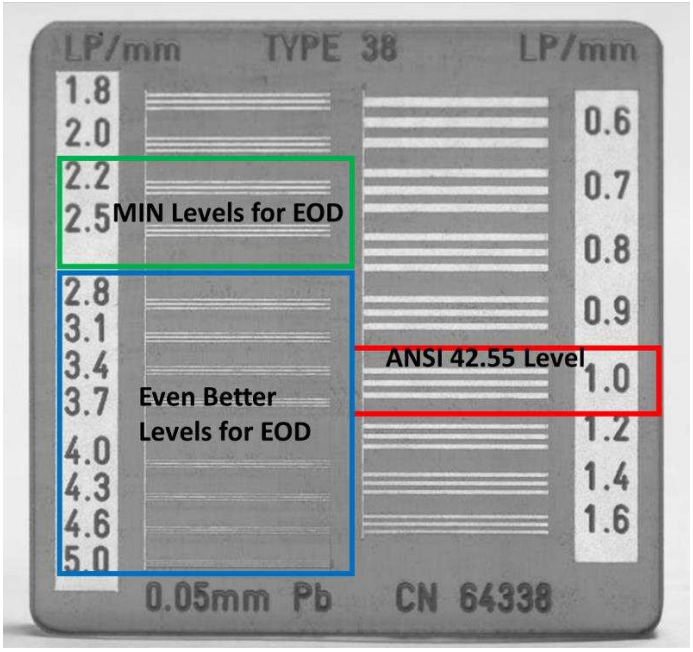
Constant potential portable X-Ray compared to a portable pulsed X-Ray: Which one is gives you a better image?

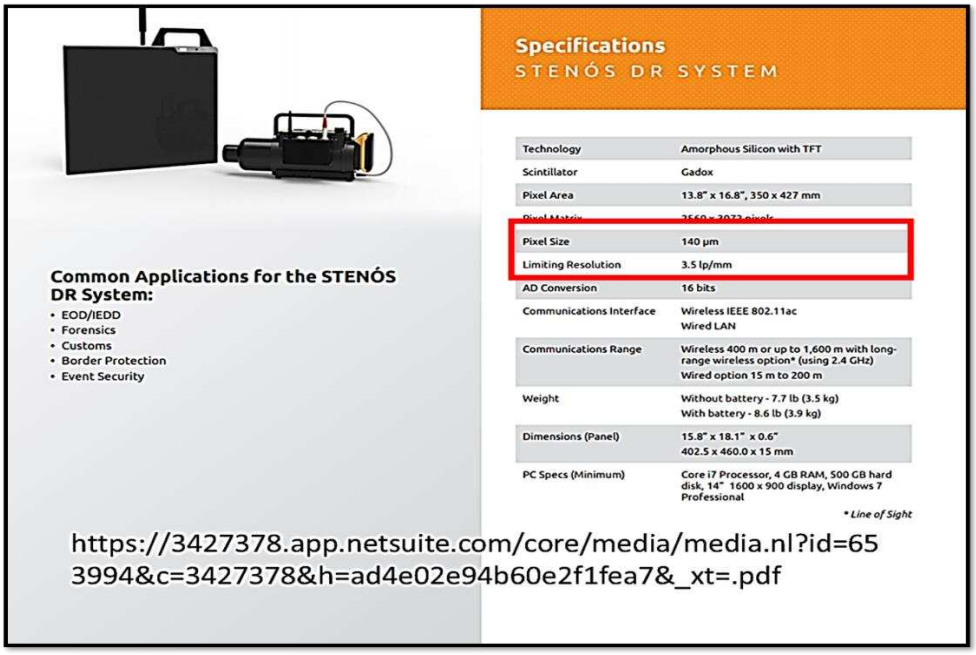
The pulsed portable x-rays have been around for many years, and most Bomb Technicians only know these systems. Once you get outside of any portable generator technology other than a pulsed generator Bomb Technicians, have a minimal understanding of the difference. Sadly, many vendors (who only sell pulsed) have spread many "Myths" about these other portable x-ray generator technologies. This article will look at both the pulsed x-ray generators and compare them to a portable constant potential portable x-ray. We will focus on which system will provide you the best overall image quality in a head-to-head test. The testing will use an industry-standard lp/mm test object to compare which system offers the best lp/mm score in an image.

We will only look at image quality in this article and not at other different factors about each system. We have also published a paper that goes into great detail about each technology and its performance in many different testing scenarios. The image quality of your system for counter IED operations is essential because the system has to provide you a very high-quality image. Almost all of the Digital Radiography systems on the market are pretty much the same, so the one that gives you the best image (and price) is typically going to be the more preferred system. Most people do not know that the x-ray generator plays a HUGE role in how good your image will be in the counter IED world. In the medical x-ray world, they are VERY aware of this fact, and all of the x-ray generators they use requires that the x-ray generator provide a very high-quality image. They test the image quality with a line pair per millimeter testing object. The better the score you get with this test, the better the overall image quality will be with your system.



For counter IED Operations, your x-ray image quality needs to be in the minimum range of 2.0 to 2.5 lp/mm. The only way to measure this is with the above lp/mm test object because that is the only way to verify what quality level you will get from that system. The overall image quality of your x-ray system is based on three factors:

1. **The Pixel Size/Pitch or Micron range of the Detector Panel:** Most people think the detector panel has a low pixel pitch, which directly equates to good image quality. Some vendors will even go so far as to list the "Limiting Resolution" in the technical specification with an lp/mm score. This is VERY misleading and, honestly, very shady when they do this because that number only means that the panel is "Capable" of that level of lp/mm. It does NOT mean that you will get that level in a real lp/mm test. You will not get close to that number in MOST scenarios in a real lp/mm test. So, if you see a vendor list limiting resolution with an lp/mm score, do not be fooled and know that the score will be much lower in a real test. This is very true if you are using a golden x-ray, as you will see in the test results.



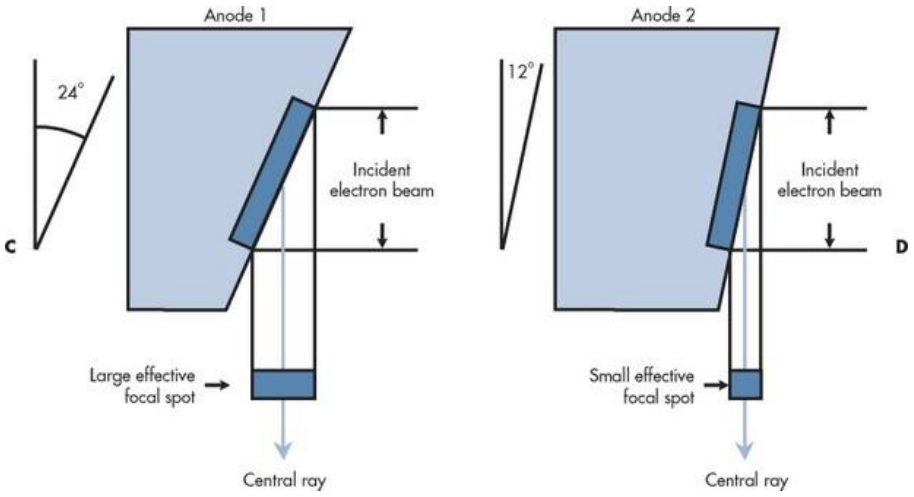
The above image is from a portable x-ray vendor's website, and you can see they list the system detectors' pixel size and the limiting resolution. Many vendors do this, but you need to understand that this is NOT an actual measurement of any system lp/mm resolution score when they are tested. Vendors never really explain these numbers, so that is why most people would see this and think, "Wow, 3.5 lp/mm". The reality is that the detector panel is "Capable" of that level, and it does not mean you will get it when you take an x-ray. Bomb Technicians do not understand this and think that the limiting resolution translates into image quality. A score is not what you will achive if you are using an x-ray generator with a sizeable focal spot size. The most common portable x-ray being used by bomb technicians has a focal spot size of 3 mm, and in the world of x-ray, that is very large. In the testing that follows, we used a Digital Radiography panel with a Pixel pitch of 150 microns and a limiting resolution of 3.1 lp/mm. You will see that

"Other" factors will determine that system's lp/mm score, and the next factor is a massive part of that measurement.

2. **Focal Spot Size of your X-ray Generator:**

   No matter how good the detector panel is, the x-ray generator's focal spot size plays a massive role in overall image quality. This is probably why vendors never talk about this, never provide actual LP/MM tests with their systems, and only provide technical specifications on pixel micron and limit resolution. As you will see in the testing, the actual scores based on the generator focal spot size are the most significant overall factor in your system's image quality. In the below link, the medical world is very aware of the effects of your x-ray generator focal spot size. However, most people have no idea how this affects your image quality in the Bomb Technician world. You also see the ranges they use for medical imaging, and I want you to remember this when comparing what levels Bomb Technicians are using (Massive difference). It would appear that the medical x-ray world is MUCH more innovative about x-ray than the Bomb Technician world.

The focal spot size is based on the size of your x-ray generator's anode and the angle. The smaller the focal spot size of the generator, the better overall image quality you are going to get. The larger you get with an x-ray generator focal spot size, the more blurring you will have in the image. The smaller anodes also create more heat, so systems with large focal spot sizes do this because they have problems dealing with the heat generated. This is true with pulsed generators as they have huge issues with heat build-up and why they have such extensive wait times. It is also why they leak oil as it expands; they heat up and leaks out. This is also why you see a Golden x-ray blow the fuze and or the tube when you do not wait to let it cool down.

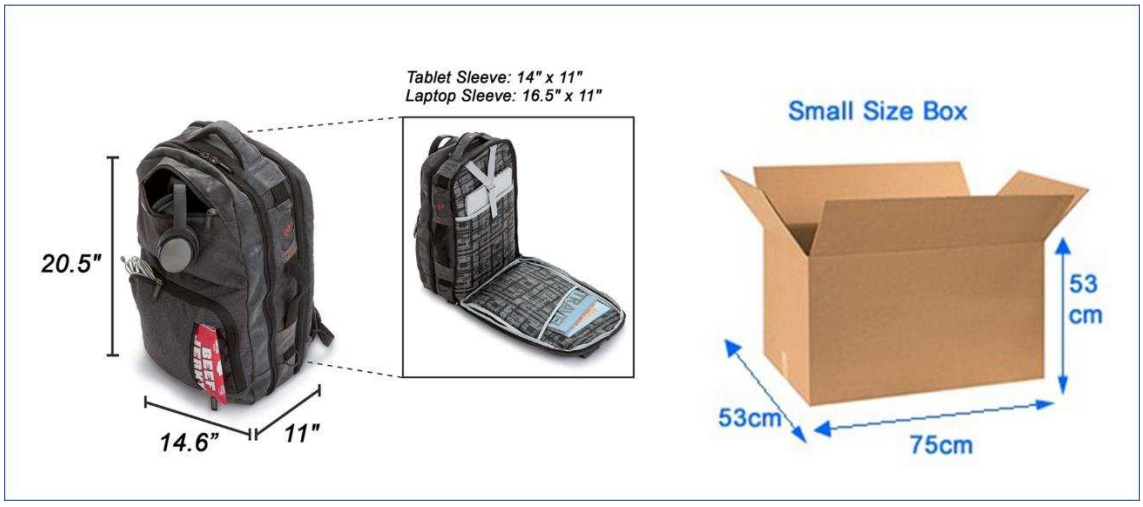


The Golden Engineering portable x-ray systems all have a focal spot size of 3.0 mm. When comparing this to what they use in hospitals, it is massively bigger and one of the main reasons they would never use a Golden x-ray for medical applications. The 3DX-RAY IGEN has a focal spot size of 0.5 mm and is significantly smaller than the Golden. In the below LP/MM testing, you will see that this equates to a staggering difference between the two systems regarding overall image quality.

3. **Other Factors:** Other factors can contribute to your overall image quality, but they are not as significant as numbers 1 and 2. These can be your system's software and even the resolution range of your tablet and laptop monitor. This is why a 16 bit (65,000 level of greyscale) is the semi-standard for your monitor's image resolution. If the vendor is using a cheap tablet/laptop, it could affect the overall image quality. The imaging software also plays a role, so the image enhancement tools can affect your image if they are of poor quality. Image enhancement software is a photoshop tool and not anything "special." However, it can be a factor if the vendor uses a very low-quality imaging algorithm in their code. Most of them hire out to get the software developed, and you get what you pay for.

Testing Plan:

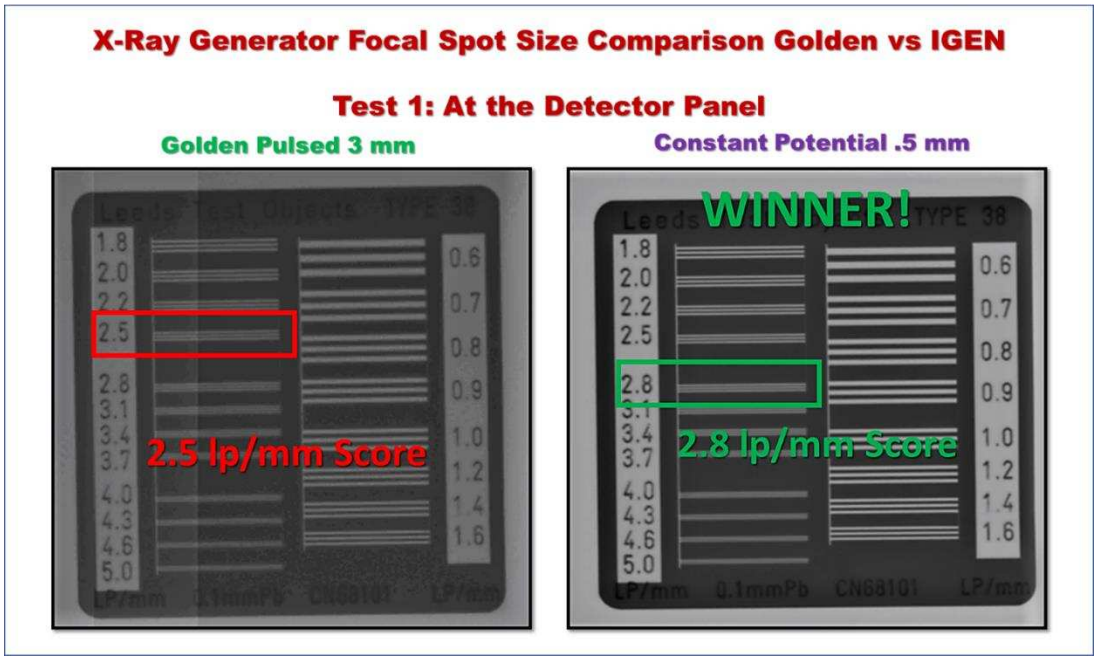
During the testing, we used a Golden Engineering 150kV unit and a 3DX-Ray IGEN 150 kV system. Both were used to fire x-rays at a 150-micron aSi panel with a limiting resolution of around 3.1 LP/MM. We used a Leeds #38 lp/mm test object to measure the image quality, ranging from 0.6 to 5.0 lp/mm. The higher the number, the better the system's image quality. The testing was done at four different distances from the detector panel. This was done to simulate a package and the various distances (or threats) located inside the container. We tested at the following distances:



1. Directly at the detector panel with the generator at 36 in (90 cm) from the panel.
2. The test object at 10 cm (4 inches) from the detector panel
3. The test object at 20 cm (8 inches) from the detector panel
4. The test object at 30 cm (12 inches) from the detector panel

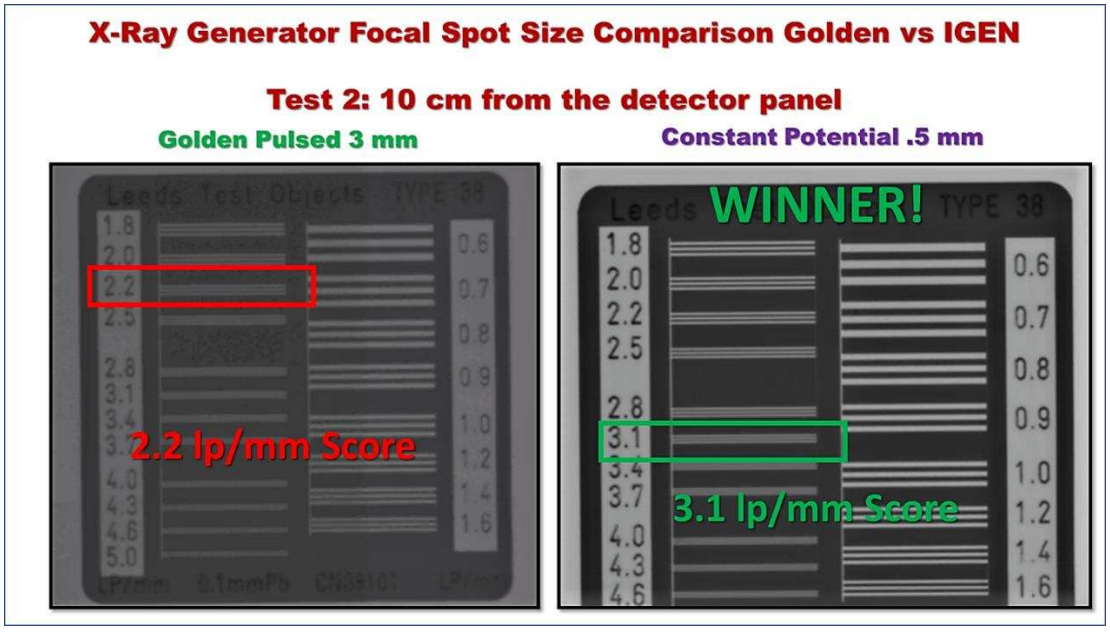
We used all of the software imaging tools to enhance the image to the best level possible. To achieve a pass on any level of the test object, you have to see in between each set of lines for that specific level. The entire length has to pass, and if the part is blocked, that level was not counted.

TEST 1 At the Detector Panel:



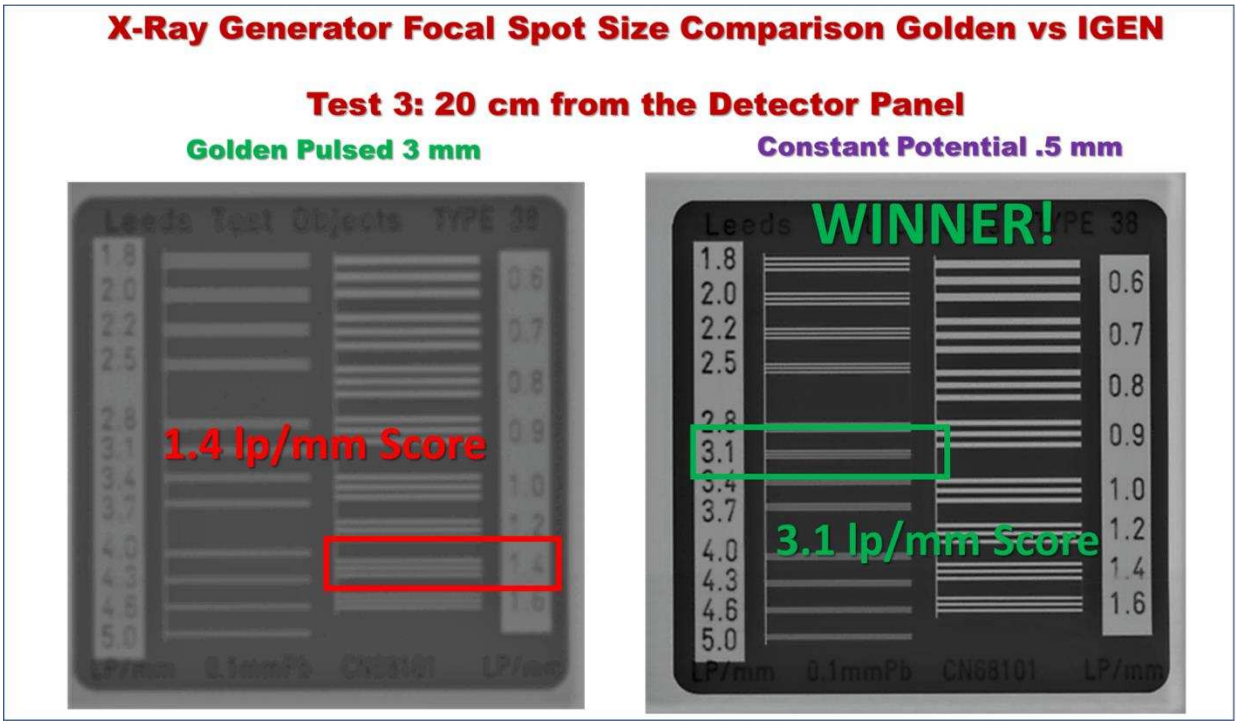
Both systems scored well at the detector panel, and both scored above the minimum requirement for counter IED operations x-ray at 2.2 lp/mm. However, there was a significant blurring effect on the image with the pulsed unit, which is a regular occurrence when the unit has such a large focal spot size. Most people will only do this test at the panel, which is not realistic and very misleading. You have to remember this is a measurement directly on the panel, and a suspect package and its contents are NOT going to be on this plane.

Test 2 10 cm (4 inches) from the panel:



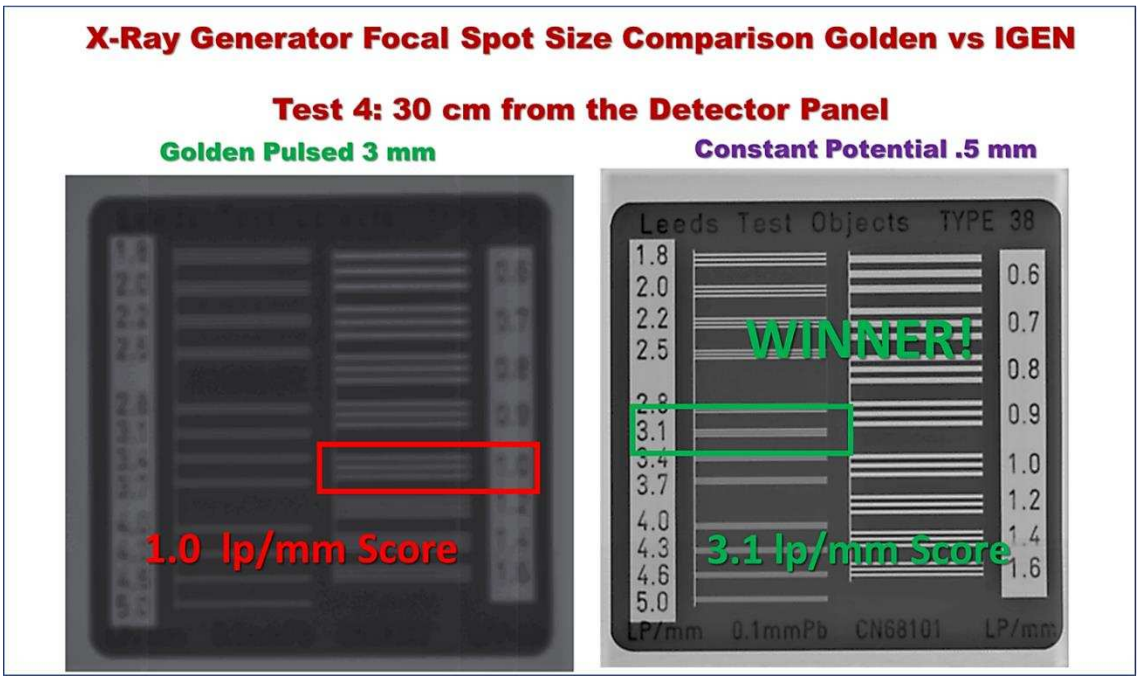
In test number 2, we saw the pulsed unit score lower by one level and the CP unit increase by one level. The lower score by the golden is what you will see with a large focal spot size with any system. The best score will be directly in the panel, but the score will drop significantly as you move outward. When vendors claim an LP/MM score, that score will be directly on the panel. They know if they move out, the score will drop, so they only do it at the panel. This, as we have already explained, is VERY unrealistic and misleading. This is also why you should always conduct these tests at four different distances in the same range as an actual bag/package.

Test 3 20 cm (8 inches) from the panel:



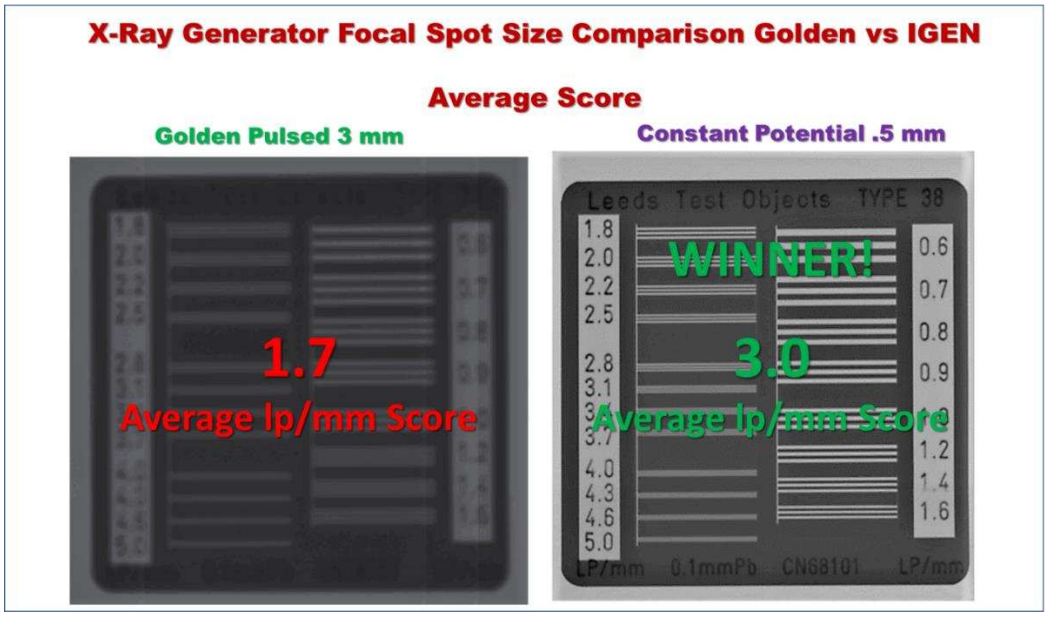
The score for the pulsed unit plummeted, but the score for the CP unit stayed the same. The pulsed x-ray score dropped well below the standard level for counter IED x-ray operations of 2.2 to 2.5 lp/mm. At 8 inches from the panel, the image quality is now an abysmal 1.4 lp/mm. You also are still seeing the significant blurring effect vs. what you see from the CP unit image. This only gets worse with the pulsed x-ray as you move farther and farther away with the generator. This is where you have to question why many experts tell people to shoot an x-ray at 6 feet (180 cm) away from the panel. This means that those "experts" had no clue that by doing this, they were significantly affecting the image quality in a very negative way. This is also why we show you these tests to understand better how all of these different aspects of your portable system can affect the image. This is also why we pointed out earlier that the medical world is much more knowledgeable about x-ray vs. the bomb technician community. Moving your generator farther away, especially if you are using a golden, is a terrible technique.

Test 4 30 cm (12 inches) from the panel:



As we already explained, when you have a very large focal spot size like the pulsed unit does, your image quality will drop as you move the generator farther away from the detector panel. When the test object is 12 inches away (Less than the thickness of a backpack or package), the pulsed unit's score can achieve drops to 1.0 lp/mm. This is an abysmal score and nowhere where you need to be for counter IED x-ray operations. HOWEVER, the CP unit is still well above the 2.2 to 2.5 lp/mm and is scoring in the 3.1 to 3.4 lp/mm range.

Average Score for Both Systems:



We took the scores for all four of the test points and averaged them together. This score is a very realistic measurement of what any x-ray system will be able to provide in over image quality. Because of its huge focal spot size, the pulsed unit had an average score of 1.7 lp/mm, and that is well below the standard of 2.2 to 2.5 lp/mm for counter IED x-ray operations. ON AVERAGE, the CP unit averages an incredible 3.0 lp/mm score and is significantly above the 2.2 to 2.5 lp/mm minimum levels.

The bottom line is that vendors do not tell you what their systems can provide for overall image quality measurement. They will use technical specifications for the panel but now you that those numbers have nothing to do with the image quality of that system. You have also learned that a constant portable generator like the IGEN will provide you a substantially higher level of image quality than a Portable pulsed x-ray. Like they always say, an image speaks 1000 words, and you have now seen the side-by-side comparison, and the CP portable unit performs at a much higher level vs. the pulsed portable x-ray.

There are many other factors that you should also compare when looking at a portable x-ray generator. The differences between a pulsed system and a constant potential unit are significant, and most people are not aware of the differences.

Differences between Pulsed and Constant Potential portable x-ray Units:

1. Overheating Problems: Pulsed generators systems are prone to overheating and require long periods to cool down before being used again. This overheating is typically why they have leaking oil issues, blow fuzes and require the tube to be replaced. The CP units do not have these issues and also have a significantly longer life span. They do not require the level of maintenance and cost associated with a pulsed unit.
2. Pulsed units have no built-in Wi-Fi: The CP units have a Wi-Fi capability built into the unit, but the pulsed requires a wireless module added to the system. The cost for this added module is typically over $2,000.00 US dollars or more ($14,000.00 for NOVO).
3. The pulsed systems cannot adjust mA or kV where the CP system can. This inability of the pulsed system to provide adjustable kV and mA seriously limits their ability to image low-density materials. This also does not allow the pulsed to do a dual-energy scan required for materials discrimination imaging. A pulsed requires a filter attachment to be added to the unit to fire a lower energy scan and provide materials discrimination imaging. However, due to the instability of the energy levels of the pulsed unit, these dual-energy scans are typically wildly inaccurate. An organic material might show up as inorganic because the measurements are wrong. Most end users have no idea this is happening, and because there is no "test" to verify these systems are working correctly, end users could be misleading.
4. Most pulsed systems cannot pass a 1-meter drop test, where most of the CP systems on the market can pass a 1-meter drop test. This weakness has been successfully "hidden" by the vendor community, and they will demand the detector panel be 1-meter drop-tested but not the x-ray generator. This makes no sense and is another example of the low level of oversight by the end-users.

When you look at all of the different technologies' different capabilities, you will find that a CP system provides an extensive increase in capability. The problem is that the end-users only know the Pulsed technology, and there is a considerable gap in understanding technology advancements in x-ray with the bomb community. Part of this can be blamed on the vendors who have no actual manufacturing capability and can only push pulsed technology and medical DR panels. Until the bomb community makes an honest effort to get "smarter" about the x-ray, they will continue to lag behind all other x-ray fields.