L3HARRIS®
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GEN III IMAGE INTENSIFIER TUBES

A Buyer's Guide to Tube Technology

L3Harris Technologies

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INTRODUCTION

The nighttime battlefield has changed dramatically over the past two decades. Today's warfighter must have the tools to succeed in a wide range of changing visual conditions, from heavy foliage to open moonlit skies; from starlight to varying levels of urban light.

This brings us to Night Vision Goggles (NVGs) and the Image Intensifier technology—commonly referred to as tubes—that warfighters use to amplify visibility in low-light scenes to the levels required for mission success.

Night vision technology has evolved significantly over the years, leading to advancements that have enhanced image quality, sensitivity, and overall performance. Much of the NVGs' performance depends on the type and quality of their tube technology.

The challenge for purchasers: there are few meaningful industry-wide testing standards that objectively evaluate one manufacturer's tube—quality, capability, durability, and other factors—against another's. Purchase decisions may come down to parsing marketing claims vs. quantitative data.

This is the guide that will arm you with the context and questions you need to self-evaluate NVG image intensifier technology before you make a purchase.

NVG "GENERATIONS" EXPLAINED

Image intensifier technology isn't new. In fact, it originates from well before World War II. It wasn't until the early sixties that night vision experienced a technological breakthrough with the then Generation I (Gen I) tube.

Since then, technology improvements have led to the introduction of additional "generations" of image intensifier tubes, noting that the designation of a generation is rooted in U.S. military definitions. To date, military specifications exist for Generations I, II, and III.

Understanding the differences in capability between generations is helpful before exploring the reasons U.S. Special Forces choose Gen III tubes from L3Harris. Briefly:

GENERATION	INTRODUCTION PERIOD	TECHNOLOGY	PERFORMANCE CHARACTERISTICS	APPLICATIONS
MILITARY-SPECIFIED GENERATIONS				
GEN I	EARLY 1960s	- Single-stage image intensifier tube - Utilized S-20 photocathode	- Low resolution - Short range (75-100 yards) - Requires external infrared (IR) light - Lifespan: ~1,000 hours	- Surveillance and limited military use
GEN II	LATE 1970s	- Microchannel plate (MCP) introduced - Improved photocathode (S-25)	- Better resolution than Gen I - Greater range and clarity - Can operate without IR in moonlight - Lifespan: ~2,500-5,000 hours	- Military applications - Law enforcement - Surveillance
GEN III	1980s	- Gallium arsenide (GaAs) photocathode - Ion barrier in MCP	- Superior resolution and brightness - Very low light sensitivity - Lifespan: ~10,000+ hours - Reduced halo effect	- Widely used in western militaries - Advanced surveillance - Tactical operations
UNFILMED GEN III FROM L3HARRIS	1990s to EARLY 2000s	- Removal of ion barrier (filmless MCP) - Auto-gating introduced to manage bright light conditions	- Exceptional resolution - Works in extremely low light - Reduced blooming in bright light - Long lifespan	- Military special forces - High-end tactical use - Low-light surveillance
GEN IV	An agreed-upon set of military specifications to define a Gen IV designation does not yet exist. L3Harris adheres to the U.S. Army's stance that there is no Gen IV tube.			

UNFILMED GEN III FROM L3HARRIS: THE HIGHEST RECOGNIZED STANDARD FOR NIGHT VISION GOGGLES

Acknowledging that Gen IV tubes exist mostly in the minds of marketers, let's take a closer look at the significant technological advancements represented by Gen III tubes over earlier generations in terms of performance and durability.

Gallium Arsenide (GaAs) Photocathode

Gen III tubes from L3Harris and others all utilize a gallium arsenide photocathode, which significantly enhances their sensitivity in low-light conditions. With this sensitivity, we can offer the high gain needed to covertly operate in ultra-dark conditions where using other tubes would force the use of active illumination, giving away the user's position to night-vision-equipped adversaries.

Microchannel Plate (MCP)

These tubes incorporate a microchannel plate that amplifies the electrons generated by the photocathode. A key innovation in the L3Harris MCP is the elimination of the input ion barrier film used in other Gen III tubes. Eliminating this film greatly increases durability—which will be discussed later in this paper—while also reducing the risk of shock damage and decreasing halo size, improving overall ruggedness and visibility in extreme use scenarios.

Our perfected filmless—or "unfilmed"—tube manufacturing process offers additional advantages, including the longest gain life of any tube on the market. This enhanced robustness allows our tubes to be exposed to many years of higher-than-normal light levels in mixed/urban environments without the rapid gain loss seen with Gen II+ tube designs.

Increased Signal-to-Noise Ratio (SNR)

The GaAs photocathode and improved MCP design introduced by L3Harris led to a higher signal-to-noise ratio (SNR) in Gen III tubes. The result is clearer and more detailed images, especially in very low-light conditions.

Higher Resolution

Gen III tubes typically offer higher resolution compared to earlier generations, providing sharper and more detailed images. This is critical for tasks that require precise visual information.

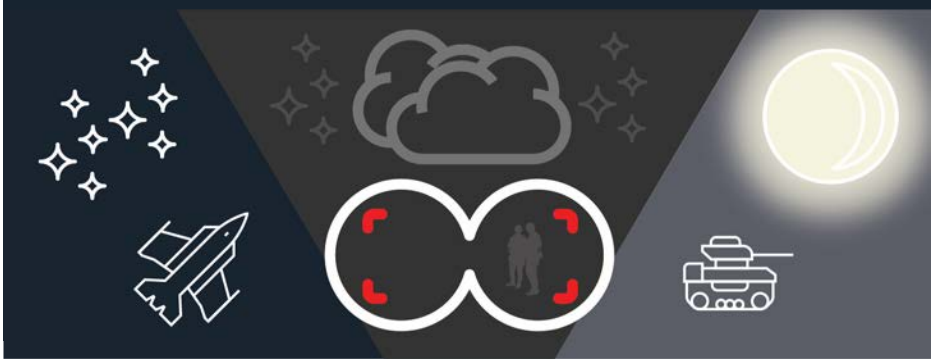
Brightness and Contrast

It should be noted that there's more to achieving maximum visibility than resolution—it also requires greater brightness and contrast. Readers may be familiar with this concept from experience with their home flat screen televisions or computer monitors. A viewer will nearly always perceive an ordinary HD screen that is based on OLED technology—which depicts brighter images with deeper blacks—as superior, when compared to a 4K screen based on standard LCD technology. L3Harris achieves this level of brightness and contrast with superior fiber optics and manufacturing processes.

Extended Operational Life

There are many interlocking factors that contribute to longer operational life in Gen III NVGs, beginning with ion barrier film. L3Harris' advanced technology eliminates it completely, while simultaneously extending gain life by years, even decades, of reliable performance. Other contributors to extended operational life are thermal management, auto-gating, and advanced manufacturing techniques. L3Harris uses proprietary processes and high-quality materials in the construction of our image intensifier tubes, yielding better durability and performance consistency, and extending the overall lifespan of the devices.

Of course, it all comes down to better low-light performance in the field. The combination of the GaAs photocathode and the advanced MCP allows Gen III tubes from L3Harris to perform exceptionally well in low-light and mixed-light conditions, providing a significant advantage in night-time military operations.



There is no industry standard for testing tubes, so it's difficult for buyers to meaningfully evaluate claims—and understand their true impact on users in the heat of battle. In the U.S. and other areas, a Figure of Merit (FoM) is the most often used metric. However, the FoM formula has become a questionable core differentiator.

FOM DOESN'T TELL THE WHOLE STORY

As discussed above, NVG performance is a result of multiple interconnected components, which means that basing purchase decisions exclusively on FoM—which only roughly correlates to range in certain conditions—may result in a mismatch between the chosen NVG and real-world mission needs. In the example below, it's much easier to see the person next to the bright light source rather than hidden behind the bloom with traditional technology.

No Anti-Bloom

Anti-Bloom

Our higher gain and anti-bloom technologies deliver superior performance with less halo effect *even on lower FoM models.*

This is good news for purchasers outside of the United States. While the U.S. government does not allow L3Harris to ship our highest FoM NVG technology overseas, *users outside of the U.S. still benefit from superior imaging performance on all our tubes and NVGs.*

This is not the case with other manufacturers' NVGs. Purchasers may be led to believe their Special Forces users can compete in the more challenging operational conditions by only investing in Gen II based on FoM alone. The truth is more complicated, and they will be missing out on key Gen III capabilities that can be difference-makers in complex Special Forces missions.

When evaluated objectively in a controlled environment, unfilmed Gen III NVGs from L3Harris are proven to offer significant advantages over other manufacturers' Gen II offerings—at comparable cost. Only our Gen III tubes provide a much higher value image intensifier that performs to a higher standard and for a substantially longer period.

To reiterate, only Gen III tubes from L3Harris—designed to the most advanced requirements and manufactured to the most stringent conditions in the industry—provide the necessary tactical advantage in the darkest real-world environments. Further, they have been proven to deliver reliable performance for over 20,000 hours of useful life, especially in the mixed-light urban locations that often define today's battlespaces.

The scientists and engineers responsible for developing the stringent testing methods that validate our tube performance offer these five reasons for choosing Gen III tubes from L3Harris:

1 Reliability and lifespan that won't leave you in the dark

There's only a certain amount of light any tube can be exposed to before it degrades. Our tubes can be exposed to higher volumes of light for a far longer period due to the combined use of GaAs photocathode material, improved tube manufacturing processes, and better internal tube components. This is a win for both the end user and purchasing decision-maker, as the overall average procurement cost and lifecycle cost are dramatically reduced.

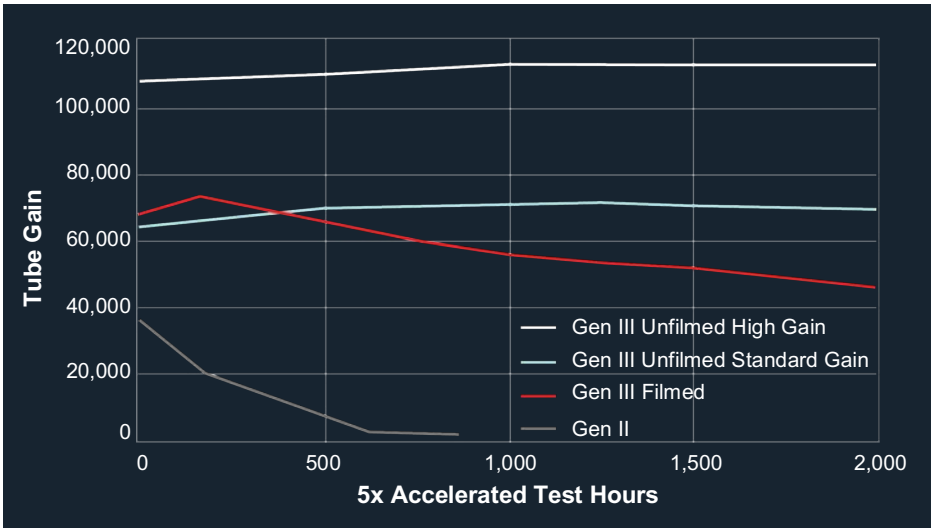


Figure 1: L3Harris unfilmed tubes offer superior stability over the military lifetime test profile exposure.

2 Durability to survive everything from small bumps to the chaos of battle

The unfilmed MCP advantage from L3Harris is critical here: our advancements in unfilmed tubes deliver extreme shock resistance when compared to filmed Gen III tubes. In filmed tubes, shock-induced flex may cause the MCP to stretch and touch the photocathode, which will damage the ion barrier film and destroy the tube. The level of shock needed to flex an MCP is not extreme—it can happen by hitting a goggle on a door frame or accidentally dropping it onto a hard surface. Because there is no ion barrier film to damage in L3Harris unfilmed tubes, the technology is the most robust and rugged choice for tough, real-world conditions.

3 Better, brighter image without halo

Halo is an effect where bright lights within the night vision scene will create a diffuse area of added brightness surrounding it. This is caused by electrons bouncing off the MCP input surface. It is most visible in areas of high contrast, as seen on the next page.

While the halo effect occurs with all image intensifier tubes, L3Harris has developed and patented technology for suppressing it—effectively sharpening the image by reducing the *smearing* effect on bright/dark boundaries in the scene. This is accomplished by suppressing the scattered electrons—removing bloom and sharpening the image—which allows our NVGs' superior resolution, brightness, and higher gain to shine through.

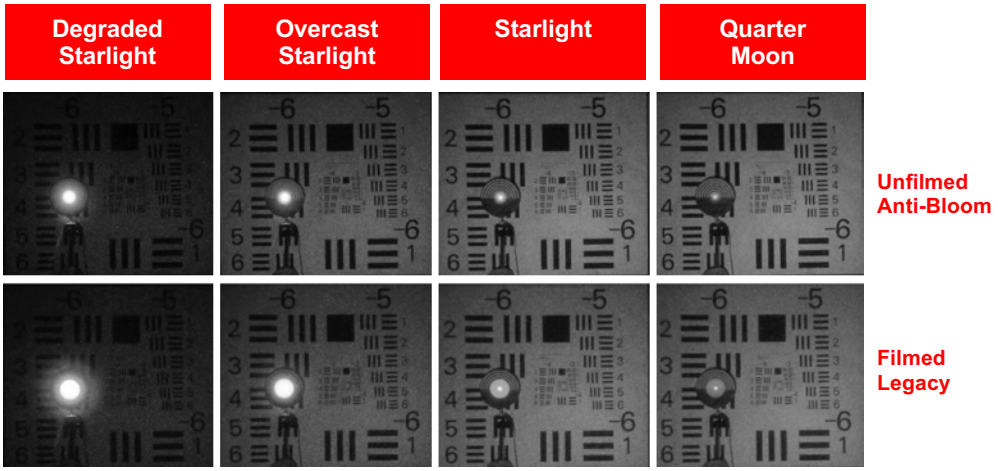


Figure 2: L3Harris' patented unfilmed anti-bloom technology suppresses the halo effect to provide a sharper image.

4

High gain without the downside

Gain, in a night vision device, is a measure of its light enhancement ability. An optimized Gen III photocathode provides higher gain to increase the tube brightness, which is always tempered by reduced gain life due to the increased stress this imposes on the tube MCP. However, L3Harris has developed a superior process that eliminates this downside to higher gain usage. This means the user is *no longer required* to choose between performance and reliability. Our high-gain unfilmed tubes can comfortably operate at a gain of over 100,000 while remaining the most stable image intensifier tubes available.

Figure 3: L3Harris unfilmed high-gain NVGs provide the brightest, most detailed image with little to no degradation in performance over the expected operational lifetime.

5 Our MILSPEC-compliant testing process

L3Harris tests Gen III reliability using the U.S. government's required MILSPEC accelerated reliability testing method, which defines 2,000 hours of accelerated reliability testing to be equal to 10,000 hours of operational life. We estimate the average operational life to be 1,000 hours of operation per year for a total of 10 years. This means that Gen III image intensifier performance during reliability testing will not degrade more than what the end-of-life requirement allows for at least 10 years or 10,000 hours of service life, generally listed as a percentage of the initial gain or a fixed lower gain limit.

This MILSPEC profile uses a fixed temperature and light exposure cycle to simulate real-world operation that plans for only rare high light exposure and predominant use in starlight equivalent conditions. This rarely, if ever, applies to the battlespace. Night vision devices must be expected to operate well in all lighting conditions, from ultra-dark—seen under trees and in buildings—to partially lit urban environments with substantial cultural lighting of all kinds. Therefore, meeting the gain life test does not always mean a night vision device is robust enough for real-world conditions. That is why L3Harris has focused on making our tube the most reliable and durable in the world: our users never have to worry that they will wear out their critical kit across all the different conditions they face.

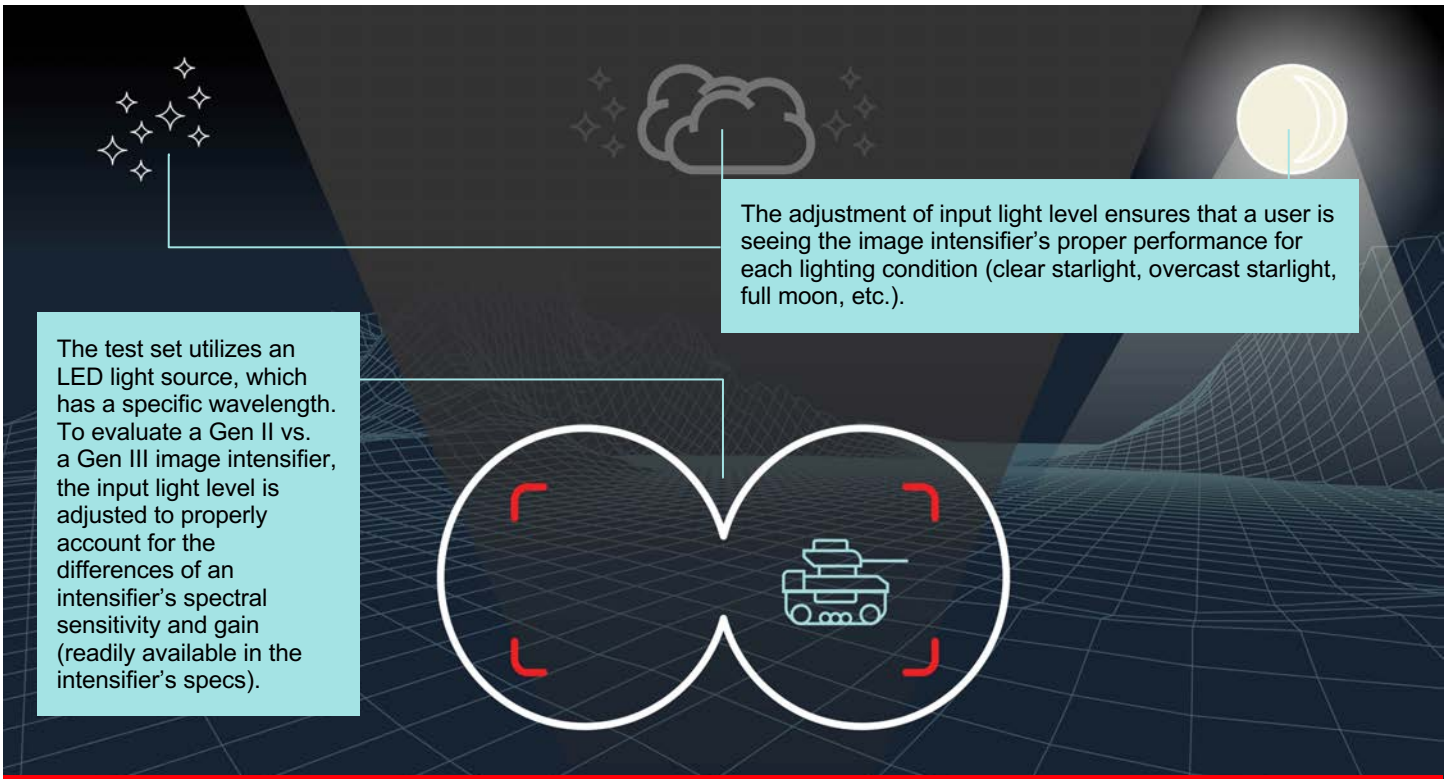
Figure 4: Hoffman Vision System HVS-126A and ANV-126A

SEE FOR YOURSELF—TESTING MANUFACTURER CLAIMS

Most test benches are proprietary to the vendor. They are typically expensive and require extensive resources to calibrate and maintain. Naturally, this puts purchasers at a disadvantage in terms of verifying manufacturer claims and performance data. Without access to test equipment, or the funding required to evaluate a statistically small sample of image intensifiers, they must trust that vendor-provided information is accurate.

However, the same tool we have in our facilities is also commercially available to help purchasers verify the accuracy of vendor-provided data. **The Hoffman ANV-126 or ANV-126A field-portable Night Vision Device Test Set** allows a user to test gain, low-light limiting resolution, high-light resolution, image quality, NVG battery, image intensifier current, and halo—all while the image intensifier is installed in a night vision system (adaptor may be required). Since the input light level is adjustable, resolution can be measured at different lighting conditions to simulate mission realities.

This solution is easy to set up and can be used by anyone. It gives you the tools you need to go beyond the FoM formula and meaningfully evaluate your prospective NVG investment using many different metrics.



The ANV-126/126A test set is used around the world for field maintenance and repair of NVG devices. While it requires an export license for non-U.S. customers, it is nonetheless fully exportable. L3Harris is ready with the experienced support you need to achieve the proper adjusted input light levels.

SUMMARY

Gen III tubes from L3Harris outperform advanced Gen II tubes due to their high gain, longer life, environmentally robust unfilmed technology, and stringent quality control processes.

Our Gen III tube characteristics collectively result in better image quality, greater durability, and enhanced performance in a wide range of conditions, making them the preferred choice for demanding Special Forces users.

Rather than relying on limited metrics to judge an NVG's performance, take matters in your own hands with a suitable Night Vision Device Test Set, or contact your L3Harris representative for a copy of our extended list of questions to help guide the evaluation of your next NVG before purchase.

For a deeper discussion about our image intensifier tubes, contact your L3Harris Representative.

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