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EXISTING REACTOR CONTAINMENT PROGRAM

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C. 1 thru 13 Extra

This document consists of
13 pages, in 6 parts
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EXISTING REACTOR CONTAINMENT PROGRAM

by

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August 15, 1958

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EXISTING REACTOR CONTAINMENT PROGRAM1. INTRODUCTION

Request was made in reference (1) for preliminary data on those engineering and study items to be included in the scope of work covered by Project CG-791, "Confinement of Radioactive Particulate Matter in 105 Building Exhaust Air". Time has not been available, of course, to accomplish any significant amount of additional engineering work. However, an effort was made to assemble all the information which is currently at hand regarding these items. The results are presented below.

2. TENTATIVE INFORMATION ON COST AND SCHEDULEa. Filtration and Minimum Building Seal (Scheme I as described in references (2) and (3))

This approach is defined as filtration of all air which is normally exhausted to the ventilation stack (no provision for any hold-up period other than that required for the air to pass through the filters and associated duct work). Also included are provisions for a fog spray system within the rear face enclosure with a supplemental fog spray and drain in the exhaust stack. It is expected to cost from \$3.5 million to \$4.0 million to equip all eight existing reactors with such systems. Completion time would be about two years from initiation of scope design.

While this method of confining potential air-borne contamination will significantly reduce the amount of fission product release following reactor incidents of a certain type, it is not intended to protect against those incidents which would result in a significant pressure build-up within the reactor building. The system would be designed to remove approximately 99.95 percent of the particulates and about 50 percent of the halogens from the air passed through it, but only minor amounts of the noble gases. An attempt to assess the degree of protection provided by such a system is contained in a later section of this document

As requested in reference (1), work has been started on scope and detail design of these facilities. This design program will require 10 to 12 months to complete and will cost from \$250,000 to \$300,000.

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- (1) HAN-69737, "Reactor Containment", J. E. Travis to W. E. Johnson, August 8, 1958.
 - (2) HW-55732, "Containment Concepts for HAPC Reactors - An Interim Report", H. S. Davis, April 29, 1958.
 - (3) HW-56585, "Filtration of Exhaust Air from Existing HAPC Reactors", R. C. Walker, July 7, 1958.

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b. Filtration with Additional Building Sealing as Well as Automatic Shutdown and Isolation of the Ventilation Supply

It is proposed that preliminary engineering studies be made of the feasible forms of supplementary building sealing which could be employed at the existing reactors. For example, it may be feasible to reinforce the existing buildings to withstand about 0.2 psig internal pressure. These studies will include careful appraisal of each individual item as to its potential contribution to either the assurance or the degree of containment. As a result of these studies it may be possible to effect some improvement in design performance, relative to Scheme I as described in reference (3), at some reasonable additional cost (probable maximum of \$15 million for all eight reactors, based on studies of Scheme II reported in reference (2)).

It is estimated that these engineering studies, including preliminary designs and cost estimates, will require on the order of six months to complete.

c. Filtration, Sealing, etc., as in (b) above, plus Iodine Removal Equipment

Available data on iodine removal are almost all based on studies of chemical process off-gas handling problems. Conditions of release as well as quantities involved would be so much different for a reactor incident that current information does not provide adequate bases for preliminary design and cost estimates of practical iodine removal systems. Attention has been given to the development of a comprehensive engineering study and experimental program to obtain the required information. It appears that six months would be required for the necessary test work and another two months for completion of the engineering analyses after the experimental data are available.

d. Containment Dome and Filtration (Scheme III, described in reference (2))

This approach to existing reactor containment can be defined as an envelop good for 2 psi differential pressure, encompassing the reactor building and equipped with air-locks, fog sprays, exhaust filters and iodine scrubbers. The cost for equipping all eight existing reactors with such low pressure domes and necessary auxiliary equipment has been estimated to be \$40 million. Due to lack of directly applicable information here at Hanford, these estimates are necessarily conservative. It is planned that the requested additional and more detailed studies be subcontracted to one or more qualified engineering firms. It is expected that a more nearly optimum envelop design can be obtained in this manner. Also, since they will have a much greater amount of information and experience from which to draw, estimated costs should be considerably more precise so that contingency and uncertainty allowances, and thus total cost, can be reduced significantly. Approximately six months would be required for this program if no undue delay is encountered in the contract negotiations.

(2) op. cit.

(3) op. cit.

Estimates of the cost of performing the engineering work outlined in Concepts b, c, and d are not very precise at this point. However, it is felt that the total for these latter three items will be between \$150,000 and \$200,000.

3. SYSTEM CAPABILITY

Reference (1) also requests preliminary information as to the degree of protection provided by each of four confinement concepts described above, to onsite personnel and to potential occupants of the Wabluke Slope Secondary Zone for a range of reactor accidents, as follows:

- a. Fission product escape from the reactor shield equivalent to that contained in four process tube charges irradiated to an exposure of 800 MWD/T.
- b. As in (a) above, for the equivalent of 150 process tubes.
- c. As in (a) above, for the complete reactor meltdown.

Available information has been reviewed and the results are presented in the following paragraphs.

Fission Product Release to Building

The quantity of fission products escaping from the reactor block for each of the prescribed incidents is listed in Table I. These values assume 100 days' operation at a 2000 MW reactor power level, and 1 minute decay time after shutdown. As in previous analyses^{(4), (5)}, the release is assumed to consist of 25 percent of the total available material, proportioned as 100 percent of the noble gases, 70 percent of the halogens, and 10 percent of the particulates. This assumption is in reasonable agreement with work by Parker and Creek⁽⁶⁾ and is in general agreement with the conditions experienced during the Windscale accident⁽⁴⁾.

In regard to the time required for fission product escape from the shield, the "worst conceivable" time, as requested, would seem to imply essentially instantaneous release. This situation is not believed credible for the incidents considered here, although it might be approached for the case of sudden pigtail rupture on a single tube with failure of the reactor to scram because of an in-operative Panel Iit gage.

It is believed that the time of emission would extend over a period of hours for the 4 Tube incident and over a period of perhaps days for the 150 Tube and Reactor Meltdown incidents, in accordance with the oxidation model developed previously in references (7) and (8). Since the assumption of sudden release maximizes the

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- (4) HW-56605, "Calculated Consequences of Accident", J. W. Healy, June 26, 1958.
 - (5) HW-53638, "Evaluation of Reactor Hazards, and Radiological Consequences", R. E. Trumble and J. W. Healy, November 18, 1957.
 - (6) CF-57-6-87, "The Volatilization of Fission Products by Melting of Reactor Fuel Plates", G. W. Parker and G. E. Creek, July 15, 1957.
 - (7) HW-56764, "Meeting with Advisory Committee on Reactor Safeguards - June 5-6, 1958, and Summary of May 9, 1958 Meeting", R. L. Dickeman, July 14, 1958.
 - (8) HW-55756, "Report for Advisory Committee on Reactor Safeguards", R. L. Dickeman, April 16, 1958.

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distances and areas involved, the uncertainties involved in the calculations are such that refinement of the release rate is felt to be unwarranted at the present time. More precise calculations will of course be made when experimental data on fission product evolution rates and effectiveness of proposed removal equipment are available.

Release Coefficients for Various Concepts

It is necessary to make rather arbitrary estimates of the efficiency with which the equipment of the various concepts will remove the fission product fractions in the case of the halogens and noble gases, because of the almost complete lack of experimental data at the present time. The assumed release coefficients are summarized in Table II.

The release coefficient for particulates is taken as 0.001, corresponding to 99.9 percent filter efficiency for all cases. This value is believed to be realistic based on actual results in separation plant filter systems and the commercial availability of filters rated at 99.95 percent efficiency or better.

Release coefficients for halogens are assumed to be 0.5 for Concepts a and b and for Concepts c and d when operated with normal ventilation and exhaust. For Concept c and d under emergency conditions, the coefficients are assumed to be 0.1 and 0.001 respectively. As presently conceived, Concept c may be required to handle about 10 percent of normal air flow under emergency conditions to avoid a pressure build-up to more than the allowable 0.2 psig. Concept d could probably process about 1 percent of normal air flow and thus more complete iodine removal can be secured in equipment of reasonable size and cost. It is hoped that experimental studies now planned will show that halogen removal significantly better than 50 percent can be achieved with the filter and fog spray system.

Release coefficients for the noble gas fraction are taken as 1.0, corresponding to essentially no removal, in all cases.

A related topic is the level of the incident at which Concepts c and d should be designed for automatic initiation of the emergency mode of operation. Confining the fission products in the building or dome implies that the reactor building must be evacuated, forfeiting any possibility of taking manual corrective action. This may be the correct course of action in a Reactor Meltdown incident but it would greatly increase the renovation costs following an incident involving a few slugs or a single tube. For the present purpose it has been assumed that the emergency mode of operation for Concepts c and d would be used for the 150 Tube and Reactor Meltdown incidents only. The basis for this choice is the feeling that renovation of an existing reactor would not be economically justified following an incident involving on the order of hundreds of process tubes, even though renovation might be technically feasible.

Comparison of Degree of Protection

In order to assess the degree of protection provided to occupants of the Wahluke Slope Secondary Zone, it is believed to be appropriate to compare the estimated distances and areas involved for the various incidents and concepts. These

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estimates are derived from the results presented in reference (4), and are summarized in Table III for the noble gas fraction, Table IV for the particulates, and Table V for the halogens. It is emphasized that significance should be attached to the differences in the values for the different concepts rather than to the absolute magnitudes given.

Reference (4) may be consulted for a detailed discussion of the bases used for deriving the limits which define evacuation and crop damage for the particulate and halogen fractions and for a discussion of the assumptions made in the calculations.

The values in Table III illustrate the range of dose which would be received by a person for the entire duration of the release due to external radiation from the noble gas plume at a distance of 10 miles from the affected reactor. This distance is representative of an average distance from the reactors to the Secondary Zone of the Slope. The Unstable column contains the range of values for the neutral and unstable atmosphere. The moderate and strong inversion cases are combined under the Stable heading. The values are based on release at ground level and cover both prolonged and sudden release. It is apparent that lethal conditions could exist under strong inversion conditions in the Full Reactor Meltdown unless persons in the path of the plume were evacuated.

Table IV gives an indication of the distances and areas affected by the particulates which escape filtration for the Reactor Meltdown incident only. Calculations have not yet been extended to include the lower releases of the 4 and 150 Tube incidents. It is reasonable to conclude, however, that the particulates from the 4 Tube release would not affect the Secondary Zone but that a 150 Tube incident would probably involve temporary evacuation. Crop damage would occur to a limited extent under neutral conditions and both temporary evacuation and crop damage would occur under inversion conditions.

Table V presents the effects of the halogen fraction in terms of the maximum distances and areas affected. Again, calculated results are available only for the neutral and moderate inversion cases for a release at ground level. It should be noted that the values for the moderate inversion condition are perhaps misleadingly low because of the assumption of ground level release and the attendant deposition correction applied to the plume.

In comparing the values for the various concepts under the Reactor Meltdown incident, it is apparent that temporary evacuation and crop damage will probably occur in the Secondary Zone. However, the beneficial effects of greater halogen removal are evident in that the distances and areas affected by the halogens can be brought more nearly into the range of those for the particulates. It should be remembered that the values are not strictly comparable because of the less restrictive nature of the halogen limits.

With respect to the degree of protection afforded onsite personnel, no significant difference is immediately evident among the reference concepts for personnel in the affected reactor area if established evacuation plans and procedures are

(4) op. cit.

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carried out. In addition, property damage in the sense of denial of land use and crop confiscation is not a factor with plant personnel.

It is expected that personnel in other plant areas would obtain somewhat increased protection against excessive radiation exposure if Concept c or d were installed and in the event that a 150 Tube or Full Reactor Meltdown incident occurred. The degree of protection cannot be assessed with confidence; however, the lower rates of fission product release to the atmosphere with these concepts, especially Concept d, would provide somewhat more time in which to carry out the established evacuation procedure.

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TABLE I

RELEASE TO BUILDING OF FISSION PRODUCT FRACTIONS

Incident	Power Level, MW	Total Inventory, Curies*	Release to Building, Curies*	Noble Gases, Curies*	Halogens, Curies*	Particulates, Curies*
0.1 Tube	0.1	4×10^5	1×10^5	4×10^4	3×10^4	3×10^4
1 Tube	1	4×10^6	1×10^6	4×10^5	3×10^5	3×10^5
4 Tubes	4	1.6×10^7	4×10^6	1.6×10^6	1.1×10^6	1.3×10^6
150 Tubes	150	6×10^8	1.5×10^8	6×10^7	4×10^7	5×10^7
Full Reactor	2000	6×10^9	1.5×10^9	6×10^8	4×10^8	5×10^8

* All activities are based on 100 days' operation and 1 minute after shutdown.

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TABLE II

RELEASE COEFFICIENTS FOR CONFINEMENT CONCEPTS

<u>Concept</u>	<u>Noble Gas</u>	<u>Halogen</u>	<u>Particulate</u>
a.	1	.5	.001
b.	1	.5	.001
c. (Normal)	1	.5	.001
(Emergency)*	1	.1	.001
d. (Normal)	1	.5	.001
(Emergency)*	1	.001	.001

* It has been arbitrarily assumed that the emergency mode of operation will apply for 150 Tube and Reactor Meltdown incidents, and that for lesser incidents the normal mode of operation would be used.

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TABLE III

PERSONNEL DOSE FROM NOBLE GASES
IN WAHLUKE SLOPE SECONDARY ZONE
FOR ALL CONCEPTS

(At 10 Miles from the Reactor)

<u>Incident</u>	<u>Unstable</u>	<u>Stable</u>
4 Tubes	- -	< 1 rad.
150 Tubes	< 1 rad.	15 - 90 rad.
Full Reactor	1 - 8 rad.	200 - >1000 rad.

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TABLE IV

MAXIMUM DISTANCES AND AREAS AFFECTED BY PARTICULATES
FOR ALL CONCEPTS

<u>Condition</u>	<u>Full Reactor Incident</u>	
	<u>Miles</u>	<u>Square Miles</u>
<u>Neutral</u>		
Long Evacuation	< 1	(< 1)
Temporary Evacuation	3	(< 1)
Crops	10	(5)
<u>Moderate Inversion</u>		
Long Evacuation	4	(< 1)
Temporary Evacuation	20	(10)
Crops	80	(100)

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TABLE V

MAXIMUM DISTANCES AND AREAS AFFECTED BY HALOGENS

Concepts a and b

<u>Condition</u>	<u>Incident</u>					
	<u>4 Tubes</u>		<u>150 Tubes</u>		<u>Full Reactor</u>	
	<u>Miles</u>	<u>Sq. Miles</u>	<u>Miles</u>	<u>Sq. Miles</u>	<u>Miles</u>	<u>Sq. Miles</u>
<u>Neutral</u>						
Long Evacuation	-	-	-	-	-	-
Temporary Evacuation	4	(<1)	7	(4)	30	(40)
Crops	30	(50)	70	(250)	300	(<1000)
<u>Moderate Inversion</u>						
Long Evacuation	-	-	-	-	-	-
Temporary Evacuation	7	(1)	9	(4)	20	(15)
Crops	20	(15)	25	(25)	40	(70)

Concept c (Emergency Operation)

<u>Neutral</u>						
Long Evacuation			-	-	-	-
Temporary Evacuation			4	(<1)	10	(7)
Crops			30	(50)	100	(500)
<u>Moderate Inversion</u>						
Temporary Evacuation			7	(1)	10	(6)
Crops			20	(15)	30	(30)

Concept d (Emergency Operation)

<u>Neutral</u>						
Temporary Evacuation					< 4	(<1)
Crops					< 30	(<50)
<u>Moderate Inversion</u>						
Temporary Evacuation					< 7	(<1)
Crops					< 20	(<15)

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