THE REMOTE OPERATION AND MAINTENANCE
DEMONSTRATION FACILITY AT ORNL

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REMOTE OPERATION AND MAINTENANCE DEMONSTRATION
The Remote Operation and Maintenance Facility is a versatile facility arranged to mock-up various hot-cell configurations. Modular units of simulated shielding and viewing windows were built to provide flexibility in arrangement. The facility is fully equipped with hoists, manipulators, television, and the other basic equipment and services necessary to provide capability for both remote operation and maintenance of several selected functional process equipment groups.
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INTRODUCTION

The Remote Operation and Maintenance Demonstration (ROMD) is one of the three major components of the Integrated Equipment Test (IET) project at Oak Ridge National Laboratory (ORNL). This project is a major phase of the Advanced Fuel Recycle Program (ARFP). Its objective is to develop technology for reprocessing advanced nuclear fuels. The IET (Fig. 1) consists of the design and construction of modifications and additions to the Advanced Fuel Recycle Facility that will provide an experimental engineering laboratory where testing on a pilot-plant scale of cold (unirradiated) systems can be performed, where the character of process equipment streams can be established, and where remote handling and maintenance procedures for reprocessing equipment can be developed. The ROMD provides the facilities and equipment necessary to accomplish a wide variety of planned demonstrations, to develop remote handling philosophy and equipment, and to provide a training area for design and operations personnel. The IET also includes structural modifications, utility system expansions, and the Integrated Process Demonstration (IPD). The IPD is an area in which specific pieces of process equipment that have evolved from development efforts can be joined together and operated as an integrated system.

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Fig. 1. The Integrated Equipment Test Project of the Advanced Fuel Recycling Plant at Oak Ridge National Laboratory.
The IET operation and experience are precursors to the design of the AFRP Hot Experimental Facility (HEF). When the HEF design is complete, the IET (primarily the ROMD section) will be modified to simulate portions of the HEF and will, within its lifetime, be used as a cold mock-up area for some of the HEF preinsertion tests and operations. Because of this dual role, a maximum of flexibility is incorporated in the ROMD design.

GOALS AND OBJECTIVES

Incorporated in the design and fabrication of ROMD are provisions for the following.

- The capability, equipment, and facilities to remotely maintain process equipment.
- The necessary equipment for the remote operation and maintenance of sampling stations and in-cell analytical tasks, as well as for the facilities for the removal of samples from the process cell.
- The equipment and facilities to diagnose equipment failures and to remotely inspect defective component parts.
- The methods and equipment consistent with process maintenance philosophy for performing maintenance on ROMD equipment.
- A demonstration of the preceding that supplies qualitative data for the engineering evaluation of on-stream efficiencies of a remotely operated and maintained radiochemical processing plant.
• Facility equipment that is designed for a minimum service life of ten years.
• A facility for the training of design and operations personnel for the HEF.

Because IET is a line-item funded project, ROMD is restricted from utilizing these funds for the development of equipment. All equipment purchased for ROMD shall be considered to be off-the-shelf, state-of-the-art hardware. After its completion and qualification, ROMD will be used by the other functional groups of AFRP (Fig. 2) for the upgrading of state-of-the-art equipment. Continuous hardware upgrading and testing has been, and will continue to be, undertaken to develop new innovative equipment and techniques for ROMD.

FACILITY DESCRIPTION

The ROMD facility modifications to Building 7602 consist of the demolition and renovation of the existing high bay and pit area. This is necessary to accommodate a simulated hot cell and its associated remote handling and ancillary equipment (Fig. 3). At the ground floor or grade level, an area approximately 18.3 m x 20.1 m (60 ft x 66 ft) is available to be used for equipment placement and operation. The existing roof over this area is being raised 7.6 m (25 ft) in order to accommodate the various required overhead-handling hardware. The raising of the building roof will allow an approximate 23.8-m (78 ft) lifting height in the ROMD pit area and a
14.6-m (48-ft) lifting height in the surrounding ground floor area. The pit is 7.6 m (25 ft) wide by 12.8 m (42 ft) long and will allow the simulation of canyon-type equipment stacking and placement. Approximately half-way down the pit is a mezzanine area that currently is intended for use as an operating and control gallery.

A storage building of approximately 53 m$^2$ (570 ft$^2$) will be constructed adjacent to the truck door.

EQUIPMENT DESCRIPTION

The key to successful accomplishment of the functional criteria for the ROMD will be in the capabilities of remote handling and ancillary equipment (Fig. 4).

Specific equipment now being designed or fabricated for the ROMD includes:

- two 18 Mg (20 ton) gantry bridges,
- two 9 Mg (10 ton) trolley hoists,
- two 900 kg (1 ton) telescoping tube trolley hoists,
- a wall-mounted vertical bridge trolley and boom,
- two 180 kg (400 lb) articulated arms,
- an integrated control system,
- a ten-camera television system,
- a television camera positioning trolley and boom,
- five master/slave (M/S) manipulators,
- simulated shielding, and
- ancillary equipment.
Gantry bridges

Two gantry bridges, each having a capacity of 18 Mg (20 tons), are being fabricated. The primary or high gantry will have a vertical leg of 8.2 m (27 ft) and a span of 18 m (59 ft). It will operate only in the raised roof portion of ROMD and have a run of 20.1 m (66 ft).

The secondary or low gantry will have a vertical leg of 2.1 m (7 ft) and a span of 16.8 m (55 ft). It will normally operate in the raised roof portion of ROMD with a run of approximately 20.1 m (66 ft); however, the capability to expand the operating area to include the adjacent component development area is an easily achieved future option.

Both bridges are designed with similar rails and gauges in order to allow for the interchange of the hoist and telescoping tube trolleys. The bridges are designed so that a trolley can be remotely raised 15.24 cm (6 in.) above the trolley rails, rotated 90°, and then lowered between the main beams of the bridge. The bridges are powered by dc-drive motors capable of providing continuous variable speed in the range of $0.254 \times 10^{-3}$ to $254 \times 10^{-3}$ m/s (0.5 to 50 fpm). Both power and control for the operation of the bridges are conducted to the bridges via enclosed contact runways (bus bars).

Trolley hoist system

Two 9-Mg (10-ton) capacity, independently controlled trolley hoists will be supplied. The trolley hoists initially will operate on the primary gantry bridge, but will be designed to
also operate on the secondary bridge, if the need arises in the future. The trolleys will use dc motors and have a continuously variable speed in the range of $0.254 \times 10^{-3}$ to $254 \times 10^{-3}$ m/s (0.5 to 50 fpm). The hoists will be double-reaveled cable units with a vertical lift capability of 24.4 m (80 ft). The hoist speed will be continuously variable in the range of $0.254 \times 10^{-3}$ to $152 \times 10^{-3}$ m/s (0.5 to 30 fpm). The hoist hook will provide continuously variable rotation in both directions and have an electrical receptacle for power tools.

Limited remote maintenance capability on the trolley hoists will be provided in the form of remote removal and replacement of the entire unit from and to the gantry bridges and of the drive motors and gear boxes from and to the trolley hoists.

Power control wiring of the units will be conveyed through a combination continuous cable reel and constant tension cable handling device.

Telescoping tube system

Two 9-Mg (10-ton) capacity, independently controlled trolleys will be supplied. These will be identical to the hoist trolleys except that each will have a 900 kg (1-ton) vertical lift capacity telescoping tube mounted in place of the 9-Mg (10-ton) hoist. Each tube will provide a minimum of 7.6 m (25 ft) vertical travel of the lower tube end and a continuously variable speed in the range of $0.254 \times 10^{-3}$ to $152 \times 10^{-3}$ m/s (0.5 to 30 fpm). The lower tube end will provide a remotely operable mechanical and electrical coupling that will accommodate either an articulated arm (180 kg capacity) or a rotatable dual hook (900 kg capacity).
The same limited remote maintenance features of the hoist system are to be employed in this system, that is, removable from gantry and removable gearboxes and motors.

Power and control wiring for these units will be conveyed through a combination power track and constant tension cable handling device.

Wall-mounted system

This system consists of a pair of rails mounted to the floor and the upper edge of the ROMD pit forming a U-shaped track on which is mounted a vertical bridge with a height of approximately 9.2 m (30 ft). The bridge-mounted trolley/boom has a minimum vertical travel of 7.6 m (25 ft) and the capacity to lift an articulated arm, loaded with 68 kg (150 lb), to its-fully extended position. A reach of approximately 4.6 m (15 ft) from the pit wall is attained via a 1.8 m (6 ft) boom. The bridge and trolley drives are dc powered with continuously variable speeds in the range of $0.254 \times 10^{-3}$ to $254 \times 10^{-3}$ m/s (0.5 to 50 fpm). The motions of the boom are continuously variable in the swing and tilt modes in the range of 0.001 to 0.016 rps (0.05 to 1 rpm).

Power and control wiring for this system will be conducted via a festoon cable system.

Articulated arms

Two independently controlled, 180-kg (400-lb) capacity articulated arms (AA) with the following controlled functions will be provided.
• Shoulder rotation,
• shoulder pivot,
• elbow pivot,
• wrist pivot,
• wrist extension,
• wrist rotate,
• parallel jaw hand,
• shoulder load hook, and
• tool power receptacle.

All controlled functions are dc powered and have continuously variable speeds over their functional ranges. The articulated arms will be totally, remotely, mechanically, and electrically removable from and replaceable to either the lower tip of the telescoping tube systems or the vertical bridge boom. Single- and dual-hook hands that are remotely interchangeable with the standard parallel jaw hand are to be provided. The manipulator is internally geared, wired, and totally sealed for washdown and decontamination.

**TV viewing system**

The ROMD operation is enhanced by a multicamera (10)- and multimonitor (12)-TV system with switching capabilities which enable the monitoring of any camera from several locations. All camera operations are controlled from either the master control station or selected remote stations.

Ten cameras are used in the facility — one portable, tripod-mounted unit and nine hard-mounted units. All cameras are equipped with pan and tilt capability. Three of the cameras provided will have high resolution (> 1000 line) black and white capability, size will be standard resolution black and white, and one will
be standard resolution color. Provisions have been made for the interchange of cameras between various locations to optimize their usage, depending on the specific operation being performed.

Twelve 53-cm (21-in.) TV monitors are planned for the facility. Eight will be located at the master control station, two will be located in the IET control room, and the other two will be portable units available for operation around the cell complex. A complex switching system (previously mentioned) will allow any of the monitors to "call up" the view as seen by any of the cameras.

**TV positioning unit**

A trolley-mounted, telescoping tube, articulated TV camera platform is being provided. This unit will be of similar basic design as the aforementioned telescoping units, except that its load carrying requirements will be revised to handle two TV cameras rather than handling an AA or dual hook. The system will provide ROMD with a pair of mobile eyes virtually anywhere in the facility.

**Integrated control system**

The ROMD remote handling and TV viewing systems will be controlled and monitored from a master control station. This station will be located on the mezzanine level of the ROMD facility and will provide the base for all remote handling activities. Adjacent to the master control console will be a patch panel. This panel will allow control of any of the remote systems to be transferred from the master console to any one of five portable consoles, which can be used at various locations in and around the cell.
All power and control center cabinetry will be located directly below the master control station in a virtually unusable portion of the ROMD pit. Convenient access to this area is provided by the addition of a floor hatch and ladder.

Simulated shielding

A highly flexible and versatile system of simulated shielding wall modules provides the illusion of isolation that is necessary to demonstrate true remote operation. These modules are easily movable and come in several sizes based on the current planned preliminary equipment demonstration. The modules are basically rectangular frames with sheet metal (aluminum) skins on the in-cell and out-of-cell sides of the frame. The units provide a wall 3-m (10-ft) high and 66-cm (26-in.) thick with the width varying from 76 cm (2 ft 6 in.) to 3 m (10 ft), depending on the specific module. Selected modules provide simulated shielding windows, M/S-manipulator work stations, periscope ports, and through-wall transfer capabilities.

Master/slave manipulators

Five M/S manipulators are being provided for those operations requiring high-dexterity manipulation. Three Central Research Laboratory (CRL) model F, rugged-duty, extended-reach units and two of the new CRL system 50 manipulators have been selected for ROMD.

Periscope

A scanning, precision optical, through-wall periscope will be located at one of the manipulator work stations to provide the photographic and visual capabilities necessary for a simulated inspection/work station.
Ancillary equipment

A variety of auxiliary support equipment, such as a lighting system and horizontal and vertical transfer systems, is being designed and fabricated for inclusion in the facility.

STATUS

The IET project is currently in the Title II design phase and is actively involved with advanced procurement of long lead-time equipment items (Fig. 5). Beneficial occupancy of the facility is projected for late 1980, and testing is scheduled to begin by the end of 1981.

Efforts are now being directed toward the detailed development of various operating philosophies, procedures, and plans for the currently envisioned demonstrations. Four cell arrangements are now contemplated, although others will eventually be required. The defined cell arrangements include a maintenance cell, a mechanical head-end cell (Fig. 6), a chemical cell, and a metallic-waste-disposal cell. Equipment for these demonstrations is being designed and developed in other segments of the program.
REFERENCES:


FIGURE CAPTION

Fig. 1 The Advanced Fuel Recycle Program Complex at Oak Ridge National Laboratory

Fig. 2 Integrated Equipment Test Interfaces

Fig. 3 AFRP Facility

Fig. 4 Remote Operation and Maintenance Facility

Fig. 5 Integrated Remote Handling System

Fig. 6 Head-End Demonstration