

MAINTENANCE OF A HIGH ACTIVITY LEVEL REPROCESSING CELL IN THE  
MARCOULE PILOT PLANT BY MEAN OF A MA23 ELECTRONIC TELEMANIPULATOR

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Communication présentée à : European Nuclear Conference '90

Lyon (FR)  
23-28 Sep 1990

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Keywords : remote maintenance  
robotic systems  
maintenance of reprocessing cell  
optical fiber transmission

## 1. Introduction

The Marcoule Pilot Facility (APM) is used to test reprocessing methods and equipment under actual operating conditions with spent fuel at semi-industrial throughput rates and during demonstration runs of significant duration.

In addition to the general objective of continuous long-term operation, the facility is also used for radioactive testing and qualification of specific process equipment items for planned or future reprocessing plants. This pilot function covers not only process operations but also other areas including remote manipulation.

A remote manipulation system using an MA23 M electronic telemanipulator will be submitted to qualification testing in this way under actual operating conditions exposed to high irradiation levels together with numerous mechanical devices.

## 2. Description of cell and telemanipulator

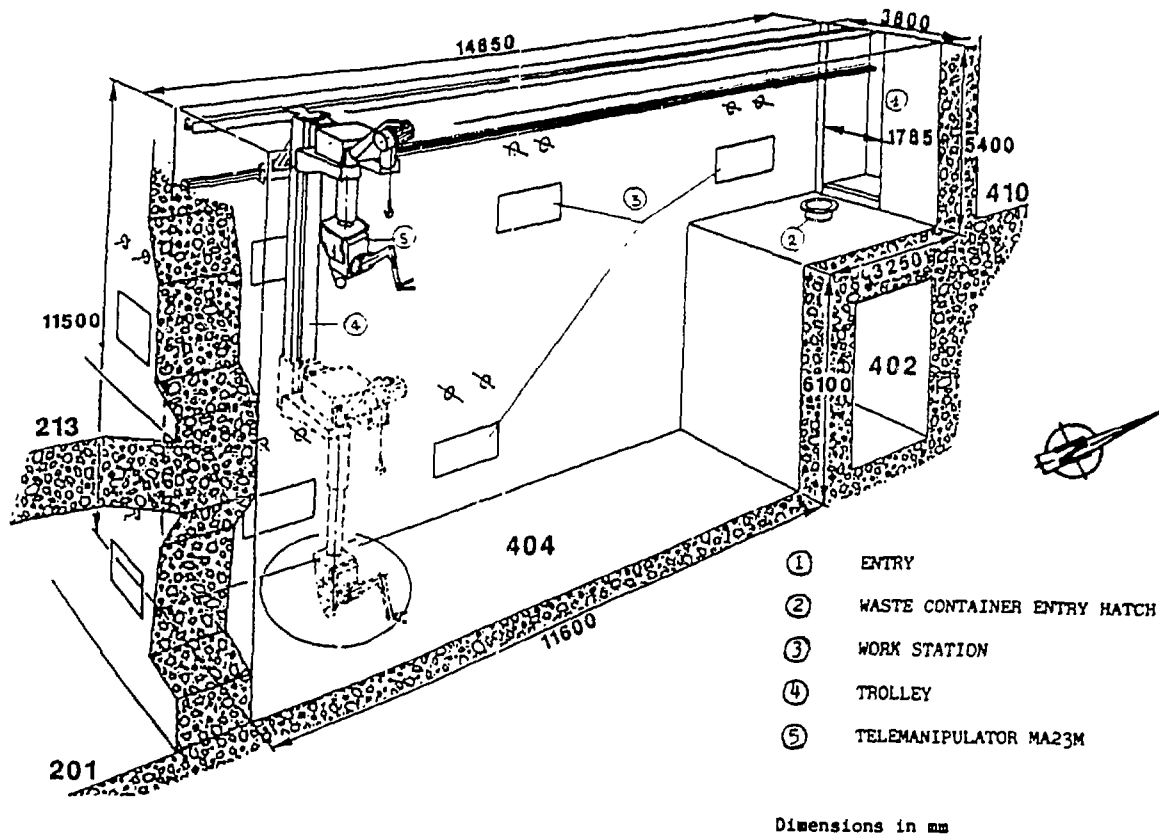
### 2.1. Reprocessing cell 404

Cell 404 is an R and D cell in which process equipment is now being installed to condition melted fuel pin structural wastes (hulls and spacer wires).

A number of factors dictate the design criteria and materials used for handling equipment in reprocessing cells :

- specifically nuclear hazards :
  - . contamination
  - . irradiation, which requires the use of special components including hardened electronic circuits : integrated dose of  $1.3 \cdot 10^6$  Gy ( $1.3 \times 10^8$  rad) due to  $^{60}\text{Co}$  equipment radiation for 6 months annual presence in cell.
- hazards related to the use of process and decontamination reagents such as  $\text{HNO}_3$  requiring the use of corrosion resistant materials.
- high temperatures that may be detrimental to electronic circuits : up to  $50^\circ\text{C}$ .
- electromagnetic environment due to induction furnace : 300 KW at 10 KHz.

- geometric constraints for subassemblies in radioactive zones, imposed by dimensional standards for cell entry or transfer provisions.



## MARCOULE PILOT REPROCESSING PLANT. CELL. 404

Cell 404 is devoted to melting structural wastes (hulls and end-caps of irradiated fuel pins).

This view shows cell 404 with its remote manipulation equipment but without its process equipment.

This process equipment will stand mostly on the cell floor close to the east wall.

Remote manipulation equipment MA23M will have access to most of the cell (inaccessible zone is situated at the top of the cell).

### 2.2. Remote manipulation equipment in cell 404

The following remote manipulation equipment was initially planned for cell 404 :

- Mechanical master-slave remote telemanipulators with small travel ranges.
- Modular remote manipulators used with a single trolley : a hoist (module 1) with a 2000 daN capacity, and a heavy manipulator ACB type 2100 AE (module 2) capable of hoisting 90 or 25 daN together with a 1000 daN hoist.
- Module MA23 M (module 3)  
 The fundamental option is to ensure simply interchangeability of the MA23 M module and the hoist or the heavy telemanipulator on the trolley.

Control signals are transmitted to the MA23 M by an optical cable at the rate of 3.5 M bauds ; this cable is connected by mechanical master-slave manipulators when the MA23 M module is installed in the cell.

Audio and video signals from the cameras mounted on the module are transmitted over a radiofrequency link in the 10 GHz band.

### 2.3. Use of remote manipulator equipment

Process-related mechanical operations are systematically automated. Remote manipulation devices are therefore used in the cell for the following type of ancillary operations :

- . load handling (wastes, flux, machining scraps, solid samples, seal-weld baskets, ingot containers)
- . process equipment servicing (scheduled maintenance or repairs)
- . periodic replacement of cell and process filters, lamps, slave arms on master-slave telemanipulators

The MA23 M module will be used for operations now performed with mechanical master-slave telemanipulators (tong handling capacity approximately 20 daN) as well as for operations now performed with the heavy telemanipulator for which the master-slave units do not have sufficient mobility or load-carrying capacity. The MA23 M allows a higher tong load and greater mobility, and can be coupled with a hoist.

## 3. Module MA23 M

### 3.1. Description

The MA23 M telemanipulator comprises four major separable component subassemblies :

- the slave arm, which executes operator commands in hostile environments
- the master arm, accessible to the operator
- the electronic control circuitry
- the signal transmission system between the manipulator arms and control circuitry

The slave arm, in the cell, is installed on a module support (sliding carriage) that allows the operator to gain access to the entire cell volume and to place the slave arm in the best position for each task.

A camera mounted on the telemanipulator and fitted to follow tong's movements and a second camera mounted on the telemanipulator's support provide the operator with a field of view corresponding at all times to the nature of the task.

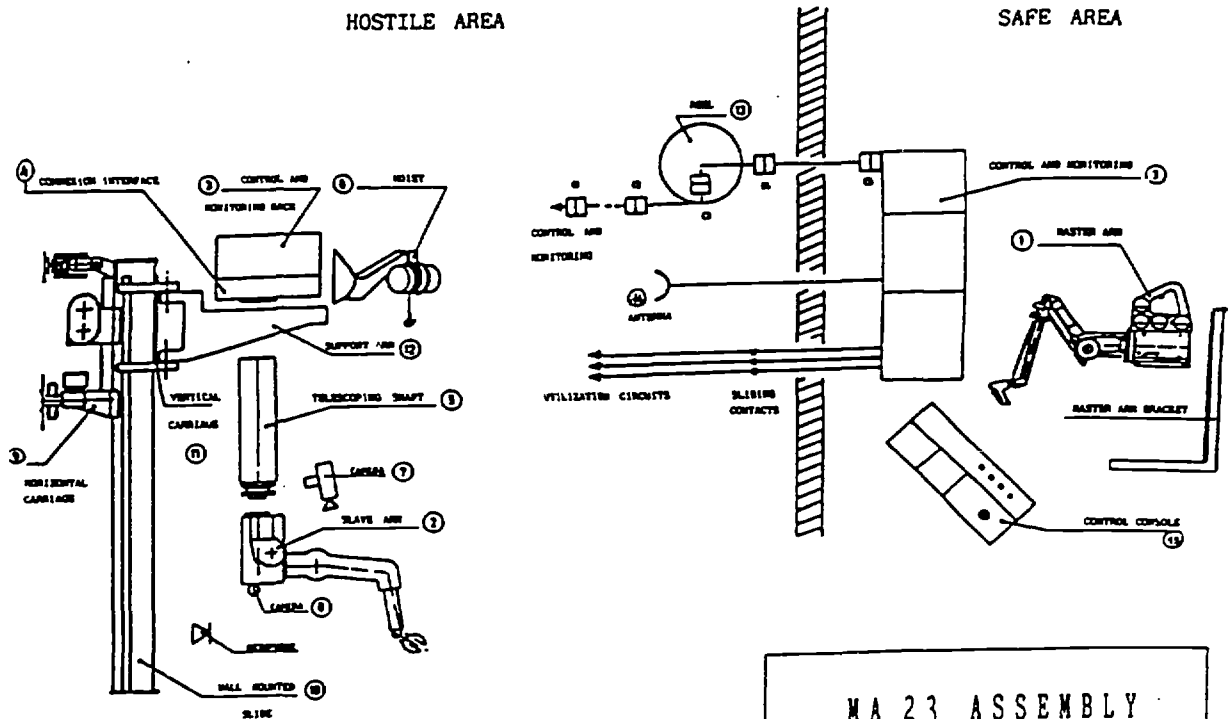
Although the MA23 M telemanipulator on its carrier provides both good dexterity and a large field of action, it does not have the power required to handle heavy loads and will therefore be equipped with a hoisting device mounted on the same carrier.

### 3.2. Improvement of MA23 M

In order to adapt the MA23 M system to the environmental conditions of the cell various improvements were developed.

- For the mechanical components the R and D effort focused on the innovative tong-toggle joint and on analysing the stresses exerted on the cables, bands and pulleys.
- For greater mobility with fewer wired links the MA23 M implements multiplexed digital control and monitoring links with slave feedback control loops relocated outside the active zone whenever possible to minimize the electronic circuitry inside the cell. Digital dates and command signals controlling the slave arm and the tong monitoring camera will be transmitted via optical cable to ensure maximum immunity to external interference from irradiation or electromagnetic fields.

Radiofrequency transmission studies for the audio and video signals led to the development of transmitter-receiver systems and transmission antennas operating at frequencies of 11 and 11.25 GHz.



MA 23 ASSEMBLY  
SCHEMATIC DIAGRAM

This schematic diagram shows

- in hostile area :
  - the slave arm (2) on its support with its cameras (7) and (8)
  - the electronic rack in hostile area (3)
  - the reel (13) of the optical cable for exchange of control and monitoring informations
  - the antenna (14) for reception of audio and video signals
- in safe area :
  - the master arm (1)
  - the control console (15)

#### 4. Qualification of the MA23 M module under active conditions

During the radioactive operating phase the in-cell time and actual operating time will be logged (with an hour-meter actuated when power is supplied to the electronic circuits). The operating time will be itemized according to the type or category of work performed, with recorded load ranges, spatial locations, etc.

Incidents and downtime will also be inventoried, with identification of the defective unit (trolley or module) and type of fault condition (mechanical, electrical or electronic). For the MA23 M module, incidents compatible with in situ repair will be distinguished from those requiring decontamination, removal of the telemanipulator and repair in a maintenance glove box.

The operating experience thus acquired will provide important information for enhancing the overall electrical, electronic and mechanical reliability. Close attention will be paid to ensure that the module and trolley control & monitoring circuits do not interfere with each other, and are unaffected by electromagnetic radiation from the induction furnace. Module safety functions, slave arm and electronic unit containment provisions and fail-safe monitoring provisions (e.g. a "dead-man" system to prevent tong opening in case of a slave arm power failure or operator fault) will also be verified.

The integrated dose rates will be measured in the electronic units mounted on the trolley and on the MA23 M module.

#### 5. Conclusion

By virtue of the process implemented and the severe environmental constraints, cell 404 will constitute a perfect test facility representative of future plant operating conditions for a remote manipulation system such as the MA23 M.

Operation under radioactive conditions will qualify the design options, assess its work potential and capabilities for ensuring reprocessing equipment maintenance, and evaluate new operating working conditions.