BY THE U.S. GENERAL ACCOUNTING OFFICE

## Report To The Subcommittee On Energy Research And Production Committee On Science And Technology House Of Representatives

# Analysis Of Alternative Approaches To Completing The Department Of Energy's Water-Cooled Breeder Program

GAO evaluated alternative approaches to completing the Department of Energy's water-cooled breeder reactor program, examined the reasonableness of staffing levels involved in defueling the water-cooled breeder facility, and obtained information on the extent of industry interest in the program's results.

GAO's evaluation disclosed that

--the Department's planned approach is a cost-effective way of completing the program when compared to other alternatives,

--personnel levels for defueling the Shippingport Atomic Power Station appear reasonable, and

--13 of 14 nuclear industry groups and utilities contacted by GAO expressed interest in obtaining the results of the fuel evaluation phase of the program.

The Department of Energy concurred with the findings of GAO's evaluation.



GAO/RCED-83-87

MARCH 25, 1983

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WASHINGTON, D.C. 20548

RESOURCES, COMMUNITY,
AND ECONOMIC DEVELOPMENT
DIVISION

B-210672

The Honorable Marilyn L. Bouquard
Chairman, Subcommittee on Energy
Research and Production
Committee on Science and Technology
House of Representatives

Dear Madam Chairman:

Your letter dated June 1, 1982, and your office during subsequent meetings raised a number of questions about the Department of Energy's (DOE's) water-cooled breeder program. Taken together, these questions concerned the advisability of continuing this program through to its planned conclusion. Specifically, your office wanted an evaluation of delaying, reducing, or discontinuing the fuel evaluation phase of the water-cooled breeder program--the so-called "end-of-life effort." In addition, your office wanted an examination of the reasonableness of staffing levels planned for the removal of nuclear fuel from the Shippingport Atomic Power Station (near Pittsburgh, Pennsylvania) plus an evaluation of the extent of industry interest in the fuel evaluation results.

On March 25, 1981, we issued a report on the water-cooled breeder program.[1] That report recommended that the Secretary of Energy discontinue operating the water-cooled breeder in January 1982 and begin conducting the end-of-life effort. DOE was planning to continue operation of the water-cooled breeder until early 1985. As we stated in our report, DOE and the nuclear industry can use the information on the attributes of the water-cooled breeder to compare this concept with other advanced nuclear technologies. This comparison would permit more judicious decisions given (1) the limited availability of Federal funds for competing energy research and development

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[1]"The Department of Energy's Water-Cooled Breeder Program--Should It Continue?" EMD-81-46, Mar. 25, 1981.

projects and (2) the limited private funds of U.S. utilities for developing commercial technologies. On October 1, 1982, the Shippingport Station discontinued power production and the end-of-life effort began.

In answer to your questions we found that:

--DOE's planned end-of-life effort is a cost-effective way of completing the water-cooled breeder program when compared to other alternatives. The other alternatives would either increase the cost of completing this program or fail to provide all of the information needed to prove that breeding actually occurred.

--Personnel levels for defueling the Shippingport Atomic Power Station do not appear out-of-line when compared to the staff levels involved in similar activities at commercial nuclear powerplants.

--Representatives from 13 of the 14 nuclear industry groups and utilities contacted by us showed an interest in the results of the core evaluation and believed that the effort should continue.

The following sections provide the details of our review. The objectives, scope, and methodology used to address your questions are shown in appendix I. Our review was performed in accordance with generally accepted government audit standards.

## DOE'S WATER-COOLED BREEDER PROGRAM

In the early 1960s, the former Atomic Energy Commission[2] worked on a concept to develop a modified water-cooled nuclear reactor that would breed additional fuel as it operated. This concept looked promising because it could (1) "build on" established water-cooled reactor technology and (2) offer the potential of using fuel more efficiently. Early research work led to the establishment in December 1965 of the light water breeder reactor project--now called the water-cooled breeder program.

The objective of the water-cooled breeder program is to develop the technology to breed fuel in a water-cooled reactor in order to use nuclear fuel more efficiently. Since water-cooled reactor technology had already been demonstrated by

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[2]The Energy Reorganization Act of 1974 (Public Law 93-438) abolished the Atomic Energy Commission and transferred responsibility for certain development functions to the Energy Research and Development Administration. Effective October 1, 1977, these functions were transferred to the Department of Energy.

operation of the Shippingport Atomic Power Station, the principal requirement was the development of the breeder core itself. Under the direction of DOE's Division of Naval Reactors, the Bettis Atomic Power Laboratory--a Government-owned facility operated by the Westinghouse Electric Corporation under contract to DOE--has had the principal role in the water-cooled breeder program. Bettis Laboratory did most of the design and development work and manufactured the water-cooled breeder core.

In 1977, the water-cooled breeder core was placed in the Shippingport Atomic Power Station and operation began. Electric power production using the breeder core was halted October 1, 1982. This core operated the equivalent of 29,000 hours at full power and produced over 2 billion kilowatts of electricity for the Duquesne Light Company. With the cessation of power production, the final phase of the water-cooled breeder program--the so-called end-of-life effort--began. Since December 1965 through the end of fiscal year 1982, $581 million has been expended on the water-cooled breeder program.

## DOE'S CURRENT PLANS FOR THE END-OF-LIFE EFFORT

The end-of-life effort includes three phases--limited partial operation of the Shippingport Atomic Power Station, defueling, and, finally, core evaluation. The effort is integrated in that discrete aspects occur concurrently; i.e., core evaluation begins before defueling is complete. DOE believes that this approach provides the safest, most efficient, and economical means of achieving the overall program goals. Core evaluation is the technical payoff on the entire research and development effort. It is this phase which will (1) prove or disprove whether breeding actually occurred and (2) determine the effects of extended operations on the breeder core materials. These goals are expected to be reached in September 1987 when all the documentation on the core evaluation phase is completed. The total projected cost for the entire end-of-life effort (fiscal years 1983-87) as currently planned is about $157.4 million as shown below.

| Phase | Cost (millions) |
|---|---|
| Shippingport Operations | $ 22.0 |
| Defueling | 62.5 |
| Core Evaluation (note a) | 72.9 |
| Total | $157.4 |

a/Includes $10.9 million for testing by the Argonne National Laboratory.

Several Shippingport systems must stay operational to maintain an environment for an orderly and safe defueling of the breeder core. Examples include plant filtration and radiation monitoring. In addition, security measures must be maintained.

The defueling phase has three stages. The first is the removal of the fuel from the reactor vessel, whereupon it is to be shipped in casks to DOE's Expended Core Facility in Idaho Falls, Idaho. The first of the 39 fuel modules in the water-cooled breeder core is scheduled to be shipped from Shippingport in July 1983; the last in September 1984. Following this last shipment, decommissioning of the Shippingport Station is scheduled to start. The second stage of defueling is the receipt and storage of the fuel at the Expended Core Facility. This involves removing the fuel modules from the casks and placing them into a water pit constructed specifically for the water-cooled breeder program at the facility. All portions of core evaluation except one are to occur at the Expended Core Facility.

Concurrent with the second stage of defueling, the two basic segments of core evaluation--proof of breeding and core examination--are scheduled to commence. Proof of breeding consists of both nondestructive and destructive assays[3] of the reactor fuel to determine if breeding has, in fact, occurred. Five hundred of the 17,287 fuel rods from 14 different modules are to be nondestructively assayed at the Expended Core Facility using a new, unique piece of equipment developed to allow this. The purpose of this assay is to measure the final amount of fissile material[4] in the fuel. If more fissile material exists than was originally placed in the reactor, breeding has occurred. Sixteen of the 500 fuel rods nondestructively assayed will be destructively assayed at the Argonne National Laboratory. Destructive assay serves two purposes: (1) provides a cross-check as to the amount of fissile material in the rods, and (2) provides correction factors for the nondestructive assay gauge.

While proof of breeding is a major focus of the core evaluation phase, core examination is also important. This examination is to confirm the theoretical data on the structural and mechanical performance of core materials and the performance

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[3]Nondestructive assay is measuring the amount of fuel in a rod without destroying it. Destructive assay consists of cutting and crushing fuel rods and then chemically dissolving them for analysis.

[4]Fissile material is that which is capable of sustaining criticality while being "burned" in a nuclear reactor.

capabilities of the fuel used in the water-cooled breeder. This examination requires that various portions of fuel modules--springs, grid spacers, and fuel claddings for example--be removed from the modules and subjected to physical, chemical, and engineering testing.

As core evaluation progresses, the final stage of defueling commences. Basically, this involves removing the fuel from the Expended Core Facility and shipping it to DOE's Idaho Chemical Processing Plant for disposal. The first fuel is scheduled to be shipped from the Expended Core Facility in June 1985; the last shipment is expected to occur in September 1987.

## POSSIBLE ALTERNATIVE APPROACHES TO THE END-OF-LIFE EFFORT

In addition to DOE's planned conclusion of the water-cooled breeder program, we examined three alternative approaches suggested by your office. The alternative approaches include:

--Removing the reactor core from the Shippingport Station, storing it at the Expended Core Facility, but delaying an evaluation until some future date.

--Removing the reactor core, shipping it to the Expended Core Facility, and transferring only a small portion of the fuel rods to the Argonne National Laboratory for analysis. The bulk of the fuel would be transferred without evaluation from the Expended Core Facility to the Idaho Chemical Processing Plant for disposal.

--Removing the reactor core and transferring it directly to disposal, thereby eliminating all of the core evaluation.

Following is our evaluation of the pros and cons of these alternatives.

### Alternative 1--delay the core evaluation

One method of altering the end-of-life effort would be to postpone the core evaluation phase. Under this alternative, the Shippingport Station would be defueled as presently planned. The core would then be shipped to the Expended Core Facility but stored for some length of time. Total defueling could be completed by September 1984. Although DOE officials told us that the fuel could be stored without adversely affecting the ability to obtain valid results during future testing, the total cost of the end-of-life effort would be increased if core evaluation were delayed.

We obtained estimates of the effects of delaying core evaluation for 1, 5, and 10 years from officials at Bettis Laboratory. The estimates showed that the total cost of the end-of-life effort could possibly increase by approximately $9.4 million, $16.8 million, and $20.4 million, respectively. These increases would occur because:

--Personnel would be released for the length of any delay and rehired for the core evaluation phase. The contract between DOE and Westinghouse requires DOE to absorb all lay-off costs. In addition, the contractor is allowed to recover various administrative costs associated with the hiring of personnel to conduct DOE projects. The lay-off and rehire costs associated with any of the postponement periods was estimated by Bettis Laboratory officials to be $2 million.

--If personnel are reassigned from this project, they would eventually have to be retrained in the proper methods for safe and efficient fuel handling when core evaluation testing was resumed. If the delay is for 1 year, retraining is expected to take about 9 months once begun and cost about $5.4 million. If the delay were 5 or 10 years, the costs increase to $10.8 and $13.4 million, respectively.

--DOE must pay a continuing overhead charge to reserve special equipment for a portion of the core evaluation phase involving the destructive assay of 16 fuel rods by the Argonne National Laboratory. If the project is postponed, DOE must decide whether to pay only the fiscal year 1983 overhead expense or to continue to hold the special equipment for the entire period of the delay. DOE says that Argonne's overhead cost is approximately $2 million per year. In our analysis, we assumed DOE would pay only 1 year of overhead expense.

During the delay, storage of core evaluation equipment in the water pit at the Expended Core Facility could adversely affect the equipment's operability. Thus, this equipment may need to be refurbished once the delay is over. While Bettis Laboratory officials anticipate that a 1-year delay would not significantly affect the equipment, refurbishing would definitely be needed if the delay were to be for 5 or 10 years. This could cost about $2 million for a 5-year delay and $3 million for a 10-year delay.

We also obtained cost estimates for storing the water-cooled breeder core at the Expended Core Facility and continuing the evaluation effort with about half of the planned staffing.

This approach would delay completion of core evaluation until 1994 and increase its costs by about $28 million. According to Bettis Laboratory officials, this increase is due to two factors. First, reducing the Expended Core Facility staff would stretch the evaluation work by 7 years resulting in additional personnel costs of $25 million and, secondly, deferral of support work at Argonne National Laboratory would result in an increase of $3 million.

Alternative 2--limited testing

Under this alternative, the only portion of core evaluation conducted would be the destructive assay of 16 of the 17,287 fuel rods by the Argonne National Laboratory. The nondestructive evaluation of 500 rods at the Expended Core Facility would not take place. According to DOE, this would eliminate about $46 million of the $72.9 million currently budgeted for core evaluation. Bettis Laboratory officials told us that testing only at Argonne would not provide confirmation that breeding had occurred.

The water-cooled breeder is expected to increase the fissile fuel by only a very small amount (1.3 percent). Thus, there is very little room for error in measuring the fuel. This small margin makes accurate measurement of the final fissile inventory imperative in order to prove or disprove that breeding did, in fact, occur. The water-cooled breeder core contains over 17,000 rods of several different types. According to Bettis officials, obtaining an accurate fissile fuel measurement requires examining many rods of each type. Based on a statistically selected sample, DOE's plans provide for the nondestructive assay of 500 specific fuel rods. This is expected to be an adequate sample to permit a high level of confidence in the resultant measurement.

Alternative 3--elimination of core evaluation

If this alternative were selected, the water-cooled breeder core would be shipped to the Expended Core Facility for transfer to storage at the Idaho Chemical Processing Plant. None of the core evaluation tests would be performed. Since all aspects of core evaluation are eliminated under this alternative, it would save over $60 million compared to DOE's planned program. However, all information and data potentially available from the core evaluation tests would be lost. According to DOE officials, losing the knowledge to be gained from experimentally proving breeding through core examination testing sacrifices the technical value of operating the water-cooled breeder core for 5 years. They added that they believed core evaluation is a worthwhile effort since it represents only about 10 percent of

the total cost--about $666 million--of the water-cooled breeder program.

REASONABLENESS OF STAFFING LEVELS AT SHIPPINGPORT

One of the concerns expressed by your office involved the current staffing levels involved in defueling the Shippingport Station. Basically, you wanted to know if the current staffing levels were reasonable given the work required. We found that personnel levels at Shippingport do not seem out-of-line when compared with those involved in refueling commercial nuclear powerplants.

The defueling of the Shippingport Station is not easily compared to refueling an operating commercial reactor. Although Shippingport is small compared to most commercial powerplants, there are more steps to defueling Shippingport than there are in refueling a commercial reactor. Unlike commercial powerplants, Shippingport was not specifically designed and constructed to expedite refueling or defueling of the reactor. Rather, when Shippingport is defueled, the reactor containment dome must be removed and then the reactor vessel head--which is welded to the vessel body--is cut from the vessel. In commercial plants the reactor containment dome is sufficiently large to allow access to the vessel head without changing the containment structure. The vessel head is simply unbolted for refueling. In addition, Shippingport has six types of fuel modules compared to one in a commercial reactor, thus necessitating operation of a broader variety of equipment.

Coupled with the differences in design and fuel type is the purpose of the Shippingport defueling. In a commercial reactor, refueling is conducted to continue operation of the powerplant. Fuel removed from a commercial reactor is not removed from the reactor site but instead is placed in storage in an onsite reactor pit. The core must be completely removed from Shippingport, however, to allow decommissioning. Because of shipping container configuration, only a limited number of the 39 fuel modules can be shipped at one time. Therefore, Shippingport defueling requires the use of various sequential operations to remove the breeder core from the reactor vessel and place it in shipping containers. Further, the modules must be carefully handled so that the validity of core evaluation results will not be adversely affected.

DOE estimates the defueling effort at Shippingport will require about 120 people. Included are fuel handlers, technicians, nuclear engineers, and supervisors. Additional personnel are required to maintain the plant, operate plant systems, and support the Shippingport defueling effort. Based on information

from four utilities on the number of personnel they used for refueling, we noted that the number of personnel involved in refueling varied from 46 to 220. The large difference exists due to the utilities' interpretation of refueling as simply fuel exchange (46) or inclusion of additional testing during refueling (220).

## INDUSTRY INTEREST IN CORE EVALUATION INFORMATION

Your office asked us about the usefulness of the information that would come from core evaluation. To respond, we contacted several utilities with nuclear powerplants and groups interested in nuclear energy. (See app. I.) We asked these groups (1) if they were familiar with the technical information already developed on the water-cooled breeder program and (2) whether the core evaluation effort should be completed. Of the 14 respondents, 13 expressed interest in the program's results and felt that the core evaluation effort should be completed. Of these, seven--three utilities and four industry groups--stated that they had used or received technical memoranda on the water-cooled breeder. One utility official believed that the more critical issues for study are the reprocessing of spent fuel and waste disposal.

While none of the respondents stated that they would be interested in commercializing the water-cooled breeder concept at this time, the general consensus was that they wanted the program completed in order to know if the water-cooled breeder concept works. Many concurred with the opinion of one utility representative who stated that while the timing of this research and development program is not immediately critical, the issue is whether the technology can be understood and can be applied later, should the Nation need it.

In addition to proving breeding, several respondents provided other comments on the usefulness of completing the core evaluation. The manager of Battelle's corrosion section told us he was interested in the material used in the water-cooled breeder's grid spacers. At this time, the applicable program technical reports only theorize on the response characteristics of this material in the reactor environment and core evaluation can determine what really happened. Therefore, he believes the completion of the core evaluation is important. The Electric Power Research Institute's evaluation of core performance group is using a computer program developed by the water-cooled breeder program to predict reactor core performance. We were told that this computer program is very advanced and is being used by the Institute to validate computer programs they use to predict commercial powerplant performance. The final accuracy of this computer program can only be verified by examining the water-cooled breeder core.

## AGENCY COMMENTS AND OUR EVALUATION

DOE concurred with our findings but suggested that some changes be made in our report. (See app. II.) Overall, DOE wanted us to stress that limited core evaluation--alternative 2 discussed on page 7--is not a worthwhile alternative. In addition, DOE recommended that we more strongly emphasize the need for determining both the degree of breeding and the fuel and structural material integrity of the Shippingport breeder core. After evaluating DOE's comments in light of the material we had presented in our draft report, we determined that any changes along the lines suggested by DOE were not warranted. Specifically, we believe the report's discussion of the alternatives is appropriately balanced and there was no significant additional information provided in DOE's comments to warrant changing our discussion of the need to determine the degree of breeding and fuel and structural material integrity.

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As arranged with your office, we are sending copies of this report to the House and Senate Committees having oversight and appropriations responsibilities for DOE; the Director, Office of Management and Budget; and the Secretary of Energy. Copies will also be available to other interested parties who request them.

Sincerely yours,

J. Dexter Peach
Director

APPENDIX I

## OBJECTIVES, SCOPE, AND METHODOLOGY

Our first and primary objective was to evaluate DOE's water-cooled breeder reactor end-of-life effort as presently planned as well as three alternative approaches. The alternative approaches we considered were (1) delaying the program at varying points of completion for various time periods, (2) conducting only certain portions of the program, and (3) discontinuing the program. We examined the feasibility, costs, and consequences associated with these alternative approaches. Our second objective was to examine the appropriateness of staffing levels for the defueling phase of the presently planned end-of-life effort.

In order to evaluate DOE's current program, alternative approaches, and staffing levels, we contacted

--senior level officials in DOE's Division of Naval Reactors;

--various officials at the Bettis Atomic Power Laboratory in Pittsburgh, Pennsylvania, who operate the water-cooled breeder program for the Division of Naval Reactors;

--the Vice President for nuclear operations at the Duquesne Light Company in Pittsburgh; Duquense has operated the Shippingport Atomic Power Station since 1957 to generate electric power;

--the Acting Director of DOE's Remedial Action program who is responsible for eventual decommissioning of the Shippingport Atomic Power Station; and

--senior level officials in the Nuclear Regulatory Commission.

Our final objective was to contact several utilities who operate nuclear powerplants as well as other industry groups to obtain their views on the value of the water-cooled breeder program's end-of-life effort. Because of time constraints we contacted those organizations whom we knew to be knowledgeable of the water-cooled breeder program. The views of these organizations may not reflect the views of the entire nuclear industry. The utilities contacted were:

--Carolina Power and Light Co., Raleigh, North Carolina;

--Commonwealth Edison Co., Chicago, Illinois;

--Duke Power Co., Charlotte, North Carolina;

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--Florida Power Corporation, St. Petersburg, Florida;

--General Public Utilities, Parsippany, New Jersey;

--Philadelphia Electric Co., Philadelphia, Pennsylvania;

--Virginia Electric and Power Co., Richmond, Virginia; and

--Wisconsin Electric Power Co., Milwaukee, Wisconsin.

Other groups we contacted included:

--Atomic Industrial Forum, Washington, D.C.;

--Battelle-Columbus Laboratories, Columbus, Ohio;

--Brookhaven National Laboratory, Upton, New York;

--Electric Power Research Institute, Palo Alto, California;

--General Electric Company, San Jose, California; and

--Project Management Corporation, Oak Ridge, Tennessee.[5]

We also reviewed a number of reports, studies, and other documents relating to the water-cooled breeder program. Much of this information was obtained while preparing our March 1981 report on the water-cooled breeder program.

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[5]Project Management Corporation is a non-profit corporation which represents the interest of utilities in the Clinch River Breeder Reactor project.

APPENDIX II

Department of Energy
Washington, D.C. 20585

FEB 7 1983

Mr. J. Dexter Peach
Director, Resources, Community and
Economic Development Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Peach:

The Department of Energy (DOE) appreciates the opportunity to review and comment on the General Accounting Office (GAO) draft report entitled "The Core Evaluation Phase of DOE's Water-Cooled Breeder Program." DOE concurs with the findings contained in the GAO draft report.

DOE, however, does want to stress that Alternative 2 - limiting core evaluation to the destructive assay of 16 fuel rods at Argonne - is not a worthwhile alternative. The non-destructive assay of at least 500 fuel rods is necessary to obtain a valid indication of core breeding performance. The Argonne work is useful only for calibrating the gage to be used for assaying these 500 fuel rods. Alternative 2 would also eliminate all core examination work.

While the draft report does note the need for determining both the degree of breeding and the fuel and structural material integrity of the Shippingport light water breeder core, DOE recommends GAO revise the report to more strongly emphasize this need. Breeding determination and core examination are essential in establishing the potential usefulness of the Light Water Breeder Reactor concept.

Careful measurement of the degree of breeding is most important. Verification that the core actually bred, i.e., produced more fuel than it consumed with sufficient margin to allow for losses in reprocessing, will mean thorium can be used as a nuclear fuel with relatively little use of our limited supplies of uranium. If the core did not breed but only performed well as a converter, i.e., produced less fuel than it consumed, the amount of uranium needed to produce a given amount of energy over a period of years would be much greater, significantly reducing the advantage of the Light Water Breeder Reactor concept.

The purpose of the core examination is to verify, through measurement and analysis of core components, the performance of

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fuel and structural material. Verification of material performance will show the core operated as planned and will demonstrate the acceptability of the design concept. Confirmation of breeding and material performance will also mean the analytical methods used in designing the Light Water Breeder Reactor can be used in other applications.

Other comments are noted in the Enclosure to this letter.

Sincerely,

Martha O. Hesse
Assistant Secretary for
Management and Administration

Enclosure
Comments on GAO Draft Report

APPENDIX II

COMMENTS ON GAO DRAFT REPORT (GAO/RCED-83-87) ENTITLED "THE CORE EVALUATION PHASE OF DOE'S WATER COOLED BREEDER PROGRAM"

| Page | Line | Comments |
|---|---|---|
| 2 | 17 | Eliminate the phrase "with any degree of certainty " to clarify the sentence. |
| 4 | 17 | Change "water pit" to "facility". |
| 6 | 24 | Strike the term "rental fee" which could be misunderstood and substitute the term "continuing overhead charge." Remove the quotation marks from the word "reserve" as the meaning is clear in context. |
| 8 | last 5 | The discussion of the Shippingport core removal effort could be misconstrued and confuse the reader. DOE suggests replacing the three sentences with:<br><br>"DOE estimates the defueling effort at Shippingport will require about 120 people. Included are fuel handlers, technicians, nuclear engineers, and supervisors. Additional personnel are required to maintain the plant, operate plant systems, and support the Shippingport defueling effort."<br><br>A new paragraph should start with the sentence beginning on Line 27 with the word "Based". |

GAO note: Page references in DOE's comments have been changed to refer to the final report.

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