E07/13/7

REGULATORY INFORMATION DISTRIBUTION SYSTEM (RIDS)
DISTRIBUTION FOR INCOMING MATERIAL

50-329/330

REC: BOYD R S
NRC

ORG: BACON J L
CONSUMERS PWR

DOCDATE: 07/10/78
DATE RCVD: 07/13/78

DOCTYPE: LETTER    NOTARIZED: NO

SUBJECT:

COPIES RECEIVED
LTR 1    ENCL 1

FORWARDING CERT OF SVC SHOWING SVC OF AMEND NOS 46 & 47 TO APPL FOR CONSTRUCTION PERMITS AND OPERATING LIC, CONSISTING OF REVISION 10 & 11 TO THE FINAL SAFETY ANALYSIS REPT, SERVED UPON U.S. EPA, CHICAGO, IL...ET-AL.

PLANT NAME: MIDLAND - UNIT 1
MIDLAND - UNIT 2

REVIEWER INITIAL: XJM
DISTRIBUTER INITIAL: M

***************** DISTRIBUTION OF THIS MATERIAL IS AS FOLLOWS ******************

CERTIFICATE OF SERVICE
(DISTRIBUTION CODE B008)

FOR ACTION: BR CHIEF LWR#4 BC**W/ENCL    LIC ASST LWR#4 LA**W/ENCL

INTERNAL: REG FILE**W/ENCL    NRC PDR**W/ENCL

EXTERNAL: LPDR'S
MIDLAND, MI**W/ENCL
ACRS CAT A**W/O ENCL

THIS DOCUMENT CONTAINS
POOR QUALITY PAGES

DISTRIBUTION: LTR 5    ENCL 5
SIZE: 1P+1P

CONTROL NBR: ~~781940015~~

*********************************** THE END *************************************

8006160412

Judd L. Bacon
*Managing Attorney*

Consumers Power Company

General Offices: 212 West Michigan Avenue, Jackson, Michigan 49201 • Area Code 517 788-1366

July 10, 1978

Director of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Att: Roger S. Boyd



MIDLAND PROJECT
DOCKET NOS. 50-329, 50-330
OPERATING LICENSE APPLICATION

Gentlemen:

Enclosed is a Certificate of Service of copies of Amendment No. 46 (Revision 10 to the Final Safety Analysis Report) and Amendment No. 47 (Revision 11 to the Final Safety Analysis Report) to the Company's application for construction permits and operating licenses for Midland Unit Nos. 1 and 2, covering service upon Mr. Robert B. Chatterton, Supervisor of Midland Township; Mr. Daniel Ranck, Chairman of the Midland County Board of Commissioners; Mr. Phillip F. Gustafson, Manager, Environmental Statement Project, Argonne National Laboratory; Executive Office of the Governor of Michigan; and U.S. Environmental Protection Agency.

Yours very truly,



B008
S
1/1

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

| | | |
|---|---|---|
| In the Matter of<br>CONSUMERS POWER COMPANY<br>Application for Reactor<br>Construction Permit and<br>Operating License | )<br>)<br>)<br>)<br>)<br>) | Docket No. 50-329<br>Docket No. 50-330 |

CERTIFICATE OF SERVICE

Amendment No. 46 (Revision 10 to the Final Safety Analysis Report) and Amendment No. 47 (Revision 11 to the Final Safety Analysis Report) to Consumers Power Company's Application for Reactor Construction Permit and Operating License for Midland Plant Unit Nos. 1 and 2 have been served today upon the following persons by deposit in the United States mail:

U.S. Environmental Protection Agency
Federal Activities Branch
Region V Office
Attention: EIS Coordinator
230 South Dearborn Street
Chicago, Illinois 60606

Executive Office of the Governor
Division of Intergovernmental Relations
Lewis Cass Building
Lansing, Michigan 48913

Mr. Robert B. Chatterton
Supervisor of Midland Township
928 Clarence Court, Route 7
Midland, Michigan 48640

Mr. Daniel Ranck, Chairman
Midland County Board of Commissioners
Midland County Courthouse
Midland, Michigan 48640

Mr. Phillip F. Gustafson, Manager
Environmental Statement Project
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439

Alice R Ginsburgh

Alice R. Ginsburgh
Attorney
Consumers Power Company

Dated: July 10, 1978

PROP

DUPLICATE COPY

Consumers Power Company

Stephen H. Howell
Vice President

General Offices: 1945 West Parnall Road, Jackson, Michigan 49201 • Area Code 517 788-0453

0505.8

June 29, 1978
Howe 114-78

BCC: RLCastleberry
CLMahaney
JLBacon
GSKeeley
PAPerry
JJZabritski
MPIeschik
DBMiller

Director of Nuclear Reactor Regulation
Attn: Mr Roger Boyd, Director
Division of Project Management
US Nuclear Regulatory Commission
Washington, DC 20555

MIDLAND PROJECT
DOCKET NO 50-329, 50-330
REQUEST FOR ADDITIONAL INFORMATION-
PROPRIETARY INFORMATION RESPONSE
FILE: 0505.8 SERIAL: 5522

Amendment 49 to the Company's application for construction permits and operating licenses contained Revision 9 to the Final Safety Analysis Report.

In Revision 9, we indicated that our response to certain NRC Requests for Additional Information was proprietary in nature and would be submitted via separate cover:

We are enclosing five (5) copies of responses to the following NRC requests for additional information.

| | |
|---|---|
| 231.10 (4.2.1.6) | Design of Absorber Material |
| 231.13 (4.2.1.6) | Conservation of Minimum Unirradiated Strength Values |
| 231.14 (4.2.1.7) | Fuel Surveillance |
| 231.16 (4.2.3.1) | Fuel Rod Stresses |
| 231.22 (4.2) | Dimensions/Spring Constants For Upper and Lower Plenum Springs |

We request that these responses be withheld from public disclosure, and in accordance with the provisions of 10CFR2.790(b), we are enclosing an affidavit prepared by Babcock & Wilcox which identifies the documents to be withheld from public disclosure and the basis for the request.

[signature]

CAL/jbr

dupe

#7810190070

Ap 4
60

AFFIDAVIT OF JAMES H. TAYLOR

A. My name is James H. Taylor. I am Manager of Licensing in the Nuclear Power Generation Division of Babcock & Wilcox, and as such I am authorized to execute this Affidavit.

B. I am familiar with the criteria applied by Babcock & Wilcox to determine whether certain information of Babcock & Wilcox is proprietary and I am familiar with the procedures established within Babcock & Wilcox, particularly the Nuclear Power Generation Division (NPGD), to ensure the proper application of these criteria.

C. In determining whether a Babcock & Wilcox document is to be classified as proprietary information, an initial determination is made by the unit manager who is responsible for originating the document as to whether it falls within the criteria set forth in Paragraph D hereof. If the information falls within any one of these criteria, it is classified as proprietary by the originating unit manager. This initial determination is reviewed by the cognizant section manager. If the document is designated as proprietary, it is reviewed again by Licensing personnel and other management within NPGD as designated by the Manager of Licensing to assure that the regulatory requirements of 10 CFR Section 2.790 are met.

D. The following information is provided to demonstrate that the provisions of 10 CFR Section 2.790 of the Commission's regulations have been considered:

(i) The information has been held in confidence by the Babcock & Wilcox Company. Copies of the document are clearly identified as proprietary. In addition, whenever Babcock & Wilcox transmits the information to a customer, customer's agent, potential customer or regulatory agency, the transmittal requests the recipient to hold the information as proprietary. Also, in order to strictly

AFFIDAVIT OF JAMES H. TAYLOR (Cont'd)

limit any potential or actual customer's use of proprietary information, the following provision is included in all proposals submitted by Babcock & Wilcox, and an applicable version of the proprietary provision is included in all of Babcock & Wilcox's contracts:

> "Purchaser may retain Company's Proposal for use in connection with any contract resulting therefrom, and, for that purpose, make such copies thereof as may be necessary. Any proprietary information concerning Company's or its Suppliers' products or manufacturing processes which is so designated by Company or its Suppliers and disclosed to Purchaser incident to the performance of such contract shall remain the property of Company or its Suppliers and is disclosed in confidence, and Purchaser shall not publish or otherwise disclose it to others without the written approval of Company, and no rights, implied or otherwise, are granted to produce or have produced any products or to practice or cause to be practiced any manufacturing processes covered thereby.
>
> Notwithstanding the above, Purchaser may provide the NRC or any other regulatory agency with any such proprietary information as the NRC or such other agency may require; provided, however, that Purchaser shall first give Company written notice of such proposed disclosure and Company shall have the right to amend such proprietary information so as to make it non-proprietary. In the event that Company cannot amend such proprietary information, Purchaser shall, prior to disclosing such information, use its best efforts to obtain a commitment from NRC or such other agency to have such information withheld from public inspection. Company shall be given the right to participate in pursuit of such confidential treatment."

(ii) The following criteria are customarily applied by Babcock & Wilcox in a rational decision process to determine whether the information should be classified as proprietary. Information may be classified as proprietary if one or more of the following criteria are met.

a. Information reveals cost or price information, commercial strategies, production capabilities, or budget levels of Babcock & Wilcox, its customers or suppliers.
b. The information reveals data or material concerning Babcock & Wilcox or customer funded research or development plans or programs of present or potential competitive advantage to Babcock & Wilcox.
c. The use of the information by a competitor would decrease his expenditures, in time or resources, in designing, producing or marketing a similar product.
d. The information consists of test data or other similar data concerning a process, method or component, the application or which results in a competitive advantage to Babcock & Wilcox.
e. The information reveals special aspects of a process, method, component or the like, the exclusive use of which results in a competitive advantage to Babcock & Wilcox.
f. The information contains ideas for which patent protection may be sought.

The document(s) listed on Exhibit "A", which is attached hereto and made a part hereof, has been evaluated in accordance with normal Babcock & Wilcox procedures with respect to classification and has been found to contain information which falls within one or more of the criteria enumerated above. Exhibit "B", which is attached hereto and made a part hereof, specifically identifies the criteria applicable to the document(s) listed in Exhibit "A".

(iii) The document(s) listed in Exhibit "A", which has been made available to the United States Nuclear Regulatory Commission was made available in confidence with a request that the document(s) and the information contained therein be withheld from public disclosure.

(iv) The information is not available in the open literature and to the best of our knowledge is not known by Combustion Engineering, EXXON, General Electric, Westinghouse or other current or potential domestic or foreign competitors of B&W.

(v) Specific information with regard to whether public disclosure of the information is likely to cause harm to the competitive position of Babcock & Wilcox, taking into account the value of the informatin to Babcock & Wilcox; the amount of effort or money expended by Babcock & Wilcox developing the information; and the ease or difficulty with which the information could be properly duplicated by others is given in Exhibit "B".

E. I have personally reviewed the document(s) listed on Exhibit "A" and have found that it is considered proprietary by Babcock & Wilcox because it contains information which falls within one or more of the criteria enumerated in Paragraph D, and it is information which is customarily held in confidence and protected as proprietary information by Babcock & Wilcox. This report comprises information utilized by Babcock & Wilcox in its business which afford Babcock & Wilcox an opportunity to obtain a competitive advantage over those who may wish to know or use the information contained in the document(s).

JAMES H. TAYLOR

Babcock&Wilcox

State of Virginia)
) SS. Lynchburg
City of Lynchburg)

James H. Taylor, being duly sworn, on his oath deposes and says that he is the person who subscribed his name to the foregoing statement, and that the matters and facts set forth in the statement are true.

James H. Taylor

Subscribed and sworn before me this 9 day of June 1978.

Eleanor M. Tankersley
Notary Public in and for the City of Lynchburg, State of Virginia

My Commission Expires June 25, 1980

# EXHIBIT B

Proprietary Nature of Material in Exhibit A

| Item | Question No. | Description of Material | Applicable Criteria |
|---|---|---|---|
| I | 231.10 | Expressions used to describe swelling, conductivity, thermal expansion, and gas release of absorber materials | c,d |
| II | 231.13 | Calculated values of clad strain for control components | c,e |
| III | 231.16 | Fuel rod stress evaluation | c,e |
| IV | 231.14, Tables 2&3 | Results of post-irradiation examination of Oconee-1 fuel assemblies | b,c,d |
| V | 231.22 | Dimensions and constants of the fuel rod springs | e |

Specific information with regard to potential harm to B&W by disclosure of this material includes the following developmental costs incurred on each of the above items.

| Item | Costs(dollars) |
|---|---|
| I | >90,000 |
| II | >50,000 |
| III | >60,000 |
| IV | >2,000,000 |
| V | >60,000 |

QUESTION:

231.10 (4.2.1.6) Please list the numerical values and equations, along with their reference sources, for the pertinent thermal-physical properties used in the design of the Ag-In-Cd and $Al_2O_3$-$B_4C$ absorber materials. A minimum list of pertinent properties should include melting point, swelling, thermal conductivity, thermal expansion and gas release. Also list the calculated expected values for end-of-life swelling and gas release and compare these to the maximum allowable design values under normal and off-normal conditions; i.e., Conditions I through IV.

RESPONSE: (Proprietary Information)

I. The following are the properties for $Al_2O_3$-$B_4C$ as functions of temperature burnup, and density where applicable.

<u>Melting Point</u>: The melting point used is the lower melting point of the mixtures' components. Since the constituents are not chemically combined, the lower melting point gives conservative estimates in the analysis. Thus, the melting point used is 3700°F (melting point of $Al_2O_3$), ---

Source: R. P. Elliott, <u>Constitution of Binary Alloys</u>, First Supplement, 1965.

<u>Swelling</u>: The swelling of $Al_2O_3$-$B_4C$ results from fast neutron irradiation damage of the alumina and thermal neutron irradiation absorption by the $B_4C$. To yield a conservative design, the swelling of both types of materials was added to gain a total pellet swelling. Thus, the interactions between the $B_4C$ particles and the alumina were not considered in the model. The swelling curve used may be described by:

$$\Delta V/V(\%) = 1.2 \times 10^{-21} \times (nvt) \text{ for } {}^{10}B \text{ burnup} < 80\%$$

and

$$\Delta V/V(\%) = 8 + 1.2 \times 10^{-21} \times (nvt) \text{ for } {}^{10}B \text{ burnup} \geq 80\%$$

Sources:

1. R. J. Burian, E. O. Fromm, and J. E. Gates, "Effect of High Boron Burnups on $B_4C$ and $ZrB_2$ Dispersions in $Al_2O_3$ and Zircaloy-2", BMI 1627 (1963).
2. W. A. Ranken, T. G. Frank, G. W. Keilholtz, "Effect of Fast Neutron Irradiation on Alumina and Yttria", LA-DC-72-535 (1971).

<u>Thermal Conductivity</u>: Since the thermal conductivity of the alumina is about 40% lower than the conductivity of $B_4C$, the addition of the small amounts $B_4C$ should, if it has any effect, slightly increase the conductivity. To be conservative, the values for alumina were used for the alumina-boron carbide pellets. This curve is corrected as a function of pellet density. The expressions are:

$k = [(D-20)/80]\, k_{100\%}$ where D is the percent theoretical density and $k_{100\%} = 6.050 \times 10^{1} - 2.225 \times 10^{-1}T + 3.639 \times 10^{-4}T^2 - 2.715 \times 10^{-7}T^3 + 7.587 \times 10^{-11}T^4$

where $k_{100\%}$ = BTU/hr. ft$^2$ °F/ft and T = °F.

Source: J. F. Lynch, C. R. Ruderer and W. H. Duckworth (Ed.) "Engineering Properties of Selected Ceramic Materials", American Ceramic Society, Columbus, Ohio, 43218, (1966).

Thermal Expansion: The thermal expansion rates of the two constituents were compared. Since the alumina has a higher rate of expansion and comprises the majority of the material, its rate was chosen for the alumina-boron carbide pellets and is conservative. The coefficient of therma expansion for alumina is $\alpha = 4.4 \times 10^{-6}$ in/in$^{o}$F.

Source: J. F. Lynch, C. G. Ruderer, and W. H. Duckworth (Ed.), "Engineering Properties of Selected Ceramic Materials", American Ceramic Society, Columbus, Ohio, 43218, (1966).

Gas Release: Calculations using data from the cited reference indicate a maximum release of 95% and a minimum release of 20%.

Source: R. J. Barian, E. O. Fromm, J. E. Gates, "Effect of High Boron Burnups on $B_4C$ and $ZrB_2$ Dispersions in $Al_2O_3$ and Zircaloy-2", BMI-1627, (1963).

II. The following are the properties for Ag-In-Cd as functions of temperature and burnup:

Melting point: 1427$^{o}$F

Source: C. R. Tipton, Jr., ed., Reactor Handbook, second edition, Vol. 1, USAEC, 1960.

Swelling: The swelling of Ag-In-Cd results from irradiation damage (void formation, etc.) and by transmutation of the constituent elements. A linear fit of available data was made resulting in the equation:

$$\Delta V/V(\%) = 7.11 \times 10^{-22} \times (nvt) \qquad (nvt) = \text{thermal fluence}$$

Source: Anderson, W. K. and Theilacker, J. S., "Neutron Absorber Materials for Reactor Control", USAEC, 1962.

Thermal Conductivity: A fit to available data was done to obtain the following model for thermal conductivity:

$$k = 30.46 + 3.048 \times 10^{-2}T - 1.266 \times 10^{-5}T^2 + 3.259 \times 10^{-9}T^3 - 5.715 \times 10^{-13}T^4 \quad \text{BTU/hrft}^{o}\text{F}$$

$$T = {}^{o}F$$

Source: Bettis Technical Review, Reactor Metallurgy, WAPD-BT-6.

Linear Coefficient of Thermal Expansion: $\alpha = 12.5 \times 10^{-6}/^{o}F$

Source: Anderson, W. K. and Theilacker, J. S., "Neutron Absorber Materials for Reactor Control", USAEC, 1962.

III. These properties are used to determine that melting does not occur and the end of life internal pressure and clad strain criteria are not exceeded. For all control components, analyses have been performed to show that pellet melting does not occur. Pellet swelling and gas release calculations have been performed to determine end of life pressures. For the control rod and axial power shaping rods these pressures are insignificant. For the burnable poison rod the end-of-life pressure is significant but remains below system pressure. Clad strain is discussed in Section 4.2.1.6.3.

QUESTION:

231.13 (4.2.1.6) Please demonstrate that the use of minimum unirradiated strength values for the control rod and burnable poison rod cladding alloys is conservative under all postulated reactor conditions; e.g. demonstrate that the increased strength due to irradiation is not affected by a decrease in ductility. Please discuss the bases for the 1% and 3% strain limits for 304SS and Zircaloy-4 cladding, respectively. Show how these limits are consistent with analytical and test results, as stated in FSAR section 4.2.1.6.3. Please list and briefly describe the control component examinations mentioned in FSAR section 4.2.1.6.4.

RESPONSE: (Proprietary information)

Cladding Stress-Strain Limits

These stress intensity limits are based on the minimum unirradiated material strength. These are conservative because strength of both materials increases with irradiation.

Cladding strain limits are applied to ensure that strain capability of the cladding is not exceeded by strain due to abosrber expansion. These strain limits take into account the loss of ductility of the material under irradiation. For 304 stainless steel cladding the strain limit is 1%. Research has shown that the ductility of this clad will remain greater than 1% total elongation throughout the lifetime specified for the control rods which is the limiting control component with 304 stainless steel clad. For Zircaloy-4 cladding the strain limit is 3%. The burnable poison rod, which is the only control component using this clad, is designed for one cycle only. It will receive much less irradiation than the control rods and thus will experience less ductility loss. The calculated strain values and safety margins for the control components are as follows:

Control Component Clad Strain

| Component | Allowable Strain | Calculated Strain | Margin |
|---|---|---|---|
| Control Rod | 1% | .99% | 1% |
| Axial Power Shaping Rod | 1% | 0 | ∞ |
| Burnable Poison Rod | 3% | 1.62% | 85% |

Control components have been visually examined following up to two cycles of operation in the reactors at the Duke Power Oconee Station. B&W destructive examinations on one burnable poison rod assembly (end-of-cycle 1) and one axial power shaping rod (end-of-cycle 3) are in progress. The axial power shaping rod contains Ag-In-Cd and therefore, will yield information which is applicable to the control rod. The test results will be used to evaluate the analytical results.

QUESTION:

231.16 (4.2.3.1) Please provide numerical values for fuel rod stresses caused by (a) pressure differential (b) ovality bending, (3) thermal, and (d) grid loads for the worst case Condition I through IV events. Provide numerical evidence to support the assertion that differential fuel rod growth and flow-induced vibration stresses do not affect these worst case stresses.

RESPONSE: (PROPRIETARY INFORMATION)

Internal Fuel Pin Pressure

a. Pressure Evaluation

Maximum internal fuel rod pressures are calculated as a function of burnup using the TACO computer code. TACO is an internal pressure and temperature distribution code and is discussed in Subsection 4.2.1.3. The internal pressure calculated for the hot fuel rod is shown in Figure 4.2-7. The hot rod power history (i.e., radial peaking factors versus burnup) is shown in Figure 4.2-8 and was determined by enveloping the maximum radial power factors obtained from fuel cycle physics calculations at various burnups. Thus, the radial power factor applied throughout the burnup was that of the hot rod although no single rod will experience the maximum radial peak during its entire core life. The calculations are based on design power which is necessary to obtain realistic values of burnup and other burnup related parameters; e.g., irradiation growth, fission gas release, and cladding creep. Fuel rod dimensions, pellet densities, and the axial peaking factors input to the code are given in Table 4.2-6. Conservatism in the thermal-physical data, determination of power peaking factors, and other input parameters associated with these pressure calculations are discussed in Subsection 4.2.1.3.1.

b. Stress Evaluation

The fuel rod cladding is subjected to external and internal pressure, thermal gradients, grid loads, ovality induced loads, vibration, and differential fuel rod growth. The fuel rod cladding stress analysis is based on several conservative assumptions that increase the actual margins of safety over the calculated margins. Section III of the ASME Boiler and Pressure Vessel Code is used as a guide in classifying the stresses into various categories, assigning appropriate limits to these categories and combining the stresses to determine the stress intensity. Present design criteria require that the internal pressure does not exceed system pressure during normal operation. This ensures that cladding stresses due to the pressure differential are always compressive during normal operation. The following stresses were addressed in the analysis:

1. Pressure differential stresses
2. Ovality bending stresses

3. Thermal stresses

4. Grid load stresses

The resulting stresses for conditions I, II, and III are summarized as follows:

The worst case is found to be in the clad inner surface

| Stress at Clad ID | Radial $\sigma_r$ | Hoop $\sigma_\theta$ | Axial $\sigma_z$ | Shear $\tau$ |
|---|---|---|---|---|
| pressure | -450psi | -21,758psi | -11,104psi | |
| ovality | | - 2,181psi | | |
| thermal | | - 4,213psi | - 4,213psi | |
| grid load | | - 3,786psi | - 5,488psi | 1592psi |

Stress intensity $S = \sigma_1 - \sigma_3$ where $\sigma_1 > \sigma_2 > \sigma_3$* without shear stress

Stress intensity $S = \sqrt{(\sigma_1 - \sigma_3)^2 + 4\tau^2}$ with a shear stress

The resulting stress intensities for the various stress categories are:

primary membrane (averaged through wall)

$S = 19{,}008$ psi

primary plus bending

$S = 23{,}489$ psi

primary plus secondary

$S = 31{,}648$ psi

Differential fuel rod growth ($\sigma_z$ = 7,887 psi) and flow induced vibration ($\sigma_z$ = 145 psi) stresses were analyzed and found not to effect the worst case stresses because the summation of the axial stress ($\sigma_z$) is the middle stress ($\sigma_2$) of the three principle stresses and will not be counted in calculating stress intensity. In addition, the flow induced vibration stress is of small magnitude and is of no significance.

Internal and external pressures, thermal gradients, and grid loads were determined and analyzed simultaneously. Conservative cladding dimensions were used. The worst case conditions for this analysis were found to occur at beginning-of-life (BOL). Long-term creep ovality stresses are addressed in the creep collapse analysis.

The primary membrane stress was found to be less than two-thirds of the minimum specified unirradiated yield strength and all stresses were less then the minimum specified unirradiated yield strength. In all cases the margin is in excess of 30%.

* $\sigma_1, \sigma_2, \sigma_3$ represent orthogonal stresses which are not necessarily principle stresses

TABLE 2

OCONEE-1 NON-DESTRUCTIVE PIE PROGRAM
SUMMARY OF RESULTS THROUGH TWO CYCLES

- Average fuel rod growth 0.3%
- Average assembly growth 0.2%
- Holddown spring preload within as-built tolerance range
- Rod bow less than 15% closure in 95% of the cases
- Average rod creepdown approximately 3 mils
- Average assembly bow 0.2 inch

TABLE 3

SUMMARY OF DESTRUCTIVE TEST PHASE RESULTS
OCONEE-1, END-OF-CYCLE 1

- No evidence of defects or significant fretting
- Average rod creepdown approximately 2 mils
- Fuel densification as predicted by model
- Internal pressure decreased 15%
- Fission gas release less than 1%
- Cladding tensile strength at 125% of unirradiated value
- Cladding total elongation at 80% of unirradiated value

QUESTION:

231.22 (4.2) Please provide the dimensions and spring constants for the upper and lower plenum springs and show quantitatively that the resistance to creep and relaxation of the spring alloy is sufficient to withstand the worst postulated flux, temperature, and stress conditions.

RESPONSE: (Proprietary Information)
The dimensions of the upper and lower fuel rod springs are summarized below:

Upper spring - Material = SS302
Wire Dia d = .062 in.
Outside dia OD = .360 in.
Number of active coil N = 27

Lower spring - Material = A - 286
Wire dia = .075 in.
Outside dia OD = .360 in.
Number of active coil N = 17

The spring constants were calculated by using the following equation:

$$K = \frac{Gd^4}{8D^3n}$$

where G: shear modulus
d: wire dia
D = OD - d
n: number of active coil

The calculated nominal spring constants are:

| | |
|---|---|
| Upper spring | 26.63 lb/in |
| Lower spring | 103.52 lb/in |

An elastic-plastic analysis of the fuel rod springs was performed. This analysis accounted for temperature, fluence, fuel column weight, and irradiation growth. Permanent set in the springs was determined for the 36 month design life accounting for plastic set, irradiation relaxation and thermal creep. The results were a permanent set of the upper spring of $\sim$ 0.9 in. and of the lower spring of 0.1 in. Since the upper spring does not support the fuel column, its set is acceptable. The set of the lower spring was determined not to cause a significant displacement of the fuel stack. Post-Irradiation Examination after one cycle of fuel rods containing lower springs showed little or no settling of the bottom of the fuel column. This supports the analytical results.