Industrial Radiography Safety: Best Practices

Presented is a high-level look at best practices for industrial applications that will provide insight into the foundational safety techniques affecting X-ray and gamma-source radiography

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Industrial radiography provides practitioners of nondestructive examination (NDE) with a powerful set of inspection tools for a wide variety of materials. The utilization of ionizing electromagnetic radiation allows objects to be scrutinized at levels not reached by other NDE techniques. Radiographic testing processes commonly involve the use of X-rays or gamma-emitting materials to produce highly detailed images for inspection.

The benefits of employing industrial radiography in crucial testing environments are numerous while the risks involved for personnel require careful consideration. The acts of minimizing risk and promoting calculated safety measures ensure that industrial radiographers are protected from harmful exposure to radiation.

“Industrial radiography presents our customers with immense benefits such as highly detailed human readable images, cost-effective and safe inspections, and exciting analysis algorithms. Maintaining a strong focus on safety and associated best practices helps all those involved realize the greatest benefits of conducting NDT using industrial radiography,” said Martin Graen, general manager, NDT Solutions, Carestream Health.

This “best practice” article is intended to provide a high-level overview of important radiography safety considerations. The implementation and management of a comprehensive safety program will aid in lowering the risk involved with the practice of industrial radiography techniques both in the workplace and out in the field. Please use this guide as a supplement to a robust safety campaign. It is important to note that many state and federal regulations and certifications are required to execute industrial radiography activities.

The powerful nature of industrial radiography presents unique challenges to those utilizing this nondestructive examination method to inspect critical components and structures. Unlike the medical industry, which operates in a mostly controlled environment, NDE often takes place in a field location or manufacturing area. This mobility leads to the need for an intense focus on safety as there are often more variables in personnel, equipment, and the environment when working in uncontrolled spaces.

The ALARA Principle

Radiographers utilize the “As Low As Reasonably Achievable” (ALARA) principle as a baseline philosophy for conducting high-energy tests. ALARA seeks to keep exposure as low as possible when weighed against potential risks and benefits of the job. This philosophy promotes fundamental ideas in controlling safety risk while performing industrial radiography.

Reduce Exposure. Minimizing short-term exposure to radiation sources such as X-ray devices and gamma-emitting materials is one of the most effective ways to avoid long-term radiation accumulation. Table 1 indicates the most common methods of reducing exposure to harmful radiation.

Track Exposure. Monitoring radiation exposure levels for involved persons enables organizations to control risk by distributing tasks according to historical data. Creating charts based on employee film badge readings allows decision-makers to allocate testing jobs based on exposure levels.

Employ Extra Layers of Safety. ALARA promotes the following safety precautions:
- Maintain direct control of camera or radiation source at all times
- A licensed radiographer must be on hand during testing with gamma sources
- Operating and safety procedures must be readily available
- Implement extra layers of shielding or use the test object as additional shielding.

Table 1 — Common Methods for Reducing Exposure to Harmful Radiation

| Shielding  | Use appropriate shielding at all test sites and on all persons |
| Distance   | Maintain adequate distance between radioactive sources and persons |
| Duration   | Minimize time spent near or within radiation fields |
| Quanta     | Utilize the smallest amount of radioactive material possible to accomplish the job at hand |

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The ALARA principle provides important universal safety considerations that all industrial radiographers must implement throughout their careers. Adhering to this basic philosophy will enhance the safety and quality of work for everyone involved in nondestructive examination operations.

**Safety Tools**

State and federal regulations require the use of radiation-detection tools when practicing industrial radiography. This safety equipment not only allows tracking and awareness of radiation activity but also provides a vast safety net for all those involved. It is essential to the success of a comprehensive safety program that radiographers maintain properly calibrated devices to use in all testing activities.

“The use of properly calibrated radiation-detection equipment is essential to the safety of the radiographer and the public,” explained Douglas Miskell, certified radiation safety officer (CRSO) and ASNT Level III RT, Quality Inspection Services, Inc. “The use of mandatory radiation-detection equipment, along with a film badge, will ensure compliance with all regulations and support safety as the top priority of any industrial radiography operation.”

A long-standing, reliable safety tool for industrial radiographers is the film badge. Carried around in a protective container, the film badge is an exposure measurement tool used for a finite period of time. Unable to be reset, the film provides an unalterable and permanent record of an individual’s radiation exposure. A significant benefit of using the film badge is that it provides reliable data that are used for job allocation and report generation. This device provides vital measurements to all involved parties and is also used in regulatory audits in most areas.

There are many other tools that are used alongside the film badge when conducting industrial radiography. A variety of dosimeters allow instant measurements of radiation to alert users of limits and thresholds as they are exceeded. Other meters are also available to detect radiation rates of exposure and elapsed exposure time.

Powerful tools are available from industry providers such as Global Dosimetry and Quantum Products that provide indispensable service and knowledge to radiographers and testing professionals. Used in combination with a film badge, the specialized devices provide strong safeguards and regulatory compliance records for organizations that use industrial radiography internally or are a service provider.

**Safety When Using X-Ray Devices**

Industrial radiography applications requiring moderate to high energy radiation intensities benefit from using X-ray emitting devices. When set up properly with regard to safety considerations, these devices provide controlled testing techniques for NDE professionals. X-ray devices are commonly used in permanent facility installations but can also be used on field operations.

X-ray protection can be provided in a number of ways depending on the installation and usage requirements. Whenever possible, protective measures should be built in as permanent features of the installation. Preferably, the X-ray generator should be located in an enclosed room or cabinet with all controls outside of the space. Protective material, most commonly lead, is used in sufficient thickness to reduce exposure in occupied areas to the lowest value possible.

If radiography must be accomplished in the shop or field and not in a permanent facility, special precautions are necessary. Lead cones (collimators) on the X-ray machine should be used to confine the beam to a single direction and angle for maximum effectiveness in usage. As in gamma ray situations, distance is also an important factor when operating in the field. Proper signage around the testing area will alert personnel and third parties of radiation activity.

Lead is the most common protective material when using X-ray devices. It combines high protective efficiency with low cost and easy availability. Important considerations when using lead as protection include eliminating leakage, ensuring sheet overlap, and properly covering screws and nails. Although lead is the most common material for X-ray attenuation, other materials may be used such as structural walls of concrete or brick.

When properly controlled, X-rays provide consistent results to industrial radiographers operating in both controlled and field environments.

**Safety When Using Gamma-Emitting Testing Processes**

Gamma radiation provides immense benefits over lower-energy X-rays by allowing maximum penetration of materials while delivering highly detailed images. Additionally, gamma source devices (referred to as “cameras”) do not require an electrical supply to operate. Industrial radiography applications that benefit from gamma radiation are most commonly seen in testing welds, machined parts, plate metal, concrete, pipe wall, and structural materials.

Because of the portable nature of gamma sources, testing may be conducted in both on-site and field operations. Common isotopes such as Selenium-75, Iridium-192, and Cobalt-60 emit gamma rays that can be extremely harmful when used without proper safety considerations. The use of Selenium-75 is becoming popular as its energy spectrum poses less of a risk of radiation exposure to workers and the public. It is important to note that government regulations dictate many controls over the transportation, handling, and usage of gamma-emitting isotopes.

“The use of Selenium-75 is increasing in popularity due to its ability to minimize radiation boundaries in work zones. Reducing these boundaries is essential to maintaining the normal and safe operation of the surrounding work areas during shutdown,” said Miskell.

The intensely penetrating nature of gamma rays forces scrutiny on not only shielding and protection methods, but also distance from the source. Lead shielding is less effective on gamma rays than X-rays and only about a 50% reduction in radiation intensity is realized with one-half inch of lead. Because of the greater thickness requirements of shielding materials, distance is the most economical method of protection while the source is in use. An “exclusion” zone is setup around the location of the radioactive material, and personnel are forbidden to enter the zone while the source is exposed. Proper signage should be placed liberally near the testing site to warn third par-
ties of radiation danger.

Another important safety consideration when working with gamma sources is scattering. A large mass of scattering material, for example a wall, will increase gamma ray exposure by as much as 50%. It is also important to adhere to transportation regulations when shipping and handling gamma sources.

When working with gamma rays, factors such as shielding, distance, scattering, and material transportation must be recognized with the highest priorities being safety and protection from harmful radiation.

Regulatory Safety Requirements

Government and state regulations exist to safeguard all those involved when practicing industrial radiography. Many states define their own specific requirements for the practice and maintain full jurisdiction over industrial radiography within their borders. Practitioners should keep governing documents on hand at all times to ensure full compliance with state authorities. Other states choose to rely on federal jurisdiction over regulatory policies rather than draft their own. In these situations, industrial radiographers must adhere to requirements set by the United States Nuclear Regulatory Commission and other participating departments.

Compliance with state and federal regulatory guidelines promotes the practice of controlled safety processes for all industrial radiographers. Regulations work to enable the safe use of radioactive devices in a variety of situations.

Best Practices Outside of the ‘Lab’

Education and reinforcement remain the two greatest tools in creating knowledgeable employees and test personnel. Many certifications require organizations to maintain annual training courses and educational seminars outlining safety within the industrial radiography domain. Requiring workers to remain informed of the latest standards in safety greatly reduces risk while performing dangerous job duties.

Risk management is also a technique that is utilized by many organizations looking to increase safety on the job site. Evaluating key risk factors for each project will provide intelligent insight into the overall cost-benefit analysis of the job at hand. When certain risks are deemed inappropriate, members of the radiography team can work to improve conditions or testing procedures to create long-term safety enhancements for future work.

Safety Equals Success

When a comprehensive safety program is in place alongside compliance with all regulatory requirements, industrial radiography provides immense benefits to both industry and society. Great achievements in manufacturing, infrastructure, transportation, and industry output are realized with the implementation of powerful radiographic tools. Best safety practices in radiography support risk avoidance, lower liability, and most importantly, long-term health to all those involved.