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TITLE

NPR Liquid Radioactive Waste

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AUTHOR

R. L. Dickeman

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By J E Savely 9-8-93

Verified By D J Harker 9-9-93

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U. S. Atomic Energy Commission
Richland Operations Office
Richland, Washington

Attention: Mr. J. E. Travis, Manager

Gentlemen:

NPR LIQUID RADIOACTIVE WASTE

Reference: Letter, same title, F. P. Baranowski to J. E. Travis,
dated March 18, 1963, PRR:FPS.

In the reference letter, a request was made for the re-examination of the sources of radioactive liquid waste arising from operation of the New Production Reactor. Concern was expressed about the routine discharge of certain waste streams and their relationship to the Columbia River. The letter in hand discusses the background and the criteria upon which the present NPR radioactive waste disposal practices are based. It also states the anticipated quantities of radioactive material, their release to the environs, and compares these to liquid wastes from the Hanford KE Reactor. Also included in this letter are brief discussions of the alternates asked to be considered by the reference letter.

SUMMARY AND CONCLUSIONS

1. In absolute quantity, the nuclides discharged to the river are expected to be small, mostly of low radiological consequence, and have been conservatively estimated. The quantities so calculated are at 35 percent of the NPR design criteria (0.001 MPC of the values specified by the NCRP, when presumed at Ringold, the point of first public use). Relatively, the quantities involved tally to less than 1.5 percent of the average quantity released by one "K" Reactor.
2. No action is planned, at this time, to further reduce the quantity of radionuclides which might reach the Columbia. There is sufficient flexibility in the existing system, and sufficient time during startup, to warrant use of real wastes to evaluate the actual degree of environmental exposure.

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Attention: Mr. J. E. Travis

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3. Should experience indicate additional controls are needed, a prompt and relatively easy solution can be applied: extending the existing crib. Such action could accommodate all potential radioactive effluents and would provide significant additional delay time and at least partial retention of most of the nuclides.

Waste Disposal Criteria

Since inception, the NPR has been designed to closely control and restrict the release of radioactive effluents to the environs. Specifically, the Technical Criteria document (HW-53612) at the time of its first issuance in November 1957, established that the combined effects of radionuclides introduced into the environs shall not exceed 0.001 of the maximum permissible limit (MPC) for any critical organ at the first point of public interest (stated as Ringold). This criteria presumes a river flow rate of 36,000 cubic feet per second and uniform distribution in the river. The MPC utilized is that specified by the National Committee on Radiation Protection and Measurement for the continuous exposure to persons occupationally utilizing ionizing radiation (NBS Handbook 69).

It is to be noted that the NPR effluent design criteria was established at one percent of the Radiation Protection Standard applied by HAPO to existing facilities..

Liquid Waste Practices

The liquid waste streams which can be presumed to be contaminated and which are routinely discharged from NPR are shown in Attachment A. Principally these are the primary coolant bleed (crib discharge) and the control rod cooling water (river discharge). Under normal operating conditions the radionuclide content of these streams is due to the activation of corrosion products and trace impurities in the coolant. Wastes directly discharged to the river have no holdup as the release is continuous and the entry point is mid-stream as part of the tertiary coolant discharge. For wastes routed to the crib a minimum delay time of eleven days has been calculated, based on no absorption in the soil. This assumption is conservative for all but radio-iodine. Strontium 90 is estimated to take 3.5 years to traverse the six hundred feet from the crib to the river. Phosphorous, although not absorbed at low temperatures, evidences a 70 percent holdup at 90 C. Ground water temperatures under the crib approaching this value are expected after the reactor has been operating. The iodine and the strontium would be present only after release as a consequence of a fuel element rupture.

The principal radionuclides contained in the primary bleed and the control rod coolant waste stream have been calculated and are listed in Attachment B. It also contains a listing of matching nuclides for the KE Reactor. The nuclides involved in the other waste streams listed in Attachment A are not separately

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noted, but match without significant exception or are substantially less than those listed in Appendix B. Most of the nuclides are short-lived, have little biological significance or are in small absolute quantity. The most significant isotope is P^{32} . Assuming no crib holdup for P^{32} , the quantity released to the river is about one curie or about 2-1/2 percent of the current 40 curies per day estimated to be discharged by the existing reactors. Using crib holdup and radioactive decay factors this quantity reduces to about 1/4 curie per day. When the total quantity of radionuclides calculated to be routinely released to both crib and river is compared against design criteria, it appears that, at Ringold, the radioisotopes total to some 35 percent of the N Reactor design criteria.

Both relatively and absolutely, the radionuclides discharged to the Columbia River during routine operation of the NPR will be a vanishingly small contribution to environmental exposure. The dose as calculated utilizes the minimum river flow. Actually, the mean annual flowrate is about 123,000 cubic feet per second, or some four times the value used. With a higher flowrate, the calculated dose would correspondingly decrease. Also, piping and valving arrangements already exist so that almost any waste stream, as needed, can be directed to either the crib, the river, or interim storage. This flexibility in waste handling provides an additional measure of protection to the environs.

Assessing the contribution to the Columbia River from a NPR fuel rupture involves considerable speculation. Some of the variables include the size of the fuel element itself, as the potential for any one fuel element is directly related to the total amount of irradiated uranium available. Also involved is the ability to detect fuel failures and the time to take corrective action. In this regard, the N fuel rupture monitor system and individual reactor tube diversion system is far superior to the system used within existing HAP0 reactors. Should a rupture occur, the diversion system will place the effluent into the crib. If it should prove necessary, operational plans can be adapted to divert the offending tube effluent into the 900,000 gallon chemical waste storage tank.

Additional Radionuclide River Reductions

The several ways suggested in the reference letter for eliminating or minimizing NPR radioactive waste each have merit and each have limitations. Their merit is chiefly in deferring and reducing the absolute quantity of gross curies released to the environs. However, our present design and planned operating practices have already reduced the absolute quantity to a very low value. The assumptions made in calculating quantities of radionuclides possible are conservative, and the considerable time which will be available after startup to evaluate the radiological potential of liquid wastes, causes us to conclude that further reductions, while technically feasible, are not warranted at this time. The built-in flexibility of NPR will allow experience to provide more realistic bases for evaluating the environmental consequences of operation. Thus, the

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remarks in succeeding paragraphs concerning the proposed alternate ways to reduce radionuclides are not based on extensive engineering studies, as these also do not appear warranted at this time.

One proposal offered was to reduce the "purity bleed" flow. At the present time, the planned flow consists of some 200 gallons per minute (gpm) for direct bleed, 365 gpm for operating the rupture monitor, and 50 gpm for maintaining temperature control of the spill cooler equipment. With operating experience very probably the flow could be reduced. However, it would appear that initially the flow could not be presumed to be reduced more than 15 to 20 percent without involving an entirely different means of achieving the necessary primary loop quality control and in-leakage to the primary pumps.

The second alternate offered was to control primary coolant water quality by use of bypass demineralizers. This could be done and was, in fact, evaluated during the planning stages in 1957 and 1958. It was not adopted, chiefly because of the additional costs involved to bleed, cool and depressurize, clean, reheat and repressurize, and then reinsert this water into the system. At the present stage of construction, the installation of a full demineralizer system would be quite expensive and would considerably delay startup. There is no room within existing structures to have the demineralizers so a new facility would have to be built, and the existing piping considerably modified or scrapped.

The third alternate offered was to hold-up effluent for radioactive decay. There is a way this could be done. Expanding the crib capacity by connecting it to a long trench paralleling the river is feasible. The cost would be reasonable, the construction time involved short, and there would be only limited disruption of existing facilities. Such an approach would enable all of the four thousand odd gallons of potentially radioactive waste generated each minute of operation to be placed in the crib. The minimum decay time thereupon would be some eleven days. By simply directing the trench away from the shoreline, the time could be considerably increased. Eleven days is sufficient to effectively eliminate the short-lived nuclides from ever reaching the river, and while the longer-lived nuclides would not appreciably decay, most of these would be adsorbed in the ground. It is not proposed this be done now. Quite probably, if additional controls for the release of radionuclides to the Columbia River appears necessary in the future, a crib extension would be the method proposed.

The fourth alternate for which an appraisal was requested was to transport the effluent to a remote crib near Gable Mountain. Again, this is entirely feasible from a technical standpoint, but would be expensive. The need to transport spent decontamination chemicals to such a location, and thus avoid placing into the river material which could adversely affect the operation of existing reactors (the P32 problem) has already caused cost estimates to be prepared. When scaled up to accommodate the higher thermal temperatures, larger volume

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and continuous operation, the estimated construction cost is 1.1 million dollars. Were such a disposal method required, these costs could probably be pared by judicious combination and selection of wastes and by finding a site closer than Gable Mountain. Nevertheless, this alternate appears unattractive at present.

Alternates five and six in the reference letter called for combining any of the above or devising other means to reduce the quantity of NPR radio-nuclides entering the river. One possible alternate is to pass all liquid wastes through a low pressure demineralizer system before discharge to the environs. Salvaging of the demineralized water and its return into the primary system is not considered worth the slight risk of extending radioactive material into uncontaminated systems if an undetected break-through in the contaminated resin beds should occur. This alternate also requires, as do all considerations of demineralizer systems, that ultimately the spent resin be disposed of. No engineering estimate of this mode of environs contamination control has been prepared.

As a concluding remark, please be assured of our awareness of the need to adequately maintain radiological control of the environs. This general subject has already had considerable examination and appraisal, as can be noted from the bibliography of Hanford documents, Attachment C. These studies are continuing. Therefore, although our present evaluation of the environmental potential of NPR does not cause us to undertake additional protective measures, if further information indicates a need to make changes, you will be promptly informed.

Very truly yours,

General Manager
N-Reactor Department

RL Dickeman:JWV:vb

Attachment

cc: 1-3 RLOO-AEC, Attn: Mr. J. E. Travis

bcc: CH Crandall
RL Dickeman
OH Greager
AB Greninger
WE Johnson
PC Jerman
RL JunkinsAR Keene
MC Leverett
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ATTACHMENT A

ACTIVITY LEVELS OF VARIOUS N-REACTOR LIQUID BLEED AND WASTE STREAMS

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Description of Bleed or Waste	Rate (gpm)	Source of Radioactivity	Normal Disposition	Alternate Disposition	Activity Level* (curies/day)
<u>NORMAL REACTOR OPERATION</u>					
1. Primary Loop Bleeds					
a. Process Tube Diversion	175/tube Up to five tubes max.	Induced radioactivity plus particulate matter from a ruptured fuel element (UO ₂ , Zr-2, and fission products)	To crib (assuming a tube is diverted only if suspected of containing a rupture)	Directly to the river (such as charge-discharge). Interim storage in chemical waste tank	Very high depending on the size of rupture 90 for 10 gm rupture
b. Purity Bleed	200	Normally only induced radioactivity	To crib	Same as above.	40
c. Rupture Monitor	365	Normally only induced radioactivity	To crib	Same as above	70
d. Constant Spill	50	Normally only induced radioactivity	To crib	Same as above.	10
2. Shield Cooling Water	1800	Induced	To river	---	10
3. Moderator Coolant Bleed	25	Induced	To crib	---	15
4. Control Rod Cooling Water	1200	Normally induced	To river when rods are not being used to irradiate materials.	To crib when rods are being used to irradiate materials.	70

* These values have been calculated to represent the activity at the time of discharge into the crib or river whichever is applicable. For those streams fed into the crib the activity will be significantly reduced due to decay and filtration before ultimate disposal into the river.

ATTACHMENT A (Continued)

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Description of Bleed or Waste	Rate (gpm)	Source of Radioactivity	Normal Disposition	Alternate Disposition	Activity Level* (curies/day)
<u>EMERGENCY OPERATION</u>					
1. Primary Loop Dump and Then Single Pass Cooling	27,000	Induced with possible cor- rosion and fission prod- ucts	To quench basin and then to crib	---	Will vary de- pending on situation
2. Moderator Coolant Dump and Then Single Pass Cooling	5,000	Induced	To crib	---	Will vary de- pending on situation
3. Fog Spray	10,700	Corrosion and fission prod- ucts	To crib via sump lift pumps	---	Will vary de- pending on situation
<u>DECONTAMINATION OPERATION</u>					
1. Single Tube	Variable	Contamination	To a chemical waste storage tank for fur- ther transport to a crib	---	2
2. Single Pass - Reactor Only	Variable	Contamination	Same as above	---	2000
3. Two Step - Complete Loop	Variable	Contamination	Same as above	---	2000
4. Three Step - Complete Loop	Variable 1,400,000 gal. total	Contamination	Same as above	---	2000
5. Moderator Cooling System	Variable	Contamination	Same as above	---	1

* These values have been calculated to represent the activity at the time of discharge into the crib or river whichever is applicable. For those streams fed into the crib the activity will be significantly reduced due to decay and filtration before ultimate disposal into the river.

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ATTACHMENT A (Continued)

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Description of Bleed or Waste	Rate (gpm)	Source of Radioactivity	Normal Disposition	Alternate Disposition	Activity Level* (Curies/Day)
5. Storage Basin Overflow	1000	Radioactive corrosion products	To river	To crib	1
6. Gas System Condensate	1	C-14, S-35, H-3	To river	To crib	Negligible
7. Miscellaneous Drains					
a. 105-N, 109-N floor drains	1500	Could contain some contamination	To river	To crib	Negligible
b. Hot lab drains	5	Activation products	To crib	To river	1
c. Rupture Monitor Cooling Water	2500	Normally induced but could become contaminated by large leaks in heat exchanger	To river	---	Normally negligible. In the event of heat exchanger leakage, the reactor would be shut down and leak repaired.
d. Dummy Decontamination	1	Corrosion products	To river	---	0.25
8. Charge-Discharge	1000	Normally very low activity unless a ruptured tube is being discharged.	To river	To crib (if discharging a ruptured fuel element)	Up to 10
9. Maintenance Single Pass	10,000	Normally very low induced radiation during shutdown.	To crib	---	Up to 100 curies initially as the primary coolant is displaced.

* These values have been calculated to represent the activity at the time of discharge into the crib or river, whichever is applicable. For those streams fed into the crib the activity will be significantly reduced due to decay and filtration before ultimate disposal into the river.

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ATTACHMENT B

RADIOACTIVITY OF EFFLUENT STREAMS - CURIES PER DAY

<u>Radionuclide</u>	<u>Half Life</u>	<u>100-N</u>		<u>100-KE</u>
		<u>Primary Bleed</u>	<u>Rod Coolant</u>	
Na ²⁴	15 hours	30	6	1700
P 32	14.3 d	1	0.1	12
Cr ⁵¹	27.8 d	1	2	1200
Mn ⁵⁶	2.6 hr	85	50	10,500
Cu ⁶⁴	12.9 hr	4	5	650
Zn ⁶⁵	245 d	1	1	25
As ⁷⁶	26.5 hr	1	1	60
Np ²³⁹	2.35 d	<u>1</u>	<u>2</u>	<u>140</u>
		~120	~70	~14,300

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ATTACHMENT C

DOCUMENTS RELATING TO NPR LIQUID WASTES

1. HW-53544, Maximum Activity Levels in NPR Heat Dissipation System, G. T. Orton, January 20, 1958.
2. HW-53612, Technical Criteria and Bases - Pressurized Water Cooled, Graphite Moderated Production Reactor, R. L. Dickeman, November 14, 1957.
3. HW-55060, Diffusion of Uranium in NPR Primary Coolant - Radiological Limits, R. B. Hall, February 20, 1958.
4. HW-57252, REV 4, NPR Water Quality Design Bases - Mixed Primary System, W. D. Bainard, July 20, 1961.
5. HW-59689, REV 2, Project CAI-816, Reactor Auxiliary Water Requirements, G. E. Wade, July 2, 1959.
6. HW-59787, Discussion on NPR Demineralizers, W. D. Bainard, March 26, 1959.
7. HW-61126, Proposed NPR Waste Disposal Systems, W. D. Bainard, July 30, 1959.
8. HW-61251 B, An Interpretation of Technical Design Criteria for NPR Liquid Waste Disposal Facilities, R. B. Hall, August 7, 1959.
9. HW-62150, NPR System Parameters, D. L. Condotta, D. E. Simpson, October 1, 1959.
10. HW-62522, NPR Liquid Waste Disposal, R. B. Hall, November 24, 1959.
11. HW-63802, NPR Waste Disposal Design Guide, W. D. Bainard, May 16, 1960.
12. HW-65540, Scavenging As a Predisposal Treatment for NPR Decontamination Wastes, W. M. Koop, June 7, 1960.
13. HW-67326, 100-N Area Aquifer Evaluation, D. J. Brown, November 4, 1960.
14. HW-67364, Laboratory Investigation of Decontaminating Solutions for Primary Loop Decontamination in the Production Reactor, J. E. Mendel, November 8, 1960.
15. HW-68425, Specific Activity of the NPR Primary Coolant Loop, D. A. Bitz, February 16, 1961.
16. HW-68484, KER-1 Decontamination With Phos-1, August 19-29, 1960, Liquid Sample Analytical Results, T. F. Demmitt, February 13, 1961.
17. HW-68863, Disposal of NPR Decontamination Wastes, W. N. Koop, March 14, 1961.
18. HW-69426, Proposed Disposal to Ground of NPR Decontamination Wastes at an Inland Site, R. E. Brown, April 13, 1961.
19. HW-70058, Analysis of 100-N Disposal Crib Influence on the Sanitary Till Field, A. E. Reisenauer, June 22, 1961.

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ATTACHMENT C (Continued)

20. HW-71929, Proposal for Final Disposal of NPR Chemical Waste, W. D. Bainard, December 5, 1961.
21. HW-72565, N-Reactor Liquid Wastes, D. A. Bitz, February 1, 1962.
22. HW-73203, The Effect of Uranium Surface Contamination on NPR Fuel Upon Fuel Rupture Detection at the NPR, R. S. Paul, April 3, 1962.
23. HW-73482, Crib Disposal of the NPR Decontamination Wastes, D. W. Benson, May 10, 1962.
24. HW-74507, Predisposal Treatment of NPR Decontamination Wastes, W. N. Koop, October 1, 1962.
25. HW-76266, January Monthly Report - Contamination Control - Columbia River, R. G. Gier, January 21, 1963.

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