past decade have demonstrated that the traditional structure of corporate and professional responsibilities has been undermined by revolutionary changes in insurance philosophy and engineering philosophy. Today atomic power technology is in the hands of a small but influential group whose members have convinced themselves that "all is well." Responsible protests are dismissed as being "beyond human credibility"—a kind of dismissal reminiscent of the few desperate protests against the operation of the gas chambers in 1942–1945.

There is a crying need for vigorous and open debate and for freedom of communication to clearly identify the monstrous gamble with human lives which has grown out of the current perversions of responsibility. A reappraisal of these responsibilities is inevitable--the choice being only whether to undertake it now or in the aftermath of a catastrophe.

It would be a sad day if an iron curtain eventually were to descend and keep independent engineers from exercising their judicial professional responsibilities in the areas of public safety. If this were to happen it would mark another step in the relentless trend towards the *technocratic petrification of our nation's freedom.*

V. The Importance of Maintaining Perspective

A New Event in Human History

Today we are confronted with the terrible responsibility of controlling a scientific power great enough to destroy all life. But this power of total destruction is also a power that can be made to serve mankind if it is applied according to the will of the Creator.

The tremendous responsibility of interpreting this power to all the world, along with the duty of determining what is to be done with it in the coming centuries, is presently in the hands of the Joint Committee on Atomic Energy of the U. S. Congress. But it is also a responsibility of the American engineering profession, and this responsibility is of a unique type which no governmental agency or politically constituted body can fulfill. It is the responsibility at the level of professional ethics.

The Overriding Importance of Professional Ethics

Ethics are a product of conscience—on the same level with faith and trust and integrity—and founded on intellectual honesty. Ethics are the dominating influence on the truly responsible engineer. In the past, for example, ethics have provided the self-disciplined guidelines for thousands of engineers in creating the miracle of safe drinking water in the communities throughout America. The people take this standard of service for granted and place their complete trust in the integrity of the engineers. It is a trust which every professional engineer must respect. Knowing more than the people do about the effect his work will have, his first duty is to *serve the public interest above all others*, no matter what his employer may want or what some governmental regulation may permit.

This is particularly important in the revolutionary new technology of atomic power where we are confronted with new responsibilities of unprecedented magnitude, and where there has been no opportunity to develop the requisite rules of law. Chief Justice Earl Warren of the U. S. Supreme Court has alerted us to such responsibilities in these words (forming part of an address delivered on November 12, 1962):

> Society would come to grief without Ethics, which is unenforceable in the Courts, and cannot be made part of Law. . . .
>
> Not only does Law in civilized society presuppose ethical commitment; it presupposes the existence of a broad area of human conduct controlled only by ethical norms and not subject to Law at all. . . .
>
> The individual citizen may engage in practices which, on the advice of counsel, he believes strictly within the letter of the Law, but which he also knows from his own conscience are outside the bounds of propriety and the right. Thus, when he engages in such practices, he does so not at his own peril—as when he violates the Law—but at peril to the structure of civilization, involving greater stakes than any possible peril to himself.
>
> This Law beyond the Law, as distinct from Law, is the creation of civilization and is indispensable to it. . . .
>
> A person able to discern the right in the midst of great confusion and to pursue it, is a person of character. A person may be learned or ignorant; he may be old or young, rich or poor, well or sick; whatever his condition he has to act, and his actions have their effect on himself and generally also on his fellow men.
>
> The education of both ministers of religion and of lay specialists, qualified to help the confused find himself in the maze of ethical problems—in my opinion, one of the urgent needs of Western democracy, as it attempts to preserve its tradition of freedom in competition with rival systems of life. . . .

Modern science has put in the hands of policy-makers a tremendous new leverage in which the mistakes can now be exceedingly large; and the importance of the *ethical* question has escalated accordingly. From this perspective engineers working in the new technology of atomic power owe it to themselves to search their consciences in terms of the following specific guidelines which may be derived directly from our Code of Ethics.

1) It shall be deemed unethical for an engineer to apply his talents and responsibilities to the location, design and construction of an atomic power plant with such a low factor of safety that, in the event of accidental failure or sabotage, catastrophic damage will result to the surrounding region and its people. (Under current official regulations the peril of sabotage may be disregarded in the design and location of an atomic power plant.)

2) It shall be deemed unethical for an engineer to apply his talents and responsibilities to the location, design and construction of a low-cost atomic power plant, with a low factor of safety, on the assumption that, in the event of a major accident or sabotage, the nation's taxpayers will compensate the survivors for damages. (Such compensation is present-day official governmental policy.)

VI. Summary

Today we are struggling with the controversial question of how to apply this revolutionary discovery of atomic energy for the benefit of man. In particular, we are groping for the right answer to the ultimate question of how to convert the energy of the atom into electricity without peril to the public—and without violating the rights of the citizens under our constitutional system of government.

Measured in these terms, our progress, if any, has been feeble, indeed; and the question "*Who* is responsible in the event of a major failure?" is passed around in a vicious circle.

Certainly, all mankind has a right to expect something better than to acknowledge the possibility of a catastrophe and to provide for covering 10 000 graves with a blanket of greenbacks! If the eager prophets who are proclaiming the blessings of atomic power were to examine the other side of their coin, they might see that such a catastrophe (from the failure or sabotaging of an atomic power plant) would precipitate a violent public revulsion against our most important industry and its directors—and ultimately against our entire system of free enterprise for having condoned such an appalling irresponsibility in the application of this new science.

The time has arrived for a thorough review of the disillusioning collapse of integrity and for facing up to the ominous challenge advanced eight years ago:

> An agreed acceptance of a number of consequent disabilities is not an appealing basis for the development, say, of nuclear power. Industry will do better than rest upon such an affront to man.

Our free enterprise system *must* provide a better answer. Atomic power stations as currently designed present a unique and incredible hazard to human life. Where in industry is the leader with the requisite courage and integrity to promote 1) the repeal of the Price-Anderson

Act, and 2) the repeal of the AEC's regulation 10 CFR Part 115 which authorizes the design and location of atomic power plants without complete protection of the public against the perils of sabotage of all types? These two steps alone would go far towards reestablishing engineering and corporate responsibility founded on integrity and on primary concern for the public interest and safety.

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Adolph J. Ackerman (SM'49) was born in New Ulm, Minn., on April 21, 1901. He attended Martin Luther College, and received the B.S.E.E. and C.E. degrees from the University of Wisconsin, Madison, in 1926 and 1933, respectively.

His experience in the planning and construction of power plants includes a six-year assignment in Brazil, where he was in charge of designing and building a million-kilowatt power program including the first large underground hydropower plants in the Western Hemisphere. For a number of years he served the World Bank, making feasibility reports on power developments located chiefly in South America and India. With the advent of the new technology of atomic power he has paid particular attention to the planning and design of underground atomic power plants, and during the past ten years has maintained a comprehensive review of atomic power developments in the U. S. Since 1952, he has been an independent consulting engineer on electric power and water resource development.

Mr. Ackerman is a member of the American Institute of Consulting Engineers, American Society of Civil Engineers, American Society for Mechanical Engineers, Eta Kappa Nu, Tau Beta Pi, and Chi Epsilon. He is a Registered Professional Engineer in the states of Pennsylvania, New York, Tennessee, California, and Wisconsin.

Discussion

Frederic A. Lang (Good Hope Road, Landenberg, Pa. 19530): Engineers have need to know each of the seldom-told stories of public safety problems that are concurrent with great strides forward in technology. Too often the safety aspects of such conquests are hidden by company policy because full public knowledge of potential safety problems would result in precautionary slackening of the rush forward. The author is commended for his personal effort in behalf of public safety and professional ethics.

We should keep forever before us the author's key statement which I quote, "Knowing more than the people do about the effect his work will have, his (the engineer's) first duty is to *serve* the public interest above all others, no matter what his employer may want or what some governmental regulation will permit." Such ethical conduct is our only hope of solving the public safety problems in the absence of specific laws and government regulation.

Corporations by definition are not able to make ethical decisions. Industrial corporations exist for the sole purpose of making a profit. Only humans, including engineers, make the needed ethical decisions. Of course, corporate interest in maximizing the profit from power generation and other business endeavors is under some control by individual engineers who can use their own ethical standards to prevent a mad rush for profits and potential catastrophe. The author properly appeals to these engineers to undertake their professional duty on safety matters.

If members of our profession fail to heed this appeal, they may expect that public safety will thereafter be derived from government regulations designed to protect the public from the dangers of otherwise uncontrolled engineering projects of great consequence. The need for professional societies will be reduced if engineers choose to abdicate their responsibilities to the public on safety problems.

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Alfred Ogram (201 East Copland Drive, Orlando, Fla. 32806): The author has clearly identified the area of professional responsibility under the violently changing conditions that have been precipitated by the advent of atomic power. Heretofore, moral function within the profession has been largely taken for granted under intuitive application of postulates that worked reasonably well under normal conditions. The arrival, however, of this spectacular but insufficiently understood and highly dangerous source of power brings with it the urgent need for a thorough reappraisal of the engineer's overall moral obligation if he is to retain professional status.

The problem is rendered especially acute because of the complications and difficulties resulting from an expansion of the central government. Any realistic analysis, therefore, must take into consideration the many facets of this form of government while reviewing the relationship of the engineer to his profession, to his client, and to the public—the third party to every contract, even though that contract may be only an employer-employee association.

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The prescription for successful voluntary individual conduct has been thoroughly covered by the great religious teachers of history. Engineers are, after all, individuals, and, as such, are subject to personal responsibility for decisions that affect the lives and safety of many other people. Thus they become their "brothers' keeper" by reason of their superior knowledge of the materials and forces with which they deal.

The application of this overriding principle of successful human conduct specifically to the engineer has been well established in its fundamental aspects by Merriman [1], Hoover [24], Ackerman [25], and others. Further development for adjustment to current problems will depend on the degree of courage displayed in answer to the question of how much weight shall be given expediency in view of an increase of central government and its effect on the decision of engineers. Is compromise with principle possible for engineers? Can intellectual honesty be right on some occasions and wrong on others?

We are confronted here with a matter of extreme importance in the development of civilization—of even more importance than the profession itself. For without a fertile political, moral and economic climate, the profession, per se, would cease to exist, and the progress of society would come to a halt—perhaps even ebb—plunging the world into a new dark age.

I refer particularly to the current trend in this country away from the principles of individual freedom, moral responsibility, and personal independence on the basis of which we, as Americans, have been able to acquire the highest standard of living the world has ever known. In place of these bright tenets of progress, we are substituting the dogma of a debilitating collectivism which, if not stoutly resisted, will engulf all the professions, reducing their members to mere technicians and puppets of ignorant or unscrupulous politicians and bureaucrats—who are even now forming a new elite to which all the rest of us will be subservient.

The engineering profession occupies a critically important position in this situation for two reasons. First, without its supporting knowledge and skills, the bureaucracy would be helpless in many areas of prime importance to the furtherance of its aims. Second, the profession, with its very existence at stake, can easily lose by default unless it maintains an aggressively moral and ethical attitude of unswerving integrity in "serving the public interest above all others."

Let us be sure we understand the issue before us. It is *not* whether atomic power should, or should not, be developed. It will be, as the need arises. The timely and vitally important questions are how and where.

The public is constantly being bombarded by massive claims and deliberate propaganda that the "how" is all settled by the offerings of the reactor manufacturers. I am not so sure! The "how" should include due regard for safety of the public, particularly when the basic material is known to be fraught with danger greater than ever before experienced by man. And as long as human beings design and build and operate, there will be mistakes and accidents. Furthermore, any engineer or other person of professional status who lends himself to the planning and building of an atomic power plant without primary dedication to the safety of the public has abrogated his professional responsibility and betrayed his trust to himself, to his profession, and to his fellow man.

The "where" is answered in conjunction with the "how." Why take undue risks when they can be avoided by underground installations as recommended by Ackerman? The

AEC's underground testing of bombs is helping to demonstrate the feasibility of confining atomic fallout under the most extreme conditions, and thus avoid exposing the public to an unprecedented peril.

From the halls of Congress [26] we have been warned that "at any point in history the 'state of the art' imposes definite limits on what is technologically feasible. Failure to probe, define, and recognize these limits leads to the choice of unrealistic and generally overly expensive goals which in turn lead to technical failures." To this Ackerman, on another occasion [26], has added that "the silence of the engineering profession (or the suppression of competent engineering analysis) on these controversial issues has allowed the nation to drift into the present perilous situation. It adds up to an arrogant exploitation of public confidence in traditional professional excellence."

So far as I am aware, this paper by Adolph J. Ackerman is the first on this momentous subject which has been presented to the members of the American Society of Mechanical Engineers. There should be much more discussion of this subject and the time is very late.

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Harold P. Green (National Law Center, George Washington University, Washington, D.C.): As an attorney, I feel no little trepidation in commenting on questions of the professional responsibility and ethics of engineers. I do so, however, because Ackerman's paper deals essentially with a problem which impinges upon a matter of fundamental concern to lawyers as well as engineers: to what societal institutions does the public look for assurance that technology will be practiced in a manner consistent with protection of the health and safety of the public?

At the threshold, it must be recognized that a serious accident in an atomic power plant could result in injury to the lives, health, and property of the public many orders of magnitude greater than might result from any previously known technology. Present national policy encourages and supports development and practice of nuclear power technology because of the enormous benefits which are expected to result. The public is required to assume the risk of a catastrophic accident cheerfully, just as it pays taxes, to support national objectives.

In a normal industry, corporate executives would think twice (at least) before they invested in a technology with such destructive potential because of the enormous public liability which might arise in the event of an accident. From the lawyer's standpoint, one of the functions of legal liability is to discourage extra-hazardous activities. Indeed, it is clear that American industry was unwilling to invest in nuclear power without firm assurance that it would be relieved of all possible liability which was not insurable on an economic basis. Since the insurance companies were unable or unwilling to provide insurance against all but a small portion of the potential risk, the Government stepped in with the Price-Anderson Act which provides positive assurance that no one who might be liable in the event of a nuclear power plant accident will have to bear one cent of liability out of his own pocket. For this assurance, industry pays a nominal annual indemnity fee to the Atomic Energy Commission which is in no way related to the actual risk. In other words, the public is required to assume the very risk which industry refused to assume.

With elimination of the deterrent effect of potential liability, the public's protection must rest with 1) "engineered safeguards" designed to minimize both the possibility and the consequences of an accident, and 2) stringent government regulation to assure adequate safety precautions. But the government regulation is admittedly designed to provide for safety without placing any crippling obstacles in the path of development of this new technology; and because nuclear power technology leapfrogs experience, the "engineered safeguards" find their validity in the predictive judgment of scientists and engineers and not in wisdom derived from experience.

Oliver Wendell Holmes wrote "the life of the law is experience." Although I am no expert in engineering, I suspect that engineering ethics are based, implicitly at least, on the principle that "there is no substitute for experience." The fundamental question which Ackerman raises when he discusses "responsibility" is whether it is right—as a matter of law, of policy, and of ethics—for the public to be required to assume a risk of unprecedently catastrophic proportions on the basis of predictive judgments by experts—who are, after all, fallible humans—where these judgments are not rooted in experience

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Robert L. Whitelaw (Virginia Polytechnic Institute, Blacksburg, Va.): I wish to endorse fully the principal argument advanced by A. J. Ackerman in his paper and, perhaps, strengthen the impact of his paper with this brief discussion.

His principal argument has been confirmed by my own experience of the past fifteen years on nuclear projects and problems of various kinds. This experience included preparing proposals and nuclear hazards evaluations on a variety of nuclear power plants, both commercial and military.[1]

It has been my observation that, despite the enormous amount of meticulous detail which the ACRS regularly requires on every projected power plant to satisfy itself that there is no "credible accident" that can threaten the public (or even the operators) and despite the volumes of paper and hours of presentations consumed on this topic, and no doubt well-intentioned there is still by common consent an unwritten agreement to treat as "incredible" the most fearful of all nuclear accidents that can occur in any plant with a highly pressurized primary system. Such an accident is, of course, the explosive rupture of the primary vessel itself, which is ruled out of the list of credible accidents for the simple reason that there is no adequate answer short of putting the plant underground or inside a mountain, as Ackerman has pointed out.

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[1] Prof. Whitelaw was formerly Project Engineer for the design and construction of the power plant of the N. S. Savannah.

It is true that the AEC requires every reactor builder to give every possible assurance of the integrity of the reactor vessel (not a "guarantee," however!), but much more than this is required to protect against possible failure of all other components and systems. Only the reactor is exempt from secondary protection against an explosive rupture whose hurtling fragments could easily open the reactor to the sky in many U. S. plants today! The question is whether this exemption is wise, especially in the light of the history of explosions in the steam pressure vessel business, despite the best of precautions; explosions that are happily rare, but nevertheless serious, and certainly not guaranteed never to happen by any responsible firm.

The further question, which Ackerman has wisely raised, is why such an issue should not be openly aired and discussed, and the public clearly appraised of its risks.

Finally, despite the current widespread concern (both national and local) over the pollution of our primary resources of air and water, there seems to be a curious silence on the part of government bodies over the long-range menace which the nuclear power industry may well be to both air and water.

On the one hand, we are insisting on long-range planning to restore the purity of our public streams and city air and ocean beaches. On the other hand, those who blithely project that electricity will be almost completely nuclear by the year 2000 - i.e., almost a 100-fold increase over present nuclear power generation - have yet to show any long-range plan by which the prodigious quantities of fuel reprocessing wastes, both gaseous and particulate, can be isolated with absolute assurance.

Is it possible that some of this unwillingness to face squarely *all* the hazards, and *all* the future problems of nuclear power generation, stems from the "atom-bomb guilt-complex," and the "Atoms-for-Peace" mania generated after the war, by which many feel compelled to promote the growth of nuclear power, no matter how great the ultimate cost, as a salve to the national conscience?

Finally, is it also possible that this obsession to see nothing but a nuclear future for the power business may well be blinding the eyes of both management and government, and deterring competent engineering from investigating better and more durable sources of power for the long-range future?