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Harold P. Green

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THE LAW OF REACTOR SAFETY

HAROLD P. GREEN*

Nuclear reactors are devices for creating and controlling nuclear chain reactions. Reactors come in many sizes and shapes and have various uses. The most dramatic and probably the most important use of reactors from the economic standpoint is to provide power in the form of electricity or heat. Some such power reactors may be stationary; others may be mobile, *e.g.*, those which exist to provide propulsive force and hence move from place to place with their vehicle.[1] Other reactors may be used for various industrial purposes such as for the testing of materials. Still other reactors are used primarily for educational and research purposes.

All reactors have safety implications in the sense that radiation is incident to their operation. This means that considerable care must be taken in operation of the reactor to assure that personnel working on or with the reactor are not exposed to dangerous radiation. Such precautions are essentially a matter of sound operating and administrative procedures. Although this phase of reactor safety is extremely important from the standpoint of legal considerations and the public welfare, it is of secondary importance. Of primary concern are the safety implications of reactor operations to the external environment and particularly to those members of society who have not voluntarily assumed the risk of working in proximity to the reactor.

This latter problem relates essentially to the possibility that operation of a reactor may give rise to consequences adversely affecting the health and safety of the general public. Such consequences might arise in the case of normal operation of a reactor if proper safeguards are not taken. For example, radioactive effluents or wastes may be discharged into the atmosphere or into water supplies, and if proper precautions are not taken, this could endanger the health and safety of the public. But the principal hazards associated with operation of a nuclear reactor are to be found in the possibility that the reactor may develop some abnormality in its functioning which may result in the accidental release into the environment of quantities of highly radioactive material. One of the characteristics of nuclear reactors

* Member, District of Columbia Bar; Consulting Editor, CCH Atomic Energy Law Reporter; formerly with Office of the General Counsel, United States Atomic Energy Commission.

1. This article does not deal with problems of reactor safety in such mobile reactors, since their use on a licensed basis is still at least several years off. The legal considerations are, however, similar to those discussed herein for stationary reactors, except, of course, for the complicating factor of mobility.

is that they contain large amounts of radioactivity in the form of fission products, *i.e.*, waste resulting from the fission process, and it is the possibility that these fission products may be released which is the principal reason why reactors are regarded as inherently capable of producing catastrophe. Another inherently complicating factor is that it is difficult to turn a reactor off in the event of malfunction since the fission products continue to generate heat for quite a while after the reactor is shut down.

The design, construction, and operation of nuclear reactors involve extremely complex scientific, engineering, and technical considerations which are far beyond the professional ken of the attorney. It would be useful, however, to describe in brief and highly simplified form some of the technical considerations pertinent to nuclear accidents.[2] Accidents which can produce escape of fission products from a nuclear reactor fall into several distinct categories:[3]

A nuclear runaway: Reactors are capable of attaining extremely high power levels in extremely short periods of time in the event control devices do not function properly. Where a power surge is not adequately controlled and limited, the reactor becomes a runaway reactor. As one eminent authority put it: "[T]he generation of heat can outstrip any conceivable cooling means."[4] Such generation of heat may cause melting, vaporization, or other disruption of the reactor structure. The energy generated would not necessarily produce anything like a bomb explosion,[5] although in some reactors something in the nature of a small "explosion" could result.[6] Danger to the environment results not primarily from the possibility of a violent blast, but rather from the possibility that the runaway may cause sufficient disruption of the system to cause the release of radioactivity into the environment. One of the principal concerns is that fuel elements may melt down with the fissionable material's coming together in such quantity and in such configurations as to cause accidental criticality, *i.e.*, an accidental chain reaction.

Reactor designers guard against runaway reactors in several ways. Adequate controls and instrumentation are, of course, quite necessary.

2. For more complete information on these technical considerations, see MCCULLOUGH, SAFETY ASPECTS OF NUCLEAR REACTORS (1957). A more elementary discussion may be found in SCHWENK & SHANNON, NUCLEAR POWER ENGINEERING 180-189 (1957).

3. This categorization is based upon MCCULLOUGH, *op. cit. supra* note 2, at 139.

4. McCullough, *Reactor Safety*, NUCLEONICS 134, 136 (Sept. 1957).

5. An explosion of considerable violence can, however, result if these events result in exothermic chemical reactions of the kind described *infra*. MCCULLOUGH, *op. cit. supra* note 2, at 140.

6. This would be more analogous to an automobile accident than to a chemical explosion, *i.e.*, portions of the reactor may be propelled "with velocities of a few meters per second." *Ibid.*

In addition it is desirable to have a "negative coefficient of reactivity." When a negative coefficient of reactivity exists, the "insertion" of additional reactivity increases the power and heat generated, which in turn causes certain changes such as expansion of fuel elements which lead automatically to a corresponding decrease in reactivity. Thus, the reactor is self-regulating. A third line of defense against runaway is to assure that the amount of excess reactivity inserted into the reactor is limited and that the rate of insertion is controlled. This can be done by rigid regulation of the rate at which the control rods may be moved and by appropriate precautions in fuel reloading operations. Finally, it is desirable that the reactor be designed in such a manner that disruption of the reactor system in the course of a runaway will shut the reactor down, and that other steps be taken to assure against accidental criticality or other factors which may cause the release of radioactivity outside the reactor.

Failure of the coolant system: All reactors require a coolant system to remove heat from the reactor. If the coolant system fails for any reason, it is not adequate merely to shut the reactor down, since, as has been pointed out, the fission products continue to generate substantial heat. Unless this situation can be prevented or brought under control, the intense heat may cause disruption of the reactor system, melt-down of the reactor, accidental criticality, or other circumstances which may result in the release of fission products. As in the case of the nuclear runaway, an accident of this kind would probably not be a particularly violent event, but it may nevertheless result in substantial hazard through release of fission products. To guard against accidents of this kind two general types of precautions are taken. First of all, the coolant system is made as reliable as possible, and some kind of separate and independent coolant system is provided for standby emergency purposes. Secondly, standby emergency arrangements analogous to fire-fighting equipment may be provided.

Chemical Reactions: Either a nuclear runaway or a coolant failure, or other possible occurrences, may produce a mixing of chemicals in the reactor which could result in a violent chemical reaction of an explosive nature. Thus, the mixing of molten uranium, oxygen, and graphite, of molten uranium and water, or of sodium and air or water can produce a substantial reaction. Designers of reactors must exert great pains to minimize the possibility of such mixings.

Despite all reasonable and prudent precautions to assure that a reactor will "fail safe," and despite the most painstaking administrative control, an accident such as is described above may occur causing disruption of the reactor vessel and dispersion of fission products out-

side the reactor. It is important, therefore, to shield the environment from radiation hazard by enclosing the reactor itself within a vapor shell, *i.e.*, a building which will withstand whatever violent event may occur within the reactor and which will contain whatever radiation may escape from the reactor itself. Even if the force of the accident is contained within the reactor enclosure, however, there is some radiation "shine" or leakage which can have deleterious effects on life outside of the structure. This suggests, finally, that some discretion must be exercised in locating the reactor so that even if there is an accident, the reactor and its containment structure are separated from neighboring populations by an exclusion area belt.[7]

It is generally believed by reactor experts that chances of a major reactor accident "are exceedingly small" and "remote."[8] The possibility was, however, regarded as of sufficiently finite significance to deter private investment in large nuclear reactors until federal legislation was enacted to provide a $500,000,000 program for indemnification of reactor operators against public liability claims arising out of reactor accidents.[9] In 1957, in connection with congressional consideration of this indemnity legislation, the AEC undertook a study of the maximum damage which could be caused by an accident in a typical power reactor.[10] It was concluded, under quite pessimistic assumptions, that in such a single accident: (1) as many as 3,400 persons might be killed and 43,000 injured, (2) property damage might range from $500,000 to $7,000,000,000, (3) people might be killed at distances up to 15 miles, and injured at distances up to 45 miles, and (4) land contamination might extend for even greater distances. At the same time, it was more optimistically stated that in most of the theoretical reactor

7. Former AEC Chairman Strauss has stated that AEC's policy is to require "multiple lines of defenses against accidents" so that "only by means of highly unlikely combinations of mechanical and human failures" could releases of fission products occur. *Hearings Before the Joint Committee on Atomic Energy on Governmental Indemnity and Reactor Safety*, 85th Cong., 1st Sess. 11 (1957).

8. See AEC, *Theoretical Possibilities and Consequences of Major Accidents in Large Nuclear Power Plants*, CCH ATOMIC ENERGY L. REP. ¶ 4036 (1957).

9. The *Atomic Industrial Forum*, the principal spokesman for the nuclear industry, stated in 1957 that the "financial protection problem" was the "major roadblock . . . to broad, effective participation by private industry in the rapid development of atomic power." *Hearings, supra* note 7, at 169. The General Electric Company told the Joint Committee in 1957 that it would halt some of its major nuclear power programs unless indemnity legislation were promptly enacted. *Id.*, at 148. The case was more euphemistically put by Walker Cisler, President of Power Reactor Development Company: "[W]e believe that no one should construct and operate a facility of the kind in question without assurance that the public would be fully protected against all possible incidents." See text at note 62 *infra*. *Hearings Before the Joint Committee on Atomic Energy on Governmental Indemnity*, 84th Cong., 2d Sess. 126 (1956). This legislation was finally enacted as 71 Stat. 576 (1957), 42 U.S.C. § 2210 (Supp. V, 1958).

10. AEC, *op. cit. supra* note 8.

accidents which were considered in the study, "the total assumed losses would not exceed a few hundred million dollars." In addition, it was estimated that the probability of a major reactor accident significantly affecting the public ranged from one in 100,000 to one in 1,000,000,000 per year for each large reactor. Taking the most pessimistic assumptions, it was estimated that if 100 power reactors were operating in the United States there would be less than one chance in 50,000,000 of a given person's being killed in any year by a reactor accident.

It is apparent from the above that, although the likelihood of a major reactor accident is not great, the potential catastrophic impact of any such accident is sufficiently great that consideration of reactor safety must bulk large in the nation's legal framework for controlling atomic energy.

Statutory Provisions on Reactor Safety

The original Atomic Energy Act of 1946[11] was singularly silent on questions of reactor safety. This is not too surprising in view of the fact that this statute provided for a government monopoly, and precluded all private ownership of reactors. Thus, all reactors which were built under the 1946 act or earlier were owned and operated by the AEC and were located at isolated AEC installations such as Hanford and Oak Ridge, which were at a considerable distance from population centers. The AEC, moreover, not being concerned with problems of economic competition, was able to build into these reactors a wide margin of safety since there was no particularly strong incentive to cut costs, especially where cost-cutting would be at the expense of safety.

The Atomic Energy Act of 1954[12] authorized private ownership, construction, and operation of reactors for the first time. Questions of the hazards resulting from operation of reactors were very much in the legislative mind when this legislation was under consideration by Congress. Even a cursory reading of the 1954 act indicates that this congressional concern with safety is reflected in the statutory provisions.

Chapter 10 of the 1954 act prohibits the manufacture, production, transfer, acquisition, use or possession of a reactor without an AEC license,[13] contains the basic provisions governing the licensing of privately owned nuclear reactors,[14] and distinguishes among several types of reactors and licenses.[15]

11. 60 Stat. 755 (1946).
12. 68 Stat. 919 (1954), 42 U.S.C. §§ 2011-2281 (Supp. V, 1958).
13. 68 Stat. 936 (1954), 42 U.S.C. § 2131 (Supp. V, 1958).
14. 68 Stat. 936 (1954), 42 U.S.C. §§ 2133-34 (Supp. V, 1958).
15. *Ibid.*

(1) *Reactors determined by AEC as being "sufficiently developed to be of practical value for industrial or commercial purposes,"* require "commercial licenses."[16] The concept of "practical value" has been interpreted by the AEC to mean economic feasibility,[17] and at the present time it seems unlikely that the "practical value" finding will be made at any time within the next several years with respect to any reactor. Commercial licenses are, therefore, something for the future, and all reactors will be licensed for the next several years under sections 104(a), (b), or (c) which are discussed below. It might be pointed out, nevertheless, that insofar as safety is concerned, the criteria for issuance of a commercial license restrict the issuance to persons "who are equipped to observe and who agree to observe such safety standards . . . as the Commission may by rule establish," and who agree to make available to the AEC such data as it determines to be necessary to protect the health and safety of the public.[18] The AEC is, moreover, expressly barred from issuing a commercial license to any person if in its opinion the issuance "would be inimical . . . to the health and safety of the public."[19]

(2) *Reactors for use in medical therapy* are licensed under section 104(a).[20] This provision includes no affirmative language as to safety, and refers explicitly to safety only in that the AEC is directed to "impose the minimum amount of regulation consistent with its obligations . . . to promote the common defense and security and to protect the health and safety of the public."

(3) *Reactors used in research and development leading to demonstration of practical value* are licensed under section 104(b).[21] As in the case of medical reactors, there is no reference to safety except that the AEC is directed to impose the "minimum amount of such regulations and terms of license as will permit the Commission to fulfill its obligations . . . to promote the common defense and security and to protect the health and safety of the public."[22] As an added wrinkle, however, it is provided that the AEC's regulations for section 104(b) facilities must be "compatible with the regulations and terms

16. 68 Stat. 936 (1954), 42 U.S.C. § 2131 (Supp. V, 1958).

17. Testimony of AEC General Manager Fields, *Hearings Before the Joint Committee on Atomic Energy on Development, Growth and State of the Atomic Energy Industry,* 84th Cong., 2d Sess. 394 (1956).

18. 68 Stat. 936 (1954), 42 U.S.C. § 2133(b) (Supp. V, 1958).

19. 68 Stat. 936 (1954), 42 U.S.C. § 2133(d) (Supp. V, 1958).

20. 68 Stat. 937 (1954), 42 U.S.C. § 2134(a) (Supp. V, 1958).

21. 68 Stat. 937 (1954), 42 U.S.C. § 2134(b) (Supp. V, 1958). All large scale nuclear power reactors now being constructed are to be licensed under § 104(b).

22. Despite this invitation, AEC's regulations do not provide for different degrees of regulation for various types of reactors.

of license" which would apply if a commercial license under section 103 were later to be issued for that type of facility.

(4) *Research reactors* are licensed under section 104(c),[23] and the AEC is directed to impose "only such minimum amount of regulation of the licensee" as it finds necessary to enable it to fulfill its statutory obligations to promote the common defense and security and to protect the health and safety of the public.

It will be noted that, despite the fact that the bulk of AEC administrative law regarding nuclear reactors is concerned with reactor safety, sections 103 and 104 are virtually devoid of standards for reactor safety. The legislative history of these provisions is equally barren. Some further light is, however, cast by those provisions, which deal with judicial review and administrative procedure. Section 182(a)[24] of the act describes the requirements for license applications. In addition to giving the AEC broad authority to determine what information must be included in the application to enable the Commission to determine *inter alia* the "technical qualifications . . . or other qualifications of the applicant," section 182(a) explicitly requires that the applicant state "such technical specifications . . . including the place of the use, the specific characteristics of the facility, and such other information as the Commission may . . . deem necessary" in order to enable it to find that the reactor processes "will provide adequate protection to the health and safety of the public."

It is apparent from the foregoing that the statute does not provide any clear and explicit standard of safety for application in determining whether a reactor license should be issued.

There is a related provision of the act which is not at all helpful in finding standards for reactor safety, but which is the most important provision of the act from the safety standpoint. This is section 185 which provides:

> All applicants for licenses to construct or modify production or utilization facilities shall, if the application is otherwise acceptable to the Commission, be initially granted a construction permit. The construction permit shall state the earliest and latest dates for the completion of the construction or modification. Unless the construction or modification of the facility is completed by the completion date, the construction permit shall expire, and all rights thereunder be forfeited, unless upon good cause shown, the Commission extends the completion date. Upon the completion of the construction or modification of the facility, upon the filing of any additional information needed to bring the original application up to date, and upon finding that the facility authorized has been constructed and will operate in conformity with the application as amended and in conformity with the provisions of this Act and of the

23. 68 Stat. 937 (1954), 42 U.S.C. § 2134(c) (Supp. V, 1958).
24. 68 Stat. 953 (1954), 42 U.S.C. § 2232(a) (Supp. V, 1958).

> rules and regulations of the Commission, and in the absence of any good cause being shown to the Commission why the granting of a license would not be in accordance with the provisions of this chapter, the Commission shall thereupon issue a license to the applicant. For all other purposes of this Act, a construction permit is deemed to be a "license."[25]

This provision contemplates that construction of a reactor will be undertaken pursuant to the provisions of a construction permit, which is essentially a form of license and is treated in all procedural respects as a license. Although the issuance of the construction permit is the principal event in the life of a reactor project since it leads to the investment of very substantial sums for construction of the reactor at a definite location in the expectation that it will be operated after completion of construction, there are no standards for issuance of the construction permit other than that the application is "otherwise acceptable to the Commission."

The construction permit provision of the Atomic Energy Act quite clearly was borrowed from the Federal Communications Act of 1934,[26] which also envisages issuance of construction permits which are to be converted into operating licenses upon completion of construction of radio stations. The legislative history of the Federal Communications Act indicates that the construction permit provisions of that act are intended to prohibit construction of radio stations until a determination is made that an operating license probably would issue in order "to free the licensing authority from the pressure for a license which might be exerted if a large expenditure had been made in the thoughtless anticipation of the granting of the license."[27] This consideration was apparently also in the congressional mind when section 185 of the Atomic Energy Act of 1954 was considered since one or two senators pointed out that a license applicant's expenditure of substantial funds on construction of a reactor pursuant to a construction permit would make it rather difficult for the AEC subsequently to refuse issuance of an operating license.[28] Similarly, industry spokesmen pointed out the necessity for the AEC's making a determination upon issuance of a construction permit that the permit would be more or less automatically converted into a license upon completion of construction, since an applicant could not be expected to invest substantial sums in construction without some assurance that it would

25. 68 Stat. 955 (1954), 42 U.S.C. § 2235 (Supp. V, 1958).

26. 48 Stat. 1089 (1934), as amended, 66 Stat. 718 (1952), 68 Stat. 35 (1954), 47 U.S.C. § 319 (Supp. V, 1958).

27. H.R. REP. No. 1416, 67th Cong., 4th Sess. 4 (1923). Decisions of the FCC have been to the same effect. See *In re WSAU, Inc. and WJIU-TV*, 10 R.R. 402 (1955).

28. 100 CONG. REC. 11196, 12014 (1954) (remarks of Senator Humphrey); 100 CONG. REC. 11560 (1954) (remarks of Senator Jackson).

be permitted to operate the reactor.[29] To allay industry's concern on this point, the Joint Committee on Atomic Energy stated in its report on the legislation that section 185 *"requires* the issuance of a license if the construction is carried out in accordance with the terms of the construction permit."[30]

Although the legislative history of the 1954 act contains a few rather weak references to the construction permit concept as a device for controlling reactor safety,[31] one could certainly not get the impression that this was uppermost in the congressional view in enacting section 185. Nevertheless, it became quite clear, immediately upon enactment of the 1954 act, that the AEC regarded considerations of reactor safety as the paramount aspect of its licensing procedures. It was publicly stated by AEC spokesmen that hazards evaluation would be the major part of the AEC's consideration of license applications, and that the principal test for issuance of a construction permit would be whether the AEC believes the proposed reactor can be safely operated at the proposed site after construction.[32]

Regulations on Reactor Safety

As has been pointed out, the safety standards for issuance of reactor licenses are rather vague, and the standard for issuance of a construction permit (*i.e.*, "otherwise acceptable to the Commission") is about as vague as is possible. Presumably the AEC was expected to establish more definite criteria and standards by promulgating rules and regulations. Thus, section 161(b)[33] of the act authorizes the AEC to promulgate safety standards and instructions governing the possession and use of radioactive material, and section 161(i) authorizes the AEC to promulgate such regulations and orders as it may deem necessary

29. Testimony of Oscar Ruebhausen, *Hearings Before the Joint Committee on Atomic Energy on S. 3323 and H.R. 8862 to Amend the Atomic Energy Act of 1946,* 83d Cong., 2d Sess. 417 (1954); Testimony of E. H. Dixon, Id. at 227.

30. H.R. Rep. No. 2181, 83rd Cong., 2d Sess. 28 (1954). (Emphasis added.) It is clear, despite this language, that conversion of the construction permit to an operating license is far from automatic, and that substantial discretion rests with AEC as to whether or not the conversion will be effected. Thus, in 1957, § 189(a) of the 1954 act was amended to require notice of and a hearing on every application for a license for a major reactor. 68 Stat. 955 (1954), as amended, 71 Stat. 579 (1957), 42 U.S.C. § 2239(a) (Supp. V, 1958). The Report of the Joint Committee on Atomic Energy on this amendment made it clear that such a hearing was to be held on both construction permits and operating licenses. S. Rep. No. 296, 85th Cong., 1st Sess. 24-25 (1957).

31. The strongest authoritative statement was by Rep. Hinshaw, a member of the Joint Committee. *Hearings, supra* note 29, at 118.

32. Testimony of Harold L. Price, Director of the AEC's Division of Licensing and Regulation, *Hearings Before Subcommittees of the House Committee on Appropriations on Second Supplemental Appropriation Bill for 1957,* 84th Cong., 2d Sess. 70 (1956).

33. 68 Stat. 948 (1954), 42 U.S.C. § 2201(b) (Supp. V, 1958).

> to govern any activity authorized pursuant to this chapter, including standards and restrictions governing the design, location, and operation of facilities . . . in order to protect health and to minimize danger to life or property.[34]

Unfortunately, however, the regulations are almost as vague as the statute.

The regulations promulgated by the AEC on reactor licensing[35] include detailed requirements as to the material which must be submitted as part of license applications.[36] Most of the information required of the applicant pertains directly to safety considerations. In addition to data as to the applicant's technical and financial qualifications[37] and a statement as to the earliest and latest dates proposed for completion of the facility, the applicant is required to submit certain technical information in the form of a "hazards summary report." The hazards summary report must include:

> (1) A description of the processes to be performed in the reactor (including quantitative data as to radioactive material to be handled and power to be generated) and the nature and quantity of radioactive effluent expected to result.
>
> (2) A description of the facility based on design criteria in sufficient detail to allow evaluation of the adequacy of measures to minimize danger to persons both on-site and off-site.
>
> (3) A description of the site and the surrounding area.
>
> (4) A description of proposed operating and administrative procedures relating to safeguards against radioactive hazards.
>
> (5) A description of plans for dealing with acts or accidents which might create radioactive hazards.
>
> (6) Meteorological, hydrological, geological, and seismological data necessary for evaluating measures prepared for protecting the public against radioactive hazards.
>
> (7) An evaluation of proposed measures and devices to prevent acts or accidents which would create radioactive hazards or to protect against the consequences should such acts or accidents occur.

34. 68 Stat. 948 (1954), 42 U.S.C. § 2201(i) (Supp. V, 1958).
35. 10 C.F.R. § 50.1-.110 (Supp. 1958).
36. *Id.* at § 50.33.
37. It should be noted that the financial qualifications of the applicant are of great significance from the reactor safety standpoint. Shortly after enactment of the 1954 Act, its principal author, Rep. W. Sterling Cole, who was chairman of the Joint Committee during the 83rd Congress, stated that data on an applicant's financial qualifications might be required by AEC "since construction or operation of a reactor under financial distress might induce the owner to take dangerous shortcuts leading to hazardous conditions." Cole, *Licensing Nuclear Facilities*, NUCLEONICS 29 (Feb. 1955). Other members of the Joint Committee have also stressed that financial qualifications are intimately connected with safety determinations. *Hearings, supra* note 17, at 107-08.

(8) A description of procedures for disposal of radioactive wastes.

(9) A description of means for sampling radioactive stock discharges.

The regulations do not spell out the manner in which these data will be considered by the AEC or the specific criteria by which the safety determinations will be made. In general, the regulations in effect merely repeat or paraphrase the statute, in specifying the standards or criteria for determining whether a license or construction permit should issue. Insofar as reactor safety is concerned, the regulations specify that a license or construction permit will be granted if:

> (a) The processes to be performed, the operating procedures, the facility and equipment, the use of the facility, and other technical specifications, or the proposals in regard to any of the foregoing collectively provide reasonable assurance that the applicant will comply with the regulations in this chapter, including the regulations in Part 20, and that the health and safety of the public will not be endangered.
>
> (b) The applicant is technically and financially qualified to engage in the proposed activities in accordance with the regulations. . . .
>
> (c) The issuance of a license to the applicant will not, in the opinion of the Commission, be inimical . . . to the health and safety of the public.[38]

The regulations also follow very closely, but somewhat expand upon, the statutory language concerning conversion of a construction permit to a license. In essence the conversion will be automatic in the absence of good cause shown to the contrary, upon completion of construction in accordance with the terms and conditions of the permit, "subject to any necessary testing of the facility for health or safety purposes."[39]

Although section 182 explicitly requires license applicants to state technical specifications which will become a part of the license or construction permit,[40] AEC regulations appear to be somewhat more lenient in providing that the AEC "may require the applicant to designate those provisions of his hazards summary report . . . which he proposes be incorporated as technical specifications," and that the AEC will indicate to the applicant which provisions of the hazards

38. 10 C.F.R. § 50.40 (Supp. 1958). This provision contains the basic standards for determinations that a license will be issued. Another provision, 10 C.F.R. § 50.45 (Supp. 1958), says that a construction permit will be issued where the application is in conformity with and acceptable under the criteria for issuance of a license. It should be noted that the quoted material includes a reference to the regulations in part 20. Part 20 defines quite explicitly the maximum exposures to radiation which AEC will permit as a consequence of activities under its licenses, and establishes certain procedures and requirements for guarding against excessive radiation exposure. 10 C.F.R. § 20.1-.601 (Supp. 1958). In this sense the AEC's standards and criteria are well-defined, but the real question in reactor safety is to provide reasonable assurance that these limitations will not be violated through an accident of some kind.

39. 10 C.F.R. § 50.56 (Supp. 1958). The "subject to" clause is, of course, a further indication that the AEC does regard the conversion of the permit to a license as being completely automatic.

40. 68 Stat. 953 (1954), as amended, 42 U.S.C. § 2232(a) (Supp. V, 1958).

summary report will be deemed to become part of the license or permit as technical specifications.[41]

Although the above provisions of AEC regulations are set forth as though they have a present reality and effectiveness, the fact of the matter is that for the most part the AEC presently regards the foregoing standards as inapplicable and uses a rather different set of rules. This situation results from the fact that reactor technology is still in its infancy, and most reactors for which licenses are sought are still in the developmental stage. This means that even though immediate construction of the reactor may be sought by the applicant, the precise design characteristics of the reactor have not yet been finally determined and, indeed, it may be still necessary to perform some experimental work, including reactor safety experiments.[42] The AEC has decided as a matter of policy (although there is no explicit statutory basis for this) that rather than delay construction and operation of reactors[43] until design details are made final and until all of the safety questions have been definitively answered, it will issue construction permits under certain circumstances notwithstanding these uncertainties.[44]

The basis for such action is found in section 50.35 of the AEC's regulations which is inconspicuously headed *Extended Time for Providing Technical Information.* This provision states that:

> Where, because of the nature of a proposed project, an applicant is not in a position to supply initially all of the technical information otherwise required . . . the Commission may . . . issue a construction permit on a

41. 10 C.F.R. § 50.36 (Supp. 1958).

42. As the AEC General Manager put it: "In this era of experimentation and development, the same factors which make it impossible for us to prepare standards and codes, also, with few exceptions, make it essentially impossible for the reactor designer to submit a complete hazard summary report at an early stage in his planning. Adequate hazard evaluation . . . can be made only on the basis of detailed and exact design specifications and operating procedures. The power reactors that are being considered today are still being developed." *Hearings Before the Joint Committee on Atomic Energy on Government Indemnity,* 84th Cong., 2d Sess. 62 (1956).

43. The justification for this is the assumed importance in the national interest of rapid development of nuclear power.

44. The AEC General Manager continued (from the testimony quoted in note 42 *supra*): "We recognized this state of affairs in our regulations and made provisions under which we could issue provisional construction permits prior to the time when we had all of the technical information needed to issue one with no conditions. . . . The applicant may submit the results of his hazard evaluation step by step as a series of preliminary hazard summary reports. . . . Such a permit is, of course, conditional and will not convert to a license to operate until the complete hazard summary report has been submitted, and we have made a finding based thereon that the final design of the specific facility provides reasonable assurance that the health and safety of the public will not be endangered by operation of the reactor in accordance with specified procedures." *Hearings, supra* note 42 at 62-63. Query, however, whether such a "conditional" permit is any more conditional than a permit issued "with no conditions." See note 30 *supra,* and text at note 39 *supra.*

> provisional basis without the omitted information . . . if the Commission is satisfied that it has sufficient information to provide reasonable assurance that a facility of the general type proposed can be constructed and operated at the proposed location without undue risk to the health and safety of the public and that the omitted information will be supplied. . . .[45]

Thus, under this provision, the AEC need not make a finding that a particular reactor with specific safety features can be built and operated at a particular site with reasonable assurance that the public health and safety will not be endangered. Rather, the AEC will permit construction under a provisional construction permit if it finds reasonable assurance that a reactor "of the general type proposed" can be safely operated at the proposed site. Such a construction permit is, of course, made provisional, subject to subsequent submission of the data omitted from the application and final AEC approval of the final design.[46] The AEC has indicated that all construction permits for power demonstration reactors under section 104(b), and "even for many research, testing, and medical reactors" will be of this provisional nature for several years.[47] Use of the provisional construction permit means, among other things, that technical specifications will most probably not be incorporated in the permit upon its issuance, although some may be incorporated from time to time as construction proceeds.[48] In all probability a provisional construction permit will remain provisional until construction is completed and will then be converted directly into an operating license without ever having been a straight "unprovisional" permit of the kind contemplated in section 185.

The distinction between the regular construction permit and the provisional construction permit has some interesting implications. The unconditional permit constitutes an approval by the AEC of the actual detailed design characteristics and safeguards of the reactor, so that even if conversion to an operating license were not automatic, a heavy burden would rest with the AEC if it had qualms about converting the permit into an operating license. The provisional permit, on the other hand, means only that the AEC is satisfied that a reactor of the general type proposed can be safely operated at the proposed location, and that such uncertainties as may exist can and will be favorably resolved as design and construction move forward. The applicant assumes the risk, however, that as new information is developed and new experiments are performed, the AEC may conclude that the reactor is not suitable for safe operation at the location

45. 10 C.F.R. § 50.35 (Supp. 1958).
46. These regulations reflect the substance of what was described in note 44 *supra*.
47. *Hearings, supra* note 42, at 63.
48. See text at note 108 *infra*.

at which it is constructed. The AEC has clearly reserved the privilege in any such case of refusing to convert the permit into a license.[49] The provisional permit does have some advantages to the applicant. It means that the AEC has approved the site in the sense that further information about the site "will not in itself have any bearing on the conversion of the permit to a license;"[50] it means also that construction may proceed and that the applicant's financial and technical qualifications are approved; and, finally, it means that the applicant will receive fuel for operating the reactor during the life of the license.[51]

SAFETY DETERMINATIONS: THE PROCEDURE

Until enactment of the Atomic Energy Act of 1954, the problem of location and safety of reactors was entirely a government problem. The AEC decided what reactors it wanted to construct, where they should be located, and what safety features should be built into them. To assist the Commission in this task, an advisory committee[52] known as the Reactor Safeguard Committee was established in 1947 to provide a panel of recognized experts to review safety studies made by AEC contractors on proposed reactors and to submit recommendations to the Commission.[53] Subsequently the AEC established an Industrial Committee on Reactor Location Problems to "balance the technical and safety aspects of reactor hazards as determined by the Reactor Safeguards Committee against nontechnical aspects giving consideration to such matters as the social and economic impact on adjacent communities. . . ."[54] These two advisory committees were merged into the Advisory Committee on Reactor Safeguards in July, 1953.[55]

49. In one case, that of the application of Power Reactor Development Company (see text at note 62 *infra*), AEC transmitted the construction permit to PRDC with a letter stating in part: "[T]he Commission wants it to be clearly understood that in issuing this construction permit the emphasis is on the fact that it is a conditional one and that the Commission can make no commitment to convert the permit to a license until it is satisfied on all safety matters." JOINT COMMITTEE ON ATOMIC ENERGY, 8TH CONG., 1ST SESS., A STUDY OF AEC PROCEDURES AND ORGANIZATION IN THE LICENSING OF REACTOR FACILITIES 132 (Comm. Print, 1957).

50. Testimony of the General Manager, *Hearings, supra* note 42, at 64. Dr. Frank Pittman, then Deputy Director of AEC's Division of Civilian Applications, stated in 1956 that the provisional construction permit would be issued "at such time as the Commission has become satisfied that the location proposed is suitable for the type and size of the reactor proposed." CCH ATOMIC ENERGY L. REP. ¶ 6601 (1956).

51. Hearings, *supra* note 42, at 63.

52. The AEC's advisory committees are established pursuant to § 161(a) of the act. 68 Stat. 948 (1954), 42 U.S.C. § 2201(a) (Supp. V, 1958).

53. 11 AEC SEMIANN. REP. 143 (1952).

54. 12 AEC SEMIANN. REP. 7 (1952). This committee came into existence primarily to deal with the problem of whether or not AEC should release from restriction certain lands known as the Wahluke Slope which had been regarded a potentially hazardous area because of the operations of reactors at AEC's Hanford plant in the State of Washington.

55. JOINT COMMITTEE ON ATOMIC ENERGY, *supra* note 49, at 27.

This new Advisory Committee has come to be the most powerful and influential group in connection with matters of reactor safety.[56]

During the pre-1954 act period, the proponent of a reactor, usually a major AEC contractor, would develop detailed plans and designs for the reactor and would submit a hazards study to the Advisory Committee. The Committee would usually meet with the proponent of the reactor and other interested persons in what was in effect an informal hearing on the safety considerations. The Advisory Committee, if not completely satisfied as to the hazards report, would make helpful suggestions or criticisms, and might request further data. Finally when fully satisfied as to the safety of the reactor, it would give its approval in the form of a letter to the Commission. Persuading the Advisory Committee of the safety of a reactor was universally regarded as the major and most significant hurdle to be overcome in obtaining a safety determination. All efforts of the reactor proponent in this connection were pointed towards the submission or presentation to the Advisory Committee. So far as is known, the Committee's consideration of these cases was not based on any formalized procedures or standards, but the cases were apparently considered in the light of various informal, unpublished criteria.[57]

After the 1954 act became law and the AEC commenced receiving applications from private parties for reactor licenses, the preexisting procedures were adapted to handle the new type of case, although the AEC recognized that it would have to build up a full time reactor hazards staff of its own and did in fact establish a hazards evaluation staff, which in 1955 became the Hazards Evaluation Branch of the Division of Licensing and Regulation.[58] The Hazards Evaluation Branch works closely and informally with license applicants, even before license applications are filed, in advising and assisting them on both substantive and procedural matters relating to safety of their contemplated reactor.[59] After the application is filed, the hazards

56. Former AEC Chairman Strauss has given "much credit" for the AEC's "extraordinary reactor safety record" to the "strict criteria laid down by our Reactor Safeguards Committee." *Hearings Before the Joint Committee on Atomic Energy on Development, Growth and State of the Atomic Energy Industry,* 84th Cong., 1st Sess. 59 (1955). Similarly, the Joint Committee has stated that one of the main factors in reactor safety has been the "great prestige" of the Reactor Safeguards Committee. S. REP. No. 296, 85th Cong., 1st Sess. 24 (1957).

57. See Chairman Strauss' reference to the "strict criteria" laid down by the ACRS note 56 *supra.* "At the present time there are no standards or criteria for reactor safeguards in the United States. . . . Nevertheless there are standards (or criteria) which are actually being used" by those charged with responsibility for reactor safety determinations. McCullough, *The Experience in the United States With Reactor Operation and Reactor Safeguards,* U.N. No. 1551, Second International Conference on the Peaceful Uses of Atomic Energy (1958).

58. JOINT COMMITTEE ON ATOMIC ENERGY, note 49 *supra,* at 111-12.

59. *Id.* at 106.

evaluation staff works with the applicant in bringing the hazards summary report portion of the application to that degree of completeness which will warrant a submission to and a formal discussion with the Advisory Committee.[60] As in the case of AEC-owned reactors sponsored by contractors, the presentation to the Committee is the culmination of the preliminary reactor safety efforts. This presentation is informal in nature and the proceedings are not public.[61] The Committee then submits its findings and determinations on the reactor to the Commission, and it becomes a basis for the Commission's final determination whether a construction permit should be issued.

Initially, the entire procedure as outlined above was conducted by AEC in an atmosphere of semi-secrecy. The license applications, including the hazards reports submitted by the applicant, were made public by placing them in the AEC's public document room. The interested public did not, however, have the benefit of any official appraisal of the safety characteristics except the AEC's ultimate determination recited in the text of the construction permit that there was "reasonable assurance" as to safety. Neither the findings of the Advisory Committee nor the specific findings of the Hazards Evaluation Branch reached the public eye.

This situation was altered as a result of the proceeding in *Power Reactor Development Company (PRDC)*.[62] This case involved a complicated, multi-faceted issue which can be stated in essence from the safety standpoint in the following manner: The Commission issued a provisional construction permit[63] to PRDC notwithstanding the conclusion of the Advisory Committee that substantial experimental and theoroetical work remained to be performed before it could be concluded that a reactor of the type proposed could be safely operated at the proposed site,[64] and the Commission's own findings of "uncertainty" as to the hazards potential of this type of reactor and

60. *Id.* at 107. The hazards evaluation staff has primary responsibility for safety determinations, and under AEC's present procedures cases will not be referred to the Advisory Committee "where the hazards considerations are fairly well established or where the modifications to existing reactors are such as to introduce little, if any, potential additional hazards." *Id.* at 112. The hazards evaluation staff apparently, however, informally "discusses the safety aspects of the reactor with its advisors (ACRS)." *Id.* at 107.

61. It is common knowledge in the nuclear industry that the Advisory Committee goes to great pains to avoid any formalization of its meetings or anything approaching "on the record" proceedings. Strangely inconsistent with this, however, is the statement of Dr. C. Rogers McCullough, Chairman of the Committee in August 1955, at a public meeting in New York City. He stated that Committee meetings on civilian reactors are open, and invited the audience to attend such meetings. Atomic Industrial Forum, *A Forum Report: Atomic Energy—A Realistic Appraisal* 191 (1955).

62. AEC Docket No. F-16.

63. See note 49 *supra*.

64. The text of the Advisory Committee report may be found at JOINT COMMITTEE ON ATOMIC ENERGY, note 49 *supra*, at 133.

its failure to find that there was "reasonable assurance that [a reactor] of the general type proposed can be constructed and operated at the proposed location without undue risk to the health and safety of the public."[65] Issuance of this construction permit led to considerable political wrangling and to formal intervention in the licensing proceedings by three international unions, who contended primarily that the construction permit was issued contrary to the statute and to the AEC's own regulations.[66]

Largely as a result of its experience in the *PRDC* case, and the concomitant furor, the AEC subsequently revised its procedures so as to provide for limited public disclosure of its safety determinations. Under these revisions, the AEC would not issue a construction permit without either ordering a hearing on the application or issuing notice of its intent to issue or deny the construction permit.[67] Where notice of intent is issued (which is the course the AEC consistently followed), the revised AEC procedures called for the appending to the AEC's notice of a memorandum prepared by the Division of Licensing and Regulation setting forth the salient facts and major factors considered in the case.[68] Insofar as concerns safety, this memorandum was based on the findings and conclusions of the Hazards Evaluation Branch. In addition, the AEC indicated that it would endeavor to rely to a greater extent upon its own Reactor Hazards Branch for advice and decisions on specific reactor safety problems, and that ultimately it would call upon the Advisory Committee for assistance on only the more difficult specific cases, and for assistance in establishing overall safety standards and criteria.[69]

These revised procedures did not, however, satisfy the Joint Committee on Atomic Energy, which pressed for and obtained enactment in 1957 of an amendment to the 1954 act which (1) established the Advisory Committee on Reactor Safeguards as a statutory committee with statutory responsibility to "review safety studies and facility license applications referred to it and . . . make reports thereon . . . , advise the Commission with regard to the hazards of proposed or existing reactor facilities and the adequacy of proposed reactor safety standards, and . . . perform such other duties as the Commission may request;"[70] (2) required that the Advisory Committee review each

65. See construction permit, *id.* at 122. It should be noted also that the permit was issued despite PRDC's failure to submit sufficient evidence to enable a finding as to its financial qualifications. *Ibid.* See note 37 *supra.*

66. The construction permit was issued on August 4, 1956. AEC granted leave to intervene on October 8, 1956. The case is now before the members of the Commission awaiting decision. For a summary of the PRDC case, see CCH ATOMIC ENERGY L. REP. ¶ 11201.

67. JOINT COMMITTEE ON ATOMIC ENERGY, note 49 *supra,* at 110.

68. *Ibid.*

69. See note 60 *supra.*

70. 71 Stat. 579 (1957), 42 U.S.C. § 2039 (Supp. V, 1958).

application for a commercial license under section 103, for a demonstration license under section 104(b), or for a testing reactor license under section 104(c), as well as any other cases specifically referred to it by AEC;[71] (3) required that the report of the Advisory Committee be made public as a part of the record of the hearing;[72] and (4) required that a hearing be held on every license application under section 103 or section 104(b) and on every license application for a testing reactor under section 104(c).[73]

These amendments are clearly intended to compel the AEC to bring reactor safety problems out into the open so that the interested public may have a better idea as to questions of safety in the construction and operation of reactors.[74] Neither the amendments nor the AEC's implementing regulations have, however, altered the procedures followed by the Advisory Committee. Despite the new statutory role of the Committee in the administrative process, the proceedings before it are still off the record.[75] This means that, although the Advisory Committee's report which is made public is probably the most important single element upon which the final safety determination of the Commission is based, there is no mechanism through which a party can attack the basis for the report.

Following issuance of the construction permit, it is expected that the license applicant will continue to furnish safety data to AEC during the construction phase.[76] This is particularly true in those cases in which the construction permit is issued provisionally with substantial hazards report material omitted. Newly submitted data will be reviewed by the Hazards Evaluation Branch, but it is not clear to what extent there will be further submissions to the Advisory Committee. Similarly, it is not clear to what extent the AEC will take formal administrative action during the construction phase. It would undoubtedly be to the advantage of the applicant to obtain AEC approval of various phases of its work as it goes along, if for no other reason than to avoid substantial expenditures on particular courses of action which may not be approved by AEC. There are a number of ways in which the applicant may handle this problem. The AEC's regulations and the construction permits themselves invite submission of additional data and reports from time to time as they become available. Such data may be submitted for the AEC's information only, or they may be submitted in the form of an amendment to

71. 71 Stat. 579 (1957), 42 U.S.C. § 2232(b) (Supp. V, 1958).
72. *Ibid.*
73. 71 Stat. 579 (1957), 42 U.S.C. § 2239(a) (Supp. V, 1958).
74. As the Joint Committee put it: "[W]hen the public is adequately and accurately informed . . . it will be in a better position to accept the construction of any reactors." S. REP. No. 296, 85th Cong., 1st Sess. 24 (1957).
75. See note 61 *supra.*
76. JOINT COMMITTEE ON ATOMIC ENERGY, note 49 *supra,* at 107.

the license application which, it will be recalled, remains in a pending status during construction. In general, the AEC has not taken formal action on such post-construction permit amendments to the application unless action is specifically requested by the applicant. From the applicant's standpoint, amendments to the application indicating the development of new data or a change in design plans strengthen its position and impose a heavier burden of proof on the AEC if the AEC wishes to raise safety questions at a later date, since the construction permit specifies that design and construction are to be in accordance with the license application and amendments thereto.[77] The applicant might, of course, be in an even stronger position if the AEC did affirmatively approve the amendments to the application, but to request AEC approval incurs some risk that the AEC may require a hearing, that other parties may intervene, or that approval may be denied.

Another option which the applicant has is to request that the construction permit be amended so as to incorporate technical specifications. Such action by the AEC would impose an even heavier burden on it subsequently to question on safety grounds the features covered by the technical specifications. Thus in one case, that of the *Commonwealth Edison Dresden Nuclear Power Station,*[78] the applicant submitted the Enclosure Section of the Final Hazards Summary Report, on the basis of which the AEC added a technical specification to the construction permit giving final approval to the reactor containment building. In this case, however, the AEC gave formal Federal Register notice of its intention to amend the construction permit and announced that a hearing would be held on the amendment in the event of a proper intervention.[79]

It should be recognized that there is really never any definite assurance, whether the construction permit is provisional or not, that it will automatically be converted into an operating license.[80] The AEC is responsible for holding a hearing on the issuance of the operating license, and even at this late date it must determine that the operation of the reactor is safe. In reaching this decision the AEC must consider not only the technical design features of the reactor, but also any new basic scientific data which may suggest that some of the safety assumptions are perhaps not valid. And even beyond these considerations, there remain the legal uncertainties bred by sec-

77. The AEC's construction permits have been issued in a fairly standardized form, but the form has undergone considerable evolution. The form now used by AEC for major reactors authorizes the applicant to "proceed to design and construct a facility of the general design concept set forth in the application and amendments thereto without further authorization."

78. AEC Docket No. 50-10.

79. 23 Fed. Reg. 1060 (1958).

80. See note 30 *supra.*

tion 183(d) of the act which makes every license "subject to . . . all of the other provisions of this chapter, now or hereafter in effect and to all valid rules and regulations of the Commission,"[81] and by section 187 which specifies that licenses are subject to modification "by reason of amendments of this chapter or by reason of rules and regulations issued in accordance with the terms of this chapter."[82]

SUBSTANTIVE CONSIDERATIONS

Although there seems to be a general recognition that specific standards and criteria for reactor safety are desirable,[83] very little progress has been made to date in formulating them. This means that designers of reactor systems are required to build safety factors into the selection of site and the specific design features of the reactor without any firm conception of the standards which must be met. It means also that they have very little practical protection against any possible arbitrary action on the part of the AEC. Thus, as a practical matter, a license applicant must acquiesce in whatever safety measures the AEC may order, regardless of cost, and regardless of whether or not the requirement seems reasonable.

In large part the absence of definite standards is attributable to the fact that the industry is still in the developmental stage, and also to the fact that many of the technical questions have not yet been answered with the certainty necessary to translate these answers into definitive standards.[84] Finally, there has been serious concern lest the premature development of quantitative standards stifle the growth of the nuclear industry.[85]

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81. 68 Stat. 954 (1954), 42 U.S.C. § 2233 (Supp. V, 1958).
82. 68 Stat. 955 (1954), 42 U.S.C. § 2237 (Supp. V, 1958).
83. As early as 1955, Dr. McCullough, Chairman of the Advisory Committee took cognizance of industry's desire for a "code so all you would have to do is open the book and find out if you comply with these regulations." Atomic Industrial Forum, *supra* note 61, at 176. Although he indicated then that work on developing standards was contemplated, he testified in May, 1958, that the AEC and the Advisory Committee have not yet "come to grips with specific standards." *Hearings Before the Joint Committee on Atomic Energy on Operation of AEC Indemnity Act,* 85th Cong., 2d Sess. 57 (1958).
84. Dr. McCullough has stated that "a discussion of the unknowns in reactor safety could be lengthy indeed." Among the unknowns to which he referred are: nuclear properties of reactor cores, many aspects of which are known only empirically and cannot be predicted on a theoretical basis; the properties of steel and other metals for nuclear plants; the effect of radiation on reactor materials; the reaction of water with other reactor materials such as aluminum, zirconium, uranium, and thorium; effects of radiation on life; problems of avoiding catastrophe in the event of a major reactor accident; etc. McCullough, *Reactor Safety,* NUCLEONICS 134, 136 (Sept. 1957).
85. "I do want to warn you, sir, that it is dangerous to come to numerical values of these standards too soon because we might stifle the industry." Testimony of Dr. McCullough, *Hearings,* note 83 *supra,* at 57. Dr. McCullough has no objection, however, to "writing such standards as long as it is clearly recognized that they are tentative and interim and must be modified as our knowledge of the field increases." McCullough, *The Experience in the United*

Some conclusions on the substantive law of reactor safety can be drawn by considering the actions taken by the AEC on specific license applications. Since the 1954 act became law, more than seventy applications to construct, acquire, or operate reactors have been submitted to the AEC. It is possible, through analysis of the license applications, the hazards reports submitted by the applicants, and the AEC's actions and memoranda on these cases, to infer some precedents and principles concerning the substantive law of reactor safety.[86]

Most of the seventy-odd applications considered by the AEC have involved research reactors. These reactors are generally small in size and power and, although they do involve potential hazards to individuals in the immediate vicinity, their catastrophe potential is not great. AEC consideration of these applications is, therefore, not particularly enlightening from the standpoint of ascertaining the substantive considerations involved in safety determinations for the larger, more socially significant reactors. These would be primarily power reactors and test reactors. To date the AEC has considered and acted on five applications for power reactors and three applications for test reactors.[87]

It is clear, for the present at least, that the major problem in reactor safety from the standpoint of administrative law is the issuance of the construction permit. In considering whether or not a construction permit should be issued, the AEC really considers the entire range of safety problems and reaches a basic decision as to whether or not the reactor is safe. To date there is little precedent available as to the conversion of the construction permits for major reactors into operating licenses,[88] but it now seems likely that once the reactor is constructed in accordance with the construction permit, reactor safety considerations will tend to relate only to matters of detail and operating procedure. These matters continue to be extremely important from the standpoint of the health and safety of the public, but they are highly technical and individualized in nature and will probably arise and be resolved in sequence. Thus, after construction of the reactor, the applicant will probably seek a license to operate the

States with Reactor Operation and Reactor Safeguards, U.N. No. 1551, Second International Conference on the Peaceful Uses of Atomic Energy (1958).

86. In only one of these cases will there be law developed on the basis of a decision in an adversary case. This is, of course, the *PRDC* case.

87. The power reactor applicants are Commonwealth Edison Company (Dresden Nuclear Power Station) (Docket No. 50-10); Consolidated Edison Co. (Docket No. 50-3); General Electric Co. (Vallecitos Boiling Water Reactor) (Docket No. 50-18); Power Reactor Development Co. (Docket No. F-16); and Yankee Atomic Electric Co. (Docket No. 50-29). In the case of the General Electric Co.'s application, a facility license has already been issued. The test reactor applicants are General Electric Company (Docket No. 50-70); National Advisory Committee for Aeronautics (Docket No. 50-30); and Westinghouse Electric Corporation (Docket No. F-22).

88. The *General Electric Co.* case (Docket No. 50-18) is the only precedent.

reactor for test operation in certain definite stages, proceeding from cautious, extremely conservative operation at the outset to normal, and perhaps somewhat experimental nature later on as each previous step is taken in a successful manner, or appropriate modifications made.[89] It seems rather unlikely at this moment that any significant body of precedent as to substantive safety law on reactor operating techniques will develop within the foreseeable future. At least, there is no such body of precedent now. Accordingly, the following discussion is limited to safety aspects of construction permits.

Neither the 1954 act nor the AEC's regulations explicitly requires a construction permit as a prerequisite to construction of a reactor. Rather, the statute and the regulations merely make it unlawful to "manufacture, produce . . . , acquire, (or) possess" a reactor without an AEC license.[90] Although this language may be sufficiently broad to embrace a prohibition against unlicensed "construction,"[91] the AEC has never given any clear indication as to its view of what constitutes "construction" of a reactor: *i.e.*, does "construction" commence when the land is cleared? When the excavation is begun? When the reactor containment building is erected? Or only when the reactor itself is assembled? In any event, the question may be academic since it is not likely that persons desiring to build a reactor, or at least a large reactor, would risk money even in clearing and excavating at the chosen site without first obtaining AEC's approval in the form of a construction permit.[92]

The problem of site is closely related to the problems of the hazards embodied in the reactor itself, the safeguards against such hazards

89. The General Electric Company has approached the problem in this manner in its power reactor license. As a consequence, it has to date filed more than twenty-five amendments to its license application as it has passed from one stage to another.

90. See text at note 13 *supra*. AEC's regulations merely repeat the statutory language on this point.

91. It seems rather unlikely, however, that these words could be interpreted so as to embrace clearing of land, excavation, and erection of a building in which the reactor is to be placed, as opposed to actual fabrication or assembly of the reactor itself. Unquestionably the AEC has clear statutory authority explicitly to prohibit such construction without a construction permit.

92. In at least one case, a license applicant apparently completed construction of a reactor before the construction permit was issued. In this case, (AEC Docket No. 50-99), the applicant filed its license application on March 27, 1958, to construct and operate a research reactor. Two months later it urged AEC to expedite action since "according to our schedule the facility will be completed and ready for the introduction of special nuclear material (*i.e.*, fuel) as early as July 1, 1958, or as late as July 15, 1958." A month later, June 26, 1958, the applicant again pleaded for prompt AEC action since, it said, the reactor "will be ready for inspection on July 14, 1958." The construction permit was finally issued on September 4, 1958, and recited the earliest completion date as September 4 and the latest completion date as October 15. The operating license was issued one day after the construction permit, on September 5, 1958, and recited that the reactor was constructed in accordance with the terms of the construction permit. There is no indication that AEC regarded anything in this case as a violation of the 1954 act.

built into the reactor, and the nature of the building in which the reactor is contained. For example, if the applicant placed a reactor within a structure which would clearly and absolutely contain the consequences of any conceivable mishap, or if the reactor itself were clearly and absolutely incapable of producing a significant accident, the reactor could safely be located in a highly populated area. On the other hand, an otherwise inherently hazardous reactor could conceivably be located in the middle of a desert without any containment at all.[93]

At one time the Advisory Committee on Reactor Safety applied an informal rule of thumb—a formula for location of a reactor based on its power level. This formula was apparently adequate for siting AEC-owned reactors at AEC installations, but if applied to privately owned power-producing reactors would necessitate location of the reactors at points uneconomically distant from the area served. Thus, of necessity, emphasis shifted to a common sense determination of safety based upon all of the many variable factors which pertain to the safety of a reactor. The principal factors considered are discussed below.

Does the reactor design afford sufficient assurance that accidents which might give rise to hazards will not occur?[94] This involves a consideration of the stability characteristics of the specific reactor type, the adequacy of controls and instrumentation, the safeguards against loss of coolant, the manner in which the reactor will be operated, etc. In most of the cases to date, the AEC has had at the time of issuing the construction permit only a generalized set of data as to the reactor design, since specific design decisions were awaiting research and development or experimental work. The principal factor in the AEC's consideration of these matters seems to have been the prior experience with reactors of a similar type. Thus in most of the cases in which the AEC has issued construction permits, it had some assurance based on previous successful and safe operation of ancestral reactors of the same general type, that a reactor of such a type could be built so as to operate safely. For example, in issuing construction permits to General Electric Company for its Vallecitos Boiling Water Reactor and to the Commonwealth Edison Company for its Dresden Nuclear Power Station, the AEC placed reliance upon "the successful

93. Dr. McCullough stated in 1956 at a Press Round Table on Reactor Safety: "[T]heoretically, you could build any reactor anywhere if you want to spend enough money and work the design in. . . ." Atomic Industrial Forum, *A Forum Report: Management, Economics and Technology for the Atomic Industry*, No. 1, 169, 176 (1956).

94. Quoting Dr. McCullough again: "We must recognize that the only way to be absolutely safe is not to build a reactor at all. . . . [L]et me warn you that we must expect accidents. Much as I would like to, I cannot believe we can be wise enough to avoid all accidents completely." *Id.* at 173.

operation of two separate boiling water reactor experiments at Argonne National Laboratory."[95] Similarly, in issuing the construction permit to Consolidated Edison Company and to Yankee Atomic Electric Company for pressurized water systems, the AEC could rely upon favorable experience with the Nautilus submarine reactor. Again, in issuing a permit to the National Advisory Committee for Aeronautics for a test reactor which "for all practical purposes is identical to the MTR at the National Reactor Testing Station in Idaho," the AEC relied upon more than four years of successful operation of the MTR.[96] Finally, in issuing a permit for a test reactor to General Electric Company the AEC based its decision in point on its finding that the technology of the proposed reactor is "fairly well understood."[97]

On the other hand, in one case[98] the AEC issued a construction permit notwithstanding the Advisory Committee's conclusion that "much information relative to the basic performance of this reactor is not known, and that several specific problems . . . must be satisfactorily solved before anyone would have assurance that operation would be safe," and its opinion that previous experience with this type of reactor "is not wholly reassuring."[99] The Commission issued the permit on the basis of its belief that the unresolved safety problems "will prove to be of a kind that can be satisfactorily resolved within a reasonable time."[100]

What is the maximum credible accident which can result despite all safeguards? "Maximum credible accident" is a term of art which in essence means

> those conditions or combination of conditions whose occurrence is considered credible and for which the consequences appear to be greater than those for any other credible accident.[101]

The "maximum credible accident" is something less than the "maximum possible accident" which is a "combination of inadvertent and deliberate actions which could cause mechanical, chemical, or nuclear events to take place with an energy release sufficiently great to release all or most of the fission products contained in the reactor," the probability of which combinations occurring is "so vanishingly

95. JOINT COMMITTEE ON ATOMIC ENERGY, note 49 *supra*, at 165.

96. CCH ATOMIC ENERGY L. REP. ¶ 11213.

97. CCH ATOMIC ENERGY L. REP. ¶ 11207.

98. PRDC, AEC Docket No. F-16.

99. JOINT COMMITTEE ON ATOMIC ENERGY, note 49 *supra*, at 133.

100. *Id.* at 122. Chairman Strauss characterized the type of reactor which PRDC proposed to construct as "the most hazardous of all reactors." *Hearings*, note 32 *supra*, at 239.

101. Notice of proposed issuance of construction permit to Yankee Atomic Electric Co., 22 Fed. Reg. 6258 (1957).

small . . . as to make it reasonable to assume that, for all practical purposes, they are not possible."[102]

Although the AEC's regulations do not expressly require this, the AEC has in its handling of applications required the applicant to submit a descriptive and quantitative analysis of what the applicant considers to be the maximum credible accident and the consequences of this accident to the health and safety of the public.[103] It appears, however, that the AEC will on occasion issue a construction permit even if it is not completely satisfied that the maximum credible accident postulated by the applicant is valid. For example, the Consolidated Edison construction permit was issued in May, 1956, but as late as April, 1958, the AEC was not satisfied that either the magnitude or the consequences of the maximum credible accident for this reactor had been established.[104] Similarly, the AEC issued a permit to Westinghouse Company for construction of a test reactor despite its dissatisfaction with the maximum credible accident postulated by the applicant, although satisfaction was expressed that when such accident is defined "it will be feasible to contain it."[105] In the *PRDC* case, the construction permit was issued despite doubt as to the magnitude of the maximum credible accident and further doubt as to whether such an accident might breach the containment structure.[106]

On the other hand, it is quite clear that both the Advisory Committee and the AEC would insist upon being completely satisfied as to the maximum credible accident before permitting operation of the reactor and, indeed, before giving final approval to (i.e., designating as a technical specification) the containment structure design proposed by the applicant.[107]

Will the building in which the reactor is enclosed contain the consequences of the maximum credible accident? This question relates to whether or not the walls of the structure will be breached by an explosion in the reactor or by the propulsion of missiles (*i.e.*, pieces of the reactor system) against the walls. It also relates to the question whether, assuming the structure is not breached and the fission products released from the reactor are contained in the building, there will be any hazardous leakage of radiation from the structure. In

102. *Ibid.*
103. Occasionally an applicant, for reasons best known to itself, avoids the use of the phrase "maximum credible accident," and uses alternative formulations. For example, in the *Commonwealth Edison* case, *supra* note 87, the concept "worst reasonable accident" was used.
104. Letter from AEC to Consolidated Edison, April 24, 1958.
105. 22 Fed. Reg. 152, 154 (1958).
106. The Advisory Committee was not satisfied that "no credible supercriticality accident resulting from meltdown could breach the container." JOINT COMMITTEE ON ATOMIC ENERGY, note 49 *supra*, at 134.
107. Letter from AEC to Consolidated Edison, April 24, 1958.

those cases in which construction permits are issued without the AEC's being satisfied as to the maximum credible accident, it obviously cannot be satisfied with the containment. Even in those cases in which the maximum credible accident is accepted by the AEC upon issuance of a construction permit and the AEC believes the containment is adequate, there is some doubt that the applicant can obtain absolutely binding approval of its containment design. This is vividly demonstrated in the case of the Commonwealth Edison construction permit issued in May, 1956. The AEC issued an amendment to the construction permit in March, 1958, incorporating therein as a technical specification the design of the containment structure prepared by the applicant based upon the enclosure section of the applicant's final hazards summary report.[108] The obvious purpose and advantage of having the technical specification is to enable the applicant to invest in construction of the envelope without fear that the AEC may subsequently find the containment inadequate. Nevertheless, even though the AEC did approve an unqualified technical specification, the Hazards Evaluation Branch was not prepared to do so without reservation. Although the Advisory Committee concluded that the maximum credible accident postulated by the applicant was the "most serious which might occur" and that the proposed containment vessel would contain this accident, and the AEC's Hazards Evaluation Branch stated that it knew of "no condition which could lead to a credible accident with more serious consequences" than that postulated by the applicant, the Hazards Evaluation Branch concluded that the maximum credible accident had not yet been "definitively established" and could not be until the design of the reactor was complete.[109] Thus, despite the technical specification, notice is served on the applicant that another look will be given the containment after a definitive conclusion is reached on the maximum credible accident based on the Hazards Evaluation Branch's evaluation of the final detailed design.

Is the site suitable? There are two aspects to the question of site suitability. The first of these concerns the effect of the site upon operation of the reactor and its safety. This requires consideration of the geology, seismology, hydrology, and meteorology of the area. It would be obviously undesirable, for example, to locate a large reactor in an area subject to heavy earthquakes or in an area which might be subject to flooding. It is necessary also that these environmental factors be such as not to compound the normal hazards of operation. For example, the weather and water conditions should be conducive to harmless dispersion of radioactive effluents and wastes

108. 23 Fed. Reg. 1060 (1958).
109. 23 Fed. Reg. 1060 (1958).

rather than to concentration of these in places where they can be hazardous.

As pointed out above, the issuance of the construction permit, even the provisional construction permit, signifies that the AEC regards the site in itself as satisfactory in the sense that no further information concerning environmental factors will have a bearing on ultimate conversion of the construction permit into an operating license.[110] Anomalously, however, the AEC has issued major construction permits despite the absence of complete information as to these environmental factors. Indeed, in some cases, this data has been little more than skeletal or fragmentary.[111] Apparently the AEC regards this type of data as being technical information within the scope of section 50.35 of its regulations, which the applicant "is not in a position to supply initially . . . because of the nature of the project," and which may be submitted after issuance of the provisional construction permit. It would appear, however, that such data is beyond the scope of the AEC's rationale[112] for the provisional construction permit, since difficulties in bringing design of the reactor to finality because of the developmental stage of the industry have no relationship to the applicant's ability to compile and supply the necessary environmental data.

The second aspect of this issue concerns the economic utilization and population characteristics of the area likely to be affected in the event there is a catastrophic accident. At this stage of nuclear technology, when so much remains in the realm of the unknown, there remains the feeling the large reactors should not be located in areas where, if the worst happens, substantial damage to the community at large would result. This feeling, of course, has had to be reconciled with the necessity for permitting power reactors to be placed in reasonably close proximity to the areas which they will serve.[113]

To date most of the applicants for reactor licenses have elected to locate their reactors at sites not in close proximity to population centers. There have been two cases, however, in which the location of a large reactor has been a cause for some concern. In the *PRDC* case, the Advisory Committee was concerned about the location of a partic-

110. See text at note 50 *supra.*
111. PRDC, AEC Docket No. F-16.
112. As described in notes 42 and 44 *supra.*
113. Former AEC Chairman Strauss warned that "inevitably, as more and more reactors are built and used, familiarity will breed some degree of contempt for the dangers." *Hearings, supra* note 56, at 59. AEC Commissioner Libby stated just a little over a year before he voted in favor of issuing the PRDC construction permit that constructing such a reactor in a populated area "requires that the safety of this type of reactor be determined experimentally" probably by "construction of a reasonably similar prototype in an isolated area and the testing of this prototype to determine kinetic behavior." *Id.* at 203.

ularly esoteric reactor type, a fast breeder reactor, at a point which included a population of 2,000,000 within a thirty-mile radius and a population of almost 200,000 within a twenty-mile radius. The AEC issued the provisional construction permit, going to great pains to stress that it was conditional, on the theory that mere construction presented no hazard, that all outstanding safety problems would be satisfactorily resolved, that in any event the AEC would never license operation of the reactor if it were not fully satisfied as to its safety, and that delay in issuing the permit would be detrimental to the national interest.[114]

In the second case, the National Advisory Committee for Aeronautics[115] proposed to construct a large test reactor at a site three miles from Sandusky, Ohio, but in the direction of likely growth of that city, the reactor to be in the center of a half-mile exclusion area with the nearest residence 3,200 feet away from the reactor. The reactor was to be used to test nuclear fuel-bearing components to destruction or near-destruction, and this contemplated use so near a densely populated area was of special concern to the Advisory Committee. The Committee concluded that the National Advisory Committee for Aeronautics experimental program could be conducted in such a restricted manner that no "appreciable hazard" to the public would result, but expressed its apprehension that successful restricted operation of the reactor and the importance of the NACA program to the national defense would lead to pressure to induce a "loosening of restrictions." Accordingly the Committee, without actually disapproving the site, suggested that a site less close to a center of population would be preferable.[116] The AEC nevertheless issued the construction permit on a provisional basis.[117]

One of the members of the Advisory Committee, Dr. Abel Wolman, offered certain independent views. He stated that he would recommend against the site and expressed the view that the applicant should be required to consider alternative sites. "I do not believe that we should freeze on a site in a situation like this merely because the applicant has chosen it."[118] Dr. Wolman has on other occasions suggested that actual construction at a particular site be deferred until the safety problems are adequately resolved, or that in cases of

114. CCH ATOMIC ENERGY L. REP. ¶¶ 6775, 6824 (1956).

115. Government agencies desiring to construct and operate reactors are required to obtain AEC construction permits and licenses to precisely the same extent and in precisely the same manner as private persons.

116. Letter From C. Rogers McCullough, Chairman of the Advisory Committee, to AEC Chairman Strauss, Nov. 5, 1957.

117. 23 Fed. Reg. 5674 (1958).

118. Letter From C. Rogers McCullough, Chairman of the Advisory Committee to AEC Chairman Strauss, Nov. 5, 1957.

doubt as to the site the applicant be required to justify his selection of the doubtful site rather than of some alternative site.[119]

It should be noted that the AEC's determination that a given reactor at a given site is sufficiently safe to warrant its construction and operation does not necessarily mean that AEC has concluded that no one off the site can be injured. On the contrary, the AEC's safety determinations have explicitly recognized that there may be some injury to the health and safety of the public if the maximum credible accident occurs in a licensed reactor. Thus, the AEC approved the technical specifications for the containment structure of the Dresden Nuclear Power Station, in the face of the Hazards Evaluation Branch findings that the maximum credible accident would result in some leakage of radioactivity which could cause some thyroid injury in a small percentage of adults exposed for an eight hour period at the site boundary and some risk of cancer of the thyroid in children similarly exposed.[120] The question, therefore, is not whether or not there is *any* risk to the health and safety of the public, but rather whether the degree of risk is *acceptable.* Here again there are no definite standards.

CONCLUSION

The above discussion is not, of course, a definitive evaluation, analysis, and interpretation of the available precedent, but merely a general assessment of the flavor and content of the precedents. This general assessment suggests that the AEC's case by case, almost *ad hoc,* approach to reactor safety has produced very little in the way of a pattern and quite a bit in the way of confusion. There are nevertheless to be found within these materials the tools of advocacy.

To date the attorneys handling reactor safety problems have shown a disinclination to be advocates in the routine licensing cases. The tendency has been, at least insofar as concerns the material in the public record, for the license applicant to acquiesce in the AEC's determinations and suggestions rather than to resist them in the sense of advocating lesser safeguards or standards as adequate. In part this is attributable to the unknown elements of reactor technology and to the necessity, from the public relations standpoint, of avoiding

119. *Hearings,* note 83 *supra,* at 58. Dr. Wolman, who is head of the Department of Sanitary Engineering at Johns Hopkins University, has said: "The committee now functions on a given site submitted by the applicant. It has always been my judgment that that site may be fortuitous for one reason or another. . . . I frequently am of the feeling that alternative site indications should accompany the applicants *(sic)* report. . . . I often find myself being pushed into a corner of accepting a facility on a location which may or may not be quite acceptable to me." *Hearings Before the Joint Committee on Atomic Energy on Development, Growth and State of the Atomic Energy Commission,* 85th Cong., 2d Sess. 125 (1958).

120. 23 Fed. Reg. 1060 (1958).

responsibility for a possible catastrophe. It is to be expected, however, that this timidity will decrease as the industry matures. In any event the material now part of the public record provides a substantial reservoir of authority and precedent which could serve an applicant well, even at the present time.

One further point need be made. The AEC's existing practice of handling reactor licensing cases on an individual basis without particular regard for consistency or precedent may be conducive to maximum development of reactor technology at the present time. Such an approach is not, however, consistent with the long-term development of a sound body of administrative law which would furnish a basis for sound economic judgments on the part of the nuclear industry. It is likely that such rules of the game will not commence to be developed until pressure from industry in reactor licensing proceedings before the AEC forces the AEC to follow, distinguish, or explicitly reject precedent in its safety determinations.[121]

121. A possible alternative, of course, is to amend the act so as to establish some more definite criteria and standards for reactor safety, and so as to make more explicit the meaning of some of the licensing procedures. In particular, the nature and significance of the construction permit might well be clarified.