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

APPLICANT'S TESTIMONY CONCERNING
NRDC CONTENTIONS 6.b.1, & 6.b.3

Dated: November 1, 1932

D503

Q.1. Please state your names and affiliations.

A.1. My name is George L. Sherwood, Jr. I am employed by the U. S. Department of Energy as a Licensing Engineer in the Clinch River Breeder Reactor Plant (CRBRP) Office in the Office of Nuclear Energy. I am responsible for review and integration of and assisted in the preparation of all portions of this testimony.

My name is Douglas C. Newton. I am employed by the U. S. Department of Energy as a Nuclear Engineer in the Division of Waste Repository Deployment. I am primarily responsible for preparation of the portions of this testimony concerning waste management activities for the CRBRP fuel cycle.

My name is William M. Hartman. I am employed by the U. S. Department of Energy as the Manager, LMFBR Fuel Supply and Process Development, in the Office of Breeder Technology Projects. I am primarily responsible for preparation of the portions of this testimony concerning the description of fuel fabrication activities in the CRBRP fuel cycle.

My name is Orlan O. Yarbro. I am a member of the staff of the Oak Ridge National Laboratory, Fuel Recycle Division. I am primarily responsible for preparation of the portions of this testimony concerning reprocessing activities for the CRBRP fuel cycle.

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

A.2. Yes, we have. Copies are attached to this testimony.

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

A.3. This testimony addresses the adequacy of the NRC staff's analyses of the environmental impacts of the CRBRP fuel cycle. This issue is defined in the Natural Resources Defense Council, Inc. (NRDC) and the Sierra Club's Contentions 6.b.1 and 6.b.3 as follows:

> 6. The ER and FES do not include an adequate analysis of the environmental impact of the fuel cycle associated with the CRBR for the following reasons:
>
> b) The analyses of fuel cycle impacts in the ER and FES are inadequate since:
> (1) The impact of reprocessing of spent fuel and plutonium separation required for the CRBR is inadequately assessed;
>
> (3) The impact of disposal of wastes from the CRBR spent fuel is inadequately assessed;

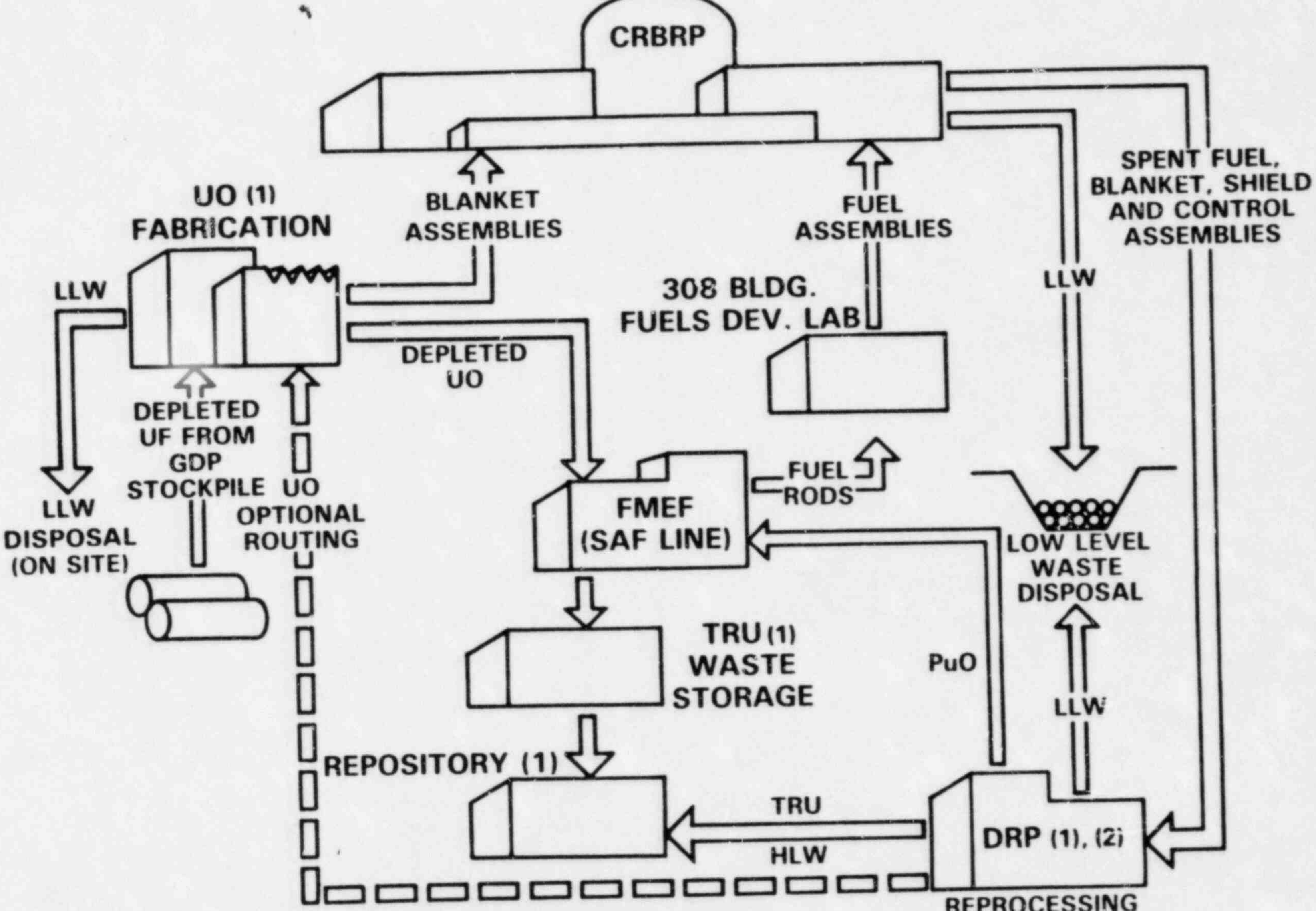
Q.4. What is the principal issue raised by the intervenors?

A.4. The principal issue is whether the analyses of the environmental impact of the CRBRP fuel cycle presented in the NRC staff's FES Supplement (EIS) are adequate. In particular, Intervenors allege that the Applicants' Environmental Report (ER) and the NRC staff's FES do not contain adequate analyses in regard to (a) reprocessing of spent fuel and plutonium separation and (b) disposal of wastes for the CRBRP.

Q.5. What are the elements of the CRBRP fuel cycle?

A.5. Exclusive of transportation, the CRBRP fuel cycle consists of fuel fabrication for both core and blanket fuel, spent fuel reprocessing and associated waste management, as shown in the following illustration. The fuel cycle and fuel cycle facilities for the CRBRP are depicted below.

CRBRP FUEL CYCLE



(1) SPECIFIC FACILITIES OR SITES NOT YET ESTABLISHED

(2) STORAGE OF PuO, UO, TRU AND HLW AT DRP UNTIL SHIPPED

FIGURE 1

10-82-2929-1-1

Q.6. What is involved in Fuel Fabrication?

A.6. Fabrication of mixed oxide (MOX) core fuel is planned to be performed at the Secure Automated Fabrication (SAF) line, to be installed in the Fuels and Materials Examination Facility (FMEF), presently under construction at DOE's Hanford reservation. CRBRP fuel fabrication will require about 65 percent of the SAF line operational schedule (15 of every 24 months). Therefore, about 4 metric tons (MT) of the SAF line annual capacity of 6 MT MOX is needed to support the CRBRP.

The basic SAF line fabrication process includes receiving and assaying of nuclear ceramic powders, blending of the powders, pelletizing and sintering the powders into fuel pellets, and loading these pellets into finished fuel pins. The mechanical assembly of welded fuel pins produced by the SAF line into fuel assemblies is planned to be performed in Building 308 on the Hanford Reservation.

Blanket fuel fabrication (7.5 MT/yr of depleted uranium) for the CRBRP will be carried out at a yet to be selected commercial facility. In addition, uranium dioxide (UO_2) pellets (3.5 MT/yr) will be fabricated from UO_2 powder at this facility for use in the axial blanket portion of fuel pins being fabricated in the SAF line.

Q.7. What is involved in spent fuel reprocessing?

A.7. The CRBRP core and blanket fuel assemblies will be reprocessed to recover and purify uranium and plutonium for recycle back to the CRBRP. Separation of the fission products from the fissile and fertile material is based upon liquid-liquid solvent extraction. The conventional Purex process, modified as required for specific nuclear fuels, is the basic process. The Purex process utilizes a tributylphosphate (TBP) extractant in a normal paraffinic hydrocarbon (NPH) solvent. The uranium and plutonium products are converted to oxides in a form to be used directly in fuel fabrication.

The Department of Energy has plans to demonstrate technology for commercial reprocessing of LMFBR fuels by reprocessing of CRBRP (and other) fuels in a Developmental Reprocessing Plant (DRP) (formerly called the Hot Experimental Facility).

Q.8. What is involved in waste management?

A.8. Low level wastes (LLW) will be produced during reactor operation and during fuel fabrication and fuel reprocessing operations as well. LLW will be transported to shallow land burial sites for disposal.

Transuranic wastes (TRU) are produced during fuel fabrication operations involving plutonium and during fuel reprocessing. TRU produced at the SAF line will be stored at the existing DOE transuranic waste storage site on the Hanford Reservation and later shipped to a Federal repository for disposal. TRU produced during operation of the DRP will be shipped to a Federal repository for disposal.

- High level waste (HLW) is produced during fuel reprocessing. HLW produced at the DRP will be fixed in a matrix with a very low leach rate, packaged in stainless steel cylinders and shipped to a Federal repository for disposal. Metal scrap generated at the DRP will be partially compacted, packaged into stainless steel cylinders and shipped to a Federal repository for disposal.

Other wastes are the Kr-85 and I-129 captured at the DRP. The Kr-85 (in a metal matrix) will be loaded into cylinders. One cylinder will be required for every 28 years of CRBRP operation. I-129 will be fixed in concrete as barium iodate and packaged in a 55-gallon drum. One drum will be required for every 20 years of CRBRP operation. Filled cylinders and drums will be sent to a Federal repository for disposal.

Q.9. What are the major classes of environmental impacts associated with the CRBRP fuel cycle?

A.9. There are three major classes of impacts associated with the CRBRP fuel cycle; radiological impacts, radioactive waste management impacts, and nonradiologial impacts. Each of these classes of impacts are summarized as follows:

A. Radiological Impacts

The following table gives annual average population whole body exposures for the CRBRP fuel cycle, as presented in the EIS.

CRBRP FUEL CYCLE POPULATION EXPOSURES

Step	Exposure (Person-rem)
Core Fuel Fabrication	<0.1
Blanket Fuel Fabrication	<0.1
Spent Fuel Reprocessing	140
Waste Management	Small
Total	140

It was estimated in the EIS that operation of the CRBRP would result in general population annual total body exposures of 0.1 person-rem and annual average worker exposures of 1,000 person-rem. These exposures are very small compared to the expected year 2010 U.S. population exposure due to natural background radiation of 28,000,000 person-rem.

B. Radioactive Waste Management

Low Level Wastes. The projected quantities of Low-Level Waste (LLW) from the CRBRP presented in the EIS are lower, when compared on a per MWe basis, than the quantities produced by a Light Water Reactor (LWR). (NRC estimates of annual low-level waste volumes for a 1000 MWe LWR, presented in Table 3.3 of NUREG-0116, ranged from 651 to 658 cubic meters, or about 0.6 cubic meters per MWe. CRBRP is expected to produce about 97.5 cubic meters, or less than 0.3 cubic meters per MWe.) The LLW from the CRBRP fuel cycle would, over a 30-year period, require only about 0.2% of the current capacity of existing commercial LLW disposal facilities.

Transuranic Wastes (TRU). The approximately 6,000 55-gallon drums of TRU which will result from the entire CRBRP fuel cycle over the 30-year period could be disposed of in a Federal repository. If this respository is designed for the same loading ratio for TRU as the Waste Isolation Pilot Plant, then the CRBRP TRU wastes would occupy about one part in one thousand of the capacity of a typical 2,000 acre repository.

High Level Wastes (HLW). The amount and relative toxicity of HLW from the CRBRP fuel cycle to be disposed of are about the same as those from an LWR when compared on a per MWe basis. The HLW from the CRBRP fuel cycle over a 30-year period will consist of about 180 which together would occupy a volume of roughly 100 cubic meters.

Other Wastes. Quantities of other radioactive wastes are so small that disposal of these wastes would represent insignificant environmental impacts.

C. Non-Radiological Impacts

The following table provides a summary of the primary non-radiological impacts for the CRBRP fuel cycle, for annual average requirements.

CRBRP FUEL CYCLE NON-RADIOLOGICAL ENVIRONMENTAL IMPACTS

Land use	90 acres
Water use	17 million gallons
Equivalent coal	12,000 MT
Chemical effluents (MT)	
SO_x*	440
NO_x*	140
HC*	3.4
CO*	35
Particulates*	120
Fluoride*	0.006
Ammonia	6.7
Nitrate**	7.3
Ammonia**	3.2
Flouride**	1.3

*Atmospheric

**Liquid

Q.10. What are the major elements of conservatism in the estimates of CRBRP fuel cycle radiological environmental impacts?

A.10. Radiation exposures for the CRBRP fuel cycle were calculated conservatively in the EIS analyses with the result that estimates presented in the EIS would overestimate the actual impacts. There are significant elements of conservatism in the reprocessing and waste management segments of the CRBRP fuel cycle analysis.

Q.11. What are the primary elements of conservatism in the analyses of reprocessing impacts?

A.11. For assessing environmental effects from reprocessing, the NRC staff used the higher of the two values for the source term of individual isotopes derived from staff evaluations (NRC-ORIGEN-2 basis) and from the Applicants' analyses (in Section 5.7 of the ER). The result of this approach is to use the most conservative assumption for each isotope. This results in an overestimate of environmental effects. Two isotopes dominate the estimated radiological impacts: tritium (H-3) and carbon 14 (C-14).

The NRC staff's source term assumed that all of the tritium produced at the reactor is transferred to and is released from the reprocessing plant. Substantial data exists to indicate that about 90% of the tritium generated at the reactor will diffuse through the cladding into the sodium coolant, where it will be removed by the sodium cold traps. The tritium source terms and resulting doses are expected to be a factor of 10 less than the values presented in the EIS. As tritium is one of the primary contributors to population dose (52%), this represents a significant reduction in the total population dose.

The C-14 source term in the EIS conservatively assumed that the C-14 produced in both the fuel and the cladding is released during reprocessing, when in fact the C-14 in the cladding remains with the cladding and would be disposed of at a permanent repository. As a result of this, the C-14 source term quoted in the NRC-ORIGEN2 analysis is the more likely value and is a factor of 1.7 lower than the value that was used for the EIS. In addition, C-14 that reaches the dissolver off-gas system will be removed along with the Kr-85 by the krypton removal system. This is expected to reduce the C-14 release by a factor of 2 to 10. The combined effects of the corrected source term and C-14 retention are expected to reduce the C-14 release and resulting environmental effects by at least a factor of 3 below that given in the EIS. As carbon-14 is the other primary contributor to population dose (47%), this represents a significant reduction in the population dose, as shown in the following table.

SPENT FUEL REPROCESSING DOSE REVISIONS

Isotope(s)	EIS Release Estimate (Ci)	Expected Release (Ci)	Whole Body Population Dose (person-rem) EIS Estimate	Expected
H-3	5.9×10^3	5.9×10^2	73	7
C-14	1.4×10^1	4.7	66	22
Others	----	----	1	1
		Total	140	30

The net effect of the staff's assumptions is that the EIS estimate of the U. S. total body population dose due to reprocessing is a factor of about 5 higher than the expected doses.

Q.12. What are the primary elements of conservatism in the analyses of waste management impacts?

A.12. The NRC staff estimated that the waste from CRBRP would occupy no more than 1% of the capacity of a reference repository and then proceeded to allocate CRBRP disposal impacts on this basis. In actuality, the CRBRP wastes would occupy somewhat less than 1% of the capacity of a typical repository. The thermal design criterion currently under consideration by DOE is 100 kw per acre of repository, regardless of rock type. Since the CRBRP waste produces about 4 kw per canister, the 180 canisters of CRBRP HLW will produce about 720 kw of heat and will require about 7.2 acres. This is about 0.36% of the capacity of a 2,000 acre repository. Thus, the staff estimate of 1% is too large by a factor of about three, based upon this analysis.

Q.13. What are the major elements of conservatism in the EIS analysis of non-radiological impacts?

A.13. Since the NRC staff overestimated the fraction of a repository needed for CRBRP wastes by about a factor of three, the share of natural resources and effluents needed for HLW management is overestimated. A reduction of the values in Table D.4, page D-7 of the EIS by about two-thirds would be a more realistic allocation.

In assessing reprocessing the CRBRP fuel cycle, the staff in the EIS conservatively allocated all the non-radiological impacts of operating the DRP to the CRBRP, when in fact the CRBRP fuel reprocessing would account for only about 8% of DRP design capacity. This assumption leads to overestimates of land, water, and chemical effluents estimated for the CRBRP fuel cycle by factors between 3 and 10.

Q.14. Why was the recycle mode used for the fuel cycle analyses?

A.14. The NRC staff analyses in the EIS are based upon the recycle mode, where spent fuel from the CRBRP is reprocessed to recover uranium and plutonium. The plutonium is then shipped to the SAF line and recycled as fresh fuel for the CRBRP. Initially, plutonium would be supplied from material already in existence, which was not produced specifically for the CRBRP. The environmental impacts associated with production of this material have already occurred or would occur whether or not the CRBRP is constructed and operated. Thus, the recycle mode is the case which is most representative of the conditions in the fuel cycle over the thirty year lifetime of the CRBRP.

Q.15. What are your conclusions concerning Intervenors' contentions relating to the fuel cycle?

A.15. The Intervenors contended that the analyses of CRBRP fuel cycle impacts in the FES and ER were inadequate. This testimony and analyses in the EIS show that this contention is not valid, since the EIS contains conservative estimates of the environmental impacts of the CRBRP, spent fuel reprocessing, and HLW disposal.

STATEMENT OF QUALIFICATIONS

GEORGE L. SHERWOOD, JR.

George L. Sherwood is a Nuclear Engineer in the Office of the Clinch River Breeder Reactor Plant, under the Deputy Assistant Secretary for Breeder Reactor Programs, U.S. Department of Energy. In this position he is primarily responsible for assessing environmental impacts of breeder reactors, particularly the CRBRP.

Dr. Sherwood received a B.S. in Physics from Rensselaer Polytechnic Institute in 1965, and a Ph.D. in Nuclear Engineering from Northwestern University in 1969. He served in the U.S. Army Corps of Engineers from 1969 to 1971. In 1971, Dr. Sherwood joined the U. S. Atomic Energy Commission (AEC) as an Environmental Engineer. He transferred to the U. S. Energy Research and Development Administration (ERDA) when AEC was dissolved in January 1975, and to DOE when ERDA was dissolved in October 1977. Dr. Sherwood has been a Nuclear Engineer or an Environmental Engineer with DOE and predecessor agencies since 1971. The only exception is when he was Chief of the Environmental Safety and Effects Branch from 1975 to 1977. He has directed environmental R&D activities and managed the preparation and review of many environmental documents for nuclear energy projects and programs during this entire period.

Dr. Sherwood is a member of the American Nuclear Society, Sigma Xi and the Society for Risk Analysis. He received an ERDA Special Achievement Award in 1976. He was awarded an RPI scholarship (undergraduate) and Walter P. Murphy and AMU-ANL fellowships. He has also served part-time since 1969 as Adjunct Professor, Department of Physics and Geoscience, Montgomery College, Rockville, Maryland.

STATEMENT OF QUALIFICATIONS

DOUGLAS C. NEWTON

Douglas C. Newton is a Nuclear Engineer in the Division of Waste Repository Deployment of the U. S. Department of Energy.

Mr. Newton graduated from the University of Oklahoma in 1967 with a Bachelor of Science degree in Electrical Engineering. In 1973 he received a Masters degree in Nuclear Engineering and a Masters degree in Business Administration from the University of New Mexico.

After graduation from the University of Okalahoma he served two years as an officer in the United States Army, supervising teams in the escort of shipments of hazardous materials (chemical and biological warfare agents and sensitive explosives).

Following military duty he was employed by Public Service Company of New Mexico from 1971 to 1974 as an Electrical Engineer.

In 1974 he joined the U. S. Atomic Energy Commission as a Nuclear Reactor Engineer in the Safety Office for the Liquid Metal Fast Breeder Reactor Program. Over the next four years he worked for the AEC, and successor agencies (ERDA and DOE) on R&D programs concerned with sodium fires, radiological assessments, and post-accident heat removal. Responsibilities included identification of safety issues, formulation of plans to resolve these issues, and the technical direction of contractors to accomplish supporting work.

From 1978 to the present he has worked in Waste Management for the Department of Energy. His responsibilities have included oversight of DOE interactions with NRC for licensing nuclear waste repositories, coordination with EPA in the development of a standard for nuclear waste repositories, interactions with NRC in the development of their rule, 10 CFR 60, for high-level waste repositories, and the preparation and review of environmental documents for the waste disposal program.

STATEMENT OF QUALIFICATIONS

WILLIAM M. HARTMAN

William M. Hartman is the Manager, LMFBR Fuels Supply and Process Development, in the Office of Breeder Technology Projects of the U. S. Department of Energy.

He received a Bachelor of Science degree in Metallurgy from the Pennsylvania State University in 1964 and a Master of Science degree in Nuclear Engineering from the University of Wisconsin in 1970.

Upon graduation in 1964, he was commissioned an officer in the United States Navy. His initial assignment was to Naval Nuclear Power School where subjects included nuclear physics, reactor core design, power plant characteristics and thermodynamics plus six months operating experience on the S3G prototype reactor.

Following completion of Naval Nuclear Power School and submarine training, he served on the nuclear submarine USS Daniel Boone from 1966 to 1969. His duties included responsibility for the nuclear propulsion plant, electrical generating and distribution systems, and for the reactor protection and control systems. He was qualified to supervise operation of S5W reactor plants. Training included radioactive materials handling, radiation protection of personnel and health physics.

In 1970, he joined the Atomic Energy Commission (AEC) as a Quality Assurance Engineer with responsibility for development of codes and standards for application to sodium cooled fast breeder reactors. Duties focused on specification of reactor fuels and materials.

From 1976 to 1978 he was a Nuclear Engineer with responsibility for test fuel fabrication and fuel postirradiation examination.

Since 1978, he has managed the LMFBR fuel supply program which encompasses development of automated fuel fabrication equipment, assuring the fabrication capability to support breeder reactors, and the design, installation, testing and operation of the Secure Automated Fabrication (SAF) Line.

STATEMENT OF QUALIFICATIONS

ORLAN O. YARBRO, JR.

Orlan Yarbro is a member of the staff of the Oak Ridge National Laboratory, Fuel Recycle Division. His present position is Program Manager of Integrated Equipment Test Facility Operations with responsibilities for equipment installation and operation of a nonradioactive facility for development and demonstration of breeder fuel reprocessing.

His formal education was obtained from the University of Tennessee, where he received a B.S. degree in chemical engineering in 1954. He then attended the 1954-1955 session of the Oak Ridge School of Reactor Technology.

Since 1955, he has been employed at Oak Ridge National Laboratory. From 1955 to 1968, he was involved with the design and operation of a number of radioactive chemical processing systems. Since 1969, he has been associated with liquid-metal fast breeder reactor (LMFBR) fuel reprocessing development programs with specific responsibilities in the area of developing advanced off-gas treatment systems, conceptual design of a LMFBR fuel reprocessing hot pilot plant, and in the development of the head-end components for breeder reprocessing.