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PROPOSAL FOR ELIMINATION OF 100 PERCENT INSPECTION FOR URANIUM GRAIN SIZE

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EV Padgett

This document consists
of 11 pages.

PROPOSAL FOR ELIMINATION
OF 100 PERCENT INSPECTION FOR URANIUM GRAIN SIZE

by

W. F. Stevenson
Quality Control Unit
Fuels Engineering Subsection
Production Fuels Section-IPD

March 30, 1965

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PROPOSAL FOR ELIMINATION
OF 100 PERCENT INSPECTION FOR URANIUM GRAIN SIZE

A. INTRODUCTION

Uranium cores have a grain size specification of A8 to A3. Large grain size is denoted by a small "A" number and small grain by larger "A" numbers. Grain sizes smaller than A9 denote an untransformed core which presumably has a high rupture potential. Grain sizes larger than A3 cause swelling, or bumping, of the fuel thus increasing the probability of rupture failure.

Presently, tests are made on all cores received to determine compliance to the above specifications. The tester used for this purpose is the UT-2 Tester which gives the test results in voltage values. Calibration of the tester is done by adjusting the tester to read out a voltage value which has been arbitrarily specified for a certain known grain size standard.

Presently, the vendor is also testing the outgoing product on a sampling basis.

B. SUMMARY

As a result of a recent study and analysis of all pertinent factors applicable to this situation, it is concluded that 100% inspection of all lots received at HAPO for compliance to grain size specifications is neither warranted nor economically justifiable. In lieu of the present screening, a system is proposed to insure that screening is effected only when there is an economic incentive.

Such a system requires that the Feedsite (NLO) maintain its present process control sampling plan of 5 cores per ingot. A sampling receiving inspection at HAPO will be used to detect major shifts in the quality of cores to insure that screening is used only when there is an economic incentive. This sampling inspection, in place of the present 100% screening, will result in an estimated annual savings, to IPD, of \$52,500, based on the 0.0057% defective rate currently observed in the incoming material received at HAPO.

C. DISCUSSION

This study was conducted to determine the most economic (to IPD) course of action for grain size inspection. The alternatives are:

1. Continue 100% inspection of lots;
2. Use lots "as is" with no inspection at all; or
3. Use sampling plan on all lots to determine whether screening is necessary for any particular lot.

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One hundred percent inspection for any characteristic is economically justifiable only when the unit cost of inspection is less than the expected unit failure cost with no inspection. In the case here, the unit inspection cost has been set at \$0.035⁽¹⁾. The expected unit cost for failures, in the absence of any inspection, is: the probability of receipt at HAPO of an out-of-specification core (57×10^{-6})⁽¹⁾ times the probability of rupture of such core (1×10^{-4})⁽²⁾ times the cost of a reactor failure (arbitrarily set at \$20,000). This figure, \$0.000114 is the expected unit grain size failure cost to IPD if no grain size testing at all were done.

The probability of rupture set at 1×10^{-4} , above, may be debated. Although this may be, at best, a subjective estimate, it is concurred in by responsible persons close to the situation and represents one of those instances where a management decision, with the accompanying risks, must be made on the basis of the best subjective estimates available. As a matter of reassurance, it should be noted that even though the above probability of rupture were increased 100 times, the unit failure cost is still 67% less than the unit inspection cost.

Comparison of Annual IPD Screening Cost Versus No Screening.

(Assume present observed defective rate of .0057% is constant for both situations.)

1. Screening

2,500,000 @ \$ 0.035 \$ 87,500.00

2. Use of Material "as is"

2,500,000 @ \$ 0.000114 \$ 285.00

It is obvious that, under the above conditions, screening is not economically justifiable for IPD. It is of interest to note that the probability of failure (stated above as 1×10^{-4} , i.e., 1 out of 10,000) could be increased a hundredfold and "no screening" would still be the more economic course of action. It can also be seen that there is some point at which screening is more economic. In the case here, that point is an increase in the defective rate of the incoming material to >1.75% (providing that the probability of rupture for a given defective element remains constant at 1×10^{-4}).

Since it can be shown that screening, to be economically justifiable, is contingent upon the quality level of the incoming material, it follows that some sampling must be performed to provide information regarding the quality level. An efficient sampling plan will, with a high degree of assurance, indicate when the quality level of the incoming material is of a magnitude that demands screening be effected to achieve the most economic operation.

Consider the situation where the defective rate for the incoming material is 1.75%. At this level of quality, and with a rupture probability of

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1 x 10⁻⁴, the cost to IPD of using this material "as is" (without screening) would be, for 1,000,000 pieces:

$$1,000,000 (.0175) (.0001) (\$20,000) = \$ 35,000.$$

If all this material were screened, however, before using (assuming perfect screening) the IPD cost would be the same, i.e.,

$$1,000,000 @ \$ 0.035 = \$ 35,000.$$

Therefore, 1.75% defective is the point at which it does not matter (from an economic standpoint) whether the material is screened before use or not. Our sampling plan then, should have a .5 probability of detecting lots of material that are of this percent defective. At the same time we desire our sampling plan to be sufficiently efficient to detect lots having a greater percent defective so that such lots may be screened and to pass lots which are less than 1.75% defective.

From Quality Control Manual #3, Quality Policy and Procedures for Procured Materials, we see that for an average lot size of 4000, and Inspection Level II, a sample size of $n = 200$ is specified. The operating characteristic curve for this sampling plan has, for a specified AQL of .65, its .5 probability of acceptance near the 1.75% defective point (see Figure 1). Thus, of the various sampling plans contained in Mil Std 105D (Standard Plans for Attributes Inspection) the sampling plan with an AQL = .65 is most appropriate for use here. Note, for example that use of this plan will insure, with 13% risk, that lots ranging in size from 3200 to 10,000 and having 1% defective will be used "as is". On the other hand, similar size lots which are 3% defective have an 85% chance of being screened.

To minimize the amount of sampling inspection involved, an attributes multiple sampling plan (see Quality Control Manual #3) will be used. Initially, normal inspection and Inspection Level II will be used. Receiving Inspection shall be responsible for operation of the sampling plan in accordance with the policies and procedures as specified in Quality Control Manual #3 and as directed by Quality Control. As stated above, an AQL of .65 will apply. Sampling inspection shall be performed on all lots of "K" material. Screening shall be performed on all other lots, which are received from the vendor, and on all "K" lots that are rejected by the sampling plan. The implementation of the proposed system at HAPO will not require any changes in the present procedures used at NLO. To accomplish this degree of inspection at HAPO two testers, one operator, and three-quarters maintenance man will be required.⁽¹⁾

The Specialist, Nondestructive Testing, shall be responsible for assuring the legitimacy of the material accepted and rejected by the line testers used. Coordination must be effected between Receiving Inspection and the Specialist prior to the rejection of any inspection lot.

The Specialist, Nondestructive Testing, shall be responsible for the implementation of a system to insure continued agreement between the testers

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used at the vendor's site and the testers used at HAPO. This system shall also insure agreement between testers within each testing site and within each tester over time. Such system shall be documented, approved by Quality Control, and issued in sufficient quantity to all tester operating personnel. Vendor Liaison personnel shall be responsible for assuring compliance, by vendor personnel, to such directives and instructions.

Vendor Liaison shall be responsible for effecting, and designating to Receiving Inspection, inspection lots of such nature as to insure the maximum, practical homogeneity as concerns the grain size characteristic. Vendor Liaison shall also, to the extent practicable, critique the vendor's plan for control of the heat treatment operation, observe compliance to such plan, and call to the vendor's attention any discrepancies or violations observed.

Receiving Inspection shall be responsible for early notification to Vendor Liaison and Quality Control of any detrimental trending of grain size quality.

Implementation of this system can be effected immediately upon approval.

W. F. Stevenson, Senior Engineer
Quality Control

WFS/eb

Attachments: 5

REFERENCES:

- (1) See Attachment #3
- (2) See Attachment #4

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FIGURE I
OPERATING CHARACTERISTIC CURVE FOR SAMPLING PLAN

ATTACHMENT #1

October 27, 1964

W. A. Eline
L. H. Rice

UT-2 SAMPLING

To effect and justify the implementation of an economic inspection procedure to determine compliance of incoming uranium to the established grain size specifications it is necessary that the following probabilities be estimated to the best of your knowledge:

1. Probability of receipt of an out-of-spec core at HAPD. This can possibly be arrived at by review of past inspection records taking care to ensure that the rejects from such inspection were, in truth, outside of the present grain size limitations and were not rejected for such other causes as cracks, striations, etc.
2. Probability of failure of a fuel element whose uranium core is outside the grain size specification. Such probability for cores outside the small grain specification may be different from the excessively large grain cores. It is recognized that estimates of such probabilities may be subjective and theoretical but in the interest of implementing the most economical and business-like approach to this problem, it is necessary to arrive at some estimate of the monetary consequence of failing to find an out-of-spec core. The probability estimates here should take into consideration, if appropriate, the effect of placement of out-of-spec cores in the various regions of the reactor, i.e., central, fringe, upstream, downstream, etc.
3. Unit inspection cost with the UT-2 Testers. This should include operator salaries, maintenance and repair, amortization of capital equipment, supervisory costs, and handling.
4. Probability of an out-of-spec core being produced at HLO. This may be arrived at from knowledge of the reject rate at that point and knowledge of the methods and degree of control exercised over the heat bath treatment.

Your cooperation and early written reply will be appreciated.

W. F. Stevenson

ATTACHMENT #2

October 23, 1964

To: W. A. Kline
313 Building
300 Area

From: L. H. Rice
3717 Building
300 Area
ORIGINAL SIGNED BY
LEROI H. RICE

UT-2 SAMPLE TESTING

Some points to keep in mind on the UT-2 sample testing plan are:

1. The information I need will be the identification of ingots which are 100 percent tested, the reason, and the number and voltages of pieces rejected.
2. The sample testing should be applied only to lots with a "K" prefix (KY, KZ, KV, etc.). Miscellaneous, oil quench, induction heat treat or special lots which are identified with the prefix C, L, X, etc. must continue to be 100 percent UT-2 tested.
3. The 60 cards received with each shipment contain information on the ingot numbers, the box numbers, lot numbers, and the number of pieces in each lot. Printouts of these cards can be available at the time the cars are unloaded.
4. The internal controls in effect at NLO include:
 - a. Sample UT-2 testing of five cores from each ingot with 100 percent testing of an ingot if a reject core is found in the sample.
 - b. One-hundred percent testing of each ingot in which the number of cores transferred to NLO final inspection does not agree with the number of pieces blanked minus the pieces withheld or rejected in manufacturing.
 - c. Tester operation as outlined in NLO SOP 15-C-101. A revision of this SOP should be available soon.

LHR:nn

cc: EV Padgett
LB
File

IRRADIATION PROCESSING DEPARTMENT
GENERAL ELECTRIC
 RICHLAND, WASHINGTON

ATTACHMENT #3

October 29, 1964

W. F. Stevenson, Engineer
 Quality Control
 313 Building, 300 Area

UT-2 SAMPLING

In reply to questions 1 and 3 of your letter dated October 27, 1964, the requested estimates are as follows:

1. Probability of an out-of-spec core being received at HAPC. The following percentages are based on a period from June 1, 1964 to October 21, 1964. The throughput was estimated from QC records and the defective rates are taken from QC Lab records of all UT-2 rejects incurred during this period.

Throughput	100.00	%
Reject rate	0.081	%
Good cores (false rejects)	0.019	%
Surface defects	0.0563	%
Large grain rejects	0.0046	%
Difference rejects	0.0011	%
OUT-OF-SPEC CORES (GS)	0.0057	%

Considering that during at least the past two years no real untransformed or quench crack material has been detected, and that the large grain material detected would not cause a reactor failure (questionable material is double checked by a visual grain size determination), we can assume that the only received cores that could possibly cause a reactor failure are the 0.0011% in the difference category.

2. Unit inspection cost with the UT-2 testers is based on direct labor and IME for 4 operators to operate the testers and handle material; 1-1/2 maintenance men to maintain the testers; and amortization of the test equipment over a 10 year period.

Unit cost at the present rate \$ 0.035

Unit cost of a 3-piece per ingot sample plan \$ 0.014
 (2 testers, 1 operator, 3/4 maintenance man)

WAK/eb

cc: WA Blanton JT Stringer
 EV Padgett WA Kline/LB
 LH Rice

W. A. Kline
 W. A. Kline, Specialist
 Nondestructive Testing
 Quality Control

IRRADIATION PROCESSING DEPARTMENT

GENERAL ELECTRIC

RICHLAND, WASHINGTON

99352

ATTACHMENT #4

February 9, 1965

W. F. Stevenson, Engineer
Quality Control Unit
Fuels Engineering Operation

UT-2 SAMPLING

The probability of failure of a transformed core with out-of-specification grain size may be estimated as $1/10^4$. This is at best an educated guess, as we have no data to base the estimate on.

The probability of producing an out-of-specification core at NLO may be arrived at by adding the percent UT-2 rejects at NLO and HAPO. The UT-2 reject rate at NLO for the period April through September 1964 was 0.27 percent.

Vendor Liaison

LH Rice:rh

cc: WV Padgett
LB
File

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