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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

In the Matter of UNITED STATES DEPARTMENT OF ENERGY PROJECT MANAGEMENT CORPORATION TENNESSEE VALLEY AUTHORITY (Clinch River Breeder Reactor Plant)	Docket No. 50-537

APPLICANTS' DIRECT TESTIMONY
CONCERNING NRDC CONTENTIONS 7a) and 7b)

Dated: November 1, 1982

DS03

Q.1. Please state your names and affiliations.

A.1. John R. Longenecker, Acting Director, Office of the Clinch River Breeder Reactor Plant (CRBRP) Project, Office of Breeder Reactor Programs, U.S. Department of Energy.

Carl A. Anderson, Jr., Project Manager, Large Plant Projects, Westinghouse Advanced Reactors Division.

Narinder N. Kaushal, Deputy Assistant Director for Engineering, Clinch River Breeder Reactor Plant Project.

Q.2. Have you prepared statements of your professional qualifications?

A.2. Yes. Copies are attached to this testimony.

Q.3. What subject matter does your testimony address?

A.3. This testimony addresses NRDC Contentions 7a) and b) which allege that adequate analyses of alternatives to the CRBRP have not been performed.[1] Specifically, NRDC contends that

> 7. Neither Applicants nor Staff have adequately analyzed the alternatives to the CRBRP for the following reasons:
>
> a) Neither Applicants nor Staff have adequately demonstrated that the CRBRP as now planned will achieve the objectives established for it in the LMFBR Program Impact Statement and Supplement.
>
> (1) It has not been established how the CRBR will achieve the objectives there listed in a timely fashion.
>
> (2) In order to do this it must be shown that the specific design of the CRBR, particularly core design and engineering safety features, is sufficiently similar to a practical commercial

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1 Contention 7 c) (Site Selection) is the subject of separate testimony.

size LMFBR that building and operating the CRBR will demonstrate anything relevant with respect to an economic, reliable and licensable LMFBR.

(3) The CRBR is not reasonably likely to demonstrate the reliability, maintainability, economic feasibility, technical performance, environmental acceptability or safety of a relevant commercial LMFBR central station electric plant.

b) No adequate analysis has been made by Applicants or Staff to determine whether the informational requirements of the LMFBR program or of a demonstration-scale facility might be substantially better satisfied by alternative design features such as are embodied in certain foreign breeder reactors.

Q.4. What will this testimony show in relation to NRDC Contentions 7a) and b)?

A.4. This testimony shows that:

1) the CRBRP will meet the objectives established for it in the LMFBR Program Final Environmental Impact Statement (FEIS) (Supplement to ERDA-1535) in a timely manner. (See Q/A 5-16)

2) completion of design, construction and operation of the CRBRP will provide a demonstration which will be relevant to the development of commercial LMFBR central station electric plants. (See Q/A 17-21)

3) the informational requirements of the LMFBR Program or of a demonstration-scale facility will not be substantially better satisfied by alternative design features such as are embodied in certain foreign breeder reactors. (See Q/A 22-31)

Q.5. What are the LMFBR Program objectives and timing for CRBRP?

A.5. The LMFBR Program objectives for CRBRP are set forth in the DOE Final Environmental Impact Statement (FEIS) on page 57 as follows:

- o to demonstrate the technical performance, reliability, maintainability, safety, environmental acceptability, and economic feasibility of an LMFBR central station electric power plant in a utility environment;
- o to confirm the value of this concept for conserving important nonrenewable natural resources.

In addition, the programmatic timing of the CRBRP has been established by the DOE FEIS and the record of decision as "as soon as possible."[2]

Q.6. How were the CRBRP objectives implemented in the design?

A.6. Rather than completing the plant design to the end and then subjecting it to a check to see if the Project objectives would be met, the Applicants have followed a systematic approach in which the basic objectives of the Project were made an integral part of the design at the outset. The design was then developed around these objectives and has been continually checked at each stage of the process to assure that they would be met.

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2 See 47 Fed. Reg. 33771 (August 4, 1982).

The Project objectives quoted above have been translated into four tiers of requirements for the design. The first tier consists of a set of design guidelines which define the characteristics and criteria for the Project which, if implemented, were judged to be necessary and sufficient to assure meeting the Project objectives.

Examples of design characteristics include three loops, power level (approximately 1000 MWt) and design lifetime (30 years). Examples of design criteria include high availability, low containment leakage (less than 0.1% per day) and low refueling time (less than 20 days per year).

The design guidelines then flow down to the second tier requirements in the Overall Plant Design Description (OPDD). The OPDD defines the characteristics and criteria for the plant as a whole. The OPDD includes, for example, general design criteria, codes and standards (e.g., ASME, IEEE), overall availability requirements, and maintenance requirements. The OPDD also identifies the 56 plant systems and defines the scope of each.

The OPDD requirements flow down to the third tier requirements for each of the 56 system design descriptions (SDD). For each plant system, the SDD defines the system performance requirements, including the interface requirements between systems. These interface requirements include, for a given system, all interface requirements imposed on it by other systems and the specific interface requirements imposed on other systems by the given system. The SDD also provides a description of each system and the components within that system. Finally, the SDD describes operation, maintenance, and test outlines for the particular system.

The requirements of the SDD flow down to the fourth tier to form requirements for Equipment Specifications (E Specs). The E Specs establish detailed component design requirements necessary to meet the system performance requirements set forth in the SDD.

These five descending tiers of requirements--from the Project objectives, to design guidelines, to overall plant design descriptions, to system design descriptions, and finally, to equipment specifications--assure that the Project objectives are an integral part of each level of the design.

Q.7. How have the Applicants assured that the objectives implemented for the CRBRP will be met?

A.7. The Applicants have established systems for in-process measurement and control over all elements of the Project to assure that the objectives and requirements implementing those objectives will be met. The Applicants have established a formal system of management policies and requirements, including three major elements which are pertinent here. These are design reviews, configuration management, and quality assurance.

Formal design reviews must be conducted for all systems and major subsystems of the plant. The design reviews are conducted by teams of independent reviewers which, for any given system or subsystem, include all disciplines necessary for review of the technical subject at hand. The design review teams evaluate a given system or subsystem against the requirements of the SDD and OPDD and, if any deficiencies are noted, recommend actions to assure that these requirements are met. Figure 1 is a typical checklist employed by these design teams, which illustrates the scope of a design review.

Figure 1

RECOMMENDED
DESIGN REVIEW CHECK-LIST

DATE ____________________

CONTRACTOR ____________________
DESIGN ENGINEER ____________________
TYPE OF REVIEW ____________________

SYSTEM/COMPONENT ____________________
PO COG ENGINEER ____________________

	YES	NO
1. Has the design been baselined? Date of baselined or expected ________________		
2. If not baselined, is design in conformity with:		
(a) CRBRP Plant Reference Design Report?		
(b) Demonstration Plant Guidelines?		
(c) System Design Description?		
3. Has the requirement of PSAR 1.1.3 concerning NRC Regulatory Guides been satisfied?		
4. Have all applicable RDT Standards been applied in accordance with Appendix B of the MPR?		
5. Have any new or supplemented standards been developed in accordance with RDT Standard F2-2?		
6. Does the design satisfy RDT Standard F2-2 for:		
(a) Design criteria?		
(b) Codes, standards and practices?		
(c) Engineering studies?		
(d) Parts, materials and processes?		
(e) Design descriptions?		
(f) Specifications, drawings and instructions?		
(g) Identifications?		
(h) Acceptance criteria?		
(i) Interface control?		
7. Does the design satisfy OPDD-10 requirements for:		
(a) Performance?		
(b) Safety?		
(c) Interfaces?		
(d) Limits of the individual system?		
(e) Overall plant layout?		
8. Has the contractor submitted Work Agreements and/or 189's as appropriate?		
9. Were they properly approved?		
10. Has the contractor prepared a SDD?		

Figure 1 (cont.)

	YES	NO
11. Does the SDD cover the following system requirements:		
(a) Overall?		
(b) Interface?		
(c) Safety?		
(d) Reliability?		
(e) Maintainability?		
(f) Operations?		
(g) Arrangement?		
(h) Design parameters?		
(i) Flow paths?		
12. Does the SDD provide definitive system related requirements for the generation of component specifications?		
13. Have specifications been developed for:		
(a) Configuration?		
(b) Arrangement?		
(c) Performance parameters?		
(d) Materials?		
(e) Processes?		
(f) Selection of parts?		
14. Does the SDD confirm that the design will meet all requirements?		
15. Are necessary inspection devices provided for in the SDD?		
16. Are the needs for maintenance and inspections adequately covered?		
17. In regards to safety, is the design for		
(a) Level 1?		
(b) Level 2?		
(c) Level 3?		
18. Does the design emphasize and enhance safety?		
19. Is the design adequately supported by studies, evaluations, analysis and/or calculations?		
20. Are the above documents available and have they been properly identified in the Engineers Data Book?		
21. Will the design provide reliability of operations as required by Section 10, MPR?		

Figure 1 (cont.)

	YES	NO
22. Will the design system/component be easily installed into the Plant of System?		
23. Do Design Layout Drawings indicate that E-Spec requirements will be met?		
24. Are all critical dimension identified?		
25. Is the approval procedure for any critical dimension properly defined?		
26. Have all interfaces been considered?		
27. Does the system/component require special sources of support, I.E. power, air or environment?		
28. Have these special sources of support been adequately defined?		
29. Has sufficient access been provided for necessary inservice inspection as required by the ASME Code Section XI, 3?		
30. Has the contractor developed procedures for forwarding design review reports as required by Section 3.1.7.1.2. of the MPR?		
31. Have trade-off studies or analyses been conducted for alternate designs?		
32. If so, were these studies justified and properly approved?		
33. Have adequate studies and analyses been conducted to justify fabricability?		
34. Is the cost properly justified? If not, amplify.		
35. Is the schedule realistic? If not, amplify.		
36. Are adequate technical data available to support any changes proposed by the contractor?		
37. Can the same performance be achieved by utilizing an existing or off-the-shelf design?		
38. Can a cheaper material be used without degrading plant safety?		

Figure 1 (cont.)

	YES	NO
39. Can the system/component be fabricated cheaper:		
(a) At the plant?		
(b) At the site?		
(c) Within the building housing system/component?		
40. Have plans been developed for any special transportation required?		
41. Has a plan been developed for spares?		
42. Has the RM/A-E, as appropriate, established Design Requirements Baselines for contractors through E-Specs and ICD's?		
43. Have any ICD's been released based on "limited" vice "precise" data?		
44. Is the design engineer conversant with RDT Standard F1-2 (PREPARATION OF SYSTEM DESIGN DESCRIPTIONS)?		
45. Is the design engineer conversant with RDT Standard F2-2 (QUALITY ASSURANCE PROGRAM REQUIREMENTS)?		
46. Are all principal design data under formal control?		
47. Does the contractor have an adequate procedure for working level control of the design?		

At a minimum, design reviews are conducted for each system or major subsystem at each of three principal stages of design: (a) conceptual, (b) preliminary, and (c) final. At the conceptual design stage (at approximately 30% design completion), a review is conducted at the system or subsystem level. At the preliminary design stage (at roughly 60% design completion), a design review is conducted at the system, subsystem and component level. At the final design stage (when the design is essentially complete), the design is reviewed at the system, subsystem and component level to assure that all SDD and OPDD requirements are met.

In addition to the three stages of design review discussed above, special design reviews are conducted on an as-needed basis for key systems and subsystems, key components, and for purposes of systems integration. In terms of key systems and subsystems, examples include the core restraint system review and the heterogeneous core review. In terms of key components, examples of reviews include those conducted for the reactor vessel and the main sodium pumps. In terms of system integration reviews, examples include the availability review of the entire nuclear steam supply system, and the maintainability review conducted for the head access area.

The second major element used for in-process measurement and control to assure that the Project objectives will be met is configuration management. As results are obtained from a design review, the Project proceeds to "baseline" the design of that specific system. The Project has implemented a formal configuration management plan whereby specific elements of given system design are baselined, i.e., formally approved and established as the reference plant design.

At the conceptual design stage, the system requirements in the SDDs are baselined. At the preminiary design stage, the system descriptions in the SDDs are baselined. At the final design stage, the outlines for operations, maintenance and tests are baselined.

After a given system is baselined, any changes to that design require formal review and approval of an engineering change proposal. All engineering change proposals are reviewed to insure that a particular change satisfies the higher tier requirements established for that system.

The third major element, the Quality Assurance Program, assures that throughout the process of design, construction and operation, procedures are adhered to and that documentation is both traceable and complete. In addition, the Quality Assurance Program includes inspection of equipment to assure that the requirements of Equipment Specifications and SDDs are met.

In summary, through design reviews, configuration management, and quality assurance, the tiers of requirements which implement the CRBRP objectives are subjected to in-process management and control to insure that the objectives implemented for the CRBRP will be met.

Q.8. How will the CRBRP achieve its objective of demonstrating technical performance?

A.8. The actual testing and operation of the plant will demonstrate the achievement of the technical performance objective. The technical performance objective encompasses the technical parameters established for the Project. CRBRP will be designed, constructed, and operated to achieve the plant's technical parameters. The major parameters of interest here are: plant thermal power production, steam conditions, and electrical power production. The specific design characteristics of the plant provide a high degree of assurance that each of these parameters will be met.

Thermal power production is a function of core heat generation, core flow, and heat transport from the core in the heat transport system. The thermal power production parameter for the CRBRP is 975 MWt.

There is reasonable assurance that the CRBRP core will perform as expected. A series of experiments have been conducted at the Zero Power Plutonium Reactor (ZPPR) in Idaho using a CRBRP core configuration mock-up. In these experiments various core-physics related parameters were measured and were compared against calculated values to test the ability to predict nuclear power production in the core. The agreement between the calculated and measured values provides confidence that the calculational techniques are vaild and that the CRBRP core power distribution will be properly calculated.

It is reasonable to expect that the heat transport from the core will meet the thermal power production design parameters for CRBRP. The basic flow characteristics through the core have been determined by scale-model hydraulic tests. The analytical tools for calculating basic heat transfer from the core are well established through experience with the Experimental Breeder Reactor-II (EBR II), the Fast Flux Test Facility (FFTF), and light water reactors (LWRs).

Similarly, the overall heat transport system can be expected to meet the design parameters for plant thermal power production based upon experience from EBR II and FFTF. The major HTS components are sodium pumps and Intermediate Heat Exchangers. A prototype of the main sodium pump is currently being tested and has been found to perform satisfactorily to date. The Intermediate Heat Exchanger (IHX) is similar to the one sucessfully used in FFTF and can be reasonably expected to perform acceptably in CRBRP. Thus, the core heat generation, coolant flow through the core, and heat transport from the core is reasonably likely to meet the design parameter for thermal power production.

The design parameters of importance to the CRBRP steam conditions are pressure, temperature, and flow. The conditions, and electrical power production, and thus, meet the overall objective of technical performance.

Q.9. How will the CRBRP meet its reliability objective?

A.9. The CRBRP is being designed to function as a baseload unit, for which it is generally accepted to mean that it will be available from 60-90% of the time. The CRBRP has been designed to reach the baseload reliability of about 75% within the 5-year demonstration period. Rather than designing the plant and evaluating availability after the fact, the Applicants have made reliability analyses an integral part of the design process from the outset. The plant has been specifically engineered using these reliability analysis techniques to assure that the availability goal will be met. These analyses made use of an existing data base for the availability performance of similar components and systems. The CRBRP systems were subdivided into subsystems, and the subsystems were in turn subdivided into components. The availability of each CRBRP component or subsystem was then assessed using the existing data base. The CRBRP reliability assessment showed that the plant would meet its reliability goal. In addition, however, the assessment identified specific elements of the design which could be improved so that the Project's ability to meet the goal would be enhanced. Two specific examples illustrate this point. First, as a result of this review, it was determined that providing

CRBRP design parameters for steam conditions are: (1) pressure 1450 psi; (2) temperature 900° F; and (3) flow 3.3 millions pounds per hour. The steam, feedwater and condensate systems for CRBRP are similar to those currently in use in LWR's and fossil power plants, and the CRBRP conditions of pressure, temperature and flow fall within the range of parameters experienced for LWRs and fossil-fueled plants. The design of the CRBRP steam generator module has been verified by model and feature tests in both water and sodium. A full size prototype is currently being tested to assure that the plant units will meet the design parameters for steam conditions. Based upon the results of testing to date and the experience available for LWRs and fossil fueled plants, it is likely that the CRBRP will meet the design parameter for steam conditions.

The CRBRP design parameter for electrical power production is 350 MW electric. Electrical power production for CRBRP will be achieved through the use of a turbine generator which is similar to those currently in use in LWRs or fossil fired plants. The turbine will operate at conditions of temperature, pressure, and flow which fall within the range of parameters experienced for LWRs and fossil plants and, thus, is reasonably likely to meet the design parameter for electrical power production.

In summary, it is likely that CRBRP will achieve its design parameters for thermal power production, steam redundant heaters on the equalization lines would increase the plant availability by 1.6%.

Secondly, inclusion of certain piping changes would allow maintenance operations for one Radioactive Argon Processing System (RAPS) compressor while the other is operating, thereby increasing the plant availability by 0.6%. Action has been taken to implement both of these design modifications for the CRBRP.

Thus, specific analyses conducted for CRBRP reliability, along with the actions taken to enhance reliability, provide reasonable assurance that the CRBRP is likely to meet it reliability objectives.

Q.10. How will the CRBRP achieve its objective of maintainability?

A.10. Maintainability encompasses the ability of the plant operator to perform preventive and corrective maintenance on the plant with minimal adverse impact on the amount of time the plant is available for generation of electricity. The actual goals to be achieved in maintainability are constrained by requiring maintenance in a time frame that supports the plant reliability goal. The Clinch River Breeder Reactor Plant design includes specific features and requirements to enhance maintainability. Maintainability reviews are required parts of the design and design review process. The OPDD, SDD and E Specs establish specific maintainability requirements for CRBRP systems and components in successively greater detail. These requirements include:

- o All in-sodium components must be designed to drain freely of sodium so that, upon removal, liquid sodium does not freeze inside the components and thus complicate maintenance operations.
- o Major components must be either removable or repairable in place.
- o Ample space must be provided around all major equipment to assure ease of access for maintenance. In order to assure that this requirement would be met, the Applicants developed a detailed scale-model of the Clinch River Breeder Reactor Plant (one-half inch to one foot). This scale-model has been applied as an engineering tool in review of all equipment arrangements to assure that no unforeseen interferences would occur which could impact maintainability. (See Figure 2.)

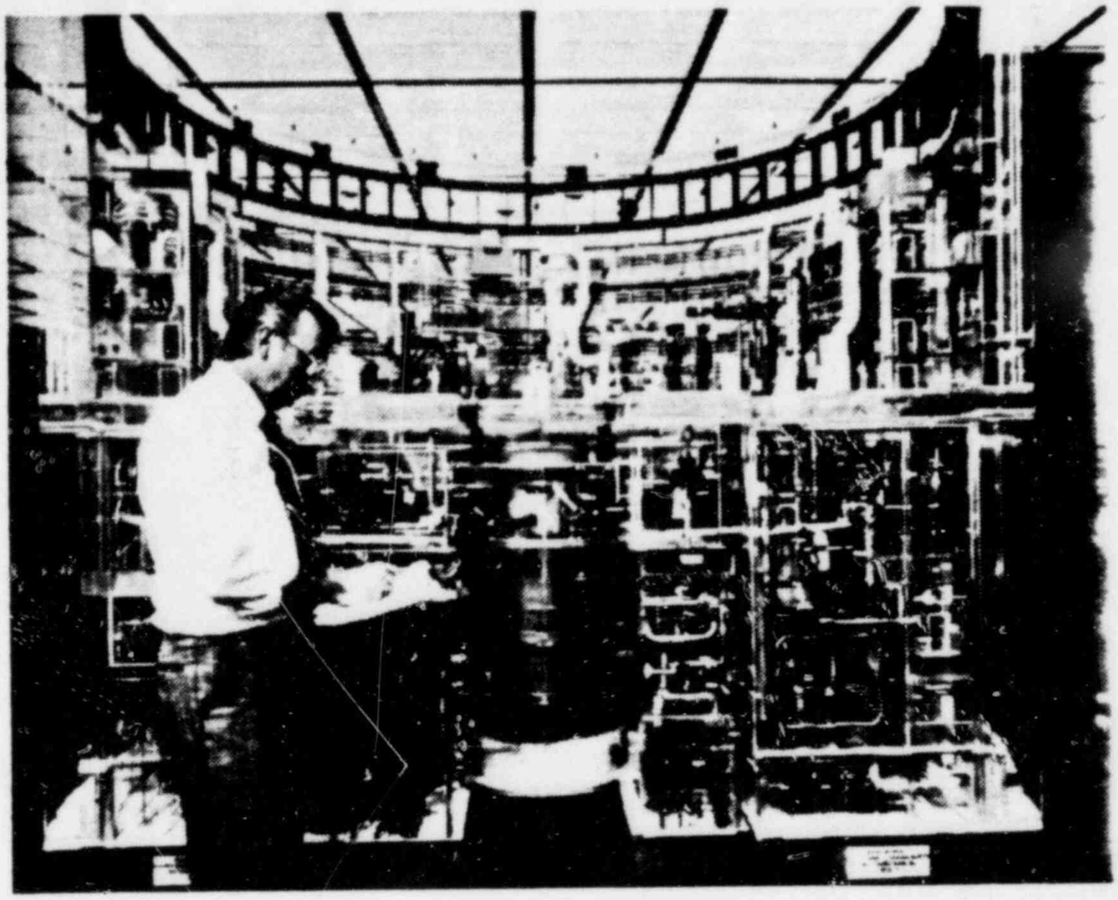

Figure 2

In specific areas of the design where maintenance operations are expected to be critical to meeting the availability objectives, detailed models were built to verify that maintenance operations could be performed satisfactorily. For example, the reactor head access area is a portion of the plant in which there is a relatively high density of equipment. In addition, during refueling operations, there are equipment movements (e.g., rotating plugs on the reactor closure head) in this area. These conditions required careful review to assure that maintenance operations can be satisfactorily accomplished. In order to ensure that this could be done, a full-scale mock-up of the reactor head access area was constructed and used by the reactor component and systems designers to ensure that necessary operations and maintenance activities could be accomplished in the reactor head access area. (See Figure 3.)

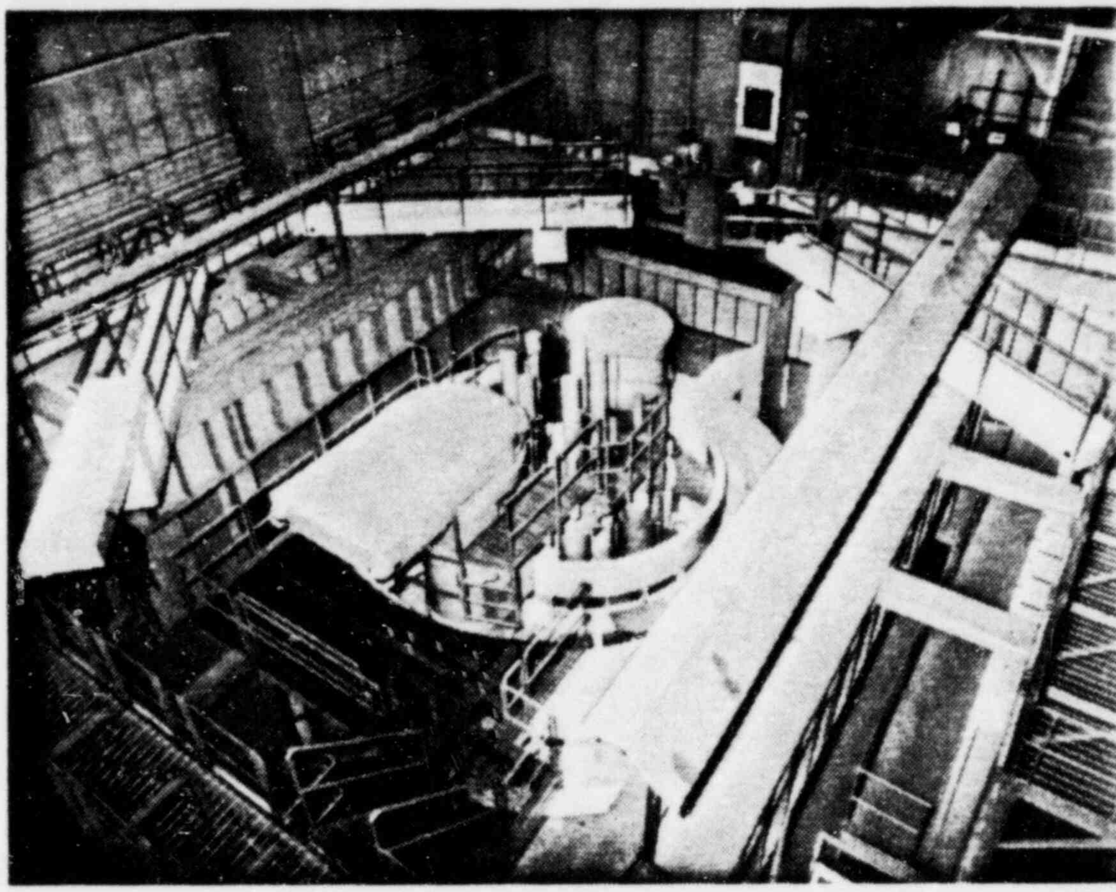

Figure 3

As a second example, the high density of equipment in the area surrounding the reactor head made it necessary to construct a full-scale mock-up of the secondary control rod drive mechanism so that the designers could simulate and fully characterize the actual maintenance operations anticipated for those components.

In summary, the systematic application of maintenance requirements, maintenance reviews, and specific scale modeling make it likely that the CRBRP will meet its maintainability objectives.

Q.11. How will the CRBRP design achieve its safety objective?

A.11. The demonstration of the safety objective of the Clinch River Breeder Reactor Plant will be achieved when the plant is licensed and operated within the limitations imposed by applicable regulations, guides, and instructions, while achieving the other objectives established for the Project. While the ultimate demonstration concerning this objective must await the Construction Permit and Operating License proceedings and completion of the demonstration period, the present record suggests that it is reasonably likely that this objective will be met. The NRC Staff's June 1982 Site Suitability Report concluded that "...the proposed CRBRP site is suitable for a facility of the general size and type proposed from the standpoint of radiological health and safety considerations." In addition, the NRC Staff's February 1977 Final Environmental Statement concluded that

"...it is within the state-of-the-art to design, construct and operate the CRBRP in such a manner that the consequences of accidents will not be significantly different from those already assessed for LWRs." The NRC Staff's July 1982 Draft Supplement to the Final Environmental Statement does not alter this conclusion. The Applicants' testimony concerning NRDC Contentions 1, 2, and 3 confirms this FES conclusion.

Q.12. How will the CRBRP achieve its objective of demonstrating environmental acceptability?

A.12. The CRBRP will achieve its objective of environmental acceptability by conducting construction and operation in conformance with applicable Federal and State environmental regulations. The CRBRP will satisfy all applicable Federal and State regulatory requirements (see Chapter 12.0 of Applicants Environmental Report). The NRC Staff's Final Environmental Statement concluded that the environmental impacts of construction and operation were acceptable. Thus, it is likely that the CRBRP will meet the objective of environmental acceptability.

Q.13. How will the CRBRP achieve its objective of demonstrating economic feasibility?

A.13. The economic feasibility objective will be achieved by developing comprehensive cost, material quantities, and performance information for the CRBRP, thus providing a data base from which one could extrapolate to commercial-size central station power plants. The cost data base will include planned and actual costs for all elements of the project including design, construction, and plant operation. The project has established a system for compiling this comprehensive cost information in a form which permits cost analysis and evaluation for all the plant elements at a very detailed level. Examples of materials quantities data include length of piping, length of electrical cabling, and volumes of concrete in the various plant structures. This CRBRP data is currently being used in development of the LDP cost estimate. In the future, the cost and performance data established for the CRBRP can be used to project the cost and economics of other future LMFBR plants. Thus, the CRBRP is reasonably likely to meet the objective of demonstrating economic feasibility.

Q.14. How will the CRBRP achieve its objective of operating the plant in a utility environment?

A.14. The objective of operating the Clinch River Breeder Reactor Plant in utility environment will be met by operation on the Tennessee Valley Authority (TVA) system, supplying power to that grid, while being operated by personnel of TVA.

Q.15. How will the CRBRP achieve its objective of confirming the value of the LMFBR in conserving non-renewable resources?

A.15. The objective of confirming the value of the LMFBR in conserving important non-renewable natural resources will be demonstrated by the plant's ability to generate electricity utilizing available uranium resources, including the otherwise unused U-238. The only currently available resources for central station generation of electricity are hydroelectric, natural gas, oil, coal and uranium-235. A large share of U.S. central station electrical generating capability now uses non-renewable natural resources--oil, natural gas, coal, uranium U-235--and hydroelectric power is limited. The CRBRP will demonstrate the ability to generate electricity utilizing an otherwise unusuable natural resource--uranium-238. Thus, operation of the CRBRP will meet the objective of confirming the value of the LMFBR concept for conserving important non-renewable resources.

Q.16. How will CRBRP achieve its objectives in a timely manner?

A.16. The programmatic timing of CRBRP contemplates completion of CRBRP as soon as possible. Consistent with satisfaction of all other Project objectives, and the exercise of all lawful means to that end, the Applicants are committed to take all actions necessary to complete CRBRP as soon as possible. Project research and development is approximately 97% complete, and the design is approximately 87% complete. Seventy percent of the hardware is on order or delivered. Site preparation activities have commenced. The NRC Staff has issued its Site Suitability Report and Final Environmental Statement for the Project. On the basis of these factors, it is likely that CRBRP will meet its objectives in a timely manner.

Q.17. How were the type and size of the CRBRP configuration established?

A.17. The type is by definition an LMFBR. The overall configuration of the plant, after intensive reviews, was selected as a loop-type plant. The discussion in Answer 25 below provides a summary comparison of the loop-type plant versus a pool-type plant.

The size, or the gross power rating (975 MWt, 325 MWt per loop), of the CRBRP was selected as a reasonable midpoint between FFTF (400 MWt or 133 MWt per loop) and commercial size reactors (2400-3800 MWt, 600-1270 MWt per loop). Extrapolations of size by a factor of 2.5 to 3.5 are considered to be a prudent compromise between the need for advancement in technology and keeping the scale up risks acceptably low. Development of LWR technology followed approximately the same path. Foreign LMFBR programs have utilized similar extrapolation factors. The information obtained from a plant of the size of CRBRP is relevant to a commercial size reactor in that a similar extrapolation of the technological base from the CRBRP would lead to a commercial size LMFBR.

Q.18. How is the CRBRP design relevant to the development of commercial size LMFBRs?

A.18. The next plant under development by DOE and U.S. electric utilities and private industry is the Large Developmental

Plant (LDP). This is a 1000 MWe or 2550 MWt plant. Note that the LDP size extrapolation from CRBRP is similar to the extrapolation from CRBRP to FFTF. This extrapolation factor for LDP was established after an intensive interaction and analysis by the industry and DOE based on balancing considerations of advancements in technology and attaining a low risk basic design. The overall configuration of the plant is again "loop-type," established after studies and analyses conducted independent of CRBRP. Furthermore, based on the concept already developed for LDP, an assessment was made by DOE and the industry on the bases available for the design of LDP systems. Table 1 shows the results of this assessment. As can be seen from this table, CRBRP systems design provides a basis for all the LDP systems designs.

TABLE 1

EXTRAPOLATION BASE FOR LDP

LMFBR SYSTEMS

System No.	Title	Experience Base CRBRP	FFTF	LWR
11	Power Transmission	X	X	X
12	Building Electrical	X	X	X
13	Grounding & Cathodic Protection	X	X	X
15	Communication	X	X	X
16	Lighting	X	X	X
19	Site Improvements	X	X	X
20	Balance of Plant (BOP) Building	X		X
21	Reactor Support Building	X	X	
22	Compressed Gas	X	X	
23	Auxiliary Coolant	X	X	
24	Radioactive Waste	X	X	X
25	Heating, Ventilation, and Air Conditioning (HVAC)	X	X	X
26	Plant Fire Protection	X	X	*
27	Reactor Containment	X	X	
28	Recirculation Gas Cooling	X	X	
31	Reactor System	X	X	
32	Reactor Enclosure	X	X	
41	Reactor Refueling	X	X	

TABLE 1 (Continued)

EXTRAPOLATION BASE FOR LDP

LMFBR SYSTEMS

System No.	Title	Experience Base CRBRP	FFTF	LWR
44	Maintenance (Nuclear Island)	X	X	
45	Maintenance (BOP)	X		X
51	Reactor Heat Transport	X	X	
52	Steam Gen. Aux. Heat Removal	X		
53	Steam Generator	X		
54	Recirculating Gas Instrumentation	X	X	
55	Reactor Containment Instrumentation	X	X	
56	Reactor Heat Transport Instrumentation	X	*	
57	Auxiliary Coolant Fluid Instrumentation	X	X	
58	Radioactive Waste Instrumentaion	X	X	X
59	HVAC Instrumention	X	X	X
60	Plant Fire Protection Instrumentation	X	X	*
61	Inert Gas Receiving & Processing Instrumentation System	X	X	

TABLE 1 (Continued)

EXTRAPOLATION BASE FOR LDP

LMFBR SYSTEMS

System No.	Title	Experience Base CRBRP	FFTF	LWR
62	Impurity Monitoring & Analysis Instrumentation System	X	X	
63	Aux. Liquid Metal Instrumentation System	X	X	
64	Reactor Refueling Instrumentation System	X	X	
66	Leak Detection Instrumentation System	X	X	
67	Plant Annunciator System	X	X	X
68	Piping & Equipment Electrical Heating and Control System	X	X	
69	BOP Instrumentation & Control	X		X
71	Feedwater & Condensate System	X		X
72	Main and Auxiliary Steam System	X		X
73	Heat Rejection System	X		X
74	River Water Service System	X		X
75	Treated Water System	X		X
76	Waste Water Treatment	X		X

TABLE 1 (Continued)

EXTRAPOLATION BASE FOR LDP

LMFBR SYSTEMS

System No.	Title	Experience Base CRBRP	FFTF	LWR
81	Auxiliary Liquid Metal	X	X	
82	Inert Gas Receiving and Processing	X	X	
85	Impurity Monitoring and Analysis	X	X	
90	Plant Control System	X	X	X
91	Data Handling and Display	X	X	X
92	Reactor and Vessel Instrumentation	X	X	
94	Fuel Failure Monitoring	X	X	
95	Flux Monitoring	X	X	X
96	Radiation Monitoring	X	X	X
97	Site Investigation	X	X	X
98	Construction Facilities Equipment & Services	X	X	X
99	Plant Protection	X	X	X
TOTAL NUMBER OF SYSTEMS		56	44	29

X Direct data base
* Partial data base

In addition to similarities at the system level, there are strong similarities between CRBRP and LDP at the subsystem and component level. For example, in the reactor system the LDP reactor core is of heterogeneous design, as the CRBRP core. The fuel material, structural material, fuel assemblies, blanket assemblies, shield assemblies, control assemblies, control rod drive mechanisms, upper internals structure, core restraint, instrumentation, reactor head and shielding are essentially identical. Thus, in the case of the independent effort to develop the design for the LDP, which is essentially of commercial size, CRBRP provided much relevant information.

In the same manner that a large portion of the information obtained from CRBRP is directly relevant to LDP, the information from the design, construction, and operation of CRBRP can also be reasonably expected to provide significant information of relevance to commercial LMFBRs of the future.

Q.19. What is the relevance of information generated by CRBRP which is independent of the speci'ic design?

A.19. A significant contribution of the CRBRP to the overall LMFBR program is development of a strong base of technological information. This technological base encompasses the sum-total of the experience with the design, construction, and operation of the CRBRP. Examples of this technological base would be information concerning materials properties, analytical methods (e.g., thermal hydraulic analysis codes) and the associated data bases. This technological base then forms the foundation for the next step in the development of technology. The process continues, ultimately leading to a final product, in this case a commercial size breeder plant with the desired characteristics. In this context, even experience which leads to rejection of certain design concepts is relevant inasmuch as the rejection of a design concept is based on prior knowledge and experience. CRBRP will provide substantial information which is independent of the specific design concerning materials, properties, analytical methods, and design studies which will be of substantial value to future LMFBRs.

Q.20. How will the CRBRP core design be relevant to core design in commercial size LMFBRs?

A.20. The heterogeneous core configuration as used in CRBRP is expected to be adopted in future LMFBRs. The design of the core assemblies, blanket assemblies, shield assemblies, and control assemblies is not expected to change radically. The core restraint is expected to be similar. Most importantly, the methodology developed for heterogeneous core analysis will be directly applicable to design of larger LMFBRs.

As previously noted, extensive tests of the CRBRP heterogeneous core configuration were conducted at the Zero Power Plutonium Reactor (ZPPR). These tests provided valuable feedback on the validity of analytical tools. As a result of this experience, the core design on the LDP and larger LMFBRs can proceed with a higher degree of confidence.

Q.21. How will CRBRP engineered safety features be relevant to commercial size LMFBRs?

A.21. The major engineered safety features (ESFs) in CRBRP, such as reactor containment, the liners in the cells containing sodium piping, features to mitigate the effects of sodium spills and fires are all relevant to larger or commercial LMFBRs. The types of events against which these ESF's must be designed are characteristic of the LMFBR, regardless of size. Design, construction, testing, and operation of these engineeering safety features will, as indicated earlier, demonstrate the acceptability of these features and provide relevant information for future LMFBRs.

Q.22. Has consideration been given to whether the information objectives of the CRBRP might be substantially better satisfied by design features found in other reactors?

A.22. Yes. There are no design features which have been identified in either the U.S. LMFBR Program or in the designs utilized in foreign programs which are substantially better alternatives for satisfying Project objectives than the design features that have been incorporated in the CRBRP.

Q.23. How were the basic design characteristics for CRBRP initially chosen?

A.23. The design characteristics of CRBRP were the product of intensive review and assessment and analysis of the LMFBR program needs. This process established the design objectives and guidelines, as well as the more detailed top-level design requirements. The basic plant features, concepts and parameters had their genesis in conceptual design studies performed by Atomics International, General Electric, and Westinghouse, each teamed with a utility and an architect-engineer, during the Project Definition Phase (PDP) of the LMFBR program in 1968. The PDP was initiated to determine the major features of an LMFBR demonstration facility. Due to the competitive nature of the PDP and the availability of information from foreign breeder programs through international exchange agreements, the PDP designs (completed in 1971) encompassed all of the information then available to each of the participating reactor manaufacturers.

The designs proposed by the PDP studies, which also included consideration of on-going studies on the optimum features of commercial LMFBR's, were evaluated in detail in 1972 by two utility/industry advisory committees. This evaluation resulted in the formulation of the initial design characteristics.

Competitive designs and proposals responsive to the above-mentioned design characteristics were solicited by the Atomic Energy Commission (AEC) for the demonstration plant project. The proposals received were evaluated and features from each were factored into the basic design concepts of the CRBRP.

After selection of the Commonweath Edison/TVA proposal, trade-off studies were performed, including but not limited to plant size, primary loop configuration (pool vs. loop), primary pump location, refueling concept, number of heat transport loops, steam cycle selection, steam generator concept, and decay heat removal concept. The results from the studies were factored into the decisions made relative to specific Clinch River Breeder Reactor Plant features.

Thus, the major design featurs of CRBRP were the product of a systematic review and were responsive to the needs identified by the ultimate user--the utility industry.

Q.24. What design features, different from those contained in the CRBRP design, have been identified by NRDC as potentially advantageous?

A.24. These alternative design features are: (1) the pool-type primary system configuration, (2) use of flywheels on sodium pumps, (3) lower system operating temperatures, (4) third shutdown system, (5) core catcher, and (6) no-vent containment.

Q.25. Is the pool-type system configuration a substantially better alternative?

A.25. No. In a loop-type configuration, such as CRBRP, the major primary heat transport system components are interconnected with the reactor vessel by means of coolant-carrying piping. In a "pool-type" configuration, the primary system components are in a "pool" of sodium contained within a vessel which also houses the reactor core.

It should be noted, however, that many features, for example, intermediate heat transport system (IHTS), steam generator system (SGS), the turbine generator, and auxilary systems, are common to both concepts. Therefore, much of the information obtained from a loop plant such as CRBRP, including contributions to the overall technology base, is relevant to either concept. Pool-type systems have been considered since the very early period in LMFBR development. Early U.S. fast reactors were built both in pool (EBR-II) and loop (SEFOR and Fermi-I) configurations. In foreign reactors, early test LMFBRs were built only in loop configurations (DFR, Rapsodie and BR-5). The current generation of larger plants includes both loop (SNR-300, BN-350, Joyo and Monju) and pool (Phenix, PFR, Superphenix, BN-600). Recent evaluations performed in the U.S. have indicated no clear superiority of one system over the other. In these evaluations, attention was given to safety, maintainability, cost and duration of fabrication and construction, and economy of operation. On a purely functional basis, both pool and loop-type LMFBRs are feasible and neither has a significant overall advantage over the other. Considering fabrication/construction differences between pool and loop-type reactors, the cost and schedule estimate differences are generally recognized to be within the range of uncertainty of the estimating accuracy. However, there is a lack of large pool-type reactor construction experience in this country, and there is a schedule risk associated with the greater estimated field labor requirements for a pool-type reactor. Therefore, there is no substantial advantage of the pool concept over the loop concept, and CRBRP in a loop plant configuration has a higher likelihood of meeting its objectives and timing.

Q.26. Is the use of flywheels on sodium pumps a substantially better alternative?

A.26. No. The CRBRP primary flow coastdown characteristics (the flow vs. time after power is removed from pumps) have been selected by balancing two competing requirements:

1. The need to provide adequate coolant flow to the core and radial blanket for all design basis events including postulated loss of power to all three primary pumps, and
2. The need to minimize the thermal transients associated with reactor and plant trips.

Too little flow might result in inadequate core cooling, while too much flow may result in overcooling and thermally stressing plant components during transients. The required flow coastdown characteristics for the CRBRP sodium pumps are being provided by building directly into the pump drive rotor (as opposed to the addition of a separate flywheel) sufficient inertia so that the required momentum of the pump-drive motor assembly will be available. This inertia satisfies both of the above requirements.

Transient overpower (TOP) and loss-of-flow (LOF) events which are beyond the design base have also been considered. The addition of a heavy flywheel would be ineffective in significantly reducing the likelihood or consequences of such events. For the postulated transient overpower (TOP) events that assume failure of both reactor shutdown systems, there would be no advantage for a heavy flywheel b cause the pumps continue to run in that event. For the postulated loss of flow (LOF) events that assume failure of both reactor shutdown systems, the addition of heavy flywheels would not change the overall conclusions. The time for initiation of boiling would increase slightly, but once boiling is initiated, the sequence of events is controlled by the phenomena related to boiling, which are not affected by a flywheel. Increased pump inertia produced by the flywheel would not change the likelihood of sodium boiling and the resultant consequence of a non-energetic core meltdown.

On the other hand, increasing the pump inertia by means of a flywheel beyond that required to provide adequate coolant flow increases the rate of temperature change associated with system thermal transients, thereby adding to the fatigue damage associated with transients. Thus, adding a pump flywheel would not be a substantially better design alternative than the CRBRP design.

Q.27. Is system operation at lower temperatures a substantially better alternative?

A.27. No. The system operating temperatures of the CRBRP were selected based upon plant performance analyses that considered equipment constraints, steam conditions, desired fuel performance, thermal transient and creep effects and cycle efficiency. Lower system temperatures have been considered for CRBRP as well as for future plants. For normal operations and accidents within the design basis, a balancing of the advantages and disadvantages of lower system operating temperatures shows that this is not a substantially better design alternative. Lowering the operating temperatures without lowering the design temperatures would have the effect of increasing equipment sizes and costs and decreasing efficiency, while providing more margin to system limiting conditions and slightly improved fuel performance. However, at any given design temperature, the prudent designer would provide the same structural design margins between operation and design temperatures, and there is no net benefit to be derived from lower operating temperatures.

Events beyond the design base have also been considered in relation to selection of system operating temperatures. The effect of choosing a lower plant operating temperature would not significantly change the transient overpower hypothetical core disruptive accident (HCDA) consequences because the current transient overpower scenario results in molten fuel release from the pin before coolant boiling occurs. Thus the overall conclusions regarding the transient overpower HCDA would not be influenced by a choice of lower operating temperature.

The effect of lower operating temperatures on the likelihood and consequence of a loss-of-flow HCDA is similar to that described for pump inertia selection. The time to initiate boiling would be slightly increased, but the likelihood or consequences of sodium boiling would not change. Thus, the overall conclusions regarding the loss-of-flow HCDA would not be influenced by a choice of lower operating temperature.

In summary, when all of the above factors are considered, lower CRBRP operating temperatures would not be a substantially better alternative for meeting project objectives.

Q.28. Is a third shutdown system a substantially better alternative?

A.28. No. As discussed in Applicants' testimony concerning NRDC Contentions 1, 2, and 3, there are two control rod systems in CRBRP. The systems are diverse--that is, they have different operating principles and use different components, and they are redundant--that is, each system is designed to shut the reactor down without action by the other system. Each system is also internally redundant--that is, each system by itself is designed to shut down the reactor even if any one control rod in that system does not function.

A third shutdown system is unnecessary, because, as shown in Applicants testimony concerning NRDC Contentions 1, 2, and 3, all credible failure modes are addressed by the primary and secondary shutdown systems. A third shutdown system would not address any other known failure modes, and would not provide a significant reduction in risk to the public health and safety. Therefore, the addition of a third shutdown system would not be a substantially better alternative.

Q.29. Is inclusion of a core catcher in the design a substantially better alternative?

A.29. No. Core catcher is the name associated with the features in a plant design that would provide for the ability to retain some or all of the core subsequent to an over-power or undercooling accident that results in melting of the core and subsequent meltthrough of the reactor vessel and guard vessel. The Applicants have analyzed the benefits which would be obtained from inclusion of a core catcher in the design and have compared the protection afforded to the public health and safety with and without the inclusion of a core catcher in the design. A core catcher is generally assumed to include means for keeping this core debris from penetrating further into the bottom of the reactor cavity. It should be noted that (a) the core catcher does not in any way reduce the likelihood of an HCDA and that (b) any active features provided in the core catcher have to perform in an extremely hostile environment subsequent to an HCDA and are inaccessible at a time when they are required to function.

As shown in Applicants' testimony concerning NRDC Contentions 1, 2, and 3, the overall approach to CRBRP design has been to include in the design such features that make the likelihood of a core melt so unlikely that one need not include a core melt in the spectrum of Design Basis Accidents. However, as further shown by the Applicants' testimony concerning NRDC's Contentions 1, 2, and 3, the Applicants have provided margins and design features in CRBRP to mitigate the consequences of HCDAs and to assure that the residual risks from HCDAs can be made acceptably low. There is no substantial further advantage to inclusion of a core catcher in the design.

Q.30. Is a no-vent containment a substantially better alternative?

A.30. No. CRBRP containment design includes provisions for venting the containment in a controlled manner. In the normal mode of operation, there is negligible radioactivity in the containment atmosphere and the containment is continuously vented. This provides for access to the containment during operation, thus improving operability and maintainability of the plant.

The atmosphere in the containment is continously monitored. In the event that any significant radioactivity levels are detected in the containment effluent, the containment atmosphere is isolated through the use of containment isolation valves. Under such circumstances, the containment is essentially unvented and for all design bases may be kept unvented for as long as it is desired.

The CRBRP design has provision for filtering and cleanup of the vent discharge from the containment. Thus, when a decision to vent the containment is made, protection to public health and safety is provided by assuring, through cleanup of the discharge, that the radiological releases are acceptably low.

Elimination of the capability to vent the containment in normal operations is not advantageous to demonstrating the CRBRP objectives. The analysis has shown that, even with venting, the radiation dose guidelines are not exceeded. Thus, the health and safety of the public is assured even with a vented containment. On the other hand, elimination of venting during normal operation makes the containment access during normal operation (operability, maintainability) difficult. This is contrary to basic objectives of the CRBRP. Thus, under normal operation and design basic condition, a no-vent containment is not a significantly better alternative.

In the event of a beyond-the-design-base Hypothetical Core Disruptive Accident (HCDA), the containment is isolated through the containment isolation system on detection of high levels of radioactivity in the atmosphere. CRBRP analysis shows that, subsequent to an HCDA, the containment may have to be vented in order to maintain the containment pressure within the containment vessel capability.

Even under the HCDA condition, there is still no particular advantage to elimination of the containment capability to vent through a cleanup system and to maintain a no-vent condition indefinitely. CRBRP analysis shows that even under the HCDA conditions, through the use of controlled filtered vent, the radiological releases for such accidents are acceptably low.

Design measures could be taken to increase the probability that no vent would be required. One cannot in practice, however, foresee all contingencies. Therefore, it is prudent and advantageous to include a filtered controlled vent capability to assure that containment integrity cannot be challenged.

On balance, a no-vent containment is not a substantially better alternative.

Q.31. What conclusions do you draw?

A.31. Although alternatives to specific CRBRP features have been identified by NRDC as potentially advantageous, none are substantially better than those presently incorporated in the design.

STATEMENT OF QUALIFICATIONS

John R. Longenecker

Acting Director, Office of the Clinch River

Breeder Reactor Plant Project

Office of Breeder Reactor Programs

U.S. Department of Energy

John R. Longenecker is Acting Director of the Office of the Clinch River Breeder Reactor Plant (CRBRP) Project in the Department of Energy (DOE). Included within his responsbilitiy is the licensing and program management of the CRBRP, and direction of the conceptual design of the Liquid Metal Fast Breeder Reactor (LMFBR) Large Developmental Plant.

Prior to this assignment, Mr. Longenecker served in the Department of Energy as Director, Division of Plant Development; Chief, Conceptual Design Study, Division of Reactor Research and Technology (RRT); Technical Assistant to the Program Director, Nuclear Energy Programs; and in various capacities in the Energy Research and Development Administration's (ERDA) Division of Reactor Research and Development, including Special Assistant to the Director, Acting Assistant Project Director for Procurement for the CRBRP, Acting Chief of CRBRP Mechanical Components Branch, and Reactor Engineer for various LMFBR projects. He joined the Atomic Energy Commission in 1973 and served there in the Division of Reactor Development and Technology prior to the formation of ERDA in 1975, and DOE in 1978.

Prior to entering Government service, Mr. Longenecker was employed by the Ford Motor Company as a research engineer and by the firm of John Robinson and Associates as a structural engineer.

Mr. Longenecker received both Bachelor of Science and Master of Science degrees in solid state mechanics from the Pennsylvania State University.

STATEMENT OF QUALIFICATIONS

Narinder N. Kaushal

Engineering Division

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Dr. Kaushal is the Deputy Assistant Director for Engineering at the Clinch River Breeder Reactor Plant Project. In this capacity he serves as the principal technical, administrative and operating official of the Engineering Division, coordinating and executing approved programs, policies and decisions of the Assistant Director for Engineering.

From February 1978 until August 1982, Dr. Kaushal served as the Chief, Reactor and Plant Systems Branch. In that capacity, he directed the day-to-day activities of CRBRP participants involved in the design, development, fabrication, test, evaluation, installation, checkout, startup test, safety, operation, and plant security of the major systems and components of the reactor and balance-of-plant.

From February 1975 to 1978, Dr. Kaushal served as the Chief, Instrumentation, Control and Electrical Branch, with a full range of CRBRP management responsibilities for the reactor and plant controls, instrumentation and electrical systems.

He holds bachelor's degrees in mathematics and physics, a masters degree in both physics and electronics, and a doctorate degree from Rensselaer Polytechnic Institute in nuclear physics and solid-state physics. From 1967, when he received his doctorate degree, until he joined the CRBRP Project in 1974, he was a Research Associate in the Nuclear Engineering Department of Rensselaer Polytechnic Institute (RPI). In this capacity he conducted research at the RPI Linear Accelerator Laboratory, and had supervisory responsibility for the Fast Neutron Spectrum Program.

STATEMENT OF QUALIFICATIONS

Carl A. Anderson, Jr.

Project Manager, Large Plant Projects

Westinghouse Advanced Reactors Division

Madison, Pennsylvania 15663

Since January 1979, I have been Project Manager, Large Plant Projects, with responsibility for reactor design and development of the LMFBR plant to follow Clinch River; technical interactions with LMFBR programs in the United Kingdom, France, Germany and Japan; fusion development; and other advanced reactor programs.

I received the degree of Mechanical Engineer from Stevens Institute of Technology in 1956, and the degrees of Master of Science in Mechanical Engineering in 1957, and Doctor of Philosophy in Nuclear Engineering in 1961 from Massachusetts Institute of Technology. In 1971, I completed the Program for Management Development at the Harvard Business School.

From 1961 to 1964, I was employed by Sandia Corporation at Sandia National Laboratory, Albuquerque, New Mexico, first as a Section Supervisor and later as a Division Supervisor. I directed design, construction and operation of the Sandia Engineering Reactor and the Sandia Nuclear Assembly for Reactor Experiments. I supervised a nuclear dosimetry laboratory, a gamma irradiation facility, cryostats, hot laboratories, remotely operated machinery, and pulsed neutron experiments.

From 1964 to 1967, as a Staff Member of the Los Alamos Scientific Laboratory in Los Alamos, New Mexico, I participated in fast reactor research and development. The work centered on the Fast Reactor Core Test Facility and the LMFBR cores planned for operation therein, with associated work on correlation function analysis, fission product yields, heat transfer, mechanical design and plant transient analysis.

I joined the Westinghouse Electric Corporation Advanced Reactors Division in 1967.

From 1967 to 1968, I was Project Manager responsible for the 1000 MWe LMFBR Design Study and the Large Sodium Pump Study.

From 1968 to 1971, I was Manager, LMFBR Reactor Engineering, responsible for conceptual design and analysis of the reactor for the Westinghouse LMFBR Demonstration Plant. This included the nuclear, thermal-hydraulic and mechanical design of components within the reactor vessel.

From 1971 to 1974, I was Manager, FFTF Reactor Engineering. I directed the design, procurement and fabrication of the FFTF reactor, including reactor vessel, head, instrument trees, in-vessel handling machines, shielding, core support structure, core basket, core restraint system, flux monitor system and control rod systems.

From 1974 to 1975, I was Manager of Technology, responsible for the Division's fuels and materials research and development, sodium loop testing, friction and wear testing, fast breeder fuel fabrication and testing, and stress analysis methods development.

From 1975 to 1976, I was Reactor Plant Project Manager in the CRBRP Project. I supervised the analysis, design, procurement and fabrication of those portions of the plant for which Westinghouse was technically responsible, including: fuel, radial blanket, shield, control system, reactor vessel and head, core support structure, reactor internals, primary piping, intermediate heat exchanger, check valves, instrumentation and controls.

From 1976 to 1979, I was Project Manager, Prototype Large Breeder Reactor. In this position I was responsible for all aspects of the effort to design the Prototype Large Breeder Reactor, a near-commercial LMFBR.

I am a member of the American Society of Mechanical Engineers, the American Nuclear Society, the American Association for the Advancement of Science, and the Society of the Sigma Xi.

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(Clinch River Breeder Reactor Plant)	)
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