

Twelve things to know before buying an X-ray test tool

A guide for investing in diagnostic imaging quality assurance

The purchase of a diagnostic imaging test tool is an important decision with long-term significance to a healthcare facility. X-ray test tools are traditionally not replaced often, but can be used frequently—sometimes daily. Diagnostic imaging utilization in the medical field continues to expand, exposing more patients to this life-saving but potentially-dangerous equipment every day. Efforts to reduce risk to both patient and facility have never been higher, and new legislation affecting diagnostic imaging quality assurance (QA) professionals continues to make the docket in both local governments and on the national arena.

Many factors can be considered when choosing the right X-ray test tool, and different professionals may find value in diverse elements. For some, price can play a key role in purchase decisions; others may seek value in features that help them with their daily work or in meeting specific QA objectives.

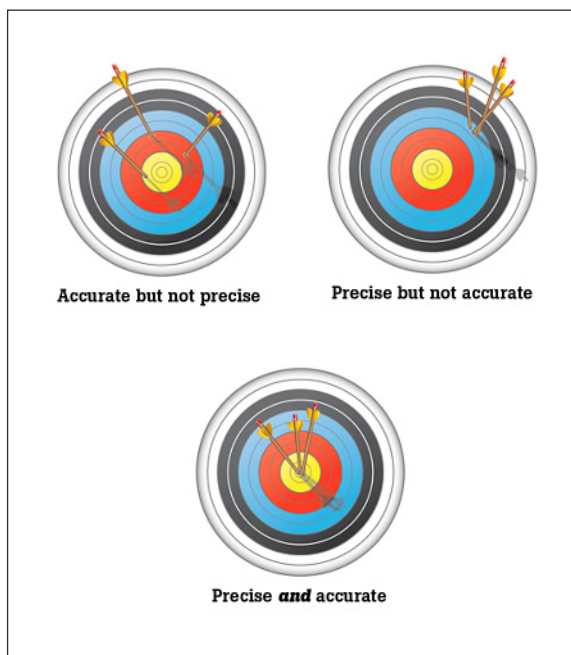
With over forty years as the leader in medical-device test and measurement and the legacy of two of the most trusted names in diagnostic imaging quality assurance—Keithley and Victoreen—Fluke Biomedical is a key partner in the field of X-ray test and safety. We've compiled our wealth of experience to help you with this important decision with these twelve factors you should consider before purchasing your next X-ray test tool.

1 Choose a tool that delivers accurate, repeatable results.

Accuracy and precision of results are foremost in importance of any diagnostic imaging QA device decision because patient safety is the primary goal. But what do we mean by accuracy and precision? Often the two terms are used synonymously, but in the world of test and measurement accuracy and precision are two very important distinctions.

Accuracy is how close a measurement of a quantity is to that quantity's true value. Precision, also known as repeatability, is the degree to which repeated measurements under unchanged conditions show the same results. A test-and-measurement tool can be accurate but not precise, precise but not accurate, neither, or both. It is imperative your choice of diagnostic imaging test-and-measurement tool is both accurate and precise.

Ensuring an X-ray test tool is both accurate and precise through its entire performance specification is key to ensuring integrity of your test results. You must be able to trust the integrity of test results to maintain confidence in what those results are telling you. Before purchasing your next X-ray test device, make sure it meets the industry standard of $\pm 5\%$ across the whole specification 100% of the time for all modalities. If your potential test tool cannot perform within $\pm 5\%$ for all kV and mA settings and changing dependencies, stop your evaluation there and begin looking for another X-ray test tool.



2 Choose a tool that calculates all results in one exposure—including HVL

Patient safety is always our primary goal, but system uptime is extremely important to your facility. Radiology departments can be a major source of revenue for a healthcare operation. Choosing a tool that allows you to manage short blocks of testing time helps you avoid costly non-billing downtime and impact to patients in need of care.

Until recently, complicated menu structures and repeated exposures were considered a necessary evil to manage diagnostic imaging quality and safety testing. Traditionally, HVL measurements required two or three exposures—complete with aluminum filter changes with each—and extra calculations of questionable repeatability to complete. Today, technology is available to produce all core measurements in a single exposure—including state-of-the-art digital HVL algorithmic calculations. Choosing a test tool that gets you in and out all in one exposure allows you to maintain patient safety without compromising radiology uptime.



3 Find a tool that offers ion chamber technology

Ion chambers have inherent technical advantages that make them a key tool for performing dose measurements for certain modalities. Most important of these are energy independence, accuracy, and the ability to measure back scatter.

Energy independence

Ion chambers are energy independent, and exhibit a flat energy response over a wide range of beam qualities. This means ion chambers do not need to be optimized for specific energies or kV to provide acceptable performance. For modalities like mammography and CT, where there are regulatory dose limits, and radiographic equipment that can exhibit a wide range of beam qualities, ion chambers are the preferred method of measurement. Solid-state detectors are energy dependent and must be optimized for specific energies. It is possible to design solid-state detectors to use multiple detectors with different filtrations to apply across the diagnostic X-ray range in order to bridge an acceptable energy



response; however, not all solid-state detectors are created equal. Understand the range and limitations of this technology before you buy.

Accuracy

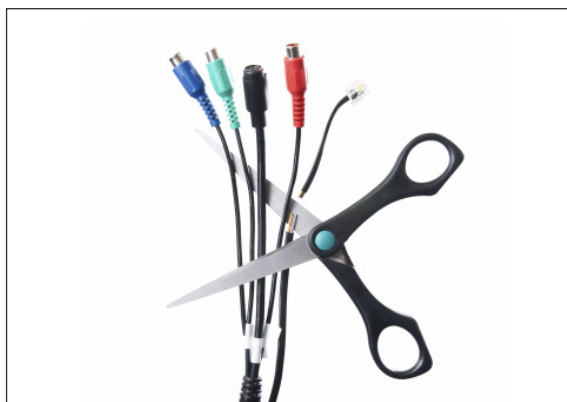
The energy independence of ion chambers is one of the main reasons these tools are known for precision accuracy. Ion chambers are accurate up to $\pm 1\%$ as opposed to industry-wide-approximate $\pm 5\%$ accuracy with solid-state technology. This precision is indispensable for modalities like CT where exactitude is vital to meeting ALARA requirements. Ion chambers are also essential to support the test requirements where center-of-beam measurements are required, as seen in ABC and AEC auto controls.

Back scatter

Ion chambers are omnidirectional, meaning they will respond to X-rays from all directions. This is an important characteristic to support dose measurements because back scatter affects patient dose. A myriad of variables can create back scatter, from air, table, and other materials. With the ability to measure all directions of scatter sans external calculations, ion chambers are excellent tools to help you form a true understanding of the dose a patient will experience. Solid-state detectors are shielded on all sides and only receive X-ray energy from one direction: the top face of the detector array. Corrections may be applied to solid-state measurements to attempt to account for scatter, but such cannot correct for all variables since all measurements and machines are different.

4 Look for a product that limits cables as a primary requirement.

Did you know the number one source of downtime with this class of instrumentation is cable failure? Faulty cables trigger vast numbers of results discrepancies, troubleshooting downtime, equipment/room downtime, test failure and replacement costs every year. Cables are also one of the biggest invisible resource drains in all of X-ray test and measurement. Cables increase time to set-up and take-down, and often mandate extra travel between machine and user in order to protect the user from the beam. Wireless technology is available to avoid the pitfalls of old-fashioned tethered technology. Save time and money in the long run by choosing a test device that eliminates these unnecessary hassles.



5 Get a test tool with automated beam-filtration correction and waveform recognition.

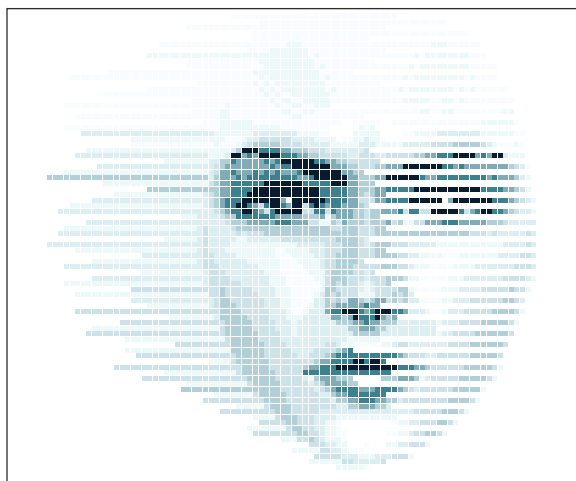
Automation in the medical field has proven to increase productivity and reduce human error to improve patient safety. Any time you can implement or improve automation you can benefit both facility and patients. Until recently, it was customary to perform manual calculations (corrections) for beam filtration when performing measurements; it was also necessary to pre-select the correct fluoro or dental waveforms to yield true measurements in those modalities. Now these are both automated.

Manual calculations against external charts and graphs, a time-consuming process fraught with potential error, are a fix—not a value-added process. Auto correction technology allows you to avoid non-value-added manual calculations, automatically correcting for beam filtration during kV measurements and for both kV and beam filtration during dose measurements.

Another helpful automated technology is auto waveform detection. Fluoro and dental applications previously required manual selection of different waveforms to apply the appropriate algorithms and measurement parameters. New auto technology can detect, for example, the difference between a pulse or continuous fluoro beam and automatically set the appropriate algorithm and parameters to achieve the correct results. This automation technology saves you unnecessary extra steps, avoids manual error and frustration, and makes testing more efficient.

6 Find a diagnostic imaging quality assurance tool with a high sampling rate.

An easy way to think about sampling rate is to think of samples as a determination of overall resolution. In images, for example, the more pixels are present in a picture, the higher the resolution or clarity of the image. With test and measurement, the more samples are taken during a measurement, the more accurate the measurement becomes. High sampling rates mean more data is being captured during a measurement, including artifacts that may not otherwise be visible in low-frequency samples. Capturing higher frequency samples yields greater accuracy with devices like the GE AMX4, which operates at a kHz rate that challenges the ability of low-sample test devices. Remember as diagnostic imaging technology evolves it is important to find a test tool that can sample at more than two times the operating parameters of the device under test.



Sample sizes are comparable to pixels in an image: higher is more precise

7 Look for a product that is durable and can handle frequent use.

Quality assurance systems are only as strong as their weakest link. While other buying decisions are critical, if a test device doesn't work properly, you can't do your job. Therefore, when considering test device technology, keep a few things in mind: moving parts, battery life/wireless technology, and overall quality of design.

In the design world we know every moving part introduces a potential failure point. How many moving parts are included in the design of your X-ray test device? Choosing a test tool with as few moving parts as possible will likely help you avoid malfunctions and/or faulty readings, reduce overall cost through the life of the product, and extend the life of the tool—all of which equate to return on your investment.

Battery life is an often-overlooked feature with the potential to negatively-affect your workflow. Long battery life for both detector and display is essential for both productivity and schedule-planning. With that in mind, did you know the number one source of power drain on an X-ray test tool is the type of wireless technology used in the device? Bluetooth may seem a viable choice based on general awareness of technology, but Bluetooth devices require roughly 100 times the energy as ZigBee wireless, a lesser-known but comparable (and often preferred in medical environments) wireless technology. Bluetooth test devices require frequent battery recharging—which, in turn, negatively affects the overall battery life of the product.

Overall ruggedness is also a factor to consider when purchasing a tool you hope to use for years to come. These test devices are often subjected to transport from room to room, facility to facility in cases, on carts, in car trunks and in shipping containers. They can be bumped, dropped, and stored in an array of non-ideal conditions considering the role they play in your patient safety platform. Keep this in mind the next time you make a test device purchase and select a tool with uncompromised durability to ensure your X-ray test device works correctly when you need it.

8 Get a test tool capable of three kV measurements: peak, average, and PPV.

These three kV measurements are critical to forming true understanding of an X-ray beam and troubleshooting discrepancies as they occur. The highest kV detected in a beam is known as kV peak. The ability to detect kV peak as a separate measurement within the big-picture duration of the beam allows you an important clue to machine performance. A kV peak that is notably higher than the rest of the wave may be indicative of a problem (overshoot), as all modern X-ray machines should have relatively-fixed kV outputs between the three kV measurements through the duration of the beam.

The measurement traditionally used to report kV is kVp average, which is a normalized calculation of all the peaks detected in a beam. kVp average mimics the measurement with an invasive kV divider and an oscilloscope.

A newer measurement to look for is peak practical voltage, or PPV, which is defined in the new IEC61676 standard that outlines requirements for dosimetric instruments used for non-invasive measurement of X-ray tube voltage in diagnostic radiology. PPV detection technology was developed to account and correct for variations and ripples within a waveform. By normalizing the waveform, a potential true kV measurement can be deciphered.

Together, kV peak, kVp average, and PPV measurements provide a broad picture and better perspective of an X-ray waveform. Ensure your test device calculates all three so you have the information required to truly understand the characteristics of the beam you are testing.

9 Look for software flexibility that can be customized to fit your needs over time.

Following the standard set forth by legacy tools like the Triad and NERO systems, most modern X-ray test devices come with free or purchased software to help you capture data for compliance reporting. These systems can be extremely helpful in meeting compliance testing requirements, as well as reducing human error thanks to automatic data capture and electronic data transfer. Before selecting the software package that is best for you, consider the flexibility of the offering. Don't settle for reporting tools that require you to adapt to the tool—find a tool that is adaptable to your work model. Open-architec-

ture reporting tools, like Excel-based packages, are easily-customizable and flexible to meet your needs both today and in the future. On the other hand, for complex work models that require standardization across entire fleets, the ability to tightly control test protocol and reporting to meet the exacting needs of your program may require a new level of flexibility—that of a software specifically designed for fleet testing/reporting automation.

Not all QA reporting packages are created equal. Take a look at the flexibility of the offering from your test tool provider and ask yourself if their solution truly allows you capture data in a way that will meet your needs throughout the life of your test tool and in the future of your quality and safety program.



10 Find a tool that allows you to handle both quick-checks and thorough QA testing with ease.

There can be a colossal difference between a cadence or troubleshooting quick-check and an in-depth quality assurance analysis, but such shouldn't affect your choice of test tool. You need a system that handles both with ease. Small X-ray test devices, preferably those with wireless/handheld displays that give you all needed quick-check information quickly and easily, are extremely helpful for rapid testing because they offer a grab-and-go solution. But there are limits to the recording and/or reporting capabilities of a handheld solution for times when comprehensive documentation is required. Look for a system that offers appropriate support for both models. A great solution to meet this need is a PC interface that can be deployed when it is necessary to see and record waveforms or capture/report complex data.

11 Go for a product that allows both invasive and non-invasive mA measurements.

The ability to access generators for direct measurements are changing. Mounting safety concerns regarding direct measurement and high voltage, even where traditionally only trained service professionals may have operated, have resulted in manufacturers limiting and even eliminating this access more frequently than ever before. Having a system that allows you to accommodate non-invasive mA measurements is no longer a convenience issue—it's a mandate. But as non-invasive testing emerges as the only way you can test, it may likely prove to be a more popular methodology than taking invasive measurements. It's safer, faster and more convenient, and yields more and better information than traditional invasive measurement techniques. So before investing in a new X-ray test tool, ensure it is capable of non-invasive mA measurements to ensure your systems are covered in the future.

12 Purchase X-ray test tools from a manufacturer with strong calibration laboratories and customer care.

X-ray test devices are mission critical, so post-purchase support is an important consideration when investing in a brand. The reputation and certifications of the calibration laboratory, as well as their quality practices and systems should be strong to ensure verifiable calibrations and healthy equipment support over time. Ask for your manufacturer's laboratory certification documentation, turnaround-time commitments and guarantees.

When you are without your test tool, it isn't working for you. Check to see if a manufacturer has a calibration/repair facility in a location near you to avoid workflow interruption and downtime inherent in shipping your device to remote laboratory locations. Find out what warranties are offered and what post-sale support packages are available to help you extend the life of your test tool. Some manufacturers offer not only extended warranties, but product care plans and even post-sale training platforms to help you maximize your return on investment.

Customer support is an indication of brand integrity. We all require different levels of support, and the manufacturer you choose should be adaptable to meet your specific needs and requirements. Ensure the brand you choose will continue to provide adequate support to you and your team throughout the life of your test device.

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