DEP

The Delft Electronic Products guide to:

Image Intensifiers

Digitised Image Intensifiers

Intensified CCD's

Photon Counters

Delft Electronic Products B.V.
Dwazziewegen 2, 9301 ZR Roden
P.O. Box 60, 9300 AB Roden
The Netherlands
Tel : +31 (0)50-5018808
Fax: +31 (0)50-5013510
E-mail : sales@dep.nl
http://www.dep.nl
Trade Register No.: 04019659

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1 INTRODUCTION 6

2 NIGHT VISION 101 7

2.1 HOW NIGHT VISION WORKS 7
2.2 GENERATIONS: ABOUT HOW THE TUBES ARE MANUFACTURED 8
2.2.1 GENERATION I 8
2.2.2 GENERATION II 8
2.2.3 GENERATION III 8
2.3 PERFORMANCE FAMILY: ALL ABOUT HOW TUBES PERFORM 9
2.3.1 SHD-3™ TECHNOLOGY 9
2.3.2 XD-4™ TECHNOLOGY 9
2.3.3 XR5™ TECHNOLOGY 10
2.3.4 ICMOS TECHNOLOGY 10
2.4 TWO PERFORMANCE REGIMES 11
2.5 LOW LIGHT LEVEL PERFORMANCE 12
2.5.1 THE SIGNAL TO NOISE RATIO 12
2.5.2 GAIN AND EBI 15
2.5.3 SPECTRAL BEHAVIOUR 16
2.6 HIGH LIGHT LEVEL PERFORMANCE 17
2.6.1 LIMITING RESOLUTION 17
2.6.2 CONTRAST AND MTF 18
2.6.3 MOB 21
2.6.4 LUMINANCE DYNAMIC RANGE 21
2.7 XD-4™ VERSUS OMNIBUS IV/V 22
2.7.1 LOW LIGHT LEVEL REGIME 22
2.7.2 HIGH LIGHT REGIME 23
2.7.3 MISCELLANEOUS 24
2.7.4 SUMMARY 24

3 HOW TO SELECT AN IMAGE INTENSIFIER? 25

3.1 TRIANGLE OF CHOICE 25
3.2 OPTION A: GENERATION FAMILY 26
3.3 OPTION B: FIELD TEST 27
3.4 OPTION C: DATA SHEET 28
3.5 SUMMARY 29

4 XR5™ IMAGE INTENSIFIERS 32

4.1 TECHNICAL SPECIFICATIONS: XR5™ 33

5 XD-4™ IMAGE INTENSIFIERS 34

5.1 TECHNICAL SPECIFICATIONS: XD-4™ 35

6 SHD-3™ IMAGE INTENSIFIERS 36

6.1 TECHNICAL SPECIFICATIONS: SHD-3™ 37

7 INTENSIFIED CCD (ICCD) 40

7.1 INTRODUCTION 40
7.1.1 DESCRIPTION OF BASIC ICCD 41
7.2 PERFORMANCE CHARACTERISTICS OF THE BASIC ICCD 41
7.2.1 MTF AND RESOLUTION 41
7.2.2 SIGNAL-TO-NOISE RATIO 42
7.2.3 LIFETIME 42
7.3 INTEGRATED SYSTEMS 43
7.4 INTENSIFIED CCD'S, MODEL XX1700 44
AVAILABLE OPTIONS FOR ICCD 45

8 SPECIAL IMAGE INTENSIFIERS, SPECIAL ICCD'S AND SPECIAL ICMOS 46

8.1 INTRODUCTION 46
8.2 TYPES OF IMAGE INTENSIFIER COMPONENT OPTIONS 46
8.3 GATED TUBES 49

9 PHOTON COUNTERS 50

9.1.1 INTRODUCTION 50
9.1.2 MCP PHOTON COUNTERS 51
9.1.3 MCP PHOTON COUNTER WITH CCD READ-OUT 53
9.1.4 MCP PHOTON COUNTER WITH RESISTIVE ANODE READ-OUT 54
9.1.5 HYBRID PHOTO DIODE (HPD) 56

10 SPECIFICATION AND MECHANICAL CHARACTERISTICS 58

1 INTRODUCTION

LEADING IN TECHNOLOGY

For more than 30 years, DEP has enjoyed recognition as the leading European manufacturer of high performance Image Intensifiers for Night Vision and Surveillance equipment. During that time, DEP products have become well known for their superior performance and image quality. DEP offers reliable and professional support to its customers pursuing tomorrow's increasingly challenging requirements.

HIGH PERFORMANCE

Because of our unique track record and our broad knowledge we can offer our customers an outstanding support in developing challenging products, surpassing the latest demanding requirements. The revolutionary DEP Early Vision™ Co-Development Program has been established to provide you with our latest know-how and to shorten your time-to-market for new products.

STATE-OF-THE-ART PRODUCTS

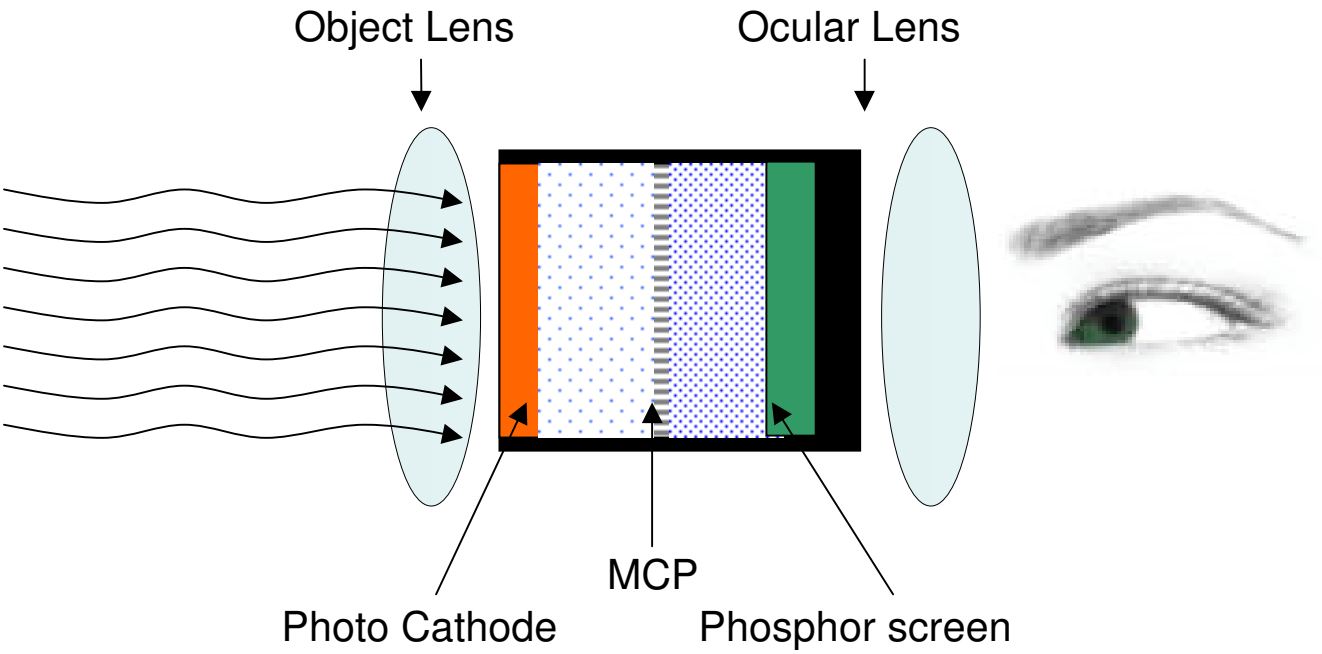
The XR5™ image intensifier, successor to the well-known and successful XD-4™ image intensifier, reveals even more details of the night and offers and eXtended Range (XR) capability to its new technology. The XR5™ image intensifier enables the user to see even more during a full 24-hour operation and in situations with fast changing light conditions. The XR5™ image intensifier is equipped with an Auto-Gating feature, which adds security and survivability to the users night vision kit.

BEYOND NIGHT VISION !

DEP produces a variety of different Image Intensifiers suited for applications running from X-rays to the Near-Infrared wavelength band. The application determines which type of input window and photocathode should be used. In this document DEP has put together the specifications of standard image intensifier tubes providing an overview of the product range of Delft Electronic Products BV.

2 NIGHT VISION

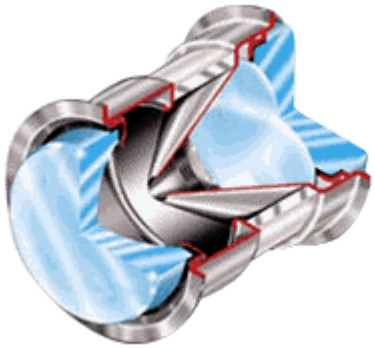
2.1 HOW NIGHT VISION WORKS



An Image Intensifier is a vacuum tube that amplifies a low light-level scene to observable levels. The object lens collects light and focuses it onto the Image Intensifier. At the photocathode of the Image Intensifier the incoming light is converted into photoelectrons. These photoelectrons are accelerated in an electric field and multiplied by a Micro Channel Plate (MCP). The MCP is a very thin plate of conductive glass containing millions of small holes. An electron entering a channel strikes the wall and creates additional electrons, which in turn create more electrons (secondary electrons), again and again. Subsequently the highly intensified photoelectrons strike the phosphor screen and a bright image is emitted that you can see.

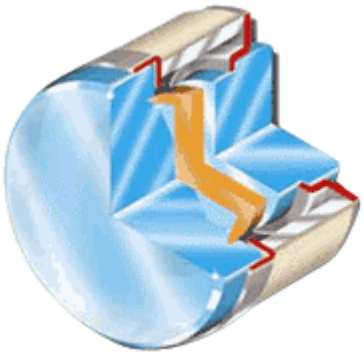
2.2 GENERATIONS: ABOUT HOW THE TUBES ARE MANUFACTURED

2.2.1 GENERATION I



It started with electrostaticaly focused Generation I tubes featuring high image resolution, a wide dynamic range and low noise.

2.2.2 GENERATION II



Introduced the Micro Channel Plate for much higher gain in the 1980's. The original image resolution was less than that of the first generation intensifiers but the gain was much higher up to 30000 fL/fc.

2.2.3 GENERATION III

In the late 1980's an Image Intensifier with a Gallium-Arsenide (GaAs) photocathode was developed showing an enhanced sensitivity in the Near-Infrared. In the late 1990's GEN III tubes with greatly improved performance appeared on the market. These types are called GEN III Omni III and GEN III Omni IV.

2.3 PERFORMANCE FAMILY: ALL ABOUT HOW TUBES PERFORM

SHD-3™ TECHNOLOGY

The SHD-3™ (Super High Definition) is an upgrade of the well-known DEP Super Generation tubes. It can be used in a large range of applications, but was developed especially for night vision. It is available in both inverting and non-inverting 18 mm formats with various constructions. DEP image intensifiers with SHD-3™ technology: night vision is clearly about seeing things in the very dark.

XD-4™ TECHNOLOGY

The European Standard for low-light level imaging showing superior performance in a wide range of night vision applications under severe conditions. This new technology has been developed by DEP in 1996. Available in inverting and non-inverting 18 mm formats with various constructions. DEP state-of-the-art image intensifiers with XD-4™ Technology: it is image performance that counts.

2.3.3 XR5™ TECHNOLOGY

XR5™ Ultimate Night Vision Technology

IRIS™

The XR5™ image intensifier, successor to the well-known and successful XD-4™ Technology image intensifier, reveals even more details of the nights and offers an eXtended Range (XR) capability thanks to its new technology.

Furthermore, the XR5™ image intensifier enables the user to see even more during a full 24-hour day/night operation. This is done by the use of a fully integrated Auto-Gating unit, which controls the image not only during day-night-day transitions but also during dynamic lighting conditions, e.g. in night operations in urban areas. In practice this means no blooming to hinder your mission but dependable imagery throughout. DEP state-of-the-art image intensifiers with XR5™ Technology: your best choice to maintain your combat effectiveness under all circumstances.

2.3.4 ICMOS TECHNOLOGY

ICMOS™

A newly developed proprietary method of coupling virtually any available CMOS sensor to an Image Intensifier Tube results in a minimum loss of gain and MTF and combines improved output quality with ease of development.

The smaller dimensions and rugged component structure allows system integrators to construct compact and high performance systems with all the benefits of a high resolution digitised image.

Compared to conventional Intensified CCD cameras, the new ICMOS cameras require less operating electronics and enable easy windowing.

2.4 TWO PERFORMANCE REGIMES

An image intensifier tube is an amplifier of residual light. If there is no light, there will be no image. If there is only a small quantity of light, one will be confronted with the fact that light exists of individual particles called photons. As a consequence there will not be a continuos illumination but a 'hail like' bombardment by single photons. At very low illumination levels, there will not be enough photons for the human eye to form an image. Increasing illumination will increase the number of photons and a noisy image will pop up. With such a noisy image it will not be possible to see small details; the resolution will be dependent on the light level. This regime is called the ‘low light level’ or ‘shot noise limited’ regime. In this regime the quality of the picture will be dependent on the light level. If there is enough light, the noisiness will disappear. The quality of the picture is much higher and must be described by sharpness and contrast. It will not depend on the illumination intensity.

Figure 1 shows that the limiting resolution in the low light level is dependent on the illumination, while at higher levels it is constant.

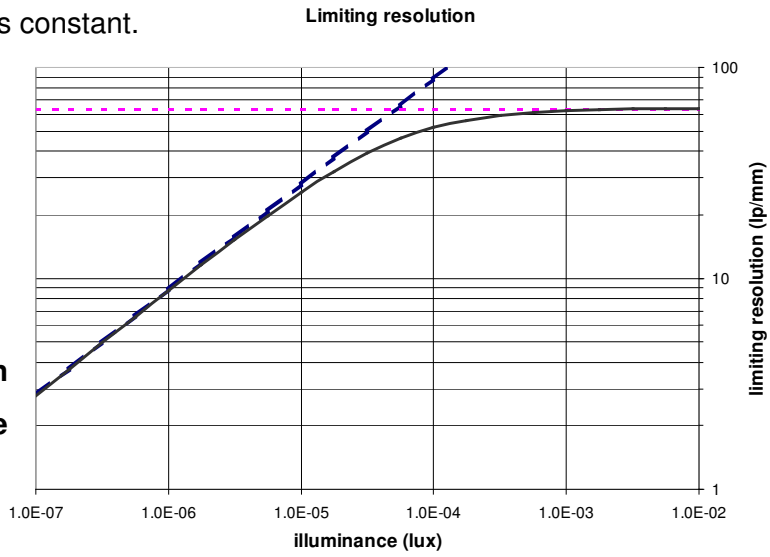


Figure 1. The limiting resolution as a function of illuminance showing the high and low light level regimes

2.5 LOW LIGHT LEVEL PERFORMANCE

2.5.1 THE SIGNAL TO NOISE RATIO

In the low light regime the information density is mainly determined by the noisiness of the image. This effect is illustrated by the images in figure 2 below. At very low light levels no structures are visible at all. The 'image' consists of light speckles, but our eyes cannot make a picture from it. That the information is there could be demonstrated by integrating on a photographic film or with a CCD camera. If the light level increases the larger 20lp/mm target becomes visible. The smaller 60lp/mm target is still hidden in the noise. At these light levels the information we get from the image intensifier tube is mainly determined by its noise performance.

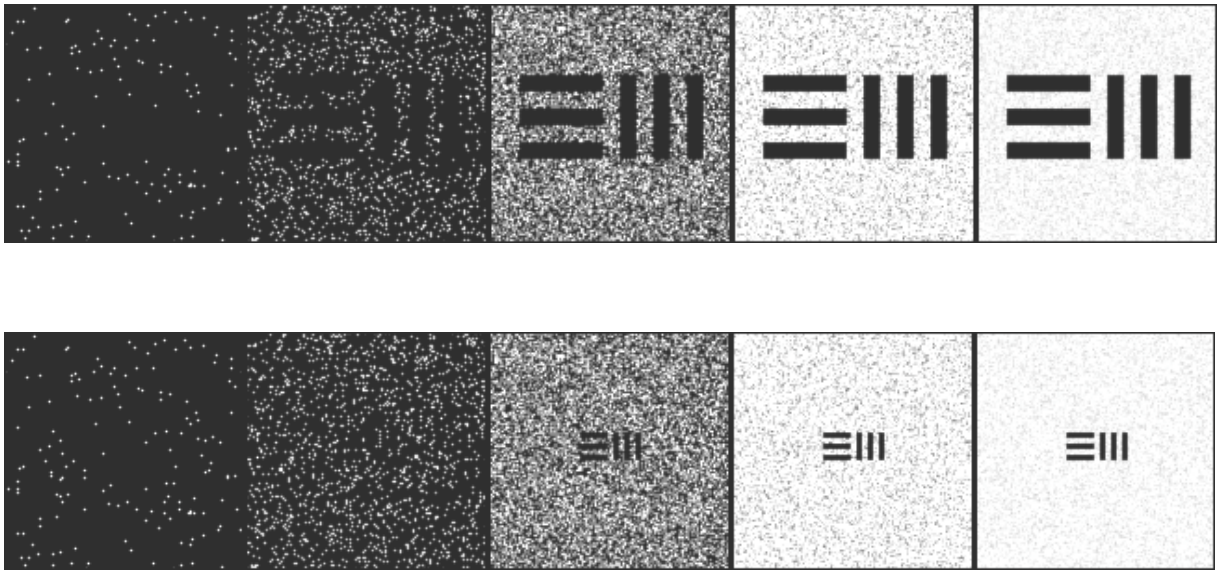


Figure 2. The 20 lp/mm and 60 lp/mm targets at different light levels

A number of factors play a role in the noise performance of an image intensifier:

- The intensity of the available light. The noisiness is a square root function of the light level. An increased intensity of light by a factor of 4 yields a reduction of noise by a factor of 2.
- The cathode sensitivity. Not every incoming photon is transferred into an electron; the quantum efficiency of a photocathode is in the range of 10% - 30%. A photon which is not transferred into an electron does not contribute to the image, thus increases the noisiness above its theoretical minimum value.

  The MCP adds to the noisiness of the image by trapping photoelectrons. These trapped electrons will not be amplified. Especially the MCP film in GEN III tubes, needed to protect the GaAs photocathode, is a photoelectron killer. More then 50% of the emitted electrons get trapped by the MCP film. A photoelectron formed at the cathode, but lost at the film, could as well not be formed. This process is a substantial reduction of the **effective** cathode sensitivity.

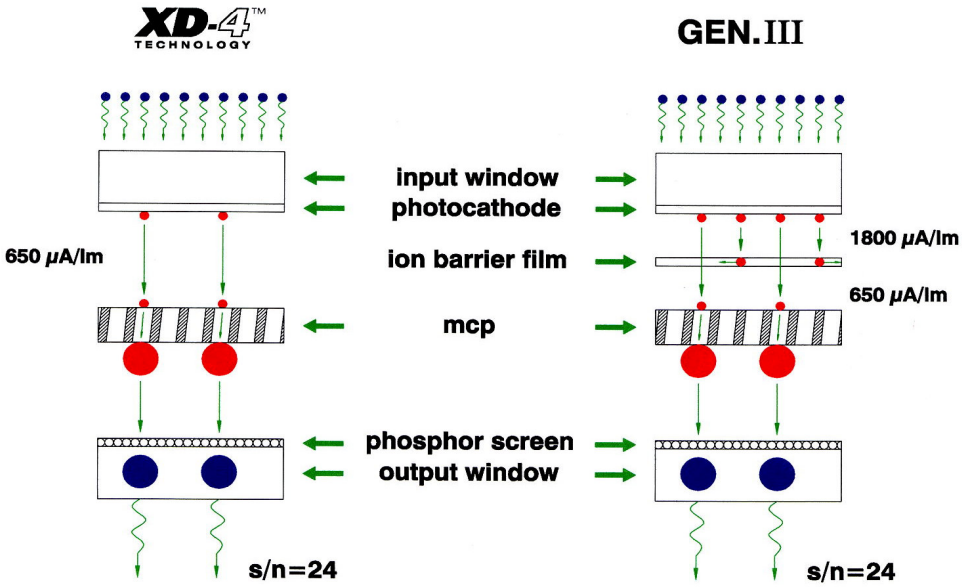


Figure 3. Visualisation of the difference between XD-4 and GEN III

The best way to describe the noisiness of the picture at low light levels is the signal to noise ratio (S/N). The test to assess this parameter uses a light level of 10^{-4} lux over an illuminated area of ∅ 0.2 mm. Because of the limited light available, the output brightness will not be constant but will fluctuate with time. The average brightness divided by the sigma of the fluctuation is called the S/N. At illumination levels different to the test level of 10^{-4} lux, the S/N can be calculated by using the square root law described below.

The S/N of an image intensifier is mainly determined by the number of photoelectrons that finally contribute to the screen output brightness. This is expressed by the following formula that is valid for the photon noise limit:

$$S/N = \sqrt{\frac{AES}{\Delta f Q F}}$$

With: A = area of interest [m^2]
E = input illumination [lux]
S = 2850K photocathode sensitivity [A/lm]
Δf = applicable bandwidth [Hz]
q = elementary charge [1.6×10^{-19} C]
F = image intensifier noise factor

Δf is defined by the observing element used at the output and the phosphor. For given conditions like in the MIL-Spec. this equation can be reduced to:

$$S/N = \sqrt{\frac{S}{F_e}}$$

with F_e being an effective noise factor in which the effects of the operating conditions are incorporated. Last equation shows that both higher photocathode sensitivity and a lower effective noise factor contribute to a better S/N.

A major problem for the GEN III tubes is that many of the created photoelectrons are stopped in the ion barrier film on top the MCP and do not contribute to the output brightness. This is a fundamental problem for filmed MCP tubes, as the film prevents part of the signal photo-electrons to reach the MCP holes and hence don't get multiplied and don't participate in the output brightness. The decrease in Detected Quantum Efficiency caused by the film can be as high as 40%. Comparing the noise factors can prove the correctness of this theory: DEP with an effective noise factor of: 1.4 versus GEN III with an effective noise factor of 3.8.

Notwithstanding the considerably higher photocathode sensitivity of GEN III tubes, one obtains for DEP tubes S/N ratios that are **at least equal but often better** than those of GEN III. The main reason for this is the absence of an ion barrier film in the DEP image intensifiers which leads to a significantly lower noise factor.

2.5.2 GAIN AND EBI

A higher gain of the tube will not make the picture less noisy, it will only increase the intensity of the noise. Above a certain level, comfortable to the eye, increase of gain will not help to improve performance.

The Equivalent Background Illumination (EBI) is the thermal emission of the cathode. Because it is expressed in terms of illumination it can directly be compared to the cathode illumination of the scenery. At extremely low illumination levels the EBI adds a haze to the image.

2.5.3 SPECTRAL BEHAVIOUR

The S/N ratio (and cathode sensitivity) is measured with a tungsten source, having a defined spectral distribution, the so-called 2850K source. The spectral distribution of this source is chosen to be similar to the infrared distribution of starlight. The spectral distribution of a real scenery depends not only on the illumination circumstances (infrared starlight or blue/green moonlight) but also on the reflectivity of the scenery. Forest reflects more (infra-) red light and coastal areas and deserts have a more blue/green character. To predict the performance of an image intensifier tube, the **spectral** S/N is a useful piece of information (see figure 6).

2.6 HIGH LIGHT LEVEL PERFORMANCE

2.6.1 LIMITING RESOLUTION

From a certain light level on the image quality will no longer depend on the S/N ratio of the tube and the illumination level. The imaging quality of the tube has taken over. The most common parameter to describe high light level performance is the limiting resolution. This is the maximum line density on an USAF target that a human observer can resolve. This performance indicator has a number of drawbacks:

- it is subjective (there are optimistic and pessimistic observers)
- steps in the USAF target are large (the phantoms are separated by 13%, yielding steps of 8 lp/mm in the region of 60 lp/mm)
- the optics of the projection and observation system plays an important role
- different criteria are used (some want to see clearly distinguished lines, others want only to recognise the direction of the lines)
- not only the limiting resolution, but also the contrast for larger structures plays an important role for the field performance.
- Taking the named factors into account the ‘world-wide’ systematic error of the measurement is more than 10 lp/mm.

2.6.2 CONTRAST AND MTF

A more objective performance indicator is given by the modulation transfer function (MTF). To discuss this, first the term contrast has to be introduced. By definition the contrast is:

C = (max. brightness – min. brightness) / (max. brightness + min. brightness)

Look at the example in figure 4. Both plots show the brightness as a function of position. The solid line shows a fluctuation from dark to bright, while the dotted line is modulated from dark grey to light grey. The associated contrasts are:

C_{solid} = (100 – 0) / (100 + 0) = 100% and C_{dotted} = (60 – 40) / (60 + 40) = 20%

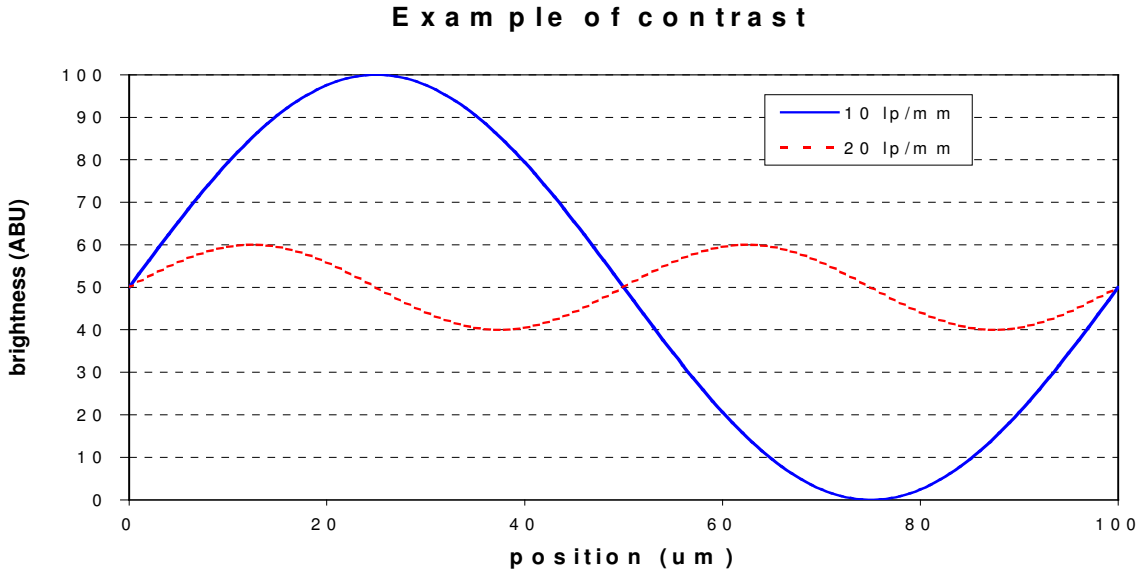


Figure 4. Example of contrast

The modulation transfer function of an imaging system gives the contrast of the output when a 100% modulation at the input is applied. This output contrast is given as a function of spatial frequency (lp/mm).

The MTF at low line pairs gives the contrast for large objects. The MTF at high line pairs the contrast for small objects. The limiting resolution is closely related to the contrast at high line pairs. Usually it coincidences with a contrast of 5% - 10%, dependent on the way of measurement.

A good contrast at low and medium line pairs (up to 30 lp/mm) gives a 'clear' image. A low MTF value gives a 'hazy' impression. In this case a lot of observers will have the impression of an un-sharp image. Despite the bad contrast at low line pairs, the limiting resolution can be high. These differences are shown in the image processed photographs of Venice on the following page.

The MTF function for the left top of the image is relatively high at low line pairs but drops quickly above 30lp/mm. As a consequence the (10 times magnified) 60 lp/mm resolution target is not visible. The MTF of the right bottom part of the image drops quickly at low line pairs (giving the hazy impression) but stays at an acceptable level for up to 60 lp/mm. The (again magnified) 60lp/mm target is still clearly visible.

Most observers will prefer the top-left image with the lower limiting resolution!

Some care must be taken by comparing the MTF figures from different types of instruments. US measurements tend to give higher values for the same tubes than ODETA based European Measurements. It is always preferable to compare different tubes on the same instrument.

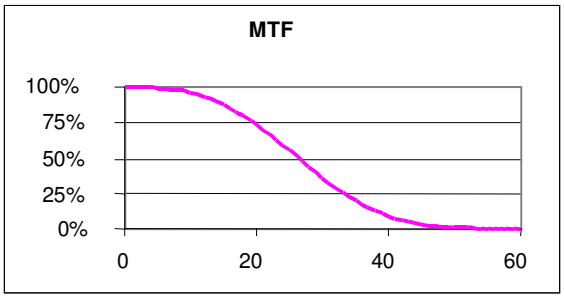
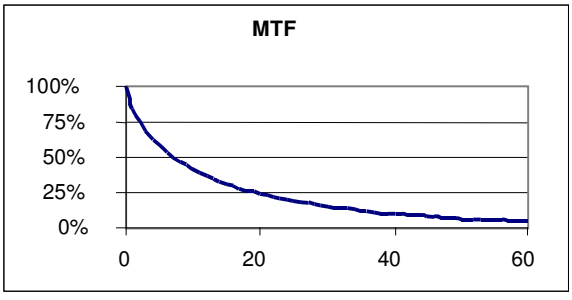


Figure 5. The image shows the consequence of MTF.

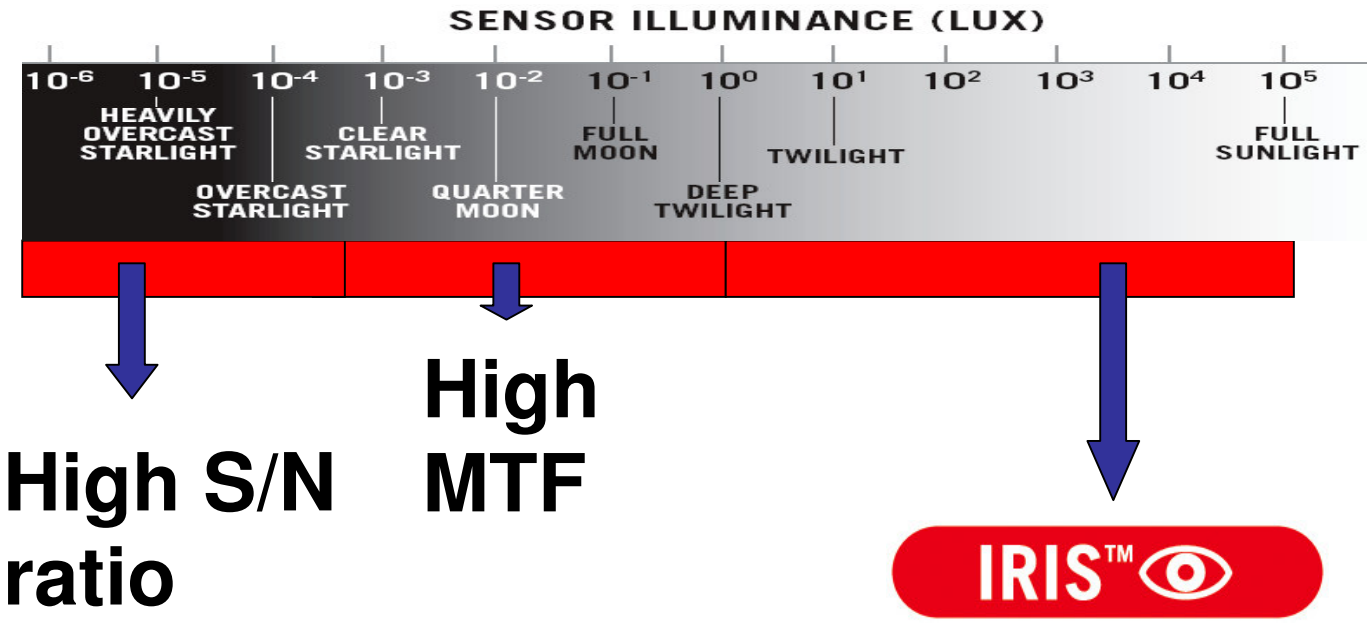


2.6.3 MOB

At high light levels the intensity of the screen will be determined by the setting of the 'maximum output brightness' (MOB). This value is usually set between 5 cd/m^2 and 15 cd/m^2. In this regime the gain is dependent on the light level and will be below the pre-set value of the low light level gain. The signal to noise ratio (and indirectly the cathode sensitivity) and EBI play no role in this high light level regime.

2.6.4 LUMINANCE DYNAMIC RANGE

The XR5™ image intensifier enables the user to see even more during a full 24-hour day/night operation. This is done by the use of a fully integrated Auto-Gating unit, which controls the image not only during day-night-day transitions but also during dynamic lighting conditions, e.g. night operations in urban areas. An integrated unit has automatic control over the gain and gating of this tube type when it becomes active at the higher light levels. In practice this means no blooming to hinder your mission but dependable imagery throughout.



2.7 XD-4™ VERSUS OMNIBUS IV/V

This paragraph compares performance of DEP XD-4™ tubes with the performance of GEN III Omnibus IV/V tubes.

2.7.1 LOW LIGHT LEVEL REGIME

As mentioned in the paragraph about low light level performance, the best indicator for field performance in this regime is the signal to noise (S/N) ratio. The Omnibus IV/V requirement is 21, similar to the XD-4™ minimum specification. Also the typical values are 24 for both cases. EBI and gain of XD-4™ and Omnibus IV/V have comparable values.

Figure 6 shows the spectral signal to noise ratio. The graph shows a slight advantage for the GEN III cathodes (dotted line) in the infrared region and a clear advantage for XD-4™ (solid line) in the green/blue region. This sensitivity is a significant advantage in sandy deserts and coastal areas and when artificial lighting is used.

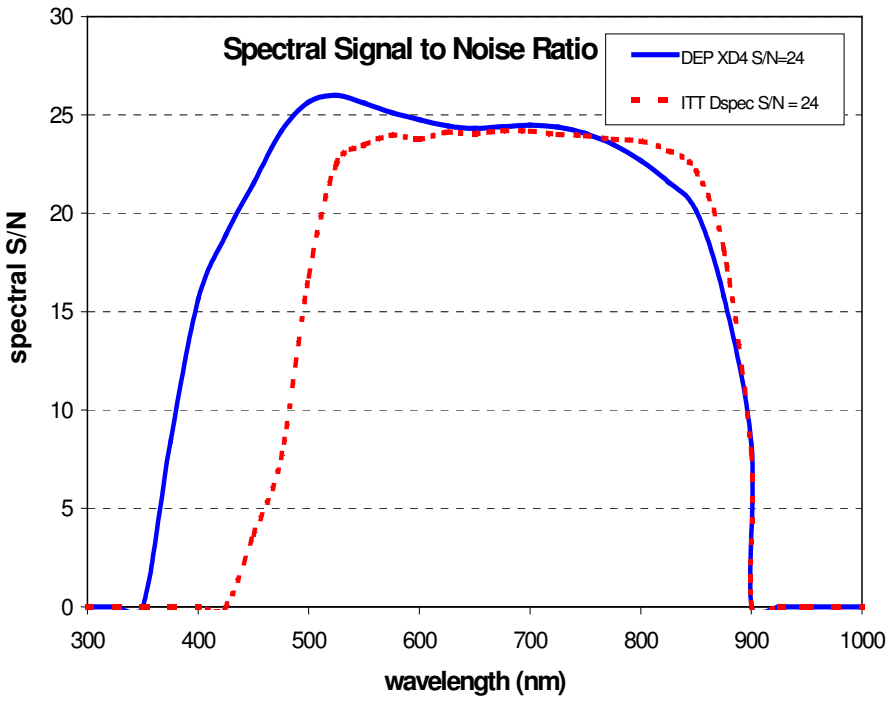


Figure 6. The spectral signal to noise curve for XD-4™ and GEN III, Omnibus IV/V.

2.7.2 HIGH LIGHT REGIME

The limiting resolution of XD-4™ and Omnibus-4/5 is comparable. When measured with similar test set-ups there is an advantage for the XD-4™ tubes. This is confirmed by the MTF graphs, measured with the same device, shown in figure 7.

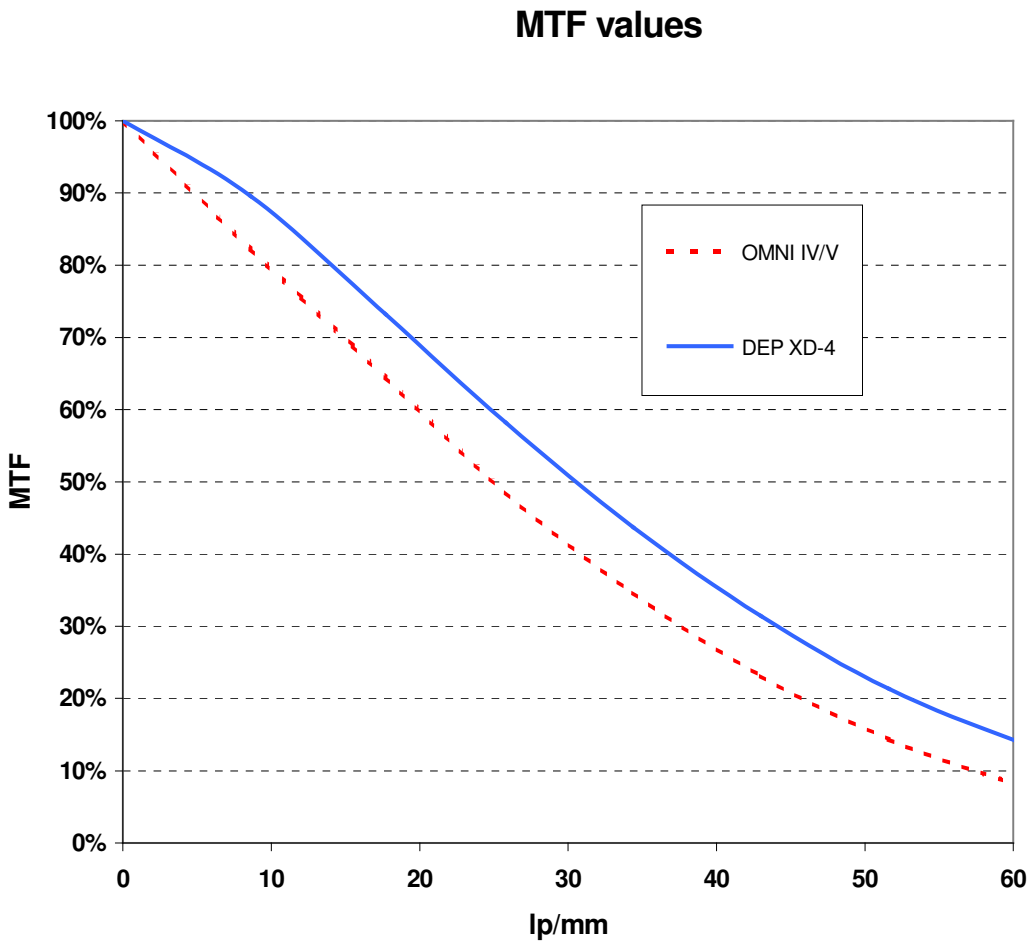


Figure 7. The MTF of Omnibus IV/V and DEP XD-4™

2.7.3 MISCELLANEOUS

Apart from the factors determining the image quality, there are a number of factors in advantage of DEP's XD-4™ technology. Namely:

- Robustness: XD-4™ will survive a shock of 700g, while the Omnibus-4/5 tubes are limited to 75g.
- Halo: the halo of XD-4™ is smaller and less intense.
- Battery life.
- Burn-in and behaviour at over-illumination

2.7.4 SUMMARY

For the assessment of an Image Intensifier tube it is essential to differentiate between low light level regime and the high light level regime. In the low light level regime the best performance indicator is the **signal to noise ratio**. A good cathodes sensitivity is just a way to achieve a good S/N value and has no benefit of it's own.
In high light level regimes the **limiting resolution** is a useful parameter, but the **MTF** is more objective and is a more valuable tool to predict image quality.

Comparing GEN III Omnibus IV tubes against DEP's XD-4™ there is a clear balance in performance and in addition a substantial better MTF for the XD-4™. This is confirmed by field tests of the tubes. Besides performance do come advantages for the XD-4™ in terms of robustness, smaller and less intense halo, lower battery consumption, and better protection against over-illumination.

3 HOW TO SELECT AN IMAGE INTENSIFIER?

3.1 TRIANGLE OF CHOICE

There are several options to choose an image intensifier for night vision devices. In order to select the best image intensifier there are three options to choose from as shown in the “triangle of choice”.

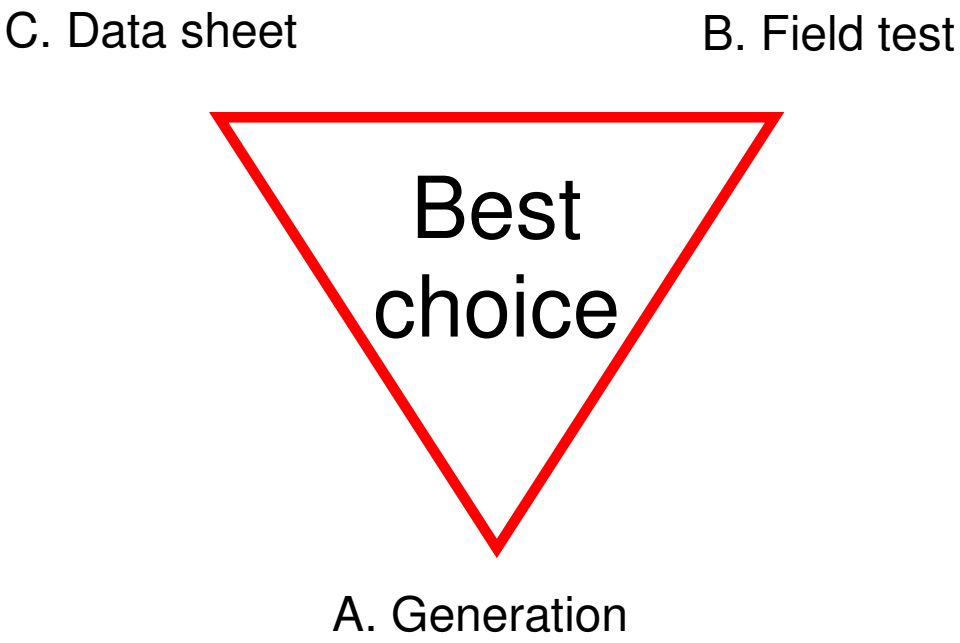


Figure 8. Triangle of choice options

The first option is simple: just choose the latest generation. The second option is to focus on field-testing. The last option number three, is to base the selection on datasheets.

3.2 *OPTION A: GENERATION FAMILY*

The simplest way to choose an image intensifier is to choose the latest Generation. But, how do you know that the latest generation is really the best product you will get?

Categorised on <u>manufacturing</u> technology used:

- **Generation I**
- **Generation II ➔ MCP**
- **Generation III ➔ cathode material**
- **Generation IV? ➔ unfilmed MCP**

All about: THE MANUFACTURING PROCESS

In paragraph 3.2 'Generations' the history of the generation story is explained. In short: Generation I had a low gain and no MCP. Then image intensifiers with MCP were developed and called Generation II. Next came the image intensifiers which used GaAs as cathode material: Generation III. The definition of Generation IV would be an unfilmed MCP in the image intensifier, but was called GEN III Omni VI. These are all technical issues, they tell how image intensifiers are produced, but not how they perform. The US industry in close co-operation with the US Army night vision labs defines the generations. When European companies innovate image intensifiers in another way, resulting in tubes with superior performance but not fitting in a Generation definition, the Americans will tell it is Generation II technology! Meaning that it is old fashioned and not attractive. Throughout the years this has become a paradigm: an American marketing story. Looking at the number of the generation tells only about how an image intensifier is manufactured. What is technically inside? It does not tell anything about the performance of a tube.

3.3 *OPTION B: FIELD TEST*

Quote: “I don’t care about paper specification, I decide by field testing.”

All image intensifier manufacturers suffer from production spread. Therefore minimum values for performance have to be specified.

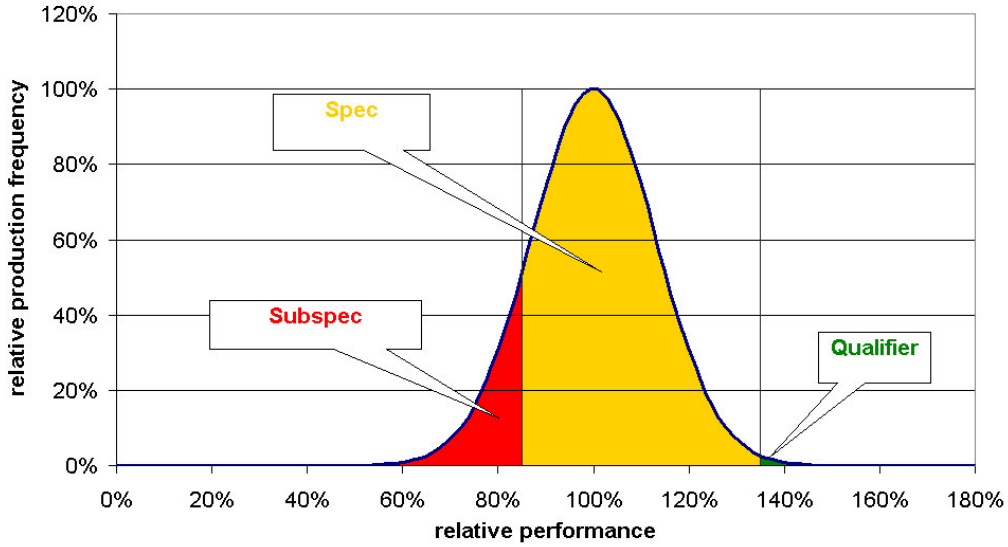


Figure 9. Production spread

Figure 9 shows the production spread. On the horizontal axis you see the image quality on the vertical production output.

You want to make a certain quality, but you make a range of qualities. E.g. for a typical order the minimum specification is 85%. All production with lower quality will either be scraped or used for orders requiring lower quality. Usually, for qualifiers the tubes with the best performance are selected over 100%. The difference between production tubes and qualifiers depends not only on the average quality but also on the production spread.

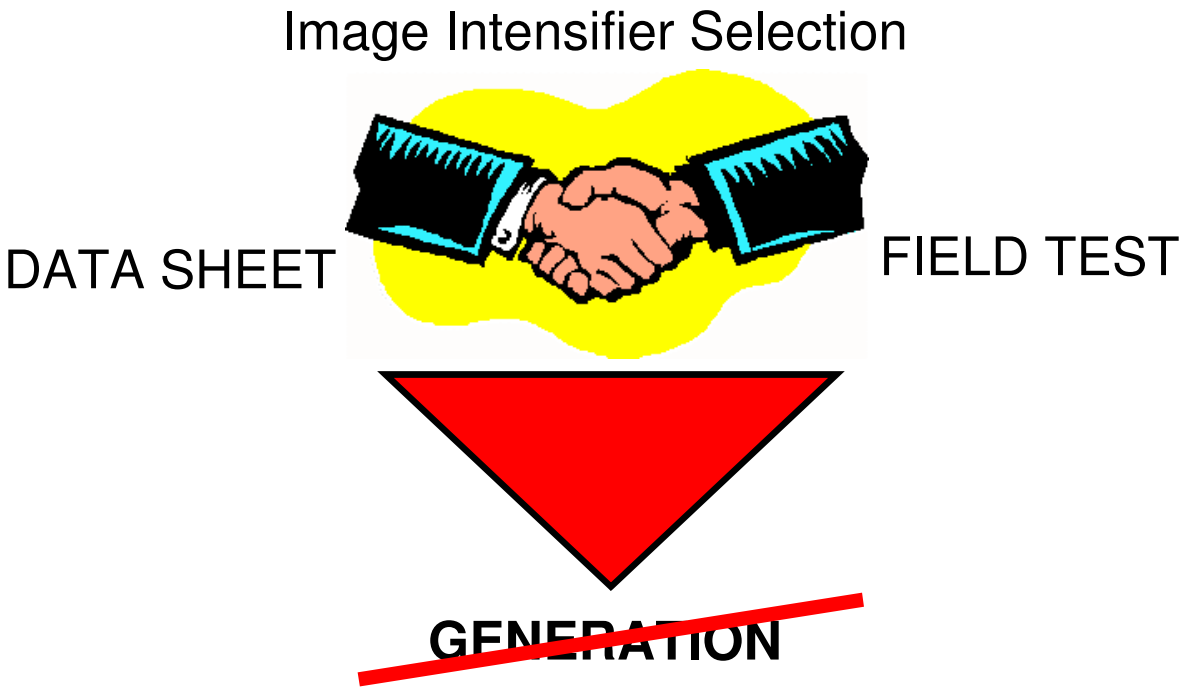
3.4 ***OPTION C**: DATA SHEET*

Image intensifiers have many variables. Specifications as many as 40 pages combined into a document. This paragraph will explain about the most important data of an image intensifier that assesses the image quality of an image intensifier.

For the assessment of an image intensifier tube it is essential to differentiate between low light level regime and the high light level regime. In the low light level regime the best performance indicator is the **signal-to-noise ratio** (**S/N**).

In high light level regimes the **limiting resolution** is a useful parameter, but the **MTF** is more objective and is a more valuable tool to predict image quality.

3.5 SUMMARY



Forget about the generations.

It is marketing and is does not tell you anything about the performance of image intensifiers. Because of production spread one cannot solely rely on field performance test. Also data sheets are not directly comparable so should not be used stand-alone.

To asses the image quality from field testing of tubes with very well known and described performance, relate field performance to data sheet performance and established correction factors for the different manufactures data sheets.

Image Intensifier families

Technology family

- Generation II
- Generation III
- Generation IV?

How is it made?
(Who cares?)

Performance family

- SHD-3™
- XD-4™
- XR5™

How does it perform?
(User benefits!)

DEP has introduced the performance family. Differences between SHD-3™, XD-4™ and XR5™ are defined in terms of performance. Also at DEP performance steps are driven by innovation. The different approach and the different technology results that DEP's innovations do not fit in the US Generation definitions.

An image intensifier is a member of the performance family based on its performance and not on the manufacturing technology used. In other words: if an individual GEN III tube (GaAs cathode, no film) has a lousy performance (remember the production spread), it's still a GEN III tube.

If an individual tube manufactured with all the latest technology used for XR5™ has not the required performance, it will **not** be an XR5™ but a lower grade - NOW we are talking performance !.

DEP

PRODUCT LINE:

IMAGE INTENSIFIERS

4 XR5™ Image Intensifiers

As a result of sustained and continuing product development, DEP is proud to introduce the latest, innovative XR5™ Image Intensifier with unprecedented performance for any environment and any circumstance.

The XR5™ Image Intensifier, successor to the well-known and successful XD-4™ Image Intensifier, reveals even more details of the night and offers an eXtended Range (XR) capability thanks to its new technology.

Furthermore, the XR5™ Image Intensifier enables the user to see even more during a full 24-hour day/night operation. This is done by the use of a fully integrated Auto-Gating unit, which controls the image not only during day-night-day transitions but also during dynamic lighting conditions such as those experienced, for example, in night operations in urban areas. In practice, this means no blooming to hinder your mission but dependable imagery throughout. In addition, the halo is the smallest on the market.

The XR5™ Image Intensifier from DEP represents the new European standard for Night Vision and is available in a variety of inverting and non-inverting 18 mm formats.

The new XR5™ is your best choice to maintain your combat effectiveness under all circumstances.

4.1 TECHNICAL SPECIFICATIONS: XR5™

Resolution	Minimal	Typical	Maximal	UNIT
Limiting resolution	64	70		lp/mm
Modulation Transfer Function:				
2.5 lp/mm		93		%
7.5 lp/mm		82		%
15 lp/mm		67		%
25 lp/mm		46		%
30 lp/mm		35		%

Signal to Noise	Minimal	Typical	Maximal	UNIT
Signal to noise (@108µlx)	25	28		

Luminance dynamic range	Minimal	Typical	Maximal	UNIT
Auto-Gating and Automatic Brightness Control	1.0E-06		5.0E+04	lux

Other Technical Data	Minimal	Typical	Maximal	UNIT
Phosphor: P20*				
Operational Lifetime	15.000			hrs
Gain at 2E-05 lux	30.000/π		50.000/π	cd/m2/lx
Max. Output Brightness	2		17	cd/m2
E.B.I.			0.25	µlx
Luminous sensitivity at 2850K	700	800		µA/lm
Radiant sensitivity at 800nm	65	78		mA/W
Radiant sensitivity at 850nm	50	65		mA/W
Input voltage	2		3.7	Volt
Input current			35	mA
Output uniformity at 2850K		1.8:1	3:01	
Weight (18mm)		80	95	grams
Shock	500			g

* also available in P43 phosphor

5 XD-4™ Image Intensifiers

The XD-4™ is the top grade of the DEP Image Intensifiers. With the introduction of the XD-4™ technology a new European Standard for low light imaging was born providing an unprecedented performance in Night Vision applications.

The XD-4™ Image Intensifiers perform extremely well in all environmental conditions. Its wide spectral sensitivity range makes that a perfect picture is obtained no matter in which area the user is (foliage, on water, snow, desert, rocky and barren land) and what the light conditions are (down to heavily overcast starlight).

The XD-4™ Image Intensifiers provide as well a superb image under very dynamic light conditions.

The base for the unique performance of the XD-4™ is the used technology by DEP. This has resulted in greatly improved performance parameters that are crucial for good observation, such as the Signal-to-Noise Ratio (SNR), the Modulation Transfer Function (MTF) and Resolution under all circumstances. Add to this the very long lifetime throughout its complete luminance dynamic range and you will be convinced of its unique performance.

The performance parameters of the XD-4™ Image Intensifier are listed in the table below. Highlights of the XD-4™ specification are the typical SNR of 24, the resolution of 64 lp/mm and over and - very important - the high MTF at low and intermediate spatial frequencies. The latter gives the image its sharpness and contrast.

It goes without saying that the XD-4™ tubes can be supplied in every common mechanical construction including inverting and non-inverting fibre-optic output, which also means that users have the opportunity to upgrade the performance of existing Night Vision Equipment via a drop-in XD-4™ Image Intensifier.

5.1 TECHNICAL SPECIFICATIONS: XD-4™

Resolution		Minimal	Typical	Maximal	UNIT
Limiting resolution					
	Type I	55	58		lp/mm
	Type II	60	64		lp/mm
Modulation Transfer Function:					
2.5 lp/mm			92		%
7.5 lp/mm			80		%
15 lp/mm			58		%
25 lp/mm			38		%
30 lp/mm			30		%

Signal to Noise	Minimal	Typical	Maximal	UNIT
Signal to noise (@108µlx)	20	24		

Other Technical Data	Minimal	Typical	Maximal	UNIT
Phosphor: P20*				
MTTF (to S/N=12)	15.000			hrs
Gain at 2.10-5 lx	30.000/π		50.000/π	cd/m2/lx
Max. Output Brightness	2		17	cd/m2
E.B.I.		0.15	0.25	µlx
Output uniformity at 2850K		2:01	3:01	
Weight(18mm)		80	95	grams
Shock	500			g
Luminous sensitivity at 2850K	600	700		µA/lm
Radiant sensitivity at 800nm	50	60		mA/W
Radiant sensitivity at 850nm	40	50		mA/W

* also available in P43 phosphor

6 SHD-3™ Image Intensifiers

The SHD-3™ type of Image Intensifier is an upgrade of the well-known DEP Super Generation tube. The SHD-3™ technology combines the very good sensitivity of the Super Generation Image Intensifier with superior resolution and MTF (see table on the next page below).

These improvements produce a much higher contrast in the image. Like for the XD-4™ tube, other strong points of the SHD-3™ Image Intensifier are that it is sensitive in a wide spectral band thus providing good contrast in all scene circumstances and that no burning occurs until quite bright light levels are experienced.

The SHD-3™ Image Intensifier is characterised by a guaranteed Signal-to-Noise Ratio (SNR) of 18 at 108 µlx and a guaranteed limiting resolution of 45 lp/mm. Of course also here it applies that the SHD-3™ tube can be supplied in almost every mechanical construction which makes it compatible with both old and new night vision devices.

6.1 TECHNICAL SPECIFICATIONS: SHD-3™

Resolution		Minimal	Typical	Maximal	UNIT
Limiting resolution					
	Type I	45	48		lp/mm
	Type II	50	54		lp/mm
Modulation Transfer Function:					
2.5 lp/mm		86	88		%
7.5 lp/mm		66	70		%
15 lp/mm		44	50		%
25 lp/mm		22	30		%
30 lp/mm		18	22		%

Signal to Noise	Minimal	Typical	Maximal	UNIT
Signal to noise (@108µlx)	18	20		

Other Technical Data	Minimal	Typical	Maximal	UNIT
Phosphor: P20*				
MTTF (to S/N=12)	10.000			hrs
Gain at 2.10-5 lx	30.000/π		50.000/π	cd/m2/lx
Max. Output Brightness	2		17	cd/m2
E.B.I.		0.15	0.25	µlx
Output uniformity at 2850K		2:01	3:01	
Weight(18mm)		80	95	grams
Shock	500			g
Luminous sensitivity at 2850K	500	600		µA/lm
Radiant sensitivity at 800nm	43	55		mA/W
Radiant sensitivity at 850nm	33	45		mA/W

* also available in P43 phosphor

DEP

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DEP

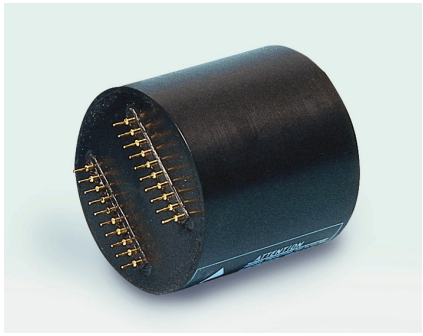
PRODUCT LINE:

INDUSTRIAL, ANALYTICAL and SCIENTIFIC applications

7 Intensified CCD (ICCD)

7.1 INTRODUCTION

CCD is an abbreviation for Charge-Coupled Device. A CCD is a pixelised silicon light sensor that converts light into charge within the pixels and transfers the charge packages sequentially to an amplifier reading out the charge packages occurs with camera electronics. CCDs are commonly used as image sensors in professional and consumer television cameras and camcorders, and as image sensors in digital still cameras.



ICCDs are Image Intensifiers coupled to a CCD by means of either relay lens or fibre optics. DEP uses highly efficient fibre optic coupling because of its excellent performance. A compatible camera system should be used to readout the image. An ICCD camera consisting of an ICCD connected to monochrome camera electronics produces a monochrome composite video signal that can be viewed on a monitor. The compact ICCD package makes sure that low light level cameras are lightweight and compact. This can be a vital detail in surveillance and security situations.

ICCD cameras are of great help in guarding territories or properties where artificial lighting is not allowed or not available. Other applications include police surveillance, licence plate registration, highway patrol and the recording of wildlife movies. A fast shutter option can be supplied, when ICCDs have to operate in strongly varying light conditions e.g. during day and night.

The flexibility in image intensifier design opens possibilities for different applications like forensic criminal investigation and fire alarm systems. The fire alarm systems are able to

operate in full daylight because of the image intensifiers solar-blind photocathode technology called SB-200™.

7.1.1 DESCRIPTION OF BASIC ICCD

For proper imaging at light-levels down to heavily overcast starlight conditions DEP XD-4™ type of Image Intensifiers can be used. The compact XX1700 ICCD consists of a double proximity focused XD-4™ Technology image intensifier directly coupled to a CCD via a fibre-optic minifier. The demagnification is adapted to the format of the CCD used.

Two basic types exist:

- A tube de-magnifying from 18 to 11 mm matching to a 2/3 – inch format CCD
- A tube with a demagnification from 18 to 8 mm for matching to a 1/2 – inch CCD.

The designs are very flexible, which means that any CCD of the right format can be coupled to the respective Image Intensifiers.

7.2 PERFORMANCE CHARACTERISTICS OF THE BASIC ICCD

The performance of the ICCD's is expressed in terms of MTF and resolution, signal-to-noise ratio and lifetime.

7.2.1 MTF AND RESOLUTION

A way to determine the sensitivity of sensors is to measure the resolution behaviour as a function of light level. The resolution at high light-levels is determined by the MTF contributions of the individual tube components. The resolution plateau lowers when the number of intensification stages increases.

At lower light-levels image details become obscured by noise which means that now the signal-to-noise ratio is the important factor for the resolving power. Both higher photocathode sensitivity and higher gain lead to a higher resolution in this light-level range.

7.2.2 SIGNAL-TO-NOISE RATIO

Another method of measuring the performance of image forming systems is based on signal-to-noise ratio (S/N).

Noise in ICCD has three distinct origins:

1. dark noise of the image intensifier and CCD
2. photon noise which depends on the illumination level detector performance
3. structural noise due to unwanted light modulation

Background noise gives rise to a 10 dB dependence for the S/N as a function of input illumination, photon noise has a 5 dB dependence, whereas for structural noise S/N = constant. A higher gain gives an improved S/N in the photon counting limit. The much higher photocathode sensitivity of a XD-4^{TM} Technology image intensifier leads to a markedly improved S/N.

7.2.3 LIFETIME

The expected lifetime for Super Generation, SHD-3^{TM} and XD-4^{TM} tubes lies – at room temperature – in the range of 15000 hours. The expected lifetime is here defined as the time after which still 50% of the original sensitivity is left. The lifetime specification is valid throughout the luminance dynamic range provided that at high light levels the automatic brightness control is active.

7.3 INTEGRATED SYSTEMS

For enabling observation during night-time, Black and White CCD Cameras are being connected to image intensifiers, either by lens coupling or fibre-optic coupling. De-magnifying Generation 2, Super Generation, SHD-3™ and the highly sensitive XD-4™ image intensifiers are available for this purpose. For imaging under very low light-level conditions, Super Generation, SHD-3™ or XD-4™ types should be used.

The gating option offers the possibility to use the ICCD camera as well under daylight circumstances. Auto-gating ICCD's based on the XR5™ Image Intensifiers of DEP deliver a perfect image 24 hours a day without need for an external gain management system.

Delft Electronic Products BV couples any type of commercial available 1/2-inch and 2/3-inch format or larger CCD to their state-of-the-art 18mm image intensifiers. 1/3-inch format CCD's are an option as well.

The type of CCD and camera to be used depends on the specific application of the customer. After the application has been defined it should be determined what requirements of the relevant performance parameters are. With this information and the application an ICCD will be defined according to the specification.

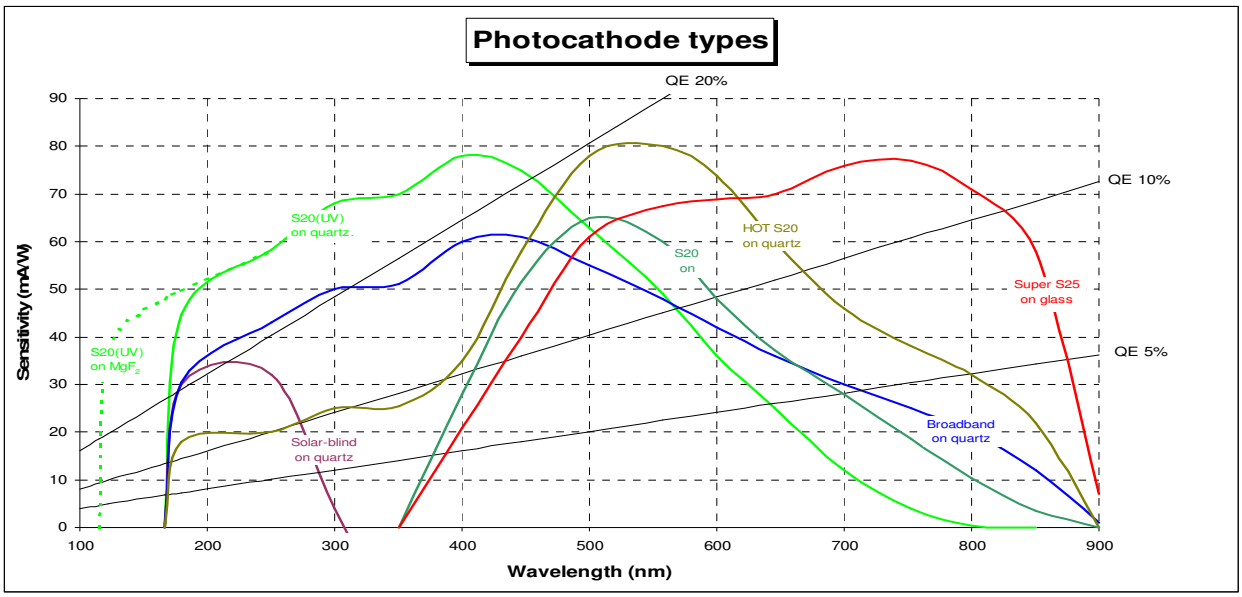
7.4 INTENSIFIED CCD'S, MODEL XX1700

Description:

The **XX1700 Intensified CCD (ICCD)** consists of a DEP 18 mm format Image Intensifier fibre-optically coupled to commercially available CCD's. The fibre-optic coupling is done in house. The flexible design enables a perfect match to the application with respect to the type of DEP Image Intensifier used, the type of CCD used (amongst others ½-inch and 2/3-inch format) and the installation of extra features like, e.g., gating.

Applications:

- Surveillance
- Industrial Instrumentation
- Analytical Instrumentation
- Scientific Research



7.4.1 AVAILABLE OPTIONS FOR ICCD

- A variety of different photocathodes matched to a wide range of applications, i.e. Super-S25, XD-4™, S20(UV), hot S20, broad band and Solar Blind
- Different types of phosphor, determined by the application: P20, P43, P46, P47
- Gating, from slow to ultra-fast (subnanosecond range)
- Various options for the integrated power-supply
- High gain dual MCP Image Intensifiers
- Flexibility in CCD-type
- ICMOS device

8 Special Image Intensifiers, Special ICCD's and Special ICMOS

8.1 INTRODUCTION

DEP serves the communities of Analytical Instrumentation, Industrial Instrumentation, Scientific Research and Surveillance with a wide range of special custom made Image Intensifiers, Intensified CCD's and ICMOS devices, Photon Counters and Low Light-Level Detectors.

8.2 TYPES OF IMAGE INTENSIFIER COMPONENT OPTIONS

- Format: 18 mm, 25 mm or 40 mm useful diagonal
- Input window: Quartz, Glass, Fibre-optic and MgF_2
- Type of photocathode: S20 and S20UV, broadband, S25 and Super-S25, hot S20
- Types of phosphor: P20, P43, P46 and P47
- Output window: fibre-optic or Glass
- Gating: slow gating (faster than 100 ns), fast gating (faster than 5 ns) and ultra fast gating (faster than 300 picoseconds)
- Integrated or separate power-supply depending on the exact type, equipped with External Gain Control (EGAC) and either with or without Automatic Brightness Control (ABC)
- Option: chevron MCP-stack, either 40/40 or 40/80 (dual MCP tube).

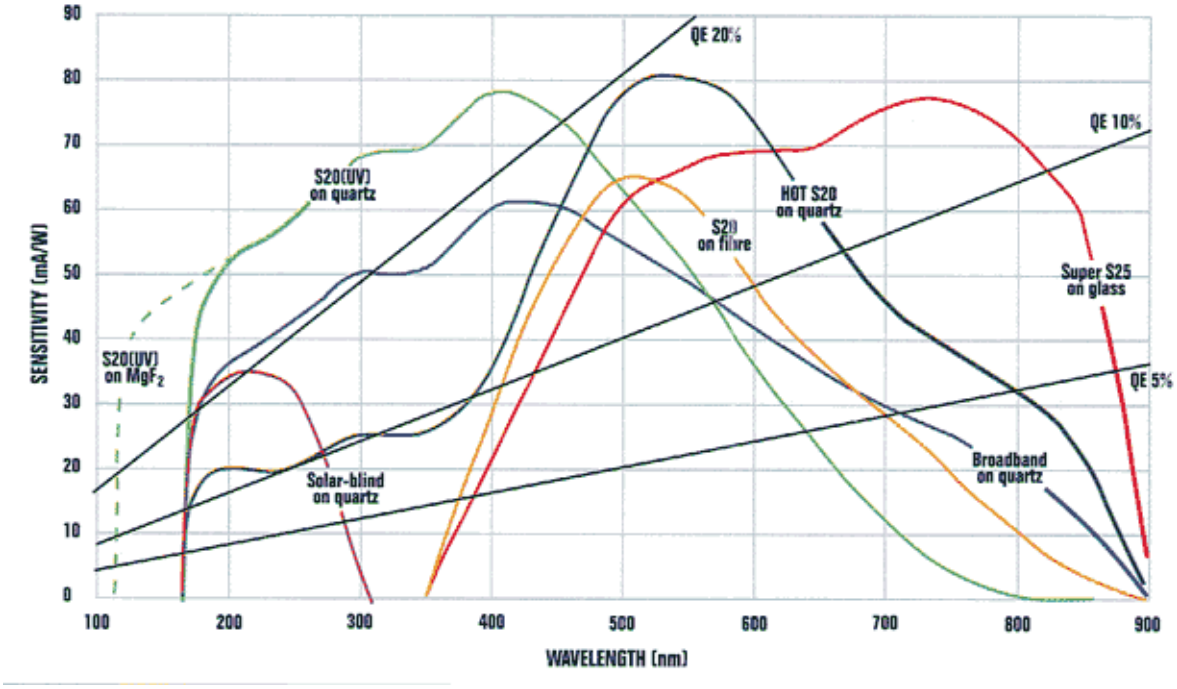


Figure 10. Photocathode types

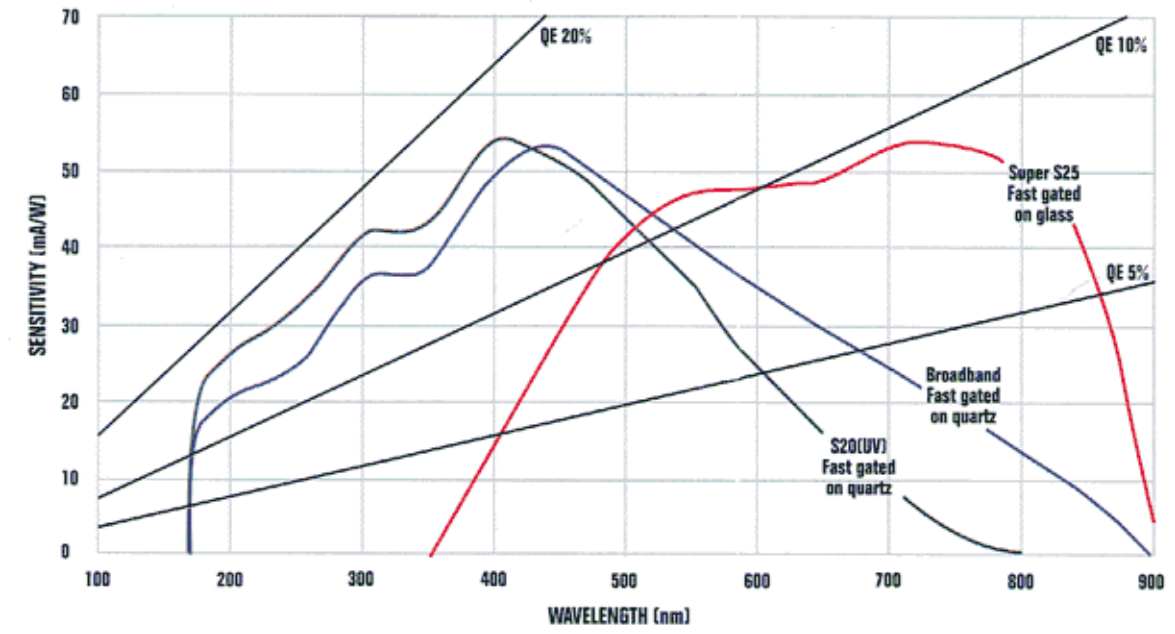


Figure 11. Photocathode types (fast gated)

Common Phosphor types:

Phosphor type	Efficiency (photons/e^-/effective kV)	Decay time down to 1 %
P20	35	220 ms
P43	18	3 ms
P46*	6	2 µs
P47*	6	0.4 µs

*) the decay time for these phosphors is measured at 1 µs exposure time.

8.3 GATED TUBES

Fluorescence is the phenomenon that a specimen emits a weak light signal after it is excited by a light source. Besides amplification to observable levels fluorescence detection requires the presence of a fast optical shutter to block the effect of the excitation light. The ease with which the MCP-based Image Intensifiers of DEP can be gated makes them ideal candidates for fluorescence imaging and fluorescence spectroscopy.

The MCP-based Image Intensifiers of DEP can be gated down to the nanosecond range and beyond because of:

- an excellent shutter ratio in the range of 1.0E09 through which contrast is well maintained down to the minimum gate time.
- A short Iris Delay lying in the subnanosecond range if there is a metallic underlay underneath the photocathode. The Iris Delay is the time difference in opening of the photocathode between the edge and the centre of the tube.
- A big advantage of the DEP Image Intensifiers is that gating can be done with voltage pulses across the front gap of 240 Volt only. How fast a particular tube can be gated in practice is determined by its Iris Delay. With respect to the gate speed the DEP tubes can be divided into 3 categories:
- Slow gate-able tubes: these tubes without underlay gate faster than 100 ns (18 mm and 25 mm tubes) or 300 ns (40 mm format tubes). DEP produces compatible Gate Units, model number PP0100U.
- Fast gate-able tubes: these tubes with underlay gate faster than 5 ns
- Ultra fast gate-able tubes: these tubes with a special construction gate faster than 300 picoseconds.

9 Photon Counters

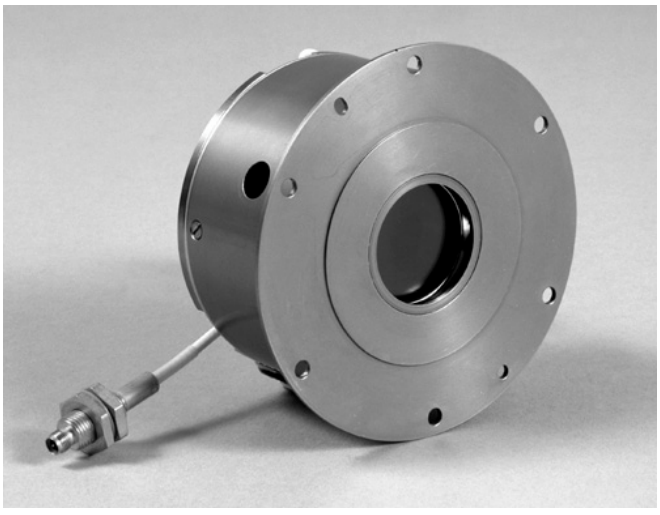
9.1.1 INTRODUCTION

Photon Counters can detect each photoelectron almost without any noise.

This can be realised by a few different techniques. The important ones are:

- MCP (Micro Channel Plate) detectors with resistive read-out. This is an Imaging Photon detector (IPD).
- MCP detectors with Phosphor/CCD readout. This is an Imaging Photon Detector as well.
- Hybrid Photo Diode (HPD). The HPD is produced in single-pixel and multi-pixel versions up to 163 - pixels.

DEP produces all these types.



MCP detector

Multi Pixel HPMT

9.1.2 MCP PHOTON COUNTERS

Micro Channel Plates (MCP) are often used in image intensifiers to amplify the signal.

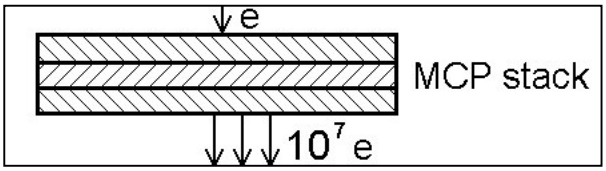


Figure 12. MCP amplification

The photon counter version has a stack of two MCP's which is operated in the saturation mode. This mode has a very high MCP gain and a peaked Pulse Height Distribution (PHD). The quality of the PHD is characterised by:

- High gain: G
- Small gain spread: ΔG
- The depth of the valley

In figure 13 these numbers are visualised. A high quality MCP photon Counter has a low ΔG/G and a low valley.

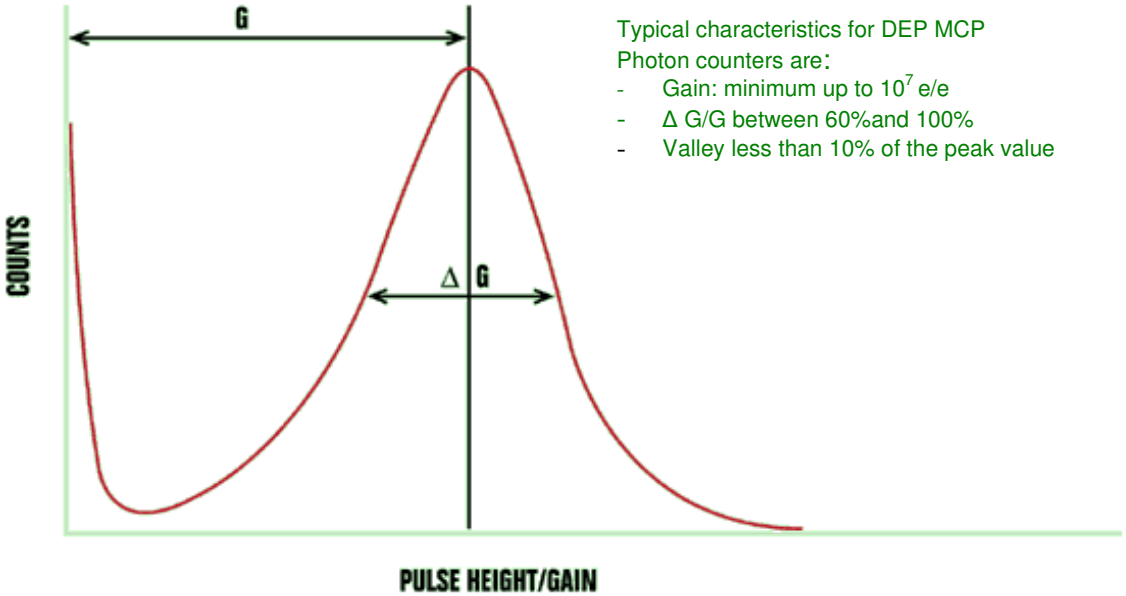


Figure 13. Saturated Pulse Height Distribution for MCP photon counters

Typical characteristics for DEP MCP photon counters:

- Gain: minimum up to 10^7 e/e.
- $\Delta G/G$ between 60% and 100%
- Valley less then 10% of the peak value

A photon counter is able to record each event. Each event will then be judged by the electronics: low gain events will be rejected. The low gain tail of the PHD is noise. The peaked part represents the real events. By putting the discrimination level in the valley, the optimal setting for a photon counter is achieved. A low valley characterises a high quality photon counter.

9.1.3 MCP PHOTON COUNTER WITH CCD READ-OUT

After the MCP amplification step, the information has to be read out. A conventional way to do this is by first converting the electron-image to a visible image with the aid of a phosphor screen. A CCD + camera can then read the image. Usually a de-magnifying fibre optic taper is used to match the input diameter of the image intensifier to the CCD format.

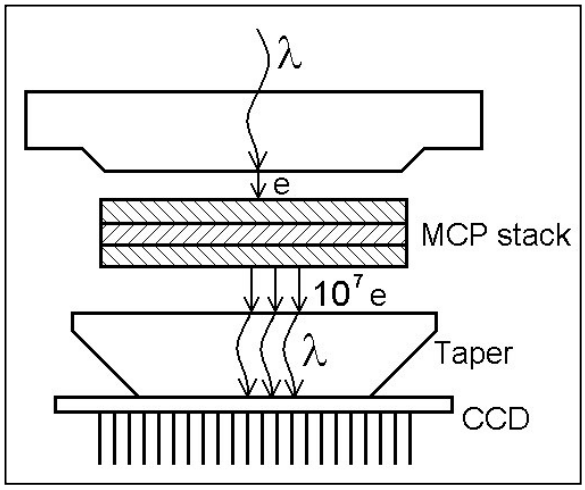


Figure 14. MCP amplifier with CCD read-out

The timing limitation of the CCD solution is set by the frame rate. The minimum frame is ~ 10 milliseconds. So the maximum rate is about 100 Hertz.

9.1.4 MCP PHOTON COUNTER WITH RESISTIVE ANODE READ-OUT

Another way of recording of the signal is to use conductive or resistive read-out plates. The latter is the most popular one.

The signal is read as follows:

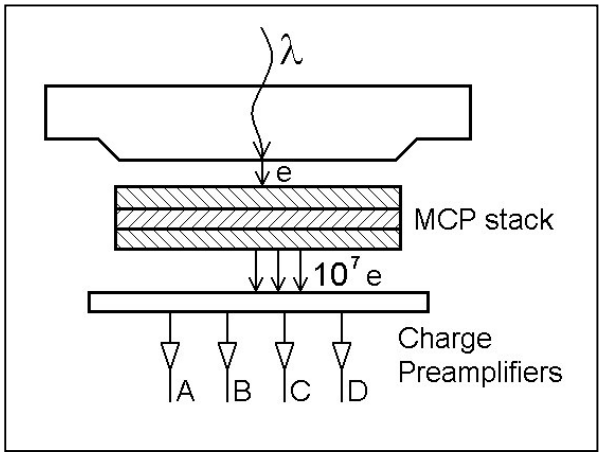


Figure 15. Resistive anode intensifier

An amplified event is collected on the anode plate. The charge spreads out to the contacts A, B, C and D. With the aid of charge preamplifiers the signals can be measured.

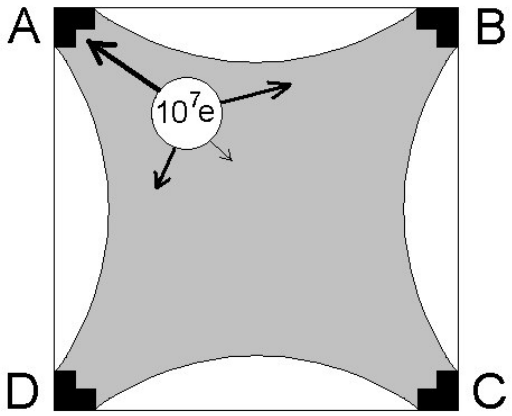


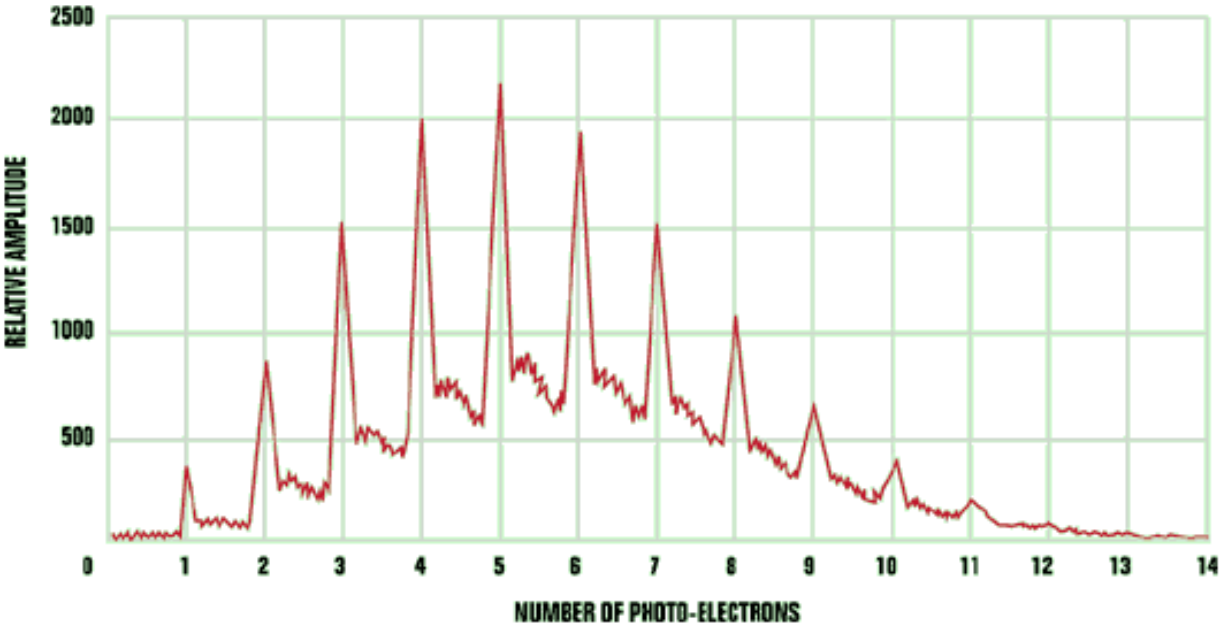
Figure 16. Resistive anode plate

The contact that is closest to the event will record the highest current.

The shape of the anode plate is such that the following algorithm will help to easily determine the centre of the event:

$$X = \frac{(A+B)-(C+D)}{A+B+C+D} \qquad Y = \frac{(B+C)-(A+D)}{A+B+C+D}$$

The resistive anode intensifier is very fast. The preamplifiers set much of the speed limit. Inside the intensifier the event has duration in the range of nanoseconds.



9.1.5 HYBRID PHOTO DIODE (HPD)

The Hybrid Photo-Diode (HPD) consists of a PIN diode integrated in a vacuum tube. Like for Image Intensifiers, the HPD is equipped with a photocathode in which the photons are converted into photoelectrons. After acceleration the photoelectrons bombard the diode and secondary electrons are created inside the diode. By using proper preamp's a measurable signal is obtained. Both single pixel and multi-pixel devices are available. The HPD is an example of a Photon Counter.

One diode/single pixel Multi Pixel HPD

Figure 17. Pulse Height Distribution of an HPD

DEP

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10 Specification and mechanical characteristics

Use this summary as a quick reference to select the image intensifier required. You will find details on the selected tube in the performance sheet hereafter.

COMMON NIGHT VISION IMAGE INTENSIFIERS

DEP TYPE identifier	Performance	Typical Resolution	Typical S/N	Input Window	Output Inverting	Compatible with
XX2540B	XR5™	70	28	Glass	Yes	Aviator Golden Bullet like 10160
XX2540D	XR5™	70	28	Glass	Yes	MX-10160, F9800, small ANVIS
XX2550F	XR5™	70	28	Glass	No	MX-10130, F9810, PVS-7 Uni.
XX2040CX	XD-4™	64	24	Glass	Yes	Aviator Golden Bullet like 10160
XX2040AU	XD-4™	64	24	Glass	Yes	MX-10160, F9800, small ANVIS
XX2040AR	XD-4™	64	22	Glass	Yes	MX-10160, F9800, small ANVIS
XX2050BL	XD-4™	64	24	Glass	No	MX-10130, F9810, PVS-7 Uni.
XX2040AN	XD-4™	64	22	Glass	Yes	M-868, fat ANVIS, flying leads
XX2040C	XD-4™	58	24	Glass	Yes	MX-10160, F9800, small ANVIS
XX2050R	XD-4™	58	24	Glass	No	MX-10130, F9810, PVS-7 Uni.
XX1940AM	SHD-3™	48	20	Glass	Yes	MX-10160, F9800, small ANVIS
XX1950DK	SHD-3™	48	21	Glass	No	MX-10130, F9810, PVS-7 Uni.

COMMON Industrial, Analytical and Scientific IMAGE INTENSIFIERS

DEP TYPE identifier	Performance	Typical Resolution	Typical S/N	Input Window	Output Inverting	Compatible with
XX1700DN	XD-4™	60	22	Glass	-	-
PP0340AT	Gen II	34	-	Quartz	No	-
PP0400G	Gen II	30	-	Fiber	No	-
XX1440ES	Gen II	40	-	Quartz	Yes	-
XX1450KT	Gen II	45	-	Quartz	No	-
XX1450XK	Gen II	45	-	Quartz	No	-
XX1450TJ	Gen II	48	-	Fiber	No	-
XX2050AH	XD-4™	58	20	Glass	No	-
XX2050F	XD-4™	58	24	Glass	No	-

DEP

Image Intensifier Tubes

Performance Level : XR5™
DEP Tube Type : XX2540B

Format	: 18 mm
Tube Name	: Small ANVIS (Golden Bullet)
Compatible	: MX-10160, F9800
Applications	: to be used in Aviator Goggles.

General Tube information

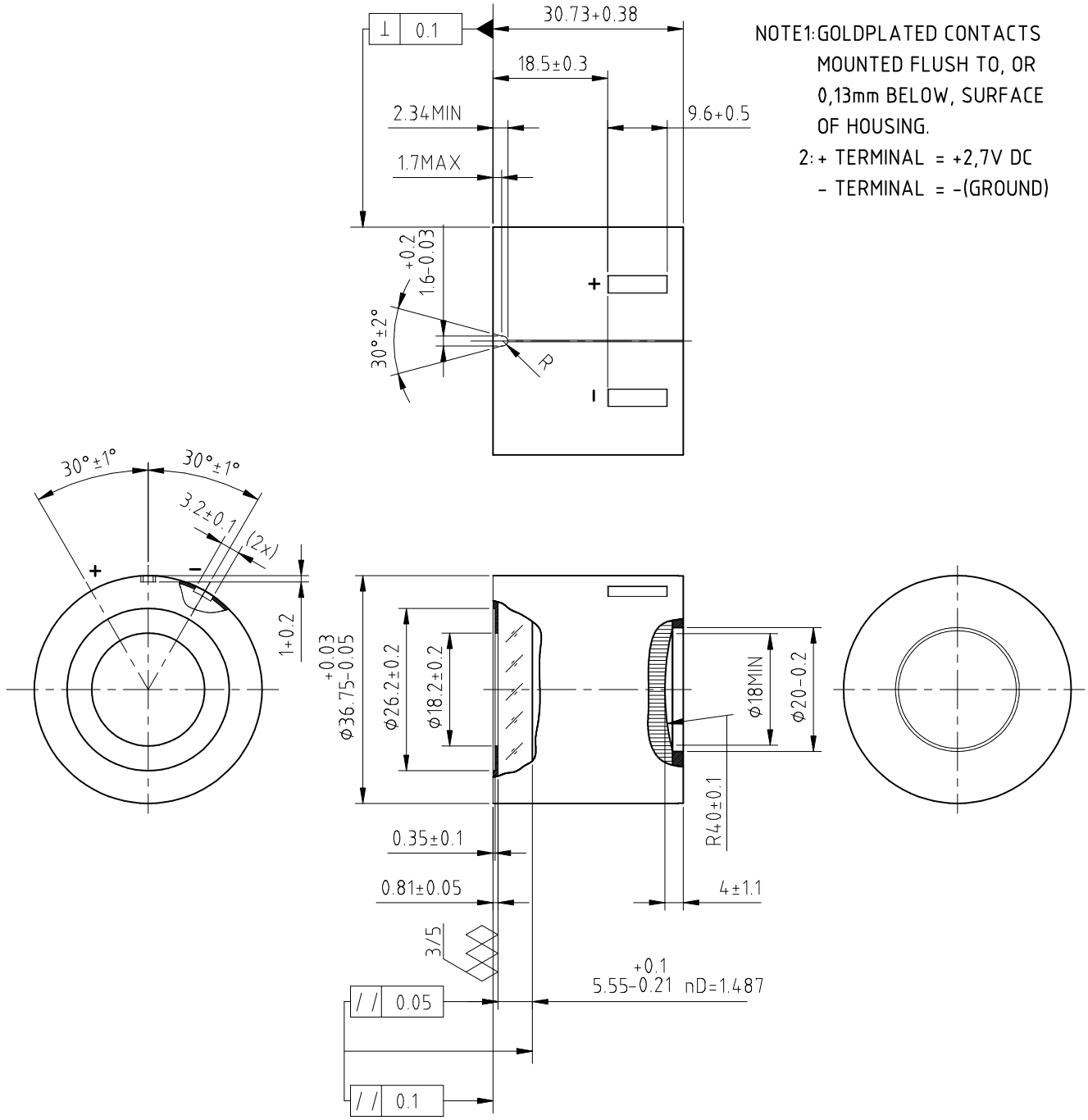
Input Window	Glass
Output Window	Inverting Fibre Optic
Magnification	1
Electrical controls	Automatic Brightness Control (ABC) Bright Source Protection (BSP) Auto-Gating
EMC	MIL-STD-461, MIL-STD-462
Electronic connections	gold plated contacts
Weight	80 grams
Useful Cathode Diameter	17.5 mm
Phosphor	P43

Tube Characteristics

		Typical	Min.	Max.	Unit
Optical	Limiting Resolution	70	64		lp/mm
	Modulation Transfer Function				
	2.5 lp/mm	93			%
	7.5 lp/mm	82			%
	15 lp/mm	67			%
	25 lp/mm	46			%
	30 lp/mm	35			%
	Signal to noise (@108 µlx)	26	23		
	Gain at $2x10^{-6}$ fc	45.000	30.000	50.000	fL/fc
	Life time	15.000			hrs
	Max. Output Brightness (MOB)	6	4	8	cd/m^2
	EBI	0.15		0.25	µlx
	Output Uniformity at 2850K	1.8:1		3:1	
	Luminous Sensitivity at 2850K	800			
	Radiant Sensitivity at 800 nm	78			mA/W
	850 nm	65			mA/W
	Shock resistance	700g			m/s^2
Electrical	Operating Voltage	2.7	2.0	3.7	V
	Input Current			35	mA
Environment	Operating temperature (8 hrs)		-45	+52	˚C
	Storage temperature (8 hrs)		-51	+65	˚C
	Luminance dynamic range		$1x10^{-6}$	$5x10^4$	lux

	new	cancelled		new	cancelled
A1	⌀20-0.2	⌀19-0.2	.		

VK



NOTE1: GOLDPLATED CONTACTS MOUNTED FLUSH TO, OR 0,13mm BELOW, SURFACE OF HOUSING.
2: + TERMINAL = +2,7V DC
- TERMINAL = -(GROUND)

DELFT ELECTRONIC PRODUCTS BV

ISO 128	screw thread ISO 965	finish ISO 1302	material:	drawn: JK	A0	13-12-00
A4 glass ISO 10110	geometr. tolerances ISO 1101	dimensions: mm	scale: 1 : 1		A1	25-10-01
				sheet: 1 of 1		
					183-0787A1	TV

IMAGE INTENSIFIER XX1440,XX1940,XX2040,XX2540

DEP

Image Intensifier Tubes

Performance Level : XR5™
DEP Tube Type : XX2540D

Format	: 18 mm
Tube Name	: Small ANVIS
Compatible	: MX-10160, F9800
Applications	: to be used in Goggles, Monoculars and other systems.

General Tube information

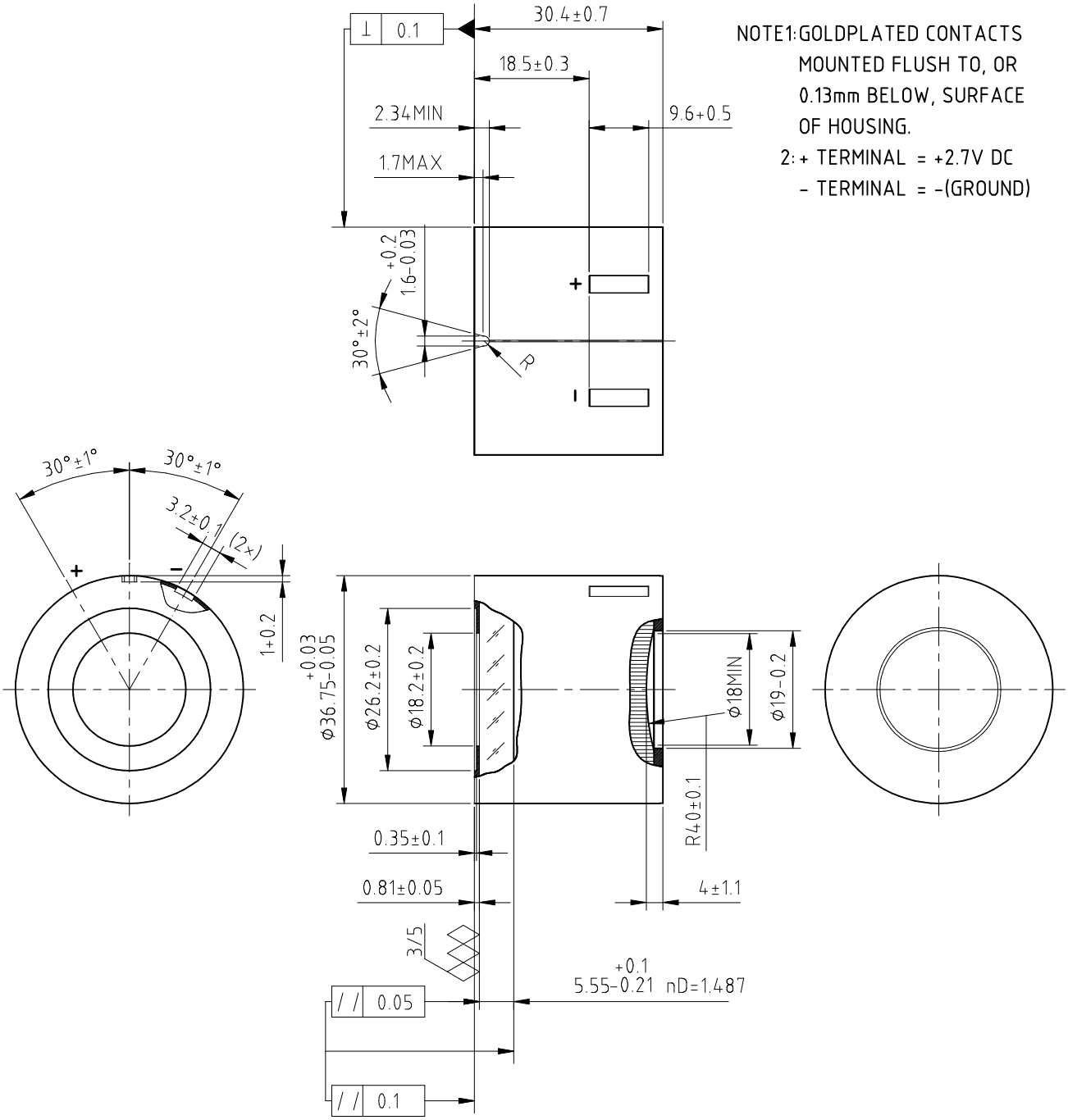
: Input Window	Glass
Output Window	Inverting Fibre Optic
Magnification	1
Electrical controls	Automatic Brightness Control (ABC)
	Bright Source Protection (BSP)
	Auto-Gating
EMC	proof
Electronic connections	gold plated contacts
Weight	80 grams
Useful Cathode Diameter	17.5 mm
Phosphor	P20

Tube Characteristics

		Typical	Min.	Max.	Unit
Optical	Limiting Resolution	70	64		lp/mm
	Modulation Transfer Function				
	2.5 lp/mm	93			%
	7.5 lp/mm	82			%
	15 lp/mm	67			%
	25 lp/mm	46			%
	30 lp/mm	35			%
	Signal to noise (@108 µlx)	28	25		
	Gain at $2x10^{-6}$ fc	45.000	30.000	50.000	fL/fc
	Life time	15.000			hrs
	Max. Output Brightness (MOB)	6	4	8	cd/m^2
	EBI	0.15		0.25	µlx
	Output Uniformity at 2850K	1.8:1		3:1	
	Luminous Sensitivity at 2850K	800			
	Radiant Sensitivity at 800 nm	78			mA/W
	850 nm	65			mA/W
	Shock resistance	700g			m/s^2
Electrical	Operating Voltage	2.7	2.0	3.7	V
	Input Current			35	mA
Environment	Operating temperature (8 hrs)		-45	+52	˚C
	Storage temperature (8 hrs)		-51	+65	˚C
	Luminance dynamic range		$1x10^{-6}$	$5x10^{4}$	lux

	new	cancelled		new	cancelled
A1	9,6+0,5; 0,8±0,05	9,5±0,05; 0,8±025	.		
A2	nD=1.487	nD=1.87			

VK



NOTE1: GOLDPLATED CONTACTS MOUNTED FLUSH TO, OR 0.13mm BELOW, SURFACE OF HOUSING.
2: + TERMINAL = +2.7V DC
- TERMINAL = -(GROUND)

DELFT ELECTRONIC PRODUCTS BV

ISO 128	screw thread ISO 965	finish ISO 1302	material:	drawn: JK	A0	3-11-92
A4 glass ISO 10110	geometr. tolerances ISO 1101	dimensions: mm	scale: 1 : 1		A1	6-10-93
					A2	16-9-98
				sheet: 1 of 1		

IMAGE INTENSIFIER XX1440,XX1940,XX2040,XX2540

183-0124A2 TV

DEP

Image Intensifier Tubes

Performance Level : XR5™
DEP Tube Type : XX2550F

Format	: 18 mm
Tube Name	: PVS-7 Universal
Compatible	: MX-10130, F9810
Applications	: to be used in PVS-7A/B/D Night Vision Goggles, and other systems.

General Tube information

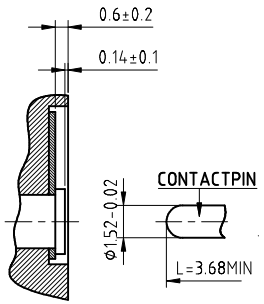
: Input Window	Glass
Output Window	Non-Inverting Fibre Optic
Magnification	1
Electrical controls	Automatic Brightness Control (ABC) Bright Source Protection (BSP) Auto-Gating
EMC	proof
Electronic connections	contacts
Weight	98 grams
Useful Cathode Diameter	17.5 mm
Phosphor	P20

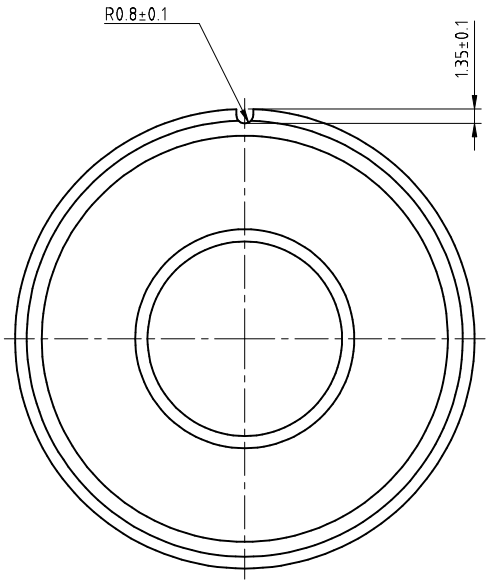
Tube Characteristics

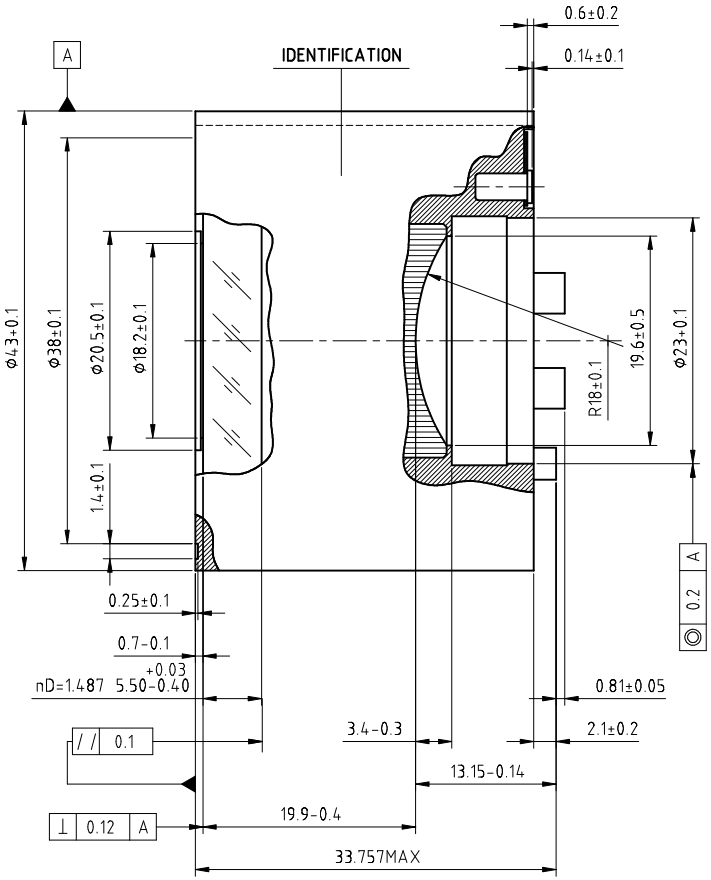
		Typical	Min.	Max.	Unit
Optical	Limiting Resolution	70	64		lp/mm
	Modulation Transfer Function				
	2.5 lp/mm	93			%
	7.5 lp/mm	82			%
	15 lp/mm	67			%
	25 lp/mm	46			%
	30 lp/mm	35			%
	Signal to noise (@108 µlx)	28	25		
	Gain at $2x10^{-6}$ fc	45.000	30.000	50.000	fL/fc
	Life time	15.000			hrs
	Max. Output Brightness (MOB)	6	4	8	cd/m^2
	EBI	0.15		0.25	µlx
	Output Uniformity at 2850K	1.8:1		3:1	
	Luminous Sensitivity at 2850K	800			
	Radiant Sensitivity at 800 nm	78			mA/W
	850 nm	65			mA/W
	Shock resistance	700g			m/s^2
Electrical	Operating Voltage	2.7	2.0	3.7	V
	Input Current			35	mA
Environment	Operating temperature (8 hrs)		-45	+52	˚C
	Storage temperature (8 hrs)		-51	+65	˚C
	Luminance dynamic range		$1x10^{-6}$	$5x10^{4}$	lux

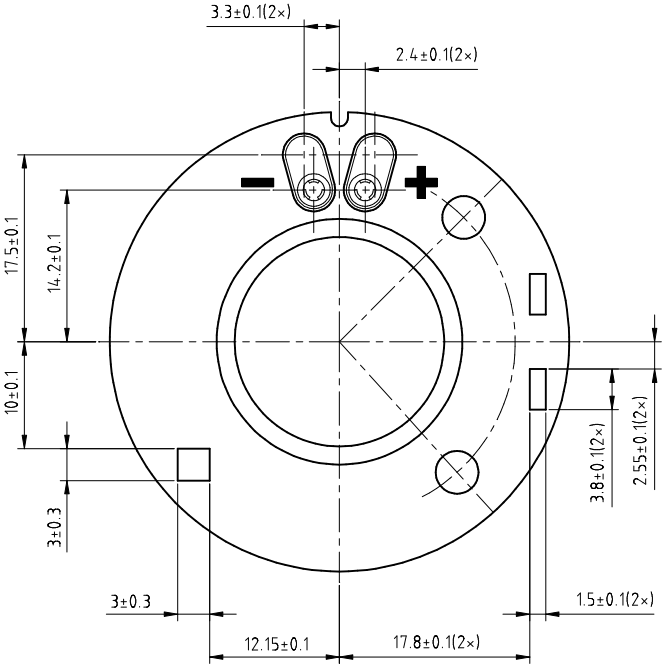
NOTE 1: REFERENCE CIRCLE [A] IS THE CYLINDER WITH THE SMALLEST DIAMETER THAT FITS AROUND THE PLASTIC HOUSING
2: + CONTACT = +2.7V DC
- CONTACT = -(GROUND)
3: CONTACTPIN DIAMETER 1.5mm

	new	cancelled		new	cancelled
A1	⌀20.5±0.1; $5.50^{+0.03}_{-0.40}$	⌀20.3±0.1; $5.55^{+0.03}_{-0.05}$; 30°	.		









VK

DEP DELFT ELECTRONIC PRODUCTS BV	ISO 128	screw thread ISO 965	finish ISO 1302	material:	drawn: JK	A0	2-8-00
	A3	glass ISO 10110	vorm- en plaatstol. ISO 1101	maateenheid: mm	scale:	A1	9-4-01
IMAGE INTENSIFIER XX1950,XX2050,XX2550					sheet: 1 of 1		
					183-0769A1		TA

DEP

Image Intensifier Tubes

Performance Level : XD-4™
DEP Tube Type : XX2040CX

Format	: 18 mm
Tube Name	: Small ANVIS (Golden Bullet)
Compatible	: MX-10160, F9800
Applications	: to be used in Aviator Goggles.

General Tube information

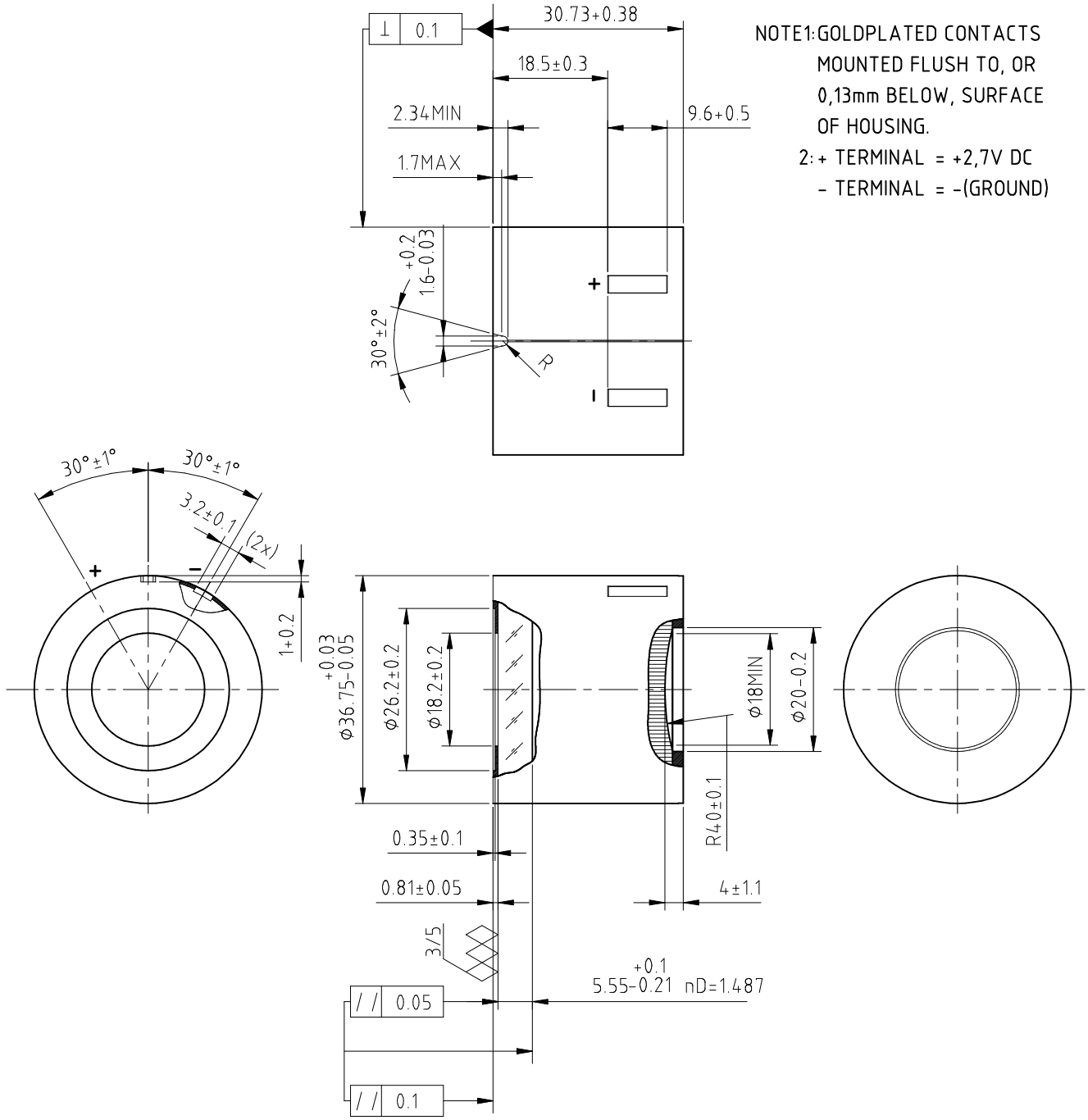
Input Window	Glass
Output Window	Inverting Fibre Optic
Magnification	1
Electrical controls	Automatic Brightness Control (ABC) Bright Source Protection (BSP)
EMC	MIL-STD-461, MIL-STD-462
Electronic connections	gold plated contacts
Weight	80 grams
Useful Cathode Diameter	17.5 mm
Phosphor	P43

Tube Characteristics

		Typical	Min.	Max.	Unit
Optical	Limiting Resolution	64	60		lp/mm
	Modulation Transfer Function				
	2.5 lp/mm	92	88		%
	7.5 lp/mm	80	72		%
	15 lp/mm	64	54		%
	25 lp/mm	45	40		%
	30 lp/mm	35	30		%
	Signal to noise (@108 µlx)	24	20		
	Gain at $2x10^{-6}$ fc	32.000	28.000	38.000	fL/fc
	Life time		10.000		hrs
	Max. Output Brightness (MOB)	6	4	8	cd/m^2
	EBI	0.15		0.25	µlx
	Output Uniformity at 2850K	2:1		3:1	
	Luminous Sensitivity at 2850K	700	600		
	Radiant Sensitivity at 800 nm	60	50		mA/W
	850 nm	50	40		mA/W
	Shock resistance	700g	500g		m/s^2
Electrical	Operating Voltage	2.7	2.0	3.7	V
	Input Current	22	16	26	mA
Environment	Operating temperature		-45	+52	˚C
	Storage temperature		-52	+65	˚C

	new	cancelled		new	cancelled
A1	⌀20-0.2	⌀19-0.2	.		

VK



NOTE1: GOLDPLATED CONTACTS MOUNTED FLUSH TO, OR 0,13mm BELOW, SURFACE OF HOUSING.
2: + TERMINAL = +2,7V DC
- TERMINAL = -(GROUND)

DELFT ELECTRONIC PRODUCTS BV

ISO 128	screw thread ISO 965	finish ISO 1302	material:	drawn: JK	A0	13-12-00
A4 glass ISO 10110	geometr. tolerances ISO 1101	dimensions: mm	scale: 1 : 1		A1	25-10-01
				sheet: 1 of 1		
					183-0787A1	TV

IMAGE INTENSIFIER XX1440,XX1940,XX2040,XX2540

DEP

Image Intensifier Tubes

Performance Level : XD-4™
DEP Tube Type : XX2040AU

Format	: 18 mm
Tube Name	: Small ANVIS
Compatible	: MX-10160, F9800
Applications	: to be used in Goggles, Monoculars, and other systems.

General Tube information

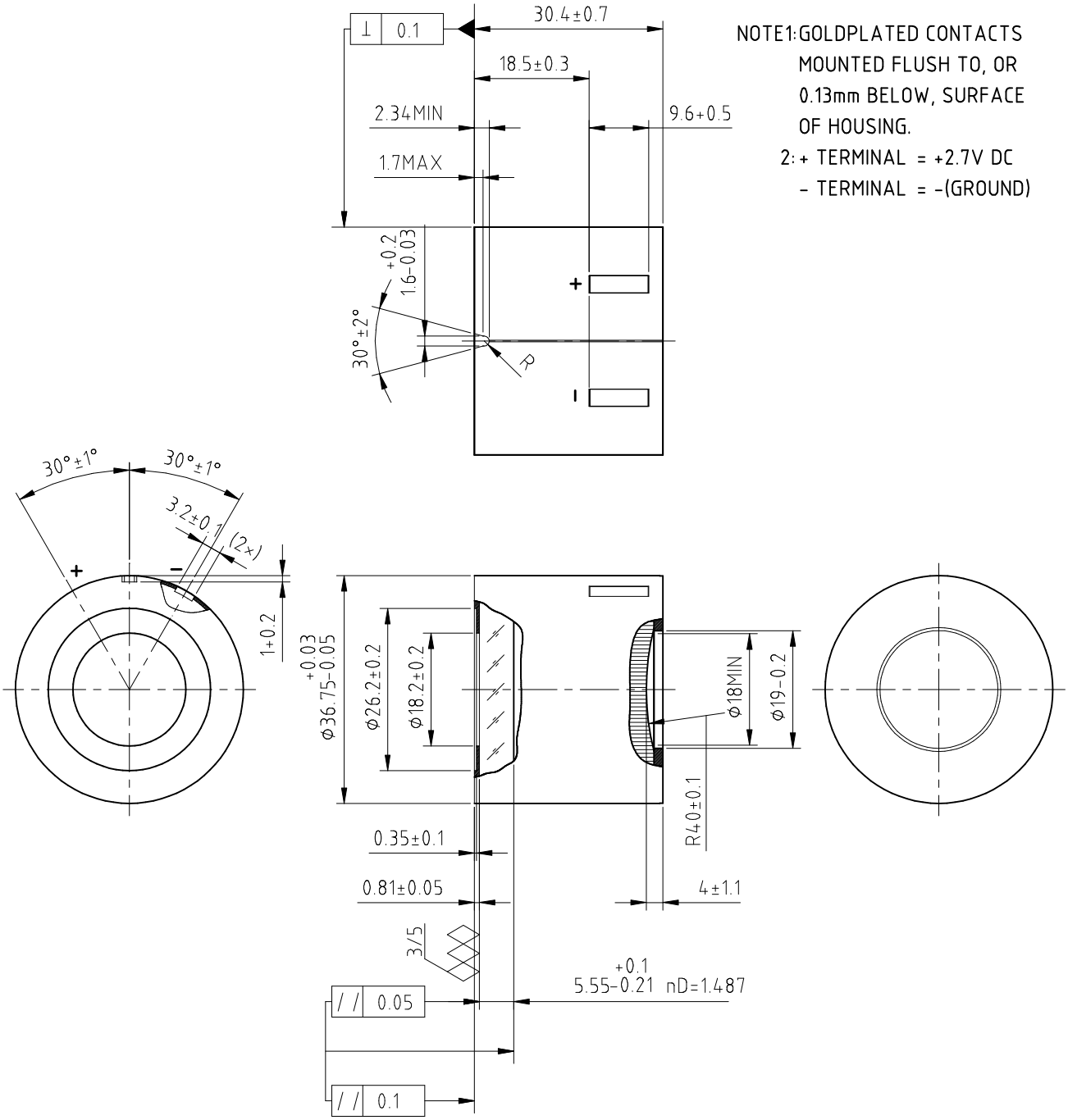
: Input Window	Glass
Output Window	Inverting Fibre Optic
Magnification	1
Electrical controls	Automatic Brightness Control (ABC)
	Bright Source Protection (BSP)
EMC	proof
Electronic connections	gold plated contacts
Weight	80 grams
Useful Cathode Diameter	17.5 mm
Phosphor	P20

Tube Characteristics

		Typical	Min.	Max.	Unit
Optical	Limiting Resolution	64	60		lp/mm
	Modulation Transfer Function				
	2.5 lp/mm	92	90		%
	7.5 lp/mm	80	72		%
	15 lp/mm	64	54		%
	25 lp/mm	45	40		%
	30 lp/mm	35	30		%
	Signal to noise (@108 µlx)	24	20		
	Gain at $2x10^{-6}$ fc	32.000	28.000	38.000	fL/fc
	Life time		15.000		hrs
	Max. Output Brightness (MOB)	6	4	8	cd/m^2
	EBI	0.15		0.25	µlx
	Output Uniformity at 2850K	2:1		3:1	
	Luminous Sensitivity at 2850K	700	600		
	Radiant Sensitivity at 800 nm	60	50		mA/W
	850 nm	50	40		mA/W
	Shock resistance	700g	500g		m/s^2
Electrical	Operating Voltage	2.7	2.0	3.7	V
	Input Current	22	16	26	mA
Environment	Operating temperature		-45	+52	˚C
	Storage temperature		-51	+65	˚C

	new	cancelled		new	cancelled
A1	9,6+0,5; 0,8±0,05	9,5±0,05; 0,8±025	.		
A2	nD=1.487	nD=1.87			

VK



NOTE1: GOLDPLATED CONTACTS MOUNTED FLUSH TO, OR 0.13mm BELOW, SURFACE OF HOUSING.
2: + TERMINAL = +2.7V DC
- TERMINAL = -(GROUND)

DELFT ELECTRONIC PRODUCTS BV

ISO 128	screw thread ISO 965	finish ISO 1302	material:	drawn: JK	A0	3-11-92
A4 glass ISO 10110	geometr. tolerances ISO 1101	dimensions: mm	scale: 1 : 1		A1	6-10-93
					A2	16-9-98
				sheet: 1 of 1		

IMAGE INTENSIFIER XX1440,XX1940,XX2040,XX2540

183-0124A2 TV

DEP

Image Intensifier Tubes

Performance Level : XD-4™
DEP Tube Type : XX2040AR

Format	: 18 mm
Tube Name	: Small ANVIS
Compatible	: MX-10160, F9800
Applications	: to be used in Aviator Goggles, and other systems.

General Tube information

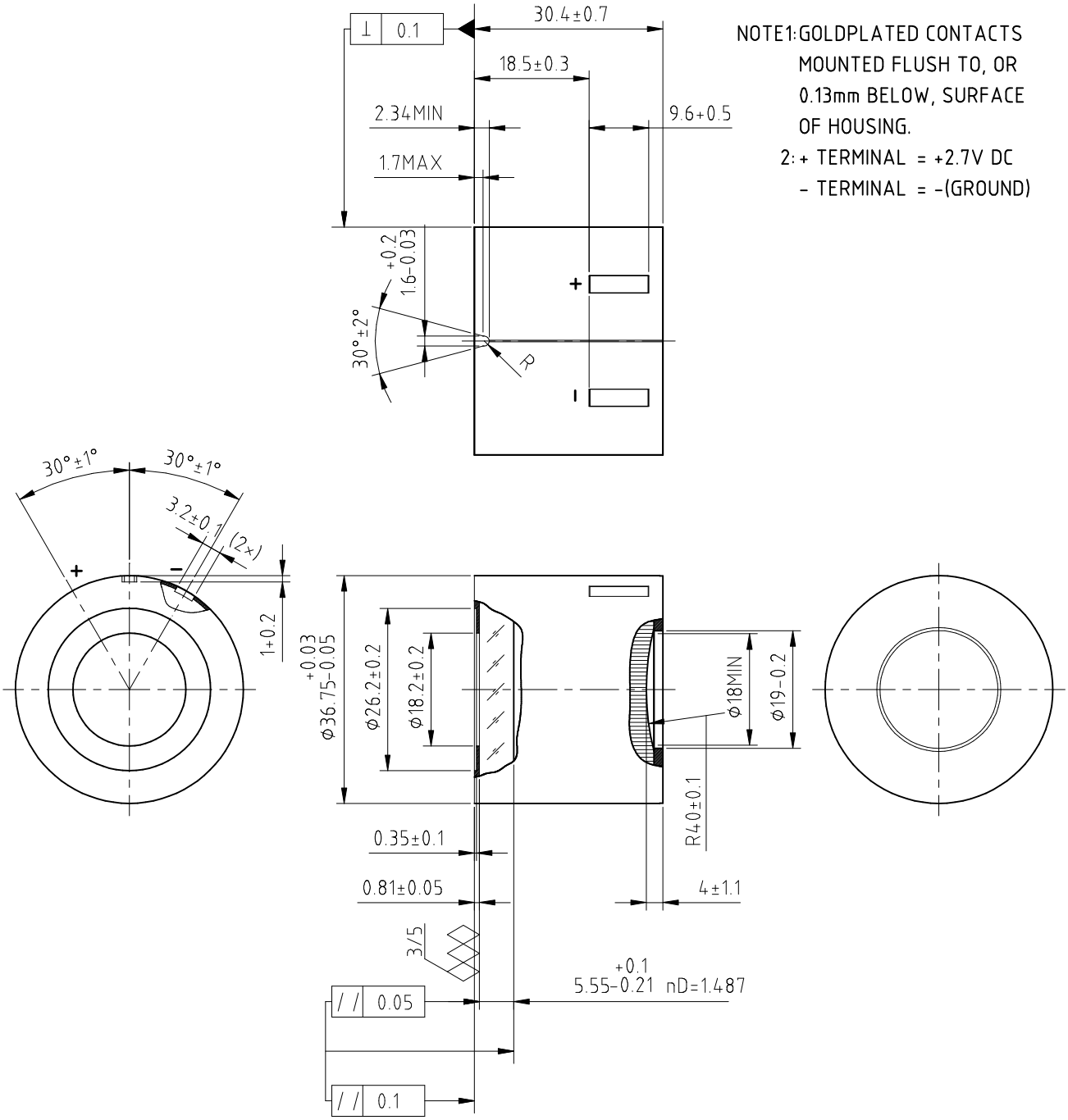
: Input Window	Glass
Output Window	Inverting Fibre Optic
Magnification	1
Electrical controls	Automatic Brightness Control (ABC) Bright Source Protection (BSP)
EMC	proof
Electronic connections	contacts
Weight	80 grams
Useful Cathode Diameter	17.5 mm
Phosphor	P43

Tube Characteristics

		Typical	Min.	Max.	Unit
Optical	Limiting Resolution	64	60		lp/mm
	Modulation Transfer Function				
	2.5 lp/mm	92	90		%
	7.5 lp/mm	80	76		%
	15 lp/mm	65	60		%
	25 lp/mm	45	40		%
	30 lp/mm	35	30		%
	Signal to noise (@108 µlx)	22	20		
	Gain at $2x10^{-6}$ fc	39.200	32.000	45.000	fL/fc
	Life time		10.000		hrs
	Max. Output Brightness (MOB)	6	4	8	cd/m^2
	EBI	0.15		0.25	µlx
	Output Uniformity at 2850K	2:1		3:1	
	Luminous Sensitivity at 2850K	700	600		
	Radiant Sensitivity at 800 nm	60	50		mA/W
	850 nm	50	40		mA/W
	Shock resistance	700g	500g		m/s^2
Electrical	Operating Voltage	2.7	2.0	3.8	V
	Input Current			26	mA
Environment	Operating temperature		-45	+52	˚C
	Storage temperature		-51	+65	˚C

	new	cancelled		new	cancelled
A1	9,6+0,5; 0,8±0,05	9,5±0,05; 0,8±025	.		
A2	nD=1.487	nD=1.87			

VK



NOTE1: GOLDPLATED CONTACTS MOUNTED FLUSH TO, OR 0.13mm BELOW, SURFACE OF HOUSING.
2: + TERMINAL = +2.7V DC
- TERMINAL = -(GROUND)

DELFT ELECTRONIC PRODUCTS BV

ISO 128	screw thread ISO 965	finish ISO 1302	material:	drawn: JK	A0	3-11-92
A4 glass ISO 10110	geometr. tolerances ISO 1101	dimensions: mm	scale: 1 : 1		A1	6-10-93
					A2	16-9-98
				sheet: 1 of 1		

IMAGE INTENSIFIER XX1440,XX1940,XX2040,XX2540

183-0124A2 TV

DEP

Image Intensifier Tubes

Performance Level : XD-4™
DEP Tube Type : XX2050BL

Format	: 18 mm
Tube Name	: PVS-7 Universal
Compatible	: MX-10130, F9810
Applications	: to be used in PVS-7A/B/D Night Vision Goggles and other systems.

General Tube information

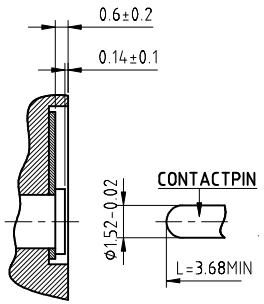
: Input Window	Glass
Output Window	Non-Inverting Fibre Optic
Magnification	1
Electrical controls	Automatic Brightness Control (ABC) Bright Source Protection (BSP)
EMC	proof
Electronic connections	contacts
Weight	98 grams
Useful Cathode Diameter	17.5 mm
Phosphor	P20

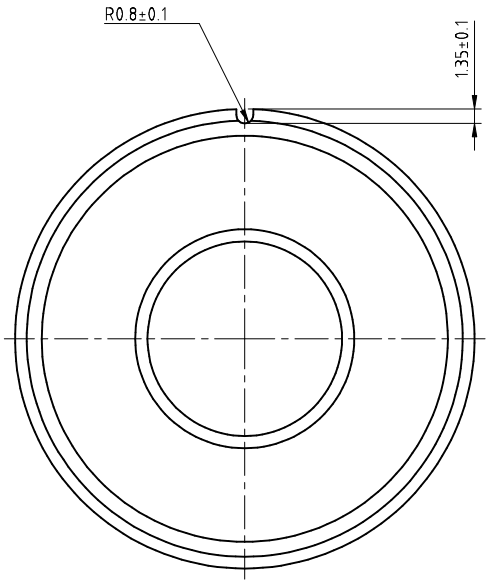
Tube Characteristics

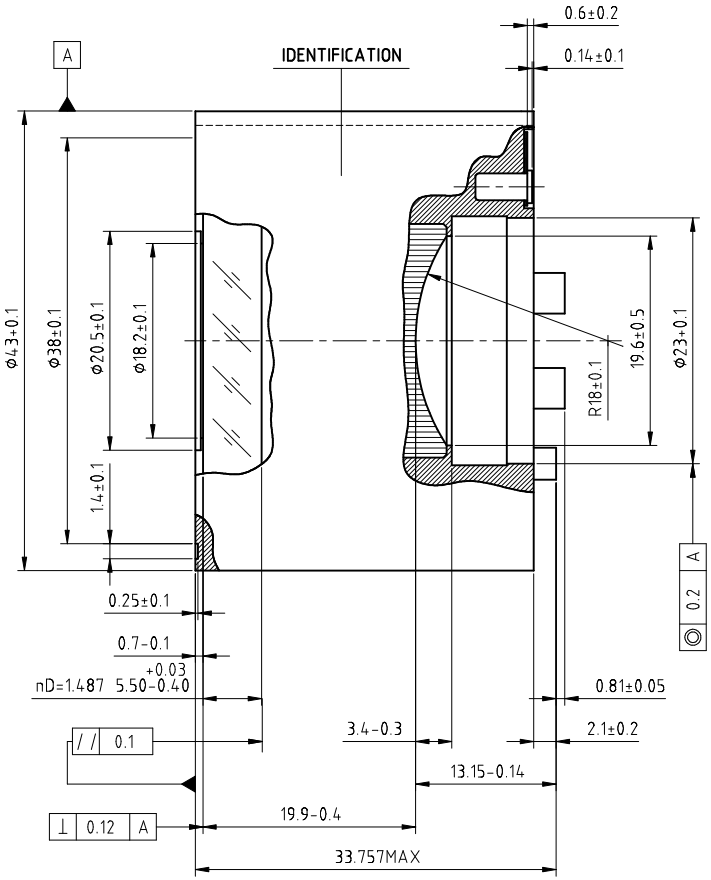
		Typical	Min.	Max.	Unit
Optical	Limiting Resolution	64	60		lp/mm
	Modulation Transfer Function				
	2.5 lp/mm	92			%
	7.5 lp/mm	80			%
	15 lp/mm	58			%
	25 lp/mm	38			%
	30 lp/mm	30			%
	Signal to noise (@108 µlx)	24	20		
	Gain at $2x10^{-6}$ fc	35.000	30.000	40.000	fL/fc
	Life time	10.000		hrs	
	Max. Output Brightness (MOB)	10.2	6.8	13.6	cd/m^2
	EBI	0.15		0.25	µlx
	Output Uniformity at 2850K	2:1		3:1	
	Luminous Sensitivity at 2850K	700	600		
	Radiant Sensitivity at 800 nm	60	50		mA/W
	850 nm	50	40		mA/W
	Shock resistance	700g	500g		m/s^2
Electrical	Operating Voltage	2.7	2.0	3.8	V
	Input Current			22	mA
Environment	Operating temperature		-45	+52	˚C
	Storage temperature		-51	+65	˚C

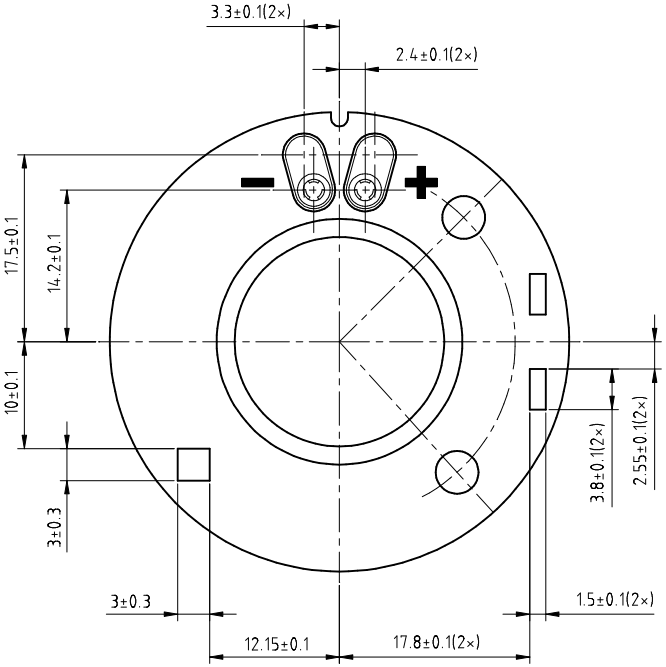
NOTE 1: REFERENCE CIRCLE [A] IS THE CYLINDER WITH THE SMALLEST DIAMETER THAT FITS AROUND THE PLASTIC HOUSING
2: + CONTACT = +2.7V DC
- CONTACT = -(GROUND)
3: CONTACTPIN DIAMETER 1.5mm

	new	cancelled		new	cancelled
A1	⌀20.5±0.1; $5.50^{+0.03}_{-0.40}$	⌀20.3±0.1; $5.55^{+0.03}_{-0.05}$; 30°	.		









VK

DEP DELFT ELECTRONIC PRODUCTS BV	ISO 128	screw thread ISO 965	finish ISO 1302	material:	drawn: JK	A0	2-8-00
	A3	glass ISO 10110	vorm- en plaatstol. ISO 1101	maateenheid: mm	scale:	A1	9-4-01
IMAGE INTENSIFIER XX1950,XX2050,XX2550					sheet: 1 of 1		
					183-0769A1		TA

DEP

Image Intensifier Tubes

Performance Level : XD-4™
DEP Tube Type : XX2040AN

Format	: 18 mm
Tube Name	: fat ANVIS
Compatible	: MX-868
Applications	: to be used in Goggles, and other systems.

General Tube information

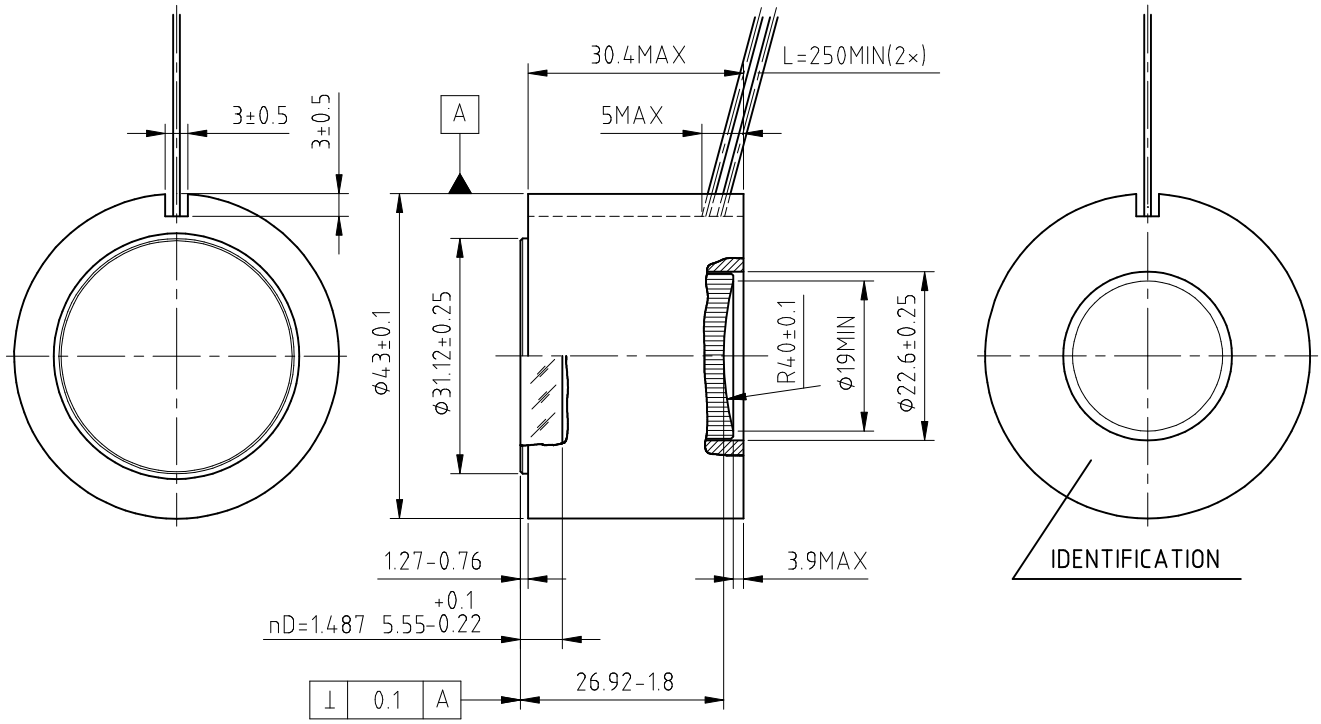
: Input Window	Glass
Output Window	Inverting Fibre Optic
Magnification	1
Electrical controls	Automatic Brightness Control (ABC) Bright Source Protection (BSP)
EMC	proof
Electronic connections	flying leads
Weight	98 grams
Useful Cathode Diameter	17.5 mm
Phosphor	P20

Tube Characteristics

		Typical	Min.	Max.	Unit
Optical	Limiting Resolution	58	55		lp/mm
	Modulation Transfer Function				
	2.5 lp/mm	92	88		%
	7.5 lp/mm	80	72		%
	15 lp/mm	58	54		%
	25 lp/mm	38	35		%
	30 lp/mm	30	25		%
	Signal to noise (@108 µlx)	22	20		
	Gain at $2x10^{-6}$ fc	28.000	31.000	37.500	fL/fc
	Life time		10.000		hrs
	Max. Output Brightness (MOB)	4.5	3	6	cd/m^2
	EBI	0.15		0.25	µlx
	Output Uniformity at 2850K	2:1		3:1	
	Luminous Sensitivity at 2850K	700	600		
	Radiant Sensitivity at 800 nm	60	50		mA/W
	850 nm	50	40		mA/W
	Shock resistance	700g	500g		m/s^2
Electrical	Operating Voltage	2.7	2.0	3.8	V
	Input Current	12		24	mA
Environment	Operating temperature		-45	+52	˚C
	Storage temperature		-52	+65	˚C

	new	cancelled		new	cancelled
.			.		

NOTE 1: REFERENCE CIRCLE [A] IS THE CYLINDER WITH THE SMALLEST DIAMETER THAT FITS AROUND THE PLASTIC HOUSING.
2: RED WIRE = +2,7V DC
BLACK WIRE = -(GROUND)



DEP ISO 9001 Certified
DELFT ELECTRONIC PRODUCTS BV

ISO 128	screw thread ISO 965	finish ISO 1302	material:	drawn: JK	A0	9-3-92
A4 glass ISO 10110	geometr. tolerances ISO 1101	dimensions: mm	scale: 1 : 1		A1	15-1-93
					A2	7-11-96
				sheet: 1 of 1		

IMAGE INTENSIFIER XX1440,XX1441,XX1940,XX2040

183-0047A2 TV

DEP

Image Intensifier Tubes

Performance Level : XD-4™
DEP Tube Type : XX2040C

Format	: 18 mm
Tube Name	: Small ANVIS
Compatible	: MX-10160, F9800
Applications	: to be used in Goggles, Monoculars, and other systems.

General Tube information

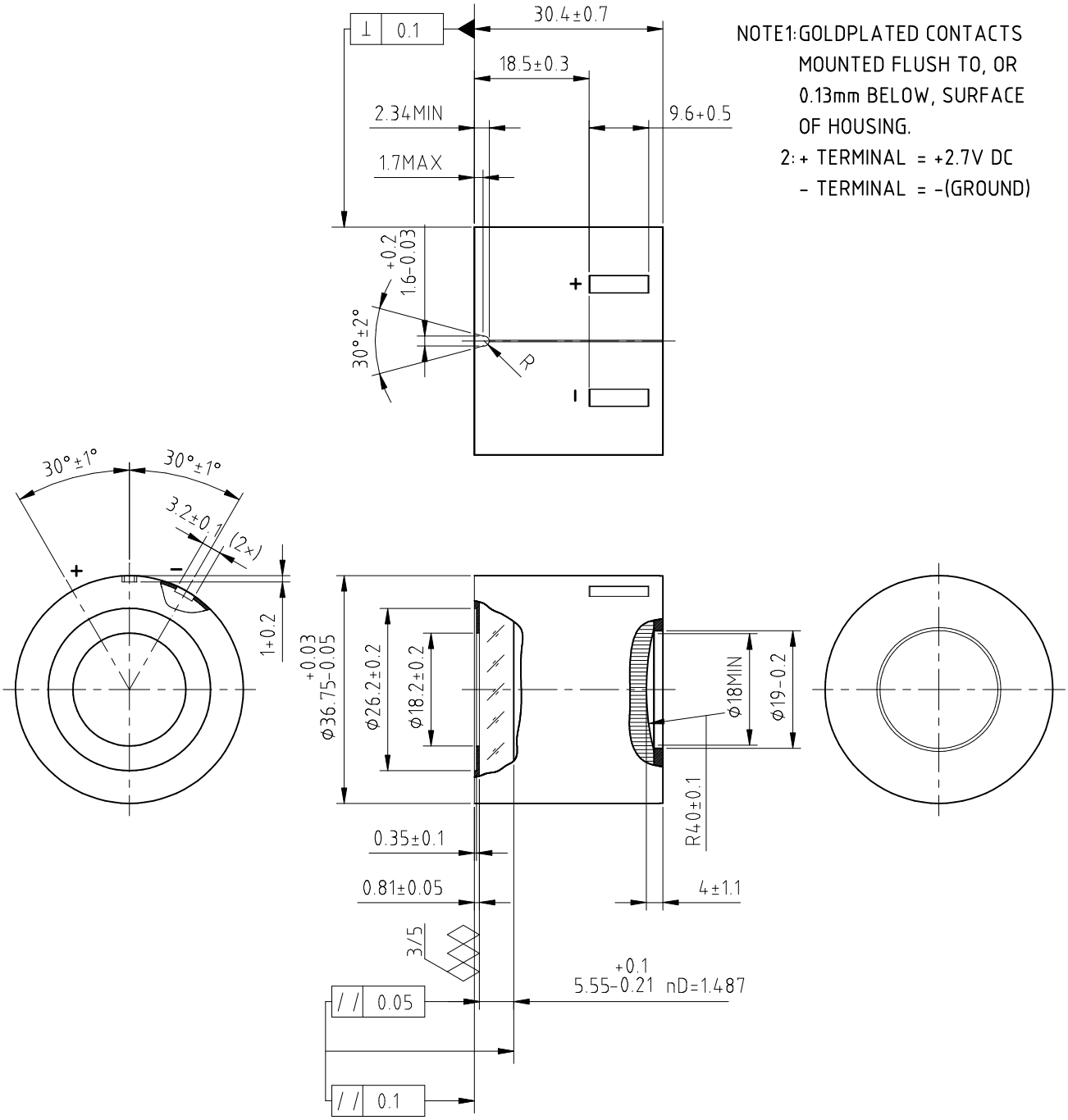
: Input Window	Glass
Output Window	Inverting Fibre Optic
Magnification	1
Electrical controls	Automatic Brightness Control (ABC) Bright Source Protection (BSP)
EMC	proof
Electronic connections	contacts
Weight	80 grams
Useful Cathode Diameter	17.5 mm
Phosphor	P20

Tube Characteristics

		Typical	Min.	Max.	Unit
Optical	Limiting Resolution	58	55		lp/mm
	Modulation Transfer Function				
	2.5 lp/mm	92	86		%
	7.5 lp/mm	80	72		%
	15 lp/mm	58	54		%
	25 lp/mm	38	35		%
	30 lp/mm	30	25		%
	Signal to noise (@108 µlx)	24	20		
	Gain at $2x10^{-6}$ fc	28.500	25.000	32.000	fL/fc
	Life time		15.000		hrs
	Max. Output Brightness (MOB)	6	4	8	cd/m^2
	EBI	0.15		0.25	µlx
	Output Uniformity at 2850K	2:1		3:1	
	Luminous Sensitivity at 2850K	700	600		
	Radiant Sensitivity at 800 nm	60	50		mA/W
	850 nm	50	40		mA/W
	Shock resistance	700	500g		m/s^2
Electrical	Operating Voltage	2.7	2.0	3.8	V
	Input Current	22	16	26	mA
Environment	Operating temperature		-45	+52	˚C
	Storage temperature		-51	+65	˚C

	new	cancelled		new	cancelled
A1	9,6+0,5; 0,8±0,05	9,5±0,05; 0,8±025	.		
A2	nD=1.487	nD=1.87			

VK



NOTE1: GOLDPLATED CONTACTS MOUNTED FLUSH TO, OR 0.13mm BELOW, SURFACE OF HOUSING.
2: + TERMINAL = +2.7V DC
- TERMINAL = -(GROUND)

DELFT ELECTRONIC PRODUCTS BV

ISO 128	screw thread ISO 965	finish ISO 1302	material:	drawn: JK	A0	3-11-92
A4 glass ISO 10110	geometr. tolerances ISO 1101	dimensions: mm	scale: 1 : 1		A1	6-10-93
					A2	16-9-98
				sheet: 1 of 1		

IMAGE INTENSIFIER XX1440,XX1940,XX2040,XX2540

183-0124A2 TV

DEP

Image Intensifier Tubes

Performance Level : XD-4™
DEP Tube Type : XX2050R

Format	: 18 mm
Tube Name	: PVS-7 Universal
Compatible	: MX-10130
Applications	: to be used in PVS-7A/B/D Night Vision Goggles, and other systems.

General Tube information

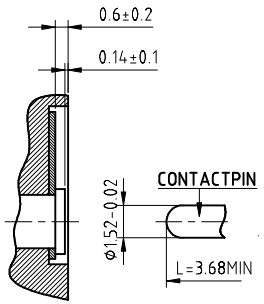
: Input Window	Glass
Output Window	Non-Inverting Fibre Optic
Magnification	1
Electrical controls	Automatic Brightness Control (ABC) Bright Source Protection (BSP)
EMC	proof
Electronic connections	contacts
Weight	98 grams
Useful Cathode Diameter	17.5 mm
Phosphor	P20

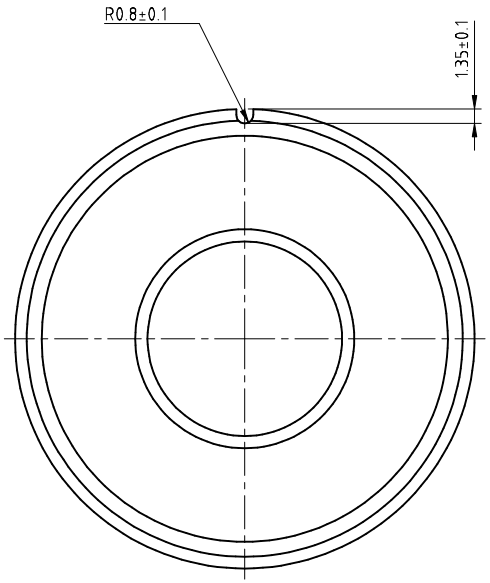
Tube Characteristics

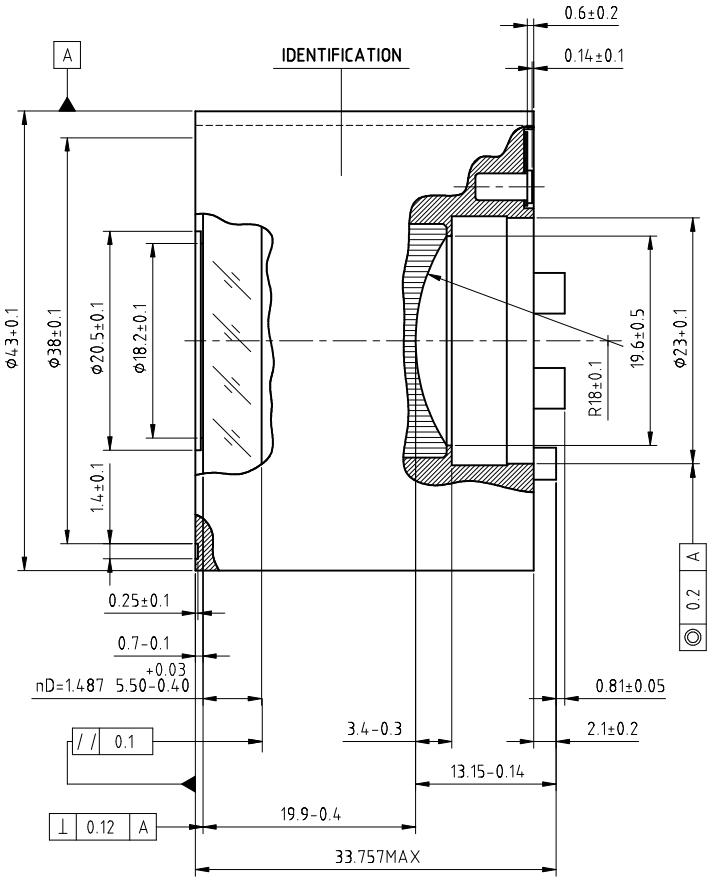
		Typical	Min.	Max.	Unit
Optical	Limiting Resolution	58	55		lp/mm
	Modulation Transfer Function				
	2.5 lp/mm	92	90		%
	7.5 lp/mm	80	72		%
	15 lp/mm	58	54		%
	Signal to noise (@108 µlx)	24	20		
	Gain at $2x10^{-6}$ fc	35.000	30.000	40.000	fL/fc
	Life time		10.000		hrs
	Max. Output Brightness (MOB)	10.2	6.8	13.6	cd/m^2
	EBI	0.15		0.25	µlx
	Output Uniformity at 2850K	2:1		3:1	
	Luminous Sensitivity at 2850K	700	600		
	Radiant Sensitivity at 800 nm	60	50		mA/W
	850 nm	50	40		mA/W
	Shock resistance	700g	500g		m/s^2
Electrical	Operating Voltage	2.7	2.0	3.8	V
	Input Current			22	mA
Environment	Operating temperature		-45	+52	˚C
	Storage temperature		-51	+65	˚C

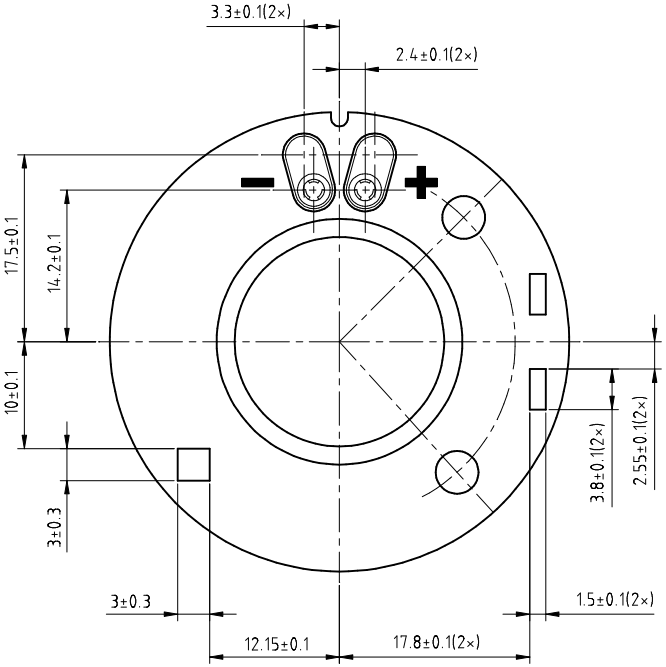
NOTE 1: REFERENCE CIRCLE [A] IS THE CYLINDER WITH THE SMALLEST DIAMETER THAT FITS AROUND THE PLASTIC HOUSING
2: + CONTACT = +2.7V DC
- CONTACT = -(GROUND)
3: CONTACTPIN DIAMETER 1.5mm

	new	cancelled		new	cancelled
A1	⌀20.5±0.1; $5.50^{+0.03}_{-0.40}$	⌀20.3±0.1; $5.55^{+0.03}_{-0.05}$; 30°	.		









VK

DEP DELFT ELECTRONIC PRODUCTS BV	ISO 128	screw thread ISO 965	finish ISO 1302	material:	drawn: JK	A0	2-8-00
	A3	glass ISO 10110	vorm- en plaatstol. ISO 1101	maateenheid: mm	scale:	A1	9-4-01
IMAGE INTENSIFIER XX1950,XX2050,XX2550					sheet: 1 of 1		
					183-0769A1		TA

DEP

Image Intensifier Tubes

Performance Level : SHD-3™
DEP Tube Type : XX1940AM

Format	: 18 mm
Tube Name	: Small ANVIS
Compatible	: MX-10160
Applications	: to be used in Goggles, Monoculars and other systems.

General Tube information

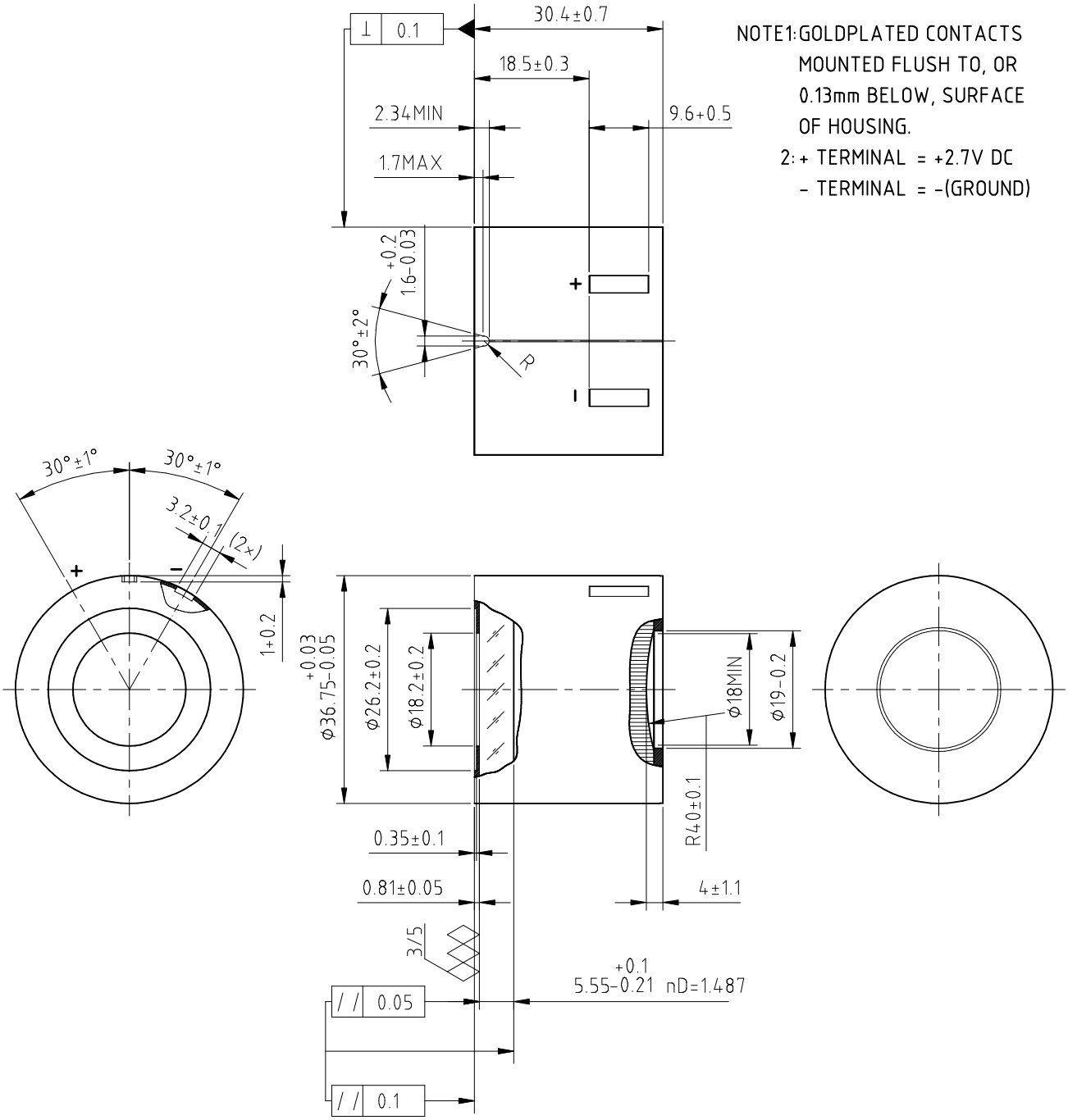
: Input Window	Glass
Output Window	Inverting Fibre Optic
Magnification	1
Electrical controls	Automatic Brightness Control (ABC) Bright Source Protection (BSP)
EMC	proof
Electronic connections	contacts
Weight	80 grams
Useful Cathode Diameter	17.5 mm
Phosphor	P20

Tube Characteristics

		Typical	Min.	Max.	Unit
Optical	Limiting Resolution	48	45		lp/mm
	Modulation Transfer Function				
	2.5 lp/mm	88	86		%
	7.5 lp/mm	70	66		%
	15 lp/mm	50	44		%
	25 lp/mm	30	22		%
	30 lp/mm	22	18		%
	Signal to noise (@108 µlx)	21	18		
	Gain at $2x10^{-6}$ fc	23.250	18.500	28.000	fL/fc
	Life time		10.000		hrs
	Max. Output Brightness (MOB)	3	2	4	cd/m^2
	EBI	0.15		0.25	µlx
	Output Uniformity at 2850K	2:1		3:1	
	Luminous Sensitivity at 2850K	600	500		
	Radiant Sensitivity at 800 nm	55	43		mA/W
	850 nm	45	33		mA/W
	Shock resistance	700g	500g		m/s^2
Electrical	Operating Voltage	2.7	2.0	3.4	V
	Input Current	16		26	mA
Environment	Operating temperature		-30	+52	˚C
	Storage temperature		-35	+65	˚C

	new	cancelled		new	cancelled
A1	9,6+0,5; 0,8±0,05	9,5±0,05; 0,8±025	.		
A2	nD=1.487	nD=1.87			

VK



NOTE1: GOLDPLATED CONTACTS MOUNTED FLUSH TO, OR 0.13mm BELOW, SURFACE OF HOUSING.
2: + TERMINAL = +2.7V DC
- TERMINAL = -(GROUND)

DELFT ELECTRONIC PRODUCTS BV

ISO 128	screw thread ISO 965	finish ISO 1302	material:	drawn: JK	A0	3-11-92
A4 glass ISO 10110	geometr. tolerances ISO 1101	dimensions: mm	scale: 1 : 1		A1	6-10-93
					A2	16-9-98
				sheet: 1 of 1		

IMAGE INTENSIFIER XX1440,XX1940,XX2040,XX2540

183-0124A2 TV

DEP

Image Intensifier Tubes

Performance Level : SHD-3™
DEP Tube Type : XX1950DK

Format	: 18 mm
Tube Name	: PVS-7 Universal
Compatible	: MX-10130
Applications	: to be used in PVS-7A/B/D Night Vision Goggles and other systems.

General Tube information

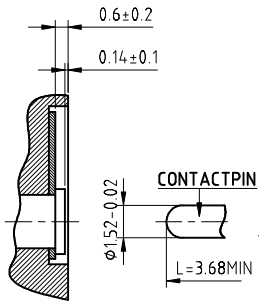
: Input Window	Glass
Output Window	Non-Inverting Fibre Optic
Magnification	1
Electrical controls	Automatic Brightness Control (ABC) Bright Source Protection (BSP)
EMC	proof
Electronic connections	contacts
Weight	98 grams
Useful Cathode Diameter	17.5 mm
Phosphor	P20

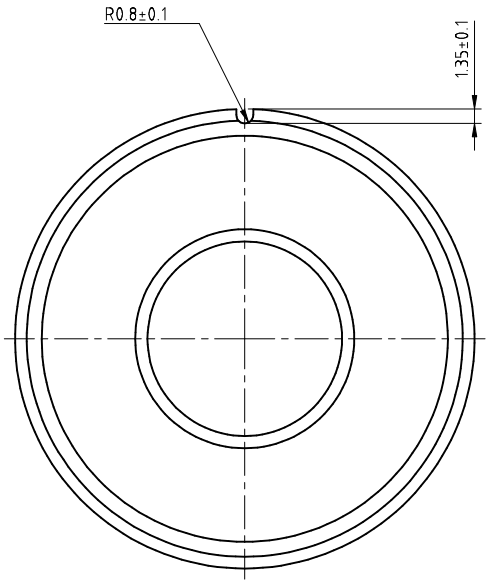
Tube Characteristics

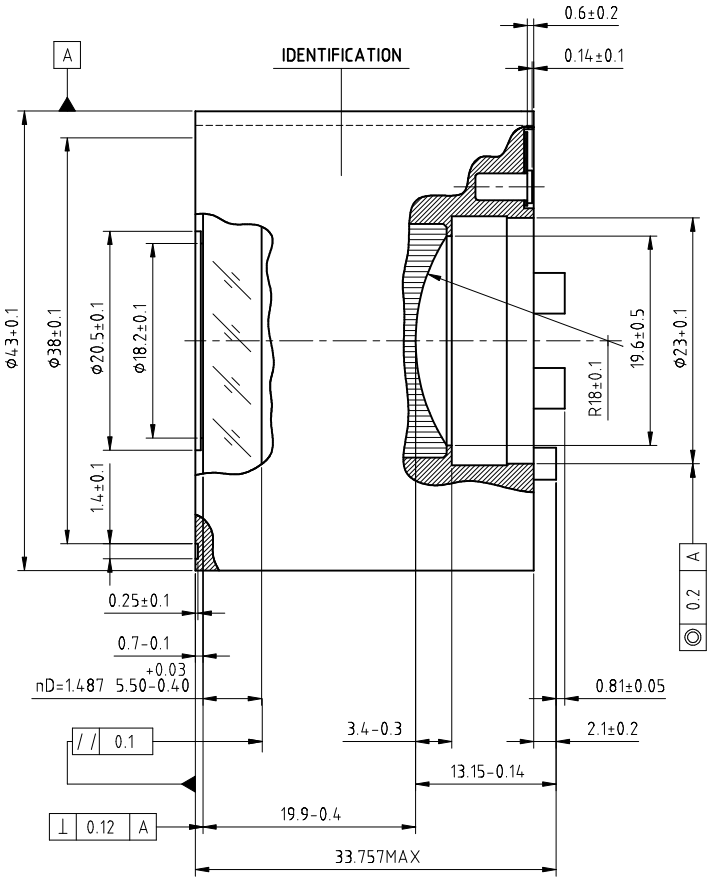
		Typical	Min.	Max.	Unit
Optical	Limiting Resolution	48	45		lp/mm
	Modulation Transfer Function				
	2.5 lp/mm	90	88		%
	7.5 lp/mm	76	70		%
	15 lp/mm	54	50		%
	25 lp/mm	35	30		%
	Signal to noise (@108 µlx)	21	18		
	Gain at $2x10^{-6}$ fc	33.000	28.200	37.700	fL/fc
	Life time	10.000			hrs
	Max. Output Brightness (MOB)	6	4	8	cd/m^2
	EBI	0.15		0.25	µlx
	Output Uniformity at 2850K	2:1		3:1	
	Luminous Sensitivity at 2850K	600	500		
	Radiant Sensitivity at 800 nm	50	45		mA/W
	850 nm	40	35		mA/W
	Shock resistance	700g	500g		m/s^2
Electrical	Operating Voltage	2.7	2.0	3.8	V
	Input Current			24	mA
Environment	Operating temperature		-45	+52	˚C
	Storage temperature		-51	+65	˚C

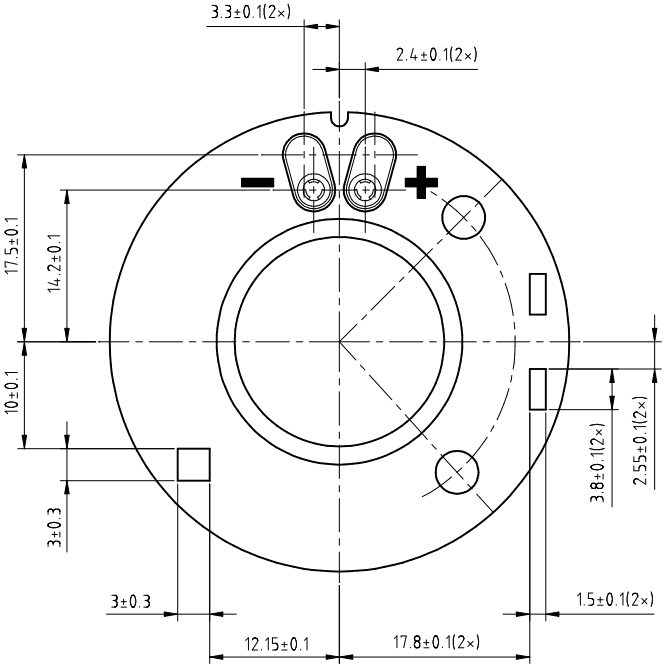
NOTE 1: REFERENCE CIRCLE [A] IS THE CYLINDER WITH THE SMALLEST DIAMETER THAT FITS AROUND THE PLASTIC HOUSING
2: + CONTACT = +2.7V DC
- CONTACT = -(GROUND)
3: CONTACTPIN DIAMETER 1.5mm

	new	cancelled		new	cancelled
A1	⌀20.5±0.1; $5.50^{+0.03}_{-0.40}$	⌀20.3±0.1; $5.55^{+0.03}_{-0.05}$; 30°	.		









VK

DEP DELFT ELECTRONIC PRODUCTS BV	ISO 128	screw thread ISO 965	finish ISO 1302	material:	drawn: JK	A0	2-8-00
	A3	glass ISO 10110	vorm- en plaatstol. ISO 1101	maateenheid: mm	scale:	A1	9-4-01
IMAGE INTENSIFIER XX1950,XX2050,XX2550					sheet: 1 of 1		
					183-0769A1		TA

DEP

Image Intensifier Tubes

Performance Level : XD-4™
DEP Tube Type : XX1700DN

Format	: 18 mm
Tube Name	: Sony ICX423
Format	: 2/3-inch
Applications	: low light level applications, surveillance.

General Tube information : Input Window Glass
EMC proof
Electrical connections flying leads
Useful Cathode Diameter 17.5 mm
Phosphor P20

Tapered Fibre optic

Typical	**Min.**	**Max.**
0.63	0.61	0.65

Tube Characteristics

		Typical	**Min.**	**Max.**	**Unit**
Optical	Limiting Resolution	60	55		lp/mm
	Signal to noise (@108 µlx)	22	20		
	Luminance gain* (max. gain at 0V)	22000	19000		fL/fc
	Life time	10.000			hrs
	Max. Output Brightness (MOB)	3	2	4	cd/m^2
	EBI	0.15		0.25	µlx
	Luminous Sensitivity at 2850K	700	600		µa/lm
	Radiant Sensitivity at 800 nm	55	50		mA/W
	850 nm	45	40		mA/W
Environment	Operating temperature	+20	-20	+50	˚C
	Storage temperature		-30	+60	˚C

*External gain control (EGAC)
The gain can be adjusted by a voltage between 0 and 10 V from its pre-set maximum value at 0 V to a nihil gain at 10 V.

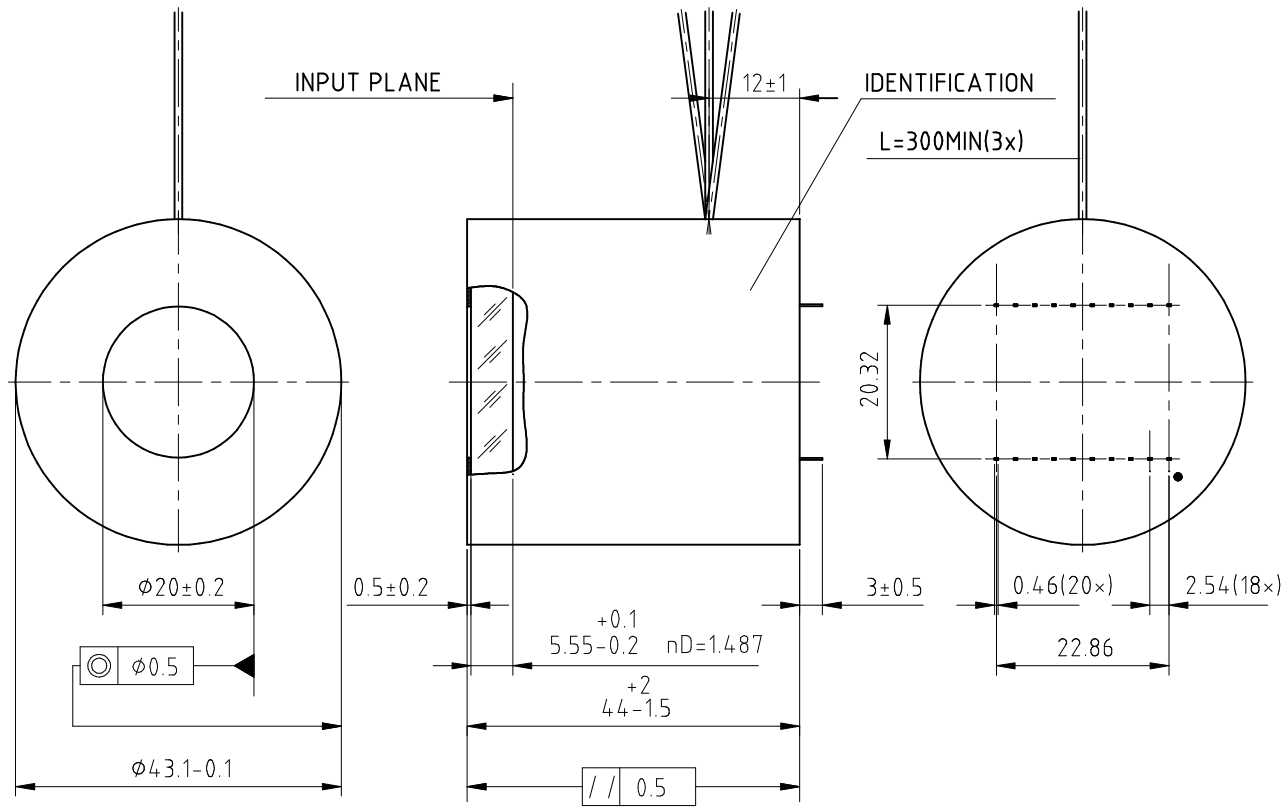
Low-Light Level Image Sensor

	Minimum	Nominal	Unit
Resolution	520	540	TV-lines/ Picture Height

Image Sensor
Type: Sony ICX423 high resolution interline CCD compatible with CCIR B/W TV-system.
Image area (2/3"): 8.8 mm (hor) x 6.6 mm (vert)
The Image Sensor is directly coupled to the tapered fibre-optic.

	new	cancelled		new	cancelled
A1	??		.		
A2	nD=1.487	nD=1.47			

VK



NOTE: RED WIRE = +2,7V DC
BLACK WIRE = -(GROUND)
GREEN WIRE = GAIN CONTROL (0-10V DC)

DEP
DELFT ELECTRONIC PRODUCTS BV

ISO 128	screw thread ISO 965	finish ISO 1302	material:	drawn: JK	A0	18-3-93
A4 / glass ISO 10110	geometr. tolerances ISO 1101	dimensions: mm	scale: 1 : 1		A1	24-1-94
					A2	22-3-00
				sheet: 1 of 1		

LOW LIGHT LEVEL IMAGE SENSOR XX1700

183-0164A2 TV

DEP

Image Intensifier Tubes

Performance Level : GEN II
DEP Tube Type : PP0340AT

Format	: 25 mm
Applications	: Analytical/Industrial Instrumentation

General Tube information

: Input Window	Quarts
Output window	Non inverting Fibre Optic
Magnification	1
Electrical controls	Gating and external gain control
Electrical connections	Wires
Useful Cathode Diameter	24.5 mm
Phosphor	P43

Tube Characteristics

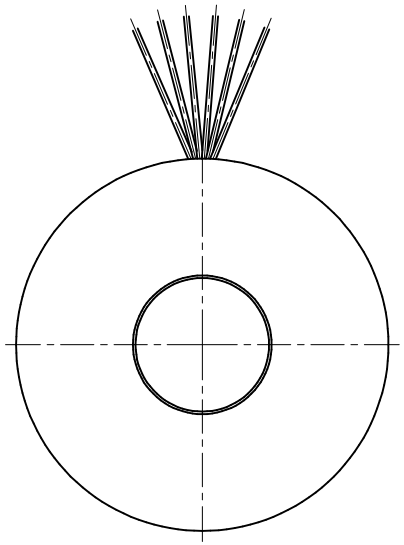
		Typical	Min.	Max.	Unit
Optical	Limiting Resolution	35	28		lp/mm
	Gain at V_c = 0V	4.000	3.180		cd/m^2/lx
	EBI	0.1		0.2	µlx
	Radiant Sensitivity at 270 nm	55	50		mA/W
	440 nm	45	40		mA/W
	Non Uniformity			40	%
Electrical	Gateable down to 100ns				
	Iris delay		30		ns
	Supply voltage	4	5 6		VDC
	EGAC control voltage (Vc)	0	10		VDC
Environment	Operating temperature	+20	-30	+60	˚C
	Storage temperature	+20	-30	+50	˚C

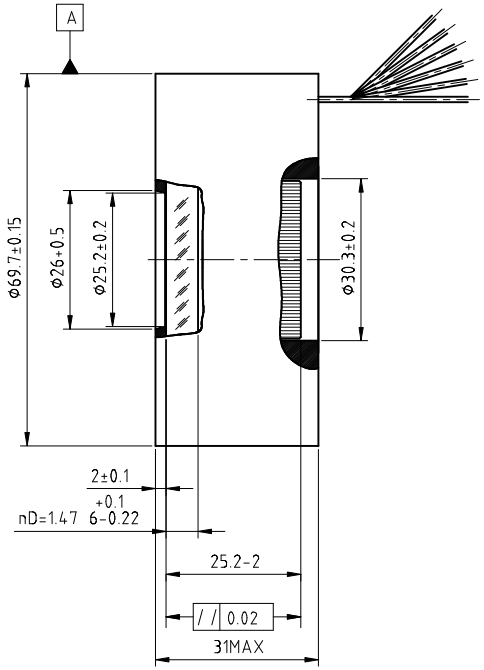
The luminance gain of the image intensifier is adjustable by means of an external control voltage from its pre-set maximum value at V_C = 0 V to a nihil gain at V_C = 10 V.

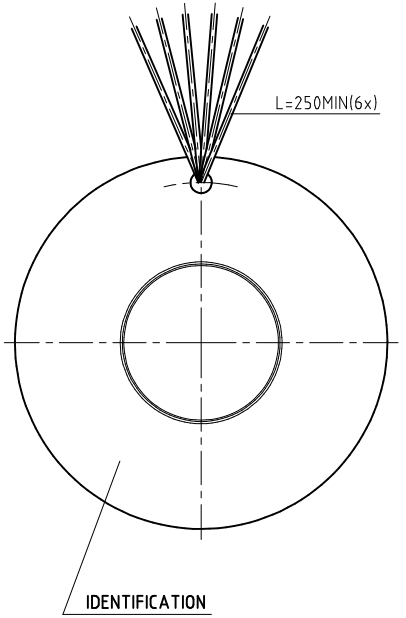
A spectral photocathode sensitivity curve, vignetting curves and an EGAC curve shall be provided with the test data.

	new	cancelled		new	cancelled
.			.		

VK







NOTE 1:REFERENCE CIRCLE [A] IS THE CYLINDER WITH
THE SMALLEST DIAMETER THAT FITS AROUND
THE PLASTIC HOUSING
2:RED WIRE = +5,0V DC
BLACK WIRE = -(GROUND)
WHITE WIRE = MCPin
BLUE WIRE = CATHODE VOLTAGE FOR CONT. OPERATION
YELLOW WIRE = CATHODE
GREEN WIRE = EGAC (0-10V DC)

DEP
DELFT ELECTRONIC PRODUCTS BV

ISO 128		screw thread ISO 965	finish ISO 1302	material:	drawn: JK	A0	30-7-96
A3	glass ISO 10110	vorm- en plaatstol. ISO 1101	maateenheid: mm	scale: 1 : 1			

IMAGE INTENSIFIER PP0340, PP0370

sheet: 1 of 1

183-0421A0 TA

DEP

Image Intensifier Tubes

Performance Level : GEN II
DEP Tube Type : PP0400G

Format	: 40 mm
Applications	: Industrial Instrumentation

General Tube information

: Input Window	Fibre Optic
Output window	Fibre Optic
Magnification	1
Electricalc connections	Wires
Useful Cathode Diameter	40 mm
Phosphor	P43

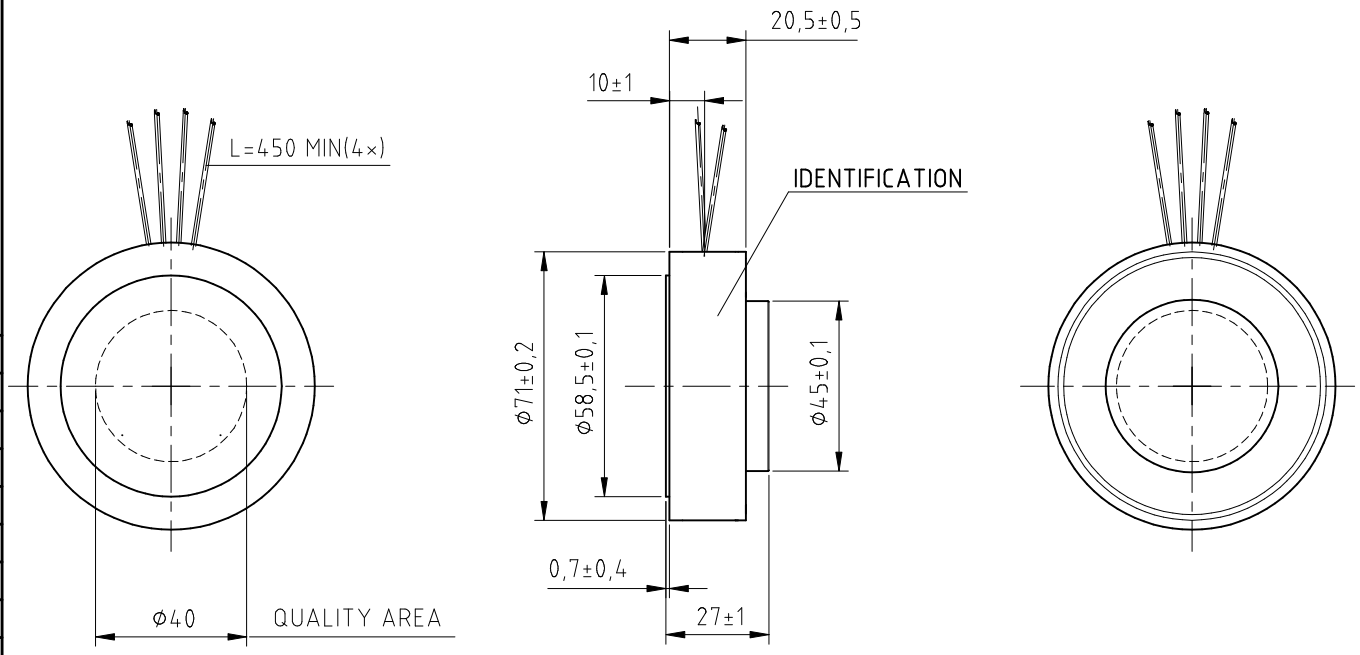
Tube Characteristics

		Typical	Min.	Max.	Unit
Optical	Limiting Resolution	30	28		lp/mm
	Gain		4000		cd/m^2/lx
	EBI	0.02		0.05	µlx
	Radiant Sensitivity at 440 nm	45	40		mA/W
	480 nm	45	40		mA/W
	Uniformity within quality area			40	%
Electrical	Gateable down to 1µs				
	Supply voltage	4	5	6	VDC
	EGAC control voltage (Vc)	0		10	VDC
Environment	Operating temperature	+20	-20	+50	˚C
	Storage temperature		-20	+50	˚C

Operating conditions:

	Name	Min.	Nom.	Max.	Unit	Remarks
Anode voltage	V_A	5400	5700	6000	VDC	ref. to $V_{MCP-OUT}$
MCP output voltage	$V_{MCP-OUT}$		*	*	+VDC	ref. to V_{MCP-IN}
MCP input voltage	V_{MCP-IN}		0		-VDC	grounded
Cathode voltage (on)	V_{C-ON}	160	200	240	-VDC	ref. to V_{MCP-IN}
Cathode voltage (off)	V_{C-OFF}	30	40	240	VDC	ref. to V_{MCP-IN}

	nieuw	vervallen	vakmanschap:GOED/FOUT		datum:	
			pers.nr.:		paraaf:	
				min.	gemeten	max.



NOTE : BLUE WIRE = CATHODE
WHITE WIRE = MCP-IN
GREEN WIRE = MCP-OUT
YELLOW WIRE = ANODE

DELFT ELECTRONISCHE PRODUCTEN	amerikaanse proj.	schroefdraad DIN 13 6g/6H NEN 3222	ruwheid ISO 1302	materiaal:	get.: AHJM	A0 27-2-96
	glas DIN 3140	vorm- en plaatstol. ISO R1101	maateenheid: mm	schaal: 1:2	gec.:	
					gec.:	
					gez.:	
					aantal bladen:1 blad:1	

BEELDVERSTERKER PP0400, PP0410
(image intensifier)

183-0397A0 TA

DEP

Image Intensifier Tubes

Performance Level : XD-4™
DEP Tube Type : XX1440ES

Format	: 18 mm
Tube Name	: small ANVIS
Applications	: Industrial Instrumentation

General Tube information

: Input Window	Quartz
Output Window	Inverting Fibre Optic
Magnification	1
Electrical controls	Automatic Brightness Control (ABC) Bright Source Protection (BSP)
EMC	proof
Electrical connections	contacts
Weight	80 grams
Useful Cathode Diameter	17.5 mm
Phosphor	P43

Tube Characteristics

		Typical	Min.	Max.	Unit
Optical	Limiting Resolution	40	36		lp/mm
	Gain at $2x10^{-6}$ fc	6.000	5.000	8.000	cd/m^2
	Life time	10.000			hrs
	Max. Output Brightness (MOB)	6	4	8	cd/m^2
	EBI	0.15		0.25	µlx
	Output Uniformity at 2850K			3:1	
	Radiant Sensitivity at 270 nm	50	40		mA/W
	400 nm	60	50		mA/W
Electrical	Operating Voltage	2.7	2.0	3.4	V
Environment	Operating temperature	+20	-30	+60	˚C
	Storage temperature	+20	-30	+52	˚C

	new	cancelled		new	cancelled
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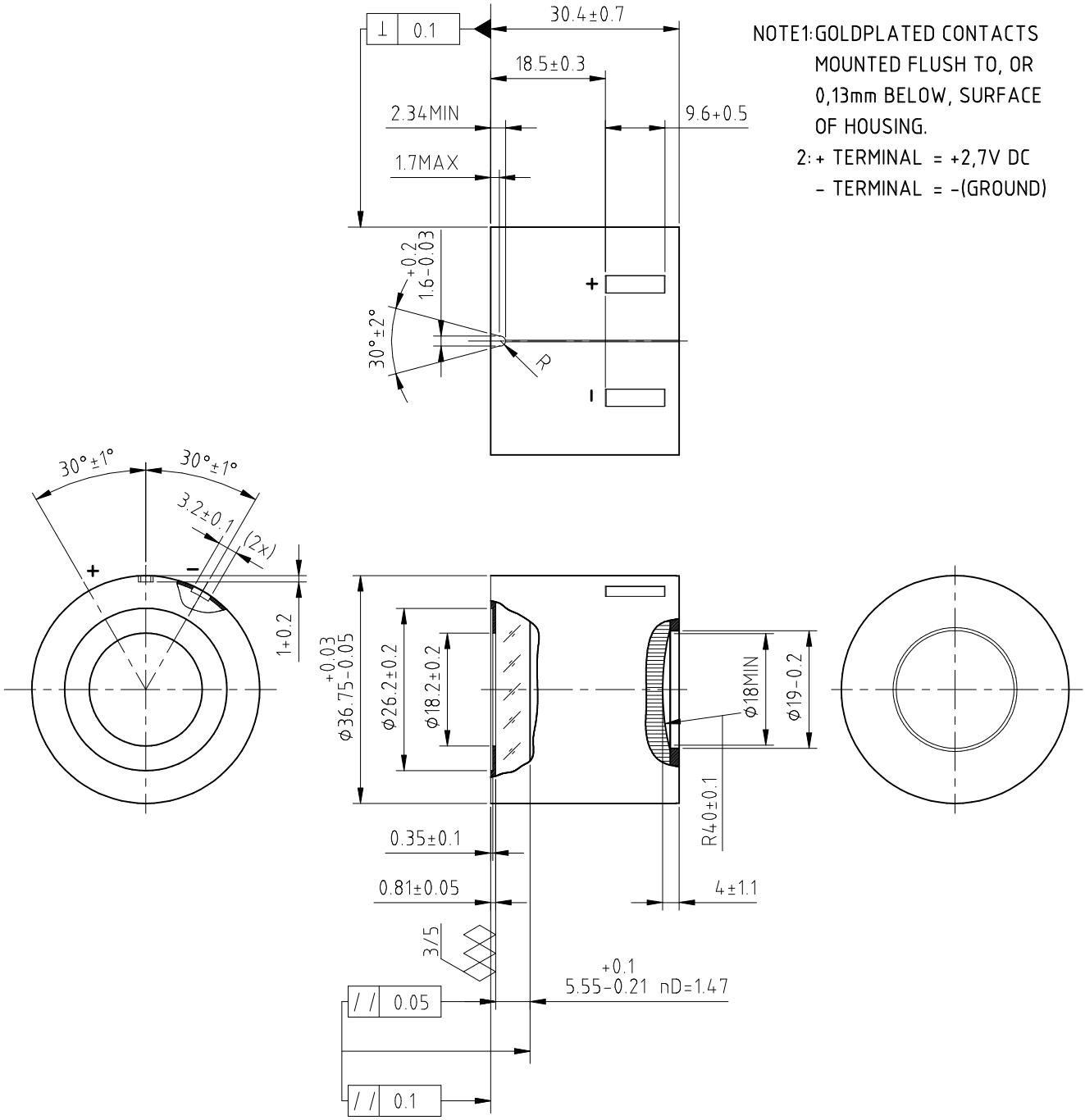


NOTE1: GOLDPLATED CONTACTS MOUNTED FLUSH TO, OR 0,13mm BELOW, SURFACE OF HOUSING.
2: + TERMINAL = +2,7V DC
- TERMINAL = -(GROUND)

VK

DEP ISO 9001 Certified
DELFT ELECTRONIC PRODUCTS BV

ISO 128	screw thread ISO 965	finish ISO 1302	material:	drawn: JK	A0	25-8-99
A4	glass ISO 10110	geometr. tolerances ISO 1101	dimensions: mm	scale: 1 : 1		

IMAGE INTENSIFIER XX1440,XX1940,XX2040

sheet: 1 of 1

183-0685A0 TV

DEP

Image Intensifier Tubes

Performance Level : GEN II
DEP Tube Type : XX1450KT

Format	: 18 mm
Applications	: Analytical/Industrial Instrumentation

General Tube information

: Input Window	Quartz
Output window	Fibre Optic
Magnification	1
Electrical controls	Automatic Brightness Control (ABC) Bright Source Protection (BSP)
Electrical connections	Wires
Useful Cathode Diameter	17.5 mm
Phosphor	P43

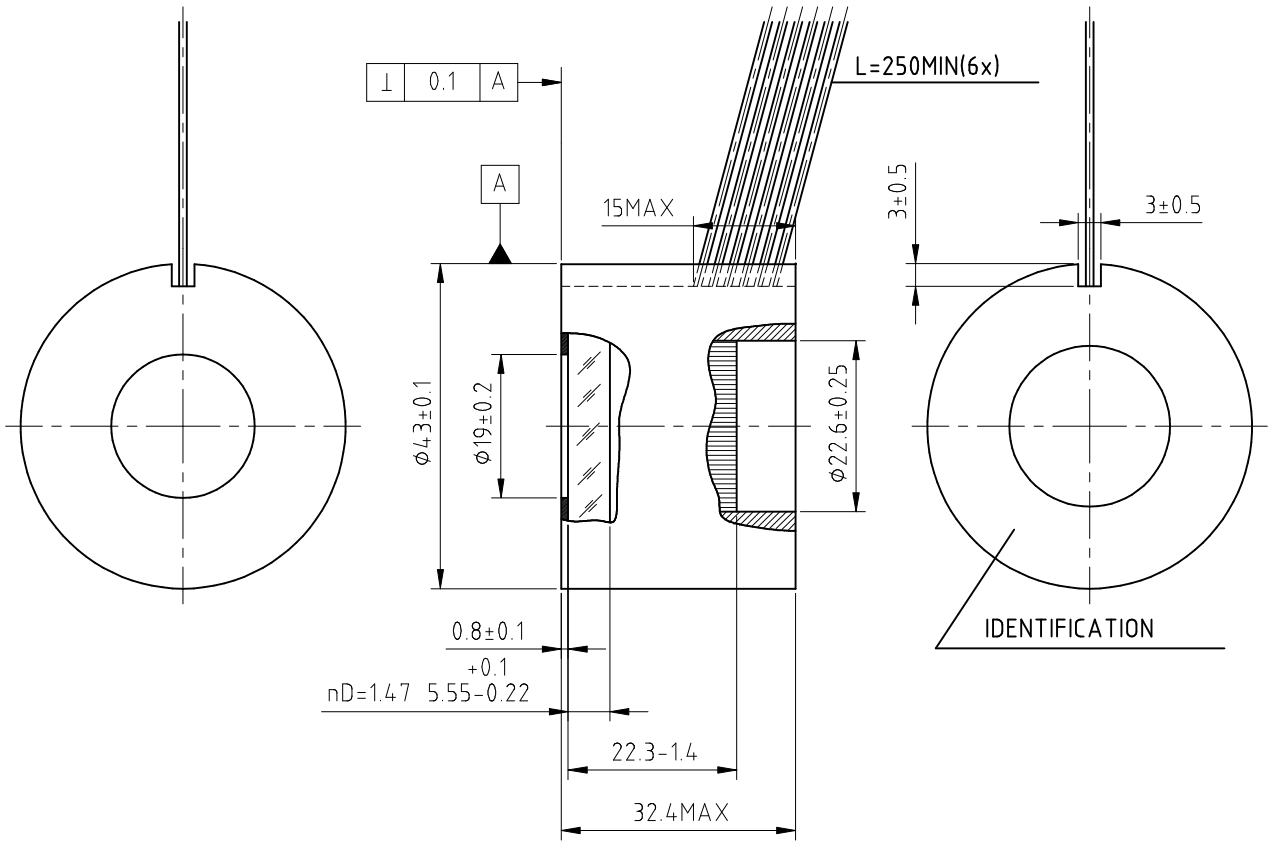
Tube Characteristics

		Typical	Min.	Max.	Unit
Optical	Limiting Resolution	45	40		lp/mm
	Max. output Brightness (MOB)	3	2	4	cd/m^2
	Luminance gain	4000 3180			$cd/m^2/lx$
	EBI	0.01		0.02	µlx
	Radiant Sensitivity at 440 nm	60	50		mA/W
	480 nm	50	45		mA/W
	Non Uniformity			50	%
Electrical	Gateable down to 100ns				
	Operating voltage	2.7	2	3.4	VDC
Environment	Operating temperature	+20	-30	+50	˚C
	Ambient temperature	-30	+20	+45	˚C

The luminance gain of the image intensifier is adjustable by means of an external control voltage from its preset maximum value (typ. 4000 $Cd/m^2/lx$) at V_C=0 V down to a value which is at least a factor of 100 lower at V_C=10 V.

	new	cancelled		new	cancelled
.			.		

NOTE 1:REFERENCE CIRCLE [A] IS THE CYLINDER WITH
THE SMALLEST DIAMETER THAT FITS AROUND
THE PLASTIC HOUSING.
2:RED WIRE = +2,7V DC
BLACK WIRE = -(GROUND)
WHITE WIRE = MCPin
BLUE WIRE = CATH.VOLTAGE FOR CONT. OPERATION
YELLOW WIRE = CATHODE
GREEN WIRE = EGAC



VK

DEP ISO 9001 Certified DELFT ELECTRONIC PRODUCTS BV	ISO 128	screw thread ISO 965	finish ISO 1302	material:	drawn: JK	A0	28-11-95
	A4 glass ISO 10110	geometr. tolerances ISO 1101	dimensions: mm	scale: 1 : 1			
IMAGE INTENSIFIER XX1450,PP0360					sheet: 1 of 1		
					183-0383A0		TV

DEP

Image Intensifier Tubes

Performance Level : GEN II
DEP Tube Type : XX1450XK

Format	: 18 mm
Applications	: Analitical Instrumentation

General Tube information

: Input Window	Quartz
Output window	Fibre Optic
Magnification	1
Electrical controls	External Gain Control (EGAC)
Electrical connections	Wires
Useful Cathode Diameter	17.5 mm
Phosphor	P43

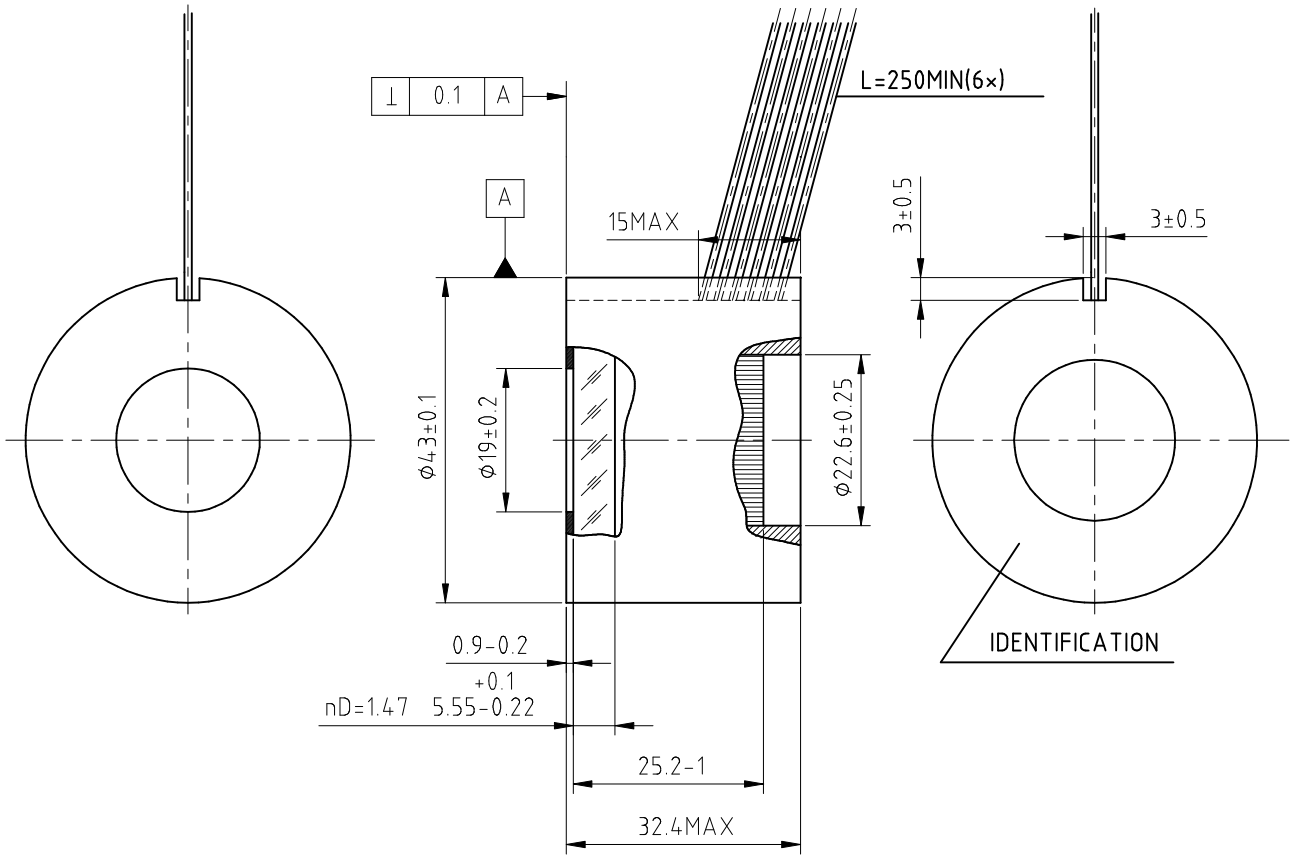
Tube Characteristics

		Typical	Min.	Max.	Unit
Optical	Limiting Resolution	45	40		lp/mm
	Luminance gain		3.180		cd/m^2/lx
	EBI	0.15		0.25	µlx
	Photcathode sensitivity:				
	wite light		380		
	800 nm		33		mA/W
	850 nm		25		mA/W
Electrical	Gateable down to 5ns				
	Operating voltage	2.7	2	3.4	VDC
Environment	Operating temperature	+20	-30	+50	˚C
	Ambient temperature	-30	+20	+50	℃

The luminance gain of the image intensifier is adjustable by means of an external control voltage from its pre-set maximum value (typ. 4000 cd/m^2/lx) at V_C=0 V down to a value which is at least a factor of 100 lower at V_C=10 V.

	new	cancelled		new	cancelled
.			.		

NOTE 1:REFERENCE CIRCLE [A] IS THE CYLINDER WITH
THE SMALLEST DIAMETER THAT FITS AROUND
THE PLASTIC HOUSING.
2:RED WIRE = +2,7V DC
BLACK WIRE = -(GROUND)
WHITE WIRE = MCPin
BLUE WIRE = CATH.VOLTAGE FOR CONT. OPERATION
YELLOW WIRE = CATHODE
ORANGE WIRE = EGAC (0-10V)



VK

DEP ISO 9001 Certified
DELFT ELECTRONIC PRODUCTS BV

ISO 128	screw thread ISO 965	finish ISO 1302	material:	drawn: JK	A0	13-1-98
A4	glass ISO 10110	geometr. tolerances ISO 1101	dimensions: mm	scale: 1 : 1		

IMAGE INTENSIFIER,XX1450,XX1950

sheet: 1 of 1

183-0544A0 TV

DEP

Image Intensifier Tubes

Performance Level : GEN II
DEP Tube Type : XX1450TJ

Format	: 18 mm
Tube Name	:
Format	:
Applications	:

General Tube information : Input Window — Quarts
Output window — Fibre Optic
Magnification — 1
Electrical connections — Wires
Useful Cathode Diameter — 17.5 mm
Phosphor — P43

Tube Characteristics

		Typical	Min.	Max.	Unit
Optical	Limiting Resolution	50	45		lp/mm
	Luminance gain		15000		fL/fc
	Cathode sensitivity :				
	Q.E. at 270 nm		11		%
	Q.E. at 800 nm		1		%
	Q.E. at 850 nm		0.2		%
	Peak Q.E.	14	12		%
	Uniformity (within active area)			10	%
	EBI	0.1	0.2		µlx
Electrical	Gateable down to 5ns				
	Operating voltage	2.7	2	3.4	VDC
	Stripcurrent			13	µA
	Iris delay			1.6	ns
Environment	Operating temperature	+20			˚C

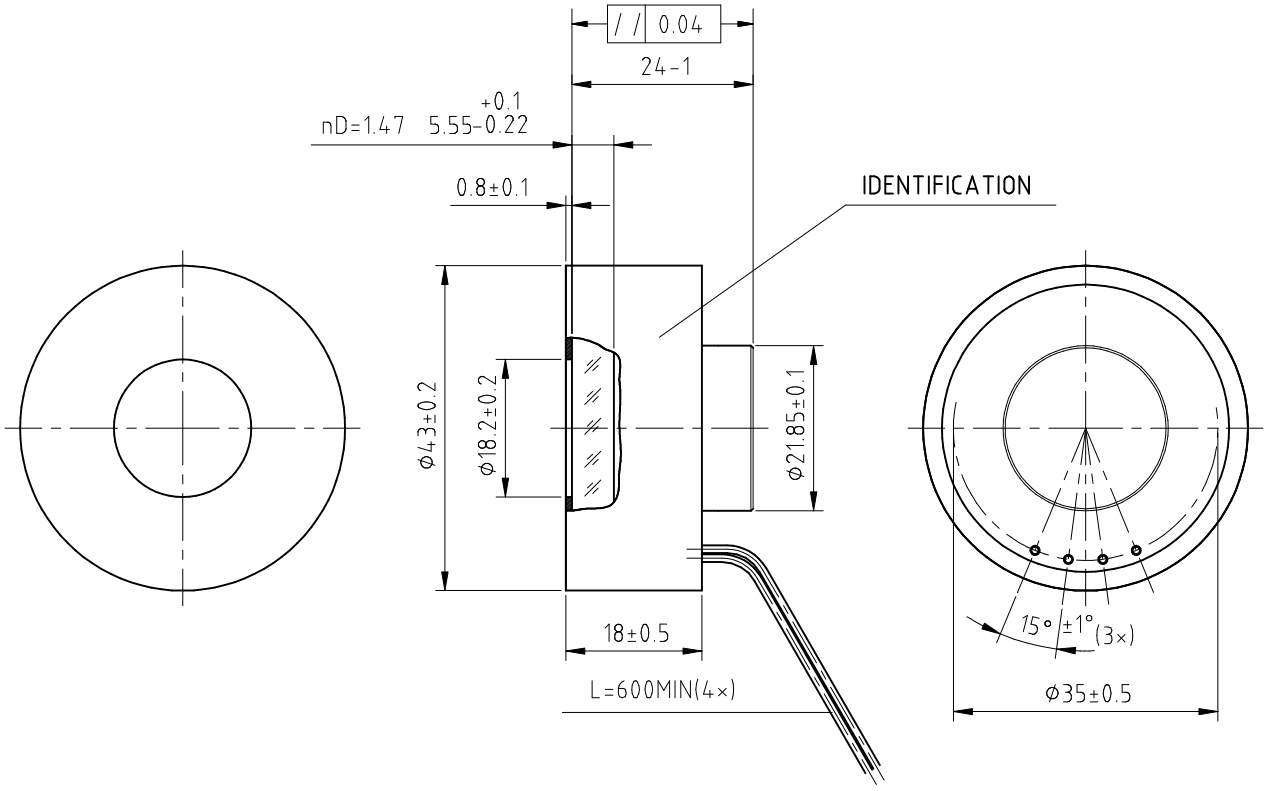
Operating voltages:

	Name	Unit	Maximal	Nominal	Remarks
Anode voltage	V_A	VDC	0		grounded
MCP output voltage	$V_{MCP-OUT}$	-VDC	6000		ref.to anode
MCP input voltage	V_{MCP-IN}	-VDC	*	*	ref.to$V_{MCP-OUT}$
Cath. voltage (on)	V_{C-ON}	-VDC	200		ref. to V_{MCP-IN}
Cath. voltage (off)	V_{C-OFF}	+VDC	40		ref. to V_{MCP-IN}

* The value that matches the mentioned gain and the maximum value will be indicated on the test sheet.

	new	cancelled		new	cancelled
.			.		

VK



NOTE: BLUE WIRE = CATHODE
RED WIRE = MCPin
BLACK WIRE = MCPout
YELLOW WIRE = ANODE

DEP ISO 9001 Certified
DELFT ELECTRONIC PRODUCTS BV

ISO 128	screw thread ISO 965	finish ISO 1302	material:	drawn: JK	A0	17-3-95
A4	glass ISO 10110	geometr. tolerances ISO 1101	dimensions: mm	scale: 1 : 1		

IMAGE INTENSIFIER XX1450,XX1950

sheet: 1 of 1

183-0319A0 TV

DEP

Image Intensifier Tubes

Performance Level : XD-4™
DEP Tube Type : XX2050AH

Format	: 18 mm
Tube Name	: fat Anvis

General Tube information

: Input Window	Glass
Output Window	Non-Inverting Fibre Optic
Magnification	1
Electrical controls	Automatic Brightness Control (ABC) Bright Source Protection (BSP) External gain control.
EMC	proof
Electronic connections	contacts
Weight	98 grams
Useful Cathode Diameter	17.5 mm
Phosphor	P20

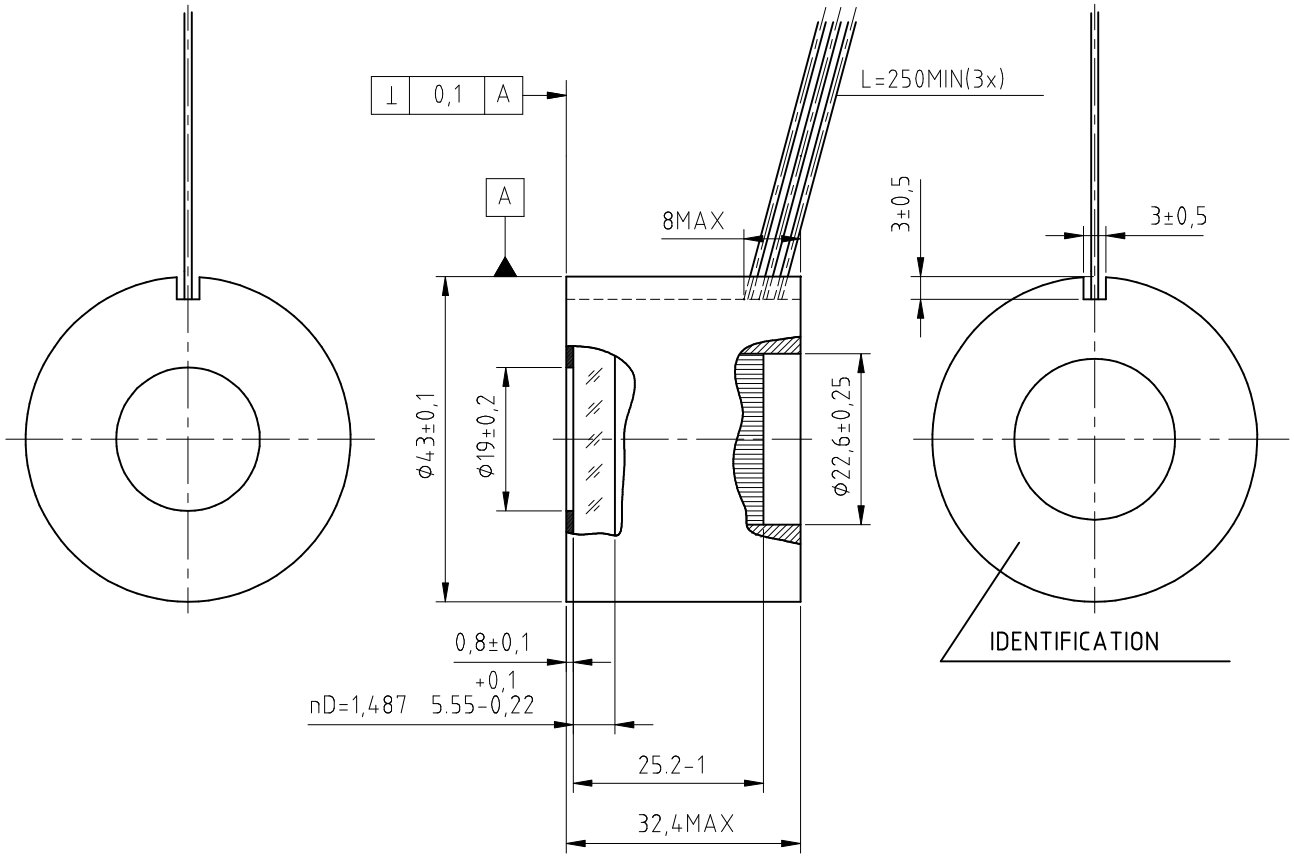
Tube Characteristics

		Typical	Min.	Max.	Unit
Optical	Limiting Resolution	58	55		lp/mm
	Modulation Transfer Function				
	2.5 lp/mm	92			%
	7.5 lp/mm	80			%
	15 lp/mm	58			%
	25 lp/mm	38			%
	30 lp/mm	30			%
	Signal to noise	20	17		
	Gain at $2x10^{-6}$ fc		21.980		fL/fc
	Max. Output Brightness (MOB)	12.5	10	13.6	cd/m^2
	EBI	0.15		0.25	µlx
	Luminous Sensitivity at 2850K	700	600		
	Radiant Sensitivity at 800 nm	60	50		mA/W
	850 nm	50	40		mA/W
Electrical	Operating Voltage	2.7	2.0	3.8	V
	Input Current			22	mA
Environment	Operating temperature		-45	+52	˚C
	Storage temperature		-51	+65	˚C

The luminance gain of the image intensifier is adjustable by means of an external control voltage from its pre-set maximum value (typ. 7500 $cd/m^2/lx$) at V_C=0 V down to a value which is at least a factor of 100 lower at V_C=10 V.

	new	cancelled		new	cancelled
.			.		

NOTE 1:REFERENCE CIRCLE [A] IS THE CYLINDER WITH
THE SMALLEST DIAMETER THAT FITS AROUND
THE PLASTIC HOUSING.
2:RED WIRE = +2,7V DC
BLACK WIRE = -(GROUND)
GREEN WIRE = EGAC



VK

DELFT ELECTRONIC PRODUCTS BV

ISO 128	screw thread ISO 965	finish ISO 1302	material:	drawn: JK	A0	6-5-97
A4 / glass ISO 10110	geometr. tolerances ISO 1101	dimensions: mm	scale: 1 : 1			

IMAGE INTENSIFIER XX1950, XX2050

sheet: 1 of 1

183-0487A0 TV

DEP

Image Intensifier Tubes

Performance Level : XD-4™
DEP Tube Type : XX2050F

Format	: 18 mm
Tube Name	: fat ANVIS

General Tube information

: Input Window	Glass
Output Window	Non-Inverting Fibre Optic
Magnification	1
Electrical controls	Automatic Brightness Control (ABC), Bright Source Protection (BSP), Gating and External gain control.
EMC	proof
Electronic connections	flyng leads
Weight	98 grams
Useful Cathode Diameter	17.5 mm
Phosphor	P20

Tube Characteristics

		Typical	Min.	Max.	Unit
Optical	Limiting Resolution	58	55		lp/mm
	Modulation Transfer Function				
	2.5 lp/mm	92			%
	7.5 lp/mm	80			%
	15 lp/mm	58			%
	25 lp/mm	38			%
	30 lp/mm	30			%
	Signal to noise (@108 µlx)	24	20		
	Gain at $2x10^{-6}$ fc		30.000	40.000	fL/fc
	Life time	15.000			hrs
	Max. Output Brightness (MOB)	3	2	4	cd/m^2
	EBI	0.15		0.25	µlx
	Output Uniformity at 2850K	2:1		3:1	
	Luminous Sensitivity at 2850K	700	600		
	Radiant Sensitivity at 800 nm	60	50		mA/W
	850 nm	50	40		mA/W
Electrical	Operating Voltage	2.7	2.0	3.8	V
	Input Current			22	mA
	Gateble down to	10	100		ns
Environment	Operating temperature		-45	+52	˚C
	Storage temperature		-51	+65	˚C

The luminance gain of the image intensifier is adjustable by means of an external control voltage from its preset maximum value (typ. 10.000 $cd/m^2/lx$) at V_C=0 V down to a value which is at least a factor of 100 lower at V_C=10 V.

	new	cancelled		new	cancelled
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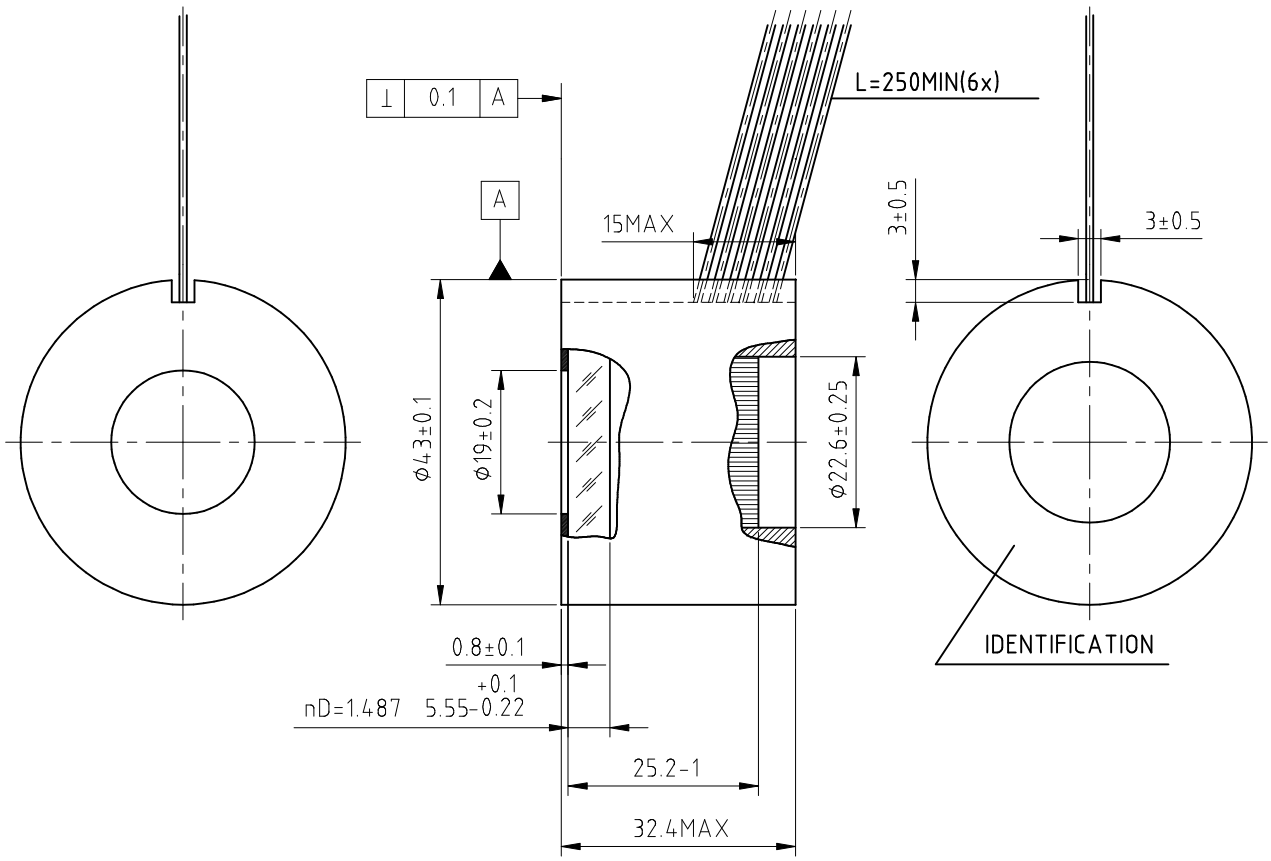
NOTE 1:REFERENCE CIRCLE [A] IS THE CYLINDER WITH
THE SMALLEST DIAMETER THAT FITS AROUND
THE PLASTIC HOUSING.
2:RED WIRE = +2.7V DC
BLACK WIRE = -(GROUND)
WHITE WIRE = MCPin
BLUE WIRE = CATH.VOLTAGE FOR CONT. OPERATION
YELLOW WIRE = CATHODE
GREEN WIRE = EGAC



VK

DEP ISO 9001 Certified
DELFT ELECTRONIC PRODUCTS BV

ISO 128	screw thread ISO 965	finish ISO 1302	material:	drawn: JK	A0	1-2-93
A4 glass ISO 10110	geometr. tolerances ISO 1101	dimensions: mm	scale: 1 : 1		A1	22-11-93

IMAGE INTENSIFIER XX1450,XX1451,XX1950,XX2050

sheet: 1 of 1

183-0148A1 TV