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Draft No. 1
JBG
2/26/59

Subject: MINUTES OF THE ACRS ENVIRONMENTAL SUBCOMMITTEE MEETING HELD FEBRUARY 18, 1959, IN WASHINGTON, D. C.

The ACRS Environmental Subcommittee met at 10:00 a.m., on Wednesday, February 18, 1959, in Washington, D. C.

Attendance: ACRS Subcommittee

C. R. McCullough
K. R. Osborn
L. Silverman
C. R. Williams
F. A. Gifford

J. B. Graham, Exec. Assistant

BNL

Kenneth Downes
Irving Singer

A background summary on site criteria prepared by Dr. Gifford (attached as Appendix A) was distributed to and read by the participants of the meeting.

Mr. Downes stated that, in the studies he had seen, the effect of an adequate warning system (civil defense) and the advantage of decontamination factors readily obtainable in the field were generally neglected. Dr. Silverman observed that the most recent information on D.Fs. was as follows:

MEDIA	REMOVAL EFFICIENCY (%)*
Turkish towel (2 thicknesses)	95
Handkerchief	80
Gas Mask	99.98
Respirator	90

*For 1 micron particles (optimum for lung retention)

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Efficiencies for gas masks vary widely and are closely related to how well the facepiece fits the subject. Experiments with respirators in some cases show as high as 99 per cent removal and others as low as 50 per cent (Hanford data). Dr. Williams suggested that since one could not always depend upon successful execution of an evacuation plan the gains therefrom should be looked upon as gravy. Dr. Silverman reviewed the use of weighting factors (presented earlier) which apply to various aspects of the reactor and permit a quantitative approach to the making of the judgment upon the acceptability of the reactor - site combination.

Dr. McCullough stated that it was his understanding that Mr. Price might publish site criteria for public comment in late March or early April. There is a need to publish some "numbers" since operation without numbers, as has been done in the past, implies acting in an arbitrary manner.

Dr. McCullough said that the Committee must be certain that there is agreement on the philosophy which lies behind the choice of the numbers as well as the numbers themselves. In addition, one must decide on whether to state a minimum value (e.g. exclusion radius) for the best situation which must be increased in certain cases or a maximum requirement for the worst case which may be relaxed to a given degree based upon the merits of the particular case. Dr. Williams stated that on the basis of zoning experience if one sets a minimum the tendency is to reduce that minimum. He suggested stating the larger value and allowing reduction in special cases.

In the parts that follow the underscored portions were presented as an outline by Dr. McCullough. The portions not underscored were explanatory remarks or summaries of the discussion which followed.

I. Damage to Humans

A. Employees 5 rem/yr. This applies for the period from 18 years of age to 48 years of age. It was agreed that for the moment this problem would be deferred. Some hold that the term employees should apply only to those immediately concerned with the operation of the reactor.

B. Public

1. Vicinity .5 rem/yr

2. Total Population .05 rem/yr.

II. Damage to Property (crops, soil, etc.) If shortage of farmland exists this could be a problem. Not so for United States. It was agreed that this problem should be deferred.

Dr. McCullough differentiated normal vs. abnormal operation. In the course of normal operations one can expect cladding failures, stuffing box leaks, bearing failures, etc. These may result in release of some radioactivity and Part 20 should govern. Part 20 does not however apply to the abnormal operation (accident) brought about by cracking of a pump casing, rupture of high pressure piping, etc. It is not possible therefore to define an acceptable emergency dose since one cannot predict the accident. The concept of 25R as an acceptable emergency dose is not valid. It is valid, of course, under the concept for which it was initially defined.

This was in connection with the willingness to expose an individual to a dose, which could be fairly accurately estimated in advance, in order to save life or valuable property. Further, one should have interest beyond the exposure to an individual at the site boundary. What doses are seen as a function of distance beyond the site boundary and how many people are exposed?

III. Degree of Protection

A. Definite time Period - 10 years. Description of events, effects, probabilities, etc., are more realistic if one considers a period of time such as 10 years. For example, in the operation of 100 large reactors such as Dresden over a 10-year period several fuel elements may burn releasing their activity. One can design against all reasonable accidents but one can neither predict them nor insure that there can never be one.

B. Exposure Limit

1. Whole body gamma dose)
)
2. Internal dose) For entire Atomic Energy program* - 200,000 Roentgen Units**

The application to site criteria follows. (Assume principal portions to be underlined.)

A formula is derived which permits comparison of sites for the case where power level is the only variable. All reactors are assumed to have fission product inventories resulting from 200 days of continuous

* excluding the Isotopes program

** exposure to an individual in excess of 1000 rem is counted as 1000.

operation. Each reactor is apportioned its fair share as follows:

$$\frac{\text{Thermal power (Mw) x 10 years}}{\text{U. S. Capacity for 10-year period}} \times 200{,}000 \text{ R.U.}$$

$$= \frac{\text{MW(th)} \times 10}{5{,}000 \times 10} \times 200{,}000 \text{ R.U.}$$

or 40 Roentgen Units per thermal MW

One can compute a maximum accident and an "average" accident. An arbitrary release fraction (not without basis) of .003 is assumed for the purpose of the calculation. This is the fraction of the fission product inventory which is assumed to be released outside the container.

Thus

$$40 \text{ MW (th)} = (.003)\ f \text{ (population density, wind/rose)}$$

The population density distribution and the wind rose are unique to the site.

Another factor to be considered, F, is a function of the type of reactor (T) and its use (U).

$$F = F\ (T,U)$$

For example one could assume PWR as a base at F = .1 and assign other F values as follows:

PWR	F = .1
Dresden	F = .5
Testing	F = 5
Experimental	F = 10

Adding a containment factor (C) the generalized formula can be written:

$$\text{MW (th)}\ F\ C\ R \left[f\ \left(\rho_{x,y} \right) \vec{U}_{x,y,z} \right) \right] \geq 40 \text{ R.U.}$$

where

F = factor for type and use
C = containment factor
R = release fraction

ρ = population density distribution in x, y plane

$\vec{u}$ = wind velocity vector in x, y, z coordinate system

Based upon population density figures given them, Singer and Downes computed

12,000 R.U. for PWR and

326 R.U. for VBWR

[Fair share is 9,600 for PWR and 2,000 for VBWR (assumed power of 50 MW)]

IV. Kinds of Accidents

1. Nuclear runaway
2. Local overheating
   a. Deposits on fuel elements (crud)
   b. Flow stoppage in channels
   c. Flux peaking
   d. Oscillations
3. Loss of cooling
4. Chemical reaction
   a. Inside reactor
   b. Outside reactor
5. Dependent sequences

V. Containment

The following classes of containment, described by Dr. Silverman at an earlier meeting, were reviewed briefly:

Class	Rating	C Value
1. No containment	0	large
2. General building contraction(less than 0.2 psi) with controlled release and provisions for recirculating accumulated fission products through gas cleaners by recycling enclosure gases through collector.	1	intermediate
3. Containment with controlled release for pressures beyond 0.2 to 2 psi with effluent cleaner for all fission products accumulated below these limits through effective cleaning devices.	2	small
4. High integrity pressure shell capable of containing all pressure rises, and fission products for further treatment.	2	small

Effects of missiles on containers must be considered in the assignment of these ratings or C values.

VI. Population Density

It was noted that the reactor owner has no control over the population density in the area. The establishment of a reactor facility may in itself bring about an increase in population density in the surrounding area.

It was agreed that the following statement expresses the Subcommittee's view: "The population distribution should be such that accidental leakage of radioactivity shall not cause the product of the average dose times the number of people exposed to 1 rem or more to exceed 40 times the reactor power in thermal megawatts". This is for a ten-year period - or 4 roentgen units per megawatt, per year, for ten years.

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EXCLUSION AREA

There was considerable discussion about the necessary exclusion area around reactors of different powers. Although it is obvious that the selection of certain arbitrary distances for reactors of various powers may be a simple solution, some thought should be given to the basic reason for an exclusion area.

It has been generally stated that exclusion area is for the purpose of protecting against gamma shine in case of accidents and also to give a certain amount of time for warning, evacuation, or other alleviating measures. Mr. Downes made a point that for protection against gamma shine from an unshielded container full of fission products the exclusion area should be approximately three-quarters of a mile. This is for a 500 Mw reactor. He made the point that there is no significant difference in the distance for half versus all of the fission products.

After considerable discussion the Subcommittee generally agreed that the basic principle of an exclusion area should be for the protection of the public outside of it from the gamma shine. The exclusion distance should be such that for the uniform distribution of 100 per cent (or somewhat less) of the gross fission products within the container the dose at this distance would be (according to our notes the Subcommittee did not agree upon any definite number but values of the order of 25 rem and 100 rem were mentioned). Because the greatest part of the dose is delivered in the first hour the actual time to be specified for the accumulation of the dose is not particularly sensitive, but some number should be arrived at. Values for this should range from 4 to 24 hours.

The Subcommittee was of the opinion that shielding within the container could be substituted for distance even to the extent of reducing the exclusion distance to substantially zero provided that the leakage rate was sufficiently low. The view was expressed that it might be necessary to specify some small exclusion area even with adequate shielding.

The Subcommittee discussed the question of whether or not any activity should be permitted in the exclusion zone without reaching any firm recommendations. One view was that there would be no objection to a large heavy industrial installation, such as an oil refinery, within the exclusion area. It was the consensus that a certain amount of activity could be permitted within this area but that these activities should be limited to those in which persons could be under control and evacuated rapidly in event of accidents.

For comparison purposes the AEC exposure history for a nine-year period was cited.

Number of persons exposed	Exposure range (rem)
187,000	0-1
8,500	1-5
560	5-10
73	10-15
19	> 15

The meeting was adjourned at 4:15 p.m.

SITE CRITERIA

In general the location, design, construction, and operation should be such that all prudent safely conservative principles should be observed to prevent as far as possible injury to persons in the case of an accident. Although the site of a reactor cannot be properly assessed independently of the reactor and its use, nevertheless, it is useful to evaluate these factors independently as far as possible and the guide lines are set out in the following this in view.

The site has certain characteristics independent of the reactor, including population density, meteorology, geology, hydrology, and seismology. Of these the population density is presently the main consideration and in many cases the meteorology is the second most important aspect. The other factors are not to be neglected but are perhaps more easily taken account of in the design. As a guide for the decision that the site, independent of the reactor type, use, and containment, is suitable the number of roentgen units* accumulated by the population surrounding the reactor for an assumed release of gross fission products of .3 per cent during average nighttime meteorological conditions shall be not greater than 40 per megawatt thermal power.

This guide may be modified by appropriate factors which consider the type of the reactor, the experience with the use of this type of reactor, the usage of the reactor, the type of containment used, the amount and

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*Roentgen units are defined as the number of people affected multiplied by their equivalent whole body dose in rem from 1 to 1000. Doses greater than 1000 are counted as 1000, doses less than 1 rem are neglected.

kind of leakage which is specified for the containment and the appropriate geological, hydrological, and seismological factors. Credit also may be claimed for adequate warning and effective use of counter measures. These appropriate factors will be proposed by the applicant and will be accepted or modified by the appropriate hazard evaluation authorities.

Exclusion Area. The exclusion distance will be such that in the event of the uniform dispersion of 100 per cent of the gross fission products in the reactor within the containment structure or building, the dose accumulated by a person at the minimum exclusion distance due to gamma rays in 24 hours will be not more than 100 rem. Appropriate shielding can replace distance.