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UPDATE ON THE HOT FUEL EXAMINATION FACILITY (HFEF) COMPLEX*

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MASTER

ABSTRACT

The Hot Fuel Examination Facility (HFEF) Complex[1,2] continues to provide primary postirradiation handling and examination support for the US, US/Japanese, and US/United Kingdom Liquid Metal Fast Breeder Reactor (LMFBR) fuels and materials development and reactor safety programs. For the last several years, such support has also been provided for other US nuclear programs. These include the Light Water Reactor Safety Program, the Three Mile Island No. 2 (TMI-2) reactor accident-recovery programs, the Light Water Breeder Reactor Program, the US Air Force Neutron Radiography Program, and Defense Nuclear Programs. The HFEF facilities have been refurbished and upgraded and capabilities have been added to accommodate these programs and to maintain the HFEF Complex as a world-class, state-of-the-art hot-cell complex.

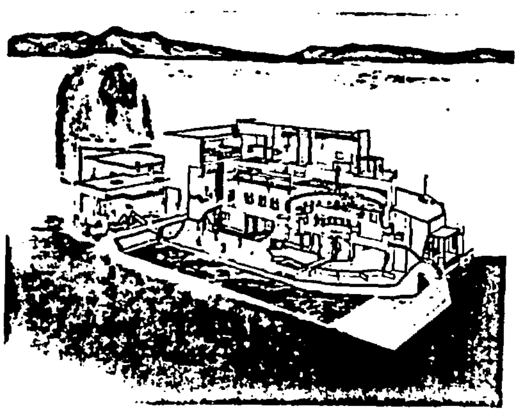

Fig. 1. Cutaway View of the Hot Fuel Examination Facility/South

*Work supported by the US Department of Energy, Reactor Systems, Development and Technology, under Contract W-31-109-Eng-38.

INTRODUCTION

The Hot Fuel Examination Facility (HFEF) Complex is located at the Argonne National Laboratory-West Site (ANL-West) of the Idaho National Engineering Laboratory (INEL). The HFEF Complex continues as one of the premier hot-cell facilities in the world for postirradiation handling and nondestructive and destructive examinations of irradiated nuclear fuels, materials, and components. The HFEF Complex is comprised of two large hot-cell facilities; HFEF/South (Fig. 1) and HFEF/North (Fig. 2). Each of these facilities has an air-atmosphere hot cell and an inert-gas (argon) atmosphere hot cell.

HFEF BASIC PROGRAM SUPPORT

For many years HFEF facilities have been utilized primarily for postirradiation handling and examination of LMFBR experiments, and for LMFBR experiments from collaborative programs by the US and the United Kingdom and Japanese, respectively. These experiments have been irradiated in the Experimental Breeder Reactor No. 2 (EBR-II) or the Transient Reactor Test Facility

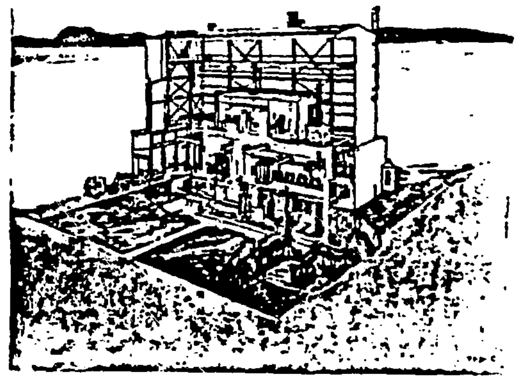

Fig. 2. Cutaway View of the Hot Fuel Examination Facility/North

(TREAT) at the ANL-West Site of the INEL, in the Fast Flux Test Facility (FFTF) at the Hanford Engineering Development Laboratory (HEDL) near Richland, Washington, or in the United Kingdom Prototype Fast Reactor (PFR) at Dounreay, Scotland. Most of these experiments have been conducted for the development of fast reactor fuels, materials, or safety.

NEW HFEF PROGRAMS SUPPORT

In recent years, the HFEF Complex has been increasingly engaged in support for other nuclear programs in addition to the basic LMFBR programs which it previously serviced almost exclusively. Its large size and versatility give HFEF unique capabilities for certain state-of-the-art remote handling and examination operations.

For EG&G-Idaho, HFEF has used its modern, unique Neutron Radiography (NRAD) Facility and systems[3,4,5] for neutron radiography, and for state-of-the-art neutron tomography of large fuel-rod bundles. These bundles are irradiated in the Power Burst Facility (PBF) at the INEL as part of the multi-nation Organization for Economic Cooperation and Development (OECD) light-water-reactor Severe-Fuel-Damage (SFD) safety-development program.

Also for EG&G-Idaho and the water-reactor program, HFEF prepared and analyzed some of the earliest metallographic samples of debris from the damaged core of the TMI-2 reactor.

For Westinghouse Electric Corp. (Bettis Atomic Power Laboratory) in support of the Light Water Breeder Reactor (LWBR) program, irradiated urania-thoria seed and blanket fuel rods from the decommissioned Shippingport, Pa., reactor were radiographed using the very high resolution neutron radiography capability available only at the HFEF NRAD facility.

Destructive examinations of the Shippingport LWBR Zircaloy-4-clad rods are now underway. These examinations include metallographic sample preparation, optical and electron microscopy, and several analytical and radiochemical analyses. Remote chemical decrudding of some of these rods, and analytical and radiochemical analyses of the crud, will begin in 1986.

Also for EG&G-Idaho and the US light water reactor program, HFEF has examined irradiated fuel rods from a Loss of Fluid Test (LOFT) light-water-reactor safety test. At HFEF, the LOFT test has been subjected to nondestructive examinations, destructive metallographic-sample preparation, and microscopy. In 1986, HFEF expects to provide neutron radiography and tomography of the irradiated central fuel module from the last of the OECD-LOFT water-reactor safety tests. This test was the most severe nuclear safety test conducted in the LOFT program, and neutron radiography tomography should provide invaluable information concerning the posttest condition of the damaged fuel module. The LOFT test program was terminated in 1985.

Neutron radiography and neutron tomography have become recognized as extremely important nondestructive postirradiation examination tests, of potential benefit to almost all nuclear irradiation research and development, and maintenance or production activities. HFEF is now applying its technical expertise and experience to assist the United States Air Force in establishing the first Air Force neutron radiography aircraft inspection facility at the McClellan Air Force Base, Sacramento, California.

RECENT HFEF FACILITY AND CAPABILITY ADDITIONS AND UPGRADES

Second Neutron Radiography Beam and Radiography Station

The original neutron radiography system in the HFEF NRAD facility is called the East Radiography Station (ERS). The ERS directs a well-collimated 4.4-m (14½-ft) long neutron beam from the east side of the HFEF 250-kW TRIGA reactor core toward specimens lowered through a penetration in the floor of the HFEF/N main cell. A second radiography station, called the North Radiography Station (NRS), has been added to the NRAD Facility (Fig. 3). The NRS directs an extremely well-collimated beam of neutrons 16.5-m (54-ft) long from the north side of the TRIGA reactor in a direction 90° from the ERS beam tube. The NRS neutron beam is directed to a newly constructed, highly shielded radiography room located in an appendage constructed at the north side of the original HFEF/N facility. This radiography room, and the specimen and radiography fuel-handling systems, can accommodate unirradiated specimens for neutron-radiography development work, as well as highly irradiated specimens for production radiography. For irradiated components, specimen elevator and specimen positioning systems enable the highly irradiated specimens to be lowered into the below-ground-level radiography room directly from their shielded shipping casks positioned at the main operating (ground) level of the NRS appendage. As a result, irradiated specimens can be introduced into the neutron radiography system, radiographed, and returned to their shielding casks without being introduced into the HFEF/N main cell. Because of the great length of the NRS collimated neutron beam, extremely high resolu-

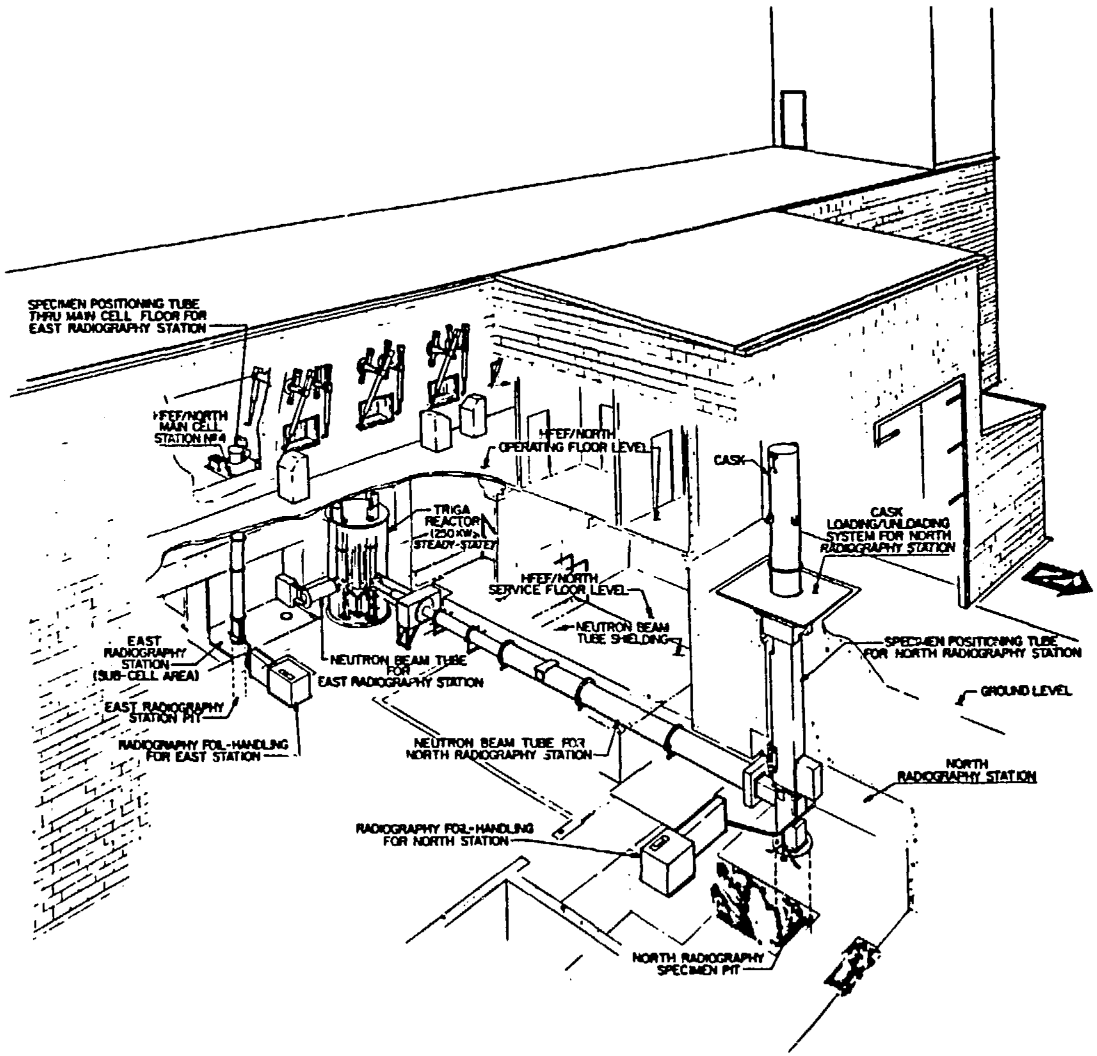

Fig. 3. Cutaway View of the HFEF Neutron Radiography Facility

tions are achieved in radiographs obtained using this system. The NRS specimen elevator and positioning systems include a precision angular-positioning device. This device rotates the test subject for multi-angle radiography. The resulting neutron radiographs are then digitized for computerized tomographic reconstruction. Such tomography now is frequently requested, especially for fuel bundles and subassemblies, and for package sodium loops. Cross-sectional views of such objects are computer reconstructed for visual examination and analyses.

Heavy Duty, Remote Milling Machine in HFEF/North Main Cell

A large, remotely controlled milling machine has markedly increased HFEF capabilities to provide precision remote machining of irradiated components. This system comprises a heavy-duty Spindle Wizard, Series 2 Machining Center,[a] complete with a General Numeric 6M CNC microprocessor remote control system (Fig. 4). Components of this modern milling machine system have been modularized insofar as practical. This modularization has proven very advantageous to machine operations, tooling and fixturing changes, and remote maintenance and repair of the in-cell machine.

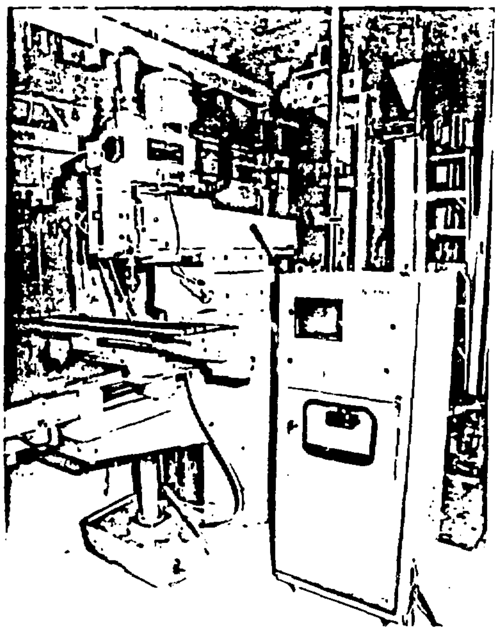

Fig. 4. Basic Spindle Wizard Series 2 Machining Center and General Numeric Microprocessor Control System before installing in the HFEF/North Main Cell

[a]Supplied by Spindle Wizard, a Division of Lesnor Maehr Mfg Corp, Farmingdale, New York 11735.

Neutron Radiograph Microdensitometer

A modern, state-of-the-art Perkin-Elmer PDS Model 1010A microdensitometer has recently been added to the HFEF/N Data Acquisition Laboratory. This microdensitometer is a computer-controlled flatbed scanning photodigitizer. It has proven extremely efficient and reliable for generating vast quantities of precisely digitized data from neutron radiographs generated in the HFEF/N NRAD Facility. Digitizing of the radiographs is necessary for computerized reconstruction of neutron tomographs.

OTHER HFEF FACILITY AND CAPABILITY ADDITIONS AND IMPROVEMENTS

Deep Pit in HFEF/N Truck Lock

A steel-lined, 9.1 m- (30-ft) deep pit (Fig. 5) has been constructed in the HFEF/N truck

Fig. 5. Deep Pit for Shielding Casks in HFEF/North Truck Lock

lock to accommodate shielding casks of various lengths. The pit is 1 m (39 in.) in diameter over the upper 4.3 m (14 ft) length and 0.3 m (12 in.) in diameter over the lower 4.9 m (16 ft) length. Consequently, shielding casks of different lengths can be positioned in this pit with their top ends at convenient working heights (Fig. 6). Use of this pit eliminates inconvenient, inefficient, and marginally safe scaffolding that was previously used to position workers for these operations.

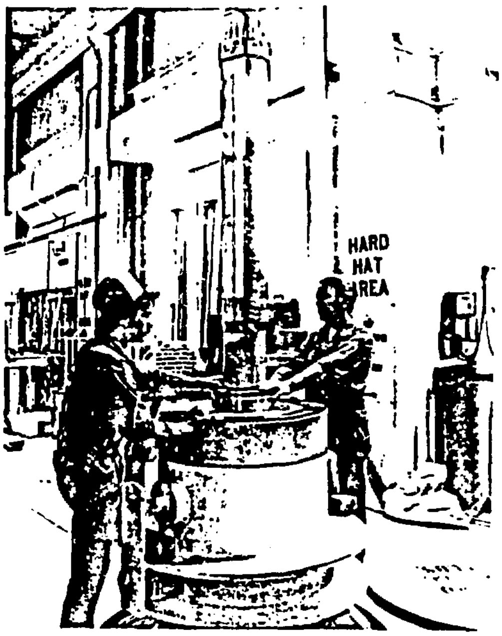

Fig. 6. Convenient Height Access to Cask Top End in Deep Pit of HFEF/North Truck Lock

CRL System 50 Master/Slave Manipulators

Seven Central Research Laboratory (CRL) System 50 gas-sealed master/slave manipulator systems[b] have recently been installed (usually individually--not in pairs) at selected work stations of the HFEF/N main cell. The ruggedness and higher-capacity of the System 50 manipulators have substantially improved operational effectiveness and efficiency. They also have markedly reduced the frequency of maintenance and repair required when lighter-duty, gas-sealed, CRL Model J master/slave manipulators were used at these heavy-duty work stations. To continue HFEF's established (and very successful) practice of repairing and maintaining sealed master/slave manipulator slave-ends only in gloveboxes, an extension has been added to the HFEF/N manipulator repair glovebox in the HFEF/N high bay. This extension allows complete overhaul, maintenance, and repair of the large System 50 manipulator slave-ends with methods used on the smaller CRL Model J, Model A, and Model L manipulators used in the HFEF facilities.

[b]Manufactured by Central Research Laboratories, a Division of Sargent Industries, Red Wing, Minnesota 55066.

HFEF/S Fixed-air Sampling System

A fixed air-sampling system, similar to the system in HFEF/N,[6] has been installed and activated in HFEF/S. This passive system (Fig. 7) has 68 air-sampling heads monitoring the facility out-of-cells atmosphere with sensitivity several orders of magnitude beyond that of the portable alpha and beta/gamma constant air monitors deployed throughout the facilities.

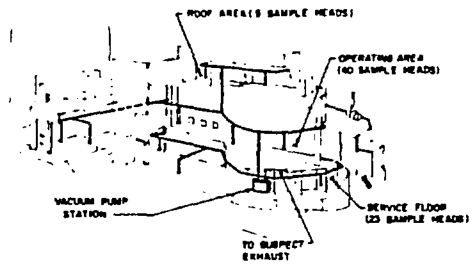

Fig. 7. Illustration of HFEF/South Fixed-air Sampling System

Load Capacity Increase for Overhead Electromechanical Manipulators

Since initial operation of the HFEF facilities (HFEF/S in 1964, HFEF/N in 1975), the load-carrying capacity of all 10 bridge-type, overhead electromechanical manipulators has been 340 kg (750 lb). Design changes in the grip units now allow these power manipulators to safely provide 907 kg (2000 lb) load-lifting capacity. This increase significantly improves the versatility of these very important in-cell overhead handling systems.

HFEF/S Argon Cell Refurbishment[7,8] and Air Cell Repair

Remote and contact decontamination of the HFEF/S argon cell was completed in 1983, and the two 4.5-t (5-ton) capacity bridge cranes were refurbished. Two of six overhead-bridge electromechanical manipulators were removed from the argon cell, and the remaining four were completely refurbished. New remotely removable/repairable, redundant, bridge-drive systems were added to each electromechanical manipulator. The mercury-vapor lamps in the HFEF/S argon cell were replaced with improved units like those used in HFEF/N. In addition, the in-cell glass slabs of the hot-cell viewing windows were carefully cleaned and repaired, and an argon-gas blanketing system was installed to protect the window oil systems and glass-slab interfaces from moisture and chemical reactions. The hot-cell argon-gas circulation and purification systems were completely overhauled. Refurbished, this large cell (Fig. 8) is now ready to support new DOE programs when and as required. Currently, the hot cell is expected to become a key facility for remote reprocessing and refabrication of EBR-II uranium/plutonium/zirconium-alloy metal fuel as a part of the Argonne Integral Fast Reactor (IFR) Program initiative.

Fig. 8. View of the Interior of the Refurbished HFEF/South Argon Cell

HFEF/S Air Cell Refurbishment

The overhead bridge crane and the two electromechanical manipulator systems in the HFEF/S air cell also were refurbished in 1983. The in-cell, glass slab sections of the shielding windows in the air cell were carefully cleaned and repaired, and an argon cover-gas system was installed for protection of the window oil systems and glass slab interfaces. The cooling system for the in-cell subassembly floor-storage pits, and the cell ventilation system, also were significantly improved.

EBR-II Blanket Subassemblies Remote Retrieval from In-ground Storage

In 1985, HFEF completed a two-year activity for the remote recovery of some 300 irradiated EBR-II radial blanket subassemblies from in-ground storage caissons in the ANL-West Radioactive Scrap and Waste Facility (RSWF). These operations required remote retrieval of the subassemblies from their storage holes using specialized remote-handling and viewing devices designed and fabricated for this activity. The subassemblies were transferred in shielding casks to the HFEF/S air cell for positive identification and verification of their physical condition. The subassemblies were then remotely packaged in-cell and shipped to the Rocketdyne hot-cell facilities in Canoga Park, California. There the subassemblies will be remotely handled and processed so the fissile material can subsequently be used for other DOE programs.

Sodium Waste Processing Demonstration

Radioactive solid wastes present special storage and disposal problems in the US nuclear programs. As part of the DOE Sodium Waste Technology Program for developing and demonstrating techniques for removing sodium from prototypical nuclear solid wastes and components, HFEF operated a sodium process demonstration facility (SPD) at ANL-West. Unirradiated components were used in these activities. This program is expected to be resumed in the future as the necessity for properly processing sodium-contaminated radioactive wastes becomes even more evident to the nuclear industry.

Irradiated Element Spacer-wire Removal and Rewrapping Capability

Because profilometry (diameter measurements) of irradiated fuel elements and material capsules has become an increasingly important requirement in many LMFBR experimental irradiations programs, HFEF has added a new remote wire-rewrapping machine. This machine (Fig. 9) is installed at Station No. 8 in the HFEF/N main cell to enable axial profilometry, rather than spiral profilometry only, of the experimental irradiations. It remotely removes from irradiated elements by shearing the wire-to-cladding welds at the top and bottom extremities of the elements. Following axial profilometry of the wireless elements, the wire-wrapping system spirally forms new spacer wires to the elements at specified spacing pitches, and remotely rewelds the wire to the top and bottom end-plugs. The tungsten inert gas (argon gas) welding method is used in a fillet weld configuration. Following inspections of the weld, the rewound elements are normally used in subassemblies remotely reconstituted at HFEF for additional irradiation in EBR-II.

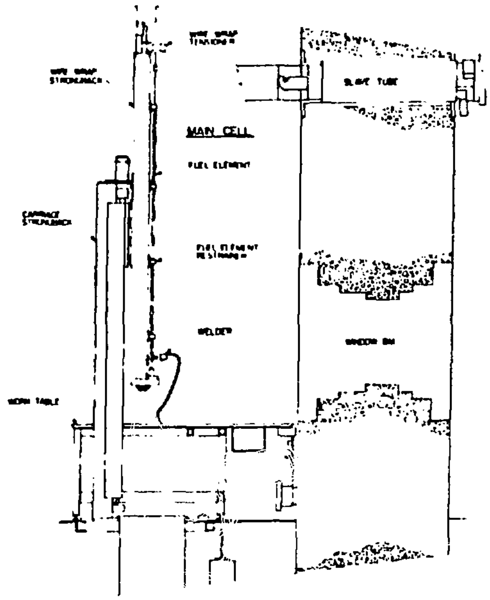

Fig. 9. Irradiated Element Spacer Wire Wrapping Machine

Figure 10 presents a plan view diagram of the current layout of the HFEF/N hot-cell capabilities for postirradiation handling and examination activities.

SUMMARY

In addition to providing the principal postirradiation examination support for United States, US/United Kingdom, and US/Japanese LMFBR programs, the HFEF Complex is broadening its role by supporting other US nuclear programs. To date these programs have included Light Water Reactor safety programs, the Light Water Breeder Reactor program, defense materials-related nuclear programs, and neutron radiography technical support to the United States Air Force.

As a versatile national asset, HFEF expects to continue broadening its involvement in these and other domestic (and possibly foreign) nuclear programs. To support the proposed ANL Integral Fast Reactor program and the above-mentioned diversified programs, additions have been made to the HFEF facilities, and HFEF capabilities have been upgraded. Such improvements are expected to continue so the HFEF Complex can be maintained as a world-class, state-of-the-art, hot-cell facility.

REFERENCES

1. J. P. Bacca, "Postirradiation Handling and Examination at the HFEF Complex", Proc. of Conf. on Postirradiation Examination, May 1980, British Nuclear Energy Society, London, 193 (1981).

2. J. P. Bacca, "History and Status of the Hot Fuel Examination Facility Complex", Proc. 27th Conf. Remote Syst. Technol., 10 (1979).

3. G. C. McClellan and W. J. Richards, "Neutron Radiography at the NRAD Facility", Ninth Biennial U.S. TRIGA Users' Conference, Papers and Abstracts, 1-45, 1984.

4. G. C. McClellan and W. J. Richards, "Neutron Radiography Applications and Techniques at the Hot Fuel Examination Facility", Proceedings of the First World Conference on Neutron Radiography, edited by John P. Barton, D. Reidel Publishing Company, Dordrecht, Holland, 437 (1983).

5. W. J. Richards and G. C. McClellan, "Neutron Radiography at the Hot Fuel Examination Facility", Proc. 27th Conf. Remote Syst. Technol., 203 (1979).

7. J. C. Courtney, et al., "Air Sampling System at the Hot Fuel Examination Facility/North", Proc. 25th Conf. Remote Syst. Technol., 21 (1977).

7. J. P. Bacca, et al., "Decontamination and Refurbishment of the Hot Fuel Examination Facility/South (HFEF/S) Argon Cell", Decontamination and Decommissioning of Nuclear Facilities, Edited by Marilyn M. Osterhout, Plenum Press, New York, 215 (1980).

8. M. F. Huebner, et al., "Hot Fuel Examination Facility/South Argon Cell Decontamination and Refurbishment", Proc. 29th Conf. Remote Syst. Technol., 58 (1981).

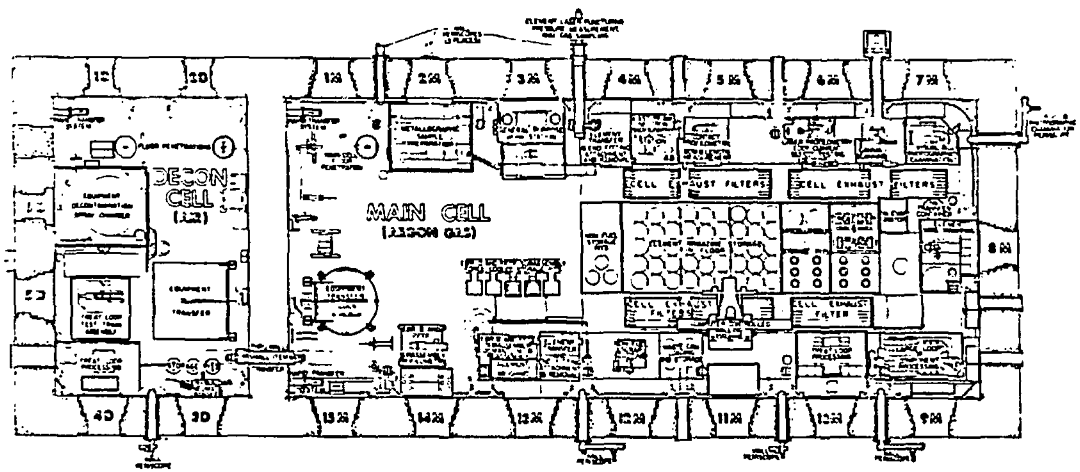

Fig. 10. Plan View of Current Capability Layout in HFEF/North Hot Cells