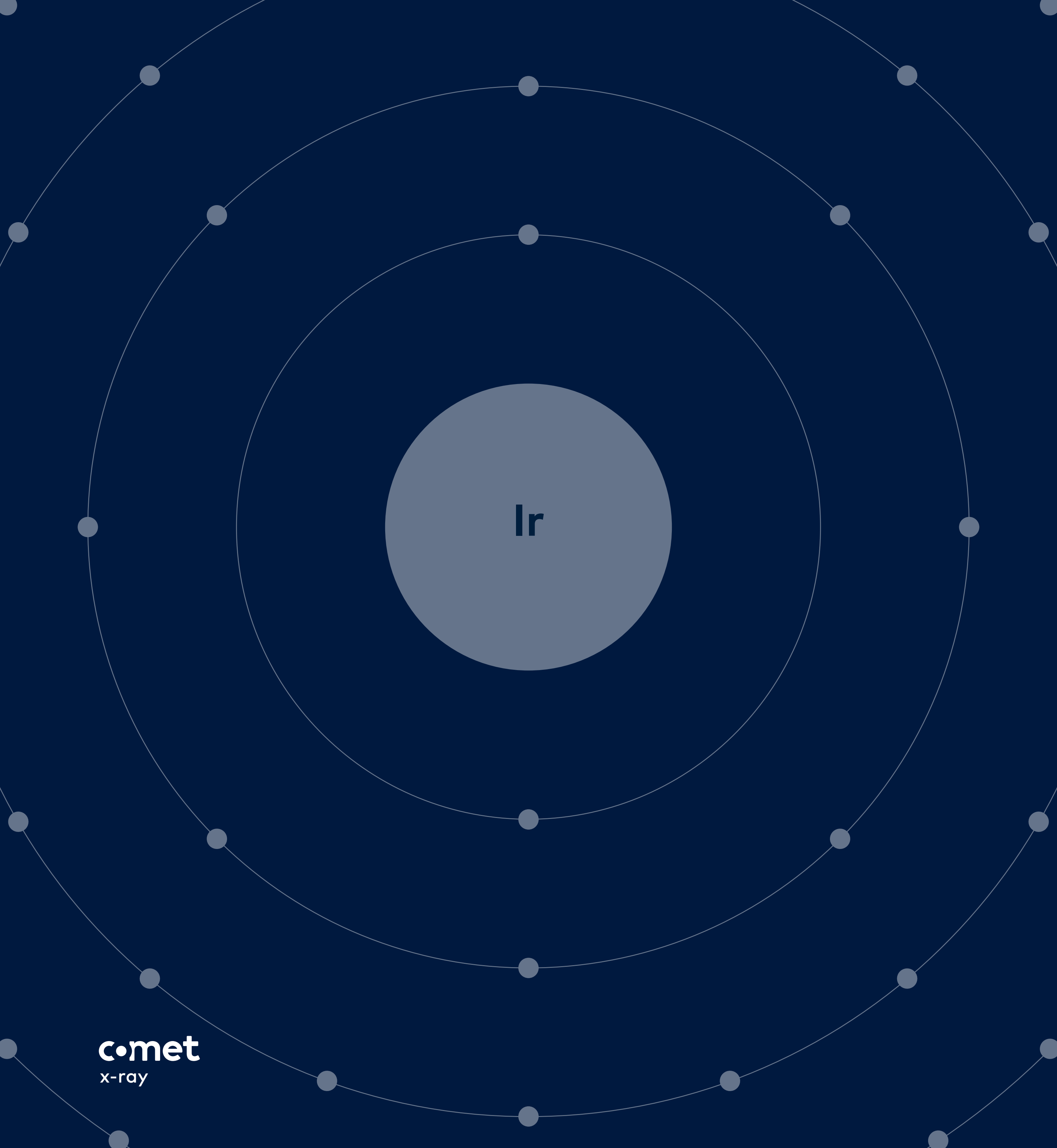
Focus topics | January 2025

Evaluating the shift from Gamma to X-ray



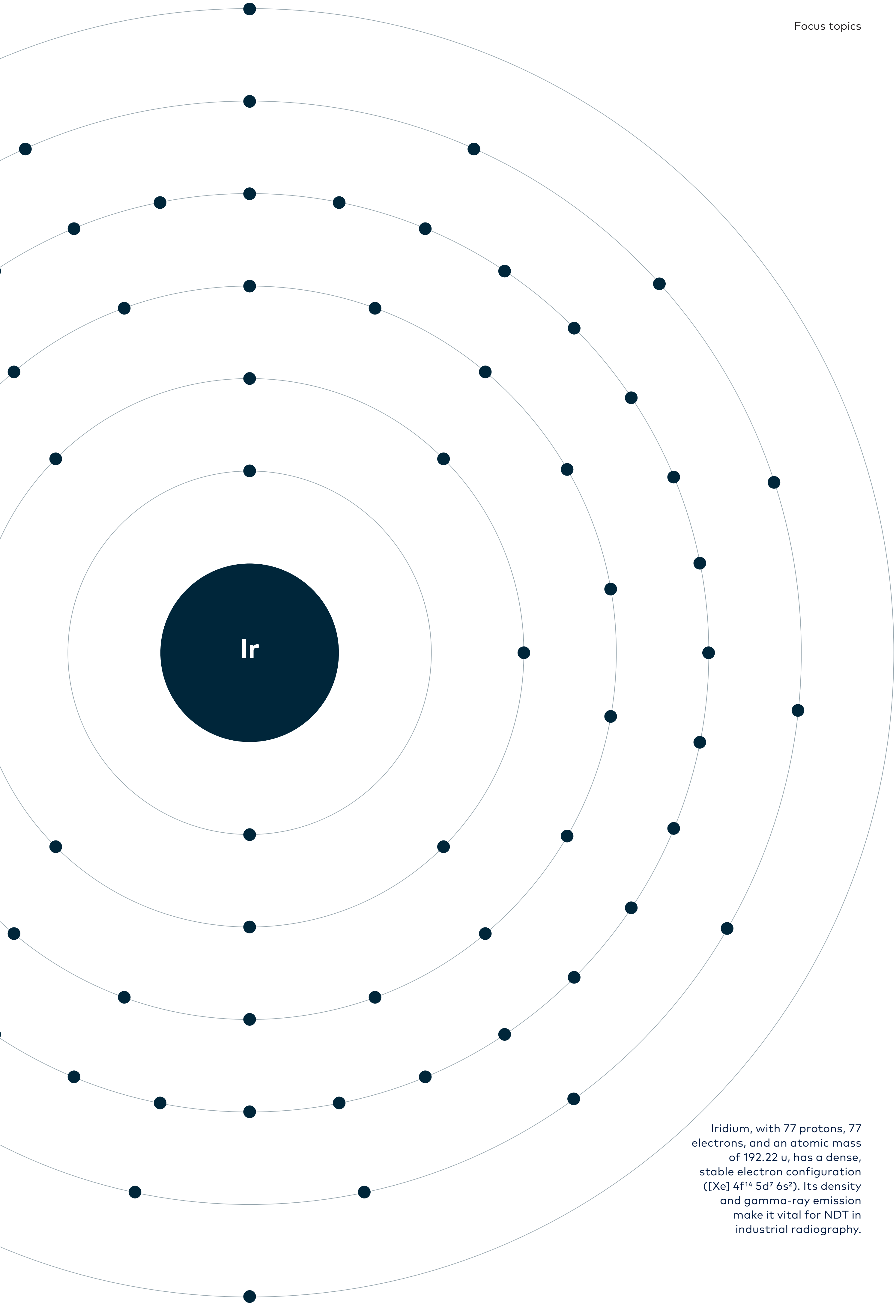
comet x-ray

Summary

In industries critical for our society such as oil and gas, power generation, and manufacturing, non-destructive testing (NDT) plays a pivotal role in ensuring the integrity and safety of critical components. Gamma-ray inspection has long been a preferred method due to its portability and high penetration power, particularly in remote or rugged environments. Meanwhile, advancements in mobile X-ray & portable technology, such as the Comet X-ray ECO-, EVO-, and XMB series, offer a compelling alternative with distinct advantages in safety, efficiency, and imaging quality. This document explores the unique strengths of both gamma-ray and X-ray systems, helping industry professionals evaluate the best approach for their specific needs.

Introduction

Industrial inspection requires a balance between portability, accuracy, safety, and efficiency. While gamma-ray sources have traditionally been favored for their simplicity and reliability in challenging environments, X-ray systems have evolved to address modern demands for flexibility and safety. Each technology has its merits, and selecting the appropriate method depends on the specific inspection requirements and operational constraints. This document examines both options, highlighting their respective advantages and limitations.



Iridium, with 77 protons, 77 electrons, and an atomic mass of 192.22 u, has a dense, stable electron configuration ([Xe] $4f^{14}$ $5d^{7}$ $6s^{2}$). Its density and gamma-ray emission make it vital for NDT in industrial radiography.

Comparison of Gamma and X-ray Inspection

Safety and Radiation Control: Gamma sources emit radiation continuously, necessitating stringent safety protocols, secure handling, and compliance with complex regulations. This constant emission can pose risks if not carefully managed. X-ray systems, on the other hand, produce radiation only when powered and activated, reducing exposure risks and simplifying operational workflows.

Image Quality: Gamma-ray systems are effective for inspecting thick or dense materials, providing sufficient penetration for critical inspections. However, their images tend to have lower resolution, which can make detecting fine defects more challenging. X-ray systems excel in producing sharper, high-resolution images, making them ideal for identifying smaller flaws and ensuring detailed evaluations of welds, pipelines, and pressure vessels.

Flexibility and Adjustability: X-ray systems allow for adjustable energy levels, enabling inspections across a variety of material thicknesses and densities. In contrast, gamma-ray systems rely on fixed energy outputs determined by the isotopes, which limits adaptability but remains effective for standard applications.

Portability: Gamma-ray systems are often compact and highly portable, often used in remote or rugged environments where power access is limited. However, they require heavy shielding containers for transport and operation. Modern X-ray systems have become increasingly portable, designed for ease of deployment in industrial settings, though they typically require access to electricity or battery power.

Space constraints: Despite the ongoing miniaturization of electrical X-ray equipment, gamma-ray systems offer certain advantages, particularly due to their compact collimators. These systems are often the best or only viable option in confined spaces or specific challenging scenarios.

Cost Considerations: Gamma-ray systems often have lower upfront costs, ranging from $20.000 to $30.000, making them accessible for smaller operations. However, ongoing costs for isotope replacement, regulatory compliance, and waste disposal can accumulate over time. X-ray systems have a higher initial cost, approximately $40.000-80.000, but their operational expenses are significantly lower due to minimal maintenance and the absence of radioactive materials.

Understanding Isotope Decay

Isotope decay describes how radioactive isotopes lose their radioactivity over time through radioactive decay. The half-life is the time it takes for an isotope to half its activity, called decay. For example, Iridium-192, a commonly used isotope in industrial radiography, has a half-life of approximately 74 days. This means its intensity decreases significantly over a few months, requiring frequent replacements to maintain adequate radiation levels.

Radioactive decay is an exponential function, meaning the radiation output decreases by half with each passing of the half-life period. The mathematical formula for determining the remaining radiation level at any time is:

$$N(t) = N_0 \cdot \left(\frac{1}{2}\right)^{\frac{t}{T}}$$

Where: N(t): Remaining activity at time t, N0 = 100: Initial activity, T= 74: Half-life in days, t: Time elapsed in days

Common Isotopes in Industrial Applications

Iridium-192

Half-life
~74 days.

Application
Commonly used in non-destructive testing (NDT) for inspecting welds and pipelines.

Decay rate
Requires frequent replacement to maintain effective radiation intensity.

Cobalt-60

Half-life
~5.27 years.

Application
Used in industrial radiography and sterilization of medical equipment.

Decay rate
Slower than Iridium-192, allowing for longer usage intervals but requiring careful monitoring.

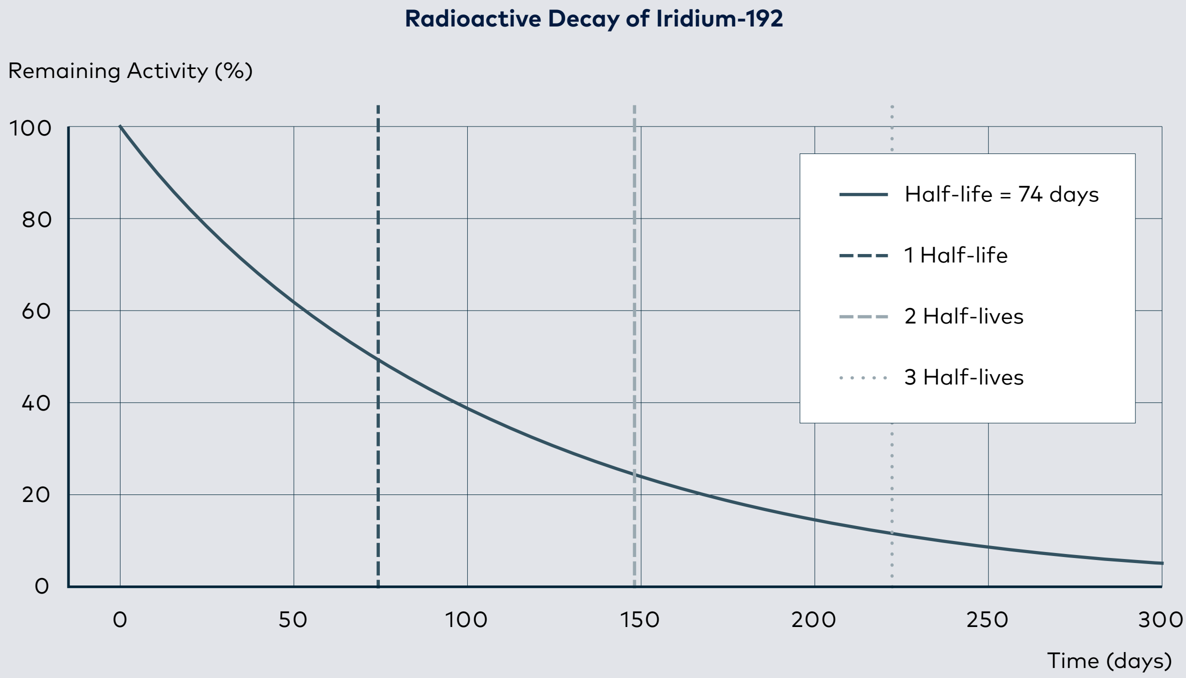
Selenium-75

Half-life
~120 days.

Application
Often used in NDT for specific imaging requirements.

Decay rate
Intermediate, offering a balance between intensity and replacement frequency.

Visualizing Isotope Decay
A decay curve demonstrating the exponential reduction in radiation intensity over time for isotopes like Iridium-192 is included. This graph illustrates the rapid decrease in activity, highlighting the challenges of maintaining consistent inspection performance as the isotope decays.



Practical Implications in Industrial Use

Regular Source Replacement
As isotopes decay, their radiation intensity diminishes, which affects the quality and speed of inspections. For example, an Iridium-192 source may need replacement every 3–6 months to maintain adequate penetration power.

Increased Exposure Time
To compensate for lower intensity as an isotope decays, operators must increase exposure times during inspections, reducing efficiency and potentially disrupting workflows.

Safety and Compliance
Decaying isotopes require secure storage and transport due to persistent radiation. Handling old or spent sources demands strict adherence to hazardous waste disposal regulations.

The decay of isotopes also increases exposure times during inspections and reduces efficiency, further complicating workflows. Additionally, gamma-ray sources continuously emit radiation, creating persistent safety risks and requiring strict regulatory compliance for storage, transport, and disposal.

By contrast, X-ray systems eliminate these challenges. They produce radiation on-demand, ensuring consistent output without the diminishing intensity associated with isotope decay. This capability not only enhances operational efficiency but also significantly reduces long-term costs and safety concerns.

Cost-Benefit Analysis

Switching from gamma-ray to X-ray systems can deliver substantial cost benefits over time. A typical gamma-ray setup, including equipment and isotope replacements, costs approximately $35.000 annually.

This includes $7.500 for equipment maintenance and $12.500 for regulatory compliance, safety protocols, and isotope replacements. Additionally, disposal of radioactive materials can add $5.000 annually.

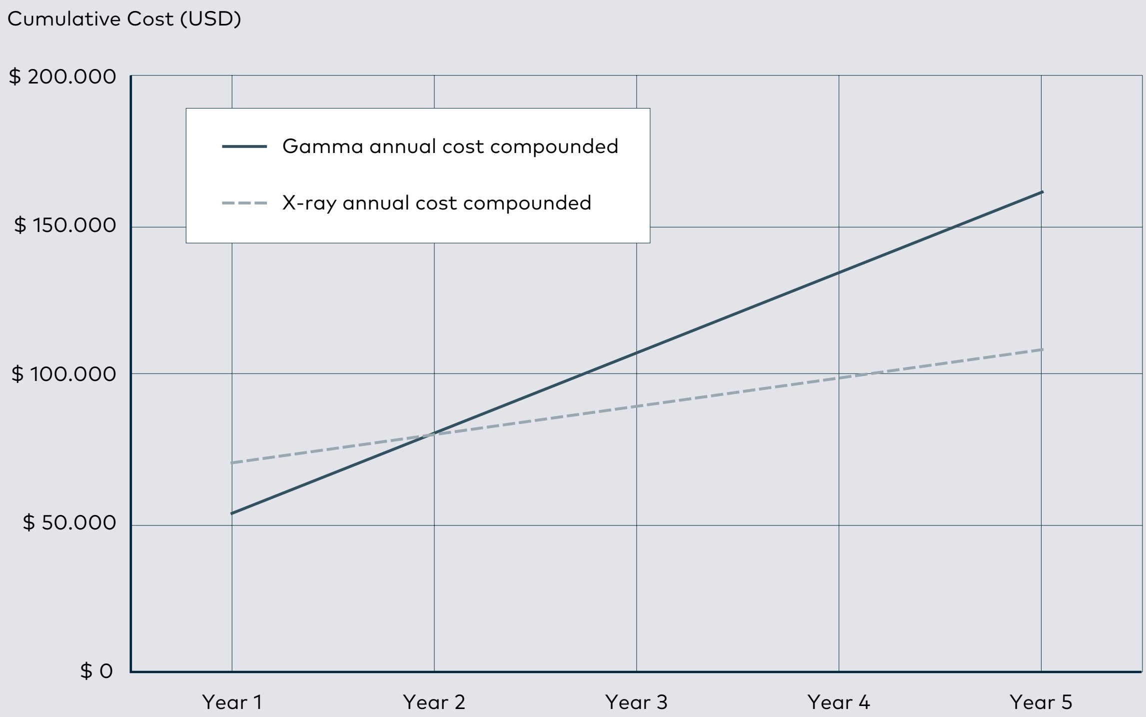
In contrast, as example portable X-ray systems like the Comet EVO 300 kV have an upfront cost of $60.000.

However, operational expenses are significantly lower, averaging $10.000 annually for licensing, maintenance and power.

Over a five-year period, the total cost of ownership for gamma-ray systems would amount to $152.500, while the cost for an X-ray system would be $110.000.

The cost savings of $42.500, combined with enhanced safety and imaging capabilities, make X-ray systems a more attractive investment. *

Gamma and X-ray annual expenses



*** Variability & Verification Recommended**
The cost estimates in the table are approximate figures based on industry trends and general assumptions as of 2024. Actual expenses may vary depending on supplier pricing, usage, location, and regulatory requirements. Readers should obtain official quotes and expert advice before making financial or operational decisions.

Benefits of Transitioning to X-ray Systems

The transition from gamma-ray to X-ray systems offers numerous potential benefits for industrial inspection:

Enhanced safety eliminates the risks of continuous radiation emissions, protecting technicians and simplifying workflows.

Superior image quality allows for the detection of smaller defects, improving inspection accuracy and ensuring the longevity of critical components.

Regulatory simplicity reduces the complexities of transport, storage, and compliance associated with gamma-ray sources.

Cost-effectiveness over time minimizes operational expenses and regulatory hurdles.

Environmental responsibility supports corporate sustainability goals by reducing hazardous waste.

Higher throughput due to shorter exposure time.

Comet portable & mobile X-ray systems: Leading the Charge

The Comet XMB, EVO and ECO series exemplify the advantages of modern mobile X-ray systems. These devices combine high portability with advanced imaging capabilities, making them suitable for various industrial applications. With adjustable energy settings, these systems cater to diverse material thicknesses and densities, ensuring precision and efficiency. Engineered for rugged environments, the XMB, EVO and ECO series provide durable, reliable solutions that meet the demands of heavy industry. Most importantly, their on-demand radiation feature enhances safety, providing peace of mind for operators and stakeholders alike.

Conclusion

Gamma-ray inspection has long been a staple in non-destructive testing. Still, its inherent limitations in safety, flexibility, and long-term cost-effectiveness make it less viable in today's industrial landscape. Mobile X-ray systems, such as the Comet XMB, EVO and ECO series, represent a significant leap forward, offering a safer, more adaptable, and environmentally friendly alternative which covers the majority of applications. By transitioning to X-ray technology, businesses can enhance safety, improve inspection accuracy, and achieve greater operational efficiency.

Curious about the Comet X-ray ECO, EVO and XMB series?

Discover how the Comet XMB, EVO and ECO series can change your inspection processes. Contact our local representative or our team today to schedule a consultation. Experience the future of non-destructive testing with cutting-edge mobile X-ray systems tailored to your industrial needs.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