OPTIONAL FORM NO. 10
5010-104

UNITED STATES GOVERNMENT

Memorandum

TO : A. R. Luedecke, General Manager
Headquarters

DATE: May 19, 1961

FROM : S. R. Sapirie, Manager
Oak Ridge Operations

SUBJECT: PROPOSED REACTOR SITE CRITERIA

OE:MEJ

The attached are the comments on the subject guide submitted by the Oak Ridge National Laboratory and are transmitted as required. These comments were received on May 2, 1961, which is consistent with the requirement that all comments be issued within 120 days after publication of the proposed guide. ORO comments were completed and transmitted in our memorandum to you dated January 16, 1961, subject "Proposed Reactor Site Criteria."

S. R. Sapirie

Enclosure:
ORNL Comments - Reactor Site Criteria

CC: W. F. Finan, Headquarters, w/encl.
F. K. Pittman, Headquarters, w/encl.
R. C. Armstrong, w/encl.
J. W. Ould, w/encl.
H. M. Roth, w/encl.
L. H. Jackson, w/encl.
L. Dubinski, w/encl.
E. E. Stokely, w/encl.
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OAK RIDGE NATIONAL LABORATORY
OPERATED BY
UNION CARBIDE NUCLEAR COMPANY
UCC
POST OFFICE BOX X
OAK RIDGE, TENNESSEE

May 1, 1961

U. S. Atomic Energy Commission
Post Office Box E
Oak Ridge, Tennessee

Attention: Dr. H. M. Roth

Gentlemen:

Subject: Federal Register, February 10, 1961, Notice of Proposed Guide, Reactor Site Criteria (10 CFR Part 100)

When the subject guide was published for comment on February 10, 1961, it was requested that all comments and suggestions be submitted to the Secretary, U. S. Atomic Energy Commission, Washington 25, D. C., marked Attention: Director, Division of Licensing and Regulation, within 120 days after publication of the proposed guide. Accordingly, our comments are attached hereto for your subsequent transmittal to Washington.

A previous statement on this subject was contained in our letter of June 19, 1959, Center to Sapirie, on "Federal Register, May 23, 1959, Title 10, Chapter 1, Notice of Proposed Rule Making". This letter was also prepared in response to a request for comments, although since the letter was never filed in the Public Documents room, I do not know if they were transmitted to Washington.

Our interest and concern in this matter are not only derived from the problems of the several reactor projects with which we are concerned, but also from our more general activities in nuclear safety. As you will note, we believe that the present proposal contains many serious deficiencies which should be corrected before the guide becomes part of the AEC regulations.

Yours very truly,

J. A. Swartout
Deputy Director

Attachment
JAS:WBC:sh
cc: T. J. Burnett
R. A. Charpie
W. B. Cottrell
H. G. MacPherson
. R. Center

Critique of Proposed Guide: Reactor Site Criteria (10 CFR Part 100)[1]

The Commission's attempt[1] 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 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.

Implied Restrictions as to Type of Reactor, Safety Features, and Containment

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.

Use of Specific Values for Siting Factors

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.

Population Exposures

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 there any 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 the 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.[2,3]

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. In 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.

Mobile Reactors

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[4] 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).

Incredible Accidents

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.

Iodine Exposure Equivalent to 25-rem Whole Body

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,[5] NCRP,[6] and FRC[7] 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[8] in which an exposure limit of 25 rem to the thyroid was used.

Exposure per Inhaled Curie of Iodine

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)[9] and the corresponding NCRP report,[6] the following values are calculated[10] 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.[11] This slightly larger breathing rate also is more appropriate in view of the concomitant exposure off-site 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

Geological and Hydrological Considerations

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 satisfactory 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 bearing on the rate of movement of escaped activity through the soil.

Accidents Other Than the Maximum Credible Accident

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.[3,4] 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

References

1) U S. Atomic Energy Commission, "Reactor Site Criteria, Notice of Proposed Guides (10 CFR Part 100)", released February 10, 1961.

2) C. R. McCullough, "What Price Safety?" unpublished paper presented at the ANS Summer Meeting in Gatlinburg, Tennessee, June 19, 1959, and partially reviewed in Nuclear Safety 1(2), December 1959, p 2, and Nuclear Safety 1(4), June 1960, p 3.

3) W. B. Cottrell, "Criteria for Accidental Activity Releases from Nuclear-Powered Ships", presented at the IAEA Symposium in Sicily, November 14-18, 1960.

4) W. B Cottrell, et al., "Environmental Analysis of the NS Savannah Operation at Camden", ORNL-2867, revised January 1961.

5) "Recommendations of the International Commission on Radiological Protection Radiation Protection", adopted September 9, 1958, Pergamon Press.

6) "Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposures", National Bureau of Standards (U.S.), Handbook No. 69, June 5, 1959.

7) Federal Radiation Council, "Background Material for the Development of Radiation Protection Standards", Report No. 1, May 13, 1960.

8) "Maximum Permissible Dietary Contamination after the Accidental Release of Radioactive Material from a Nuclear Reactor", British Medical Journal, I, 967-9 (1959).

9) Report of ICRP, Committee II, "Permissible Dose for Internal Radiation", 1958 revision, Health Physics, 3:1 380 (June 1960).

10) T. J. Burnett, "Reactor Siting Trends and Developments", Nuclear Safety 2(4), June 1961.

11) T. J. Burnett, "Reactor Hazard vs Power Level", Nuclear Science and Engineering 2, 382-393 (1957).