Emerging standards in cargo screening

New technical and performance standards in X-ray cargo screening systems enable users to make parametric comparisons between competing products and systems

Dr. William A. Reed, Varian Medical Systems, Las Vegas, NV, USA

X-ray cargo screening has emerged quickly in the marketplace to become the dominant technology for inspecting trucks and large containers in a cost efficient and non-intrusive manner. Because these are complex systems containing numerous interdependent sub-systems, officials have increasingly called for objective metrics and benchmarks to identify, assess, and compare the available offerings. To that end, this article discusses emerging standards that are developing in the industry to satisfy this need.

Cargo and vehicle screening standards

Recently the Institute of Electrical and Electronics Engineers (IEEE), under accreditation from the American National Standards Institute, published the first generally accepted standard for determining imaging performance of X-ray cargo screening systems. Known as ANSI N42.46-2008, this standard was created through the sponsorship of the National Committee on Radiation Instrumentation and intended to be used to determine imaging performance of both X-ray and gamma-ray inspection systems.

This standard is applicable to all types of vehicles, whether empty or loaded, including marine containers, air cargo containers, railroad cars, and palletized and unpalletized cargo larger than one square meter in cross-section. It also applies to systems with X-ray sources that operate at single and multiple energies, as well as those systems intended for backscatter operation.

The standard is intended to define the process and equipment required to accurately measure the performance of imaging systems that are covered within its scope. Meeting the standard requires users to complete a set of tests that characterize the imaging performance of a screening system. In addition to the specific tests, the standard specifies that the radiation field around the equipment be measured as part of the characterization of system performance. This provides a contour map of radiation related to the 100mrem per year value that is considered safe for workers who may be present for 2,000 hours per year. It also specifies the measurement of other related radiation exposure levels for the purpose of comparing systems.

The primary intent of the standard is to allow manufacturers, potential users, and other parties to have a consistent indicator of screening system performance when using a system for the inspection of actual cargo and vehicles. To achieve this, the standard specifies that a test fixture be utilized with the capacity to detect a specified test object located behind steel plates of varying thicknesses (see Figure 1). With such a fixture, standard measurements are obtainable for a number of imaging test requirements, generally consisting of penetration, spatial resolution, wire detection, and contrast sensitivity.

Penetration

During the test process, specified test objects are placed in various locations in the container being tested. The test objects are defined in the standard and consist of carbon steel in the shape of a 'kite-like' arrow. A test fixture holds the test object at random directions (cardinal orientations only), and proper identification of the arrow direction during the scan is evidence of successfully passing the test (see Figure 2). Additional carbon steel plates are placed in front of the test object to measure penetration.

Figure 1. A test fixture with movable steel plates.

Spatial resolution

The spatial resolution test is intended to measure the minimum separation between the features of a test object that can be detected in an X-ray scanning system. It is conducted in air without blocking plates and must be performed in both horizontal and vertical orientations, at specified points within the container.

For this test, the test object is a steel line pair gauge with three slots in a steel plate, or with three square steel rods in a base. In both cases, the width ('d') of the material shall be equal

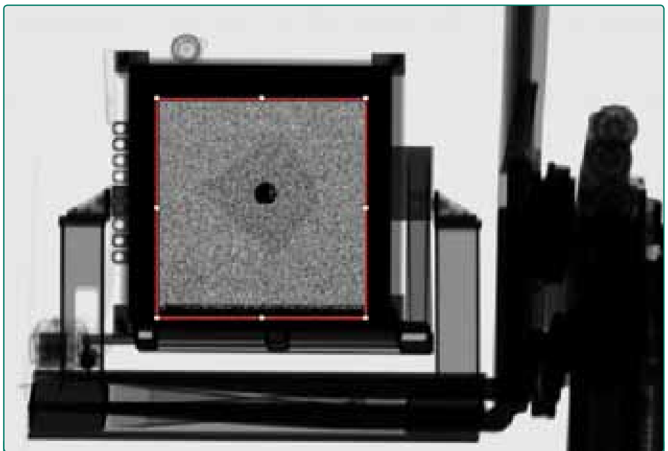

Figure 2. A test arrow located behind steel plates.

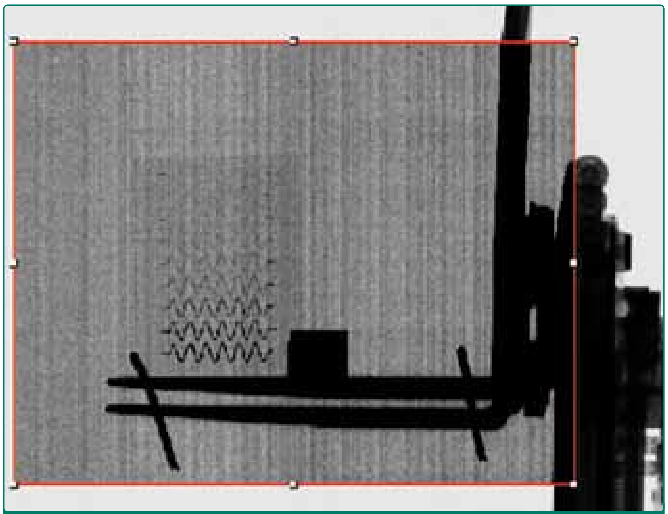

Figure 3. Wire test behind steel plates.

to the distance between the plates or rods. To complete the test, incremental values of 'd' are used, including a value that results in an indiscernible difference between the material and adjacent spaces.

Wire detection

The wire detection test is to determine the smallest diameter of wire that can be observed in an X-ray scan. The test can be performed in air or with steel blocking plates as determined by the manufacturer (see Figure 3). More specifically, the standard specifies the use of bare copper wires of varying diameters (typically 10 to 24 AWG) formed in a sinusoidal pattern. Again, the test object is to be placed at specified locations in the container and oriented in vertical and horizontal directions. Wires are considered to be detected when the majority of their length is observable on the X-ray scan.

Contrast sensitivity

This test is to measure the minimum incremental thickness of steel that can be seen on an X-ray image. It utilizes a thin, arrow-shaped steel test object located behind steel blocking plates of a specified thickness. The ability to determine the orientation of the arrow on the X-ray is evidence of contrast sensitivity for the thickness used. The complete test requires three thicknesses of steel blocking plates, which correspond to 10 percent, 50 percent and 80 percent of the maximum penetration thickness determined in the penetration test. The contrast sensitivity metric is expressed as a percentage, and equates to the ratio of the minimum thickness of the test object to the total thickness of the combined test object and blocking plates.

Taken together, these standards define a common methodology and language but do not establish fixed performance criteria for cargo screening systems. While this makes interpretation more difficult, it makes sense considering that cargo screening systems are designed with different missions in mind and sometimes to meet the local requirements of their customers. It also allows direct comparison between systems that report data from these tests, and can serve to establish relative performance between competing systems.

Note that these tests (except for the radiation field measurement) produce system-level metrics and provide imaging measurements that are a function of both the source and the detection equipment. In other words, more sensitive detectors in one system may compensate for a weaker source in another system, producing essentially the same imaging results, albeit with different radiation field patterns. Therefore, test data cannot generally be established solely for an X-ray source, or for a detector array, but only for a combined system.

Digital data standardization

Another emerging standard in cargo security is the data formatting of X-ray images. This follows the path of medical imaging, where X-ray data formats have long been standardized and are transportable among various devices and systems. For cargo security, the resulting images frequently become forensic and evidentiary tools, requiring high-integrity standards for compatibility, transmission, and storage.

Within the U.S., the Department of Homeland Security, working in conjunction with the National Electrical Manufacturers Association (NEMA), is in the process of creating such a standard. This work is based on the latest version of the original NEMA DICOM imaging standard published in 1985 (ACR-NEMA Standards Publication No. 300-1985), which is used in the medical field for X-ray images of patients. However, the new standard will be specifically tailored for industrial images, especially those relating to security applications such as baggage scanning and cargo screening. Like the medical version, its intent is to achieve a manufacturer-independent digital file that can be accessed with third party computer software. Eventually, this potential for standardized raw data storage will provide opportunities for the development of more software tools and data handling capabilities.

Cargo screening systems are now available from a wide variety of manufacturers and serve the needs of a diverse marketplace. While technical and performance standards are just emerging, they will increasingly offer a systematic approach to parametric comparisons between competing products and systems. Over time, these and other standards will provide the basis for best-in-class operational metrics and system performance for each application.

ABOUT THE AUTHOR

Dr. William A. Reed is the Commercial Manager for Varian Medical Systems' Security and Inspection Products Group. He holds a master certification in contract management, and has extensive experience in both engineering and program management for security equipment manufacturers along with both U.S. and international patents for the design of security products.

ABOUT THE COMPANY

Varian's Security and Inspection Products Group addresses many types of threats by providing cargo screening system manufacturers and others with products for high-energy X-ray imaging. Varian's specialized linear accelerators are at the heart of cargo screening operations in some of the world's major ports.

ENQUIRIES

William A. Reed, PhD, CCM

Tel: +1 (702) 938 4863
Email: bill.reed@varian.com
Web: www.varian.com/sip