

~~W. G. ...
P. ...
W. ...
Y. G. ...~~

ATOMIC ENERGY COMMISSION

REACTOR SITE CRITERIA

Report to the General Manager by the Director,
Division of Licensing and Regulation

~~XXXXXXXXXX~~

THE PROBLEM

- publication for public comment*
1. To consider the ~~adoption~~ of proposed site criteria.

SUMMARY

2. This paper supplements and modifies AEC-R 2/19 which contained a proposed regulation establishing reactor site criteria. Copies of AEC-R 2/19 were furnished to the Advisory Committee on Reactor Safeguards and the subject was discussed by the Commission with the ACRS on January 12 1960. In that meeting some of the members of the Committee expressed objections to various provisions of the regulation, as a result of which the Commission instructed the staff to attempt to work out a compromise with the ACRS on this subject.

3. On Saturday, January 14, the Director, Division of Licensing and Regulation, and other staff representatives met with the ACRS and agreed upon the basis for a compromise.

4. On Tuesday, January 17, the Director, Division of Licensing and Regulation, and staff members met with Dr. T. J. Thompson, Chairman, ACRS, and Dr. Franklin A. Gifford, Member, ACRS, and prepared a draft of criteria based on the compromise previously agreed upon. A copy of the compromise draft is attached as Appendix "A".

A/G

1. The attachment contains some minor editorial improvements which do not affect the form or substance of the compromise draft worked out with Dr. Thompson. These will be reviewed with Dr. Thompson.

5. Dr. Thompson is now in the process of seeking the concurrence of members of the ACRS in this draft of criteria.

6. The important differences between the draft criteria proposed in AEC-R 2/19 and the compromise draft now proposed by this paper are as follows:

a. The present draft is essentially a combination of the portions of the ACRS letter of December 13, 1960, which were emphasized at the ACRS meeting with the Commissioners, and the regulations previously proposed by the staff, after ACRS consultation, in AEC-R 2/19, with some significant modifications.

b. The words "rules" and "regulations" have been changed to "guides" wherever they appear, ~~so that the criteria do not appear to be rules or regulations.~~

95
c. Dr. Thompson felt that the Committee would insist on a statement to the effect that these criteria are primarily applicable to reactors on which experience has been gained but may be applied, with greater conservatism, to other reactors. A recognition of this principle is contained in the present draft.

d. The statement of considerations contains a statement of three general concepts considered important by the ACRS: first, the objective of avoiding serious injury to individuals off-site if an unlikely, but still credible, accident should occur; second, the objective that even in a more serious accident (not normally considered credible), the numbers of people killed should not be catastrophic; and third, the recognition of the importance of total population dose which will be given further study in an effort to develop a criterion on this point. Meanwhile, to give recognition to this ^{that objective} principle, the proposed guide states that in some instances the

2/ This would include the so-called "maximum credible accident" and any lesser accident.

distance to very large cities may need to be greater than the distances stated in the guide.

SS
e. The nomenclature on several points has been modified, i.e. the "evacuation area" around the reactor site has been changed to "low population zone", and the use of the term "bench mark" to identify the results of initial calculation of various distances around the reactor has been eliminated. However, the table of distances and the basis for calculating those distances for a standardized reactor as outlined in Appendix ^{Annex 1 to} "A" have been preserved as a suggested initial step in the determination of the exclusion area, the low population zone, and the population center distance.

f. The concept of maximum credible accident has been eliminated but the reference to the assumed fission product release both in the guides and in the table attached will adequately serve the same purpose.

7. Parts of the previous draft ^{contained in AEC-R 2/19} have been reorganized and edited to make the criteria more flexible in consonance with the philosophy of guides rather than regulations, but the essential criteria of the previous draft have been preserved.

8. ^{and} ~~It should be noted that the guides apply to stationary reactors only.~~

STAFF JUDGMENTS

9. ~~The~~ ^{and} The Division of Biology and Medicine, the Division of Reactor Development, the Office of General Counsel, ~~and the Office of Health and Safety~~ concur in the recommendations of this paper.

RECOMMENDATION

10. The General Manager recommends that the Atomic Energy Commission:

a. Approve publication in the Federal Register for comment of the proposed reactor site criteria for power and test reactors, attached as Appendix "A".

b. Note that the action recommended in (a) above should be deferred until the Chairman, ACRS, has had the opportunity to obtain the comments of the full Committee on Appendix "A".

c. Note that a copy of the proposed criteria will be sent to the Joint Committee on Atomic Energy *prior to publication in the Federal Register*

d. Note that an appropriate news release will be issued.

e. Note that this paper is unclassified.

OFFICIAL USE ONLY

1/17/61

- 1 -

App "A"

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} ~~particular~~ attention be paid to physical characteristics of the site, which ~~may cause an incident or may~~ be of significant importance in increasing or decreasing the hazard resulting from an incident. Moreover, inherent or engineered design features of the reactor are of paramount importance in determining the possibility and consequences of any release of radioactive effluents. All ^{of those} ~~these~~ factors must be considered in determining whether location of a proposed reactor at any specific site would create an undue hazard to surrounding population.

OFFICIAL USE ONLY

OFFICIAL USE ONLY

- 2 -

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 ~~[being sought by these guides]~~ are ~~[that]~~:

- (a) Serious injury to individuals off-site 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 when compared with a conservative standard as yet to be specified. 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.

which It is believed ~~[that these objectives]~~ can be achieved under the criteria set forth in the proposed 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

OFFICIAL USE ONLY

OFFICIAL USE ONLY
OFFICIAL USE ONLY

- 3 -

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.

(List of Section Headings)

OFFICIAL USE ONLY

OFFICIAL USE ONLY

- 4 -

AUTHORITY:

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 definiteness to eliminate the exercise of agency judgment in the evaluation of these sites, this part is designed 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. This part applies to applications filed under Part 50 of this chapter for construction permits and operating licenses for power and testing reactors.

The site criteria contained in this part are designed primarily for 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 to specify 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} ~~a prerequisite~~, of course, that the reactor be carefully and competently designed, constructed, operated, and inspected.

OFFICIAL USE ONLY

OFFICIAL USE ONLY

...than 5000 residents

...to the nearest boundary of a densely populated center

(1) "Population center distance" means the distance from the

of residents within the area.

ways, scope and extent of advance planning, and actual distribution

will depend on many factors such as location, number and size of high-

from a specific area, or instructed to take shelter, on a timely basis

case. Whether a specific number of people can, for example, be evacuated

population within this zone because the situation may vary from case to

These guides do not specify a permissible population density or total

protective measures could be taken in the event of a serious accident.

is such that there is a reasonable probability that appropriate pro-

the exclusion area which contains residents the total number of which

(2) "Low population zone" means the area immediately surrounding

public health and safety will result.

appropriate limitations, provided that no significant hazards to the

operation of the reactor may be permitted in an exclusion area under

to ready removal in case of necessity. Activities unrelated to

normally be prohibited and, in any event, residents shall be subject

the public health and safety. Residence within the exclusion area shall

measures are made to control traffic on the highway or railroad to protect

with normal operations, and provided appropriate and effective arrange-

highway or railroad is not so close to the facility as to interfere

This area may be traversed by a highway or railroad, provided such

reactor, access to which is under the full control of the reactor owner.

(a) "Exclusion area" means the area surrounding the

§ 100.3 Definitions. As used in this part:

OFFICIAL USE ONLY

OFFICIAL USE ONLY.

- 6 -

d. "Power reactor" means a nuclear reactor of a type described in § 50.21 (b) or 50.22 of Part 50 of this chapter designed to produce electrical or heat energy.

e. "Testing reactor" means a "testing facility" as defined in § 50.2 of Part 50 of this chapter.

OFFICIAL USE ONLY

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 and its 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:

- (i) 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 1/4 to 1/2 mile from the surface location of a known active earthquake fault.
- (ii) Special meteorological conditions at the site and in the surrounding area should be ^{considered.} examined.
- (iii) Geological and hydrological characteristics of the proposed site may have a bearing on the consequences of an escape of radioactive material from the facility.

Power and testing 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 unless special precautions are taken,

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 ~~extensive and~~ 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 rate from the core (See Appendix A, par. - 2 a. for suggested values), leak rate from the containment, and meteorological conditions suitable to his site to derive an exclusion radius, a low population ^{zone} radius, 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 receive a total radiation dose to the whole body of not more than 25 rem or a total radiation dose of not more than 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 receive a total radiation dose to the whole body of not more than 25 rem or a total radiation dose of not more than 300 rem to the thyroid from iodine exposure.

OFFICIAL USE ONLY

-10-

- (3) A population center distance of at least 1-1/3 times the distance from the reactor to the outer boundary of the low population zone. Where very large cities are involved, a greater distance may be necessary.

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 the NCRP recommends 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) Appendix A of these guides contains a conservative example of a calculation for a generalized reactor which can be used as an initial estimate of the exclusion area, the low population zone, and the population center distance.

FOR OFFICIAL USE ONLY

OFFICIAL USE ONLY

OFFICIAL USE ONLY

OFFICIAL USE ONLY

Annex 1
-11-
APPENDIX A
OFFICIAL USE ONLY

Example of a Calculation of Reactor Siting Distances

1. On the basis of calculation methods and values of parameters described below, initial estimates of distances for reactors of various power levels have been developed and are listed in the following table:

| <u>Power Level</u> <u>(Thermal Megawatt)</u> | <u>Exclusion</u> <u>Distance (Miles)</u> | <u>Low Population</u> <u>Zone</u> <u>Distance (Miles)</u> | <u>Population Center</u> <u>Distance (Miles)</u> |
|---|---|---|---|
| 1500 | .70 | 13.3 | 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 | 8.0 | 10.7 |
| 600 | .38 | 7.2 | 9.6 |
| 500 | .33 | 6.3 | 8.4 |
| 400 | .29 | 5.4 | 7.2 |
| 300 | .24 | 4.5 | 6.0 |
| 200 | .21 | 3.4 | 4.5 |
| 100 | .18 | 2.2 | 2.9 |
| 50 | .15 | 1.4 | 1.9 |
| 10 | .08 | .5 | .7 |

2. This table has been based upon the following assumptions:

a. The fission product release to the atmosphere of the reactor building is 100% of the noble gases, 50% of the halogens and 1% of the solids in the fission product inventory. This release is equal to 15.8% of the total radioactivity of the fission product inventory. Of the 50% of the halogens released, one-half is assumed to condense out on the 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% per day of the

OFFICIAL USE ONLY

OFFICIAL USE ONLY

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.

π is a constant 3.1416.

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:

$$u = 1m/sec; \nabla y = \left[\frac{1}{2} C_y^2 d^{2-n} \right]^{\frac{1}{2}};$$

$$\nabla z = \left[\frac{1}{2} C_z^2 d^{2-n} \right]^{\frac{1}{2}}; C_y = .40; C_z = 0.07, n = 0.5$$

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:

| <u>Isotope</u> | <u>Exclusion Q (curies/megawatt)</u> | <u>Low population Q (curies/megawatt)</u> |
|------------------|--|---|
| I ¹³¹ | .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:

| <u>Isotope</u> | <u>Dose (rem)</u> |
|------------------|-------------------|
| I ¹³¹ | 329 |
| I ¹³² | 12.4 |
| I ¹³³ | 92.3 |
| I ¹³⁴ | 5.66 |
| I ¹³⁵ | 25.3 |

OFFICIAL USE ONLY

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:

$$D = 483 \frac{B e^{-ur}}{4\pi r^2}$$

$$\int_0^t - 0.21 dt$$

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 $(1 + ur + \frac{ur^2}{3})$

u 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.