APPENDIX "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 attention be paid to physical characteristics of the site, which may be of significant importance in increasing or decreasing the hazard resulting from an incident. Moreover, the inherent /or engineered design/ characteristics and the specifically designed safeguard features of the reactor are of paramount importance in /determining the/ reducing the possibility and consequence of /any/ accidents which might result in the release of radioactive /effluents/ materials. All of these /factors/ features of the reactor plus its purpose and method of operation (~~such as the difference between power and testing reactors~~) must be considered in determining whether location of a proposed reactor at any specific site would create an undu hazard to the health and safety of the public.

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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 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.

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.

(List of Section Headings)

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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 [designed] 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. 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] apply primarily [for] 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. [to specify] 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 [owner] licensee. This area may be traversed by a highway, [or] railroad, or waterway, provided [such highway or railroad is] 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

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highway, [or] railroad or waterway, in case of emergency, to protect the public health and safety. Residence within the exclusion area shall normally be prohibited. [and,] 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 is 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 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.

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.

(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. Unless special precautions are taken, [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.

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 ~~in depth~~.

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(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 [redacted] from the core [(See Appendix "A", Par. - 2 a. for suggested values),] , as illustrated in Appendix A, the expected demonstrable leak rate from the containment, and meteorological conditions [suitable] pertinent to his site to derive an exclusion [radius,] area, a low population zone [radius,] 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 [of not more than] in excess of 25 rem or a total radiation dose [of not more than] in excess of 300 rem to the thyroid from iodine exposure.

(2) A low population zone of such size that an individual located any 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 [of not more than] in excess of 25 rem or a total radiation dose [of not more than] in excess of 300 rem to the thyroid from iodine exposure.

(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. In ~~fixing this distance~~ applying this guide due consideration should be given to the population distribution within the population [redacted] center. Where very large cities are involved, a greater distance may be necessary because of total population dose considerations. ~~Consideration should also be given to the total integrated radiation dose which might be given to the population in the event of an accident. As a result of the further study to be carried on by the Commission, appropriate modifications of this distance may be made.~~

Indeed!

tion workers which [illegible] 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 establihsing 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] an example of a calculation for [a generalized] hypothetical reactors which can be used as an initial estimate of the exclusion area, the low population zone, and the population center distance. ~~It must be emphasized that Appendix A does not in itself constitute a set of criteria. The assumptions of such a calculation will doubtless be modified as new evidence develops.~~

The calculations described in Appendix "A" are a means of obtaining preliminary guidance. [redacted] 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 and site involved. The numerical values stated for the complex variables listed in Appendix "A" represent approximations that presently appear reasonable, but these numbers may need to be revised as further experience and technical information develops.[1]

1/ This paragraph is intended to accommodate the additions suggested by the ACRS immediately above and repeated in part in paragraphs 1a. and 2 of [redacted] Annex 1.

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ANNEX 1 TO APPENDIX "A"

Example of a Calculation of Reactor Siting Distances

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2. On the basis of calculation methods and values of parameters described below, above initial estimates of distances for reactors of various power levels have been developed and are listed in the following table: below. ~~These estimates can only be considered as a means of obtaining preliminary guidance since each reactor site will almost certainly require variation from these values.~~

Power Level (Thermal Megawatt)	Exclusion Distance (Miles)	Low Population Zone Distance (Miles)	Population Center Distance (Miles)
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

1. The calculations of this Appendix are ~~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 release, one-half is assumed to condense out on the 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% 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.

~~The above assumed release of fission products from the fuel does not necessarily represent the action of fission products which may be released on their accounts.~~

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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:

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$u = 1m/sec; \sigma y = [I/2Cy^2 d^{2-n}]^{1/2};$

$\sigma z = [I/2Cz^2 d^{2-n}]^{1/2};$ $Cy = .40;$ $Cz = 0.07,$ $n = 0.5$

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}	.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:

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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:

$$D = 483 \frac{Be^{-ur}}{4\pi r^2} \int_0^t t^{-0.21} \, dt$$

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.

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