Chocolate Warfare

Night Vision
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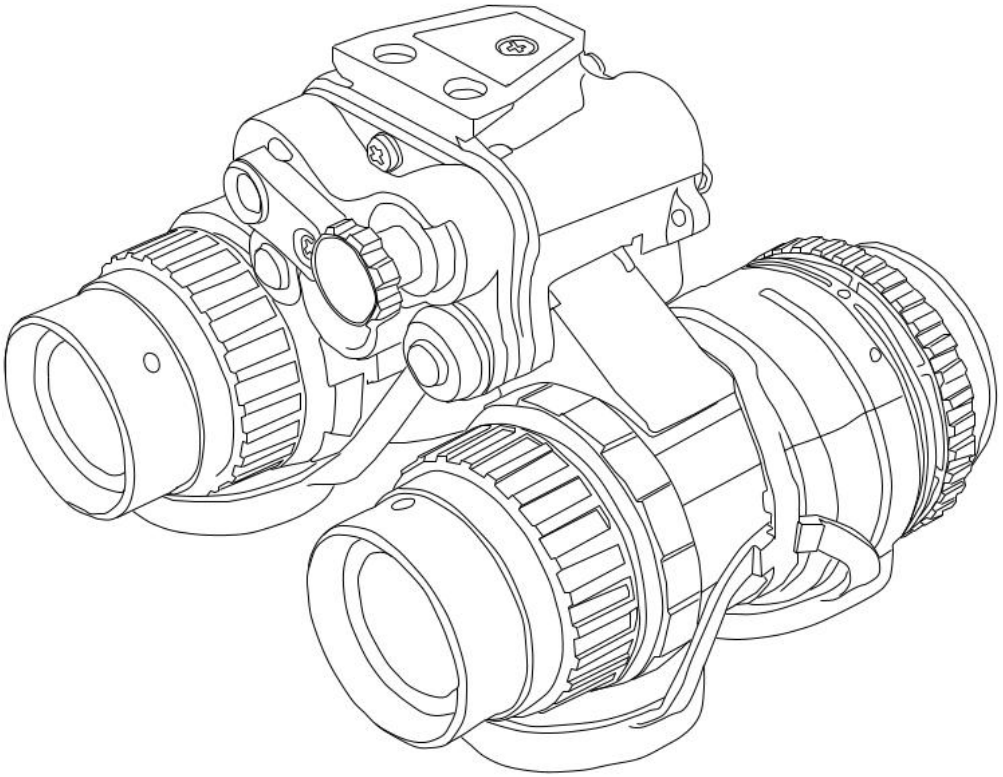
chocolate-warfare.com



Introduction

Night Vision refers to the ability to see in low light or complete darkness. This technology is achieved through the use of specialized devices that amplify available light or provide their own source of illumination.

Night Vision technology has a variety of applications, including military and law enforcement operations, hunting, and surveillance. It is also used in industrial and scientific applications, such as in the oil and gas industry, and in astronomical observations.

With the advancement of image intensifiers, it has become more accessible and affordable, making it possible for a wider range of people to use it for various purposes.

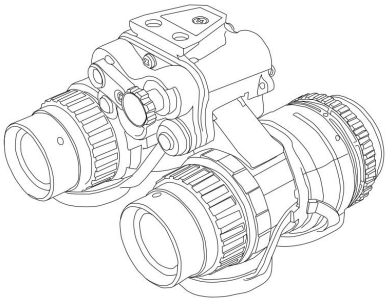
Night vision technology can be challenging for many people to comprehend as it involves complex concepts and technical specifications. It's not uncommon for people to find the details of image intensification difficult to understand and the various devices and their specifications can be overwhelming. However, with some effort and understanding, it's possible to gain a basic knowledge of night vision and its applications.

This handbook aims to provide a foundational understanding of night vision devices, including the preparation and use of such devices. By the end of this handbook, readers will have a basic understanding of the key components and considerations involved in purchasing and utilizing night vision equipment.

This handbook will not cover the use of handheld, weapon mounted or clip-on night vision.

Seeing in the dark

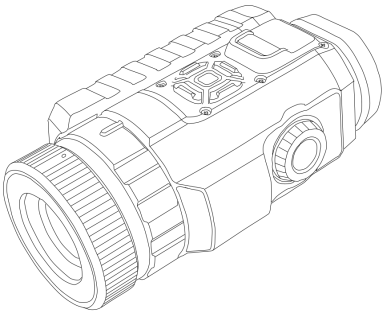
Three different types of night visions:



Night Vision
for
Navigation

Image intensifiers commonly referred to as night vision are analog devices and require no digital processing. It brings three major benefits:

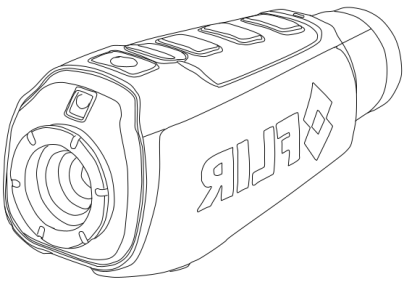
- Best performance under low light conditions,
- Undelayed vision,
- Low power consumption



Digital Night Vision
for
Recording

Digital cameras offer today a decent performance under low light environments and have the capacity to display colors.

- Colors may help identification
- You can distinguish white light from Infrared light
- Recording yourself in the night makes you look cool.



Thermal Imager
for
Detection

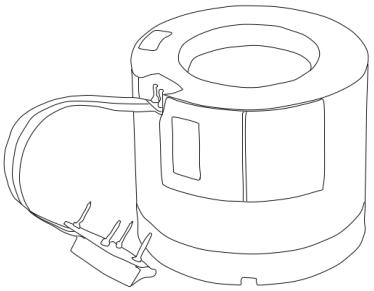
Thermals have nothing to do with dark environments but because the night is colder than the day, the contrast of temperature for living things, vehicles or any heat source over the environment makes thermals an unbeatable tool for detection.

Why is night vision better for navigation than other types of devices? Aside from pure light amplification performance, it is because of the lack of digital processing. Digital cameras and thermals suffer from both poor resolution and image delay due to the video processing and display. Moreover, this processing consumes a lot of power which leads to only a few hours of autonomy whereas a light intensifier unit can operate up to 50h on a single AA battery.

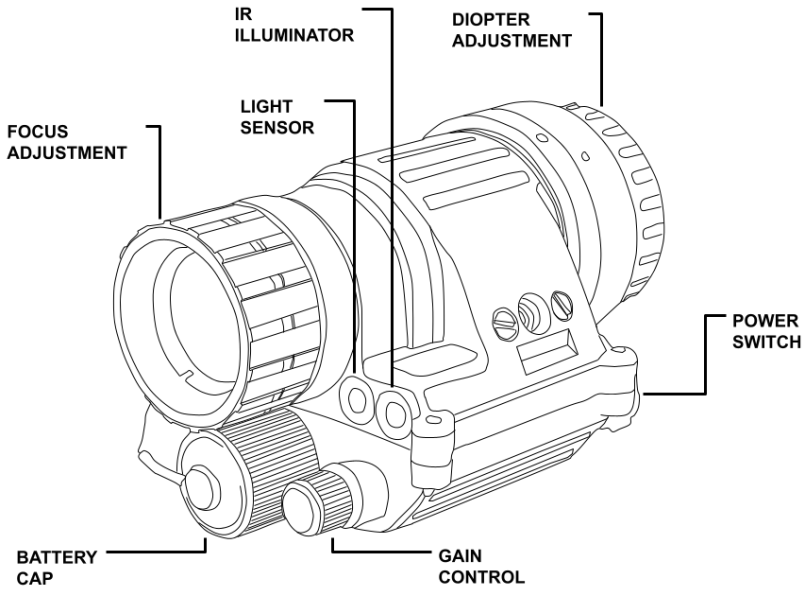
Digital night vision performance will certainly be on par with current night visions in the near future. However, the lack of autonomy cannot be addressed with the current state of microprocessor and battery technologies.

Major components

Night vision devices own similar components. The PVS14 is a perfect example:



11769 Image intensifier tube



PVS14 monocular components

Image intensifier tube
The expensive part of your night vision device where the light is amplified and projected on a phosphor screen.

Focus adjustment
Adjusts the sharpness image of the viewed object or environment.

Diopter adjustment
Focuses the eyepiece lens for use without corrective glasses. Adjusts for the sharpest image of the intensifier screen.

IR Illuminator and light sensor
The embedded illuminator provides an infrared beam allowing you to see in a no-light environment. Remember, no light, no intensification. The light sensor is a protective mechanism which will shut the power if your night vision is turned on in a bright environment[1].

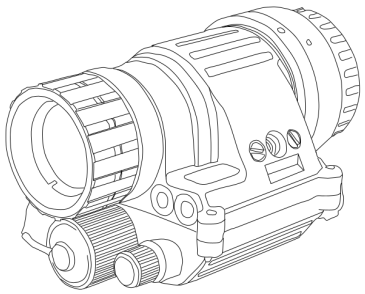
Gain control
Allows the user to adjust the brightness of the output of your night vision device.

Some night vision devices may have more or less features than this example.

[1] Image intensifiers may be autogated which is another protective mechanism against bright expositions.

Housings

The housing provides electrical power, adjustment controls and sometimes other features. Housings host one or multiple image intensifiers. Here is a short overview:



PVS 14

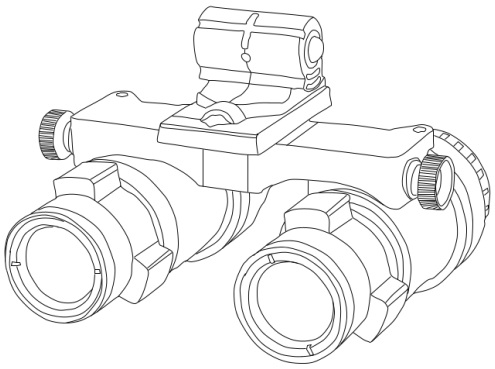
Monocular

Weight: ~ 340 grams

FOV[2]: 40°

1 image intensifier

The simplest form of housing.
Can be used alone or two can be bridged together to create a binocular system.



ANVIS 9

Bridged Binoculars

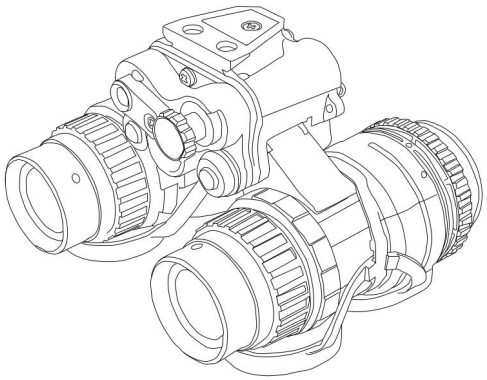
Weight: 540 - 640 grams

FOV: 2x 40° overlapping

2 image intensifiers

Best for piloting, driving

Bridged binoculars have better collimation[3] than articulated binoculars which is particularly important for reading instruments.



PVS 15

Articulated Binoculars

Weight: 500 - 700 grams

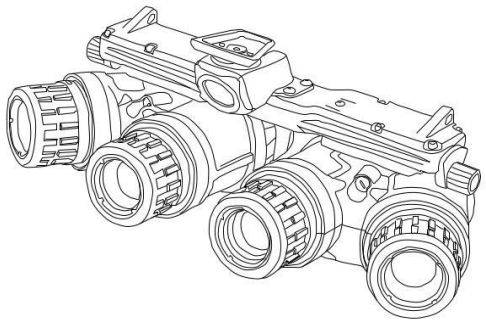
FOV: 2x 40° overlapping

2 image intensifiers

Best for navigating on the ground.

Binoculars benefit from having two image intensifiers which enable stereoscopic vision and thus perception of depth. The articulation enables ergonomic adjustments reducing its footprint and neck strain.

[2] Field of view: both human eyes have approximately 200° horizontal field of view, including peripheral vision.
[3] Collimation: Process of aligning the two independent optical axes of each pod so they both point exactly straight in three dimensional space. Bad collimation would result by seeing double, forcing our brain to constantly correct our vision and causing headaches.



GPNVG

Panoramic

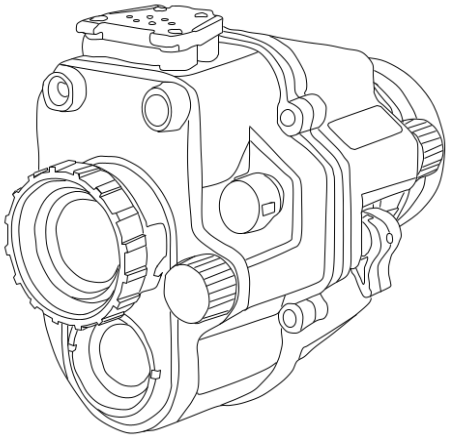
Weight: ~ 800 grams

FOV: 97°

4 image intensifiers

Best for dynamic shooting

Panoramic devices have a much wider FOV which is critical for shooting, moving and communicating.



PSQ 20

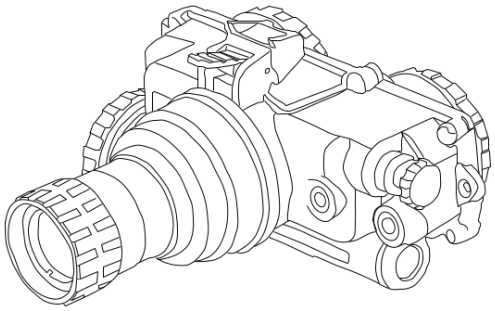
Thermal Overlay

Weight: n/a

FOV: n/a

Best for navigation and detection

Thermal overlays integrate advantages from both night vision and thermal. Manufacturers now offer monocular, binoculars and even panoramic devices with thermal overlays.
Clip-on thermals on night visions are available as well.



PVS 7

Goggles

Weight: ~ 680 grams

FOV: 40°

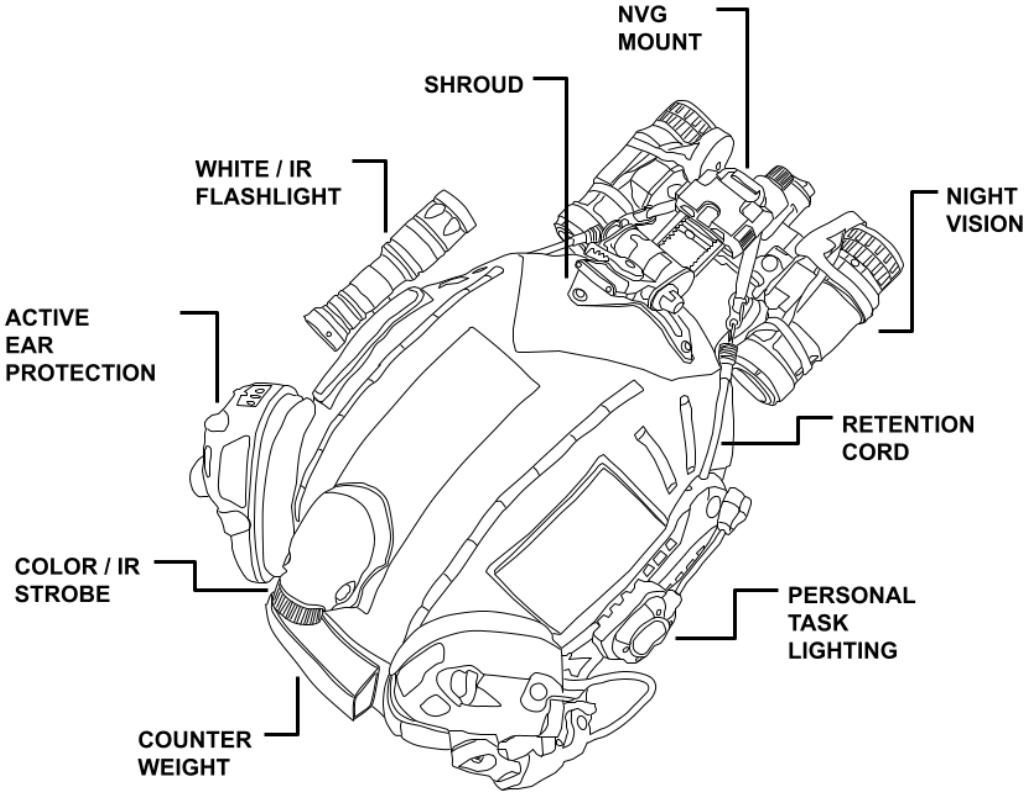
1 image intensifier

Best for observation[4].

Goggles reduce eye fatigue by having both eyes equally illuminated by a single image intensifier. Goggles have gradually been abandoned in favor of binoculars and thermal devices.

[4] Especially when a 3x magnifier is attached to the front lens.

Helmet setup



2023 helmet setup

Shroud
Interfaces your helmet with the night vision mount. Shrouds have an impact on helmet integrity. Most military helmets come now with preinstalled shrouds.

NVG mount
Wilcox L4G24 became the standard mount. Some night vision housings require specific mounting solutions.

Night vision
Housing dictates the NV mount to use. Several housings have no battery and require an external battery pack.

Retention cord
Shock cords have two effects: reduce stress and wobbles on the NVG mount. It also prevents the device from dropping to the ground in case of mount failure.

Personal task lighting
Small lights enable you to do personal tasks such as writing notes or reading a map when night vision is not necessary. Red light is preferred[5].

Counter weight
Counter weight and/or battery pack help to balance the helmet, reducing neck pain. Holds batteries or simple lead weights.

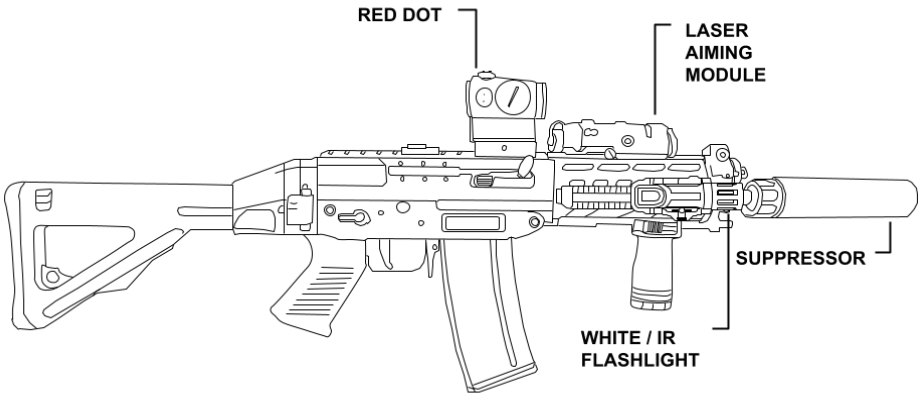
Color / IR strobe
Used for signaling your position to your comrades by using either visible or IR light.

Active ear protection
May be connected to your comms. Improve situational awareness.

White / IR flashlight
Flashlights allow you to illuminate the floor or the ceiling during CQB.

[5] Using red light in the dark slows down the constriction of your pupil, which helps delay your loss of natural night vision.

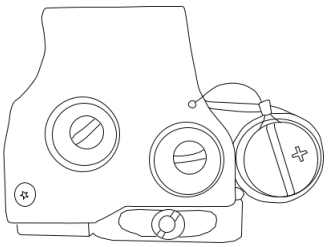
Rifle Setup



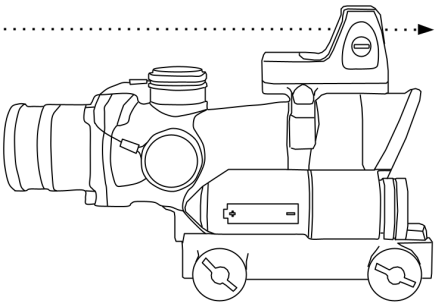
SIG 553 SB with Aimpoint T1, L3 LA-5
Inforce WML and Surefire 556 RC2 suppressor

Suppressors
The muzzle flash produced by the rifle when firing can temporarily blind the user or harm your NV. Moreover, it reduces sound signature which is a tactical advantage.

Passive aiming
Holographic sights are preferred for passive aiming.
Optic risers for red dots and holographic sights make it easier.
Prism and magnified optics are not practical for passive aiming, a piggyback red dot can be a good solution.



Eotech EXPS 3
Holographic sight



Trijicon ACOG TA02 LED
with piggyback Trijicon RMR Type 2

Active Aiming
Laser aiming module must have three components slaved[6] together: IR illuminator, Visible laser and IR laser.
Many users attach importance to the laser output power but the power of the illuminator and the ability to focus the beam is much more important.
Privilege a parallel zero with the rifle rather than convergent.

<u>High power IR laser:</u>
Use for directing fire and signaling to other NV users.

<u>Low power IR laser:</u>
Use for aiming and shooting.

<u>Visible laser:</u>
Use for zeroing the rifle and signaling.

[6] Salved means the IR and visible laser share the same zero and adjust together.
Slaved illuminator ensures the lasers stay in the center of the beam.

Night Vision 101

Preparation

BATTERIES

- Remove batteries when stored.
- Avoid rechargeable batteries.

CLEAN

- Purge the housing with Nitrogen.
- Use sacrificial lenses.
- Clean the optics.

FRAGILE

- Avoid impact.
- Use retention cords.
- Use a padded pouch/case for storage.

EXPOSITION

- Cover during daylight.
- Avoid bright lights.
- Be careful with lasers, especially reflections.

Principles

Avoid detection
Having the ability to see clearly in low light conditions does not mean that you are completely invisible to others. Even if your opponent does not have night vision technology, their eyes may still have adjusted to the darkness, allowing them to detect your presence.

Camouflage principles still apply at night:

- Shapes
- Silhouettes
- Movements
- Light
- Color
- Heat
- Noise
- Smell
- Traces
- Reflections

Friendly fire
Friendly fires are a result of mixed factors such as communication breakdowns, misidentification of targets, and human error.
Mark your teammates using IR strobe, IR light sticks or patches according to the tactical situation. Friendlies must be aware of your location.

Outdoor

- Set a wide aperture.
- Avoid additional illumination

Indoor

- Set a small aperture[7].
- Use additional IR illumination directed to the floor or ceiling.

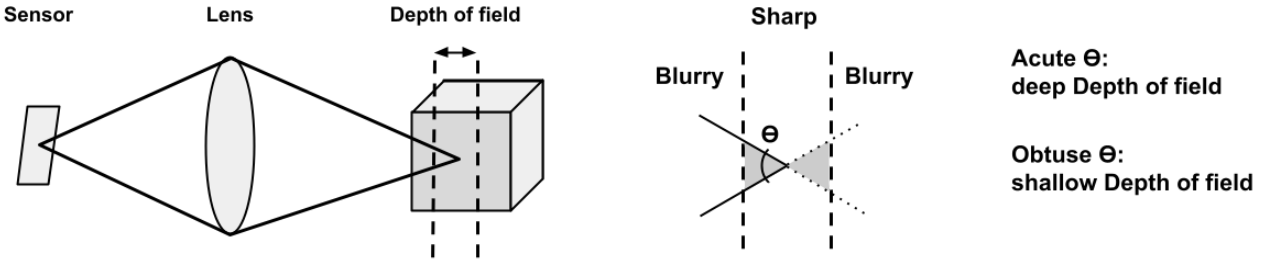
[7] Assuming you have an adjustable aperture. If not, you may use the NV covers with pinholes.

Depth of Field

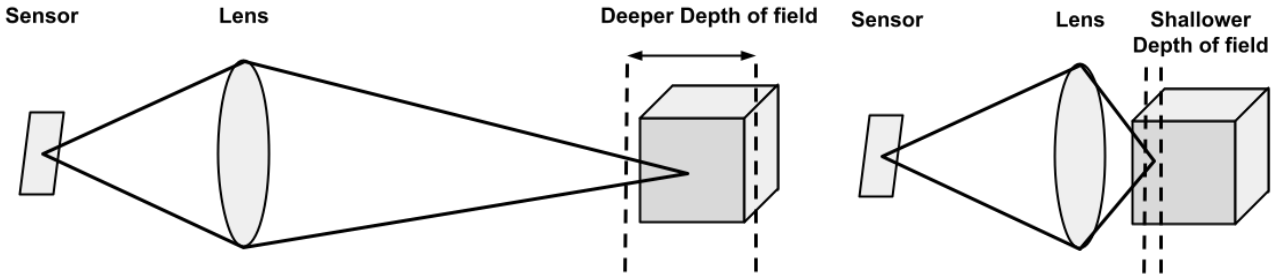
Understanding fundamentals of optic help to understand how objective lens and aperture affect the depth of field which is particularly important for night visions.

Definition of Depth of field

Depth of field refers to the distance between the nearest and farthest objects in a scene that appear acceptably sharp to a sensor (human eye, camera, image intensifier etc.).



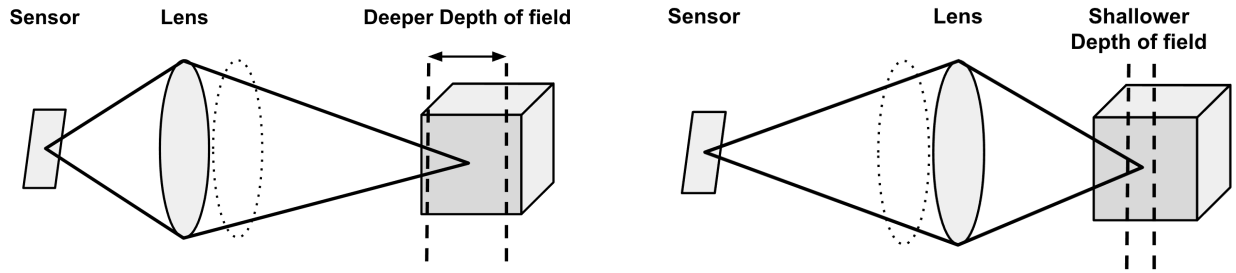
Distance effect on Depth of field



Larger distance: deeper Depth of field

Shorter distance: shallower Depth of field

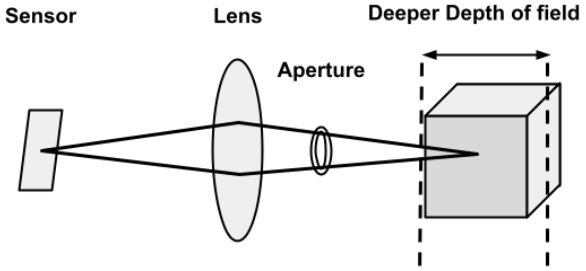
Focal length effect on Depth of field



Shorter focal length: deeper Depth of field

Longer focal length: shallower Depth of field

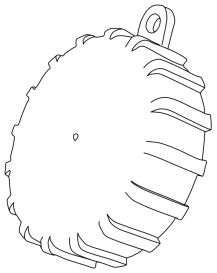
Aperture effect on Depth of field



Smaller aperture provides deeper Depth of field but fewer light goes on the sensor.

Covers & adjustable apertures

Covering night vision devices during daylight hours protects them from damage caused by exposure to bright light, including sunlight[8].



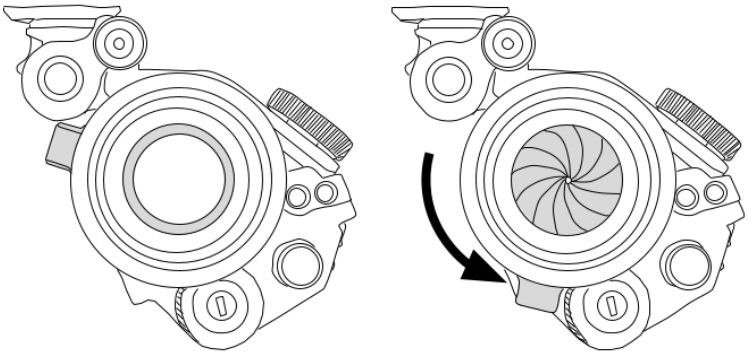
A PVS14 cover

In addition to providing protection from light damage, covering the night vision device can also help to protect it from physical damage and contamination, such as scratches, dust, and moisture. This will help to ensure that the device remains in good working condition and is ready for use when you need it.

Covers usually have a pinhole restricting the amount of light into the device, making it usable during daylight.

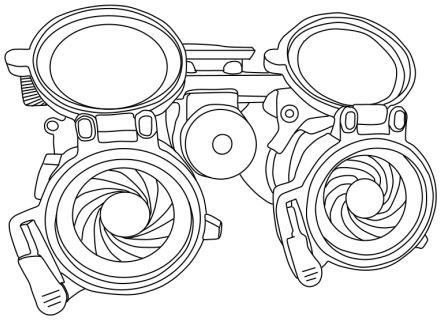
Adjustable apertures

External apertures restrict the amount of light going into the night vision. The image will be sharper than without due to the effect of the aperture on depth of field. There must be enough visible or IR illumination so the image intensifier can work properly.
Adjustable apertures are particularly important in CQB[9] so you can keep a sharp vision for every task such as moving, communicating, breaching, identifying and shooting. It also protects your vision against white light illumination from opponents.



The Matbock Tarsier Eclipse™ allows changing the aperture for a deeper field of view.

It is even better to use a combination of flip covers, adjustable apertures and sacrificial lenses.
Opaque covers protect the image intensifier and the sacrificial lenses regardless of the environment. The sacrificial lenses protect your optics and the adjustable apertures allow you to control the depth of field of your vision.



RNVG with Butler Creek scope cover, adjustable aperture and sacrificial lens.

[8] Image intensifiers can be damaged with sunlight even if the device is turned off.
[9] Close Quarter battle.

Image Intensifiers

Generation 0 and 1

Development started in the 1930's.

Numerous techniques used.

Gain is around 1000x light intensification Requires a lot of ambient light or an infrared spot to operate.

Life expectancy of a Gen 1 device is about 1,500 hours of use.

Do not expect anything for those devices.

Generation 2, 2+, 3 and 4

Gen2 was introduced in the 80's.

Introduction of microchannel plate design and more sensitive photocade.

Gain bumped above 40'000x.

No clear distinction between gen 2 and gen 3.

Some gen 2 tubes may have similar or better performance than lower grade gen 3.

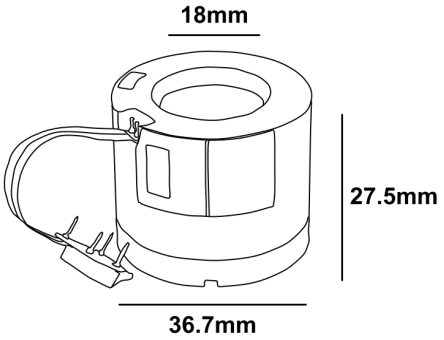
ITAR[10]classifies any image intensifier with a FOM[11] lower than 1800 as gen 2 instead of comparing manufacturing processes.

Gen 4 are essentially high spec gen 3 with fast autogating and low halo.

Life expectancy of Gen 2 is 5'000 hours of use, Gen 3 and 4 are +10'000 hours of use.

Tube formats
Current industry standards for headborne units are MX11769 and MX10160. The main difference between the two is the pigtail wire for controlling the manual gain knob on your device. Note that MX11769 can be converted to MX10160 by either removing the pigtail or soldering a resistor.

Other tube formats exist for older night vision devices or other applications than headborne units such as firearm clip-on units.

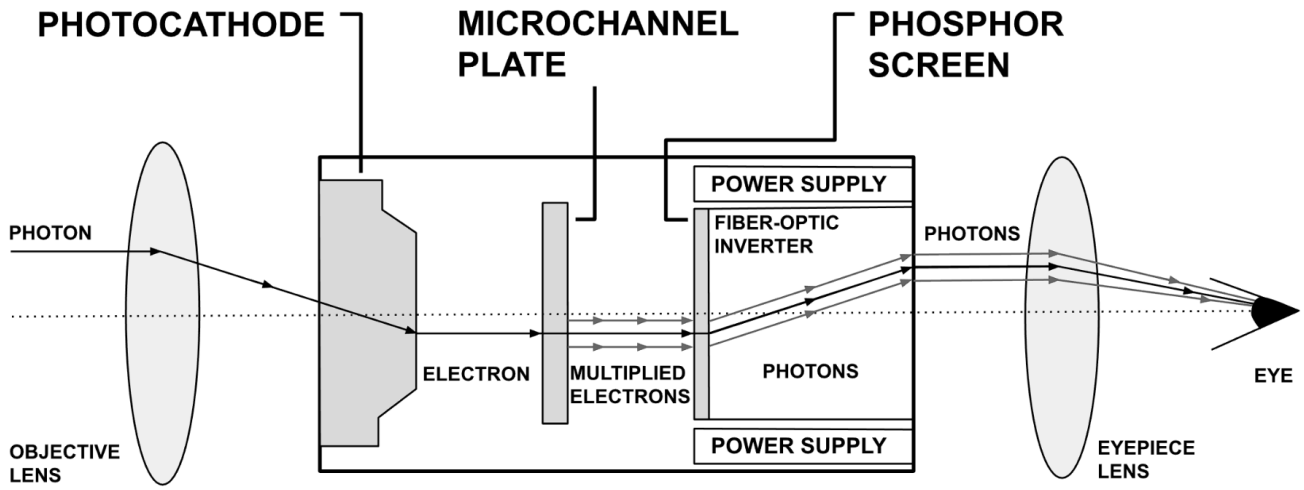


11769 Image intensifier tube with removable pigtails for gain control

[10] International Traffic in Arms Regulations
[11] Figure of Merit

Function

The manufacturing of image intensifiers is highly complex. However, the overall concept of an image intensifier is easy to understand:



Function diagram - not to scale.

1) A photocade captures the photons and converts into electrons.
2) The electrons are accelerated through an electrical field.
3) Accelerated electrons hit a microchannel plate that in turn will generate more electrons.
4) The multiplied electrons are accelerated again.
5) Electrons hit a phosphor screen layer that converts them back into photons.

Image intensifiers coming out the same manufacturing line are unique and must be measured in a laboratory hence the importance of their associated Specification Sheet.

The specification sheet will classify the category and the value of an image intensifier.

Understanding Specification Sheets[12]

Main properties of an image intensifier:

Name	Définition	What it means	How to compare
Resolution	Measured in line pairs per millimeter (lp/mm) at the center of the tube.	Everything above 64 lp/mm look the same to the eye in a headborne unit. Higher resolution will be more important in clip-on application than helmet worn.	Higher is better
SNR	Signal-to-Noise ratio Measured a given fixed light level of 108 µlx.	Determines how clean or noisy the image, especially when it gets really dark	Higher is better
FOM	Figure of Merit	FOM = Resolution * SNR Often used as a marketing number for an estimation of tube performance. Because the human eyes can't see the difference above 64 lp/mm, higher resolution has an exaggerated effect on FOM result.	"Higher is better"
EBI	Equivalent Background Illumination Measured in lumens per square centimeter (lm/cm2) at 21°.	The EBI level determines the lowest light level at which an image can be detected. Below this light level, objects will be masked by the EBI. Affected by ambient temperature, EBI is more critical in hot environments.	Lower is better
Halo	Bloom from a 0.35mm input light source measured in mm	Determines how much bloom light sources will have. Important for urban environments or driving with incoming lights.	Lower is better
Gain	Luminance Gain and/or Photocathode Sensitivity	How many times the light was multiplied before it got to your eyes. Not to be confused with gain control.	Higher is better

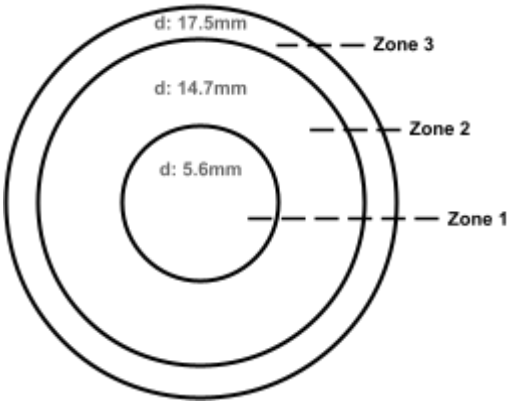
[12] Credits: Hoplopfheil

Black spots & Blemishes
Black spots are factory defects out of the production line. They are specified on the specification sheet per size in microns and zones.

Blemishes are damaged on the image intensifier, mostly because of bright light exposition while on use.

Environments are full of blemishes and shadows. Most of black spots or blemishes are barely noticeable if:

- Size < 200 microns (0.2mm).
- Located outside of zone 1.



Milspec zone definition

Gain control
Optional feature allowing the user to adjust the brightness of the output of your night vision device. Reducing the brightness may result in better contrast and relieve your eyes from excessive brightness. Low brightness level may allow you to retrieve your peripheral vision if there is enough light around.

Autogating
Optional feature of the image intensifier against bright light expositions. It enables the amount of light reaching the intensifier to be automatically gated i.e., it frequently switches ON and OFF the tube, hence brighter lights do not cause any damage to the unit.

Phosphor color
Because the human eye has more abilities to discern contrasts with green color than other colors. P43 green phosphor is the color of choice for night vision display. P45 white phosphor are also available, they may feel more natural. However, there is no scientific evidence proving that one is better than the other. It comes down to user preference.

Optics
Optics are parts of the housing of your night vision device. They have a strong impact in light transmission, glare elimination and image distortion.

Ion barrier film[13]
Gen 3 introduced an ion barrier film on the MCP which drastically improves the service life of the image intensifier but degrades its performance. Three generation of Ion barrier film were made:

- Thick filmed: introduced in 1982. Thick filmed tubes do not offer significant performance over Gen 2 but have a much longer life expectancy from to 5,000 to +10,000 hours of use.
- Thin filmed: introduced in 1996. Represents the majority of image intensifiers available on the market today.
- Filmless: introduced in 2014 but made more reliable after 2018, unfilmed or filmless tubes are using a different technology. Filmless tubes deliver the best performance.

[13] https://gloomgroup.com/blogs/night-vision-info/night-vision-filmed-vs-unfilmed-tubes

Contract Tubes

Image intensifier tubes without detailed specification sheets often refer to OMNI[14] classification which is a standard developed by the US military. Contract tubes must meet or exceed such requirements.

Summary:

Contract	OMNI IV	OMNI V	OMNI VI	OMNI VII	OMNI VIII	OMNI IX
Year	1996	1999	2002	2006	2010	2020
Resolution	64	64	64	64	64	72
SNR	21	21	25	28	25	33
EBI	2.5	2.5	2.5	3	3	2
Halo	1.25	1.25	0.9	0.7	1	0.75
Gain	40k - 70k	40k - 70k	50k - 80k	50k - 80k	40k - 110k	80k-160k

Buying an image intensifier[15]

Good specs in 2023

<u>If a specification sheet is available:</u>

- Resolution: min. 64 lp/mm
- SNR; 30 or higher
- FOM: doesn't matter.
- EBI: Less than 1.0
- Halo: Less than 1.0
- Gain: doesn't matter.

A picture of the image intensifier working against a white wall will show black spots and blemishes.
Again, a spotless tube is satisfying but spots outside zone 1 and below 0.2mm in size are perfectly fine.

<u>If no specification sheet available:</u>

OMNI VII or more.[16]

Autogating is a must for protecting your tube against bright lights.

[14] OMNIBUS: Latin word "for all".
[15] Credits: Hoplopfheil
[16] Not all image intensifier contracts have autogating.

Conclusion

In conclusion, night visions offer a significant advantage for those who require visibility in low-light and no-light conditions. However, it is essential to remember that night vision devices require proper training to ensure optimal performance and prevent injury.

Training is critical for anyone using night vision devices, especially for those using these devices for shooting or other high-risk activities. Proper training can help to ensure that users understand the capabilities and limitations of their night vision device, know how to use the device safely and effectively, and are aware of the potential risks associated with using night vision devices.
In particular, shooting with night vision requires specialized training to master techniques such as maintaining proper aim and alignment, understanding range estimation, and accounting for the specific characteristics of the night vision device being used. With proper training, users can improve their situational awareness, extend their operational capabilities, and increase their effectiveness in low-light and no-light conditions.

This handbook has provided a comprehensive overview of the technical characteristics and basic principles of night vision, as well as guidance on how to select, set up, and use a variety of night vision devices. However, it is essential to remember that the information presented here is not a substitute for proper training, and users should seek out qualified instructors and training programs to ensure that they are using their night vision devices safely and effectively.

We hope that this handbook will serve as a useful resource for those seeking to learn more about night vision technology, and that it will encourage users to seek out the necessary training to use these devices safely and effectively in the field.

Contribution

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