



HOPEWELL DESIGNS, INC.
ENGINEERING, MANUFACTURING, & SERVICE

Capabilities of a New Self-contained, High Dose Rate Co-60 Irradiator: The GR420

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April 18, 2023



Outline

- History and Background
- Safety
- Radiation Parameters
- Compatibility with Legacy Accessories
- Modernized Control
- Form Factor
- Service and Support



History and Background

The need to replace legacy Gammacell 220 irradiators was identified at the 2015 CIRMS meeting.

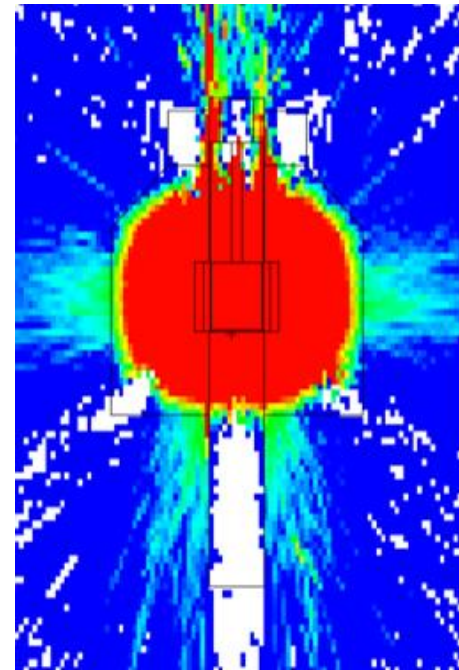
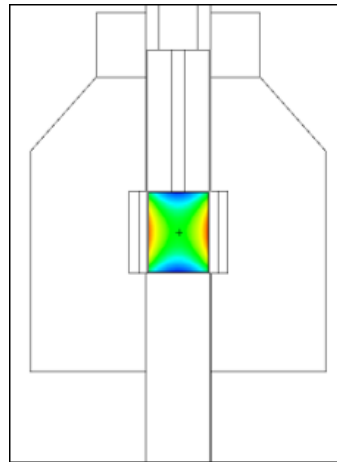
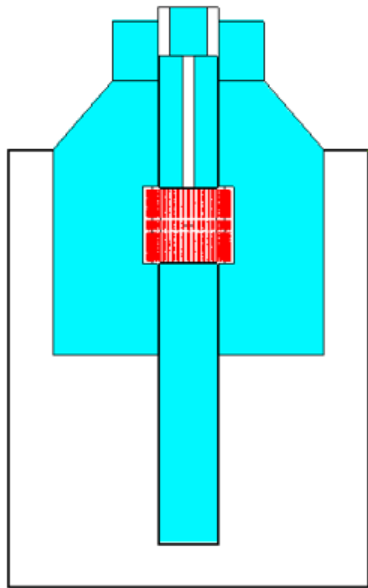
The screenshot shows a web page from the CIRMS (Coordinated International Radiation Metrology Society) website. The page is titled "Roadmap to Resource Gammacell 220 Irradiators" and is part of a "Needs Report". The page content includes:

- Objective:**
 - Establish a roadmap to resource Gammacell 220 irradiators
- Background:** For business reasons, Nordion (Sterigenics), has withdrawn resourcing support for current Gammacell 220 irradiators. There exist myriad Gammacell 220 irradiators across North America that face limited options for resourcing (i.e. replenishing cobalt-60 sources) inside the cells. Some of these irradiators are located in academia and national labs such as at NIST. Maintaining traceability to primary standards at NIST is of foremost concern so as not to impede commerce. Maintaining research capabilities at national labs and academic sites is of secondary near-term concern, but critical to maintain long-term US competitiveness in research areas concerning ionizing radiation.
- Suggested needs for next generation self-contained irradiators:**
 - Uniform calibration volume with dose control and measurement validation at 1 cm spacing
 - Temperature range of -75C to 75C with 1C temperature accuracy
 - Dose control within 3% for industry, and within less than 2% for NIST
- Action Items:**
 - 1a – Develop agreements, contracts or indemnification documents such as liability waivers from at least NIST and preferably from other national labs to Nordion (or some other corporate entity) to enable resourcing (replenishing) of Gammacell 220 irradiators, which serve as a critical piece of the US primary standards process and help maintain traceability standards; or
 - 1b - Provide a national strategy to update US infrastructure in regards to self-contained gamma irradiators; or
 - 1c - At a minimum, provide a reasonable protocol for academia, labs and industry for the disposal of partially depleted cobalt-60 sources in existing Gammacell 220 irradiators; and
 - 2 - Do not over-react to regulations surrounding cesium-137 and cobalt-60 sources and provide a forum for proper education about lifecycle management including upfront and ongoing costs (money, time, personnel, liability), safety and ongoing traceability.

Added to CIRMS Needs Report in 2015

Hopewell began development and research

- Baseline studies of Gammacell 220 using MCNP to use as a benchmark





History and Background

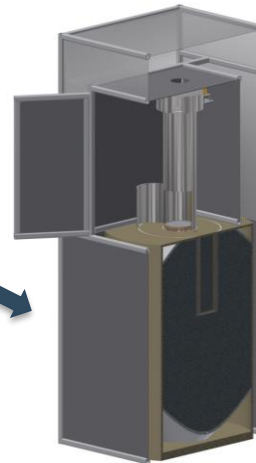
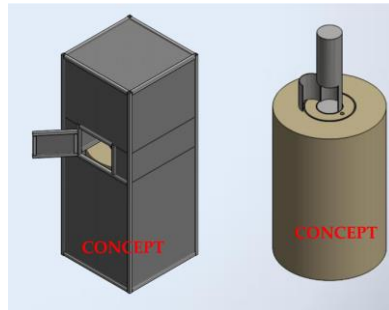
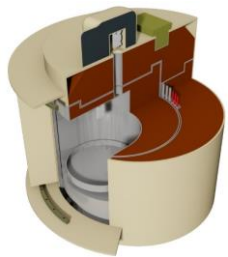
Worked with industry and users to identify desired specifications and areas for improvement

- Address high exposure rates to workers
- Larger chamber volume
- Improve dose uniformity
- System that is serviceable with available spare parts



History and Background

- Multiple rounds of design and prototype to arrive at a solution
 - Similar and familiar operation
 - Existing accessories and fixtures are easily adapted
 - No depleted uranium shielding



- 5 Years of development from initial concept to production unit

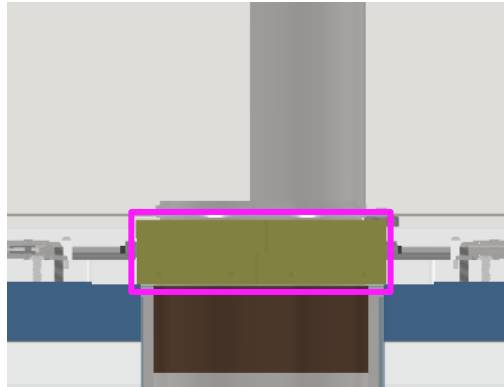


Outline

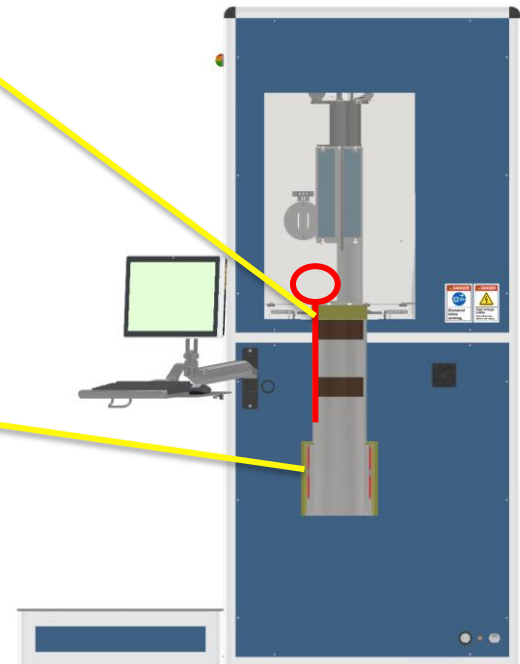
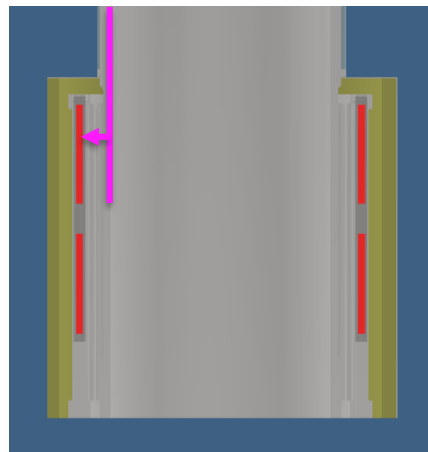
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Reduce steaming along chamber walls
 In order to reduce dose to extremities while loading chamber

- Added shielding collar



- Moved sources back slightly from the chamber walls

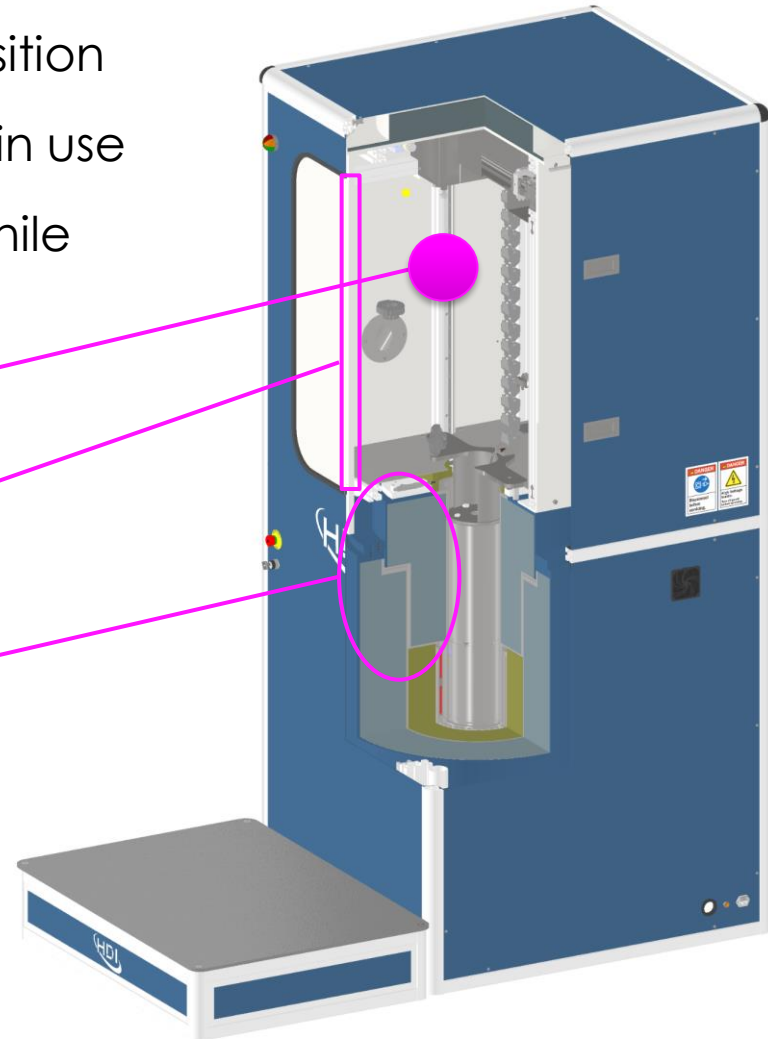


- Reduce dose to worker during transition
- Secure chamber access when not in use
- Unable to access chamber area while exposure is in progress

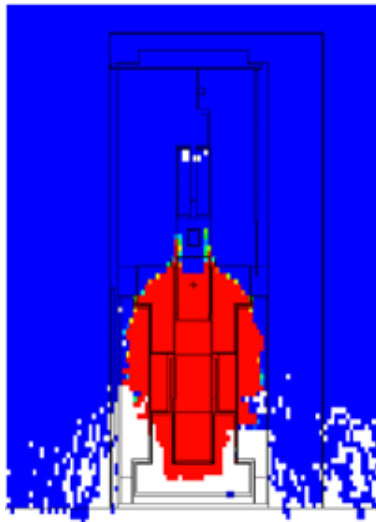
Enclosed upper access area

Shielded door

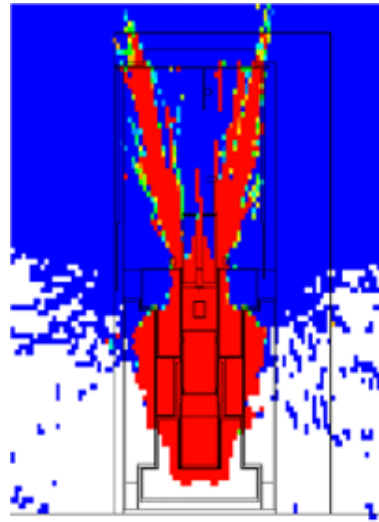
Increased shielding
around top of main shield



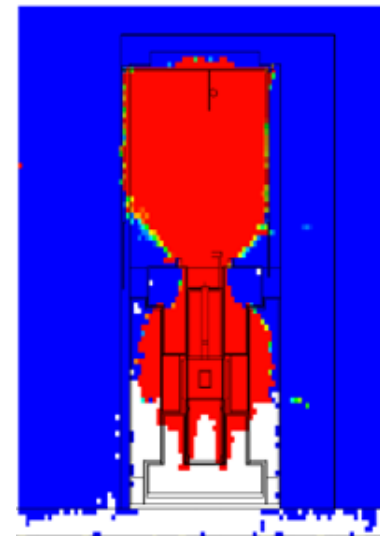
- External dose rates < 2 mrem/hr at 30 cm
 - In all modes of operation
 - With full 36 kCi loading
 - This is up to a 10 times reduction compared to legacy systems with a 24 kCi loading.
- Maximum dose rate to extremities < 10 mrem/hr
 - This is approximately a 10 times reduction compared to legacy systems.



Load / Unload



Transition



Irradiate

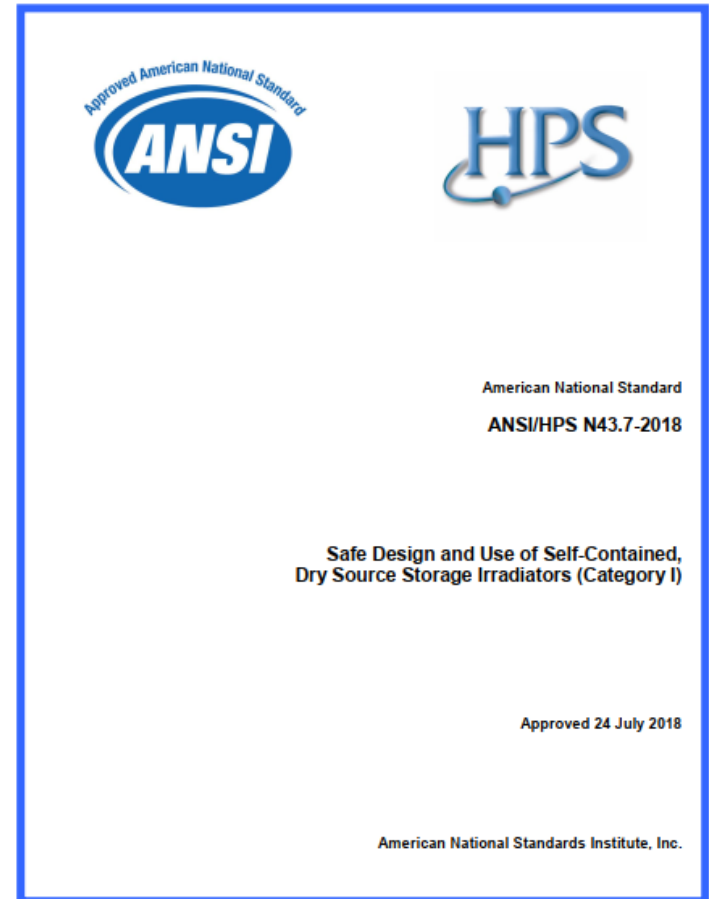


Safety Target Areas

- The GR420 design and operation is compliant with **ANSI N43.7-2018**

Safe Design and Use of Self-Contained, Dry Source Storage Irradiators (Category I)

- U.S. NRC Sealed Source and Device Registration (Approved March 2021)





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Radiation Parameters

Goals

- Improved dose uniformity
 - *Dose Uniformity Ratio (DUR) = $\frac{\text{Highest Dose in Volume}}{\text{Lowest Dose in Volume}}$*
 - Gammacell 220 had 1.8 DUR throughout volume (computed with MCNP).
- Rotate sources at 6 RPM
 - Contributes to improved dose uniformity
 - Reduces need for a turntable within the chamber
- Increased chamber volume
 - 7" diameter vs existing 6" diameter
- Low, repeatable transition dose

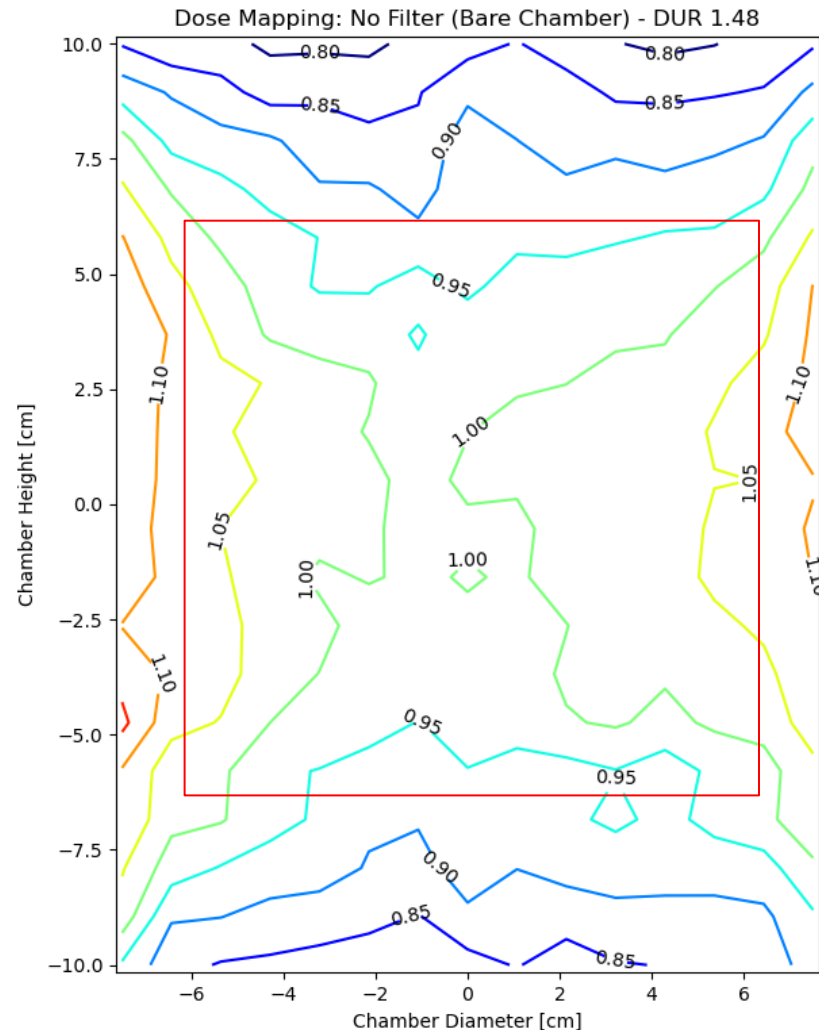


Radiation Parameters

Dose Uniformity

- DUR of 1.48 for chamber volume of 6" dia x 8" height
- Central volume of approx. 5" dia x 5" height is within +/- 10% of the center dose of chamber

**From calibration data with a GR420 loaded with 23,755 Ci Co-60*





Radiation Parameters

Low, repeatable transition dose

Total Activity	Transition Dose
24 kCi	~ 13 Gy
24 kCi w/ 67% attenuator	~ 3.5 Gy
36 kCi	~ 20 Gy



Radiation Parameters

Centerline dose rate

Total Activity	Dose Rate
24 kCi	~ 3.4 Gy/s (12.2 kGy/h)
36 kCi	~ 5 Gy/s (18 kGy/h)



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Legacy Accessories

- Compatible with many legacy accessories from Gammacell 220
 - Larger chamber volume
 - If it fits in the Gammacell 220, it fits in the Hopewell GR420
 - Same diameter access port above the chamber
 - 1.25" ID
- Most existing accessories can be easily adapted to work in the GR420



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Modernized Control

- Computer and Programmable Logic Controller (PLC)
 - Datalogging capabilities
 - Simple and intuitive operator interface
 - PLC controlled timer





Modernized Control

Comprehensive database stores data related to each irradiation

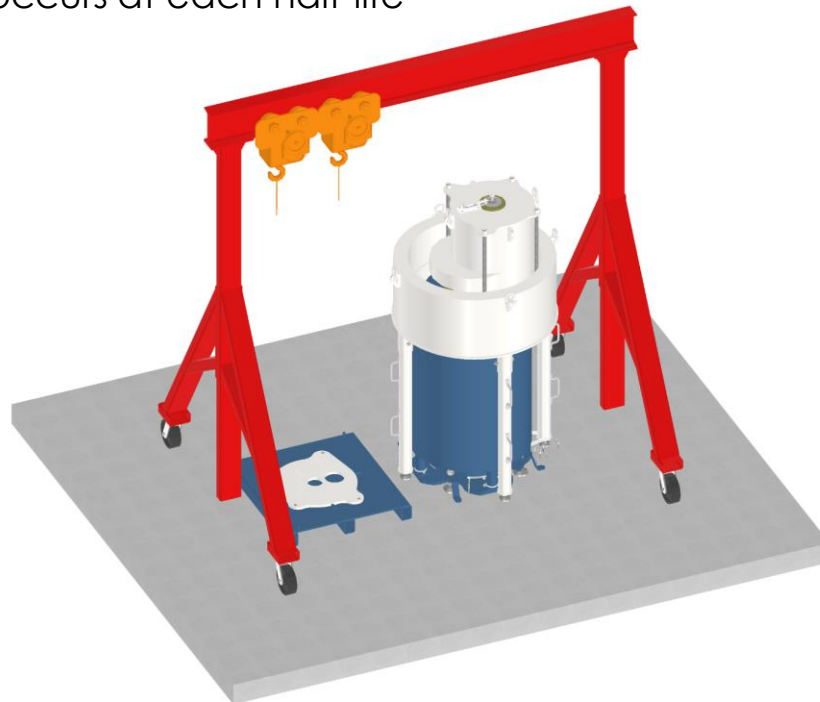
Field Name	Data Type	Description (Optional)
ExpBatchID	Number	Parent ID of one or more sets of exposures
ExpBatchGUID	Short Text	Internal use for ORM
ExternalBatchID	Short Text	Used to map an external data source to ExpBatchID
ExpSetID	Number	Parent ID of one or more exposures
ExpSetGUID	Short Text	Internal use for ORM
ExternalSetID	Short Text	Used to map an external data source to ExpSetID
ID	AutoNumber	Unique identifier for each exposure
GUID	Short Text	Internal use for ORM
ExternalID	Short Text	Used to map an external data source to ID
ExternalSampleID	Short Text	Used to track a DUT or sample being irradiated
Operator	Short Text	User of the Irradiator Control software
Comment	Short Text	Freeform comment
ExposingTransitionDuration	Number	Seconds timed by PLC while chamber moves from shielded to exposed
FullyExposedDuration	Number	Seconds timed by PLC while chamber is fully exposed
ShieldingTransitionDuration	Number	Seconds timed by PLC while chamber moves from exposed to shielded
ExposingTransitionDose	Number	Decay-corrected dose accumulated while chamber moves from shielded to exposed
FullyExposedDose	Number	Dose accumulated while chamber is exposed using PLC timing and mean life equation
ShieldingTransitionDose	Number	Decay-corrected dose accumulated while chamber moves from exposed to shielded
StartRate	Number	Calculated dose rate as of the beginning of the exposure
EndRate	Number	Calculated dose rate as of the end of the exposure
ExpPresetTime	Number	If a timed exposure, the total target time in seconds, otherwise -1
TargetDose	Number	If a targeted dose exposure, the total target dose in Gray, otherwise -1
ExposingTransitionStart	Date/Time	Computer timestamp when chamber is seen moving away from the shielded position
FullyExposedStart	Date/Time	Computer timestamp when chamber is seen in the fully exposed position
FullyExpRunningSec	Number	Calculated from PC time, so not as accurate as FullyExposedDuration
FullyExposedEnd	Date/Time	Computer timestamp when chamber is seen moving away from the exposed position
ShieldingTransitionEnd	Date/Time	Computer timestamp when chamber is seen in the shielded position
StartTemp1	Number	Temperature at start of exposure
EndTemp1	Number	Temperature at end of exposure
StartPressure	Number	Atmospheric pressure at start of exposure
EndPressure	Number	Atmospheric pressure at end of exposure
StartHumidity	Number	Relative humidity percent at start of exposure
EndHumidity	Number	Relative humidity percent at end of exposure
BasicState	Short Text	Indicates state of irradiator at time that this record was last updated
TotalDoseThisExposure	Number	Sum of ExposingTransitionDose, FullyExposedDose, and ShieldingTransitionDose
DBLastUpdated	Date/Time	Internal use for ORM
AvgTemp1	Number	Average temperature recorded during exposure
SrcSel	Number	Source Selection that corresponds with ECalcData table



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- Developed a system for loading sources on site
 - Reduced down time
- System holds up to 36 sources
 - 8-12 sources loaded installation
 - Enough source storage space to perform at least 2 reloads to full capacity
 - *Assuming reloading occurs at each half-life





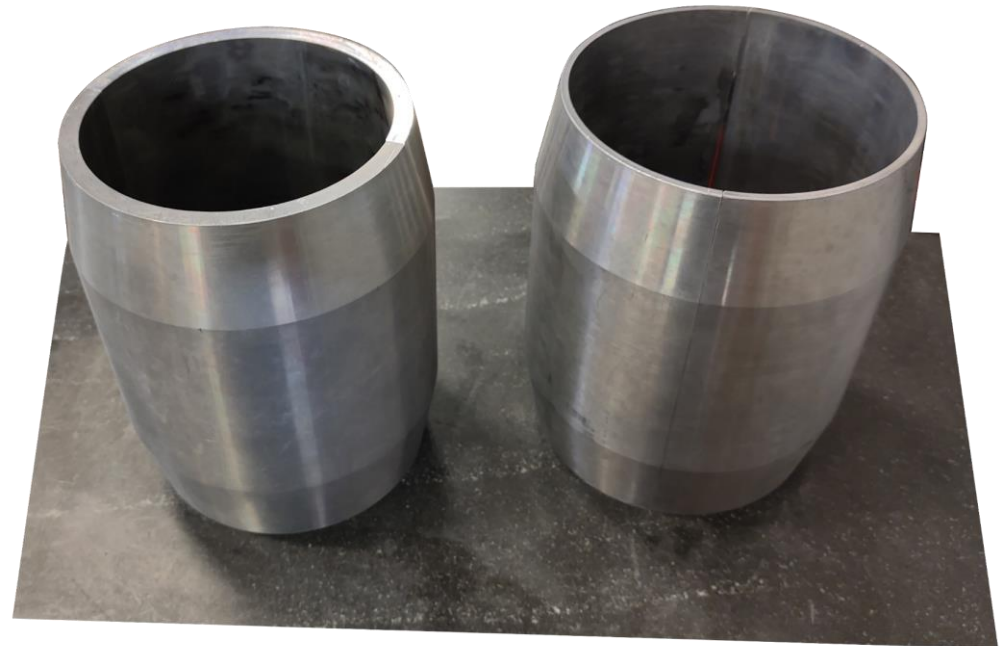
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Service and Support

- Confidence to move forward for the next generation
- A strong company, committed to servicing and supporting these systems into the future
 - Annual maintenance
 - Calibration services
 - Available accessories
 - Attenuators
 - Filters
 - Flatteners
 - Temperature control systems
 - Custom design services





Questions?

The GR420 ...
A CIRMS Needs Report
success story.

Thank you!