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October 22, 1960

Honorable John A. McCone
Chairman
U. S. Atomic Energy Commission
Washington 25, D. C.

Subject: REACTOR SITE CRITERIA

Dear Mr. McCone:

You have asked that we supply you with criteria which could be used for judging the adequacy of proposed sites for reactors. The Advisory Committee on Reactor Safeguards has devoted considerable time to this problem. A large part of our delay in submitting site criteria stems from the fact that we believe it is premature to establish quantitative limits on the variables involved in site evaluations - especially if such limits will appear in Federal regulations, or otherwise be announced as Commission policy. We recognize that the correctness of the numbers which could be selected now cannot be proved by experimental or empirical data, and, therefore, these numbers would give a false sense of positiveness which could not be supported upon detailed scrutiny. Numbers chosen now will be expected to change as more information develops. For example, a quantitative calculation of dosage must include some estimate of the fraction of the total fission product inventory which may be air-borne. This fraction is currently under experimental examination and the estimate may be subject to change.

The Committee believes that the officially endorsed numbers could stifle progress toward a better selection of numbers. The ideas and interpretations from applicants themselves have played a major part in the formulation of the current bases for site evaluation. It would be a significant loss to stop the flow of new ideas from the applicants. The Committee also believes that it is possible that the appearance of quantitative numbers in a Federal regulation or policy statement will reduce the continual

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awareness of the applicant that he has assumed a responsibility to be alert to and to act on unforeseen disadvantages of a site even after the site has been approved. The Committee, therefore, advises that a quantitative statement of site criteria not be included in Federal regulations.

These comments do not mean that the ACRS has no bases for judging the adequacy of sites. They merely emphasize that site selection is still largely a matter of judgment. Inasmuch as the ACRS has been making site and reactor evaluations, it may be helpful to review the framework on which these judgments are being made. It is a prerequisite, of course, that the reactor be carefully and competently designed, constructed, and operated. It should be inspected during all these stages in a manner to assure preservation of the intended protection of the public. Also, these factors are applicable only to those reactors on which experience has been developed. Reactors which are novel in design, unproven as prototypes, or which do not have adequate theoretical and experimental or pilot plant experience belong at isolated sites - the degree of isolation required depending on the amount of experience which exists.

Our site evaluations stem from several concepts. These are overlapping, but not conflicting:

1) Everyone off-site must have a reasonably good chance of not being seriously hurt if an unlikely but credible reactor accident should occur.

2) The exposure of a large segment of society in terms of integrated man-rems should not be such as to cause a significant shortening of the average individual lifetime or a significant genetic damage or a significant increase in leukemia - should a credible reactor accident occur.

3) There should be an advantage to society resulting from locating a plant at the proposed site rather than in a more isolated area.

4) Even if the most serious accident possible (not normally considered credible) should occur, the numbers of people killed should not be catastrophic.

Incidentally, the concept has been proposed by others that the damage to people from reactor accidents can be accepted if it is no greater than that experienced in other industries. We reject this suggestion as premature, and follow rather the concept that the consequences of reactor accidents must be less than this. The reasons for this rejection are twofold: First,

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we do not have sufficient information on the probability of reactor accidents to make use of this concept in site evaluations. We do use, of course, the fact that the probability of a serious accident is very low. Second, we recognize that the atomic power business has not yet reached the status of supplying an economic need in a manner similar to that of more mature industries; and, therefore, arguments for taking conventional risks for the greater good of the public are somewhat weak. At the same time, we do not want to imply that the restrictions placed on site locations during the developmental period of atomic power will necessarily be carried over to the period of maturity of the atomic power industry.

The reduction of these concepts to a judgment as to the adequacy of a proposed site requires further logic and the introduction of some numerical estimates. We believe that the searching analysis which is necessary at this stage should be done independently by the owner of the reactor, using the characteristics which are peculiar to his site and to his specific reactor. This step, we believe, is essential in developing his continuing alertness to his responsibility to the community surrounding the site. However, in Committee deliberation, we balance his analysis against a generalized accident which serves as a reference point from which we can better understand the analysis submitted by the applicant.

Our generalized accident analysis assumes that a serious accident has occurred and predicts in rough terms the consequences of such an accident. It is obvious that the generalized accident is an arbitrary artifact subject to change and has value only so far as it aids judgment. As a matter of fact, for certain reactors and conditions judgment will indicate that the generalized accident is too severe. In the generalized accident, we must make numerical assumptions as to the amount, type and rate of radioactivity release (the source term), the dispersal of the radioactivity in the air and in the hydrosphere, and the effect of this radioactivity on people.

Source Term

An arbitrary accident is assumed to occur which results in the release of fission products into the outermost building or containment shell. About 100% of the total inventory of noble gases, 50% of the halogens, and 1% of the non-volatile products are assumed to be so released. It is then assumed that this mixture leaks out of the outermost barrier at a rate defined by the designed and confirmed leak rate. The reasoning back of this source term is admittedly loose. It stems primarily from a present inability to be convinced that coolant cannot be lost somehow from the reactor core, either by spontaneous fracture of some element in the primary system

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a fracture caused by maloperation (instrumental or human) of the control rods. Admittedly, this assumed source term is large, but it thereby affords a factor of safety. In some cases it is justifiable to reduce this source term. It is also tacitly assumed that in this accident the outermost barrier will not be breached. The logic behind this assumption is that we require all of the components restraining the pressure of the primary system to be operating at temperatures above their nil-ductility temperature. We are, therefore, more confident, but not certain, that failure will occur by tearing rather than by brittle fracture and that the probability of ejection of missiles which penetrate the outermost barrier is low. The necessary supporting structures and shielding also protect against missile damage.

Dispersal of the Radioactivity

1) Meteorology

We assume a dilution of air-borne activity using atmospheric diffusion parameters which reflect poor, rather than average, meteorological conditions. Choice of specific parameter values follows from a survey of meteorological conditions expected to apply at the site, primarily wind and stability distributions. To analyze the generalized accident, we use the standard diffusion calculation methodology outlined, for example, in AECU-3066 and WASH-740. The atmospheric diffusion phenomena is the subject of active research, and new results can be expected to firm up and improve the present methods, although we do not anticipate major revisions in this area.

2) Hydrology

Considerations of hydrology are based on characteristics of surface and sub-surface flow as they are related to the possible release of contaminated liquids to the off-site environment. Thus, the rate and volume of surface flow and the possible presence or absence of absorbing barriers of soil between the reactor complex and important underground aquifers should be taken into consideration. These factors must be favorable for restraining the flow of radioactive materials in case of accident. Design factors, including the capability of providing adequate hold-up in the event of adverse hydrology, are also significant.

Effect of Radioactivity on People

The upper limit to the exposure to a member of the public in the generalized accident should be no higher than the maximum once-in-a-lifetime emergency dose. Such a level has not been established by AEC. We are arbitrarily using a figure of about 25 r whole body

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or equivalent integrated dose for this level. This figure is mentioned in Handbook 59 of the National Bureau of Standards, pages 69-70. Since the iodine dose is often controlling, we are tentatively considering a thyroid dose limitation of 200-300 rads. The dosage so far mentioned refers to limits to people when the people are considered as independent individuals. We believe that it is essential that the Atomic Energy Commission attempt to confirm through its staff or its advisors in this field that this suggested value of 25 r whole body or equivalent is without significant biological effect on the individuals who might be subjected to this dose from the generalized accident.

When large numbers of individuals are exposed to radiation, another limit also exists because of genetic effects and because of the statistical nature of induced leukemia and the shortening of the life span. The limits of exposure to large groups of people are better expressed in terms of integrated man-rems. We are considering using a figure of 4×10^6 man-rems for this limit for the people who might be exposed to radiation doses falling between 1 and 25 rems. This figure of 4×10^6 man-rems is roughly equal to the dose received from natural background by a million people during their reproductive lifetime.

The implication of these numbers is this. About a reactor site, there should be an exclusion radius in which no one resides. Surrounding this, there should be a region of low population density, so low that individuals can be evacuated if the need arises in a time which will prevent their receiving more than a dose of 25 r. Beyond this evacuation area, there should be no cities (above 10,000 to 20,000 population) sufficiently close so that the individuals in these cities might receive more than the lower of the following: (1) 4×10^6 man-rems in the generalized accident, and (2) 200 rems under the extremely improbable accident in which the outermost barrier fails completely to restrain all of the radioactivity of the generalized accident.

The Committee wishes to emphasize again that the numbers which have been used in discussion of the generalized accident should not be formalized into regulations or Commission policy. The Committee wishes to acknowledge the help it has received from the Hazards Evaluation Branch in this matter and suggests that these individuals be encouraged to present as technical papers, but not as regulations, a complete description of their working

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approach to making judgments on the adequacy of proposed reactor sites. Such a paper, of course, would have the status of the opinion of an informed technical individual, but would not imply Committee approval, nor would it have the rigidity of a Commission policy statement.

Sincerely yours,

ORIGINAL SIGNED BY
LESLIE SILVERMAN

Leslie Silverman
Chairman

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