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NUCLEAR FUEL INSPECTION

www.enusa.es
www.tecnatom-ndt.com
NEED OF FUEL INSPECTION

Do you need to know the behavior of the nuclear fuel in your plant?
Are you concerned with regard the ability to detect, characterize and accurately sizing potential degradations in the fuel?
Are you in need of engineering services such as monitoring, degradation & operational assessment and acceptance criteria?
Do you have issues with nuclear failed fuel and are you interested in knowing the root cause?
Did you know Tecnatom and ENUSA have the capabilities to help you answering those questions?

We can offer you the best cost effective solution with a highly improved qualified systems, and an experienced and qualified inspection team providing inspection services and recommendations for your nuclear fuel.

Since the mid 90’s Tecnatom and ENUSA have been cooperating in the development and use of SICOM inspection systems for spent fuel assemblies characterization at PWR and BWR nuclear power plants. ENUSA engineering department is responsible for the assessment of the inspection results.

We have developed dedicated systems to cover different needs of the nuclear power plants, providing the best performance quality. Most systems are fully designed, and manufactured by ourselves and validated by the customers under strict specifications in order to increase the reliability and accuracy of the systems with regard the following objectives:

- Guarantee a safe operation.
- Optimize the economic performance of the fuel cycle.
- Locate and characterize flaws on failed fuel.
- Determine root cause of failed fuel.
- Redefine/Confirm fuel behavior models.
SICOM INSPECTION SYSTEMS

SICOM equipments are perfectly integrated to ensure effective, safe and quick nuclear fuel assembly inspections. SICOM family is a technologically advanced solution that allows to characterize a wide range of fuel assembly components and evaluate integrity of the fuel assembly.

SICOM-COR
SICOM-DIM
SICOM-ROD
SICOM-LEN
SICOM-LIM

SICOM-G-FR
SICOM-NG-FA
SICOM-UT
SICOM SIPPING ON LINE
SICOM SIPPING IN CAN
The SICOM family is comprised by the following inspection systems:

- **SICOM-COR**
  System for peripheral fuel rod oxide layer measurements and visual inspection.

- **SICOM-DIM**
  System for dimensional characterization of the fuel assemblies.

- **SICOM-ROD**
  System designed for inspection and characterization of fuel rod (Corrosion, profilometry, thickness loss, section loss, crack detection and its length).

- **SICOM-LEN**
  Designed for fuel rod length measurement with artificial vision technique.

- **SICOM-LIM**
  Designed for cleaning crud deposits in peripheral rods in a PWR fuel assembly.

- **SICOM-G-FR**
  System for fuel rod radiometric characterization. Measurements on pellet stack length for burnup verification and on plenum area for Kr-85 concentration (fuel rod internal pressure determination).

- **SICOM-NG-FA**
  System for fuel assembly radiometric characterization. Gamma and neutron detectors for burnup verification.

- **SICOM-UT**
  Detection of failed fuel rods.

- **SICOM SIPPING ON LINE**
  Detection of leaking fuel assembly during refueling activities.

- **SICOM SIPPING IN CAN**
  Detection of leaking fuel assembly at spent fuel pool.
SICOM-COR

- Performs Oxide Layer measurements on peripheral fuel rods of a fuel assembly by means Eddy current Testing (ET).
  Dimensional characterization (fuel rod to top nozzle gap, spacing between rods) can also be carried out by Visual Testing (VT).
- Light inspection system. Installation on racks of the spent fuel pool.
- Scan of entire length of fuel assembly by means of the manipulating fuel crane (axial position information is acquired on each scan).
- Uncertainty of the oxide layer after measurement validation of ± 6 microns.
- Integrity Visual inspection, focusing on:
  - Upper / Lower nozzles and springs.
  - Rods, Grids and plugs.
  - Spacing between rods.
  - Rods displacements.

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SICOM-DIM

- Full length measurement of fuel assembly.
- Dimensional characterization of fuel assembly by LVDT’s devices
  - Grid width measurements.
  - Deviations from vertical axis on every grid (Bow).
- Fuel assembly twist determination with respect to the lower nozzle.
- Upper nozzle inclination with respect to the lower nozzle (Tilt).
- Length of fuel assembly.

<table>
<thead>
<tr>
<th>MEASUREMENT</th>
<th>UNCERTAINTY (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tilt</td>
<td>± 1.0</td>
</tr>
<tr>
<td>Length</td>
<td>± 0.5</td>
</tr>
<tr>
<td>Grid width</td>
<td>± 0.2</td>
</tr>
<tr>
<td>Bow</td>
<td>± 0.4</td>
</tr>
<tr>
<td>Twist</td>
<td>± 0.4</td>
</tr>
</tbody>
</table>
SICOM-ROD

System designed for inspection and characterization of fuel rods in PWR and BWR fuel type.

Capabilities:
- Oxide Layer measurement by ET.
- Profilometry by LVDT’s devices.
- Bobbin coil inspection by ET.
- Rotating coil inspection by ET.

<table>
<thead>
<tr>
<th>MEASURE</th>
<th>TECHNIQUE</th>
<th>UNCERTAINTY</th>
</tr>
</thead>
<tbody>
<tr>
<td>OD diameter</td>
<td>LVDT</td>
<td>± 10 µm</td>
</tr>
<tr>
<td>Oxide layer thickness</td>
<td>ET Coil</td>
<td>± 6 µm</td>
</tr>
<tr>
<td>Cross section loss</td>
<td>Bobbin Coil</td>
<td>± 3 %</td>
</tr>
<tr>
<td>Local loss of wall thickness</td>
<td>RPC</td>
<td>± 10 %</td>
</tr>
<tr>
<td>Crack length</td>
<td>RPC</td>
<td>± 1 mm</td>
</tr>
</tbody>
</table>
SICOM-LEN

- Fuel rod length measurement with artificial vision technique. Uncertainty <0.7 mm.
- System applicable to measurement of fuel rods PWR and BWR.
- Automatic generation of reports and inspection records.

SICOM-LIM

- System designed for cleaning crud deposits in peripheral rods in PWR fuel assembly.
- Cleaning of fuel assemblies performed before SICOM COR inspection to get more reliable oxide thickness measurement.
SICOM NG-FA

Radiological characterization of the spent fuel assembly by means of a Gamma and neutron detectors. System validated with real fuel assembly.

Measurements:

- Burnup.
- Gamma and neutron profiles.

Neutronic spectrum on the 4 faces of the fuel assembly.

Gamma profile of the fuel assembly.

Gamma spectrum on the 4 faces of the fuel assembly.
SICOM G-FR

Radiological characterization of the spent fuel rods. System validated with real fuel rods.

Measurements:

- On pellet stack length: profilometry axial burnup and average burnup.
- On plenum area: Kr-85 concentration for fuel rod internal pressure determination.

Kr 85 Spectrum in the plenum area

Gamma Spectrum
SICOM-UT

Detection of failed fuel rods by UT method. Validated system with real fuel assembly. Acquisition system with digital automatic data evaluation and reporting. Post-inspection re-edition and re-evaluation, without repeating data acquisition.

System features:

- X, Y movement system.
- InspectView Software.
- Acquisition, Analysis, Mechanical systems.
- UMAC technology interface with Ethernet.
- Communication.

Vision system.
Emitter/Receiver UT probe.

Easy analysis representation map

Automatic analysis report

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SICOM SIPPING IN CAN

Sipping OFF-LINE designed to operate in spent fuel pool.
Release of fission products by vacuum.
Liquid sampling system, separation process for gas phase.
Beta detector for gas Kr-85.
System validated with real failed fuel assemblies.

Specific software to record and check operation parameters.
SICOM SIPPING ON LINE

The Sipping ON LINE is performed during the normal fuel handing during core download. No time consuming on critical path.

The system consists of three main components: Suction unit, Process unit and Digital unit.

The dedicated software platform is based on outstanding spectrometry applications. Several Regions of interest can be followed graphically at the same time as well as the spectra appears in real time on the display.
REFERENCES AND CERTIFICATIONS

Tecnatom and ENUSA have wide experience in performing nuclear fuel inspection campaigns in numerous European nuclear power plants (NPP). In all of them, inspections have already successfully been performed.

Several systems and inspection procedures have been qualified in a real components for both national and abroad customers.

Our main references are:
- Almaraz NPP.
- Ascó NPP.
- Belleville NPP.
- Forsmark NPP.
- Garoña NPP.
- Olkiluoto NPP.
- Tihange NPP.
- Trillo NPP.
- Vandellos NPP.

Inspection Team:
- Wide expertise from Team Leaders.
- Well experienced and trained inspection technicians.
- High qualified engineering department for the assessment of inspection results.