



## Non-contact 3D Measurements for Nuclear Industry using NOVACAM™ 3D metrology systems

**Keywords:** 3D non-contact optical inspection, NDT, 3D mapping of bore holes, shafts, cylinders, chambers, inner cavities, GD&T, internal diameter (ID), ID characterization, surface topography, cylindricity, porosity, splines, surface and dimensional defects, roughness, film thickness, geometric tolerances of internal features, dimensional, radiation, radioactive, extreme heat

### Introduction

In the nuclear industry, the need for high-precision measurements is ever-critical. This need starts in the production of nuclear reactor components (cladding, slot welding, etc.) and continues into high-radiation labs and production environments – in gloveboxes, hot cells, and nuclear reactors. The industry also measures and monitors the usage rate of fuel pellets and rods, and must analyze damage to all structural material affected by radiation, high temperatures, and high pressures.

### 3D metrology systems that match nuclear industry needs

Measurement requirements of the nuclear industry are typically three-fold:

- High-precision measurement with rugged systems that either resists high radiation, temperature and pressure or that can measure from across glass
- Measurement in hard-to-reach spaces such as inside tubes, bores, and slots
- Capability for inline manufacture inspection.

Novacam Technologies provides several 3D metrology systems that are uniquely suited for the metrology needs of the nuclear industry.

Their benefits include:

- **Micron-precision 3D measurement of dimensions, roughness, and defects** obtained using fiber-based optical probes that operate even in radioactive, hot and high-pressure environments.
- **Ability to measure through glass, in air, or through water**
- **Ability to measure even inside hard-to-reach spaces** such as inside diameters of cladding tubes and deep narrow slots
- **Ability to measure high-aspect ratio surface features** (channels, blind hole bottoms, etc.)
- 3D metrology systems that can be integrated with robot arms, gantries and various precision stages
- **High-speed scanning** at up to 100,000 3D measurements per second.

### Examples of nuclear applications where NOVACAM systems perform

#### *1) Production of components for nuclear reactor facilities (non-radioactive)*

##### **Zirconium tube blank ID & OD**

- Defect detection and dimensional (GD&T) measurements of tube ID and OD in the pilgering process
- Detection of defects on blanks early in the process eliminates unnecessary added-value work

##### **Chamfers on zirconium tube blanks**

- Ensuring min-max tolerances on chamfer dimensions

### Slot measurements

- Long and narrow slots present difficult geometry for metrology
- Dimensional, defect and roughness measurements with 1-mm diameter probe.
- Fine roughness surfaces, micron-precision dimensional measurements and difficult to measure features inside the slots. Probe is supported with a carbon fiber boom

### Hard-to-access welding

- Inspection and dimensional GD&T of welding inside deep and narrow slots

### ID surface of nuclear fuel cladding

- Roughness measurements, defect detection

## 2) Gloveboxes (containing radioactive materials)



### Fuel pellet inspection and GD&T measurements

### Spent fuel rod inspection

- Inspection for cracks and scratches

### Defect inspection on rubber replicas of zirconium pressure tubes

## 3) Hot cells



### GD&T measurements of spent fuel

### Defect measurements (cracks, scratches, etc.)

### Measurement of deformation and bulges

## 4) In-situ measurements at nuclear reactors

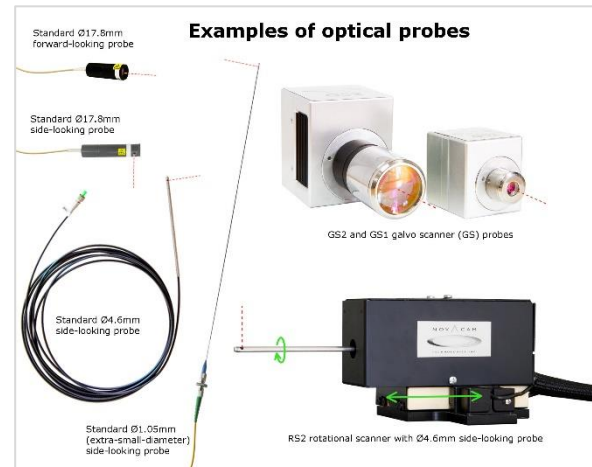


### Tubular primary and secondary cladding

- Vertical underwater measurements of long tube ID
- Horizontal in air measurements of long tube ID
- Detection of surface cracks in weld inspection inside reactor cooling systems
- Valve inspection within nuclear cooling systems

## Versatile fiber-based optical probes

NOVACAM 3D metrology systems are based on low-coherence interferometry technology. The systems are modular; they measure with fiber-based optical scanning probes that are connected to the signal-processing detector (Microcam-3D/4D interferometer) by an optical fiber.



Advantages of scanning with probes:

- **For inline measurements, the probes are easy to integrate** with precision stages, robot arms, or gantries thanks to their small size and fiber-based design.
- **The probes are able to measure through air, water, glass, and many semi-transparent materials.** Measurements inside glove boxes or hot cells may often be done through windows, depending on the composition of the window layers (lead glass, cooling solution, etc.).
- **Custom probes with large standoffs** enable measurements of radioactive material from large distances.
- **The probes may be deployed directly in radioactive environment** (for example, inside glove boxes, hot cells or in situ) while the system detector (MICROCAM™-3D/4D interferometer) remains outside. Glass shielding may be installed to protect the

optical probe lens. The glass shielding may be periodically changed.

- Even when the optical probes and stages get irradiated, with the fiber optics and glass turning gradually yellow under intense radiation, **probes can be periodically replaced at relatively low cost.** The detector (MICROCAM-3D/4D interferometer) stays outside the radioactive environment, so it is not affected and does not have to be replaced.

### Additional options to support radioactive environments

Novacam supplies radiation-hardened fiber optic cables that sustain higher radiation doses for longer periods of time.

Optical components for the probes (including lenses) made from quartz last longer than ordinary glass.

Probes can be mounted behind a lead shield, leaving only a mirror exposed to radiation.

Novacam provides stages with magnetic encoders that can operate in a radioactive environment

### Conclusion

Novacam encourages nuclear industry engineers in charge of measurement to contact us to discuss your applications and your particular metrology challenges.

#### NOVACAM 3D metrology systems for nuclear industry

System name	Type of optical sensor
OPTICAL 3D PROFILOMETER™ system	Forward-looking or side-looking probe
BOREINSPECT™ system	Side-looking rotational probe
TUBEINSPECT™ system	Side-looking probe
EDGEINSPECT™ system	Galvo (raster) scanner
SURFACEINSPECT™ system	Galvo (raster) scanner

- All NOVACAM systems include MICROCAM™-3D or 4D interferometer (19" rack-mountable instrument) and a mini desktop-size PC or laptop that hosts NOVACAM data acquisition software and, typically GD&T analysis software
- Technical specifications are available upon request.

### An invitation – watch NOVACAM 3D metrology systems in action

To see NOVACAM 3D metrology systems in action, please watch the systems in action here:

<https://www.novacam.com/resources/novacam-metrology-videos/>



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