8/1/61

COMMENTS ON SITE CRITERIA

received as of July 25, 1961

A copy of the proposed Part 100, published for comment on February 11, 1961, is attached for reference, following the comments.

August 1, 1961

A/295

Comments on Site Criteria

Symbol	Date	Organization	Respondent
UPa	2/16/61	University of Pittsburgh, Institute for Urban Studies	William L.C. Wheaton
NEDH	2/27/61	Cancer Research Institute, New England Deaconess Hospital	Shields Warren
MA	3/2/61	Maritime Administration, U. S. Dept. of Commerce	Thomas E. Stakem
LADWP	3/7/61	City of Los Angeles Dept. of Water and Power	Ivan L. Bateman
TOAEC	4/5/61	USAEC, Tokyo Office	W. Herbert Pennington
AERP	4/6/61	Atomic Energy Research Project (U. of Michigan Law School)	Lee M. Hydeman
AIF(1)	4/6/61	Atomic Industrial Forum	W. Kenneth Davis
DFAI	4/18/61	Submitted by Atomics International from article in Deutscher Forschungsdienst	J. J. Flaherty
ORNL	5/1/61	Oak Ridge National Laboratory	J. A. Swartout
NYDH	5/2/61	State of New York, Dept. of Health	James H. Lade
FPB	5/5/61	French Power Bureau	D. C. Lefebvre, Sr.
NSPC	5/5/61	Northern States Power Company	Earl Ewald
PP&L	5/5/61	Pennsylvania Power and Light Co.	Jack K. Busby
ASA	5/11/61	American Standards Association, Sectional Committee N6	M. C. Leverett
BAAPC	5/25/61	Bay Area Pollution Cdntrol District	Spencer Duckworth
SOC	5/29/61	Socony Mobil Oil Company, Inc.	Dayton H. Clewell
ConEd(3)	5/31/61	Consolidated Edison Co. of New York	J. F. Fairman
JAIF(3)	6/1/61	Japan Atomic Industrial Forum, Inc. (Submitted to U.S. Atomic Industrial Forum)	Seinosuke Hashimoto

Symbol	Date	Organization	Respondent
NMPC	6/2/61	Niagara Mohawk Power Corporation	M. H. Pratt
AC(3)	6/6/61	Allis-Chalmers Manufacturing Co.	H. Etherington
AI(2)	6/7/61	Atomics International	W. L. Sequeira
AEP	6/8/61	American Electric Power Service Corporation	Philip Sporn
BECH(3)	6/9/61	Bechtel Corporation	W. Kenneth Davis
WEST(3)	6/9/61	Westinghouse Electric Corporation	Charles H. Weaver
APPA	6/13/61	American Public Power Association	Alex Radin
PEC	6/15/61	Pennsylvania Electric Company	Louis H. Roddis, Jr.
ACRS	6/16/61	Advisory Committee on Reactor Safeguards - Testimony to JCAE	Theos J. Thompson
GE	6/16/61	General Electric Company	George White
ARF	7/6/61	Armour Research Foundation	Fred Kremer, Jr.
JAPC	4/14/61	The Japan Atomic Power Company	Daigoro Yasukawa

(1) The Atomic Industrial Forum has submitted a subsequent proposed revision to the Site Criteria, incorporating their comments more comprehensively. Accordingly, the comments expressed in the April 6 submission are not included herein. The extensive revision proposed by AIF has been reprinted and circulated, and is not included herein, because of its length.

(2) Atomics International has submitted a proposed complete revision, reflecting their comments and recommendations. It is reproduced herein at the end of this document.

(3) These organizations stated explicit concurrence with the views expressed in the revision proposed by the Atomic Industrial Forum.

Comments on Reactor Site Criteria*

I. General Comments

LADWP: "The proposed guides are considerably more definitive than the ones published on May 23, 1959, and are quite helpful. We suggest, however, expecially in the case of proven reactor designs that you qualify even further the limitations proposed. Particularly we would favor the use of qualifying numerical factors rather than words. Where precise factors cannot be determined, perhaps upper limits or maxima could be supplied."

AERP: In our judgment the criteria are a distinct improvement over the criteria issued on May 23, 1959.

The format of treating the criteria as "proposed guides" is commendable since it would seem undesirable at this stage in the development of reactor technology to issue rules establishing precise criteria on any one aspect of reactor safety, and particularly on the difficult matter of siting such facilities. Of course, mere use of the term "guides" may not accomplish the desired results of permitting regulatory flexibility and of avoiding the implication that the criteria set forth are intended to be definitive rules. Moreover, there is some confusion as to just what is intended because of the use of the word "criteria." In a regulatory context, a criterion connotes something more definitive than a guide. To avoid any possibility of confusion, it might be well to use the term "guide" in place of the term "criteria" throughout the document.

Another difficulty with the proposed guides is the retention of, and emphasis placed upon, the concept of a maximum credible accident. It is difficult for us to discern how a maximum believable accident can be identified with the kind of precision which the proposed rule appears to contemplate. Moreover, at least in the case of engineering test reactors the less serious, and also less remote, accidents would appear to be more important factors in the determination of site than the single accident deemed to be the maximum credible accident. As an alternative, we would suggest consideration of a requirement that each applicant be required to identify the various types of accidents which are credible for the particular type of reactor being proposed. The applicant also could be required to identify the worst of these possible accidents, but the safety determination should not be predicated solely on the worst accident. The Commission should be able to provide guidance for the kind of accidents to be considered.

ORNL: The Commission's attempt to make available to the public an AEC guide for its evaluation of proposed sites for nuclear reactors is to be commended. Such a criteria guide could eliminate some of the guess

* All statements are direct extractions from comments received.

work and speculation on the part of the uninitiated as to what the Commission regards as important in its site evaluations. At the same time, as the Commission is aware, the criteria should not be so restrictive as to remove the incentive for the development of inherently safer reactor systems and improved safety features including containment techniques other than the containment vessel.

The proposed criteria guide establishes the exposures which constitute the upper limit of the hazard to the health and safety of the public which would be "permitted" as a consequence of the "maximum credible reactor accident." We believe that this is the most important achievement of the proposed guide even though we do not agree with some of the values presented.

We also believe, however, that the proposed guide in its present form is overly restrictive and that it has certain other shortcomings. More specifically, it is written so as to preclude its applicability to reactors other than water reactors and to containment techniques other than pressure containment. In addition, the most important deficiency of the guide is the arbitrary establishment of "population center distances" without relating these distances to allowable population exposures. An immediate consequence of such a policy is to preclude, out of hand, the operation of a mobile reactor (as the NS Savannah) in a populated area.

Although we endorse the intent and some of the content of the proposed guide, we recommend that the guide not be released unless the specific modifications, discussed under the appropriate headings below, are incorporated.

It is apparent throughout the proposed guide that it was written for a specific class of reactors and a specific type of containment. This is unfortunate since reactor types and design features, as well as kinds of containment, vary substantially from one installation to another. The inclusion in the criteria of several sample calculations for different types of reactors with various kinds of containment would avoid the implication that all reactors must have the same containment provisions and are subject to the identical maximum credible accident (mca). Such a presentation would also have the advantage that it would identify some of the important, different factors associated with other reactor and containment types. In addition, the AEC should clarify its position with regard to the extent to which special safety provisions may be allowed in ameliorating the consequences of accidents, e.g., the emergency spray cooling of a reactor core, recirculating filter systems within the container, etc.

The proposed criteria state that one of the basic objectives is that in the event "a more serious accident should occur, the number of people killed should not be catastrophic." The accident in question here is defined as that "not normally considered credible." All the good that might be derived by the criteria will be undone if the reactor

designer is to be left with the objective that some incredible unspecified accident should not kill a "catastrophic" number of people - whatever that number might be considered to be. One may infer from the criteria that the population center distance requirement resolves this problem as far as the AEC is concerned. It is, nevertheless, important to define the problem, i.e., the incredible accident which must be considered, and the exposures (both individual and population) which would be considered acceptable for that accident. It must be that there are other satisfactory solutions than the "population center distance," else the Savannah would again be excluded from New York Harbor.

The preoccupation with the maximum credible accident would appear, by definition, to be completely justified as far as public safety is concerned if not as regards plant operability. Thus, reactor accidents are contained so that the resulting off-site exposures cannot exceed the prescribed values. If the installation has waste-disposal facilities, hot fuel storage and handling facilities, hot maintenance or analytical facilities which are outside the containment provisions of the reactor installation, the potential accidents in these facilities should also be evaluated. It is apparent that the maximum credible accident in these facilities should not be as catastrophic as the maximum credible reactor accident, but there are at present no restrictions as to the location of these supplemental services relative to the site boundary. The small activity releases from such accidents may, however, result in substantial exposures to nearby persons including those off-site. Furthermore, it would appear that accidents in these supplemental facilities although less severe would have a much greater probability of occurring than the maximum credible reactor accident. Accordingly, we believe that the allowable exposures from these "minor" accidents should be much less than that from the reactor mca. We would suggest that the maximum occupational quarterly exposures (i.e., 3-rem whole body, etc.) be employed as the design limit for occupational workers and that 0.1 of this be employed as the design limit for an individual at the site boundary. The suggested exposure limits for the various parts of the body are tabulated below.

TABLE I

Maximum Exposure for Nominal Radiation Accidents

Part of Body Exposed	Exposure to Occupational Workers (r)	Exposure to Public Residing Near Controlled Areas (r)
Bone	7.3	0.73
Skin and thyroid	8	0.8
Total body and gonads	3	0.3
Other organs	4	0.4

NYDH: We feel that establishing some guide for reactor sites is desirable.

NSPC: In the statement of considerations, and elsewhere, the proposed guide emphasizes the necessity of the use of judgment in the application of the criteria and the impossibility of exact calculation. Elsewhere, however, language is used which appears to set definite limits. For example, in 100.11(a)(3) "... at least 1-1/3 times...", we believe there are facilities already licensed which may not meet these arbitrary minimums, although full consideration of all the related factors would undoubtedly confirm the initial judgment that they are safe. In view of the intense interest and potential controversy surrounding the interpretation of these guides, it seems to us that the inclusion of these definite minimums may cause difficulties to both the operator and the Commission.

PP&L: We believe that the guides outlined in the proposed criteria are most desirable for preliminary evaluation of potential reactor sites.

ASA: The Steering Committee of the American Standards Association Sectional Committee N6 wishes to establish as a matter of record its general acceptance of the "Proposed Guides" dealing with reactor site criteria which appeared as 10 CFR Part 100 in the February 11, 1961 Federal Register. The Committee feels that the Guides represented are a great improvement over the "Notice of Proposed Rule Making" which was published in 1959.

The Guides should be reviewed in the light of the recent SL-1 incident and consideration given to further prudent relaxation of siting restrictions based on experience gained on this incident.

An effort should be made to establish the trade-offs which can acceptably be effected between engineering safeguards incorporated in the reactor system and the various distances specified in the present Guides.

It is important to emphasize that increasing the key distances is not the only acceptable method of achieving an acceptable degree of safety for the construction of a reactor of a given power level.

SOC: We concur fully with the basic objectives as stated there.

The question, of course, is how to achieve these valid objectives while still permitting practical reactor siting for commercial use and therefore for public good.

ConEd: We believe the attempt to establish limitations for a "maximum credible accident" is the major positive feature of the proposed guide. However, we believe the AEC proposal has a most important omission which is absolutely necessary; that is, a relationship between "once-in-a-lifetime dosage" from an accident and the size and density of the "population at risk." We feel that there obviously is a relationship between dosage and population, and that this can be defined in some relatively simple

mathematical way. Recognizing fully that the establishment of proper dosage limits to the population is a complex determination best made by the Commission and its experts, we are nonetheless including a sample graph relating dosage and population, together with an accompanying explanation of the assumptions, as a sample of what appears to us possible and desirable. The attached graph with its accompanying explanation is designated as "Reactor Siting Evaluation - Once-in-a-Lifetime-Dosage Criteria." In setting up this graph, we have established limits both for whole body dose and for iodine dosage to the thyroid based upon the numerical values given in the proposed guide. We believe the applicant for site approval should be required to demonstrate that both of these limits would be met. Moreover, if any other radioactive isotopes would be released in a reactor accident in concentration sufficient to result in hazard to the public, limits should be set for these isotopes which the applicant would also have to meet.

With the permissible dosage in the case of a maximum credible accident defined, the suitability of the site in the event of such an accident rests on the adequacy of the construction when related to the meteorology, geology, seismology, and hydrology of the site to safely contain, control and eventually dispose of the products of the accident within these limits. These then become matters of submission to the AEC and subject to their determination as to the adequacy of the assumptions concerning the cause and consequences of the accident and the adequacy of the plant construction and the natural features of the site.

JAIF: <u>The proposed regulation attempts to regulate quantitatively the site evaluation, but it would not be equal to evaluating site in which such fractuating factors as reactor type and environmental conditions of the site are introduced</u>.

The proposed regulation appears to give quantitative criteria for evaluation of sites. If reasonable, quantitative regulation for site evaluation would lead to simplification of procedures of actual site evaluation and might be, as far as it goes, desirable. With the current stage of nuclear development taken into consideration, such an attempt would inevitably invite many oppositions. It is essentially impossible to try to incorporate into a uniform quantitative criterion all such factors as particular property, safety designs and site environments of each reactor plant. The only way to make it possible would be to cover all conceivable cases by assuming a hypothetical accident which approximates theoretical upper limit. Such appears to be the case of the proposed regulation of the Commission. Assumption of this type, it is true, is conservative and stands on safer side, but this proposed regulation would prove too uniform to be practical for such reactors with improved safety designs helped by rapidly progressing nuclear technology. Until it becomes possible to have a working quantitative regulations, we hope that the regulation allows for case-by-case evaluation for proposed sites.

Although Notice of Proposed Guides says that the criteria "are utilized as guides in evaluating proposed sites" it leaves room for some doubts that they are as effective as regulation. At any event, their legal nature is not very clear.

It is remarked that the proposed criteria are utilized as guides in evaluating proposed sites. Although this could be interpreted as meaning that they aim at identifying a number of factors considered in evaluating such proposed sites, these criteria are regarded by the Commission as federal regulation, which, like other AEC regulations, might exercise as powerful a binding force. The nature of the proposed criteria still remain ambiguous. For instance, Sec. 100.11 which provides that "an applicant should assume a fission product release from the core as illustrated in Appendix "A", ..." is considered to be mixing regulation with guides and appears contradictory. Although an explanation that the numeric values employed in the regulation are "guides" which are essentially flexible could meet the above argument, a fear could not be denied that those figures come to be fixed in the mind of general public and the authorities. It would also be exceedingly difficult to attempt to revise the figures once set forth. Such an inclination towards fixing originally flexible values has been well experienced in the case of many regulations of almost all the countries. Experiences teach us that regulations should be so made as to allow case-by-case evaluation of proposed site until it becomes possible to make quantitative judgment helped by reasonable knowledge and information.

We hope that the regulation be flexible enough to eliminate fetters of fixed values and at the same time be expressed by clear-cut and definite terms.

Our basic approach to the proposed regulation on site criteria will be summed up as follows:

The three principles which the proposed regulation refers to as the basic objectives to be achieved under the criteria are generally acceptable. Considerations given by the Commission to the effect that the extent of hazards caused not only by credible accident but also by serious accident which is not normally considered credible should be minimized are also found reasonable.

The core of the problem, however, lies in to which extent we should assume the size of accidents in actually evaluating sites for reactors. Although the provisions of the proposed regulation do not refer to this, an example of calculation given in Appendix "A" as "a means of obtaining preliminary guidance" seems to reveal the Commission's approach to this point.

Such an approach of the Commission as we see it is as follows: The appendix contains an example of calculation for a "serious accident of a hypothetical reactor" and no such expression as "maximum credible accident" is employed here. In this connection, it is reminded that Dr. Clifford K. Beck presented to the Winter Meeting of the American

Nuclear Society held in San Francisco last December a paper which contains a proposal for site criteria almost similar to the AEC proposed regulation. In his paper, Dr. Beck defines an accident based upon similar assumptions to that of appendix "A" to be "maximum credible accident." However, since maximum credible accident has its proper assumption for each specific plant according to reactor types and safety designs, the accident illustrated in appendix "A" should be interpreted not as maximum credible accident but as "hypothetical" one. This inevitably leads us to regard the accident as illustrated in the appendix "A" as literally hypothetical and not as a maximum credible accident.

It is our opinion that the basic approach to setting forth site criteria should be based upon maximum credible accident of each specific reactor taking into consideration its safety features. This will be by far more practical and flexible a method than all-put-in-together system in that the former allows much consideration of property, safety devices and operation technics of each specific reactor. Undoubtedly it is admitted that one difficulty with this approach is how to link maximum credible accident with a hypothetical accident or hypothetical release which has to be taken in consideration with respect to "serious accident not normally considered credible" when we attempt to evaluate the extent of hazard to general public. However, this is a matter of judgment which has to be left for insight and discretion of the agency. With sufficient specialized knowledge, wisdom and fair-mindedness on the part of hazard analyses and those who check on such analyses, this method will lead to the best, if not absolute, conclusion for each specific case of accident based upon knowledge and information presently available. If we define such serious accident as exceeds the scale of maximum credible accident and release of radioactivity caused thereby or assumed separately under the amount of radioactivity release of maximum credible accident respectively as "hypothetical accident and hypothetical release for evaluation of public hazards," they will offer basis for fixing values of low population zone distance or population center distance.

Although it remains undeniable that a certain degree of ambiguity of such a method will possibly raise a number of arguments in evaluating acceptability of each proposed site, this method, by leaving much room for efforts to be made by reactor constructors to work out such safety design as will meet requirements of the proposed site, will help progress nuclear technology and develop atomic industry.

NMPC: The Guide has been useful to us in connection with preliminary site analysis studies made by us.

We are in agreement that the siting requirements of each nuclear plant should, as stated in the Guide, be determined, among other considerations, on the merits of its particular design, including the specific meteorological conditions of the particular site. We believe the Guide, as it now stands, accomplishes to a large degree, its intended purpose in that it identifies in a reasonable manner certain of the major siting factors which must be considered during these early stages of reactor development.

As experience is obtained on nuclear plant operation more quantitative data will become available. A regulatory Guide of this nature can, therefore, in this respect, become quickly obsoleted by the rapid advancement of the art. In order to prevent the continued usefulness of this Guide from being affected adversely as time goes on, it is assumed that the Guide will be updated periodically to alleviate, as warranted, the obvious economic disadvantages encountered in locating nuclear plants away from load centers.

AC: We are in complete accord with the recommendations to be made by the Atomic Industrial Forum and are a party to those recommendations.

In addition we would suggest that under the introductory paragraph headed "Statement of Considerations," paragraph (b) and the last two sentences of paragraph (c) be deleted.

AI: Need for Flexible Guides

The formulation of general criteria, methods and factors which must be considered in the evaluation of reactor sites could stimulate the growth of the nuclear power industry by encouraging the development of sites for future reactor installations. At the same time, the formulation of proper criteria will prevent unnecessary expense and activity by industry in site selection and development and will provide suitable motivation for industry to pursue the development of reactor technology.

It is obvious that the types of information required in site evaluation and the methods of evaluating such information are evolutionary items. Therefore, it is not possible at this time to list explicitly either all the factors or the specific methods for treating the factors required in site evaluation. This is recognized in the "Statement of considerations" of the Proposed Guides. Therefore, in the adoption of any set of guides or criteria, it is imperative that they be so written as to permit flexible administration. Such guides or criteria should specify that nothing therein shall obligate the Commission to approve or disapprove any reactor site because such site meets or fails to meet the criteria set forth in the guides. Additionally, applicants for a construction permit are free to demonstrate to the Commission the applicability and significance of site criteria other than those set forth in the guides.

Site Evaluation to Establish Design Criteria

The primary objective in the establishment and use of guides for reactor site evaluation is the prevention of serious injury to persons offsite and excessive exposure of large numbers of persons in terms of total population dose should any credible accident occur. In the Proposed Guides, a hypothetical reactor has been used, and from a consideration of the characteristics of the reactor, the site and its environs, methods are given to calculate distances which are designed to accomplish this objective. If it is possible to base site criteria on considerations

of a site and its environs, and very general reactor data, as is done in the Appendix A to the Proposed Guides, then it is also possible to determine for a given site an acceptable release of radioactivity (from a reactor or any other source) and to use this information to establish one of the design criteria for a reactor.

Since site selection for a reactor depends on many factors other than the type of reactor (e.g., a primary determining factor in selecting an electrical power station site by the utility industry is power needs), it is more logical to establish a maximum radioactivity release for a site than to select a site on the basis of an assumed release.

Approached thusly, there is no need to assume "a fission product release from the core" as provided in Section 100.11 (a) of the Proposed Guides. Rather, an exclusion area, a low population zone and population centers will be known for a given site, independent of an assumed radioactive release, by virtue of such facts as population distribution and density at the site, the area under full control of licensee, and the avenues of egress from the site and its environs. It is then possible to determine, from the meteorological characteristics of the site and its environs, for each area the radioactivity release at the site that will give the radiation exposure acceptable for that area, as defined in the guides. The worst combination of meteorological conditions at the site will be assumed in making the above determination. The radioactivity release that will give a radiation exposure acceptable in all areas will then be selected as the maximum radioactivity release for the site.

This approach assumes a definition of the radiation exposure acceptable in a population center as distinct from the Commission's proposed establishment of a distance which such a center must be from the site. We would define an acceptable radiation exposure for a population center in the same terms as acceptable exposures are defined in the Commission's Guides for the exclusion area and the low population zone.

The maximum radioactivity release determined for the selected site would be one of the design criteria for any reactor to be located at such site. Accordingly, the reactor designer would be obliged to design the reactor facility so that reasonable assurance could be given that the facility can be built and operated so that any maximum credible accidental release of radioactivity would not exceed the maximum radioactivity release established for the site. The reactor designer would be free to utilize safety factors intrinsic to particular reactor types and to apply advances in reactor technology without restrictions relating nuclear power to distance.

Under our approach, any references to or assumptions of reactor characteristics need not be included in the Guides. Accordingly, Sections 100.2 (b), 100.10 (c), 100.11 (b) (1) and (2), and Appendix A and all references thereto would be eliminated. The manner in which this revised approach would be applied is exemplified in Enclosure 2.

Review and Approval Procedure

Under the approach recommended above, prior to selection of a reactor type, a prospective applicant would evaluate the site selected and

determine design criteria for any reactor to be located at such site. Such evaluation and determination would be subject to review by the Commission.

Thereafter, applicant would demonstrate to the Commission reasonable assurance that the reactor designed for the selected site could be built and operated to satisfy all site criteria. The characteristics of the proposed reactor and the extent to which its design incorporates well-proven engineering standards and unique or unusual factors, having a significant bearing on the probability or consequence of an accident, would all be considered. Commission approval of design at this stage would result in issuance of a construction permit.

Finally, the Commission would review the as-built facility to determine that the design criteria approved had in fact been met. Granting of an operating license would proceed in fundamentally the same manner as at present.

Statement of Considerations

We believe that the basic objectives in establishing guides for site evaluation can be stated more succinctly and in a manner at once clearer and less alarming to the general public.

Objective (b) of the Proposed Guides is not clear because the phrases "not normally considered credible" and "the number of people killed should not be catastrophic" are subject to a considerable range of subjective interpretation. In addition, the latter could provoke public alarm without need.

The last two sentences of objective (c) of the Proposed Guides seem to imply that, regardless of the reactor type or design or of the inter-relationships between population distribution and density, special safety developments, and distances, power reactors can never be located in or very near large cities. Further, it is implied that the Proposed Guides are not adequate in some cases. Since it is believed that these implications should be avoided, it is suggested that the last two sentences in objective (c) be deleted.

It is recommended, therefore, that the basic objective in the establishment and use of the Proposed Guides be stated as:

> "Serious injury to individuals offsite should be avoided and the exposure of large numbers of people in terms of total integrated population dose should be low, if any unlikely, but still credible, accident should occur."

AEP: The proposed guides represent in one respect a desirable improvement over the proposal published by the AEC two years ago and on which I commented in my letter to you of August 21, 1959. They establish upper limits on the radiation dosages to which members of the public should be exposed in the event of an unlikely but still credible nuclear incident. This feature of the proposed guides will, I believe, prove helpful to the industry. But I continue to find the proposed guides disappointing in

their emphasis on isolation and population factors, and particularly in their failure adequately to stress the relationship between these factors and the engineering design and safeguards of the particular reactor facility.

While there would be some advantages to the nuclear power industry in having a set of reactor site criteria which could be applied as a rule of thumb to all reactor concepts, this cannot be the case as long as reactor concepts are in different stages of development, have different accident potentials, and may have altogether different engineering safeguards. We need to bear constantly in mind that engineering safeguards can often compensate for unfavorable site characteristics. We must be extremely cautious that in our zeal to assure the safety of the public we do not penalize those reactor concepts for which the technology is well-known and those facility designs which are conservatively engineered by establishing site criteria which meet the requirements of less well-known concepts of less conservative designs. We must be careful also in establishing site criteria not to freeze site requirements on the basis of today's knowledge and technology. Until we have more knowledge and experience with nuclear plants, we must necessarily be conservative in evaluating the likelihood of serious accidents and in our calculations of radiation exposures that might result. At the same time site criteria need to be flexible enough to allow for growth in our knowledge and experience. Assumptions about accidents and their consequences which prudence requires us to make today are likely in time to prove either unrealistic or too conservative.

Statement of Considerations. Subparagraph (b) of this statement should, in my opinion, be deleted. It implies that even after all credible accidents have been considered, some further factor of conservatism of undefined proportions needs to be applied to site evaluations against the contingency that a "more serious incident not normally considered credible" might occur. It requires that reactors be so located in such event that "the number of people killed should not be catastrophic."

The wording of subparagraph (b) is unfortunate and may give rise to unjustified public apprehensions. But the main difficulty with the subparagraph as a statement of objectives is that it is so lacking in definition as to be unworkable. I see no alternative in evaluating reactors and their location than for experts to come to conservative conclusions as to the types of accident which might occur, including the maximum nuclear incident which is plausible enough to warrant consideration, and to base their safety determination on this judgment. The proposed guides will in practice provide very little guidance if licensing officials are expected to apply some further undefined margin of safety in order to take care of unidentified contingencies which technical experts do not consider credible.

I suggest deletion also of the last sentence of subparagraph (c). The preceding sentence states that the Commission is considering establishing, for large population centers, lower limits on maximum dosages than those contained in Section 100.11; if so, it is entirely appropriate to advise potential licensees of this fact. It does not follow, however, as stated in the last sentence, that this will necessarily result in

greater population center distances than suggested by the proposed guides. Engineering safeguards and other considerations may more than offset distance factors. In any event, the potential dosages to which population centers might be subjected, and not arbitrary distances, should be the determining consideration.

BECH: We believe that the formulation and publication of criteria by the Commission is useful to industry and encourage the Commission to continue this effort.

We believe that the general form and approach used in the proposed criteria is logical and of value to those contemplating the construction of nuclear power plants. Such a guide will be of most use at the time that reactor types, alternate sites and general engineering features are under consideration. The Criteria must recognize the importance of the protective engineering features which will or can be incorporated into the design without at the same time requiring engineering details which will only be available at the time of preparing the definitive design. The Criteria should also be sufficiently flexible to take account of experience and new data as these are developed.

Site selection is a major factor in the initiation of new nuclear power plants, which in turn, is generally recognized as an important national goal. The modifications which we suggest are intended to allow for future improvements through design and operating experience and to avoid public dispute on the intent of the proposed guide.

We have worked closely with the Atomic Industrial Forum Reactor Safety Committee and wish to indicate our support and approval of their recommendations.

WEST: Westinghouse has participated in an Atomic Industrial Forum group which studied the proposed guides. This group has prepared a redraft which was forwarded to Mr. Harold L. Price by Mr. W. Kenneth Davis on June 6, 1961. The information submitted in this letter and its enclosures are consistent with Westinghouse views on the subject and we will make no further comment.

APPA: I would like to note that the Commission's efforts to develop industrial process steam reactors also appear to raise questions about the consistency of AEC's proposed guides on site criteria. As you know, it is not economically practical to transmit steam for long distances. In most cases, it is necessary that the industrial plants using process steam be located closely around the steam-producing plant. The Commission's distance-from-population criteria for reactors seem to us incompatible with the Commission's expenditures of time and money for the development of process steam reactors. This seeming incompatibility raises the question of whether the Commission intends to modify its reactor site criteria in order to enable process steam reactors to be used and, if so, what such modifications would mean in respect to future power reactor site criteria.

A statement of general Association policy on atomic power adopted by our Board of Directors in 1956 stated that "the atomic power industry and

related activities should be regulated with scrupulous care and impartiality to protect at all times the public health and safety." Consequently, we would support whatever site criteria are necessary to safeguard the public health and safety.

At the same time, the great majority of local public power agencies are municipally owned systems, and so the Association hopes that the site criteria for nuclear power plants will not make it economically impossible for large numbers of the municipal systems to utilize nuclear generating units when they are developed to the point of economic practicality.

There seems to be some conflict between these two positions. The Commission's proposed site criteria require nuclear power plants to be located some distance from the edge of a populated area, and for municipal power systems this distance requirement introduces costs and operating problems which in many cases would be prohibitive.

These distance requirements may well be necessary and prudent during the present developmental phase of power reactor technology. However, they should be recognized and established as criteria for this phase, and not regarded as necessarily establishing the pattern for nuclear power plant location for all time. Recognition of this fact might diminish considerably the concern with which many view the current and proposed requirements for locating reactors some distance from large or concentrated populations.

From our standpoint it would be most unfortunate if the proposed site criteria led to a conclusion at this time that nuclear power plants will always be impractical for those many municipal systems which cannot afford to locate their generating units a long distance from the edge of the city. We would hope that by the time economic plants have been developed, the technology would have advanced sufficiently to allow some easing of the distance criteria.

We recommend, therefore, that the AEC site criteria guides state explicitly that the criteria are those necessary or desirable during this developmental period -- that AEC will continue efforts to develop plants which are inherently safe enough so that at some future time distance from population may be less important -- and that the criteria therefore are subject to change in the future as the technology evolves and as further experience is gained in the design, construction and operation of nuclear reactors.

The lack of population control in the vicinity of a reactor once the site has been approved and the license issued, and the seemingly different philosophies which AEC applies to stationary and civilian ship reactors appear to us to raise basic questions about the site criteria applying to the proximity of reactors to population. In raising these questions, we do not mean to imply that we are opposed to the separation of reactors from population centers. We do believe that whatever criteria are applied should be reasonably clear, consistent and enforceable.

ACRS: This is the second attempt to write a suitable set of guides on the subject and, even in this case, the Committee is strongly of the belief that this document whould be treated only as flexible guides. The difficulties which have beset this one attempt serves to point out the folly of early regulation of the technical aspects of reactor safety without laying the preliminary groundwork.

You will note also that the document recognizes tacitly that the ACRS and the AEC as a whole are not as yet completely willing to trade distance for engineering design. This is a reasonable position at this stage in the development of the atomic energy industry and in view of the projected future population growth.

The intent and desire of the ACRS is that this be a very flexible document and that deviations from this document should be allowed in cases where an applicant can show that his design or his siting of the reactor leads to a safe situation. In fact, the ACRS would like to encourage applicants to come in with deviations in those cases in which they believe that a valid reason for deviation exists. It also recognizes the need for differentiation between reactor types, uses, and method of operation. For instance, the differences between test and power reactors can be considered in this way. Let me emphasize again that the ACRS is very anxious that the industry as a whole be governed by a flexible guide which will permit growth and development of the industry in a most natural and straightforward manner. We deplore the present tendency to state in the form of precise regulations technical matters which, if defined legally, become completely unacceptable technically.

In connection with the development of these site criteria, it is interesting to point out that the atomic energy industry itself has a somewhat schizophrenic approach to the subject. On the one hand, they would like, and in fact some members of the utility industry insist upon, guidance in the selection of sites in a simplified form such that they can, with some surety, take options on land and develop sites unobtrusively so that real estate exploiters will not take advantage of the situation. This is an understandable motive and one with which the ACRS is very sympathetic. At the same time, other members of the reactor community, and in fact in some cases even the same members, are anxious that the site criteria not be too restrictive so that they will be able to develop new sites which may be closer to major population centers. It is difficult, if not impossible, to state a simple, straightforward set of guidelines with numerical values without at the same time making these rather flexible and quite restrictive. Therefore, it is and has been the ACRS position that this proposed regulation should be viewed as a guide and not, in a true sense, as a regulation.

GE: General Electric welcomes the development of site criteria as a useful step in the direction of making reactor regulation more predictable and less burdensome. Reactor regulation must move in the direction of standardization in order to avoid becoming a major bottleneck when a significant fraction of all new power plant additions will be nuclear. We recognize that the transition from the present pattern of regulation on a case-by-case review basis to regulation by standards must come gradually, and that regulation by standards cannot completely supplant individual review. Preservation

of flexibility in the regulatory process is of great importance, particularly at the present stage of the nuclear business. However, the need for flexibility should not let us lose sight of the crucial importance of developing standards. Because the development of standards is a difficult and time-consuming task, it is desirable to start now.

We fully concur with the statement of purpose in Section 100.1 of the Commission's proposed site criteria that "it is not possible to define such criteria with sufficient definiteness to eliminate the exercise of agency judgment in the evaluation of these sites...." Nonetheless, the issuance of site criteria now can accomplish two useful purposes. First, they should enable a utility contemplating the construction of a reactor to make at least a preliminary determination whether a proposed site is likely to be acceptable for a reactor designed with customary safety features. In the favorable case, such a preliminary determination should be possible without extensive engineering work and prolonged consultation with AEC. A negative indication, on the basis of the site criteria, should not be regarded as conclusive. It would, however, mean that detailed engineering work and consultation with AEC would be necessary before it can be determined whether the site is or can be made acceptable, because of the range and variety of engineering features which may be available to compensate for site deficiencies.

The second purpose which would be served by issuing site criteria of admittedly limited value would be to provide a basis for their development and improvement. In the regulatory area, as well as in the technical area, much "development work" is required. In both areas, actual experience is likely to lead to the fastest progress.

To permit the site criteria to be improved in the light of greater knowledge and experience, periodic revision should be required. Such revision should take place at intervals no greater than two years. We regard the inclusion of such requirement for periodic revision to be of the greatest importance.

We endorse the development of site criteria and agree that criteria should be published at this time. The criteria should provide for periodic revision.

We welcome the recognition by the Commission of the limitations of site criteria: published criteria cannot eliminate the exercise of agency judgment.

ARF: We have no objections to the proposed regulations.

II. Specialized Comments

MA: It is assumed that these siting guides were also not intended to apply to nuclear ships. If this assumption is correct, it is requested that an amendment be made to the notice of February 11, 1961, to the effect that the SAVANNAH is not subject to these criteria and that the guides are intended for land-based reactors only.

Otherwise, since the Commission has applied certain parallel procedures for licensed reactors to the SAVANNAH, the public may very well assume (at the forthcoming public hearing, for instance) that the proposed guides would also be applied.

TOAEC: The reactor site criteria guides that were issued by USAEC February 10, 1961, under press release No. D-38, have caused quite a reaction among the Japanese concerned with the development of atomic power. They are particularly concerned about the numbers given in the table on the last page wherein exclusion distances from population centers are recommended. The general consensus has been that if these criteria were applied in Japan, they would be very hard pressed to find any suitable sites for the type of power reactors that they plan to build.

DFAI: (Note: The following was submitted by AI. It is a partial translation from the German Newsletter "Deutscher Forschungsdienst," April 5, 1961, pp 68, 69.)

An appendix to the ground rules gives a table which contains distances up to the boundary of the "exclusion area," the "low population zone," and the "distance to cities," calculated under certain assumptions considered as normal and determined according to the thermal output of the reactor concerned. Accordingly, a nuclear power plant of 200 electrical megawatts would not be allowed closer than 20 km (abt. 14 miles) to the boundary of a population center of even not more than 20,000 inhabitants. Since no reactor operator wants to dispense from the outset with the possibility of a future increase of the plant output, as is common practice also for conventional power stations, the safety distance of the site would have to be enlarged right from the beginning. It would mean a job for a population statistics expert or geographer to find areas in Europe with a minimum distance of 20 km away from the nearest population center of 20,000 inhabitants, while at the same time meeting the natural requirements for the construction of a nuclear power plant, e.g. cooling water availability, connection to high-tension grid system, etc. In this context it should be emphasized that according to the AEC proposal such site criteria will be applied only to proven reactor systems, whereas reactor of a more novel design should be put up only in remote areas, according to American standards.

In view of the fact that in the Federal Republic of Germany - because of the lack of own experience - people have to resort largely to results developed in the United States, and considering further the general tendency here to adopt American precautions regarding radiation protection and reactor safety in a more stringent rather than a more lenient interpretation, then an almost frightening outlook will result. If the new proposed ground rules of the AEC were to become obligatory in the U. S., and were subsequently taken over by the EURATOM signatories, it would prove difficult to pinpoint any suitable site at all for larger nuclear power plants.

Once before, a similar "Notice of Proposed Rule Making" issued by the AEC in May 1959, along lines met with surprisingly strong echo and criticism. At the time, the said publication provoked comments from about one hundred interested parties whose rejection of the site criteria was almost unanimously supported by the argument that - if the proposed rules were enacted - this would entail a serious obstacle to the further development of uses of nuclear energy. Moreover, it was too early yet to set up any specific criteria and consequently the ground rules would be bound to base largely on assumptions, since experimental or practical experience had not been available in the past. Now the AEC appears to be of the opinion that such experience has been accumulated meanwhile. There is reason to believe already at this stage that the new attempt to spell out and lay down a procedure for firm principles to determine proposed reactor plant sites, will meet with the same reactions as previously, during the 120-day period when objections may be raised.

In any case, also we in the German Federal Republic will have to deal with these concepts and principles in a serious and thorough manner. Primarily, we will have to make sure that in this field no precedential decisions are taken which will jeopardize a continued growth of the German nuclear industry, where there is no genuine need for such decisions.

ORNL: The application of this criterion to mobile reactor installations is much more than just an academic question since the advent of nuclear-powered shipping. Whatever the motives may be for permitting a nuclear-powered military or merchant vessel to sail into populated harbors, the AEC will be called upon to define the relative hazard in terms of the site criteria which it has established for stationary reactors. If it is indeed essential to public safety that nuclear reactors not be located near populated areas, then it is likewise essential that nuclear merchant ships not be permitted in populated harbors. The feasibility of nuclear ship propulsion can be proven just as well operating from a Yorktown area as can the feasibility of a stationary nuclear power plant at an isolated location.

An examination of the ultimate hazard from the NS Savannah has led us to the conclusion that the Savannah may be safely operated in a populated harbor. With comparable containment provisions, it would appear likely that any stationary nuclear plant could be situated in as close proximity to a population center with no greater risk to the public.

In view of the relative hazards of stationary and ship nuclear plants, together with the stated Navy and Maritime programs for their nuclear vessels, one may well ask what ground rules are nuclear ships to be judged by and why. Although Navy vessels may be dismissed from further consideration here on the grounds that national defense may justify some risk, the NS Savannah cannot.

The use of the population exposure concept rather than the questionable derived concept of a "population center distance" resolves the problem for mobile reactors and at the same time properly identifies a basic element in reactor hazards evaluation. Thus the NS Savannah may safely enter the New York Harbor because both the maximum individual exposure and the total population exposure which would result following the mca are acceptable. In a similar manner, these two conditions may be satisfied for any reactor in any location unless the ground rules for credible accidents are to be changed (see below)

JAIF: The proposed guides on reactor site criteria published by the United States Atomic Energy Commission on February 11 this year has brought about a great deal of repercussion among the related quarters of the Japanese industry.

We consider that it is now a sort of world wide common sense that in the field of nuclear energy even domestic legislations cannot be made without influencing or being influenced by the situation abroad.

It is recalled that during Diet deliverations on the legislation of Atomic Hazard Indemnity Law in Japan some number of comments were offered by the United States, - an example of such a prevalent common sense. No doubt, such comments were accepted by us as useful instruments in formulating more fitting law in that field.

It is in conformity with this approach that we are this time offering our comments on the proposed regulation.

It is imagined that the approach of the proposed regulation, if enacted as it is, will most probably be applied to Japan mechanically so that only very little room will be left for flexible working mechanism. This is told from the past experiences. Then, it is easily imagined that undue importance will be impressed upon the mind of general public over the population-distance relations, without allowing considerations for reactor design and environmental conditions which per se have a great deal to do with siting evaluation.

Traditionally, there is found in Japan a trend to claiming that such criteria should be severer than the most severe ones, - an inclination justifiably arising from the people's sentiments over safety of nuclear energy forged through experiences of atomic explosions in and out of Japan.

We are, as you know, working on a program to introduce U. S. type nuclear power plants. If such criteria as proposed by the AEC should come to have practical, if not legal, effects on the minds of general public, the program will have to be affected and the cooperative relations between Japan and the U. S. nuclear industries would be greatly jeopardized.

The regulation formulated in the United States which takes leadership in the related matters has a deep effect on Japan. It has been extremely difficult in Japan to secure a land of wide area for reactor site due to her high population density, and at the same time with frequent danger of earthquakes the site problem has been the target of heated arguments with respect to reactor installation. Research and its findings in the United States which leads the world in the field of reactor development are apt to be promptly employed in such arguments. The site problem is not free from this, either.

It would, therefore, be an unavoidable sequence that the site criteria of our country will be greatly influenced by that of the United States if it has been effectuated as regulation.

In the light of the above, we earnestly wish that the proposed regulation, taking into full consideration the basic approach to site criteria we will explain in B of this comments, would be made more flexible, easier to be utilized by designer, constructor and operator of reactors and would employ more difinitive expressions so as not to create any misunderstanding on the part of the general public.

APPA: There seems to be another inconsistency, as far as remoteness from population is concerned, in the Commission attitude in respect to nuclear-powered civilian ships, which the Commission and the Maritime Administration are attempting to develop. If such ships are to be of practical use, presumably they will have to enter populous harbors on a regular basis, and this implies a different policy for mobile reactors than for stationary reactors despite the greater possibilities for accidents with the former.

To illustrate the point, if one applies the examples cited in Appendix "A" of the proposed criteria to the 70,000 thermal kilowatt U.S.S. Savannah reactor, it should be surrounded by a controlled exclusion area of more than 800 feet in radius and by a "low population zone" about 1.6 miles in width, and should remain at least 2.1 miles from the outer edge of any large city. Obviously, no such requirements are contemplated.

I recognize that the Savannah has been designed and built with special features to enhance the inherent safety of the power plant and, furthermore, that a ship would be in port and near population only intermittently. Nevertheless, the Navy apparently believes that its nuclear-powered vessels, also designed for maximum safety, require special operating limitations. Last year, Admiral H. G. Rickover testified that the Navy has been issued orders that "there must be an actual military or national necessity before a nuclear ship can go into a populated harbor."

It is not clear why the Commission should have what seems to be a different attitude toward distance from population for civilian nuclear ships than it does for stationary reactors.

JAPC: The proposed regulation has been drawing a great attention in Japan from the general impression the readers receive therefrom.

Japan is densely populated, and, therefore, it makes exceedingly difficult to procure land of wide area, and additionally Japan is constantly jeopardized to the danger of earthquake - all these leading to hot argument in selecting the site of reactor. Under such circumstances prevailing here, it is very likely to see any result of research or survey made in the States, who is the leader internationally in the field of reactors, promptly quoted in these arguments, thus to impose a great influence on siting decision. The present proposal of the Atomic Energy Commission was to set various quantitative levels for siting, and, therefore, influence it would exert will be exceedingly great in Japan. Quantitative regulation may be desirable to be set forth for siting but only when such has been found reasonable in a sense that it would thereby simplify the procedures for actually selecting the site.

However, if any quantitative regulation is forced to be executed at this present stage of development, it would encounter with many contradicting disputes. It would be intrinsically unreasonable to incorporate all the complicated conditions involved in the reactor characteristics, safety/protection design and surrounding conditions into a quantitative unitary standard, and, therefore, if one should yet try to enforce it, then it would inevitably make him to seek after the theoretical upper limit whereby he must cover all the cases of hypothetical accident. The present proposal as published by the Atomic Energy Commission looks to be the same representing accident very near to such upper limit. When the fact that progress is actively rolling on in developing reactors and particularly existing reactors that have been improved in the safety design are considered, it can not help to regard the regulation as proposed to be too rigidly unitary and unpracticable. Because of the great influence internationally the United States withholding in the nuclear field, it is almost definite that Japan's standard for the site selection will be considerably affected thereby.

Based on the above notion, we wish most earnestly that the Atomic Energy Commission would fully consider our basic concept of site criteria presented hereunder and moderate the proposed regulation to be more flexible. In case our impression so received is found to be different from what truly intended by the Commission, then we wish that you would express the regulation in more plain manner so that the parties affected would not be led to any misinterpretation.

Should these figures of exclusion area, low propulsion zone and population center distance as appearing in the Appendix "A" be adopted for granted, it would eventually make it practically impossible to find a site in Japan for installing any U. S. type reactor.

For the above reason, in view of the fact of the great influence the Proposed Regulation is very likely to impose on Japan, we wish most earnestly the Atomic Energy Commission authority would re-consider the following matters.

III. COMMENTS ON MULTIPLE REACTORS AT ONE SITE:

LADWP: Is the power level to be used for determining distances for population the total power level of all nuclear units on site or only the power level of the largest unit?

FPB: We would appreciate it if you could specify for us whether the power levels given are for a single reactor or for the entire nuclear installation which may comprise several reactors.

In the majority of multiple reactor installations, the reactors are generally located at some distance one from the other. What policy would be envisaged by the A.E.C., however, in the case of two or more reactors located in the same building, as planned by the British at the Sizewell nuclear station?

ASA: Where more than one reactor is located at a particular site, the thermal rating used in hazards calculations pertaining to the total installation should lie somewhere between the thermal rating of the largest single reactor and the sum of all reactors present. If there is negligible possibility that an accident in one reactor could cause an accident in another at the same site, then the thermal rating of the largest single reactor should be the value used in hazards calculations.

AI: The Proposed Guides are not clear as to the manner of evaluating a site at which more than one reactor may be located. Since site criteria are to be based on the consequences of an unlikely but credible accident, not the probability of the accident, it is recommended that as to each independent reactor there must be reasonable assurance that any maximum credible accidental release would not exceed the maximum radioactivity release established for the site. If an incident in a reactor at the site may initiate an incident in any one or more reactors at such site or if two or more reactors are otherwise mutually dependent, there must be reasonable assurance as to the interrelated complex that any maximum credible accidental release would not exceed the maximum radioactivity release established for the site.

IV. COMMENTS ON "SCOPE" (100.2):

AERP: The flat assertion in paragraph 100.2 that "This conservatism will result in more isolated sites" may be too categorical. If "more isolated sites" refers to the figures given at the end of Appendix "A" the statement is misleading since the remoteness of the site will depend on the safety factors built into the facility and also may depend on whether the novelty of the facility is such that it is quite likely to be more safe than existing facilities. This minor difficulty could be overcome if the word "may" is substituted for the work "will."

ASA: A list of reactor types to which the Guides do not apply should be included in a revision of the Guides. Eventually separate Guides should be wirtten for each such reactor type. Test reactors should be excluded from the present Guides rather than being combined with power reactors.

AI: With the inclusion of the words "for construction permits and operating licenses," paragraph (a) of this section indicates that the Proposed Guides would be applied to the demonstration of the adequacy of the site before and after construction of a facility in accord with an AEC-issued construction permit. Since under our recommendation site evaluation will establish design criteria, site approval is necessary prior, and only prior, to the beginning of construction. Further reviews would be concerned with the demonstration that the reactor had in fact been built to the design criteria established for the approved site. Thus the Guides should apply only to applications for construction permits.

This section of the Guides discloses that the "site" criteria therein contained must be applied more conservatively in the case of novel and unproven reactors. On the other hand, the guides we propose are directed to site evaluation, independent of any proposed reactor, and so can be applied without variance to any site being considered.

We also cannot agree with the inference apparent in this section and instinct in the Commission's concept of a population center distance that conservatism in the building of reactors and geographical isolation of reactors are analogous. We submit that the key to conservatism in this field is reactor design, not reactor location.

AEP: The second paragraph of Section 100.2 states that the proposed site criteria should be applied with "additional conservatism" to reactors which are "novel in design, unproven as prototypes, and do not have adequate theoretical and experimental or pilot plant experience." Conservatism in this instance is equated by the proposed guides to additional isolation.

I certainly do not argue with the principle that we ought to be conservative about unproven reactor types. The conservatism should be applied, however, to the safeguards which need to be incorporated in the reactor facility and to the analysis of the probability and consequences of an accident, and not in some unrelated manner to the determination of site distances. If the reactor is unproven, and compensating safeguards are not provided, it may well be necessary to take into account types of accidents which can be ruled out for other concepts. Similarly, if an unproven reactor is thought much more likely to produce a serious incident than other concepts, it would not be unreasonable for AEC to cut back the radiation limits to which the public might be exposed simply on the grounds of greater probability of exposure. The important thing is that the hazards potential of the facility be carefully explored by competent technical personnel before coming to a judgment about the site.

The net result of applying "conservatism" to the reactor hazards evaluation may, in a given case, produce the same net result as an effort to apply such conservatism directly to site distances. But the difference in approach is important. The first approach assures that site requirements will in the end be controlled by technical considerations and will reflect the discipline of a careful examination of the potential hazards of the reactor facility in question. The danger in the second approach is that site requirements will be established on the basis of arbitrary rules not tied to specific technical considerations or safety analysis.

I suggest therefore deletion of the second paragraph of Section 100.2. Instead, I would incorporate elsewhere in the proposed guides the concept that conservative assumptions may have to be made about potential accidents and releases of radioactive material for unproven reactor types. The converse of this principle should also be stated, i.e., that as we come to have more knowledge and experience with established reactor concepts, we can reasonably expect that assumptions about the probability and consequences of accidents need be less conservative than at present.

I also suggest that the first paragraph of Section 100.2 be revised to refer to applications for "facility licenses" instead of applications for "construction permits and operating license." Those familiar with AEC licensing procedures will realize that an applicant files simultaneously, at the beginning of his project, for both a construction permit and an operating license, and that AEC's formal site review takes place at this time. Those not familiar with AEC licensing practice may assume that AEC intends two site reviews -- one at the construction permit and one at the operating license stage of licensing proceedings. AEC should not, of course, be precluded from taking a second look at the reactor and its site at the time of the operating license if technical knowledge or other circumstances have altered markedly since the issuance of a construction permit. But AEC's intention should be to settle the matter of site approval at the construction permit proceedings.

BECH: We believe that this Criteria should be restricted to power reactors since the technical and economic considerations for testing reactors are substantially different.

Section 100.2 of the proposed criteria implies that reactors which are novel in design are necessarily less safe than conventional reactors. Some novel devices or plant concepts may increase plant safety despite the lack of experience with them. Also, this section states that the only compensation for reactors which have relatively unproven safety features is greater isolation. We consider that design precautions can substitute for greater isolation and these should be given full consideration.

JAPC: In this case, it is almost unconceivable to expect that reactors more than one unit would result simultaneous accidents, therefore, no need involving to pay any consideration, for such accidents, and, therefore, the reactor capacity fundamental for evaluating the public hazard should be sufficient to be at the value equivalent to the largest reactor capacity installed therein. We wish a clear note to that effect be added thereto.

V. COMMENTS ON "DEFINITIONS" (100.3):

U Pa.: Problems arise in connection with reactor location and land use controls. The proposed criteria require nearly a square mile of land around large size reactors. Must this land be owned in fee simple by the reactor operator? If not, how is the use of the land to be controlled so as to prevent subsequent development? Should not the regulations prescribe the type of ownership or control required in the exclusion zone? If ownership is required, can any agency other than a government agency acquire such a large tract of land within the environs of any metropolitan area in the eastern half of the United States? Are the costs of local acquisition likely to be so high as to economically prohibit the location of such facilities in such areas? Are transmission losses low enough so that it is economically feasible to go further out and accept the higher costs of transmission?

ASA: The meaning of "full control of the reactor licensee" should be clarified. "Full control" could be defined as authority to determine all activities on the area including exclusion or removal of personnel or property from the area.

The "nearest boundary of a densely populated center" is difficult to establish. A clear definition of what constitutes such a boundary should be included. We feel that ultimately a man-rem type of criterion may be established, making this definition unnecessary; however, we do not suggest delaying the issuance of the Guides until such a criterion is established.

AI: We recommend, rather than defining a population center in terms of its boundary, such a center is better defined in terms of an area with a population density in excess of 5,000 residents per square mile, containing more than 25,000 residents.

JAPC: See JAPC comment in Chapter 7 of this document on "Determination of exclusion area, low population zone, and population center distance."

VI. COMMENTS ON "FACTORS TO BE CONSIDERED WHEN EVALUATING SITES (100.10):

ORNL: The guide lists geological and hydrological considerations among the factors which are considered by the AEC in evaluating a site and states that special precautions must be taken if reactors are located where "radioactive liquid effluents might flow readily into nearby streams or rivers." Inasmuch as most all power reactors will be located on the edge of water which is employed for cooling in the plant, the potential exists for released activity to escape into the water. It would be desirable to identify maximum acceptable concentrations in the river water which should not be exceeded for such an event. Some clarification of the expression "flow readily" would be in order, and it may be anticipated that the reactor designer would then be able to provide a liquid-waste system with satisfactiry safeguards. In many instances, it would appear that the greatest river contamination may result from a heavy rainout at the time of the maximum credible accident. The extent to which this should be considered and the limiting ingestion exposures (and the basis for their determination from river concentrations vs time data) should be indicated. Geological considerations appear to be a second order effect, except to the extent that they have a bearing on the rate of movement of escaped activity through the soil.

NYDH: It is suggested that the proposed guide include an evaluation of land usage such as industrial, agriculture and public watershed areas. Such factors would be of public health importance affecting larger areas and other population groups due to ground deposition of radioactive materials.

SOC: We view with concern the Site Evaluation Factors (Sec. 100.10), especially as they are interpreted by example in Appendix "A" of the proposed regulation. This approach appears to minimize the possible contributions to safety by advances in <u>design</u>, and to maximize the value of <u>isolation</u>. We believe this approach unrealistically undervalues scientific and engineering skill, both present and future.

Our direct interest derives from our research programs aimed at discovering and developing applications of nuclear radiation and nuclear heat for chemical and petroleum processing.

We are hopeful that this effort will lead to important methods of producing goods and services. To realize the potential of nuclear radiation and nuclear process heat in the petroleum and chemical industries, optimal integration with existing manufacturing complexes almost certainly will be imperative. Our nation's most favorable locations for process industry already have been identified and developed because of natural advantages such as availability of raw materials, water and transportation. These locations, for obvious reasons, have in turn become major population centers. Even if a few locations can be found which <u>now</u> meet the requirements of the proposed reactor siting regulations, and which are endowed by nature with the other requirements, installation of major manufacturing facilities will be followed very promptly by the rapid population growth so natural to such centers.

We urge reconsideration of the proposed siting regulations, especially as exemplified in Appendix "A". We believe that regulations permitting reasonable regulatory and judicial interpretation in terms of design safety, together with the population density and physical characteristics of the site, are imperative if the major peaceful uses of the atom are to be realized in the United States.

ConEd: Greater emphasis must be given to the effect of engineering design on distance requirements.

JAIF: The proposed regulation places undue emphasis on distances, without giving sufficient considerations to technical features of reactors such as safety devices. The distance limitation illustrated in appendix "A" may be applied to some cases but not to all.

It appears that full consideration is not given to additional safety devices to be incorporated by safety designs or reactor's technical features which will naturally be resorted to in attempting to install a reactor in a site which would otherwise be unacceptable. Such an undue weight on distance has a danger of giving a misled impression that the USAEC does not consider safety designs of a reactor to be a more important factor.

It is feared lest reactor operator and designer should loose any incentives to examine and work out such a safety device as to meet the given conditions of the proposed site. We, therefore, hope that importance of technology and designing be incorporated into the regulation as the major factor for reactor safety.

NMPC: It might possibly be helpful in making this point a little clearer if some of the factors affecting a specific site which should be evaluated and considered, but which are not included in the assumed figures of the example or presently stated in the Guide, were added to the siting factors outlined in the Guide itself. What we are suggesting is that the Guide should include as other important siting factors in addition to those now mentioned the necessity of considering and evaluating wind diversity, forced and natural cooling, etc. It might perhaps also be well to include the fact that the manner of operation of a plant could be a factor in determination of the site suitability.

AI: The second sentence of Section 100.10(b) (3) stipulates that "Unless special precautions are taken, reactors should not be located at sites where radioactive liquid effluents might flow readily into nearby streams or rivers or might find ready access to underground water tables." Effluent discharge should not be based on zero as a criterion. Such a criterion would be inconsistent with 10 CFR 20, which permits the release of radioactive effluents provided that specified quantities and concentrations are not exceeded. Furthermore, this statement is inconsistent with the primary purpose of these criteria which is to set forth guides for evaluating the hazards resulting from an accident

rather than ordinary operations. Since it is believed these inconsistencies were not intended, it is recommended that this section should refer to quantities of effluents resulting from an incident which would exceed maximum radioactivity releases.

AEP: Greater emphasis needs to be placed in this section on the relationship between engineering design, including special safety precautions, and the suitability of the reactor site. A particular site is safe or unsafe only in relation to the facility proposed to be located on the site and to the potential release of radioactive materials from that facility. Recognition of this principle is, of course, already reflected in the Statement of Considerations and, to some extent, elsewhere in the proposed guides. The point could be further emphasized, however, through other changes in the wording and arrangement of Section 100.10. The order of the "factors to be considered" might well be reversed, so that paragraph (c) would appear first, in the interest of giving added emphasis to the importance of engineering design. The last sentence of paragraph (b), which points out that unfavorable meteorological, geographical, and hydrological site characteristics can be compensated for by engineering safeguards, could equally be made applicable to paragraph (a) relating to population densities and distance from population centers. The last sentence of subparagraph (b) (3) could be revised to read: "If reactors are located at sites where radioactive liquid effluents might flow readily into nearby streams or rivers or might find ready access to underground water tables, special engineering precautions must be taken." This wording better reflects the fact that a reactor designer can through conservative design compensate for site characteristics which are less than those most desirable.

BECH: Similarly, Section 100.10 tends to minimize the importance of plant design features among the factors considered when evaluating sites. The inherent safety features of the plant and the extra safety provisions provided in the design should be recognized as having equal importance as well as the starting point for any site evaluation. In fact, we believe that risks can be reduced more by design than by isolation.

The statement in Section 100.10 (iii) on release of liquid radioactive effluents is in our opinion unduly alarming. It seems very unlikely that future inland sites can be found which have water supplies which are not used at some downstream point. Although contamination in the hydrographic area may be more persistent than atmospheric contamination, there is always ample time for warning before the water is used. We would suggest "The plant design must provide reasonable assurance that radioactive liquid effluents cannot accidentally contaminate usable water supplies and prevent use of the water for long time periods. The provisions to prevent accidental releases as well as the importance of the potentially contaminated water must be considered."

PEC: While I feel that there is a need for a reactor site criteria regulation, I am of the opinion that the proposed regulation is too restrictive and places too much emphasis on distance and does not give sufficient credit to engineering design features that will contribute to reactor safety. As one who had something to do with the original introduction of the idea of containment as a substitute for distance, I feel particularly that a criteria should much more clearly recognize the part engineering design plays. It seems to me that it is unwise to make this reactor site criteria regulation too definitive since each reactor site and each different type of reactor should be evaluated separately on the basis of the site characteristics and reactor concept and design features.

GE: Before commenting on specific features of the Commission's proposed site criteria, it is desirable to place site considerations into proper prospective from the standpoint of their contribution to reactor safety. One fundamental point is that the contribution which site considerations can make to the safety of the public is relatively small, when compared to the contribution made by engineering barriers to the release of fission products. The Brookhaven report estimated the probability of a serious nuclear accident to be in a range between once in a hundred thousand and once in a billion reactor years. It is doubtful whether site conditions are likely to make a contribution to this low probability greater than one or two orders of magnitude, unless reactors were located in areas more than perhaps a hundred miles from population centers.

The suggestion that reactors be "located in the desert" is again receiving some currency. A historical and an economic note are relevant. The reactors built during the first decade of the American atomic program were generally built in very isolated locations. In the early fifties it was decided that, with the addition of a pressure tight containment sphere, the SIR prototype could be built at West Milton, near Schenectady, instead of in the Idaho desert. This precedent was followed in locating the Shippingport plant near Pittsburgh. The principle that a contained reactor could be built near population centers has been followed ever since. It is clear that the economics of electrical energy transmission are such that nuclear power plants cannot be built at great distances from the load centers which they serve. The costs of transmitting electricity one hundred miles have been estimated to be in the range of 0.6-0.8 mills/kwh. This is equivalent to between one-quarter and one-third of the total nuclear fuel cycle cost of a large power reactor which can now be built.

The Anderson-Price Act, in effect, represents a Congressional judgment that reactors can be built sufficiently near population centers to make their use as power plants practical, and that it is consistent with the national interest to accept the remote, residual risk of a serious nuclear incident. It is obvious that a national policy of providing liability protection, for private reactors, on the scale of the Anderson-Price Act was only called for on the assumption that reactors were to be built close to population centers. This is fully

borne out by the legislative history of the Anderson-Price Act. The Congressional judgment underlying the Anderson-Price Act provides the key policy decision for the establishment of reactor siting criteria.

Starting out from the premise that reactors can be built near population centers, the question becomes: How near? Two separate but related considerations are relevant. First, distance from population centers is likely to have an importance from the public acceptance standpoint, which may well exceed its significance from a technical standpoint. Second, it must be recognized that our present experience with large power reactors and their safety features is quite limited. Increased experience should result in a substantially higher level of confidence in the integrity of the engineered safety features. These considerations suggest that it may well be appropriate, for the next few years, to follow a siting policy which encourages the use of sites some reasonable distance from large population centers. As public confidence in the integrity of the engineered safety factors increases, the importance attached to distance can be progressively diminished.

Recognizing the public acceptance value of distance, it is still highly desirable to use site criteria, which will make the most effective contribution to safety. As will be explained in some detail in Section IV below, we believe the arbitrary population center distance factor proposed by the Commission gives little assurance that the reactor will in fact be located so as to reduce the probability of affecting population centers. We are suggesting instead an approach which combines distance, wind direction, and other meteorological and topographical conditions so as to enable site criteria to make the most effective contribution to the reduction of the probability that a nuclear incident will affect a population center.

VII. COMMENTS ON "DETERMINATION OF EXCLUSION AREA, LOW POPULATION ZONE, AND POPULATION CENTER DISTANCE" (100.11)

UPa: If a reactor is located in what is now a low population zone and at the requisite minimum distance from a population center as defined in the criteria, what assurance is there, or what assurance should be required, that the low population zone does not subsequently become a high population zone? Given the fact that urban population will double in the next 35 to 40 years (the investment life of a facility) and given a .10 to .25 ratio for future urban density to past urban density, it is obvious that the geographical spread of urban areas will be of the order of at least four times that of existing cities. Under these circumstances, the distance of the facilities from population centers should be some function of a radius area ratio which would produce the minimum required distance at the end of the period of investment rather than at the beginning. If this is not done, then controls over population density and urban growth in the intervening years are indicated. We have, at present, no measures for assuring such control over an extended period of time in metropolitan areas where zoning is administered by scores of local governments. Perhaps we could solve this problem by increasing the distances by a factor of 25 times some annual rate of linear extension. The gravity model boys could probably devise such a formula.

NEDH: With due regard to 10 CFR Part 100 Reactor Site Criteria, may I point out that the terminology under (c) "Population center distance" by definition is an unsatisfactory one, since it refers to the distance from the reactor to the nearest boundary of a densely populated center. Furthermore, there is no definition of densely populated. For example, there are many areas in our great cities where there are not 25,000 residents, but there are hundreds of thousands of people during working hours. I believe that this should be defined as follows:

> The population boundary distance means the distance from the reactor to the nearest boundary of an area containing more than 25,000 occupants per square mile.

LADWP: What are the population center distances to very large cities? Are "low population zone" and "population center" expressed in terms of present population, or should the projected population ten or twenty years from now be considered?

ORNL: One aspect of the siting problem which clearly should be considered is the population density near the nuclear facility in question. Some appreciation for the significance of the population density factor is intimated in the proposed guide by the designation of the "low population zone" and the "population center distance." However, nowhere

in the guide is thereany definition of a satisfactory basis for determining how low the population exposure should be or any explanation of the "population center distance" (which seems to be quite arbitrarily established.)

Actually the answer to the question of the acceptable population exposure is the key which can relate the hazards of mobile (see below) as well as stationary power plants on a comparable basis. This can be done by requiring that the maximum population exposure not exceed some given predetermined value, in conjunction with the maximum exposure level which is now proposed in the guide for establishing the "exclusion area" and the "low population area." (We believe that latter is better defined as the "evacuation area.") In practice the total population exposure including persons beyond the "evacuation area," as well as those within the "evacuation area," could then be calculated for the maximum credible accident. Such an exposure has a real meaning in terms of the genetic dose to the population, and values in the neighborhood of several million man-rems have been suggested for a reactor maximum credible accident.

A criterion which is based upon both a maximum individual exposure and a total population exposure not only protects the individual but simultaneously protects the population as a whole. It seems apparent that such protection of the population is implicit in the attempt to establish "low population zones" and "Population center distances," although it is never so specifically stated. It is most important to observe that the identification of the population exposure as a basic constituent of reactor hazards assessment is but the first step in controlling the quantity in question.

This criterion proposes the use of 300-rem thyroid exposure as a conservative value which, by implication, is somehow equivalent to the 25-rem whole-body exposure. We do not question the 25-rem whole-body exposure, but we do believe that the 300-rem thyroid exposure is too high. The highest value iodine exposure equivalent that we could justify at the present time would be 150 rem. This value is derived from the fact that the ICRP, NCRP and FRC each have recommended that the occupational exposure for the thyroid should be 30 rem/yr corresponding to a dose of 5 rem/yr to the total body (a ratio of 6 to 1.) We suspect that the higher thyroid values were included in the proposed criteria on the basis that exposed persons may be treated in such a fashion as to reduce their thyroid exposure by a factor of 2. However, the use of the higher value would be justified for a particular reactor only if that installation were prepared to, and were capable of, rounding up all the persons which had been evacuated from the low-population zone and getting them to submit to the required treatment. This does not appear to be either desirable or practical.

In view of the probably controlling exposure of children, it would seem that a particular study of this inhalation exposure hazard should be made on the lines of the British study for ingestion intake following the Windscale incident in which an exposure limit of 25 rem to the thyroid was used.

NYDH: It appears desirable to clarify the 300 rem emergency dose to the thyroid from iodine and to consider modification of the factors in evaluating reactor sites.

The proposed guide considers a 300 rem thyroidal dose from iodine as a conservative value for accidental or emergency conditions. The British Medical Research Council has given consideration to biological effects of different levels of exposure. The Council has recommended that the maximum daily intake of I-131 attributable to an accident and in the period following it should not exceed a total thyroid irradiation of 25 rads. Reference to a conservative value implies that this may be an emergency acceptable dose with little likelihood of any somatic effect on the exposed group.

The National Academy of Sciences Summary Reports of 1960 "The Biological Effects of Atomic Radiation" suggests a high sensitivity of the child's thyroid to carcinogenesis. This guide indicates that the 300 rem value is related to an atmospheric exposure of an individual. Would this same value be considered applicable where ground deposition of radioiodine may occur and the uptake of this radionuclide is via milk, food or water?

ASA: It is especially gratifying that the proposed Guides suggest accidental radiation dosage values for individuals off-site against which to measure adequacy of safeguards in reactor designs.

Certain passages in these paragraphs, as well as certain phraseology elsewhere in the proposed Guides should be altered to make it clear that the intent of Appendix A is to provide an example of the method and of typical values of certain parameters to be used in the estimation of the three distances specified in the Guides. It should be specifically stated that the numerical values of the parameters given in this example are illustrative only, and that other values may be used if more appropriate to the particular case under consideration. The Committee feels that it would be desirable to include not just one such example but two or more examples, each complete with its own table of distances as a function of reactor power. This would serve to emphasize the illustrative nature of the examples and would prevent the numerical values of the parameters used in them becoming "rules."

ConEd: That the concept of a "population center distance" should be replaced by the adoption of a dosage vs population criteria. The area beyond the "low population zone" might be designated as the "extended population zone." Dosages under maximum credible incident in all three zones, exclusion, low population and extended population would have to meet the limits imposed by the dosage population criteria.

AC: We feel that it is particularly important to avoid defining a population center by a 4/3 rule.

AEP: While the intent of this section is not entirely clear, it appears, when taken with Appendix "A", to require that all applicants must assume in their hazards analyses a core melt-down and release of a significant fraction of the fission product inventory to the interior of the containment structure, such as might occur in the case of water-type reactors from a loss of coolant following rupture of the primary system.

I do not quarrel with the necessity for this assumption in the present state of technological development. Even with reactors which use water as a coolant, and despite the excellent record of the utility industry with pressurized water systems in conventional plants, the possibility of a primary system rupture cannot be entirely discounted in view of the limited experience with some of the materials used in the reactor system, particularly under radiation conditions. But surely there should be room in the proposed guides for the possibility that from accumulated experience and technical progress we will learn that a severe rupture of the primary cooling system is not a credible accident or that protective measures, such as a safety injection system, can be counted on to prevent destruction of the core.

BECH: While we recognize the problems involved in the very low probability exposure of large numbers of people to radioactivity released from a reactor incident, we do not believe that the proposed establishment of a "population center distance" as defined in Section 100.3 and used in Section 100.11 is a logical or technically sound way of dealing with this matter. The definition is inadequate for practical use and the reasoning behind the application of a factor of 1-1/3 is not set forth.

In our opinion, some method of evaluating the risk of exposing large numbers of persons should be developed taking into account the integrated man-rem exposure potential based on the proposed plant including its design features, the meteorology and the size, distance and direction of areas of substantial population.

Section 100.11 (a) states that the applicant should assume a fission product release illustrated in Appendix A, corresponding to a core meltdown, as the basis for evaluation. This would define the maximum credible accident and containment design accident for all plants. In our opinion, present design efforts and future work will make a core meltdown an extremely improbable event, even to the most critical evaluator. We believe that the statements in this section should be modified to allow this conclusion when design and operating experience demonstrates that our confidence is justified.

APPA: My second point is concerned with what seem to be some basic inconsistencies in the Commission's applications of distance requirements to nuclear reactor installations.

The Commission's policy on the proximity of reactors to population is defined in more detail in the proposed criteria than any other single factor. The criteria define with some care the requirements for a "low population zone" around a reactor and a "population center distance" from a reactor, yet it is my understanding that the Commission provisions for enforcing these requirements once an operating license has been issued are incomplete, at best.

To my knowledge, there is no definite requirement by the Commission which would prevent an industrial park or suburban housing development from springing up around a reactor, once it was licensed, and effectively abolishing the "low population zone" so carefully calculated as a requirement for issuing the license. Similarly, I understand that there is no Commission requirement which would prevent a center of population from expanding outward and decreasing or wiping out the minimum distance to the boundary of the nearest city which the Commission requires prior to granting a license.

That such development can and will occur seems certain. One possible example is furnished by a news story which appeared in the Chicago Tribune on February 2, 1961. The news item stated that "Plans for the development of more than 9,000 acres adjoining Commonwealth Edison Company's Dresden nuclear power generating plant as an industrial district were announced yesterday by four Chicago real estate firms." This is a case of area development being planned before the nearby nuclear plant even gets its final operating license.

The proposed criteria do not indicate what the Commission does in a case like this. The industrial park near Dresden may pose no problem, but what would be done in the event that a reactor site had been approved by AEC, the utility had virtually completed the plant, and then a real estate operator started building several thousand homes in the "low population zone" around the reactor? If the Commission were to issue the operating license anyway, it would have to ignore the requirements it previously said were necessary for public health and safety. If it denied the license or required the utility to add containment or operate the reactor at a lower power level, the financial hardship on the utility and its customers could be substantial.

A more likely possibility is that real estate development and outward growth of the nearest population center will occur after a reactor has been licensed and gone into operation. If the Commission's criteria are to be meaningful, it would seem necessary either to prevent such development, withdraw the operating license or require changes in containment or power level to compensate for the shrinkage in the "low population zone" and in the distance to the edge of the nearest population center. However, it is my understanding that the Commission does not have plans for such enforcement actions once a nuclear plant goes into operation.

If the proximity of population to a reactor is as important to public safety as the Commission's proposed criteria indicate, there should be some means established for enforcing them for the period of the operating license -- or until there are solid grounds for amending the license requirements. If the criteria are not to be enforced, it is not clear what is gained by establishing them in the first place.

PEC: If the regulation is too restrictive in establishing distances that reactors can be located from populated areas, it could seriously impede the development of nuclear energy for commercial power production. While the proposed regulation takes into consideration population density, no provision is made for the future development of areas and increases in population. I understand that the proposed regulation contemplated some population increase during the life of a plant. If this is so, it should be clearly stated.

ACRS: The most important single new development which is embodied in this document is the fact that it contained a set of dosage limits which can be used in the event of a very unlikely reactor accident. I believe that it is important that the Joint Committee recognize this as a real advancement. This document, for the first time, clearly enunciates the fact that such potential radiation dosages are a necessary part of the regulatory processes and form almost completely the basis for any sort of an estimate of how a reactor must be sited. These dosages are given only in the context that such accidents are very improbable indeed.

We would like to eliminate the two-hour provision on the 25 roentgen dose limit and substitute instead a limit recommended by the applicant on the basis of time to clear the area involved.

The site criteria, as published, do not completely define or take care of the problem of either genetic or somatic damage. The problem is recognized and stated in the document, but answers to this problem do not as yet exist. While other reasons have been advanced for the employment of the city distance criteria, including no lethal doses in enent of a breach of the containment, the Committee accepted this criteria as defined in the guides as a reasonable, though unprovable, statement of its judgment regarding the effects of genetic and somatic dose. The Committee believes that the so-called "man-rem" dose has much to offer as a safeguard for the general protection of the population. We went so far, in December of 1960, as to suggest to the Commission that a dose limit of 4×10^6 man-rems per accident might be reasonable. This was based on a rough estimate that this dose corresponded to an average 30-year dose to one million people from all natural sources. We suggested that this computation of dose be cut off at 1 rem whole body or equivalent thyroid, bone or lung dose. Assuming that one accident occurs in thirty years, the total man-rem to the population is about $\frac{1}{180}$ of that due to natural causes. Since this type of accident will be very infrequent indeed, if it ever occurs, the choice is conservative. We have looked at several of our present reactors which are

located near cities and we find that, on the basis of this emergency man-rem dose, the sites are about right and further agree quite well with the city distance concept as stated in the guide.

At present, we can do little more than to adopt some criteria, such as the city distance, and encourage that research be done in the area of understanding what the problems are in regard to genetic and somatic damage of large sections of the population by very small radiation doses. I should like to point out that this problem is one which exists in our entire civilization. Each year, more and more radiation is given in the form of X-rays for diagnostic and therapeutic pruposes. I am particularly in a position to know since my own son has had polio and undergoes frequent X-ray studies, which they call growth studies. Further, we at MIT are at present treating experimentally cancer patients with neutron beams at the MIT Nuclear Reactor, of which I am the Director. Therefore, the problem presented by a reactor accident, as far as total integrated dose to the entire population, is likely to be only a small part of the total problem which is presented by diagnostic and therapeutic radiation, fallout, and so on. In the long-range development of civilization, the study of genetic damage is a high priority problem and should be given considerable study.

GE: We agree with the provisions with respect to the exclusion area and the low population zone contained in Section 100.11 (a)(1) and (2) of the proposed site criteria. The use of a total radiation dose to the whole body of 25 rems and an iodine exposure to the thyroid of 300 rems represents an acceptable measure for use in these criteria. Similarly, the two hour period for the exclusion area and the period of the entire incident for the low population zone both appear reasonable.

Section 100.11(a)(3) specifies that the distance to the nearest population center of more than 25,000 shall be 1-1/3 times the distance to the outer boundaries of the population zones. We believe that the substitution of a rating system which would reflect all population centers in the surrounding area, and other environmental factors in addition to distance, would provide a much greater degree of assurance that site criteria will make a significant contribution to public safety. The use of distance alone may well be misleading. For example, it may be worse to locate a reactor a substantial distance from a city in a prevailing wind direction, than at a smaller distance in an unlikely wind direction.

The location of a reactor can be used independently from the engineered barriers, to reduce the probability that fission products leaving the site will reach population centers. The additional degree of safety against such effects contributed by site selection is a function of the relationship of the plant location to nearby population centers, and the probability that an airborne contaminant would be conveyed to such centers in sufficient concentration to produce an effect of concern.

Rating Method Recommended. It is recommended that a numerical rating method be developed which considers the most important factors which affect the natural value of a site. Such a method should be independent of reactor type, recognizing that the engineered safety features of any plant to be built near population centers must achieve an acceptable level of safety.

It is believed that a meaningful numerical method can be derived considering:

a. Number of inhabitants in each nearby population center
b. Distance from the site to each population center
c. Angle presented by population center as viewed from site
d. Fraction of time when various diffusion conditions exist, and
e. For each diffusion category, fraction of time that wind is in the population center angle

For any site, the numerical "potential risk index" would be the summation of the indices considering each nearby population center. For each population center, the index would be the summation, for each diffusion category considered, of the products of population, diffusion factor, and fraction of time that wind is in the population center angle.

It is recognized that detailed study of this approach will probably reveal additional factors which should be included. For example, the index reduction factor due to atmospheric diffusion in a given distance should include the effect of topography.

It is suggested that all population centers within approximately 50 miles of the site be considered. This distance appears reasonable in view of the probability that the wind during any period of poor diffusion conditions probably would not continue beyond this distance. While greater distances might be affected with higher wind velocities, such velocities would be accompanied by correspondingly better diffusion conditions. Such a method properly measures the value of a site with regard to all population centers which are likely to be affected, and thus provides a more equitable and realistic approach than consideration of the nearest city of a certain size only.

Meteorological Data Required. This method requires the ability to postulate general fractions of the time that various broad category diffusion conditions exist at the site, and some knowledge of the wind direction distribution during each diffusion category. For most sites, these data can generally be approximated from existing nearby or regional weather stations. Due to the vast difference between good and bad diffusion conditions, the inversion period will control numerically. Great precision in the data used will not be required, as the

order of magnitude of the over-all index for a site will indicate its natural value in affording protection. Any necessary meteorological projections could be made by impartial consultants.

Interpretation of Index. Following development of proper index factors and trial application to a number of sites, it will be possible to categorize index results as:

Index Range	Site Suitability
(low)	Suitable
(medium)	Questionable
(high)	Probably unsuitable

Some variations in the index ranges may be appropriate in order to reflect very large variations in the average inventory of fission products between different reactors.

Those sites determined to be "suitable" by this method would be eligible for reactors with engineered safety features considered appropriate in current practice. Those sites in the "questionable" or "probably unsuitable" category present the possibility of being made suitable if sufficient additional engineered barriers can be included in the plant design to reduce the probability of causing serious effects on large numbers of people to an extent at least equal to the reduction which would have been afforded by favorable site conditions. We would be pleased to cooperate with the Commission in the technical development of an evaluation method of this nature.

Meteorological conditions are usually of substantially greater importance than mileage in determining the value of a site from a safety standpoint. The Convair and Hanford studies which the Commission has sponsored have made sufficient contributions to a fuller understanding of the meteorological conditions which may affect fission product distribution. It is highly desirable that further work in this area be done and applied to the problem of reactor location.

We agree with the proposed provisions with respect to the determination of exclusion areas and low population zones, but recommend that calculations with respect to potential fission product release be based on an analysis of the maximum credible accident taking into account the specific reactor design, rather than on the basis of any uniform, arbitrary, accident assumptions.

We regard the proposed population center distance factor as technically unjustified, and recommend the development of a rating system which factors in meteorology and other environmental factors, in addition to distance. Such an approach provides a much greater degree of assurance that population center distance will make a significant contribution to public safety.

JAPC: For Japan, especially from a viewpoint of the population dose, the densely populated center containing more than about 25,000 residents, as defined under Section 100.3(c) and 1-1/3 times the distance from the reactor to the outer boundary of the low population zone referred to under Section 100.11 (3) are apparently too severe, and, therefore, certain modification is necessary.

VIII. GENERAL COMMENTS ON APPENDIX A

TOAEC: Even though the writer has explained to his colleagues the background for the guides and the way in which they will be used, the Japanese seem to think that it is only a matter of time until these numbers will become a Federal Regulation which will in turn be a rule which all enterprisers must follow. If this is the case they feel that it would be hard to set up a more flexible or liberal criteria for use in Japan because of the high density of population centers. They have appointed a committee recently to study site criteria and make recommendations for rules to be followed in Japan.

This problem is of more particular concern for the immediate future since it has been informally decided to purchase as the next power reactor a United States type in the 200 to 300 Mwe power range. This also may have a bearing on the negotiations for approval of a visit by the NS Savannah after it is underway.

AERP: One serious disability of the proposed guides is the incorporation of specific numbers in § 100.11 (a) (3) and in Appendix "A" attached to the guides. We acknowledge that specific numbers may be useful to applicants, in the form of guidance, in assisting them in selecting their sites, but they may also have an adverse effect as published in the proposed guides. While it is true that the calculations and the numbers resulting therefrom are only intended as examples as stated in paragraph § 100.11(b), the numbers may well have a limiting effect by assuming the import of standards. Indeed, a reading of the newspaper reports of this proposed rule indicates the likelihood that the numbers used of distance from populous areas for reactors of various power levels will be regarded by the public as firm limitations. Such an eventuality may result in a stifling effect on industrial ingenuity and be an inhibiting factor to new developments. These adverse effects could result from a combination of causes. The regulatory agency, wishing to avoid political and public relations problems, may be reluctant to make an exception to the distances that have been set forth in the rule. Aware of this understandable reluctance, an applicant may well conclude that an exception to the distances set forth would not warrant either the administrative difficulties involved or the investment necessary to develop and prove-out new techniques which might justify reducing the distances. Needless to say, a licensee applicant who is planning a major relations problem of trying to locate nearer to major population areas than specified by published guides.

The difficulty, therefore, is not the purpose of the proposed figures, which we recognize as a commendable effort to provide guidance to potential licensees and information to the public, but rather, it is the impact which the document will have in its present form.

We believe that the objectives may be accomplished in another manner and without the disadvantages which are likely to accompany the proposed rule in its present form. We would recommend that the guides be published without the specific numbers mentioned above or the formulas contained in the Appendix or in "100.11(a)(3), and that a supplementary document be published which summarizes the regulatory experience to date with respect to the location of reactors. Such a supplementary document would afford an applicant a sound informational base for estimating the likely action of the Agency on his proposed site without commiting the Agency to specific quantitative figures. Certainly public adherence by the AEC to the principle of regulation by precedent, rather than by rule, particularly in the reactor field where experience and standardization are lacking, would seem at this time to be more realistic.

ORNL: The following specific statements are included in the guide: "It is not possible---to define site criteria with sufficient definiteness..;" "/It is/ designed primarily to identify a number of factors considered in...evaluating...sites;" and the illustrative calculations in the guide include numerical values which "represent approximations /which/ may need to be revised...." Despite these warnings, association of exact numbers with specific readily identifiable factors will result in these numbers' being taken all too seriously even though that is obviously not intended except for the unique cases which happen to be described by those numbers.

It is essential that the difficulties anticipated above, namely the misuse of exact numbers and the implicit description of but one of several possible release mechanisms, not be promulgated in official guides. This can be done by de-emphasizing the contents of the appendix in the following manner: first, include a sample calculation for each of several other typical situations, and, second, do not include specific numbers in the calculation. Although a probable range for each factor in question might be suggested, the guide should make it clear that either the reactor designer will have to demonstrate the value of each factor for his particular installation or accept some conservative value which the Commission would designate.

PP&L: We do not feel, however, that Appendix "A" contributes to the clarification of the criteria outlined in the regulation, and we recommend that it be eliminated. While this Appendix is described as an example of a calculation for preliminary guidance, it creates an opportunity for public misunderstanding of the intended flexibility of the criteria. Moreover, through interpretive actions, the Appendix and the Table of Exclusion distances may gradually assume regulatory status, especially if it is issued as a regulation and not as a guide. The many assumptions used in the example are ultraconservative, with the result that the calculated exclusion distances can be unreasonable for a specific site and for a specific reactor type and, therefore, are not typical or average values.

If Appendix "A" is retained as a part of the regulation, we believe that the various assumptions should be stated as a range of values rather than as specific quanties. This will permit use of the calculation methods proposed by the AEC without the restrictions imposed by conditions assumed in the Appendix which, in many cases, are not realistic.

SOC: See also SOC comments included in Chapter VI of this document on "Factors to be Considered when Evaluating Sites."

ConEd: Appendix "A" should not be an integral part of the Guide and if sample calculations are deemed to be necessary, they should at least encompass more than one set of assumptions relating to design and meteorology.

JAIF: The proposed regulation says with respect to Appendix "A" that the example of a calculation is based upon approximations that presently appear reasonable, but the calculation is made on the basis of too many assumptions to make it practicable. If applied to Japan as they are, this would make it considerably difficult to procure sites. Reading the appendix, it is clear, though not so described, that the accident assumed in the appendix involves melting of total fuel elements. Such an accident is an approximation to theoretical upper limit, and as far as it goes it is conservative and stands on safer side, it is true, but such a hypothesis could never be considered to be practical with regard to full-scale reactors. In that the assumption upon which the calculation is based does not incorporate such many factors as reactor property, safety design and many other efforts to prevent melting of fuel elements, the calculation is merely formal and unrealistic.

If all the numeric values developed with regard to exclusion distance, low population zone distance and opoulation center distance were to be applied to Japan mechanically, it would practically be prohibitive to procure site where to install US type power reactor.

If the calculation made in the appendix is nothing more than an example all the references to the appendix which appear in the regulation's provisions should be eliminated and clearer description should be made in the appendix to the effect that the calculation is just an example. Furthermore, if a series of several examples of calculation be added which allow for consideration on technological features of reactor and reactor plant, the regulation, without leading to any misunderstanding, would become flexible and easy to utilize. We do hope that the regulations come out likewise.

NMPC: We were surprised in some degree to learn from articles in the trade press and various other industrial sources of the general confusion in regard to the intended application of the appendix attached to the Guide. Because of this misunderstanding, it would perhaps be helpful if it could be even more clearly emphasized that the calculation given in the appendix is presented only as an example and would not apply to any specific actual plant site.

AC: We feel that it is particularly important to eliminate Appendix A as part of the regulation.

AI: The discussion under II - General Comments and Recommendations above demonstrates that it is not necessary to postulate a fission product release or to estimate an expected demonstrable leak rate from the containment to evaluate a selected site. There is no need, therefore, for the calculation presented by way of example in Appendix A. Further, even were the Commission to follow its approach, in preference to that we propose, no sample calculation should be made a part of the Guides, less the conclusions drawn therein be substituted for the Guides.

AEP: Much of my difficulty with the proposed criteria stems from Appendix "A." It is not clear to what extent Appendix "A" is intended to freeze into future hazards analyses the assumption that a significant fraction of fission products will be released by accident from the reactor core or the further assumptions and calculations as to the radiation exposures resulting from such an accident. Whatever the intent, however, such may well be the practical effect of its adoption by the AEC. The result is largely to negate commendable efforts elsewhere in the proposed criteria to stress the importance of the individual reactor type and the engineering characteristics of the facility. A further result may be the premature codification of technical standards and data as to which we do not yet have sufficient knowledge and experience. I have, therefore, urged in the attachment to this letter that Appendix "A" be deleted from the proposed guides. If this is not done, the proposed guides should at a minimum make unequivocably clear that Appendix "A" is intended only to be illustrative of the type of hazards analysis which applicants are expected to provide in support of license applications.

It is also not clear to what extent other assumptions and numerical values contained in Appendix "A" are intended to control the applicant's hazards analysis. Whatever the intent, however, the inclusion of Appendix "A" with the proposed guides seems bound to have, to a considerable degree, the practical effect of freezing stated assumptions and numerical values. At best, Appendix "A" will shift to the applicant the burden of justifying the use of other assumptions and values. At worst, it may impose on the applicant assumptions and values which are not applicable to his reactor concept or which fail to reflect current technical judgments.

I urge therefore that Appendix "A" and all references to it be deleted from the proposed guides. Instead, the Commission would perform a more useful service for the nuclear industry by publishing from time to time in technical journals and papers sample hazards analyses for a variety of reactor plants.

BECH: The intent and importance of the example in Appendix A is not clear. Paragraph (b) of Section 100.11 should clarify this point. From our experience, it would be unreasonable to assume that Appendix A can even be used as an initial guide for the required distances without some adjustment for the reactor design, containment features, and local meteorology. We feel that Appendix A should be eliminated from the Criteria or, if retained, additional examples should be included showing calculations for plants with additional safety and containment features. Reference to any such examples should indicate that appropriate design features, site data, and technical facts should be used in preparing initial estimates of the specified distances in accordance with the Criteria.

PEC: While it is intended that the hypothetical reactor calculation given in Appendix "A" of this proposed regulation be used as a guide and is a point of departure for consideration of a particular site and type of reactor, it seems to me that there is some danger that the distance derived from this example may be interpreted by the public as applying to all reactors. I, therefore, propose that this sample calculation be deleted from the regulation or that at least three sample calculations be prepared for different types of reactors and sites having widely different characteristics.

ACRS: Further, we also believe that the example at the end should be treated simply as an example and, perhaps, should be either deleted or augmented by the addition of several other examples.

GE: We strongly question the desirability of specifying in Appendix "A" any assumptions regarding the fission product release and subsequent behavior. A number of technical objections to Appendix "A" are raised in Section V below. Our basic concern however is not with the specific technical judgments underlying Appendix "A" but rather with the assumption that uniform accident assumptions should be made. The rate of fission release is obviously dependent on the containment system and on

other features of reactor and plant design. We believe, therefore, that the exclusion area and the low population zone should both be based on the analysis of the maximum credible accident as calculated for the particular reactor and plant design, applicable site data, and on reasonable interpretations of the laws of nature.

The apparent objective of the proposed Appendix "A" is to provide a simplified accident analysis method for general application. Because the analysis of credible accidents is highly dependent upon the reactor and plant design and to a certain extent on site conditions, standardization of analytical methods does not appear desirable. The general use of oversimplified analysis methods will produce answers which may be dangerously lax for some applications and excessively restrictive in others. We question the need to publish any examples of analytical methods, since the public record, in the form of hazards reports on commercial reactor projects over the past several years, provides a wide variety of examples of analytical methods. In addition to these general comments regarding the purpose of the proposed Appendix "A," we have a number of comments on specific technical assumptions.

Appendix "A" considers two specific modes of exposure. We question the desirability of looking at direct radiation and thyroid dose only. A preferable analytical method would reach conclusions based upon whatever modes of exposure are of significance.

We do not agree with the general applicability or the technical validity of the proposed Appendix "A" and urge that the Appendix be deleted.

JAPC: The contacts presented in the examples herein are deemed to be representing the released amounts of radioactive materials at the time of serious accident in case of the hypothetical reactor and the distance criteria calculated based thereupon, and, therefore, should these be applied to any of the reactors, it appears as if technical or engineering efforts so far extended by those designing various reactors were unreasonably disregarded, and accordingly wish these examples be withdrawn.

If these examples so presented were only of the hypothetical reactor, we wish a clear statement be added thereto in respect to those reactors more advanced in the development with particular consideration being incorporated in the safety and protection design to the effect that accident evaluation be made case by case for the released amount of radioactive materials and the distant criteria calculated based thereupon to apply thereto, presenting at the same time certain typical examples therefor.

IX. SPECIFIC COMMENTS ON APPENDIX A
(Symbols denote subparagraph to which particular comment is directed.)

LADWP: A1(f): Are the assumed meteorological conditions (average worst weather conditions for average meteorological regions over the country) valid for all of the United States including Southern California?

ORNL: A.1(j) The proposed criterion tabulates conversion factors which were used to determine the dose received from breathing a specified quantity of the various iodine isotopes. We believe that the actual conversion factors are appreciably higher and suspect that the lower values in the guide were calculated from an earlier inaccurate value of the uptake of iodine by the thyroid as well as a lower breathing rate.

Using the most recent value of 0.23 for the uptake by the thyroid of iodine inhaled as an air contaminant (instead of the earlier constant of 0.15), together with the values for energies, etc., from the Report of ICRP Committee II on Permissible Dose for Internal Radiation (1959) and the corresponding NCRP report, the following values are calculated as the total subsequent dose to the thyroid per inhaled microcurie of iodine isotope for the "standard man."

Isotope	Dose (rem)
I^{131}	1.484
I^{132}	0.053
I^{133}	0.399
I^{134}	0.025
I^{135}	0.125

Rather than use an average value for the breathing rate of 20.8 liters/min for the 8-hr occupationally exposed, it is strongly felt that a breathing rate of 30 liters/min (500 cm^3/sec) is more appropriate for the conditions of activity, excitement, alarm, etc., accompanying and subsequent to a reactor accident. This slightly larger breathing rate also is more appropriate in view of the concomitant exposure offsite of children with smaller thyroids, more active metabolism, and greater sensitivity.

Hence, it is felt that exposures should be calculated using the following conversion factors for dose from breathing 1 curie/m^3/sec of each isotope:

Isotope	Dose (rem)
I^{131}	742
I^{132}	26.5
I^{133}	200
I^{134}	12.5
I^{135}	61.5

ASA: A.1(b): The leak rate from the containment vessels should be considered a time-dependent function related to the pressure within the vessel. The time behavior of the pressure should be taken into account, rather than being considered constant at its maximum value.

A.1(h): The symbol Q should not be employed for two different factors: It is suggested that the factor in paragraph (h) now designated Q be designated "Q integral."

A.1(f): A definition of "average worst" weather conditions should be included.

A.1(a): Assumptions of fission product release fractions should take into account the type of fuel under consideration. The release values used in Appendix A should not be regarded as mandatory or universally applicable.

BAAPC: A.1(e): In view of the questionable accuracy of the theoretical diffusion equations under extremely stable meteorological conditions, it is suggested that some recognition be given in the Guide to the fact that feasible field engineering techniques exist for determining the travel and diffusion of airborne material.

At least two specific chemical tracers have been extensively and successfully used for meteorological research by groups in this area. These tracer diffusion trials involved:

a) the dissemination of fluorescent particles (FP), i.e. zinc cadmium sulfide particles in the 1-5μ size range, (Aerosol Laboratory, Stanford University); and

b) the dissemination of an aerosol of uranine or rhodamine B dyes, (Stanford Research Institute).

BECH: A.1(f): We note that in the present Appendix A inversion conditions were used with the air moving in the same direction for evaluating the leakage at the outer edge of the low population zone over the entire course of the accident. This seems quite unrealistic and misleading. Assuming an inversion only 50% of the time with the air moving toward any one point 50% of the time would be a simple and more realistic worst case assumption, although still conservative. In any case, conditions pertinent to the site in question should be utilized in making the calculations.

GE: A.1(a): The fission product release assumptions are apparently based on the premise that a major portion of the fission products of the core will be available for release to the enclosure in a short period of time. We question the validity of this premise. Conservative calculations indicate that only a few percent of the core could be initially involved in an excursion, and that several hours of absence of coolant are required for a major fraction of the core to melt due to afterheat.

Only a minor allowance is made for fission products removed by plate-out. Considering the high probability of operation of both plate-out and washout mechanisms, it is probably unrealistic to picture the absence of such mechanisms, particularly when the period of interest is in the range of hours to days.

A.1(b): The uniform enclosure leakage assumed appears to ignore the phenomena which will decrease residual pressure and leakage. These are highly dependent upon type of containment.

A.1(c): In calculating decay within the enclosure, the use of gross fission product decay seems undesirable. The actual residual quantities of fission products present should be decayed in accordance with their individual half-lives.

There is no reason for ignoring radioactive decay after leakage has occurred.

A.1(d): There is no necessity for ignoring deposit of halogen and solid fission products on the ground. In the case of halogen leakage, this actually is an important method of reduction of cloud inventory. The suggested calculation method, therefore, overestimates thyroid dose due to iodine inhalation.

A.1(e): The Appendix makes no mention of elevation of release, but the results indicate that a ground level release probably was assumed. The significance of the radiological effects is highly dependent on elevation of release, which in turn is dependent on plant design factors. Even in the case of release near the ground level, ignoring the initial dilution resulting from the wake effect of the plant buildings unnecessarily overestimates off-plant effects.

A.1(f) The calculated results apparently assume no variation in wind direction or in atmospheric stability during the entire period of release. Such assumptions appear unrealistic, particularly when a leakage period of many days is considered. The absence of wind direction diversity contributes to a serious overestimate of the hazard.

A.1(k): The Appendix assumes that the enclosure is a direct radiation gamma source. This is, of course, dependent on plant design features. In the example, there appears to be no reason for the arbitrary shielding factor of ten which was assumed.

X. PROPOSED REVISION BY ATOMICS INTERNATIONAL

ATOMIC ENERGY COMMISSION

(10 CFR PART 100)

Reactor Site Criteria

General Provisions

Sec.

100.1 Purpose

100.2 Definitions

Site Evaluation Criteria

100.10 Criteria which guide the Commission in reviewing the site for a proposed reactor

100.11 Determination of permissible radioactivity release at the site for a proposed reactor

General Provisions

100.1 Purpose

It is the purpose of these guides to describe some of the criteria which guide the Commission in its review of proposed sites for power and testing reactors subject to Part 50 of this chapter. As it is not yet possible to establish site criteria with sufficient definiteness to eliminate the exercise of agency judgment in evaluating reactor sites, the criteria herein contained are interim guides for the convenience of prospective applicants for permits to construct power and testing reactors. The basic objective of such criteria is: serious injury to individuals off-site should be avoided and the exposure of large numbers of people in terms of total integrated population dose should be low, if an unlikely, but still credible, accident should occur.

Nothing herein contained shall obligate the Commission to approve or disapprove any reactor site because such site meets or fails to meet the criteria set forth below.

100.2 Definitions

As used in these guides:

(a) "Exclusion area" means the area surrounding the reactor site, access to which is under the full control of the prospective applicant. This area may be traversed by a highway, railroad, or waterway, provided these are not so close to a proposed facility as to interfere with normal operations, and provided

appropriate and effective arrangements are made to control traffic on the highway, railroad, or waterway, in case of emergency, to protect the public health and safety. Residence within the exclusion area shall normally be prohibited. In any event, residents shall be subject to ready removal in case of necessity. Activities unrelated to operation of a proposed reactor may be permitted in an exclusion area under appropriate limitations, provided that no significant hazards to the public health and safety will result.

(b) "Low population zone" means the area immediately surrounding the exclusion area which contains residents, the total number and density of which are such that there is a reasonable probability that appropriate protective measures could be taken in the event of a serious accident. These guides do not specify a permissible population density or total population within this zone because the situation will vary from case to case. Whether a specific number of people can, for example, be evacuated from a specific area, or instructed to take shelter, on a timely basis, will depend on many factors such as location, number and size of highways, scope and extent of advance planning, and actual distribution of residents within the area.

(c) "Population center" means an area with a population density in excess of 5,000 residents per square mile containing more than 25,000 residents.

(d) "Power reactor" means a nuclear reactor of a type described in 50.21 (b) or 50.22 of this chapter designed to produce electrical or heat energy.

(e) "Testing reactor" means a "testing facility" as defined in 50.2 of this chapter.

Site Evaluation Criteria

100.10 Criteria which guide the Commission in reviewing the site for a proposed reactor

In reviewing a proposed site for a power or testing reactor subject to Part 50 of this chapter, the Commission will be guided by the following criteria, except as a prospective applicant can demonstrate the applicability and significance of other criteria in lieu of or in addition thereto:

(a) The maximum radioactivity release at the site established, as provided in Section 100.11 of this Part, in terms of:

(1) The exclusion area, low population zone, and population centers.

(2) Meteorological conditions at the reactor site and environs, including the exclusion area, the low population zone, and population centers.

(b) Criteria determined by the environmental characteristics of the site, in addition to meteorology, including seismology, geology, hydrology, and usage. For example:

(1) No proposed facility should be located nearer than 1/4 or 1/2 mile from the surface location of a known active earthquake fault.

(2) Unless special precautions are taken, reactors should not be located at sites where an incident-induced flow of radioactive liquid effluents into the nearby streams or rivers or into underground water tables might result in excessive radiation doses.

A construction permit will not issue unless the proposed reactor is so designed that there is reasonable assurance the reactor can be built and operated so that a credible accidental release of radioactivity will not exceed the maximum radioactivity release for the site. A construction permit will also not issue unless there is reasonable assurance that the proposed reactor can satisfy the other criteria determined by environmental characteristics noted in (b) above. Notwithstanding some unfavorable environmental characteristics, an application for a permit to construct a reactor at a selected site may be approved if the design of the reactor includes appropriate and adequate compensating engineering safeguards.

100.11 Determination of the maximum radioactivity release for the site for a proposed reactor

Assuming the worst combination of meteorological conditions occurring simultaneously at a proposed reactor site and in the exclusion area, in the low population zone, between the reactor site and the population centers, and in such centers, determine the radioactivity releases at the site that would generate the following exposures:

(1) No individual located at any point on the boundary of the exclusion area for two hours immediately following the release would receive a total radiation dose in excess of 25 rem to the whole body, or a total radiation dose in excess of 300 rem to the thyroid from iodine exposure.

(2) No individual located on the outer boundary of the low population zone at the point nearest to the reactor site who is exposed to the radioactive cloud resulting from the release (during the entire period of its passage) would receive a total radiation dose in excess of 300 rem to the thyroid from iodine exposure.

(3) No individual located in any population center in the vicinity of the reactor site who is exposed to the radioactive cloud resulting from the release (during the entire period of its passage) would receive a total radiation dose in excess of 2-1/2 rem to the whole body, or a total radiation dose in excess of 30 rem to the thyroid from iodine exposure.

The whole body dose of 25 rem referred to above corresponds to the once-in-a-lifetime accidental or emergency dose for radiation workers which, according to NCRP recommendations, may be disregarded in the determination of their radiation exposure status. (See Addendum dated April 15, 1958 to NBS Handbook 59.) The NCRP has not published a similar statement with respect to portions of the body, including doses to the thyroid from iodine exposure. For the purpose of determining the maximum radioactivity release at a reactor site under the conditions assumed in these guides, the whole body dose of 25 rem and the dose to the thyroid from iodine of 300 rem are conservative values.

(4) The lowest of the radioactivity releases determined as above shall be the "maximum radioactivity release" for any reactor proposed to be located at the site being considered. Such maximum radioactivity release will constitute one of the design criteria for any reactor to be constructed at such site.

(5) When more than one reactor is to be located at a site, the maximum radioactivity release established for such site in accordance with the foregoing shall be applied as follows:

(a) For reactors independent of each other, the maximum radioactivity release will be one of the design criteria of each such reactor.

(b) For reactors not independent of each other in that an incident in one may initiate an incident in one or more of the others or where two or more reactors are otherwise mutually dependent, the maximum radioactivity release will be one of the design criteria of the inter-related complex.

(Reprinted from 26 Federal Register, 1224, February 11, 1961)

ATOMIC ENERGY COMMISSION

[10 CFR Part 100]

REACTOR SITE CRITERIA

Notice of Proposed Guides

Statement of considerations. On May 23, 1959, the Atomic Energy Commission published in the FEDERAL REGISTER a notice of proposed rule making that set forth general criteria for the evaluation of proposed sites for power and testing reactors. Many comments were received from interested persons reflecting, generally, opposition to the publication of site criteria, as an AEC regulation, both because such a regulation would, to some extent, incorporate arbitrary limitations and because it appeared that in view of the lack of available experimental and empirical data specific criteria could not be established.

Judgment of suitability of a reactor site for a nuclear plant is a complex task. In addition to normal factors considered for any industrial activity, the possibility of release of radioactive effluents requires that special attention be paid to physical characteristics of the site, which may cause an incident or be of significant importance in increasing or decreasing the hazard resulting from an incident. Moreover, the inherent characteristics and the specifically designed safeguard features of the reactor are of paramount importance in reducing the possibility and consequences of accidents which might result in the release of radioactive materials. All of these features of the reactor plus its purpose and method of operation must be considered in determining whether location of a proposed reactor at any specific site would create an undue hazard to the health and safety of the public.

Recognizing that it is not possible at the present time to define site criteria with sufficient definiteness to eliminate the exercise of agency judgment, the proposed guides set forth below are designed primarily to identify a number of factors considered by the Commission and the general criteria which are utilized as guides in evaluating proposed sites.

The basic objectives which it is believed can be achieved under the criteria set forth in the proposed guides, are:

(a) Serious injury to individuals offsite should be avoided if an unlikely, but still credible, accident should occur.

(b) Even if a more serious accident (not normally considered credible) should occur, the number of people killed should not be catastrophic.

(c) The exposure of large numbers of people in terms of total population dose should be low. The Commission intends to give further study to this problem in an effort to develop more specific guides on this subject. Meanwhile, in order to give recognition to this concept the population center distances to very large cities may have to be greater than those suggested by these guides.

Notice is hereby given that adoption of the following guides is contemplated. All interested persons who desire to submit written comments and suggestions for consideration in connection with the proposed guides should send them to the Secretary, United States Atomic Energy Commission, Washington 25, D.C., Attention: Director, Division of Licensing and Regulation, within 120 days after publication of this notice in the FEDERAL REGISTER.

GENERAL PROVISIONS

SITE EVALUATION FACTORS

General Provisions

§ 100.1 Purpose.

It is the purpose of this part to describe the criteria which guide the Commission in its evaluation of the suitability of proposed sites for power and testing reactors subject to Part 50 of this chapter. Because it is not possible to define such criteria with sufficient definiteness to eliminate the exercise of agency judgment in the evaluation of these sites, this part is intended primarily to identify a number of factors considered by the Commission and the general criteria which are utilized as guides in approving or disapproving proposed sites.

§ 100.2 Scope.

(a) This part applies to applications filed under Part 50 of this chapter for construction permits and operating licenses for power and testing reactors.

(b) The site criteria contained in this part apply primarily to reactors of a general type and design on which experience has been developed, but can also be applied with additional conservatism to other reactors. For reactors which are novel in design, unproven as prototypes, and do not have adequate theoretical and experimental or pilot plant experience, these criteria will need to be applied more conservatively. This conservatism will result in more isolated sites—the degree of isolation required depending upon the lack of certainty as to the safe behavior of the reactor. It is essential, of course, that the reactor be carefully and competently designed, constructed, operated, and inspected.

§ 100.3 Definitions.

As used in this part:

(a) "Exclusion area" means the area surrounding the reactor, access to which is under the full control of the reactor licensee. This area may be traversed by a highway, railroad, or waterway, provided these are not so close to the facility as to interfere with normal operations, and provided appropriate and effective arrangements are made to control traffic on the highway, railroad, or waterway, in case of emergency, to protect the public health and safety. Residence within the exclusion area shall normally be prohibited. In any event, residents shall be subject to ready removal in case of necessity. Activities unrelated to operation of the reactor may be permitted in an exclusion area under appropriate limitations, provided that no significant hazards to the public health and safety will result.

(b) "Low population zone" means the area immediately surrounding the exclusion area which contains residents the total number and density of which are such that there is a reasonable probability that appropriate protective measures could be taken in the event of a serious accident. These guides do not specify a permissible population density or total population within this zone because the situation may vary from case to case. Whether a specific number of people can, for example, be evacuated from a specific area, or instructed to take shelter, on a timely basis will depend on many factors such as location, number and size of highways, scope and extent of advance planning, and actual distribution of residents within the area.

(c) "Population center distance" means the distance from the reactor to the nearest boundary of a densely populated center containing more than about 25,000 residents.

(d) "Power reactor" means a nuclear reactor of a type described in §§ 50.21(b) or 50.22 of this chapter designed to produce electrical or heat energy.

(e) "Testing reactor" means a "testing facility" as defined in § 50.2 of this chapter.

Site Evaluation Factors

§ 100.10 Factors to be considered when evaluating sites.

In determining the acceptability of a site for a power or testing reactor, the Commission will take the following factors into consideration:

(a) Population density and use characteristics of the site environs, including, among other things, the exclusion area, low population zone, and population center distance.

(b) Physical characteristics of the site, including, among other things, seismology, meteorology, geology and hydrology. For example:

(1) The design for the facility should conform to accepted building codes or standards for areas having equivalent earthquake histories. No facility should be located closer than ¼ to ½ mile from the surface location of a known active earthquake fault.

(2) Meteorological conditions at the site and in the surrounding area should be considered.

(3) Geological and hydrological characteristics of the proposed site may have a bearing on the consequences of an escape of radioactive material from the facility. Unless special precautions are taken, reactors should not be located at sites where radioactive liquid effluents might flow readily into nearby streams or rivers or might find ready access to underground water tables.

Where some unfavorable physical characteristics of the site exist, the proposed site may nevertheless be found to be acceptable if the design of the facility includes appropriate and adequate compensating engineering safeguards.

(c) Characteristics of the proposed reactor, including proposed maximum power level, use of the facility, the extent to which the design of the facility incorporates well proven engineering standards, and the extent to which the reactor incorporates unique or unusual features having a significant bearing on the probability or consequences of accidental releases of radioactive material.

§ 100.11 Determination of exclusion area, low population zone, and population center distance.

(a) As an aid in evaluating a proposed site, an applicant should assume a fission product release from the core as illustrated in Appendix "A" of this part, the expected demonstrable leak rate from the containment, and meteorological conditions pertinent to his site to derive an exclusion area, a low population zone and a population center distance. For the purpose of this analysis, the applicant should determine the following:

(1) An exclusion area of such size that an individual located at any point on its boundary for two hours immediately following onset of the postulated fission product release would not receive a total radiation dose to the whole body in excess of 25 rem or a total radiation dose in excess of 300 rem to the thyroid from iodine exposure.

(2) A low population zone of such size that an individual located at any point on its outer boundary who is exposed to the radioactive cloud resulting from the postulated fission product release (during the entire period of its passage) would not receive a total radiation dose to the whole body in excess of 25 rem or a total radiation dose in excess of 300 rem to the thyroid from iodine exposure.

(3) A population center distance of at least 1½ times the distance from the reactor to the outer boundary of the low population zone. In applying this guide due consideration should be given to the population distribution within the population center. Where very large cities are involved, a greater distance may be necessasry because of total integrated population dose considerations.

The whole body dose of 25 rem referred to above corresponds to the once in a lifetime accidental or emergency dose for radiation workers which, according to NCRP recommendations, may be disregarded in the determination of their radiation exposure status. (See Addendum dated April 15, 1958 to NBS Handbook 59.) The NCRP has not published a similar statement with respect to portions of the body, including doses to the thyroid from iodine exposure. For the purpose of establishing areas and distances under the conditions assumed in these guides, the whole body dose of 25 rem and the 300 rem dose to the thyroid from iodine are believed to be conservative values.

(b)(1) Appendix "A" of this part contains an example of a calculation for hypothetical reactors which can be used as an initial estimate of the exclusion area, the low population zone, and the population center distance.

(2) The calculations described in Appendix "A" of this part are a means of obtaining preliminary guidance. They may be used as a point of departure for consideration of particular site requirements which may result from evaluations of the particular characteristics of the reactor, its purpose, method of operation, and site involved. The numerical values stated for the variables listed in Appendix "A" of this part represent approximations that presently appear reasonable, but these numbers may need to be revised as further experience and technical information develops.

Dated at Germantown, Maryland, this 8th day of February 1961.

For the Atomic Energy Commission.

Woodford B. McCool,
Secretary.

APPENDIX "A"

Example of a calculation of reactor siting distances:

1. The calculations of this Appendix are based upon the following assumptions:

a. The fission product release to the atmosphere of the reactor building is 100 percent of the noble gases, 50 percent of the halogens and 1 percent of the solids in the fission product inventory. This release is equal to 15.8 percent of the total radioactivity of the fission product inventory. Of the 50 percent of the halogens released, one-half is assumed to adsorb onto internal surfaces of the reactor building or adhere to internal components.

b. The release of radioactivity from the reactor building to the environment occurs at a leak rate of 0.1 percent per day of the atmosphere within the building and the leakage rate persists throughout the effective course of the accident which, for practical purposes, is until the iodine activity has decayed away.

c. In calculating the doses which determine the distances, fission product decay in the usual pattern has been assumed to occur during the time fission products are contained within the reactor building. No decay was assumed during the transit time after release from the reactor building.

d. No ground deposition of the radioactive materials that leak from the reactor building was assumed.

e. The atmospheric dispersion of material leaking from the reactor building was assumed to occur according to the following relationship:

$$X=\frac{Q}{\pi u\sigma_y\sigma_z}$$

where Q is rate of release of radioactivity from the containment vessel, the ("source term,"):

X is the atmospheric concentration of radioactivity at distance d from the reactor
u is the wind velocity
σ_y and σ_z are horizontal and vertical diffusion parameters resp.

f. Meteorological conditions of atmospheric dispersion were assumed to be those which are characteristic of the average "worst" (least favorable) weather conditions for average meteorological regimes over the country. For the purposes of these calculations, the parameters used in the equation in section e. above were assigned the following values:

$u=1$m/sec;
$\sigma_y=[\frac{1}{2}C_y{}^2d^{2-n}]^{1/2}$;
$\sigma_z=[\frac{1}{2}C_z{}^2d^{2-n}]^{1/2}$;
$C_y=0.40$;
$C_z=0.07$;
$n=0.5$

g. The isotopes of iodine were assumed to be controlling for the low population zone distance and population center distance. The low population zone distance results from integrating the effects of iodine 131 through 135. The population center distance equals the low population zone distance increased by a factor of one-third.

h. The source strength of each iodine isotope was calculated to be as follows:

Isotope	*Exclusion Q (curies/megawatt)*	*Low population Q (curies/megawatt)*
I^{131}	0.55	76.4
I^{132}	.68	1.40
I^{133}	1.19	18.5
I^{134}	.72	.91
I^{135}	1.04	5.4

These source terms combine the effects of fission yield under equilibrium conditions, radioactive decay in the reactor building, and the release rate from the reactor building, all integrated throughout the exposure time considered.

i. For the exclusion distance, doses from both direct gamma radiation and from iodine in the cloud escaping from the reactor building were calculated, and the distance established on the basis of the effect requiring the greater isolation.

j. In calculating the thyroid doses which result from exposure of an individual to an atmosphere containing concentrations of radioactive iodine, the following conversion factors were used to determine the dose received from breathing a concentration of one curie per cubic meter for one second:

Isotope	*Dose (rem)*
I^{131}	329
I^{132}	12.4
I^{133}	92.3
I^{134}	5.66
I^{135}	25.3

k. The whole body doses at the exclusion and low population zone distances due to direct gamma radiation from the fission products released into the reactor building were derived from the following relationships:

$$D=483\frac{Be^{-\mu r}}{4\pi r^2}\int t^{-0.2}dt$$

where D is the exposure dose in roentgens per megawatt of reactor power

r is the distance in meters
B, the scattering factor, is equal to $\left(1+\mu r+\frac{\mu^2r^2}{3}\right)$
μ is the air attenuation factor (0.01 for this calculation)
t is the exposure time in seconds.

In this formulation it was assumed that the shielding and building structures provided an attenuation factor of 10.

2. On the basis of calculation methods and values of parameters described above, initial estimates of distances for reactors of various power levels have been developed and are listed below.

Power level (thermal megawatt)	Exclusion distance (miles)	Low population zone distance (miles)	Population center distance (miles)
1500	0.70	13.2	17.7
1200	.60	11.5	15.3
1000	.53	10	13.3
900	.50	9.4	12.5
800	.46	8.6	11.5
700	.42	8.	10.7
600	.38	7.2	9.6
500	.33	6.3	8.4
400	.29	5.4	7.2
300	.24	4.5	6
200	.21	3.4	4.5
100	.18	2.2	2.9
50	.15	1.4	1.9
10	.08	.5	.7

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