

INNOVATION AT WORK

Connecting Visionaries in Radiation Safety, Science and Industry

Conrad Orlando Resort, FL – July 28th – August 1st



Imaging Inspections - Now You See Me, Now You Don't

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Mirion Connect | Annual Users' Conference 2025
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Nuclear Imaging Cameras





Imaging Inspections - Now You See Me, Now You Don't

- Cameras are often used (& mis-used) in both process monitoring as well as inspection applications.
- To be successful, it's important to understand the benefits & trade-offs of various imaging technologies; whether from the standpoint of radiation tolerance, size, color, optics, connectivity, or other key attributes.
- In addition, how you choose to integrate cameras into your workflow can make the difference between success & frustration..



Agenda

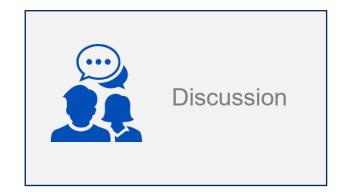














Our value proposition



We Understand Your Challenges

Delivering confident visibility. Our radiation-tolerant cameras deliver critical protection through confident visibility in the most extreme environments

We design & manufacture imaging systems for inspection, surveillance & monitoring in industries as diverse as Nuclear power plants, reprocessing & decommissioning, With thousands of systems in use worldwide, Mirion has more than 35 years of experience in serving global markets — & delivering unrivalled support & expertise to address our clients' needs. Mirion products are industry recognised for performance, quality & reliability.

Radiation Tolerant Camera Applications



Radiation Tolerant Cameras provide a full spectrum of low, medium & high dose solutions to every stage of the nuclear fuel cycle

- Operating NPPs Maintenance, ALARA/HP, Refueling/Fuel Handling, New Build
- Waste Management & Decommissioning
- Inspection & Outage Support
- Surveillance & Security

- ✓ Viewing inaccessible areas & processes
- ✓ Safety, personnel dose reduction ALARP/ALARA
- ✓ Radiological & Chemical Hazards
- √ 'Baseline' data acquisition requirements
- Safeguards
- ✓ Identification
- ✓ Navigation, Positioning & Alignment
- ✓ FOSAR
- ✓ Remote Handling & Robotics
- ✓ PLIM & PLEX

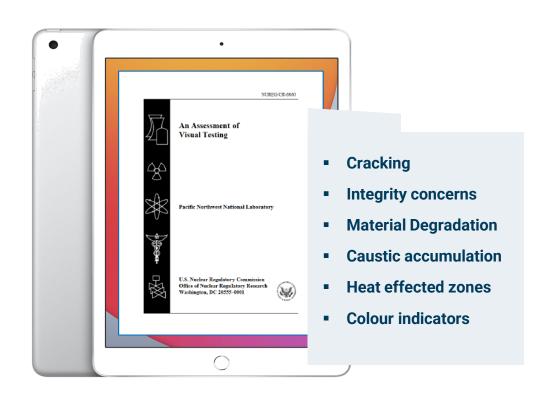


Why do we inspect





What We Want to See







What We Don't Want to See



Crud lines that resemble cracks



Machining marks that resemble weld issues



Non-threatening surface imperfections in the material

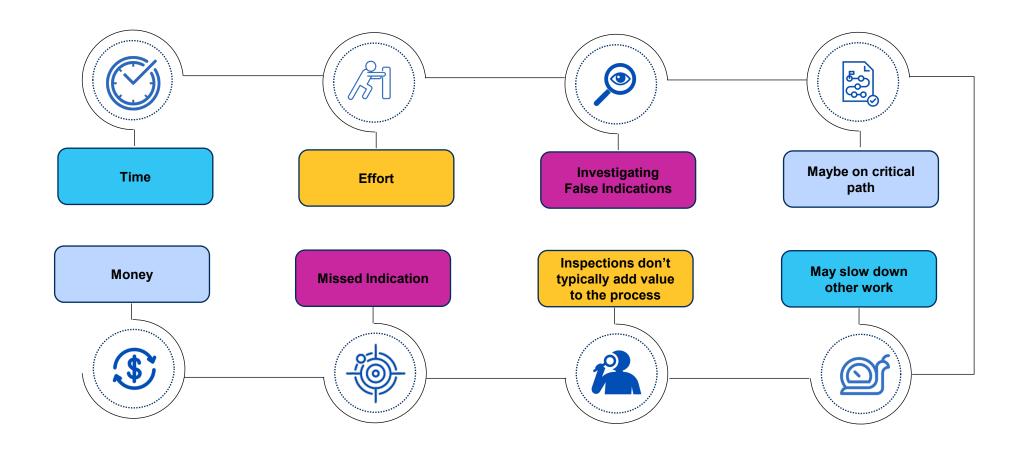


Previously researched anomalies





Why Does it Matter?





Radiation Tolerant Cameras





Low Radiation Environments

Typical of short inspection cycles (minimum exposure) &/or brand new fuel/very old fuel:

- Pipes & bore holes
- Storage ponds
- Residual radioactive environments
- · Ad-Hoc process monitoring
- Remote inspection



Medium Radiation Environments

Cameras with flexibility for a variety of environments:

- Decommissioning inspections
- Waste processing & segregation
- Ad-Hoc process monitoring
- Remote inspection



High Radiation Environments

Cameras with uncompromising radiation tolerance designed for prolonged use in high radioactive environments:

- Hot cells
- Reactor cores
- Waste processing & segregation
- · Remote inspection



Camera Controllers



- To achieve required level of radiation tolerance amount of circuitry in cameras is minimized by locating this within the controller
- Camera controller is traditionally a 19" rack mounted box which supports 1–8 cameras



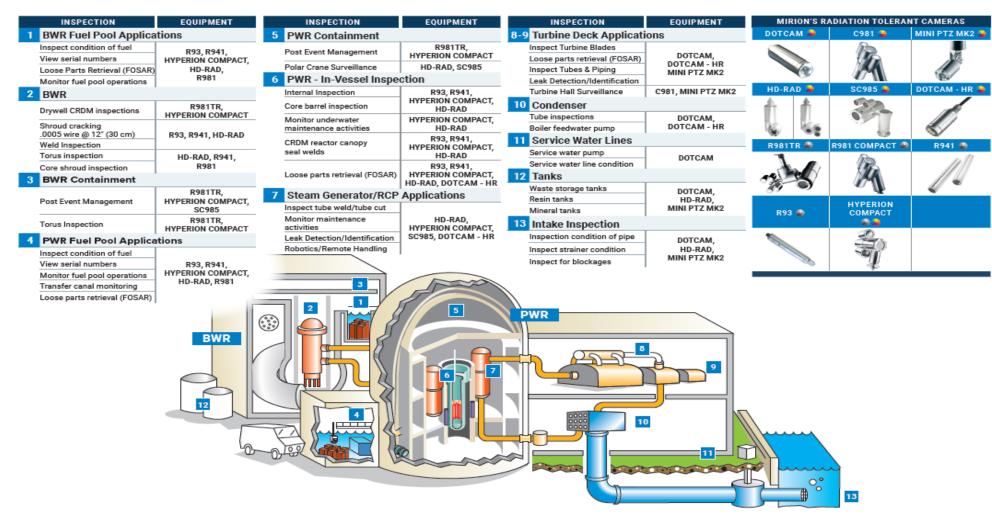


Portable Pelicase Controller

- Cameras designed for mobile inspection (Dotcam, Mini PTZ, HD-RAD) utilize Pelicase controllers
- · These are portable all in one devices featuring:
 - Screens
 - · Camera controls
 - Input / Outputs
 - Recording Functionality options



Nuclear Plant Camera Uses





Factors to Consider in selecting the Right Camera





Nuclear Cameras by Application



Nuclear Surveillance Systems

Camera	Model	Radiation Tolerance
	Hyperion Compact Gen II	High
	R981Compact	High
	R942	High
	SC985 HR	Medium
	C981	Low

Typical Applications

Safety & Security (fuel handling route), ALARA/ALARP, In-Containment /Post event monitoring, Ponds/pools & storage facilities, Hot Cell monitoring, Cranes & Bridges, Reprocessing & Vitrification, Robotics & Manipulators, Critical component monitoring, Fuel dismantling/processing

Nuclear Inspection Systems

Camera	Model	Radiation Tolerance
	R93 Camera	High
	R941 Camera	High
BCTROCKOM BCTROCKMAN	RC720 HD RAD	Medium
	RC911 Dotcam HR	Medium
	RC913 Mini PTZ Mk II	Low
	RC911 Dotcam	Low

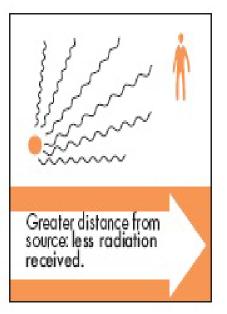
Typical Applications

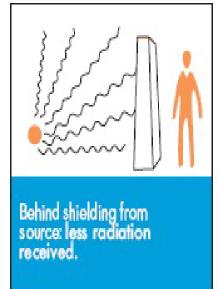
Fuel handling & identification (Wet & Dry), Remote Handling, Steering & alignment, FOSAR, In Service Inspection, PLIM & PLEX Surveys, Robotics & Manipulators, Critical component monitoring. Fuel dismantling/processing



Radiation Tolerance



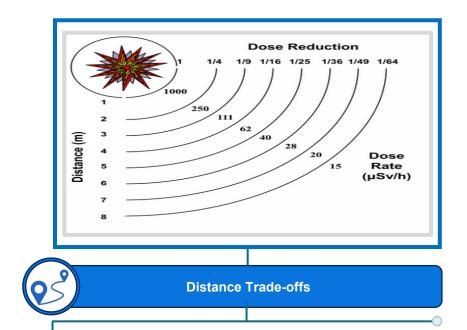




- Some things don't change:
 - Time, Distance, & Shielding
- Must consider both cumulative dose & dynamic dose
- More importantly need to understand use & workflow



Radiation Tolerance: Distance



- Distance trade-offs
 - Vibration & image instability prevalent in air as distance from pan/tilt increases
 - · Compensate with lenses: Zoom, Narrow Angle
 - But remember double the distance will quarter the radiation



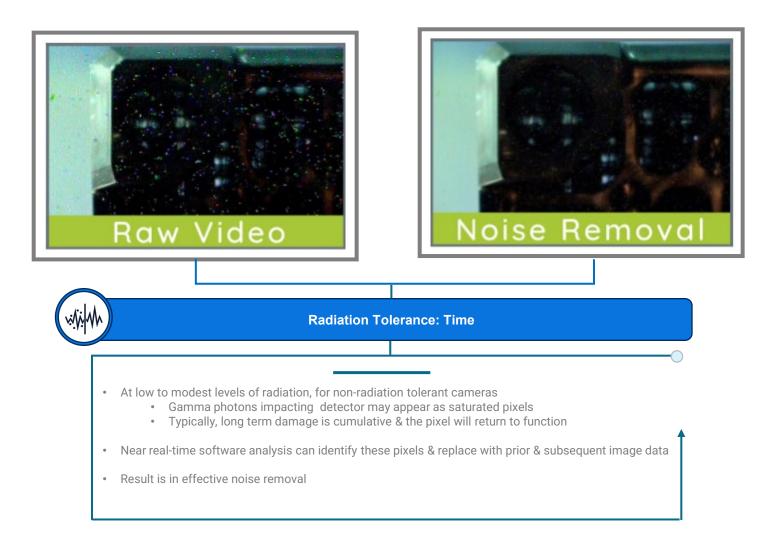


Thermal Trade-offs

- · Thermal trade-offs
 - More prevalent in underwater inspections
 - Causes "waving" distortion across video image
 - · Can significantly "hide" fine details
 - Software exists

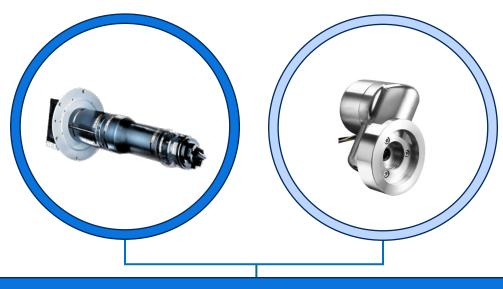


Radiation Tolerance: Time





Radiation Tolerance: Time





Shielding not as simple as placing a camera in the centre of high-Z material

Camera often directed at the source for most of its useful acquisition

- · Various methods for shielding
 - Embedded imager & optics within a shielded housing
 - Imager in shielded housing with right angle viewing mechanism
 - Utilize shielded material (i.e. fused quartz silica blocks) with electronics located outside radiation area
 - The camera to self shield by "turning around"
- · Primary trade-off is weight



Color vs Monochrome

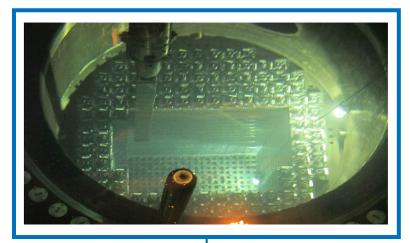




- Established in radiation
- Smaller (mostly)
- Easier to transmit/distribute
- Higher resolution (rad tol)



Size & Access





Deploy & Retrieve

- · Some camera deployments are well known, planned, & optimized
- Reactor inspection underwater deployed from the refuel bridge
- Others are more difficult
 - · Limited access hot cell with air lock tele manipulator positioning
 - Limited access glovebox



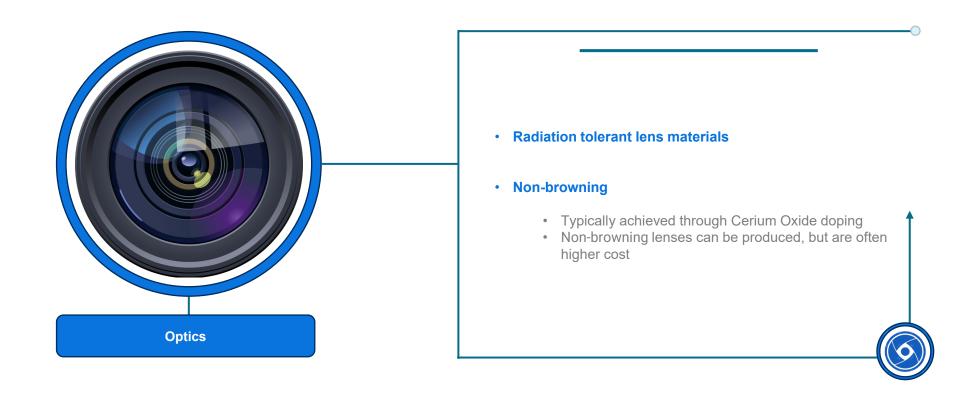


Size Matters

- Inspections carried out in limited access areas
- Often no external lighting sources
- Design/Impacts
 - Entry/egress of equipment/people
 - Size of optics
 - Size/heat dissipation of lighting



Optics - Radiation Impacts Design





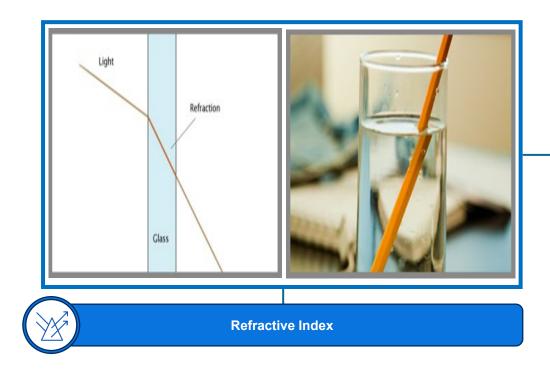
Optics - Radiation Impacts Usage

- Radiation induced discoloration caused by impurities & amorphous non-crystalline structure of the glass
- Multiple lens elements in a single lens resulting in significant reduction of light
- Also impacts lenses on the front of lights
- Some plastic-coated reflectors can deteriorate as well





Optics – Imaging Underwater



- Using a camera underwater, important to remember that the refractive index is different
- · Angle of view will be different
 - Typically 1.33x for radiation stable windows
 - Must be considered when choosing lens focal length for use underwater
- Water corrected windows will distort images when used in air



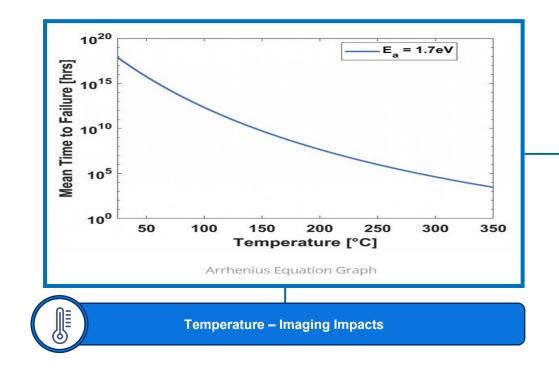
Optics/Viewing Attachments

- Support ease of inspections
- May have trade-offs
- Often impacts lighting availability
- Consider purpose-built or adapted variants
- Multi-purpose drive motors support





Temperature – Imaging Impacts



- Elevated temp provides several challenges for all cameras
- · Component life is shortened
- Many cameras packaged in stainless steel (15 watts / kelvin / meter)
- General rule of thumb: 50% reduction in lifetime for every 10°C rise when discussing semiconductor devices
- · Lighting can "self heat" & add to the thermal sources



Lighting





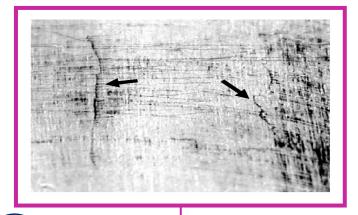
Light and Light Direction





Light & Light Direction

- Axial/in-line lighting versus offset lighting
 - Relief viewing for highlighting depth
- Polarizing filter
 - Reduce glare (air/water interface effects)
- Independent adjustability of lighting
 - Provide "3rd dimension"





Light & Light Direction

- Offset lighting highlights crack paths
- Just above right arrow, however, "hides" lateral portion of crack migration
- Lighting adjustability remains key in inspections



Useful Material

Brochures



Cameras for Extreme Environments



Radiation Tolerant Camera for Nuclear Applications

Datasheets



Website



Nuclear Plant Camera Uses

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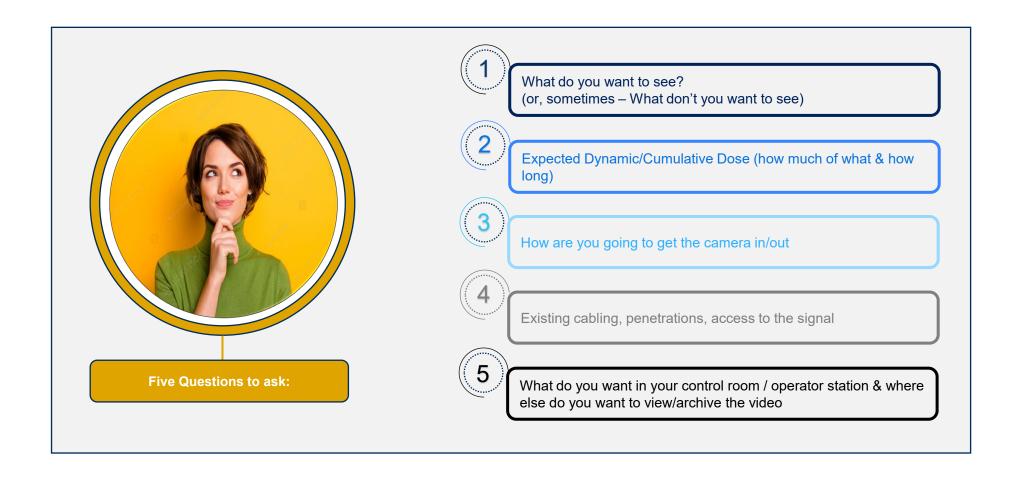
Infographics



Webinars



Closing Thoughts





Thank you



