A major purpose of the Technical Information Center is to provide the broadest dissemination possible of information contained in DOE's Research and Development Reports to business, industry, the academic community, and federal, state and local governments.

Although a small portion of this report is not reproducible, it is being made available to expedite the availability of information on the research discussed herein.

UNCLASSIFIED

HW--30430

DE91 000376

AEC RESEARCH AND DEVELOPMENT REPORT

USE OF REACTOR EFFLUENT WATER

AS STEAM PLANT BOILER FEED

By

H. V. Clukey

Radiological Engineering
Radiological Sciences Department

December 8, 1953

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

Photostat Charge \$ 4.25 for
Access Permittees
Available from
Technical Information Service Extension
P. O. Box 1001, Oak Ridge, Tennessee

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, express or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission to the extent that such employee or contractor prepares, handles or distributes, or provides access to, any information pursuant to his employment or contract with the Commission.

UNCLASSIFIED

CLASSIFICATION CANCELLED

TO UNCLASSIFIED
BY AUTHORITY OF RLO-CC-4
B.E. Gylesen 9/19/76
BY J. L. Jones DATE 10-3-1990

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

COPY NUMBER

1
2
3
4
5
6
7
8
9
10

DISTRIBUTION

H. M. Parker, H. A. Kornberg
W. A. McAdams, D. W. Pearce
J. M. Smith, H. V. Clukey
V. D. Nixon, C. R. Bergdahl, V. W. Wood
J. E. Maider, H. A. Carlberg, J. H. Black
J. C. McLaughlin, G. W. Wells, W. R. Conley
J. H. Warren, P. C. Jerman
R. H. Beaton, J. L. Boyd, C. E. Kent
300 File
Yellow File

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

USE OF REACTOR EFFLUENT WATER

AS STEAM PLANT BOILER FEED

ABSTRACT

The radiological aspects of a proposal to recover some of the heat now wasted in cooling water from the Hanford reactors by using the hot water as boiler feed for the steam plants in the 100 Areas are evaluated. The radioactive material in the hot effluent water will contaminate the boiler feed water system, cause additional radiation exposure of personnel, and increase the cost of maintenance and radiation protection, but very little radioactive material will be carried over into the steam system. At present steam loads, this proposal is economically attractive; other proposals being considered may nullify any savings from this one.

UNCLASSIFIED

INTRODUCTION

Methods for recovery of some of the heat from reactor cooling water now wasted to the Columbia River, are under investigation by the Utilities and Service Unit, Process Engineering, of the Engineering Department. The Radiological Engineering Section of the Radiological Sciences Department was asked to evaluate a proposal to use the hot effluent water as boiler feed in the powerhouses of the 100-B, D, F, and H Areas, in consideration of the problems engendered by the radioactive material in the reactor effluent water.

It is logical to take the reactor effluent water for use as boiler feed from the outlet end of the effluent retention basin, since this allows 1 - 2 hours for decay of radioisotopes and settling of larger particulate matter, gives a safety margin for switching basins or taking boiler feed from a source of uncontaminated water, allows much of the dissolved gases in the water to escape to the atmosphere, and yet results in little heat loss from the water.

The original design premise was that steam would be more reliable, even though more expensive, than electrical power, so in the four older 100 Areas steam turbines are used directly to drive some pumps and fans, as well as to supply power during electrical outages and shutdowns. Analysis of electrical outages since the Hanford project began indicates that the electrical system is sufficiently reliable, so in the new facilities and revisions to the older, direct-drive steam power is being eliminated in favor of flywheels and steam-driven emergency generators. Therefore this study was limited to the older Areas where greatest economy could be achieved, although the findings could be extrapolated to the newer facilities to achieve the additional economics.

If some other economy proposals now under consideration (HW-23513) are adopted for the older Areas, the apparent savings in this proposal may not materialize.

Should this method of heat recovery be found undesirable, a counterproposal is offered for evaluation by Process Engineering - that a heat exchanger be submerged in the reactor effluent water at the inlet of each retention basin, and softened water (to prevent scale formation) be pumped from the 184 Powerhouse through the heat exchanger and returned to the boiler feed system, to recover some of the heat otherwise wasted.

UNCLASSIFIED

CONCLUSIONS

The heat recovered from the reactor effluent water appears as a saving in heat required to raise the temperature of the boiler feed water to 230°F for deaeration and entry to the steam drum (Figure 1). The amount of heat recovered is just about equivalent to the heat in the make-up steam taken from the process header, which is required in addition to the waste steam to pre-heat the feed water. This make-up steam averages close to 10 percent of the total generated.

The temperature of the Columbia River ranges between 32°F and 72°F, averaging about 53°F. Throughout the past year, the heat extracted from the Hanford reactors by the cooling water was rather uniform, with an average temperature differential of 97.5°F. Spot measurements of retention basin inlet and outlet temperatures indicate that 5°F is probably a good annual average for temperature loss in the basin.

With an annual production of over 6 trillion pounds of steam in the four older 100 Areas, a saving of 92.5°F per pound of steam amounts to almost 600 million BTU per year, equivalent to 31,200 tons of coal.

The major items for converting to the use of effluent water for boiler feed are: the pipeline and pumps to get the effluent water from the retention basin to the powerhouse in each Area; barricades, change stations, and hand-and-foot counters for radiation control; provisions for generating steam where radioactive contamination is not tolerable; and replacement of the water softening agent and meters for higher temperature operation. Besides the capital cost of conversion, there will also be an increase in annual cost for an estimated four additional maintenance men, four additional Radiation Monitoring inspectors, spare parts discarded instead of repaired, and protective clothing.

It is not concluded in this report whether the small concentration of sodium dichromate added to the process water for aluminum corrosion control would be beneficial or harmful in the powerhouse boilers. If this proposal may be adopted, further study of this factor is suggested.

A laboratory experiment for this study indicated that a decontamination factor for radioactive material of 4000 may be achieved by water softening and evaporation in converting reactor effluent water to steam. This would reduce the activity density in steam condensate to about that now present in 100-F Area drinking water, which is considered safe for human consumption by a factor of at least 100. The economic advantage recommends that the proposal be adopted, despite the inconvenience and additional work which would be caused by distributing water and steam containing radioactive material throughout each Area where contamination is now rarely encountered.

A proposal to increase the temperature of reactor effluent water to a maximum of 105°C in any tube might increase the savings by a third over those at present steam loads from this proposal.

UNCLASSIFIED

BOILER FEED WATER

At present, boiler feed water normally is pumped from the 183 Filter Plant through a 10-inch pipeline to the 184 Powerhouse. This line is spared by an 8-inch pipe. For an emergency, there is a feed water take-off from the 14-inch line which supplies raw water from the 182 Reservoir for ash soaking and sluicing.

The incoming feed water is passed through one of three 305 cubic-foot-volume zeolite water softeners in parallel. The particular zeolite used in the 184 Powerhouses is Zeo-Dur, although the more expensive Zeo-Karb is a substitute. After about 145,000 gallons of water have been metered through each softener, it is regenerated, even though it would probably treat up to 180,000 gallons. Near the end of the run, a foam test is made with liquid soap to insure that there has been no breakthrough of the calcium and magnesium ions causing "hardness". At a feed water flow rate of 300-400 gallons per minute, a new softener is put in service every 6-8 hours.

The zeolite softeners are regenerated with about 1300 gallons of a 10% brine (salt water) backflush, the waste water going into the process sewer to the 1904 Outfall Structure and the Columbia River. Once a year the manhole is opened on each softener, and the zeolite lost, principally by backflushing, is replaced.

An emergency supply of soft water is maintained in a 75,000 gallon water tower (approx. 125 ft. head) outside the powerhouse. Once a week this tank is drawn down and refilled. In freezing weather the water in the tank is heated by steam bubbled into it from the 225 psi header in the powerhouse.

(The 100,000 gallon fire-and-sanitary water tank in each Area is heated in cold weather by steam passing through a coil and condensing into a french drain at the base of the tank. In the near future the soft water tanks in 100-D and 100-F Areas are to be eliminated. The wooden fire-and-sanitary water tanks are to be replaced with steel tanks, and a connection is to be made from each tank to the powerhouse boiler feed water system ahead of the zeolite softeners, with a check valve in the tie-line which will open in an emergency if the pressure falls in the lines from the filter plant. In 1954, the soft water tanks in 100-B and 100-H will similarly be eliminated.)

The softened feed water passes through a single-bent-tube heat exchanger where much of the heat from the continuous boiler blowdown is recovered. The feed water temperature is raised 8-10°F.

The feed water then rises to the heater-deaerator, where it first cools the vent reflux condenser, and then flows down over trays, countercurrent to 5 psi steam entering the side of the heater. Desorbed gases are bled off to the atmosphere by a vent pipe through the roof of the powerhouse.

UNCLASSIFIED

FIGURE 1 - SCHEMATIC: FEED WATER AND STEAM GENERATING SYSTEM

Sodium sulfite solution is added by a proportional pump, electrically driven, to the feed water leaving the heater. This removes any residual oxygen which would cause boiler pitting. The steam turbine-driven boiler feed water pumps lift the water to the steam drum of the boiler, under the control of a Copes regulator. Disodium phosphate solution is added to the steam drum by a proportional pump to achieve a "soft" scale, which will blowdown easily. About 200 lb. per month of each dry chemical are used in each powerhouse to maintain the individual chemical concentrations in the range of 10-20 parts per million in the steam drum water*. Samples are taken, for titration with methyl orange in the 183 water laboratory, from four water-cooled coils, one for each boiler, beside the blowdown tank.

The temperature of the feed water depends primarily on the temperature of the Columbia River, which has been observed to range from 32°F to 72°F. The outside air temperature, which has been observed to range from -23°F to 115°F, affects the water in storage basins, and with pumping and treatment may add 2-3°F. The temperature of the river for a yearly interval of moderate weather, as measured at the 181 River Pumphouse, was as follows:

TABLE 1 - COLUMBIA RIVER TEMPERATURES - MONTHLY AVERAGE OF (HW-28367)				
Areas, downstream	100-B	100-D	100-H	100-F
May 1952	51.6	50.9	50.4	51.1
June	56.8	55.9	56.5	56.8
July	61.9	61.0	61.3	61.9
August	64.8	64.9	65.3	65.7
September	64.2	64.2	64.6	64.6
October	61.7	61.7	61.9	62.2
November	53.1	54.0	54.0	55.8
December	46.4	47.7	48.0	48.6
January 1953	43.3	44.4	44.4	45.5
February	42.1	42.3	42.8	44.1
March	42.6	42.8	42.8	43.9
April	45.0	45.7	45.7	46.5

REACTOR COOLING WATER

River water is taken from the Columbia River at the 181 Pumphouse, flows through the 182 Raw Water Reservoir, and is pumped to the 183 Filter Plant where it is flocculated, filtered, and treated with necessary chemicals such as chlorine and sodium dichromate.

Depending on the treatments, there are five basic kinds of water available in each 100 Area: river, raw, filtered, fire-and-sanitary, and process. The 184 Powerhouse normally takes filtered water and treats it further for boiler feed, and also uses raw water for ash disposal. The 105 Reactor uses process water, which is filtered water to which sodium dichromate has been added, and sometimes the pH adjusted, for corrosion control.

*W. R. Conley, 10-6-53.

UNCLASSIFIED

The process water, after being used to cool the reactor, is called reactor effluent water. It flows by gravity to the 107 Retention Basins, where it is slowed down to allow time for decay of radioactive material, before it overflows and runs into the Columbia River through the 1904 Outfall Structure. An empirical relationship for the retention time of the various 100 Areas was derived from experimental data (HW-28830), as follows:

$$\begin{array}{ll} 107-B,D,F & XY = 5 \times 10^6 \\ 107-DR,H & XY = 7 \times 10^6 \end{array}$$

Where:

Y = retention time, minutes
X = effluent flow rate, gallons/min.

The different shape of the 107-C retention tanks prevent application of such equations until more data are obtained. At current monthly average flow rates*, the retention times by these equations are:

TABLE 2 - CURRENT EFFLUENT WATER RETENTION TIMES	
107-B	2.2 hours
107-D	1.75 "
107-F	2.1 "
107-DR	2.7 "
107-H	2.25 "

Monthly average temperatures of reactor cooling water are given in Table 3, for the same annual period as in Table 1. The reactor inlet temperature, of course, is nearly the same as the river water temperature; the average outlet temperature is dependent on the total amount of power generated by the reactor during the month. The temperatures of Tables 1 and 3 may not be strictly comparable because of different measuring instruments and recording methods. The Tables are laid out in order of Areas downstream on the river to show any effect of re-use of the water; the temperatures are too close to show any significant difference.

*Summary by G. E. Pilcher, Nov. 1953.

TABLE 3 - REACTOR COOLING WATER TEMPERATURES - MONTHLY AVERAGE, OF

Areas, Downstream Month	100-B		100-C		100-D		100-DR		100-H		100-F		Document HW -
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	
May 1952	56.5	158.0			56.7	150.0	55.8	146.0	56.7	144.9	56.5	152.0	24667
June	60.1	161.0			60.6	158.0	59.5	150.7	61.2	143.6	60.6	156.7	24919
July	66.9	165.7			66.6	167.0	66.2	158.0	65.8	154.0	67.1	167.0	25244
August	66.2	164.9			66.2	165.7	66.4	160.2	69.3	160.2	66.6	153.8	25524
September	65.8	164.2			66.4	166.3	66.0	157.1	68.6	158.8	66.8	166.1	25818
October	60.8	165.2			61.5	162.0	66.6	159.0	59.7	172.3	60.4	146.0	26119
November	49.6	155.0	47.7	111.2	52.9	150.8	52.7	156.8	52.4	161.0	56.7	156.7	26447
December	45.5	150.2	43.5	119.9	46.6	149.8	46.4	141.0	46.4	160.2	46.9	133.0	26741
January 1953	45.9	154.7	44.8	120.0	46.4	153.0	46.9	142.3	46.2	160.2	46.9	135.9	27053
February	45.9	151.0	41.9	126.0	46.3	126.1	45.1	134.4	46.8	143.6	46.0	154.4	27302
March	45.5	151.0	43.2	120.0	45.9	133.2			46.6	135.0	45.9	147.7	27617
April 1953	50.5	150.3	48.0	134.5	50.9	135.0	50.4	138.0	47.5	136.0	50.9	156.7	27952

As pointed out in the Introduction, it would be preferable to take the effluent water for boiler feed from the outlet of the 107 retention basin. Since routine measurements of basin inlet and outlet temperatures are not taken, the following spot measurements by R. N. Donelson in the spring of 1952 indicate the minor temperature loss in using outlet water:

TABLE 4 - RETENTION BASIN TEMPERATURES						
Basin	Gal/Min	MW	Air OF	Inlet OF	Outlet OF	Difference OF
107-B North	37,000	505	53	152	148	4
107-F West	37,000	300	49	116	110	6
107-DR West	41,300	495	57	142	137	5

Since the mean annual air temperature is 53°F, as reported by Synoptic Meteorology, it is probable that an average temperature decrease of 5°F between basin inlet and outlet is reasonable.

The average temperature increase in reactor effluent water, as shown in Table 3, excluding 100-C which was not up to normal, was 97.5°F. This indicates that the average temperature to be used in calculation of heat recoverable by using reactor effluent water as boiler feed is about 92.5°F.

Since the primary disadvantage in using reactor effluent water as boiler feed is its content of radioactive material, it is pertinent to know the total activity density (microcuries per cubic centimeter), the radioisotopes that may be present, and where they may cause trouble. The monthly maximum and average total activity densities for each 100 Area, from 1947 through 1952, are tabulated in document HW-27584. The 1952 average for each Area was as follows:

TABLE 5 - ACTIVITY OF EFFLUENT WATER TO RIVER, 1952 AVERAGES			
100-B	3.5 x 10 ⁻³	μc/cc	
100-D	3.1 x 10 ⁻³	"	
100-DR	3.2 x 10 ⁻³	"	
100-F	3.0 x 10 ⁻³	"	
100-H	3.3 x 10 ⁻³	"	

The 1953 averages are running from 50-100% greater. The maximum individual routine sample was 7.6 x 10⁻³ μc/cc*.

*Summary by J. W. Healy

The total activity density and the percent due to individual radioisotopes is observed to vary widely depending on seasonal river flow, power level of the reactor, water treatment, corrosion and film formations in the reactor tubes, and occasional mishaps such as ruptured uranium slugs. More than 40 radioisotopes have been identified or deduced in reactor effluent water. Average analysis of water from the 107-B, D, DR, F, and H retention basins during 1951, when power levels were reasonably constant and the seasonal variations spanned the entire cycle, are given in Table 6.

The analyses in Table 6 were all corrected to a time four hours after leaving the reactors for comparability, and the total activity density of the composite was $2 \times 10^{-3} \mu\text{c/cc}$. For times in the vicinity of two hours after irradiation, the percentages would be shifted toward the shorter half-life isotopes. There is believed to be a minor shift in the percentages of manganese and fission products at higher power levels. Trace amounts of other radioisotopes may be found in reactor effluent water. Uranium is present in Columbia River water, and is added from contamination on the surface of slugs and from ruptured slugs. The entire fission product spectrum and the transuranic elements are present from irradiated uranium. Tritium (H^3) and sulfur³⁵ are found in the water condensed out of the reactor cooling gas; this condensate is periodically jettied into a sewer which drains to the retention basin.

For this study, great analytical accuracy is not necessary, since it is believed the only effects of concern will be the total activity density of the boiler feed water and steam, the amount of radiocalcium and other radioisotopes extracted by the zeolite softeners, and the deposition of long-lived isotopes on interior surfaces of the water and steam systems, in drains, and in the ash basins.

The maximum permissible amount of any mixture of radioisotopes which may be assimilated in the human body can be calculated when the percentage of each radioisotope in the mixture is known. The percentages in reactor effluent vary considerably, and at least 10% is as yet unidentified, so that any maximum permissible limit to be used for occupational exposure should be calculated for the most hazardous mixture that might normally be encountered, with the clear understanding that it is not valid for unusual conditions such as ruptured slugs or reactor purging.

Calculations based on the mixture of radioisotopes listed in Table 6, and considering normally expected variations, indicate that the maximum permissible limit for drinking water is probably no less than $10^{-4} \mu\text{c/cc}$. Because most of the radioisotopes in effluent water are known, the permissible limit need not be as conservative as the $10^{-7} \mu\text{c/cc}$ suggested for mixtures of unknown composition, in the National Bureau of Standards Handbook 52, "Maximum Permissible Amounts of Radioisotopes in the Human Body and Maximum Permissible Concentrations in Air and Water" (March 20, 1953).

TABLE 6 - RADIOISOTOPES IN REACTOR EFFLUENT WATER*

Half-Life Order		Percentage Order**	
N ¹⁶	7:3s	Cu ⁶⁴	27.2
Ol ⁹	29. s	Mn ⁵⁶	24.3
Al ²⁸	2.3m	Na ²⁴	15.2
Cu ⁶⁶	5.17m	Si ³¹	6.4
Ca ⁴⁹	8.5m	As ⁷⁶	2.
Mg ²⁷	9.6m	Ba ¹³⁹	1.8
Pr ¹⁴⁶	25. m	Sr ⁹¹ &Sr ⁹²	.85(a)
Cl ³⁸	37.3m	Cr ⁵¹	.6
Ba ¹³⁹	1.42h	K ⁴²	.5
A ⁴¹	1.83h	P ³²	.3
Mn ⁵⁶	2.59h	Mo ⁹⁹	.2
Sr ⁹²	2.7h	Il ³¹	.05
Si ³¹	2.83h	Ca ⁴⁵	.03
Y ⁹²	3.5h	Ba ¹⁴⁰	.02
La ¹⁴¹	3.7h	Fe ⁵⁹	.01
Pr ¹⁴⁵	4.6h	Zn ⁶⁵	.007
Sr ⁹¹	9.7h	Te ¹³²	.007
Y ⁹³	11. h	Sr ⁸⁹ &Sr ⁹⁰	.002(b)
K ⁴²	12.4h	(R.E.&Y. Group(c))	
Cu ⁶⁴	12.9h	La ¹⁴⁰	.92
Na ²⁴	14.9h	Y ⁹³	.90
Pr ¹⁴²	19.3h	Y ⁹²	.88
As ⁷⁶	1.12d	La ¹⁴¹	.86
Ce ¹⁴³	1.37d	Ce ¹⁴¹	.86
La ¹⁴⁰	1.67d	Pr ¹⁴²	.84
Pm ¹⁴⁹	2.3d	Pr ¹⁴³	.82
Y ⁹⁰	2.55d	Ce ¹⁴³	.82
Mo ⁹⁹	2.8d	Y ⁹¹	.82
Te ¹³²	3.2d	Y ⁹⁰	.76
Il ³¹	8.14d	Pr ¹⁴⁵	.71
Ba ¹⁴⁰	12.8d	Pr ¹⁴⁶	.60
Pr ¹⁴³	13.5d	Pm ¹⁴⁹	.21
P ³²	14.3d		89.476
Cr ⁵¹	27. d		
Ce ¹⁴¹	32. d		
Fe ⁵⁹	45. d		
Sr ⁸⁹	54. d		
Y ⁹¹	61. d		
Ca ⁴⁵	152. d		
Zn ⁶⁵	250. d		
Sr ⁹⁰	20. y		

(a) Probably in fission ratio; 5.4 Sr⁹¹:5.8 Sr⁹²

(b) Decay curve indicates Sr⁸⁹ predominant.

(c) 10% of total activity; breakdown in fission ratios

* Unpublished report, H. V. Clukey

** Omitting isotopes insignificant after 2 hrs, & gases

This value of 10^{-4} $\mu\text{c/cc}$ in drinking water probably is adequate not only for reactor effluent - boiler feed water, but also for steam condensate. A special experiment conducted by the Biophysics Section for this study (Appendix A) showed that cations such as calcium, copper, barium, strontium, and the rare earths are held up in the zeolite and removed in the brine backflush. About one-third of the sodium, some manganese not incorporated in the colloidal ferrofloc, and most of the silicon, arsenic, and phosphorous which are present as anions passed through the zeolite. About one-third of the radioactivity density in the effluent water got through the zeolite, but only $1/4000$ th appeared in the steam. If all of the activity density in the steam and condensate were due to phosphorous³², which has the most restrictive permissible limit of the radioisotopes believed present in the condensate, the maximum permissible limit for drinking would be 2×10^{-4} $\mu\text{c/cc}$.

STEAM

The steam is generated in coal fired furnaces, four in each 100-B, F, & H Area powerhouse and five in 100-D, and is used in turbines to drive water pumps, blowers, and stokers, for heating buildings and process equipment, and for miscellaneous uses such as steam cleaning, sterilizing, and heating sanitary water. Of equal importance to this study is the disposal and fate of waste streams from the steam generation and distribution system.

Based on several years experience and records, it has been found sufficiently accurate to say that about 15% of the steam generated is used in the powerhouse, about 85% is distributed at 225 psi for process uses, and the heating load for administration and maintenance buildings on the 15 psi system is the same in all four areas, follows an annual cycle, and is less than 1% of the total. The building heating load for part of an annual cycle is given in Table 7.

TABLE 7 - HEATING STEAM (15 psi) FOR EACH 100 AREA			
Month	Steam - lbs* (est.)	Percent of Total in	
		100-D	100-H
August 1951	231,000	0.13	0.29
September	351,000	.20	.45
October	605,000	.31	.69
November	804,000	.41	.83
December	972,000	.45	.89
January 1952	992,000	.43	.88
February	813,000	.40	.84
March	783,000	.36	.86

*HW-28367

The steam generated and the coal consumed in each 100 Area for a recent annual cycle are given in Table 8. (The factor for converting millions of pounds steam per year in this table to gallons of water per minute is 2.7×10^{-6} ; e.g. 121 million lb/yr = 327 gpm.)

TABLE 8 - STEAM GENERATION AND COAL CONSUMPTION - 100 AREAS, 1952-53
(HW-28367)

Steam - M lbs Coal - Tons	100 Areas			
	B	D	F	H
May 1952	121,454 7,938	210,952 14,160	128,610 8,575	83,091 5,816
June	116,103 7,353	204,592 13,684	99,037 6,877	84,677 5,864
July	123,734 8,209	205,383 14,076	100,668 6,826	85,944 5,790
August	115,155 7,472	186,712 12,531	95,386 6,287	88,928 6,016
September	123,025 7,827	200,619 13,210	106,159 6,594	86,865 5,620
October	127,318 8,311	211,092 14,619	115,662 7,348	93,815 6,157
November	141,080 9,191	231,297 15,538	82,036 5,400	99,873 6,577
December	156,099 9,858	230,750 15,917	48,771 3,278	105,488 6,560
January 1953	79,234 5,327	209,064 14,380	100,030 6,373	105,494 6,950
February	128,004 8,307	138,796 9,074	126,370 7,632	96,986 6,099
March	151,650 9,711	159,248 10,514	129,898 8,301	106,328 6,699
April 1953	132,719 8,467	210,141 13,806	123,029 7,711	29,660 2,000

UNCLASSIFIED

In each Area, steam is distributed to the process buildings by an insulated pipe, suspended on poles above ground, which makes a complete loop around the Area buildings. There are both horizontal and vertical expansion jogs in this loop, and the pipes are sloped to drain condensate toward a trap at each jog. These traps blowdown continuously, venting steam to the atmosphere and discharging the condensate to french drains in the ground beneath the traps. Taking the 100-F Area as an example, there are more than 80 traps and french drains: 54 on the 225 psi loop, 24 on the 15 psi heating header, one at each process and sanitary water high tank, and one below the powerhouse miscellaneous blowdown tank.

Steam condensate inside buildings empties both into process and sanitary sewers. Process sewers empty into the Columbia River, while sanitary sewers drain to septic tanks and tile fields.

In the 184 Powerhouse, very little steam is lost to the atmosphere (see Figure 1). There may be up to a dozen tiny leaks from valves, flanges, and bearings. The deaerator and miscellaneous blowdown tank are vented to the atmosphere above the roof, the soot blowers vent through the smokestack, and pop-valves may blow inside the building. Condensate from most turbines drips into open drains, and with boiler blowdown water goes into the process sewer, as does the ash soaking water overflowing the sump. However, the ash sluice water and ashes from the sump are pumped to the ash disposal basin through a special sewer. Boiler blowdown samples are routinely carried to the 183 water laboratory for analyses.

Among the special uses of steam, other than for power and building heating, are its use in biological, chemical, and physical laboratories. In the 108-F Biology laboratories steam is used to sterilize instruments, glassware, and culture media in two autoclaves, to sterilize animal cages in a walk-in sterilizer chest, and in steam pans to heat chemical and biological solutions uniformly without local overheating. In the 141-F Animal Farm steam is used in an autoclave to sterilize surgical instruments, and also to clean the pens where animals are kept which are undergoing experiments with radioactive isotopes. In the wintertime, steam is used to melt the ice on the floors of the animal pens.

Distilled water for the 108-F laboratories is made by passing sanitary water through an ion exchanger into a still heated by a steam coil. Distilled water for other laboratories (183-B, D, F, & H; 190-H) is made by re-evaporating steam condensate with steam bubbled into the still; this minimizes scale formation, the bane of stills in which sanitary water is heated by electricity, steam, or gas flame.

The Technical laboratories use steam to heat the water in experimental process tubes. Sanitary water is heated for wash basins and showers in some buildings by a tube-and-shell steam heat exchanger. A reactor into which water has leaked is dried out by pre-heating the process water with steam in a heat exchanger in the 105 building valve pit. Steam jets are used to remove water from the 105-115 tunnel sump, and from the 105 valve pit floor drain under the chemical make-up tanks where acid may be used.

UNCLASSIFIED

EFFECTS OF USING RADIOACTIVE BOILER FEED WATER

From the foregoing description it becomes evident that radioactive material in the boiler feed water and steam systems will add many complications to the operation of the 100 Areas, for the single benefit of reducing coal consumption.

The advantage of recovering heat in the boiler feed water from reactor effluent water appears as a saving in the amount of process steam which must be diverted to heat the feed water in the powerhouse deaerator (Figure 1). Since Columbia River water with an annual average temperature of about 53°F must be heated to 230°F, the use of reactor effluent water with an average temperature after cooling in the retention basin of about 146°F, amounts to a saving of 93°F.

There will be some loss of efficiency in the boiler blowdown heat exchanger with incoming feed water at the higher temperature. The blowdown water at a temperature about 230°F raises the colder water 8 - 10° depending on the season. It would raise the hotter water only about 5°F. Since the blowdown heat would otherwise be wasted, the heat exchanger should remain in service, especially for periods when the reactor is not operating or clean feed water is being used.

The most costly item of the conversion will be getting the reactor effluent water from the retention basin to the powerhouse in each of the four Areas. Table 9 indicates that some 6700 feet of pipeline will have to be installed.

TABLE 9 - PIPELINE DISTANCE, RETENTION BASIN TO POWERHOUSE

100-B	2200 feet
100-D	1500 feet
100-F	1000 feet
100-H	2000 feet

To carry the normal and emergency loads, a 10-inch black iron pipe, like the present one from the filter plant, should be connected to the present feed water header. There should be a gate valve at each end, one of which might be electrically operated. There should be a check valve at the powerhouse to prevent return flow if the pressure falls and the filtered water lines take up the load. There might have to be some provision in the emergency tie-line from the new fire-and-sanitary water tanks to insure that effluent water does not back up into the drinking water system.

Because of radiation the pipeline would either have to be buried and marked, or fenced off and posted with Radiation Zone signs. A radiation survey at the 100-F Aquatic Biology facility indicates that the pipeline might read up to 10 mr/hr normally, and in an unusual case considerably more.

UNCLASSIFIED

It might be advisable to install a radiation monitoring instrument near the basin end of the pipeline which would either ring an alarm, automatically close a valve, or shut off the pump if the radiation level exceeded a pre-set limit. It might be entirely satisfactory to take the alarm or control signal from the presently installed outlet water activity monitoring system which records in the 105 building. A gamma-monitoring HM chamber is suspended about 18-inches over the effluent water at the outlet of the retention basin. A Beckman amplifier is mounted in the basin "outlet shack", and from this an amplified signal could be taken to a repeater meter in the 184 Powerhouse. The Beckman has a trip mechanism to send out a signal which would ring an alarm bell or actuate a control circuit at a pre-set value, which might be twice the normal radiation level.

The Zeolite water softeners will extract and concentrate radiocalcium and other radioisotopes from the incoming effluent water. A special experiment by the Biophysics Section for this study (Appendix A) showed, as expected, that cations such as copper, barium, strontium, rare earths (and including calcium which was too small a percentage to be detectable) were well held up by the zeolite and were easily removed by the brine backflush. Anions such as Silicate (Si^{31}), arsenate (As^{76}), and phosphate (P^{32}) passed through the zeolite. Manganese⁵⁶ was present in the colloidal ferrofloc used in filter plant treatment, as well as in solution from lime. The positively charged colloidal particles were well retained by the zeolite and removed by backflushing.

About one-third of the radioactive sodium passed through the zeolite while two-thirds appeared in the backflush. Since Zeo-Dur is a sodium cation exchange resin, it is surmised that two-thirds of the radiosodium ions displaced non-radioactive sodium as the effluent water passed through, and in turn were displaced by the brine backflush.

Decontamination factors for the total activity were about 2.75 in the zeolite, 1340 by evaporation, and 4000 for both. Evaporating effluent water without zeolite treatment gave a DF of about 500.

Since, in the experiment, this was the first run through new zeolite, the zeolite decontamination factor may be slightly high. About 17% of the activity entering the zeolite was not found in either the zeolite effluent or the backflush, and is presumed fixed in the zeolite. With re-use of the zeolite these exchange points might not be available for subsequent decontamination. It is believed this will have negligible effect on the water softening ability of the zeolite, although the radioactivity downstream of the softeners may increase slightly.

According to the manufacturer, the zeolite used in the water softeners now (Zeo-Dur) breaks down at temperatures greater than 130°F , and the water meters on the softeners should not be used at temperatures exceeding 100°F because of clearances in the moving parts*. It will be necessary to replace about 3700 cu. ft. of zeolite and 12 meters.

*W. R. Conley, 11-3-53

UNCLASSIFIED

Because of radiation from, and radioactive contamination in the water pipes, steam lines, boilers, and ashes, much of the 184 Powerhouse may have to be barricaded, posted, and controlled as Radiation Zones. The pipes, pumps, and softeners will read at least 10 mr/hr, so that most of the ground floor, and the water lines, heat exchanger, and deaerator on floors above must be in Radiation Zones.

The definition of a Radiation Zone, given in Radiation Protection Standard No. 1, is "an area or item of equipment where the radiation level exceeds 1 mrem/hr, or where there is 'detectable' surface contamination, or where air-borne contamination exceeds 1/10th of the applicable permissible limit".

The Biophysics Section experiment (Appendix A) included VGM survey instrument measurements, which together with calculations based on the radiochemical analyses, permit estimation of dose rates of radiation escaping from equipment in the powerhouse and other buildings (Table 10).

TABLE 10 - CALCULATED RADIOACTIVITY FOR STEAM AND ITS USES	
Steam condensate	$1.25 \times 10^{-6} \mu\text{c/cc}$
Superheated Steam @ 225 psig, 470°F	$9.3 \times 10^{-9} \mu\text{c/cc}$
Saturated Steam @ 15 psig, 250°F	$1.45 \times 10^{-9} \mu\text{c/cc}$
Saturated Steam @ 0 psig, 212°F	$7.5 \times 10^{-10} \mu\text{c/cc}$
Dose rate from 20 ft. length of 16 in. steam distribution pipe @ 1 ft.	0.0013 mr/hr
Radiation from 3 ft. steam radiator @ 1 ft.	90 d/m
Contamination on floor of steam - cleaned animal pen, 141-M	0.63 d/m beta/ft ²
Activity density from steam leak into 50 gallon sanitary water heater	$1.5 \times 10^{-7} \mu\text{c/cc}$
Skin contamination from wash water, with VGM	0.1 c/m

Contamination levels to be expected on inner surfaces of both water and steam equipment are indicated by radiation surveys made at the 100-F Aquatic Biology laboratory. Effluent water pipes there which have been drained and opened for repair have been found to read up to 5000 counts per minute with a GM instrument, at the open ends. Dose rates on surfaces wet with effluent water read 5-10 mrep/hr including 1-2 mr/hr.

The usual dose rate from a deep body of effluent water is indicated by readings from the HM chamber at the outlet end of the retention basin, up to 7 mr/hr gamma, plus the beta component measured on samples of the water, up to 4 mrep/hr. The 107-D basin currently shows the highest daily average of the four basins under consideration, with a maximum of 15 mrep/hr gamma-plus-beta.

UNCLASSIFIED

Maintenance work on any part of the system containing effluent water will therefore have to be performed under Radiation Zone controls, with the use of protective clothing, shoe covers or rubbers, gloves, and in some cases, caps. It will be necessary to provide clothing change stations, step-off pads, and used clothing hampers. "Blue tools", for contaminated zone work, will probably be required. It may be more economical to discard used fittings than to decontaminate them or set up a Radiation Zone in the maintenance shop. It will be necessary to write either standard operating procedures or Special Work Permits for such work, and to arrange for surveys by Radiation Monitoring. In addition to the personnel monitoring film badge, pocket ionization chamber "pencils" may be required for personnel entering the 184 Powerhouses.

It is estimated from experience with similar work that such maintenance, in each shift, will require an additional manhour for each maintenance man, one-half hour for preparation and one-half hour for cleanup. It is believed that one more maintenance man must be employed in each of the four 100 Areas to perform this work with the added handicap of radiation control.

Since there are many places where small amounts of steam leak to the atmosphere, such as traps, drains, vents, and leaks, there may continually be low-level radioactive contamination on floors, walls, equipment, and even personnel throughout the Area where contamination has never been present before. Although the mixture of radioisotopes in the concentrations found in effluent water is relatively harmless compared to some other process mixtures, and the steam or vapors from the water is even more innocuous because much of the radioactive material is left behind on vaporization or in the softeners, none-the-less there is always the chance that some of the more hazardous concentrations of fission products from a ruptured slug may be carried into the system.

At present, most of the buildings outside the 105 exclusion area are surveyed for radiation only quarterly, semi-annually, or annually. It will probably be advisable to increase the frequency, maybe to once a month. The time necessary for surveying each building will be increased because additional radioactivity may be found where now only the natural background is encountered, and it must be identified. Such outlying surveys are now made during incidental time; with more frequent, and slower surveys, more manpower will probably be needed.

There will also be other increases in the load on incidental manhours: for radiation monitoring on steam system maintenance, for the paperwork of SWP's and survey write-ups, for laboratory analyses, for protective clothing handling, for tool and equipment decontamination, and disposal of contaminated waste from all buildings, for badge and "pencil" servicing, and for personnel and work record-keeping.

UNCLASSIFIED

It is believed that one more Radiation Monitoring B-Inspector will be required on day shift in each of the four 100 Areas to help carry the increased load of routine and job surveys, and counting laboratory work.

It should not be necessary to add personnel in Reactor Operations, Power, or Units other than maintenance and Radiation Monitoring, for the added incidental work load.

Boiler inspections are performed regularly by a representative of the insurance company. Each of the four boilers in a powerhouse is removed from service for three months a year for overhaul of the boiler, grates, brickwork, soot blowers, coal spreaders, and draft fan. The steam and mud drums are blown down and flushed, and according to a powerhouse supervisor, the inside surfaces of the tubes and drums are shiny bright and free of any scale or dust. Radioactive material will be introduced into the fire side of the furnace by the steam soot blowers, and a small amount may be added in winter from the raw water containing recycled 190 turbine condensate, used to wash down the ashpit walls. Radiation surveys would indicate whether protective clothing and possibly respiratory protection would be needed during work inside the furnace or boiler. Since there is continual removal of concentrated boiler water, mud, soot, and ashes during operation, and a week-or-two cooling period for the furnace after shutdown, there should be negligible short-lived radioactive material in the unit and possibly not even detectable long-lived activity, when maintenance work begins.

Widespread radioactive contamination throughout the entire Area greatly increases the problem of cross-contamination. Wherever contamination is found, it must be identified, either by the experience of the surveyor and his knowledge of conditions in the Area, or by taking a sample of the contamination to the laboratory for decay and absorption studies, or even radiochemical analyses. In the 105 building exclusion area where radioactive contamination from various sources is normally encountered, as well as at a few outlying locations such as the 108B, D, and F buildings, the 189-D building, and retention basins undergoing repair, there are hand-and-shoe counting instruments for early detection of uncontrolled contamination picked up on workers.

Wherever there is effluent water and steam condensate from it throughout the Area, people and articles that contact the water may become detectably contaminated. Such people entering those facilities where hand-and-shoe counters are now located, and taking a count or contaminating someone else who takes a count, may cause undue concern and extra surveying until it can be proven what the contamination is and where it came from. Contaminated articles transferred between locations where radiation surveys are made, also may cause concern.

UNCLASSIFIED

Since the 184 Powerhouses will be the major sources of such cross-contamination, it may be necessary to install a hand-and-shoe counter in each one, and require each person leaving those buildings to take a count. Anyone contaminated should remain out of other controlled buildings until the contamination is reduced below detection levels. Otherwise it may be necessary to provide shoe covers or rubbers, and lab coats or coveralls for all who enter the powerhouse. Until some experience is accumulated in the use of effluent water as boiler feed, it would be preferable to install counters in the powerhouses, at least on a temporary basis. If they are found unnecessary, there is sufficient demand in present and new facilities to which they could be moved.

Effluent water from the outlet end of the retention basin has an effective half-life of 3 - 4 hours, and is essentially harmless in the quantities which might be taken into the human body in the course of work. However, effluent water on the skin should be washed off with soap and water without unusual delay, and certainly before leaving the facility or eating. Effluent vapors or steam may be washed off, especially before eating, or may simply be allowed to decay. Usually one or two hours decay is sufficient to reduce the contamination level from vapors below detection limits.

The fate of radioactive wastes from the steam generation, distribution, and utilization system is important. Besides the process sewers and ash disposal system, some of the sanitary waste disposal systems will be contaminated by condensate from steam traps. Although most of the radioactive material in the steam is expected to be of short half-life (Na^{24} , Si^{31} , P^{32} , Mn^{56}), some of the total activity in effluent water will get through the zeolite without capture and is expected to be entrained in the steam, especially during peak steam generation. Over long periods of time the shorter half-life radioisotopes will decay away, but the longer half-life and more hazardous ones, like strontium, barium, and the rare earths, will accumulate.

Floor drains which lose their water seals by evaporation may vent radioactive vapors, even in remote buildings.

With the use of steam made from effluent water, radioactive material may be added to the sanitary and drinking water of all the 100 and 200 Areas during the wintertime, but will be in insignificant concentrations. Condensed steam from the 190 Pumphouse Turbines is collected, and in freezing weather pumped to the 182 Reservoir to prevent the incoming raw water from freezing in the system. Since there might be about 100,000 lbs/hr of steam condensate at $1.2 \times 10^{-6} \mu\text{c/cc}$ going into about 2,000,000 lbs/hr of raw water, there might be about $6 \times 10^{-9} \mu\text{c/cc}$ added to the drinking water. Since the drinking water in the 100 Areas normally averages up to $6 \times 10^{-7} \mu\text{c/cc}$ (HW-26946-E), the additional amount from the recycled condensate is insignificant.

UNCLASSIFIED

It is worth noting that the zeolite water softeners even now show radiation through the tank walls. A very recent survey on the softeners in the 184-F powerhouse showed 1500 c/m (VGM) on the tank in use, and 400-600 c/m on the other two tanks on standby. The reading 1 in. above the zeolite in a tank opened just after being in service was 3800 c/m. The 100-F Area was chosen for the survey because, being the last reactor downstream on the Columbia River, the raw water pumped from the river contains the effluent from all other reactors upstream. On the day of this survey, the 100-F raw water showed an activity density of 1.2×10^{-6} $\mu\text{c/cc}$ and the sanitary water showed 2.4×10^{-7} $\mu\text{c/cc}$.

Tube-and-shell steam heat exchangers are used in many buildings to heat sanitary water for wash basins and showers. A leak permitting steam to enter the sanitary water until the thermostat valve closes will add about 1.5×10^{-7} $\mu\text{c/cc}$ to the activity density already present. Such contaminated water on skin would amount to about 4 counts per minute as measured with a portable VGM survey instrument, which is not detectable above the background of 50-100 c/m for such instruments. These heat exchangers are routinely pressure tested to detect leaks, and the water pressure is normally greater than the steam pressure, so any leak would probably be evident in the meantime due to "water hammer".

A leak in the still of the 108-F building would have more serious consequences, since this water is used in radiobiology experiments in which even very low activity densities are important. In addition, the autoclaves, the animal cage sterilizer, and the lab bench outlets must have steam which is free of extraneous radioactive material. It is considered advisable, if effluent water is to be used as boiler feed in the 100-F Area powerhouse, to install a separate steam boiler in the 108-F building for all except space heating. A 30KW electrically heated boiler rated at 100 lb/hr peak for about one hour is considered necessary*.

The autoclave in the 141-M Animal Farm would have to be converted to electrical heating for clean steam. There need be no change to the steam system for space heating and cleaning animal pens, and the activity in pipes and radiators would be sufficiently low that it would not interfere with counting instruments.

The effect of sodium dichromate, present at a concentration of about 1.8 ppm in the process effluent water, when admitted in feed water to the boilers, is not known by the people who were consulted who are concerned with feed water treatment. There is general belief that if sodium dichromate is good for corrosion control on aluminum, and will not make the concentrated saline acidic in the boiler, that it might even improve corrosion control on the iron surfaces in the steam system. If this proposal might be adopted, it is suggested that experiments to determine the effect of sodium dichromate should be made first. If the results are unfavorable, it may be possible to use a special ion exchanger to remove the dichromate ion, or to deactivate the ion by another chemical addition.

*L. M. Finch, 11-2-53

UNCLASSIFIED

APPENDIX AEXPERIMENT TO DETERMINE DECONTAMINATION OF REACTOR EFFLUENT
WATER BY ZEOLITE AND BOILING

1. A sample was obtained from the 107-F Retention Basin inlet on 11-11-53. The experiment was performed by the Biophysics Section, Radiological Sciences Department the same day. All data was corrected for a hold-up time of 2.1 hours, to 10:15 a.m.
2. A portion of the sample was distilled with vigorous boiling from a flask through a water-cooled condenser, until about 1/3 of the sample remained in the flask.

Another portion was poured through Zeo-Dur, in a ratio of 500 gallons of water per cubic foot of the zeolite. To the zeolite effluent was added 10-20 ppm sodium sulfite and 10-20 ppm disodium phosphate. This solution was then distilled as above.

The zeolite was backflushed with 10% brine in a ratio of 0.01 gallon brine per gallon zeolite effluent, followed by a rinse of 0.05 gallon fresh water per gallon zeolite effluent. The brine and wash water back-flushes were combined for analysis.

3. The activity densities in the two distillates, two bottoms, and combined backflush were determined by radiochemical analysis. The results, corrected to the time the sample would have reached the outlet end of the retention basin, are given below. To convert d/m/ml to uc/cc, divide by 2.22×10^6 .

Table A1 - RADIOACTIVITY IN EFFLUENT WATER AFTER ZEO-DUR AND BOILING

<u>Sample</u>	<u>disintegrations/minute/milliliter</u>								<u>Rare Ba Earths</u>
	<u>Total Beta</u>	<u>Si</u>	<u>Na</u>	<u>Cu</u>	<u>As</u>	<u>Mn</u>	<u>Sr</u>	<u>Ba</u>	
a. 107 Water - distillate	15								
b. - bottoms	7370	1602	1359	791	583	408	49		418
c. Zeolite effluent -distillate	2								
d. - bottoms	2684	1955	439		422	91			
e. Zeolite backflush	3454	41	738	19	14	2160	54	86	77
f. Fixed in Zeolite, 1st run (1245 = 7335 - 6140)									

UNCLASSIFIED

APPENDIX A - Continued

4. To indicate radiation levels through pipes and tanks, a 3500cc sample of 107-F effluent water taken a few days later (11-23-53) was run through the same experiment, except for radiochemical analysis, and readings were taken with a VGM survey meter, shield closed, through the glassware at various stages of the run. The readings, corrected to outlet time, were as follows:

Table A2 - VGM READINGS ON EFFLUENT WATER, ZEOLITE TREATED

<u>Sample</u>	<u>Counts/min.</u>
107-F Effluent Water, 250 ml in 250 ml beaker	500
Zeolite effluent "	150
Zeolite backflush "	4000
Zeolite before backflush, thru 1/8 in. porcelain funnel	6600
" , @ surface	9000
Zeolite after backflush, thru 1/8 in. porcelain funnel	4000
" , @ surface	5600

UNCLASSIFIED

LITERATURE REFERENCES

HW-24667	(Monthly Reports, Reactor Section, Operations Unit)	May 1952
HW-24919	"	June
HW-25244	"	July
HW-25524	"	August
HW-25818	"	September
HW-26119	"	October
HW-26447	"	November
HW-26741	"	December 1952
HW-27053	"	January 1953
HW-27302	"	February
HW-27617	"	March
HW-27952	"	April 1953
HW-21220	Water Requirements for the Cooling System of the Hanford Reactors - A Bibliography	M. A. Boyd 5/25/51
HW-23513	Power Generation from Hanford Production Piles	J. E. Robb, E. L. Reed 10/30/51
HW-24793	RDS-D-11 Water Plant Design Development	C. E. Kent 6/23/52
HW-25741	Reactor Section Power and Water Plant Improvement Studies	E. P. Lee 9/10/52
HW-26946-E	Radiological Sciences Dept. Report for the month of January, 1953	H. M. Parker
HW-27584	The Calculation of Beta Particle Emitter Concentration in Hanford Reactor Effluent Water	G. E. Pilcher, H. T. Norton 8/15/53
HW-28367	Steam Conservation and Expansion of Process Water Pumping Capacity, 100 Areas, RDS-D-14	V. F. Wood 6/29/53
HW-28426	Water Plant Expansion, Technical Basis	R. B. Richards 6/22/53
HW-28830	Effective Retention Time of the Hanford 107 Reactor Effluent Basins	J. K. Soldat G. R. Quimby 8/3/53

UNCLASSIFIED

END

DATE FILMED

10 / 17 / 90