History of Research Reactor Fuel Fabrication at Babcock & Wilcox

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Introduction

1982 was a year of tremendous growth for Babcock & Wilcox and its Research Reactor Fuel Facility. The Division has progressed from essentially being a non-competitor to a position where we are growing in strength (Tables 1 and 2). This paper will describe some of the general aspects of past history and where B&W is now.

Division History

The Babcock and Wilcox (B&W) Company is owned by McDermott International. Some of McDermott's products are off shore oil drilling rigs, pipe lines, and barges for laying pipe lines. McDermott grosses about $3 billion a year company and employs about 55,000 people.

B&W, a McDermott subsidiary, is primarily U.S. based and manufacturers a variety of energy oriented products. B&W builds fossil and nuclear power plants and associated equipment,

TABLE 1. BABCOCK & WILCOX (LYNCHBURG) HISTORY

McDERMOTT (PARENT COMPANY)

International
Oil Rigs, Pipe Lines, Barges
$3 Billion/Yr
55,000 employees

BABCOCK & WILCOX (CORPORATE)

Mainly U.S.A. Based
Tubular Products, Boilers
$1.8 Billion/Yr
30,000 Employees

BABCOCK & LYNCHBURG (LYNCHBURG)

Utility Power Generation DiVISION
Commercial Nuclear Fuel Plant
Naval Nuclear Fuel Division
4,000 employees

TABLE 2. NAVAL NUCLEAR FUEL DIVISION HISTORY

Located In Lynchburg

Established 1956
2100 Employees
$160 Million/Yr Sales

600,000 Ft^2 Plant Area

Main Supplier of U.S. Navy Reactor Cores & Components

Over 1800 Reactor Years of Successful Customer Operation

Extensive Quality Organization to Meet Navy Requirements

Produced Research Reactor Fuel Elements in Late 50's and Early 60's

Re-entered Business in 1981

grossing approximately $1.8 billion a year company. B&W employs about 30,000 people.

In Lynchburg, Virginia (U.S.A.) there are four operations. The utility power generation division is one. It comprises the former nuclear power and fossil fuel divisions. And B&W has a commercial nuclear fuel plant, the naval nuclear fuel division, and Lynchburg offices and laboratories of the research and development division. Altogether there are about 4,000 employees in the Lynchburg vicinity.

The nuclear fuel manufacturing site was established in 1956. Today we have 2100 employees and sales of $160 to $200 million a year. The entire plant is approximately 600,000 square feet.

Products

Our main products have been naval reactor cores and components and our customer, the U.S. Navy, has accumulated some 1800 reactor years of successful operation.

Such a record depends on a very extensive quality organization to meet the demanding requirements. This same quality organization oversees production of research reactor fuel of various types tailored to the needs of the customers.

Babcock & Wilcox produced research reactor fuel elements in the late 50's (the Eisenhower Atoms for Peace Program) and up until 1966. The Company re-entered that business in 1981.

Table 3 is a list of some fuel element types that have been made by the division. Fuel for the ATR is significant because the first core was made at the Nuclear Fuel Plant and the first critical tests were done at the R&D Division, located on the same site. These are representative lists of the types of fuel elements that Babcock & Wilcox has produced.

SPECIAL RESEARCH (1950's & 1960's)

Table 4 summarizes most B&W research into research fuel production in the decade around 1960. Increased enrichment, increased density, and different types of fuel were all investigated.

The nuclear fuel division also did considerable work on low enriched uranium in 1956 and 1957. Much of this work was a parallel effort between B&W and Oak Ridge National Laboratory. The most useful finding had to do with the discovery that silicon addition inhibited UAl_4 formation. Production of low enriched uranium followed and that was shipped to reactors in the Netherlands, Germany, and Brazil.

TABLE 3. FUEL ELEMENT FABRICATION, 1959-1966

REACTOR, LOCATION	NO.	DATE
ATR (Advanced Test Reactor), Idaho*	150	1959-61
IEA-R1, Sao Paolo, Brazil	28	1959
ORR (Oak Ridge Reactor)	158	1959-66
MTR (Materials Test Reactor), Idaho	240	1959-66
FORD, University of Michigan	48	1960-62
HOR, Delft, Netherlands	22	1960
NBS (National Bureau of Standards), Maryland	75	1960-66
PTB, Oberhausen, W. Germany	25	1961-64
JRR-2 (Japanese Research Reactor), Tokai	24	1961
NASA (PBR) Plum Brook Reactor, Sandusky, Ohio	270	1961-65
UCNR (Union Carbide Nuclear Reactor), Sterling Forest, N. Y.	22	1962
- Munich, Germany	28	1962
ETR (Engineering Test Reactor), Idaho	610	1963-66
JRR-4, Tokai, Japan	21	1965
BSF (Bulk Shielding Facility), Oak Ridge, TN	46	1966
IRL (Industrial Research Laboratories), N. J.	14	1966

*Built first core. Performed critical experiments and physics tests in B&W's Critical Facility in Lynchburg.

TABLE 4. RESEARCH INTO REACTOR FUEL

Arc Melting of U-Al Alloys

Variety of Research
Goal: Improve Homogeneity
Minimize Segregation
Eliminate Source of Blisters
Melting with Boron or Silicon Additive

UAl_3 Production

Double Melts

Silicon Added to Binary Alloy as Inhibitor Against UAl_4 Formation
(Some results were used in manufacture of elements for JRR-4)

Fuel Element Assembly

Assembly Work Done to Compare Techniques of:

Welding
Swaging
Pinning

Low Enriched Uranium (20%) Research

Work Done in 1956 - 1957

Parallel Effort Between Babcock & Wilcox and Oak Ridge National Laboratory

Fuel Material Was:

20% Enriched
45 to 50 weight % U-Al Alloy

Research Indicated That:

1 to 3 Weight % Silicon Inhibited UAl_4 Formation

Local High Density Areas Due to UAl_4 Formation

Brinnell Hardness Value = 60 for 45 weight %

LEU Fuel Shipped to:

Netherlands
Munich
Brazil

Oxide Work (1981)

Babcock & Wilcox was awarded the contract in 1981 by Union Carbide to make fuel elements for the following reactors:

(1) High Flux Isotope Reactor
(2) Naional Bureau of Standards Reactor
(3) Oak Ridge Reactor
(4) High Flux Beam Reactor at Brookhaven
(5) Boiling Water Reactor at Los Alamos.

Since then we have signed another contract to manufacture fuel elements for the Bulk Shielding Facility and to make Oak Ridge Reactor shim rods (Table 5).

Much of the oxide work had formerly been done at Texas Instruments. B&W's contract involved the phase-out at TI and the transfer of all technical and production equipment to Lynchburg.

TABLE 5. OXIDE WORK

Contract awarded in 1981 by Union Carbide Corporation to Manufacture Fuel Elements for:

HFIR (High Flux Isotope Reactor)

NBSR (National Bureau of Standards Reactor)

ORR (Oak Ridge Research Reactor)

HFBR (High Flux Beam Reactor)

OWR (Omega West Reactor)

Additional contract awarded in 1982 to manufacture fuel elements for:

BSF (Bulk Shielding Facility)

ORR Shim Rods

The transition to B&W as supplier of research reactor fuel is proceeding in four phases: training, facility installation, qualification, and production of fuel elements.

The training of B&W personnel (now complete) involved gathering manufacturing and quality control documents from Texas Instruments (TI) and schooling B&W production and QC operators in research fuel technology. Training included plant visits to TI, use of video tapes, and operation of machininery on mock-ups and preproduction hardware.

The facility was installed at B&W by March of 1982. It occupies 20,000 square feet. B&W has essentially refurbished, repainted, installed, and operationally checked out all of the equipment. The research reactor fuel element (RRFE) facility is physically separated from work underway for the U.S. Navy. RRFE is dedicated to producing research fuel.

The qualification program for each fuel element type is progressing . Some 40 plates have been made without fuel, 44 live plates have been fabricated, and two elements have been made using dummy plates.

Regular production elements have been shipped to Oak Ridge and the National Bureau of Standards (ORR and NBSR). Plates B&W received from TI were used in assembling these shipments.

The first High Flux Isotope Reactor (HFIR) will be delivered in September 1983 and by the end of 1983 we will have shipped fuel to each of the national laboratories.

Aluminide

We are working with EG&G (Idaho) as we prepare to manufacture aluminide fuel for the universities of Lowell, Michigan, Missouri, Rhode Island, Virginia, and for MIT (Table 6). HEU will be fabricated for MIT, Virginia, and Missouri. LEU aluminide will be made for Rhode Island, Lowell, and Michigan.

Equipment from Atomics International will be shipped early in 1983. Complete facility installation, check-out, and qualification work will follow and first delivery of university fuel will occur late in 1983.

Silicide

In silicide work, B&W and Argonne have agreed that we will supply two full-sized ORR elements made with U_3Si_2 (originally U_3SiAl was proposed). B&W personnel visited Argonne for one week of silicide discussions. B&W is supplying the two elements at no cost to Argonne (Table 7). The details of the bonding problem are discussed in a paper by B&W's W. W. Noel.

Summary

B&W's Research Reactor Fuel Element facility at Lynchburg, Virginia now produces national laboratory and university fuel assemblies. The Company's 20,000 square foot facility is devoted entirely to supplying research fuel and related products. B&W re-entered the research reactor fuel market in 1981.

TABLE 6. ALUMINIDE

Babcock & Wilcox was selected by EG&G for fabrication of fuel elements for universities of:

Lowell
Michigan
Missouri
Rhode Island
Virginia
and for
Massachusetts Institute of Technology

TABLE 7. SILICIDE

Industrial Participation Agreement

Signed between Babcock & Wilcox and ANL (MARCH 1982)

Babcock & Wilcox sent people to ANL for one week for silicide discussions

No Cost Contract

Signed between B&W and ANL

B&W to manufacture two full size ORR elements, made with U_3Si_2

Delivery of elements in 1983

Detailed research on bonding problems