Narrative, Gamma Radiography Sources and Equipment - Design Improvements and Industry Adoption

Slide 1:

My name is Michael Fuller and I am the director of regulatory affairs and quality assurance at QSA Global. Today I am presenting on behalf of the International Source Suppliers and Producers Association, and I will be briefly discussing advancements in industrial radiography sources and equipment that contribute to ALARA, as well as some of the current issues we face when designing equipment improvements.

Slide 2:

Application of the ALARA principle to industrial radiography has come a long way in the last hundred or so years. The process of taking a radiograph developed not long after the discovery and isolation of radium. As is often the case, man put this new technology to use before fully understanding the potentially harmful effects. Here you see a radium bobbin being positioned by hand in what has been termed the 'fish pole' technique.

Slide 3: [Projector Setup, Time-Distance-Shielding]

Over time the effects of chronic radiation exposure have become better understood. Measures were subsequently developed to minimize the exposure to the user, and their application is evident in our current radiography equipment and processes.

- High activity sources and improved film sensitivity have both helped reduce the exposure time.
- The application of distance is provided through remote controls and guide tubes to position the user further from the source when it is not shielded
- Shielding is provided both during storage of the source in the projector and by collimators at the exposure point. Further shielding is often applied through the use of bunkers or walls as available.

Slide 4: [Projector Styles]

Many projector styles are available on the market to choose from. Each has its own strengths and options, but all meet the minimum requirements for safety and security and provide the same basic functions.

Slide 5: [Source Styles]

Source designs have also seen improvements over time. Radioactive material encapsulations are robust and able to survive thousands of cycles through the equipment without fear of releasing their contents, and the assemblies are designed to minimize the chance of a disconnected source being stranded in an exposure sheath.

The source assemblies within the projector are variations of two styles, either the link style (incorporating tungsten links as shielding) or a flexible cable (sometimes referred to as a pigtail). The choice of source assembly style is driven by the source channel configuration within the projector itself (straight-through, S-tube, helicoidal)

Slide 6: [Table of Common Isotopes]

The most common isotopes used in today's radiography applications are cobalt, iridium, and selenium, with some limited applications for ytterbium. The various physical properties of each isotope, such as gamma energy and half-life, drive their application.

Slide 7: [Castings – Use of Co-60]

For example, the high energy gammas emitted from cobalt-60 give it about double the penetration ability as iridium-192, making it ideal for thick steel components. Cobalt is the most common isotope applied at foundries for radiographing large castings (valve bodies, etc.).

Slide 8: [Table of Common Isotopes – Highlight Se-75]

Thulium and cesium have been included in the table, but primarily for historical reference. These isotopes have for the most part fallen out of use.

By far the most commonly used isotope is iridium. However, since the 1990's, selenium 75 has seen increased attention and demand for a number of reasons.

Slide 9: [Table of Se-75 Benefits/Drawbacks]

Although it does not have the penetrating power as the more commonly used isotope, iridium-192, this same characteristic makes Se-75 easier to shield. Thus, devices loaded with Se-75 can be designed to effectively shield the source with tungsten, eliminating the need for depleted uranium. The softer gamma spectrum produced by Se-75 also results in a better quality radiograph (in the 3-29mm steel thickness range), and selenium lasts about 60% longer than iridium (significantly reducing the frequency of source replacement, which correspondingly enhances ALARA associated with transportation).

Slide 10: [SCAR, SAFER, Close Proximity]

In the early 2000's, a market need was identified for a radiography process that did not involve the posting of a large exclusion area. The resulting systems have been promoted as SCAR (Small Controlled Area Radiography), SAFER (Small Area For Exposure Radiography), or Close Proximity.

Slide 11: [SCAR Projectors, Then and Now]

The use of close proximity radiography is not in itself a new concept. Prior to the introduction in the 1970's of the projectors commonly found in use today, early radiography cameras retained the source within a shield, and used a moveable shutter for source exposure. Although the cameras provided shielding to the user from direct source exposure, the user's proximity to the camera subjected them to significant scatter radiation. Additionally there were restrictions on how close the source could be placed to the object to be radiographed. Today's SCAR technology offers shielded sources for close proximity with the use of remote controls (either Teleflex cables, similar to projector style setups, or through pressurized air) for performing the source exposure.

Slide 12: [Football Field, SCAR Mounted]

When combined with the use of selenium-75, the SCAR process not only provides a significant reduction in the radiation exposure to the user, it offers the benefit of reducing the exclusion area by as much as a factor of 75. This technology is ideal for use when critical operations cannot be interrupted, or for areas where evacuation of a large exclusion zone is impractical (for example, a drilling platform at sea). With such a small exclusion zone, work can continue nearby without concern of radiation exposure to non-radiation workers.

An additional benefit to using the SCAR process is the lack of source projection. Since the source never leaves the device, an incident requiring source retrieval (and additional personnel exposure) cannot occur.

Slide 13: [Design Inputs]

I'd like to take a moment to discuss the challenges that manufacturers face in bringing a new or improved piece of equipment to market. There are many inputs to designing improvements or crafting new equipment. I do want to be honest with you and point out that from a commercial aspect, safety and exposure ALARA considerations are rarely driven by customer input, but by regulation and standards.

Slide 14: [Conflicting Desires 1]

Designing a product that meets everyone's expectations can be a major challenge. Users, Manufacturers and Regulators often have differing needs or requirements. Notes: (1) fool proof design requirements (features such as interlocks) have evolved over time to address the mis-use and resulting events in the field. (2)

balancing the usability of a source or device with the preventative features can be a challenge.

Slide 15: [Conflicting Desires 2]

This next conflict is interesting from a U.S. manufacturer's perspective: the radiography industry in the U.S. is very competitive. The faster a job can be completed, the faster the radiography company can move on to another job and the more money they can make. At the same time, the less intrusive the radiography becomes for the hiring company. This directly conflicts with the perspectives in other countries, where the radiological safety is thought to be enhanced by limiting the activity of a source used for radiography.

And finally, all parties are in the business to make money.

Slide 16: [Marketing Considerations]

Once the product inputs have been addressed, and while the concept is still in development, there are still many market considerations.

Slide 17: [Alara Implementation]

The culture of ALARA in industrial radiography is primarily dictated through regulatory requirements. Source and device designs are developed not only with user and manufacturing practicality considerations, but with regulatory and standards inputs as well.

The use of close proximity or SCAR technology is seeing increased adoption, though in a limited fashion, as most radiography [setups] still require the use of projected sources.

Similarly, the use of selenium 75 has increased, but again the lower energy gamma emissions from Se-75 eliminate it as an option for many radiography applications.

Are there potential further innovations that can contribute to exposure ALARA? Possibly, but in the mean time we see a continued need to place emphasis on training, with a special focus on safety. Events occur: for example, equipment falls and crushes a projection sheath preventing the ability to retract a source assembly to its shield. But all too often the reports of these events include statements to the effect that "The radiographer's alarming ratemeter was found to be not functioning", "It was later determined that the assistant radiographer was not wearing dosimetry or alarming ratemeter", "The radiography team had a survey meter, but had left it in the truck". These are all examples of a poor safety culture and a lack of understanding of the significance of these users actions (or inactions as the case may be). Improved training, as well as embracing a culture of safety, offer the largest potential returns on investment for ALARA in the field of industrial radiography.