1 of 1

**Cover Sheet for a Hanford
Historical Document
Released for Public Availability**

Released 1994

**Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830**

**Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Institute**

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This is a **historical document** that is being released for public availability. This was made from the best available copy. Neither the United States Government nor any agency thereof, nor Battelle Memorial Institute, 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.** The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

(C) (CONFIDENTIAL)

A

April 8, 1963

HANFORD ATOMIC PRODUCTS OPERATION - RICHLAND, WASHINGTON

TITLE

GOAL EXPOSURE FOR RUPTURE-PRONE FUEL ELEMENT LOTS

☐ OTHER OFFICIAL CLASSIFIED INFORMATION
THIS MATERIAL CONTAINS INFORMATION AFFECTING
THE NATIONAL DEFENSE OF THE UNITED STATES
WITHIN THE MEANING OF THE ESPIONAGE LAWS,
TITLE 18, U. S. C., SECS. 793 AND 794, THE TRANS-
MISSION OR REVELATION OF WHICH IN ANY MANNER
TO AN UNAUTHORIZED PERSON IS PROHIBITED BY
LAW.

AUTHOR

L. J. Newell
and
R. D. Shimer

ISSUING FILE

RECEIVED

THIS DOCUMENT MUST BE LEFT UNATTENDED OR WHERE AN UNAUTHORIZED PERSON MAY HAVE ACCESS TO IT. WHEN NOT IN USE, IT MUST BE STORED IN AN APPROVED LOCKED REPOSITORY WITHIN AN APPROVED GUARDED AREA WHILE IT IS YOUR POSSESSION. UNTIL YOU HAVE OBTAINED A SIGNATURE RECEIPT FROM CLASSIFIED FILES, IT IS YOUR RESPONSIBILITY TO KEEP IT AND ITS CONTENTS WITHIN THE LIMITS OF THE SUBJECT AND FROM ANY UNAUTHORIZED PERSON. ITS TRANSMITTAL TO, AND STORAGE AT YOUR PLACE OF RESIDENCE IS PROHIBITED. IT IS NOT TO BE DUPLICATED. IF ADDITIONAL COPIES ARE REQUIRED, OBTAIN THEM FROM THE RELATIONSHIP FILE. ALL PERSONS READING THIS DOCUMENT ARE REQUESTED TO SIGN IN THE SPACE PROVIDED BELOW.

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DECLASSIFIED

(CLASSIFICATION)

DECLASSIFIED

HW-77212

PRELIMINARY REPORT

This document contains restricted information as defined by Atomic Energy Act of 1954. Its transmission in any manner to an unauthorized person is prohibited.

This report was prepared for use within General Electric Company in the course of work under Atomic Energy Contract AT(45-1)-1350. Any views or opinions expressed in the report are those of the author only.

This document classified by

H. B. Spencer

This document consists of 7 pages, No. of 49 copies.

DISTRIBUTION

1. T Prudich	26. PJ Hollifield
2. TW Ambrose	27. FW Knight
3. ER Astley	28. LW Lang
4. JT Baker	29. LC Lessor
5. JW Baker	30. CG Lewis
6. RS Bell	31. AR Maguire
7. RR Bloomstrand	32. WW McIntosh
8. CE Bowers	33. WN Mobley
9. RW Bown	34. JE Morrissey
10. MA Clinton	35. WI Neef
11. RG Clough	36. LJ Newell
12. RF Corlett	37. CA Priode
13. BR Cremer	38. WH Radtke
14. RE Dunn	39. RW Reid
15. WJ Ferguson	40. DL Renberger
16. EJ Filip	41. OC Schroeder
17. GC Fullmer	42. HG Spencer
18. SM Graves	43. JT Stringer
19. OH Greager	44. FW Van Wormer
20. AB Greninger	45. AP Vinther
21. CN Gross	46. SA Wood
22. AK Hardin	47. PJ Zimmerman
23. CM Heeb	48. 300 Files
24. DL Hirschel	49. Record Center
25. KL Hladek	

IRRADIATION PROCESSING DEPARTMENT

Classification Cancelled and Changed To

April 8, 1963

DECLASSIFIED

By Authority of D.S. Lewis

CG-PR-2, 3-21-94

By J. E. Savely 3-30-94

Verified By AK-Hanson 4-4-94

DECLASSIFIED

April 8, 1963

T. Prudich, Manager
Production Planning & Scheduling
MANUFACTURING

DECLASSIFIEDGOAL EXPOSURE FOR RUPTURE-PRONE FUEL-ELEMENT LOTSINTRODUCTION AND HISTORICAL BACKGROUND

Since 1957, a procedure has been in effect for selective treatment of fuel-element lots identified as being rupture-prone material. The procedure provides for discharging of rupture-prone metal.

Justification for classifying a fuel-element lot as rupture prone was first documented early in 1958.¹ At that time, an analysis of the rupture experience for 1955 and 1956 disclosed certain fuel-element lots sustained multiple rather than single failures before reaching goal exposure. The study was limited to the old reactors and side failures only. Several factors came to light; the first was that multiple- and single-failure lots differed with respect to exposure at first failure; first failure in multiple-failure lots was, on the average, lower. The difference in exposure was statistically significant. Secondly, 29 initial ruptures in multiple-failure lots was followed by an additional 54 failures. This was an average of about three failures per multiple-failure lot, many more than the statistical expectation. Although reasons for the performance variations were not clearly understood, the occurrence of two side failures in a lot was nevertheless a good measure of rupture proneness. Hence, recommendations for selective discharging of this category of rupture-prone material were justified.

The second criterion for classifying a fuel-element lot as rupture prone came into existence late in 1958.² At that time internally- and externally-cooled fuel elements began to exhibit a new failure mechanism: internal "hole" failures. The sudden appearance of these "hole" failures, supplemented by metallurgical examinations, indicated a decline in fuel quality due to reduced weld integrity.² Although the amount of data was limited, it was believed that lots which sustained hole failures were of poorer quality than side-failure lots. Recommendations were made at that time for preferential treatment of fuel-element lots following first hole failures and the recommendations were subsequently applied to lots which sustained end failures. These failure types are commonly referred to collectively as end-closure-defect failures. The recommendations remained in effect until June 21, 1961, when a moratorium was called on this practice in order to re-evaluate the decision rule. Re-examination of the rupture experience for the period August 1, 1958, through June 30,

¹Bloomstrand, R.R., and W.I. Neef, Analysis and Correlations of HAPO Rupture Experience with Natural Uranium Material, HW-55377, April 23, 1958, Secret.

²Bloomstrand, R.R., letter to T. Prudich, Discharging Lots Which Sustain Hole Failures, November 18, 1958.

DECLASSIFIED

HW-77212

T. Prudich

-3-

April 8, 1963

1961, showed that of 13 lots which sustained hole failures and were afforded the opportunity of incurring a second, nine did indeed repeat.³ Based on these data, the moratorium was cancelled on August 1, 1961,⁴ and the rupture-prone classification procedures reinstated. These recommendations remained in effect until March 1, 1963, when results from metallurgical examinations of several internal hole failures, sustained during the last six months of 1962, revealed the failure mechanism to be groove corrosion. At that time, a revised criterion for internal hole failures was established⁵ which provided an empirical method for separating corrosion-induced hole failures from those associated with closure defects.

Past experience has established that the failure performance of certain fuel element lots is indicative of metal quality inferior by a large factor relative to the normal production material. This material is identified as being of inferior quality, i.e., rupture-prone, when either of the following conditions occur:

1. When any lot sustains two side failures, excluding mechanical damage.
2. When any lot sustains one end-closure-defect failure.

When a fuel-element lot has been designated rupture prone, corrective action should be initiated at the earliest possible time in order to keep rupture losses to a minimum. However, to achieve the best economic solution, certain questions need to be answered. For example, consider rupture-prone material that is at ten per cent of normal goal exposure. Should this material be discharged or should it be irradiated to some higher exposure? If this material is left in, what should its new goal exposure be? These questions do not have clear-cut answers; in the past, such decisions were made for each individual circumstance based on a very few facts and estimates about the economics of the alternate actions.

This document supplies some information on the economic effect of discharging rupture-prone material below normal goal exposure and provides decision rules for discharge action. The document does not apply to material whose relative performance is a small factor (less than five) worse than normal.

SUMMARY AND CONCLUSIONS

The loss associated with low goaling rupture-prone material is quite small compared to the benefits. As illustrated in Figure 1, there is an optimum

³ Bloomstrand, R.R., On the Discharging of Lots That Incur Ruptures Caused by End-Closure Defects, HW-70446, July 20, 1961, Secret.

⁴ Bloomstrand, R.R., letter to Process Engineers, Discharging Lots After One End-Closure-Type Rupture, August 1, 1961.

⁵ Neef, W.I., Revised Rupture-Prone Lot Criteria, HW-76693, March 4, 1963, Secret.

DECLASSIFIED

HW-77212

T. Prudich

-4-

April 8, 1963

goal exposure for a given metal quality. At this optimum exposure the loss associated with irradiating rupture-prone material is minimized.

Reasonable decision rules are as follows:

1. Discharge, at the first opportunity, tubes containing rupture-prone material whose exposures are equal to or greater than 50 per cent of normal goal.
2. Discharge tubes under 50 per cent of normal goal which would be expected to reach 70 per cent of normal goal before the next scheduled outage.
3. Irradiate all tubes containing rupture-prone material whose exposures will not be expected to exceed 70 per cent of normal goal before the next scheduled outage.
4. Discharge all tubes containing rupture-prone material, regardless of exposure, if an additional rupture is incurred in the lot.
5. Return unirradiated rupture-prone material to Production Fuels Section as reject material.

DISCUSSION

In the past, when a fuel element lot was designated rupture-prone, e.g., any lot which sustained one end-closure-defect failure or two side failures, the reactor Process Engineers and Production Scheduling Operation were contacted and given the lot number of the rupture-prone material. On many occasions, questions would arise in regard to what per cent of normal goal exposure the rupture-prone material should be allowed to reach. Generalized verbal recommendations on such questions were made by Process Analysis from time to time; however, these recommendations were expedient and did not necessarily reflect the true economics of the situation. A sound and consistent decision rule for low-goaling rupture-prone material is needed. Such a decision rule should be based on economic considerations and should, in the long run, minimize the losses associated with low-goaling rupture-prone material.

The economics of low-goaling rupture-prone material were computed with the current reactor optimization program.⁶ These economics are based on reactor optimization input parameters* and a marginal product value of \$50 per gram. While the reactor optimization equations do not permit exact process simulation and optimization input parameters are subject to some uncertainty and some

⁶Sparks, G.R., Description of the Net Return Optimization Computing Program - IBM 7090 Fortran Monitor, HW-73713, May 21, 1962, Secret.

*Reactor optimization input parameters are assessed metal quality, burnout costs, incremental metal costs, Pu conversion, charge-discharge rates, etc.

DECLASSIFIED

HW-77212

T. Prudich

-5-

April 8, 1963

variation with time, these uncertainties are considerably smaller than other uncertainties that bear on the low-goaling decision.

Figure 1 presents graphically the economics of low-goaling rupture-prone old reactor natural uranium fuel. Every point in the figure represents the same Pu-240 concentration, six per cent. Calculations were made for normal fuel and fuel a factor of 10, 20, 30 and 100 worse than normal.

The data in Figure I are based on an old reactor operating under a variable goal plan and exposures which yield a plant six per cent Pu-240 specification. The six per cent Pu-240 specification requires that when a group of metal is low goaled, the remaining metal must be irradiated above normal goal to provide the same over-all Pu-240 concentration. Reactors operating on a block discharge goal plan or on a non-representative product program present somewhat different problems. Because of the higher exposure required by the non-representative program, the incentives for low-goaling rupture-prone non-representative material would be higher than indicated in Figure I, which is based on the six per cent product. When rupture-prone non-representative material is rescheduled as representative material, Figure I and a six per cent goal apply except that account should be taken of any increase in HAPO labor cost for the separation of low-goaled material from non-representative metal and any subsequent special handling. In the block discharge situation, two tubes of green metal must be discharged for every tube of rupture-prone metal. These, of course, consist of the rupture-prone material and its replacement charge. It is evident the loss associated with rupture-prone metal becomes considerably greater under a block discharge operation.

The normal-material curve (factor-of-one) in Figure I, represents the cost of low-goaling normal O-III-N fuel, or the loss associated with classifying normal material as rupture prone. This loss will only be incurred when the material discharged is, in fact, normal material; in any case, the probable loss is relatively small.

The loss associated with irradiating rupture-prone material to normal goal exposure is quite substantial. Further, there is an optimum exposure where the loss associated with irradiating this material is minimized. In fact, there is an exposure range of approximately 20 per cent around the optimum exposure of each curve where the loss changes little. If one knew the true quality of rupture-prone material, the best goal exposure for this material could be determined; however, such an exact assessment of metal quality is not possible.

Fortunately, it is not necessary to know the true metal quality to establish a reasonable decision rule. The rupture-prone material is probably between a factor of 10 and 100 worse than normal material, so it is apparent from Figure I that rupture-prone material should be discharged somewhere between 50 and 70 per cent of normal goal. A reasonable decision rule would be to discharge all rupture-prone material at the first opportunity after it reaches

DECLASSIFIED

HW-77212

T. Prudich

-6-

April 8, 1963

50 per cent of normal goal. In addition, all rupture-prone material that will reach 70 per cent of goal by the next scheduled outage should be discharged regardless of exposure. The above rules are conservative because rupture-prone material is probably less than a factor of 100 worse than normal; however, the cost of being conservative is relatively small.

Decision rules reasonable for O-III-N fuel are also adequate for all other natural and enriched production fuels. Calculations were made for K-IV-N fuel; optimum exposures in per cent of goal were within ten per cent of the values for O-III-N. Calculations were not made for enriched fuel; the curves would be some different than in Figure I, but not so much so that the same decision rule cannot be reasonably applied.

The same conclusion is reached upon consideration of a different economic basis (i.e., different objective) than a marginal product value of \$50 per gram. A spot-check was made on the effect of substituting a marginal product value of \$30 per gram. Per cent of goal exposure at the optimum discharge point for the factor-of-20 curve was shifted upward approximately five per cent. These two economic bases span the basis: minimization of plutonium total unit cost. The decision rules also apply for the basis: "maximize gram production," as long as the product specification exists. Thus the decision rules apply in several different economic climates, including all climates presently considered reasonable.

It is interesting to note that the loss associated with discharging normal material at 65 per cent of goal is roughly equivalent to the loss incurred by rejecting an equal number of unirradiated slugs for recovery. The incremental cost of recovering and recanning natural material is about \$330¹ per ton or \$40 per old-area tube. Although the cost of recovering reject material is substantial, the rupture loss associated with irradiating rupture-prone material precludes charging this material, at least in the normal manner. If the unirradiated rupture-prone material could be charged exclusively in the, say, first eight upstream slug positions, the much milder environment would probably permit satisfactory performance for most rupture-prone material. Charging in this manner would not be beneficial in any case if there were much of an increase in charging time.

While the intent of this document is to convey economic guidelines for low-goaling rupture-prone material, it is realized that situations will probably arise which might preclude the discharging at the most opportune time of material designated rupture prone.

R. D. Shimer
Process Analysis Unit
Process Technology Sub-Section
RESEARCH AND ENGINEERING

L. J. Newell
Process Analysis Unit
Process Technology Sub-Section
RESEARCH AND ENGINEERING

¹ Personal communication, P. C. McMahon to H. G. Spencer.

Wg Eyeball
RBS 4-18-63

FIGURE - I
LOSS DUE TO RUPTURE PRONE O₂N₂ FUEL

DATE

FILMED

6/10/94

END