April 29, 1960

MEMORANDUM

To: All Members of the ACRS

From: C. Rogers McCullough, Vice Chairman

Subject: REPORT OF THE ENVIRONMENTAL SUBCOMMITTEE

Please note the attached minutes and draft of criteria for sites for power reactors.

The Environmental Subcommittee believes that these proposed criteria are the best approach it is aware of up to the present time. They would not like to recommend them as final prior to a study which would tell to what extent present actual approved sites conform to these criteria.

There is also attached a suggested addenda to Class "A" by Dr. McCullough and Ray Fraley.

cc: Dr. Duffey

F/23

OFFICE ▶	ACRS					
SURNAME ▶	CRM/tw					
DATE ▶	4/29/60					

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

MINUTES OF THE ENVIRONMENTAL SUBCOMMITTEE MEETING

Washington, D. C.

April 8, 1960

Attendance:

ACRS Environmental Subcommittee

C. Rogers McCullough, Chairman
L. Silverman
F. A. Gifford, Jr.
W. P. Conner, Jr.
K. R. Osborn

ACRS Staff

J. B. Graham
R. F. Fraley

AEC Staff

C. K. Beck, DL&R (Part time)

U. S. Weather Bureau

D. H. Pack (part time)

The purpose of this meeting was to develop proposed criteria for power reactor site selection. In addition proposed criteria were developed for visitor control and food production within reactor exclusion areas (see Enclosure 3).

It was noted that as far as the ACRS was aware visitor control at a number of installations lacks any significant regard for the number of visitors, their background (i.e., need to know) or the operating condition of the reactor. Dresden had several thousand visitors before going critical. One observation balcony has been completed and others are planned to accommodate visitors to the turbine building. In addition Commonwealth Edison has agreed to a five-year lease of the Dresden exclusion area for raising corn. A proposed set of criteria was prepared and is attached as Enclosure 3.

A set of site criteria prepared by Dr. McCullough was then reviewed. A section was added covering restrictions on normal releases and a modification to permit leak rate decreases with pressure decay was added. The revised criteria are presented as Enclosure 1.

Dr. McCullough noted that Enclosure 1 covers only Class A reactors which are continuously contained reactors with little (less than two to five years) operating experience. Criteria for the following classes were not yet developed:

Class B - Contained in case of an accident - little operating experience.

Class B-Class A - but proved by experience (2-5 years)

Class D-Class B - but proved by experience (2-5 years)

Class E - Uncontained - proved by experience (more than 2-5 years)

Dr. Beck reviewed the revised criteria and offered the following comments:

a) Section V-C may be difficult to meet under inversion conditions. It was noted that the dose rate calculations are based on representative rather than worst weather conditions.

b) Section IV will be difficult to interpret practically when selecting a site since the cost of damage to people versus land is difficult to assess.

Dr. Beck noted that the proposed criteria were remarkably similar to those the HEB is preparing except in the following major areas and a number of other points which were minor.

c) The fractional fission product releases selected by the ACRS Subcommittee (100 per cent release of all fission products) were more severe than those proposed by the HEB (100 per cent noble gases, 50 per cent iodine, 1 per cent strontium).

d) The reactor design, testing and operating criteria are defined in greater detail than the HEB criteria.

Dr. Beck described the HEB criteria briefly as follows:

1) No plant is eligible for a license unless it can be decided that:

   a) the usual confidence exists that the probability of an accident is very small;

   b) the worst accident will release no more than 100 per cent noble gas, 50 per cent iodine and 1 per cent strontium. To use lower fractional releases would require proof by the applicant.

2) The containment vessel is designed so that it would not be breached by the MCA. The applicant must demonstrate that the specified and measured leak rates will apply.

3) Pessimistic assumptions must be made in the dose calculations. The HEB is preparing a standardized calculation as an example.

When the above criteria are satisfied the following must apply:

1) The exclusion area must be large enough so that a person would receive not more than 50R in two hours at the boundary.

   A limit on the number of total man-rems is also being considered.

2) An evacuation distance must exist around the reactor with no more people living in one of the eight sectors than can be evacuated in eight to ten hours. The dose rate in this area must be no more than 50 rem in 24 hours.

The dose rate beyond the evacuation area would be no more than 50 rem for continued residence.

A comparison of proposed HEB Criteria and ACRS Criteria indicated that the following differences exist:

		HEB Criteria	ACRS Criteria
I.	Maximum Dose	Expects a maximum of 50r from the MCA	Expects a few persons can receive more than 50r from the MCA**
		(Both can be reduced by efficient evacuation)	
II.	Land Contamination	Not specified	Limited
III.	Genetic Effects	Not specified	Limited
IV.	Exclusion Area	Based on 50r in two hours*	Based on four points (V-A, B, C, D)
V.	Accident Characteristics	Release of 100 per cent noble gases, 50 per cent iodine, 1 per cent strontium	100 per cent fission product release
VI.	Pessimism of Meteorology	Working out standard calculation (not yet defined)	Representative (not yet defined)
VII.	Effect of population growth with time	Not limited	Not limited

*Dr. Beck noted that the 50r includes direct shine and ingested activity converted to whole body dose by biologists.

**The MCA equals dispersion of 100 per cent of the fission products within the outer most container.

Mr. Osborn noted that the low level doses over long periods to many people from normal releases are also of concern in establishing site criteria. However, since little guidance can be obtained from the biologists and geneticists in this area the criteria must fall back on the MCA type calculations.

Mr. Pack noted that neither the ACRS or the HEB criteria gave any credit to wind direction, relative location of water intakes, etc., which affect the probability of exposing people around the reactor. It was agreed that this should be considered but is very difficult to write into criteria.

Dr. Beck was advised that the Subcommittee had worked up a set of proposed criteria regarding use of exclusion areas. A draft copy was given to him for his review. It was noted that the site criteria and limits on use of exclusion areas were preliminary in form and might be modified considerably by the full ACRS.

Dr. Beck was asked to comment if he considered boiling water reactors with turbines outside the containment (Class B) more likely to release fission products to the environment than Class A reactors. He commented that release of large amounts of fission products from a boiling water reactor is a long term situation which would provide time for adequate isolation. Therefore, he does not consider the difference significant. Dr. Beck noted that the HEB criteria provided for the various reactor classes in the first two points of the HEB criteria.

It was agreed that additional information must be compiled and evaluated in order to resolve the differences between the ACRS and the HEB proposed criteria. A letter requesting this information was drafted as a supplement to the ACRS letter to Mr. McCone dated November 16, 1959. A draft of this letter is included as Enclosure 2.

4/29/60

SUGGESTED ADDENDA TO CLASS "A" BY DR. MC CULLOUGH

CLASS A

Section I

(Add after second paragraph)

In the case of reactors in which there are only two physical barriers between the fission products and the public (for example, boiling water reactors in which the steam from the core goes to a turbine located outside the containment vessel such that only the fuel cladding and steam pipe, turbine, condenser, etc., constitute the physical barriers) these shall be considered Class A reactors if:

1) It can be demonstrated that any nuclear excursion of credible probability would not melt more than 1 per cent of the core and would not vaporize any portion of the core.

2) There is an emergency cooling system which operates automatically in case of loss of regular cooling. This emergency cooling system will prevent the melting of any portion of the core.

3) There are valves on the steamline and other lines penetrating the container which can be closed before fission products released from fuel elements in an accident can be released to the environment and it can

be demonstrated that these valves are constantly available for tight closure.

4) The demonstrated leakage rate of the parts of the primary system to which fission products can reach is such that the requirements of Sections IV and V can be met.

4/29/60

SUGGESTED ADDENDA TO CLASS "A" BY R. F. FRALEY

Items one and two may be difficult to defend as criteria since they

1) Are affected by many other considerations which are not specified (i.e., is metal water reaction considered in the nuclear excursion, is the meltdown progressive, etc.)
2) Get into plant design which can be compensated for in other ways (i.e., the Navy originally used auto emergency cooling - now use manual based on core parameters).

Item No. 3 - Suggest following changes.

"Auto valve closure with multiple instrument channels and backup valves should be provided." This eliminates dependence on operators. Manual override should be provided of course.

If valves cannot close fast enough to prevent release of any fission products the puff should be considered in the dose calculations.

Actually the statement in No. 3 that valves must close before fission products can be released to the environment appears inconsistent with No. 4 that the leak rate of these fission products must meet IV and V.

A system for core cooling in the event of a loss of coolant accident should be required as well as an emergency cooling system for loss of coolant flow accident.

Draft No. 3 4/29/60

REACTOR SITE CRITERIA

INTRODUCTION

It is entirely proper for the Advisory Committee on Reactor Safeguards to set down technical criteria which represent their own ideas of what things need to be considered and what standards of reliability must be met to adequately protect the health and safety of the public. Such criteria have no status as law or regulations. They do not need to be as detailed as such laws or regulations must be. They should be general with many subdivisions making it easy to modify or review them.

Enclosure No. 1

Draft No. 3 4/29/60

CRITERIA FOR SITES FOR POWER REACTORS

CLASS A

Section I

Reactor systems of this class must be designed in accordance with well recognized conservative design principles. The components must comply with recognized codes where such exists or with conservative design principles where there are no applicable codes.

There must be at least three continuously maintained physical barriers between the fission products and the public, for example, fuel cladding, primary system, and safety container.

There must be at least two independent methods of detecting over-power and excessively short period. At least one of these signals of abnormal condition must automatically shut the reactor down.

There must be at least two independent methods of shutting the reactor down.

The reactor must possess negative void, temperature, or power coefficients above 200°F.

There must be an emergency cooling system sufficient to prevent any melting of fuel if normal cooling fails.

Additional features dictated by good engineering judgment will be required. These may be specified in detail later. For example, it must be demonstrated that the site has the capability of providing protection equivalent to that of the legal requirements for protection against radiation such as AEC Reg. 10, CFR, Part 20, Standards for Protection Against Radiation.

Section II

The reactor system must be built in accordance with the design specifications and have been inspected at proper intervals to assure this.

Section III

The reactor must have been checked out in its initial startup to verify all design details and specifications.

It must be operated by qualified licensed personnel in accordance with detailed written operating instructions.

There must be technically qualified supervision available to interpret the data which is obtained during the operation.

There must be a detailed written procedure for maintenance of the plant.

Section IV

For a reactor meeting the foregoing requirements the characteristics of the site shall be such that the non-reparable damage to the

environment will not be greater than would be expected from a large industrial plant such as an oil refinery, chemical plant, etc.

Non-reparable damage covers those insults to land, water, or people which cannot be restored to their original conditions within the financial limits of the Atomic Energy indemnity ($560,000,000).

The injury to land would include contamination to the point that no usable produce could be grown. If this area is small enough so that its permanent retirement from use would not disrupt the life of a community and the value was less than $560,000,000 this would not be called irreparable damage.

Damage to water would make it unfit for consumption by animals or humans. If the quantity is small enough this would be reparable. Damage to water could also disrupt commercial fishing or other marine industry and result in such widespread dislocation that the damage would be irreparable.

The exposure to people will be considered in three categories.

a) Severe injuries - exposure to 450 rem or greater for whole body or equivalent for portions of the body or organs.

b) Moderate injuries - exposure to 100 rem or less for whole body or organs.

All reasonable attempts should be taken to evacuate people to reduce doses actually received.

c) Genetic where the doses are 50 rem or less for the whole body or equivalent for portions of the body or organs.

Section V

Having required that the reactor system be built so that no reasonable failure will disrupt it the only variables remaining are the leakage rates of these various physical barriers and how this affects the environment.

The leakage rate of the outermost physical barrier or shell will be used to determine a source strength for calculating the acceptability of a site. Statements on reduction may be used to define a time dependent leakage rate. In lieu of such mechanism the rate will be considered constant.

The guaranteed leakage rates of either of the outer barriers shall be such that assuming the uniform dispersion of all of the fission products or other radioactive materials in the core within the shell that assuming the representative meteorology of the site and a ground level release not more than the number of people

A) equal to the numerical value of 10 per cent the design power of the reactor in thermal megawatts - receive 450 rem or less down to 200 rem.

B) equal to the numerical value of the design power in thermal megawatts - receive 200 rem or less down to 50 rem.

C) The summation of the doses received by people between 50 rem and 0.1 rem will be less than the background radiation these same people would have received in 40 years (5 rem each).

Each reactor will have an exclusion area such that in the event of the uniform dispersion of all of the fission products in the reactor within the outermost container a person standing unprotected at the perimeter would receive a whole body gamma dose of less than 25 rem/hour /and an ingested integrated lifetime dose to the lung, bones or gut of 25 rad per hour of breathing the mixture or to the thyroid of 100 rad per hour of breathing the mixture/.

Note: The bracketed portion of the last sentence may be inconsistent with Section IV, A, B, C. This will have to be calculated.

Draft letter to
AEC Chairman

4/29/60

Subject: PROPOSED STUDY OF THE REACTOR HAZARD AND CRITERIA PROBLEM

Dear Mr. McCone:

The Advisory Committee on Reactor Safeguards, in a letter to you dated November 16, 1959, recommended a correlation and critical evaluation of existing data relating to all aspects of safety. It is hoped that this study would make it possible to establish criteria for several parts of reactor systems at an early date. The Committee suggested several categories into which this review could be divided.

At a meeting of the ACRS Environmental Subcommittee on April 8, 1960, discussion with Dr. C. K. Beck,of the Division of Licensing and Regulation, indicated that proposed site criteria being drafted by the ACRS and those being prepared by the Hazards Evaluation Branch, although in general accord, are not in complete agreement in a number of areas. To help resolve these differences it is requested that the Committee be provided with the following information:

1) A critical review of the literature and an annotated bibliography which will help define the amount of fission products which might leak out of a containment sphere after a total meltdown or total vaporization of the core.

Enclosure No. 2

2) A critical review of the literature on the time required to evacuate up to 1000 people from the area within a three to five mile radius from the reactor.

3) Once a decision has been reached on the source strength and release rates and paths to the environment, it becomes necessary to evaluate the dilution and spread of this radioactivity in the atmosphere. The biologically significant dosages resulting from population exposure to estimated activity levels should be determined for all major reactors on a basis that reflects real environmental differences among sites. Such a determination should include a range of environmental conditions which would be sufficient to bracket expected time and space variability at atmospheric dilution, and should account for the persistence of various dispersion regimes, at each site. Similar considerations apply to release of radioactivity which is carried by streams or ground water, and an equivalent study of transport and dilution of water-borne contaminant should be made.

4) A series of calculations using the meteorological techniques previously mentioned for all existing power and test reactors to determine the actual distances and

dose rate/sec involved for a unit source/sec of the significant fission products, noble gases, halogens and bone seekers. This should include isodose lines for the 1, 0.5, 0.2, 0.1, 0.05, 0.02, 0.01, 10^{-3}, 10^{-4}, rem/hour or equivalent dose rates.

5) What is the dollar value of the land to distances of 1, 2, 5, and 10 miles around all existing power and test reactors?

6) What is the cost of decontaminating urban and agricultural land down to acceptable levels as a function of the degree of contamination?

7) What knowledge is there regarding the rate of buildup of population around facilities comparable to reactor sites? What are the driving forces affecting shifts in population? A radius of 50 miles is the distance of interest.

8) What is the experience of failure of vessels and piping which have been designed according to prevailing design codes, such as ASME and ASA? What was the character of the failures?

Draft No. 3
4/29/60

LIMITS PROPOSED BY THE ACRS ENVIRONMENTAL SUBCOMMITTEE ON USE OF EXCLUSION AREAS

Visitor Control

I. Power Reactors

1) No entrance into containment vessel.

2) Retain a record of visitors who enter the exclusion area.

3) Retain a record of exposures based on measurement of guide exposures.

4) Maintain means for rapid evacuation. This should be rapid enough so that no visitor receives more than 200 rem direct gamma shine from a release of 100 per cent noble gases within the containment.

5) Control access to exclusion area.

   a) Maximum number of visitors limited to 100 persons.

II. Testing Reactors

1) No visitors with the exception of technical groups should be permitted during loop tests.

2) Technical groups should be limited to a maximum of 25 persons. All should wear film badges.

3) Visits of non-technical groups when loops are not installed should be limited by discretion of the operator but in no

Enclosure No. 3

case should exceed twenty-five persons. All should wear film badges.

Food Production

1) Food released for consumption should comply with AEC Regulation 10 CFR, Part 20, "Standards for Protection Against Radiation".