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H. D. Thornburg, Chief
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Directorate of Regulatory Operations, HQ

AUG 23 1973

RO Inspection Report No. 50-219/73-06
Jersey Central Power and Light Co.
Oyster Creek - BWR

The subject inspection report is forwarded for your information. This was a special inspection conducted by the Technical Assistance Branch relating to EXXON Nuclear Co. fuel manufacturing. Since the inspection involves proprietary data and processes of the fuel manufacturer, this information is being forwarded as attachments I and II to this memorandum and were excluded from the report.

The inspectors found that the licensee's QA program had been effective and corrective action had been taken by the manufacturer to correct the deficiencies.

R. T. Carlson, Chief
Facility Operations
Branch

Enclosures:
1. Attachment I - Proprietary
2. " II - "

3. RO Inspection Report No. 50-219/73-06

cc: RO:HQ (5)
DR Central Files
Reg. Standards (3)
Directorate of Licensing (13)
RO Regional Directors
RO Files
Central Mail & Files Unit

3/1/79

OFFICE ▶	OPS					
SURNAME ▶	Cantrell/her	Caphton	Carlson	~~O'Reilly~~		
DATE ▶	8/23/73					

Form AEC-318 (Rev. 9-53) AECM 0240

~~PROPRIETARY~~

ATTACHMENT I

FIELD NOTES - D. L. Pomeroy

Inspection - April 10-11, 1973

GPUSC - Audit of Exxon Nuclear, Oyster Creek

Docket No. - 50-219

Contains Proprietary Data on Exxon Fuel Processes

NOTES FROM GPUSC INSPECTIONS

Audit - Date	Place	Personnel
Oct. 25 & 26, '71	Richland, Washington ENC	B. H. Cherry, GPU R. F. Denning, GPU J. A. Gorman, MPR Associates

Purpose: Review Q/A - Q/C programs planned for O.C. reload fuel

Findings: 1) System satisfactory and meets Appendix B.

2) System for documenting design reviews (e.g., by Battelle) needs improvement.

3) Specific sampling requirements are spelled out on forms in the Quality Control Standard. These forms should be reviewed by the design group.

Notes:

The following notes are taken from the October 25 and 26, 1971 audit of the Exxon plant in Richland by GPU and MPR Associates During the spot check review of the Exxon documents a few specific technical concerns were identified as follows:

The QC standards do not include specific steps to be taken if a metallurgically examined sample weld is found to be unsatisfactory. It is recommended that specific steps be included such as the destructive examination of some production weld.

The QC standards presently allow fuel rods to be loaded with fuel pellets and a second end cap welded prior to the destructive examination of the first end cap sample weld having been completed. It is considered desirable to have these destructive examinations completed prior to further processing to minimize the pressures to accept borderline weld conditions. Accordingly, it is recommended that Exxon consider making completion of the destructive tests mandatory prior to further processing.

A fuel rod procduct specification permits use of pellets ground to specific lengths to be used to adjust fuel stack length during fuel rod loading. However, the process specifications and QC standards do not specifically cover the use of such pelle's. A representative stated that special grinding of pellets had not been used to date, but that possibly could be used in the future and that if used would be subject to the same offgas cycle. Accordingly, it was recommended that the process specifications and QC standards be modified to cover the use of such pellets.

Audit - Date	Place	Personnel
Jan. 20, 1972	Richland, Washington ENC	R. Denning, GPU E. Fisher, GPU R. G. Scott, MPR

Purpose: Audit fabrication of four lead assemblies

Findings: ENC is implementing a strong and effective Q/C program. Changes were recommended to accommodate the higher production rates to be used in the future.

Notes:

The following notes are based on the GPU-MPR audit of January 20, 1972. These relate to specific actions recommended to be taken by Exxon to accommodate the higher production rates that will be encountered in the manufacture of the full complement of the Oyster Creek reload fuel assemblies.

In those few areas where violation of the Exxon procedures were noted during the audit, Exxon personnel took prompt, effective, corrective action. For example, it was noted that the weld box used for final end cap welding was loaded with two different types of fuel rods (differing in cladding thickness), requiring different weld parameters and destructively evaluated weld control specimens. The operator had properly welded to control specimens, but inadvertently used the wrong parameter setting in the welding of some production rods. The Exxon personnel shut down the welding operation, removed the fuel rods in question, and sectioned representative samples to confirm the adequacy of the welding performed.

In some cases the current procedures do not accurately reflect what is actually done during manufacture. For example, the method used to check the electrode gap in the end gap welding station is not as depicted in the procedures. Also, the details of the fuel rod loading procedure differ from the sequence used in practice. The manufacturing and quality control procedures should accurately reflect what is actually done by the operators and inspectors.

A more complete and better documented weld qualification program should be performed. Currently only nominal welding parameters are qualified and little documentation of this work is available in permanent form. The welding process should be qualified over the entire range of parameters anticipated for production use. It was also noted that while the current welding parameters for the 0.392 inch thick tubing is within specification, some samples came close to the point of rejection. It is recommended that consideration be given to redefining the parameters to increase weld penetration and to provide more margin for acceptance to the control limits.

To improve the control of fuel rod welding, the following recommendations are made for Exxon's consideration:

The strip chart of welding current and voltage should be marked at the initiation and conclusion of welding of each group of rods to permit tracing accurately actual weld conditions to a specific weld joint.

It is recommended that a loading map be provided for each group of rods loaded into the weld box to assure proper identification of these fuel rods, as their serial numbers are not visible while in the welding chamber.

Currently welding can proceed in any order once fuel rods are loaded into the weld chamber. It is recommended that a rigorous sequence of welding of fuel rods within a group be followed to eliminate this potential source of error.

Exxon has prepared written weld repair procedures. These procedures were not used in the manufacture of reload fuel rods nor had they been qualified at the time of our visit. They should not be used in production prior to their complete qualification.

During the manufacture of lead assemblies, fuel pellets of only one enrichment symbol stamp on each pellet was checked to verify enrichments. These precautions together with the high level of supervisory personnel on the job were considered to provide adequate enrichment control for these lead assembly fuel rods. However, several areas were noted where the current enrichment control measures would be considered inadequate should more than one enrichment be in production in the pellet processing or storage areas, as will likely be the case for manufacture of the balance of the reload fuel assemblies. For example, the marking and identification of trays stored on table tops were not adequate to prevent inadvertent mixing of the pellets. There was no physical separation of pellets of different enrichments in these storage areas. Also, in the loading station used for fuel column weighing in preparation for fuel rod loading, it was noted that current procedures do not prohibit placing groups of pellets in different enrichments in this area. Because of the nature the station is very difficult to observe the pellet enrichment symbol at this point in the process. It is considered that rigorous separation of pellets of different enrichments should be provided for this area. It was noted that fuel rod pellets of different diameters are placed on two stacks of trays adjacent to each other at the loading station during our audit. Except for administrative control by records kept external to the loading station, it would not be posible to assure that small diameter pellets were not inadvertently placed in the large diameter tubes. Positive segregation and markings are required for this area when production quantities of materials are processed.

It was noted that workmen used powdered EP starch to keep their hands dry at the fuel rod loading station. This starch was placed near the open ends of the fuel rods being loaded and could consequently be a possible source of contamination of the fuel rods by hydrogenous material.

It was also noted that there was a bristle brush located in this loading station. It would be better practice to use stainless steel brushes to avoid the possibility of contamination of the fuel rods.

Audit - Date	Place	Personnel
April 18, 19, & 20, 1972	Sandvik Special Metals Zircaloy Technology Precision Founders	B. H. Cherry, GPU R. F. Denning, GPU J. A. Gorman, MPR Associates

Purpose: To audit ENC procedures as applied to these subvendors.

Findings: 1) Sandvik - Q/C system satisfactory - some improvements recommended.

2) Zirtech - Improvements required - control of cleanliness - no written procedure for final pickling of tubing - corrosion samples not representative - material suppliers not audited.

3) Precision Founders Q/C system satisfactory - Recommend ENC audit again during production run.

Audit - Date	Place	Personnel
June 13-14, 1972	Zirconium Technology	B. H. Cherry, GPU R.F. Denning, GPU J. A. Gorman, MPR Associates

Purpose: Follow-up in-depth audit of Zirtech's cladding manufacturing.

Findings: Zirtech and ENC have taken effective measures to upgrade Q/C program. Zirtech is now an acceptable supplier for fuel rod cladding for O.C. reload.

Notes:

The following notes apply to the audit of the Zirconium Technology Corporation, known as Zirtech, which is manufacturing the zircalloy-2 fuel rod cladding for the Oyster Creek reload fuel. This audit was conducted June 13 and 14, 1972. (Report by Gorman)

In conjunction with the audit the additional checking performed by Jersey Nuclear (Exxon) in regard to Zirtech fuel rod cladding which was previously shipped to Exxon, was reviewed by GPU and MPR. From our discussion with Jersey Nuclear we understand that this additional checking consisted of the following:

1. 100% of the cladding was subject to

   a. Dimensional inspections for ID, OD, and Length.

   b. Visual inspections for defects.

   c. Ultrasonic inspections for defects.

   d. Ultrasonic inspections for wall thickness.

2. Sampling inspections were done for straightness and surface roughness.

3. The following tests were performed for each lot of cladding:

   Four room and high temperature mechanical property tests, one chemistry test, three weight gain corrosion tests, three hydride orientation determinations, one flare test, three or four open-end and one or two closed-end burst tests, a residual contamination corrosion test of about a 90-inch cut length from one production tube together with test of one or more Zirtech supplied short length sample pieces.

4. An equivalent boron content determination was performed for each ingot of zirc-2 material involved.

Exxon indicated that the results of the above addition checks indicate that all tubing lots meet the applicable specification requirements for mechanical properties, chemistry, corrosion, hydride orientation, flare test capability, burst test ductility, and equivalent boron content. Further, while the inspections listed above has screened out some cladding because of conditions close to specification limits regarding dimensions, straightness, ultrasonic indications, etc., no significant tubing quality problems have been detected.

The latest revision to Exxon's specification for fuel rod cladding requires that the cladding having minimum high temperature (720°F) elongation of 14%. Some of the tests performed at the Zirtech cladding already at Jersey Nuclear (Exxon) indicate that a high temperature elongation below 14% to as low as 12%. While the requirement for 14% high temperature elongation was not invoked on the Zirtech cladding already at Exxon, we consider that all cladding used for Oyster Creek fuel should meet all necessary technical requirements. Accordingly, Exxon is requested to describe in detail to GPU the bases for selecting the minimum high temperature elongation of 14% to advise GPU of their evaluation of the acceptability of the Zirtech cladding on hand which may not need this requirement.

The following are some additional notes from the June 13 and 14 audit of Zirtech. These are recommendations for Exxon and Zirtech's consideration made by the GPU consultant, MPR.

The calibration of the deionizer conductivity meter should be checked periodically.

The specific responsibilities for review and sign off of material certification should be documented.

SOP No. 1 indicates that if an unfavorable Q ratio should result from reworking part of a lot, it should be separately certified. We recommend that criteria for making this decision be documented and that the persons responsible for making the decision also be identified.

The Zirtech procedure for hydride orientation determination does not agree with the Exxon's specification requirements. While we understand that, in fact, the hydride orientation has been determined in accordance with the Exxon specifications, we consider that the Zirtech procedure should be corrected to not conflict with this specifi tion.

The locations along the two blanks from which tensile test specimens are selected do not appear to be specified. We recommend that they be specified in an appropriate SOP and that the locations be selected so as to bracket the range of temperature in the annealing furnaces.

The newly developed Zirtech procedure for document control does not itself appear to be documented. We recommend that it be documented in an SOP or other appropriate document.

The internal auditing presently planned does not appear to include auditing of compliance with SOP's and inspection procedures.

Some Zirtech procedures for visual and dimensional specification s allow Zirtech to use statistical inspection if they can demonstrate that a 95/95 % confidence level can be achieved. We understand the use of statistical inspections would not be done without specific Jersey Nuclear (Exxon) approval. We request that GPU be notified if Exxon approval is ever given for such statistical inspections.

Some ultrasonic crystals which were overdue for calibration were in the active storage area, but were not tagged to indicate they should not be used. We recommend that some positive means be used to prevent inadvertent use.

We recommend that the acceptance standard for corrosion tests, for residual contamination be more formally defined by Exxon, probably through the use of physical standards agreed to by Exxon and the tubing supplier.

We recommend that Exxon formally require that tubing suppliers provide photomicrographs of the hydride tubing samples used for hydride orientation determination.

Audit - Date	Place	Personnel
October 23-24, 1972	Richland, Washington ENC	F. Denning, GPU J. Walther, GPU R. G. Scott, MPR

Purpose: Audit Q/A for UO_2 powder conversion, pellet manufacture and fuel rod manufacture.

Findings: Q/A program well documented and effectively implemented. Recommendations: 1) Strengthen control of UO_2 powder identity, 2) Control of sintering temperature - maintain 1625-1700°C. 3) Control of pellet diameter - not to use proposed expanded range - continue to hold $\pm$ 0.0005 inches, and 4) ENC to submit a plan for characterizing a number of O.C. rods to obtain meaningful post irradiation evaluation.

Notes:

The following notes are some of the details obtained from the report of this audit prepared by Mr. Scott. Under the area enrichment control, in several areas the control of the storage and handling of UO_2 powder and pellets was found to be weak as compared to the other aspects of the Exxon quality assurance program. No cases were observed to indicate that a high probability of intermixing of fuel enrichments had occurred. Some of the items noted are as follows:

We were informed that work on material of different enrichments may be carried out at different parts of the pellet production line as long as each piece of equipment is isolated and properly cleaned out between enrichment changes. However, there are no written procedures to clearly define to what extent powder and pellets of different enrichment can be simultaneously worked at various stages of the production line or to describe the physical and administrative controls used to prevent enrichment intermixing. The audit team considers that only one enrichment should be processed in a pellet production line at a time. If special work, such as sinterability testing of new powder is desired, physical barriers should be provided on the containers for such work to positively eliminate the possiblity of intermingling with other enrichments.

There were no written procedures for controlling the storage of UO_2 powder cans within, or the transfer of material in or out of, the powder storage area. This area contains UO_2 material of several enrichments in in the range of 1 to 4% enrichment. In several cases, cans of different enrichment are stored together on the same shelf.

Material control records in many cases are not being filled out properly in the powder storage or powder preparation areas and in other stages of pellet manufacture. In several cases it was difficult to determine what processing had been performed on specific powder because the pertinent records were incomplete. For example, in most cases observed, the required initials to identify that the processing steps had been performed were omitted and coding of the lot number to indicate sterotex addition, blending, dirty powder, etc., was not done. Such omissions could result in confusion in processing. For example, double addition of sterotex could be made, which could adversely affect pellet quality.

Specific cases were noted where root card information was incorrect or inconsistent with other basic inspection records. For example, the root cards for Lot 26-3 indicated that it contained more individual powder cans than permitted by the Exxon blending procedure.

Many instances of modification of inspection information on the material control tags, such as modification of powder weight resulting from addition of sterotex, powder sampling or performance of presintering runs, modification of processing history, changes of lot number, etc., were not signed or otherwise identified as to what authorized individual made the modification on the material inspection record. In one instance an individual was observed to alter information on an inspection record using his memory as the source of the new information. Later inspection record checks showed him to be in error and he found it necessary to alter the record again.

Some powder cans have tapes placed on them, that have special instructions handwritten on the tape. In one case observed the tape was not adhered well to the can. In no case observed were the special instructions identified specifically to the can by its can number so that if the tape was separated from the can, the special instructions would be lost.

Three scrap cans containing three different enrichments of material were located adjacent to the slugging press in the path of the heaviest traffic in and out of the powder storage area. This condition is considered to provide an unnecessary source of enrichment mixup.

There were large stacks of empty powder cans in the storage room. Much of the same identification was on these empty cans as was present on cans containing UO_2 powder so that it is not easy to visually differentiate from cans with UO_2 powder. This situation is not conducive to good quality control.

One powder can had a serial number on its lid only and not on the side as required. This situation could lead to inadvertent interchange of can lids and the consequent loss of identity of the powder. There is no written instruction regarding whether or not a powder can may be opened and additions or subtractions to it made while in its storage area. It is considered that except for blending with a lot material which is performed on a conveyor belt located on the side of the storage area, no powder or pellet additions to the can should be made within the storage area. This requirement would assure greater control to prevent the inadvertent intermixing of material of different enrichments.

Exxon control procedures require that machine serialization tapes be used on the lids and sides of cans to identify powder content. In some cases these numbers had been altered by a magic marker.

Currently the cans used to collect scrap are identical to those used to contain the accepted pellets in process from sintering to final inspection of pellets. It is recommended that different cans, distinguished by color, shape, etc., be provided as scrap containers. To further prevent inadvertent return of scrap material to the process line it is suggested that these cans be equipped with trap doors which make withdrawal of scrap materials difficult.

With regard to the need to provide improved physical and administrative control of UO_2 powder and pellets, it is noted that the Exxon's sampling rate for enrichment control (5 samples for every 2,000 lbs. of UO_2) will not provide sufficient information to detect inadvertent intermingling of enrichments during pellet manufacture. Also, while it is true that each pellet contains an enrichment symbol, only one randomly selected pellet from each tray loading is checked during fuel rod loading to confirm enrichment. Hence, intermingling of pellets of different enrichments, if it were to occur, would likely go undetected by current inspection procedures. While Exxon is developing gamma scanning equipment to provide verification of fuel pellet enrichment in the final fuel rod, this equipment is not available at the present time. Hence, it is most important that rigorous physical and administrative controls be used to minimize the possibility of mixing enrichments.

The gloves used by the operators to handle fuel pellets contain talc or some other white powder substance. Some fuel pellets were observed with this material on the surface. Exxon has not analyzed the material to determine its composition, nor were we able to confirm that Exxon has established that such powder will not adversely contaminate the pellets loaded into completed fuel rods (hydrocarbon content, etc.).

Audit - Date	Place	Personnel
December 18, 19, &20, 1972	ENC-Richland	R. Denning, GPU G. Allen, GPU R. G. Scott, MPR Associates

Purpose: Audit Q/A for powder storage, pellet manufacturing, fuel rod outgoing and loading fuel rod welding and final rod inspection.

Findings: 1) UO_2 powder controls improved over last inspection.
2) Resintering of pellets - question raised.

Audit - Date	Place	Personnel
February 14 & 15, 1973	ENC-Richland	E. Allen, GPU R. Denning, GPU A. A. Strasser, SMSC

Purpose: Review of mixed oxide Q/A Program
Findings: Lack of good control and communication between Exxon and the Westinghouse-Hanford Laboratories.

Notes:

The following notes are taken from the inspection made by General Public Utility Service Corporation (GPUSC) of the Exxon Nuclear Corporation (ENC) uranium-plutonium oxide lead assemblies for GPU's Oyster Creek Station. The report was prepared by Mr. A. A. Strasser of S. M. Stroller Corporation.

The summary states that the audit of the mixed oxide plant for production procedures, inspection procedures, control of test equipment, and non-conforming materials showed that Exxon Nuclear complied with the quality assurance system. Although steps have been taken by Exxon to improve the control of their second tier subcontractor for analytical services, the Westinghouse-Hanford Laboratories, the control methods are still not satisfactory and need upgrading to meet the QA system requirements. The audit of the Westinghouse-Hanford Laboratories indicated significant deviations from the quality assurance system in document control, inspection techniques, and the calibration of test instruments. A review and upgrading of the procedures is required.

A review of Exxon Nuclear's statistical treatment of quality data was made, and while the treatment in itself is correct, the assumptions for the type of data distribution are open to question. Review of the quality data is recommended as it is generated, to check whether the initial assumptions were correct and to take positive corrective actions if they are not.

The following outline contains some additional notes selected from the details of this inspection:

The Exxon Organization has been changed so that the QA manager now reports directly to the president instead of to the manager of research and engineering. The QA manager is George Trumbull and he is assisted by two part-time consultants. The change complies with our recommendations.

The specification for plutonium content was revised to include "the total plutonium content of a given UO_2-PUO_2 pellet as determined by analyzing the sample from each end and the center shall not be depart from the nominal by more than plus or minus 1.5% of the nominal." This change complies with our recommendation. There is no confidence statement associated with this part of the specification nor with the first sentence of the specification which states "the total plutonium content in any one gram sample from a UO_2-PUO_2 pellet shall be the nominal plus or minus 1.5% of the nominal. The total plutonium content of the pellet is taken as the arithmetic meaning of the three determinations made from the same pellet.

An internal recommendation has been made by Exxon to limit CL to 20 ppm max. and F + CL to 35 ppm max. The change has not been approved and until it is the existing specification of 25 ppm max. CL and 50 ppm max. F + CL will govern. Exxon stated that the approval of the new specification prior to completion of the mixed oxide production is unlikely. Exxon was urged to expedite approval of the specification. A review of the halogen analysis from prior production indicated that essentially all analyses were at levels below the detection limit of 10 ppm for each element.

The inspection and test plan for moisture total gas, plutonium macro-homogeneity, plutonium micro-homogeneity, and pellet density were revived as requested during the previous audit. The following changes were made:

Moisture and Total Gas

The actual minimum number of analyses required for the release of one lot is still 5. However, the following was added to the specification: "The pellet lot may be released based on an acceptable 5 piece sample. Subsequent outgas batches will be sampled by taking at least one moisture content sample value per outgas batch or a total of three samples minimum for gas content." In effect this means that the first outgas batch will have five moisture analyses and five total gas analyses. In order to release the lot, the number of analyses required for the release of subsequent outgas batches are one moisture analyses per batch and one total gas analysis per three batches.

Plutonium Macro-Homogeneity

The sampling plan was increased to one plutonium analysis per blend batch on the powder, after blending. Two lots will have 24 blend batches. The analytical results will be used for process control only. Each lot will be accepted on the basis of analyzing 5 pellets as described in the specification.

Plutonium Micro-Homogeneity

The sampling plan was increased to one sample per blend batch which was the minimum recommended at the previous audit.

Density

The acceptance sampling plan was increased to 10 measurements per blend batch which was previously used as process control only.

The production of the GPU mixed oxide lead assemblies is from two lots. Lot 1 consists of Eldorado UO_2 and Numec PUO_2 powder blended in 14 batches. Lot 2 is Exxon UO_2 powder and Numec PUO_2 blended in 10 batches.

This inspection report also includes an audit of the analytical services subcontractor, the Westinghouse/Hanford Laboratories. The contract is administered through Batelle Northwest Laboratories who are subcontractors to Exxon Nuclear and in turn sub-contract these services to Westinghouse/Hanford. The Westinghouse/Hanford Laboratories QA Manual is numbered HEDL-TME-71-88. The original date is May 1971. The Laboratories detailed test procedures are contained in a manual designated WHAN-IR-5. They are currently using the one designated Revision 1. During this inspection they were told that both of these documents are out of date and are being revised, and that the revisions will be issued in a few months. However, the drafts were not available at the time of this inspection. Most of the problems noted with the Westinghouse Laboratory were lack of written procedures, approval of written procedures, apparent improvements that have been made in the instrumentation, but lack of documentation of the procedures for this new instrumentation. Lack of written calibration standards, lack of written calibration requirements. (The inspectors didn't really seem to have any concern for the way they were doing things --

just that it was inadequately documented and that it had not been approved by Exxon.)

Following is a table showing the sampling plan for some critical characteristics.

Quality Characteristics	Distribution	Sampling Rate
Homogeneity (PU micro-homogeneity)	Log normal censored	1 per blend batch or 14 per lot 1, 10 per lot 2
Stoichiometry (O/M ratio)	Normal - two-sided	5 per lot
FL, CL	Unknown	5 per lot
Total gas	Normal - one-sided	1 per out gas batch, 5 per lot minimum
Moisture	Normal - one-sided	1 per 3 out gas batches, 5 per lot minimum
Plutonium macro homogeneity	Normal - two-sided	5 per lot
Density	Normal - one-sided (95/95 for UL, 95/90 for LL)	10 per blend batch or 144 per lot 1, 100 per lot 2

All confidence intervals for the above are 95/95 with the exception noted for Density.

The following discussion appears to relate to this table:

Inspection Requirements for the Mixed Oxide Fuel

First, the number of samples needed for the required 95/95 confidence interval was assumed by Exxon with past experience as a guide, in the case of homogeneity, total gas, moisture, and density, the numbers were increased at the request of GPU. After the fuel is produced and analyzed, a calculation is made to determine whether the data are within tolerance limits. A K factor is read from a table of tolerance values for the distribution assumed. The $\bar{X}$ mean and the standard deviation (σ_5) are calculated from the five or more values. The upper and lower tolerance limits are calculated from the relationship $\bar{X} \pm K\,\sigma_5$ and compared to the specification. The entire lot has to be rejected in the event that specification limits are exceeded. However, Exxon indicates that they will resample and treat the data based on criteria to be decided upon at that time.

In order to guarantee a 95/95 confidence coefficient using the normal variance unknown sampling plan, one must know the acceptable and rejectable quantity for the lot for initial characteristics in order to determine the sample size and K values. If the sample size of 5 is specified, for instance, without knowledge of the quanity levels ..om other sources, the 95/95 confidence level cannot be guaranteed. The Exxon data have to be examined after production is complete to determine whether the original assumptions are true. While the Exxon procedure is statistically correct for the assumptions made, the assumption of normality for all cases, particularly for population coverages as high as 95% is not realistic. Small departures from normality will result in large changes of the population coverage. The confidence coefficients required for this procedure are in the order of 2.5 or higher. For instance, a K of 5.079 used for the 95/95 confidence interval as determined by five samples for oxygen to metal ratio and plutonium gives a population coverage of 99.99996 and a tail of 0.00004. Obviously a small departure from the normal distribution will change the population coverage significantly and the same sampling rate may not give the same confidence interval. Another example <u>is</u> taken from the density meansurements of lot 1, batch 7 that have the $\bar{X}$ equal to 94.218 and a σ_5 of 0.353. For ten samples a K value of 2.911 was used for a one-sided normal case. The upper limit under these conditions was 95.10, within specification. For a T distribution with 4 degrees of freedom, not a particularly large departure from normality, the corresponding K value would be 6 and the upper limit will be 96.34 and exceed the specification. Because the extreme tails of a normal distribution have this property, one must be careful in making the normality assumption for high confidence intervals. A normal distribution is particularly questionable for critical impurities such moisture, halogens, etc., for which the maximum limits are small numbers. The statistical distribution of these quantities being close to zero, must, by necessity, be postively skewed, possibly with long tails on right side. A log normal sensored distribution may be closer to reality. A further difficulty in developing meaningful sample plans for these impurities is the fact that the detection limit is a significant fraction of the maximum allowable amount of the impurity and that several of these impurities occur at levels below detectability making it difficult to get historical data on their distribution.

To determine a reasonable sampling plan for halogens, the past history for F and CL analyses was reviewed. With the exception of one analysis, all values were less than detectable. As the result, Exxon has arbitrarily picked 5 samples per lot as that which would be acceptable. It was agreed that this sampling plan would be acceptable if this history continues during the production of the GPU fuel. The distribution data for C analysis was analyzed by Exxon some time ago by the application of the W test found that the data did follow a normal distribution.

Exxon indicated that they will apply this test to more recent data and also to the data generated during the production of the GPU fuel to check whether the distribution is normal.

A similar test for normality has not been made for N, although sufficient data above the detectable limits are available. Exxon indicated they will analyze past data to determine whether it follows a normal distribution or not.

A general recommendation regarding the treatment of data is that since the characteristics of the process for the GPU fuel are not completely known at this time, it would take a very large number of samples to guarantee that 95/95 confidence interval prior to production. However, the quality data can be examined after it has been obtained to check the normality assumption of the underlying distribution and the actual confidence interval obtained. The test for departure from normality used by Exxon in the past is satisfactory. In the event the desired confidence interval is not met, with a number of samples that were taken, additional samples would be analyzed or other steps such as process changes, should be instituted.

Under the heading of Dimensional Control there were some notes. An additional set of pellet diameter measurements is recommended. The pellet diameter is measured at the top, middle, and bottom of the pellet on one diameter. It is recommended that in order to determine any ovality in the pellet, the diameter of each pellet also be measured at 90° to the first set of dimensions.

The results of the sinterability tests for both the Eldorado UO_2 and the Exxon UO_2 with PuO_2 were reviewed. Variabilities in the test were slug density of 4.0 and 4.5 grams per cc, a range of green densities from 5 to 5.5 grams per cc, and temperatures from 1650 to 1675°C. The sintering tests indicated that the Eldorado UO_2 did not have the sinterability that was claimed by Eldorado. Exxon sintered the UO_2 both in their plutonium furnace atmosphere and their uranium furnace atmosphere. The required density range of 94.5 $\pm$ 1.5% was <u>just</u> reached by using a maximum green density which prevent lamination and the maximum furnace temperature: a combination of 5.5 grams per cc green density with the 1650 to 1675°C sintering temperature. A green density of 6.0 grams per cc causes lamination.

The Exxon UO_2 sintered to a density that was 1% lower than the Eldorado UO_2 and it appears that reaching the specified density with this powder will be problematical. The first resintering test was with 10 to 15 pellets initially 93 to 93.5% dense using the Eldorado UO_2. One resintering cycle is six hours at 1650 to 1675°C. These pellets have gone through three cycles and at the time of the audit were going through their fourth cycle. After the first three cycles there was no measurable change in length, diameter, weight or density. The lower than expected initial densities of the pellets represent the lower than expected sinterability of the Eldorado powder. The second sinterability test represented both Eldorado and Exxon UO_2 powder. The initial density was even lower, 92%, because of the poor sinterability of the poweder. Pellets have been re-sintered for two cycles, a maximum 1/2% increase in density was measured.

Pellets in the range of 94 to 95.5% made from the first production batch will be re-sintered in about a week to determine the behavior of the actual production pellets. The pellets being produced by Exxon appear to have adequate thermal stability, however, they will have problems meeting the specified density requirements with Exxon UO_2. This should be monitored in the future.

The following notes are items recommended for action by Exxon as noted in this inspection:

A revised fuel specification should be issued that incorporates all changes agreed to. A limitation on the number of radial and axial cracks is needed. The minimum pellet diameter specification should be eliminated. The reduced hydrogen specification should be approved. Review and revision of the analytical service procurement procedures from Westinghouse/Hanford are required to conform to Exxon's QA manual.

The following items were noted as having to do with subcontractor, Westinghouse. Recommendations were as follows:

Document Control - Updating of the written test procedures in the QA manual and implementing the document control system to prevent use of procedures before they are formally approved.

Calibration - Institute systems for periodically calibrating temperature measuring instruments, changing standard weights, taking measurement devices out of service that have not been calibrated as scheduled.

Upgrading of Test Procedures - A primary temperature measurement device should be installed in the total gas analysis apparatus. Recording of quality control should be in ink and signed off.

Audits - Additional, more frequent outside audits are required.

Audit - Date	Place	Personnel
February 14, 15, 1973	ENC - Richland	E. Allen, GPU R. Denning, GPU R. G. Scott, MPR

Purpose: To evaluate the nature of dimensional deviations noted on bundles at Oyster Creek. One upper tie plate has an excessive width of 0.006 inches and several grid spacers have maximum envelope dimensions in excess of drawing requirements.

Findings: Movement may have occurred during transfer from Richland to New Jersey.

Notes:

Exxon to follow up on:

Action to prevent reoccurrence of oversize tie plate found at Oyster Creek site.

Recommendation for disposition of fuel bundles that were channeled before peripheral rod spacing was measured together with technical supporting information.

Submittal of specific drawings, specification and quality control standard changes that are to be made to provide proper control of fuel bundle dimensional tolerances together with technical justification for those changes.

Discussion of technical basis for peripheral rod spacing requirements.

Action taken on spacer mechanical property requirements.

Action on clarification of sinterability test instructions.

Calculations to evaluate shipping load effects on the fuel bundle.

~~PROPRIETARY~~

ATTACHMENT II

AUDIT OF GENERAL PUBLIC UTILITY SERVICE CO. (GPUSC)
Parsippany, N. J.

APRIL 10-11, 1973

Field Notes - Prepared by U. Potapovs, Senior Metallurgical Engineer, Technical Assistance Branch, RO

Scope

On April 10-11, 1973, D. Pomeroy and U. Potapovs audited GPUSC regarding their overall quality assurance effort in the procurement of Oyster Creek second reload fuel from Jersey Nuclear Company. This report is addressed specifically to the review of product specifications and processing control requirements for the reload fuel.

Proprietary Information

Data contained in this report is considered proprietary to Jersey Nuclear Company.

Persons Contacted (GPUSC)

B. H. Cherry - Manager, Nuclear Fuels
E. W. Allen - Quality Assurance
R. Denning - Nuclear Fuels Engineering

Summary of Findings

1. General

The Oyster Creek third reload fuel is being supplied by Jersey Nuclear Corp. (Div. of Jersey Enterprises). The reload consists of 148 bundles some of which will contain mixed oxide (UO_2-$PU\ O_2$) rods.

Four lead assemblies (UO_2 fuel) were produced earlier and were inserted in the Oyster Creek core during Spring, 1972. Although the fuel bundle design appears geometrically very similar to the original (GE) fuel, differences were noted in the cladding thickness, pellet configuration and processing techniques.

The reload fuel has thicker cladding and dished pellets with L/D ratio of less than one. The cladding I. D. surfaces are not autoclaved. Similar to the original loading the ENC fuel bundles are designed to accommodate disassembly and reconstitution.

It was noted that the reload fuel will include 200 archive rods with a thoroughly documented material and processing history to aid in continuing fuel performance evaluation.

A description of the more significant processing techniques and component specifications of the reload fuel is certained in the following paragraphs.

2. Moisture Control During Rod Assembly

After sintering and grinding, the pellets are outgassed at a high temperature (on the order of 800°C). After outgassing the pellets are retained in a controlled atmosphere inclosure until loading into fuel rods which is accomplished in a dry glove box. At the time of rod loading, one end plug has been welded in position. A plastic cap is placed over the open end of the rod after the pellet stack has been inserted. The second end plug is welded in a controlled atmosphere chamber which is sufficiently large to accommodate the entire length of several fuel rods. The chamber is first vacuum outgassed and then backfilled with helium. Welding is accomplished using automatic heliarc equipment with a controlled welding cycle.

3. Cladding Surface Treatment

The fuel cladding (zircalloy-2) is received from the tubing supplier in stress-relieved and bright-pickled condition. A 32 rms surface finish is specified with an "aim-for" figure of 8 rms on the tube inside diameter. After the second end plug is welded in place, the loaded fuel rods are helium leak tested, etched, autoclaved and helium leak tested again. This results in the finished fuel rods having autoclaved outside surfaces while the I.D. is retained in bright-pickle condition.

4. Product Specification for Cladding

The fuel cladding is specified as ASTM B353-71 Grade RA-1 (zircalloy-2) or grade RA-2 (zircalloy-4) with certain additional requirements. All of the Oyster Creek replacement fuel is reportedly made from zircalloy-2.

The material is required to be vacuum stress relieved at 780-1000°F following cold work and have minimum tensile and yield strengths of 70 and 60,000 psi at room temperature and 50 and 40,000 psi at 720°F and the respective elogations of 16 and 14%. Burst test and 60° flare test are also specified. Straightness requirements are one part in 1200 over the entire length or .015-in per any 12-in span. The tubes are to be furnished in bright-etched condition with surface finish of 32 microinches or better and "target" finish of 8 microinches for internal surfaces.

A 100% dimensional inspection including wall thickness, I.D. and O.D. measurements is required in accordance with the applicable drawings tolerances. Each lot of tubing is required to be corrosion-tested in accordance with recommended practice G-2 of ASTM B-353 and material grain size after a 45 minute anneal at 1250°F must be less than 7 in the longitudinal direction. (per ASTM E112-63) They hydride orientation ratio must be less the 0.3 when determined in accordance with procedure described in the product specification. A 100% ultrasonic inspection (submerged method) is specified using a minimum of two transducers (circumferential & axial). If only two transducers are used, however, the inspection has to be repeated after turning the tubes end to end. An alternate method is to use 4 transducers simultaneously. Calibration Standards are square-bottomed defects (I.D. and O.D.) .004-in. wide x .002-in deep x .125-in. long. Defect indications exceeding calibration signal are rejectable.

5. Product Specification for UO_2 Powder

Moisture: Less than 0.80%

Particle Size: Less than 20 mesh U. S. sieve per ASTM B214

Density: More than .75 g/cc per ASTM B3220-70

Equivalent Boron Content: Less than 4 ppm on Uranium weight basis.

Sintering performance test: Required per specification.

6. Product Specification for UO_2 Pellets

Some of the more significant pellet requirements are as follows:

Diameter: 100% inspection required for conformance with drawing specifications. A recent revision permits decrease in pellet diameter of up to .001 below specified minimum providing that pellet density is proportionally higher (2% density increase for .001 diametral reduction).

Moisture: Required to be less than 20 ppm on single pellet weight basis and less than 10 ppm on total weight basis of pellet lot.

Pellet Density: ± 1.5% of specified value. The specified densities for Oyster Creek reload are 93.5 and 94.5.

Stoichiometry: 1.99 - 2.02

Gas content, excluding water: Less than 0.1cc/gram of pellet weight at STP as measured at 3000 ± 90°F.

Critical impurities: C <100 ppm, Cl<25ppm Fe<25ppm, H (exclusive of moisture) <5 ppm, N<75ppm.

Permissible cracking tollerances: radial, on ends: 0.010in, max. circumferential, within .10-in. of ends: less than 60°. Circumferential, center of pellets: less than 180°. Axial cracks: .125-in. max.

7. Product Specification for Fuel Rods

The specification includes all classification of fuel rods which will be used in the Oyster Creek reload core. These are: standard, high enrichment, intermediate enrichment and low enrichment fuel rods, low enrichment and high enrichment burnable position rods, and high and intermediate enrichment tie-rods. Two cladding thicknesses (.0355 and .0455) are specified. All tie rods have thick cladding, standard rods have either thick or thin cladding and position rods have thin cladding.

Each pellet stack is required to be weighed (to 0.1%) before loading. The stacklengths are measured and recorded. The rod end caps are welded in 95% min. helium atmosphere (total inert gas content must be 99.9%). The weld fusion and heat affected zone must be free of voids or non-bond indications for min. distance of .029-in. for thin-clad rods and .038-in. for thick-clad rods at any cross section. Porsity over .005-in. diameter is not permitted. No columnar grains are allowed in the heat affected zone. Statistical metallographic sampling is used to verify conformance to these requirements. A radiographic sampling plan of the loaded fuel rods is also required. The rods are helium leak tested within eight days of the final end plug welding. The outer rods are etched to remove between .0005 and .0015-in. of material and all rods are autoclaved. Visual standards are used for acceptance of rod appearance after autoclaving. No brown or white corrosion products are permitted.

Following autoclaving, the fuel rods are subjected to a second helium leak test. Limiting conditions are imp osed on finished fuel rod handling. The loaded rods must be sufficiently supported at all times to limit bowing to less than 1-in. per 3 feet.

8. Product Specification for Plenum Springs

The plenum springs are fabricated from Inconel X-750 which is procurred per AMS 5698 B, AMS 5699 B or equivalent specification. The precipitation heat treatment is performed after the coiling operation.

9. Product Specification for Grid Spacer Assemblies

The grid assemblies are fabricated from zircalloy-4 frames and Inconel 718 springs (per AMS 5596 C). The finished frames are subject to corrosion test at 389± 10°c and 1500 psi for 24 hours. Acceptance criteria requires a black shiny surface and absence of white or brown oxides.

10. Product Specification for Tie Plates

The tie plates are machined from austenitic stainless steel castings (ASTM A296, CF-3). Weld repairs are permitted prior to solution heat treatment, using type 308L electrodes.

The castings are passivated for30 minutes in 6 to 15 volume per cent of 70% nitric acide before use in assembly.