# 3. MTR Fuel Inspection at CERCA

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## ABSTRACT

The stringent specifications for MTR fuel plates and fuel elements require various sophisticated inspection techniques. In particular, the development of low enriched silicide fuels made it necessary to adapt these techniques to high density plates. This paper presents the status of inspection technology at CERCA.

## INTRODUCTION

Our presentations at the various meetings about MTR fuel have been mainly focused on the development work carried out in the field of fuel fabrication. In parallel to this work, an intensive program for improvement of inspection methods was also conducted over the past years. This program aimed at four goals :

- adapt the methods to LEU, high density fuel plates by designing new equipments.
- improve the quality of inspection by modernization of tools and machines.
- increase the efficiency and reliability of inspection by computerization of equipments.
- bring inspection closer to fabrication by "on line" inspection whenever possible.

The purpose of this paper is to present the to-day status of inspection techniques at CERCA. We shall successively examine how the four above mentioned goals have been reached.

## 1- ADAPTATION OF INSPECTION METHODS TO LEU FUELS :

High density, low enriched fuel plates contain five times as much uranium as the high enriched ones.
Slide 1 shows the main fields where inspection techniques had to get adapted to this increase in uranium loading.

### 1.1 Computerized weighing system

The five fold increase in the uranium density made the classical gamma counting method for U-235 content determination in fuel cores inappropriate any more mainly due to the higher self shielding effect in the high density cores.
A fully computerized weighing system was developed [1]. The computer network controls the weighing operations and records the weights of the powders fractions which are mixed before compaction of fuel cores. The dimensions and weights of pressed cores are also recorded and checked. This allows the calculation of the total U and $U_{235}$ contents for each core. This prevents from any weighing mistake : data cannot be put into the computer if the weights do not meet the customer's requirements.

This system has been operating since 1988. It was recently connected to the main plant computer so that the data it generates are automatically taken into account by uranium accountancy.

### 1.2 Specially designed UT machine

Increasing the core density also resulted in the appearance of false defects called the "core edge effect" (1) during ultrasonic inspection. UT machines are used to screen each fuel plate to reveal and to point out any decohesion between the cladding and the core of the fuel plate.

The difference of densities between the core and the aluminium edge of the plate led the previous UT machine to image the core edge as a decohesion defect. CERCA designed a unique UT testing equipment which takes into account this phenomenon.

Only real defects, if any, are detected, located and measured. This equipement has been routinely used for silicide fuels since 1988.

### 1.3 Fuel plates enrichment checking equipment

Finally, when developing the manufacture of low enriched fuel in the same facility as for high enriched fuel, CERCA took into account the risk of mistakenly mixing fuel cores of different enrichments despite a full identification and

traceability program was applied. In order to make sure that no mistake had occured at any step of the fabrication process, it was decided to carry out an enrichment inspection on the finished fuel plates.

An equipment based upon gamma ray spectrometry was designed and operated since 1984 (1). No customer's specifications ask for this inspection. It is carried out as part of our internal checks.

## 2- IMPROVEMENT OF THE QUALITY OF INSPECTION.

In addition to designing new equipments adapted to LEU fuels, CERCA improved the quality of its inspection by standardization and modernization of its equipments.

A few examples of modernization can be mentioned :

### 2.1 Surface defects inspection

. In order to detect tiny defects on the surface of fuel plates, operators must work in good lighting conditions. Therefore, illumination of the inspection room was carefully studied in terms of light spectrum and quantity of light to be used. An artificial daylight spectrum was selected which presents two advantages : a good visual comfort for operators which minimizes eyestrain and constant lighting conditions independent from the variations due to the weather or the time of the day encountered with natural daylight.
Other important details such as the choice of colours were also of importance and treated accordingly.

. The measurement of surface defects depth used to be carried out by light section microscope. New microscopes equiped with TV camera and using a different measurement principle were installed which allow to have a much easier and more accurate depth measurement.

### 2.2 Micrographic inspection

. The optical microscopes have been equiped with video systems delivering instant, high accuracy pictures and tapes.

. The cladding thickness measuring device was equiped with TV camera and semi automatic measuring system.

## 3- ON LINE INSPECTION.

It is generally desirable that inspection take place simultaneously or immediately after the fabrication operation. By such "on line" inspection, the operator is kept informed of the result of his work and can bring the necessary corrections in case of need.

Whenever possible, we are applying this principle to our production line. One good example of such an application is the computer assisted weighing system previously described.

Another application is the on line dimensional inspection of flat fuel plates as well as curvature inspection of bent fuel plates.

The corresponding equipments have been specifically designed and manufactured by CERCA. Our permanent development effort is materialized by the fact that the present devices already correspond to the second generation which present significant improvements with respect to the first previously developed generation.

## 4- COMPUTERIZATION OF EQUIPEMENTS.

Computerization of CERCA inspection equipements is part of the general computerization system which involves in particular workshop management, fabrication, quality and uranium accountancy. Slides 2 and 3 show the schematic organization of CERCA computer system. As far as inspection equipments are concerned, their computerization allows to improve the efficiency and reliability of inspection. It also makes the equipments more flexible and easy to adjust from one type of product to another (in our facility more than 100 different types of plates and 70 different types of fuel elements are manufactured, most of them simultaneously. Therefore quick adjustment of equipments is an important factor). Finally, computerization also allows automatic printing of results which improves presentation and reliability of documents.

As of today, the following inspection equipments are computerized :

- weighing network and gamma counting device
- UT machine
- homogeneity scanning machines
- dimensional inspection equipments (for flat and curved plates)
- surface contamination inspection equipment
- cladding thickness measurement equipments
- isotopic analysis
- impurity analysis in fuel powder
- surface image analysis

- water channel inspection machines
- fuel element dimension inspection devices

## 5- FURTHER DEVELOPEMENT

Brand new equipments have been installed in the past months (second generation of plate curvature inspection equipment, second water channel inspection machine, surface contamination inspection equipment). To-day, all the inspection equipements of the facility have been either replaced or significantly up-dated.

As far as the availability of these equipments is concerned, we have applied the same philosophy as for fabrication equipments: for each type of inspection, we have installed at least two devices, so that, in case one of them is out of order, another one is able to continue the work.

We consider this is a very important factor to guarantee a safe supply of fuel to our customers. It also allows to work on different products simultaneously.

CERCA continues its development effort to further improve the quality of its products and its service to customers. New inspection techniques are under development and will be reported next year. However, we can mention that, among others, we are developing a new technique for determination of the relative amounts of various phases in aluminide and silicide materials.

## CONCLUSION

Since it started MTR fuel production in 1960, CERCA has permanently improved its fabrication and inspection technology. The research effort was intensified when the program for development of reduced enrichment fuel started in 1978. It lead to the successful development of LEU silicide fuels which are now routinely produced on industrial level in our facility.

The sharp increase in our market shares and correspondingly our production output over the past three years has allowed us to significantly increase our investments in production and inspection equipments.

New sophisticated techniques have been introduced. Further development is going on in the frame of our very active research program for offering better and better products to our customers and keeping our advance in this field.

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References :

(1) "ADAPTATION OF INSPECTION METHODS TO LOW ENRICHED URANIUM FUEL" J.F. POUPARD - CERCA - Proceedings of the RERTR Meeting in SAN DIEGO;CA - 1988

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# INSPECTION METHODS FOR MTR FUEL

| METHODS USED FOR HEU | ADAPTATION TO LEU |
|---|---|
| URANIUM ANALYSIS | UNCHANGED |
| UAlx ANALYSIS | ADAPTATION TO SILICIDES |
| GRAIN SIZE MEASUREMENT | UNCHANGED |
| U235 CONTENT OF FUEL CORES BY GAMMA COUNTING | U235 CONTENT OF FUEL CORES BY WEIGHING METHOD |
| DIMENSIONAL INSPECTION OF FUEL CORES | UNCHANGED |
| No inspection performed when only one enrichment | ENRICHMENT CONTROL OF FUEL PLATES |
| ULTRASONIC INSPECTION OF FUEL PLATES | NEW EQUIPMENT FOR CORE EDGE EFFECT |
| X-RAY INSPECTION OF FUEL PLATES | UNCHANGED |
| VISUAL INSPECTION OF FUEL PLATES | UNCHANGED |
| CLADDING THICKNESS INSPECTION | UNCHANGED |
| DIMENSIONAL INSPECTION OF FUEL PLATES | UNCHANGED |
| SURFACE CONTAMINATION OF FUEL PLATES | UNCHANGED |
| FUEL ELEMENTS INSPECTION | UNCHANGED |

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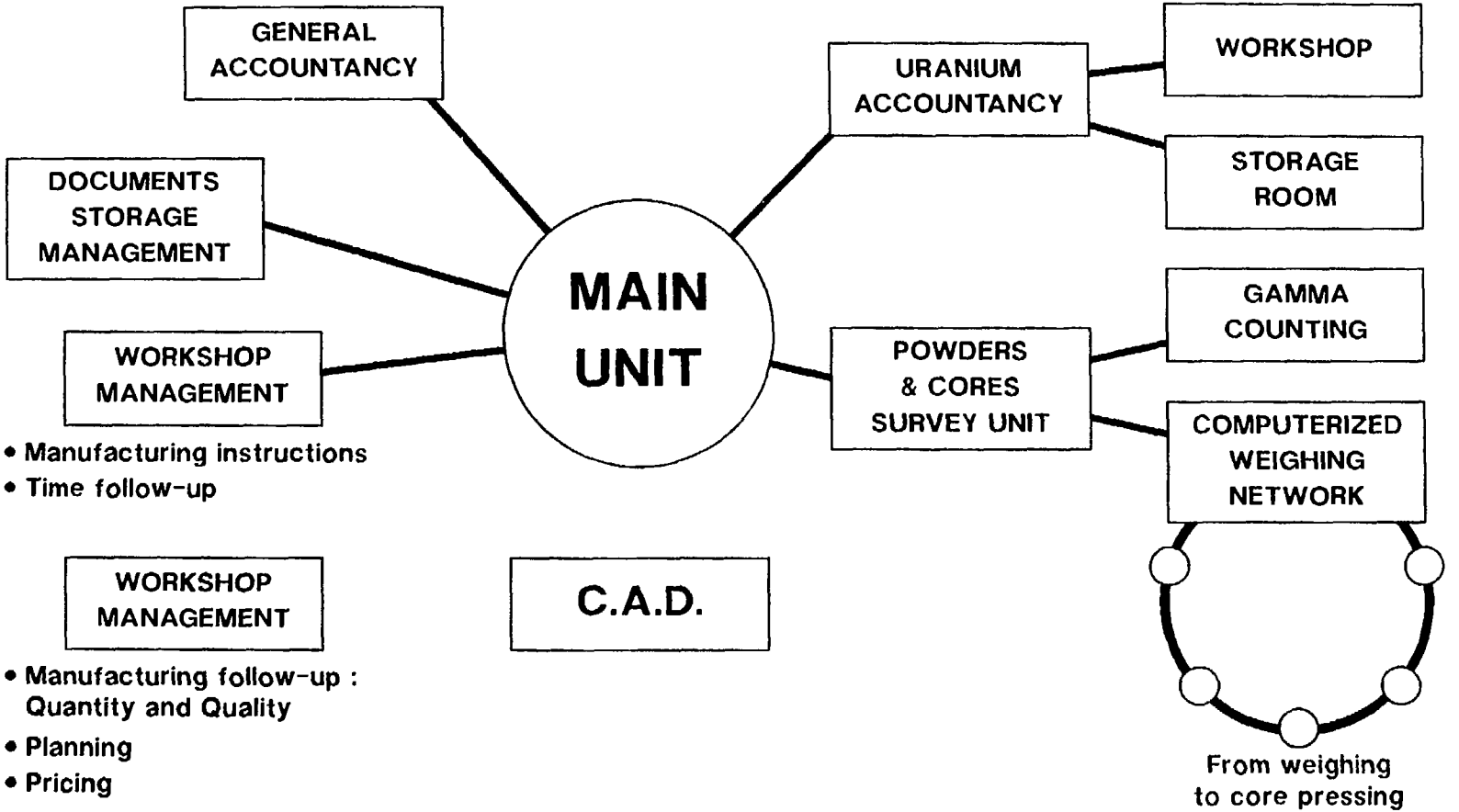
# COMPUTER ASSISTED PRODUCTION MANAGEMENT



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# COMPUTER ASSISTED COMPLIANCE TREATMENT

COMPUTERIZED
CONTROL EQUIPMENTS

- UT
- U HOMOGENEITY
- FLAT PLATE DIMENSIONS
- CURVED PLATE DIMENSIONS
- FUEL ELEMENT DIMENSIONS
- WATER CHANNELS
- CLADDING THICKNESS
- ⋮
- ISOTOPIC ANALYSIS

QC REPORT
COMPLIANCE TREATMENT

EQUIPMENTS
CALIBRATION
FOLLOW-UP