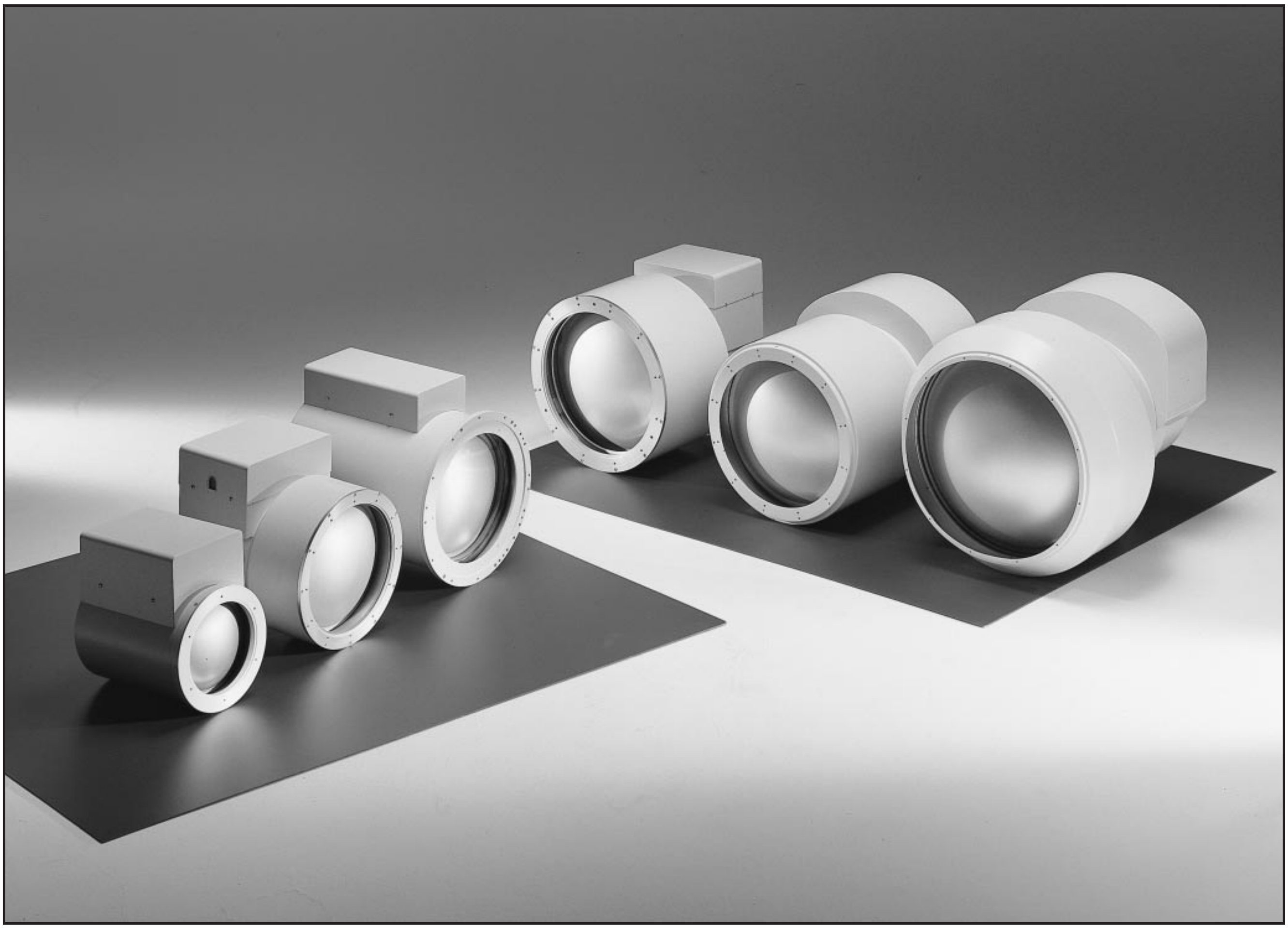
HAMAMATSU

X-RAY IMAGE INTENSIFIERS

High DQE • Excellent Image Quality • High Contrast



An X-ray image intensifier is a large image tube that converts a low intensity X-ray image into a visible image. It is used for medical X-ray TV systems, X-ray nondestructive inspection systems, etc.

With a photonic R&D background over 40 years, Hamamatsu is engaging in the production and sale of high sensitivity, high image quality X-ray image intensifiers. The image quality is worthy of receiving good reputations.

Hamamatsu now offers improved models of X-ray image intensifiers with even higher DQE (detection quantum efficiency) and higher quality images thanks to our newly developed Cs-I input phosphor screen. An aluminum input window and improvements in the output phosphor screen also allow high contrast images. These improved X-ray image intensifiers therefore provide high spatial resolution, ensuring dramatically clear and sharp images even of microstructures in stomach mucous membrans which up until now have only been visible with conventional sensitized film photography. In addition to improved input and output phosphor screens, the electron lens system designed by computer simulation techniques offers excellent image quality compatible with digital image processing. Hamamatsu provides various models of X-ray image intensifiers ranging in size from 6 to 16 inch diameter.

FEATURES

High Image Quality

Even higher image quality is realized by using a high-density input phosphor screen with a superfine, needle-like structure Csl crystal layer.

Configuration and Operational Principle

An X-ray image intensifier is a large image tube that converts a low intensity X-ray image into a visible image. X-rays incident on an X-ray image intensifier are transmitted through an aluminum metal input window with high X-ray transmittance and less scattering. They are then absorbed by an input phosphor screen (ultra-fine needle-like cesium iodide crystal) and converted into a light image. On the inner surface of the input phosphor screen, a photocathode is formed, where the light image is converted into a photoelectron image. The photoelectron image is then accelerated and focused by an electric lens (electric field) consisting of an input window, focused electrodes and an anode to collide with an output phosphor screen. The output phosphor screen then, again, converts this photoelectron into a visible light image. Since the photoelectron image is condensed by the electric lens to increase the density of electrons and simultaneously accelerated by a high electric field to collide with the output phosphor screen, the output image is approximately ten-thousandfold brighter than it would be obtained when the phosphor screen is placed at the input surface position of the X-ray image intensifier. Although the electron lens is an important factor of determining the quality of resolution, the Hamamatsu X-ray image intensifier uses a 5-electrode electron lens system having a precisely calculated and designed electron trajectories, thus giving rise to a high resolution. Hamamatsu X-ray image intensifiers are available in size from 6 to 16 inch diameter, including variable field-of-view types (zooming types) that capture more detailed information on microstructures. Each model is housed in an X-ray and magnetic shielded case along with a high voltage power supply.

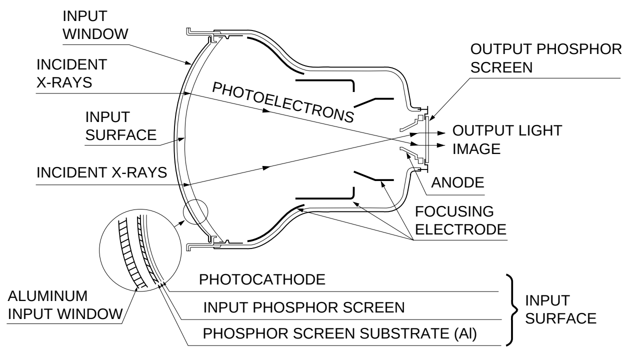


Figure 1: Construction and Operation of X-ray Image Intensifier

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CsI Input Phosphor Screen

The most influential on the signal-to-noise (S/N) ratio of the X-ray image intensifier is the X-ray absorption coefficient of the input phosphor screen. The input phosphor screen uses cesium iodide (CsI) and is structured as shown in Figure 2. As Figure 2(a) shows, if the cesium iodide is thin, many X-rays easily transmit through it without conversion into light. However, the mere use of thick cesium iodide is not enough to prevent that problem, because light generated by incident X-rays scatters in the cesium iodide, resulting in degraded levels of resolution and contrast. To eliminate the horizontal scattering of light in the cesium iodide, Hamamatsu has developed ultra-fine needle-like cesium iodide of optical fiber structure with double the conventional thickness. See Figure 2(b). By the same token, an extremely high-sensitivity photocathode, the fruit of Hamamatsu's long R&D, is formed on the cesium iodide. This newly developed input phosphor screen provides a high DQE while enhancing the levels of both resolution and contrast.

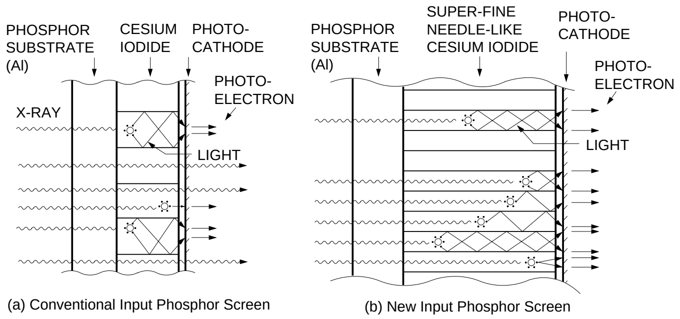

Figure 2: Construction of Input Phosphor Screen

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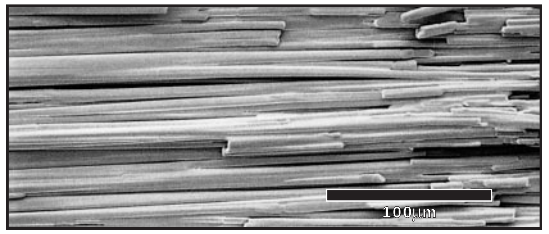

Photo: Electron Microscope Photograph of CsI Input Phosphor Screen

Output Phosphor Screen

To obtain a higher resolution, Hamamatsu uses a phosphor consisting of very fine, uniform particles for the output phosphor screen.

In addition, structural improvement has been provided to obtain a higher contrast. As Figure 3(a) shows, the output phosphor screen of conventional X-ray image intensifiers is double structured with an output phosphor screen glass plate and a vacuum glass bulb, and light scattering by this double glass structure has been a major factor of contrast deterioration. As Figure 3(b) shows, the improved models have an output phosphor screen placed in direct contact with a vacuum glass bulb to significantly reduce the light scattering, thus dramatically enhancing the contrast of fine image parts.

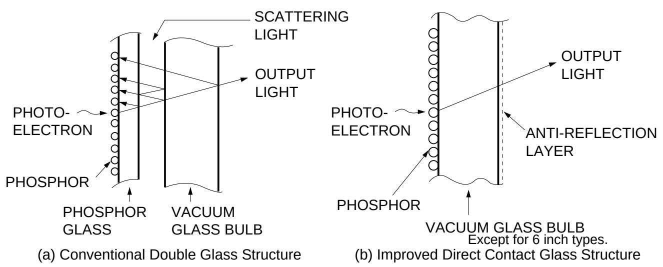

Figure 3: Construction of Output Phosphor

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Testing Conditions

Note: Test items 1 to 5 are measured with an X-ray source placed at a distance of 1 meter from the input surface of the X-ray image intensifier.

1. Input Surface Field-of-view size

This is the diameter of the field-of-view when a grid chart is positioned on the input surface of the X-ray image intensifier.

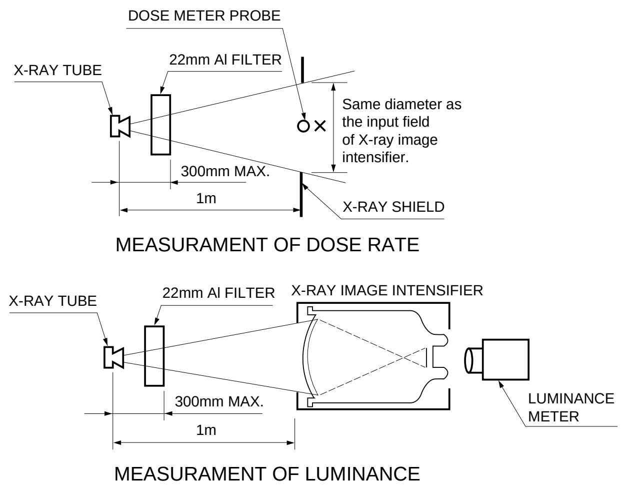
2. Limiting Resolution

A 0.1 mm thick lead or tungsten X-ray resolution chart is placed in intimate contact with the input surface of an image intensifier. Visual observations of the output image are made with a magnifying lens to determine how many line pairs (black-white striped pairs) per millimeter can be discerned from the chart. For this measurement, the X-ray tube voltage and current are adjusted to 40 to 50 kVp and 0.3 to 1.2 mA.

3. Conversion Factor (Gx)

The ratio of the luminance at the output phosphor screen (cd/m^2) to the X-ray dose rate at the input surface (μC/kg • s or mR/s)*. For this measurement, the incident X-ray quality is specified as a 7mm aluminum half-value-layer with a 22 mm aluminum filter (with an X-ray tube voltage of 75 kVp).

$$Gx = \frac{\text{Output Image Luminance}}{\text{Input X-ray Dose Rate}} \left(\frac{cd/m^2}{\mu C/kg \cdot s} \text{ or } \frac{cd/m^2}{mR/s} \right)$$



$*1\ (c/kg \cdot s) = \frac{1}{2.58} \times 10^4\ (R/S)$

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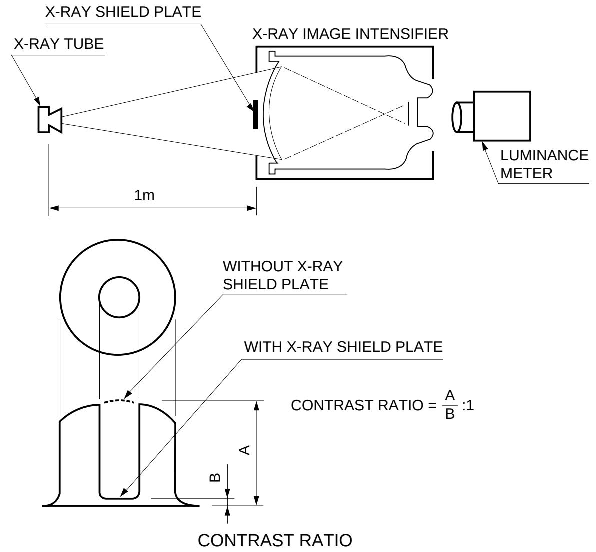
4. Contrast Ratio

A circular X-ray shield plate with a diameter equal to 10% of the effective input area and 10 mm in diameter is placed in intimate contact with the image intensifier input surface at the center. The contrast is expressed as the ratio of the output luminance with an X-ray shield in place to the luminance at the same point with the shield removed. For this measurement, the X-ray tube voltage and current are set to 50 kVp and 0.5 to 2.0mA.



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5. Distortion

The pin-cushion distortion is defined as the difference between the magnification raio of the image at the input surface center and at the periphery as follws:

$$\text{Distortion} = \frac{M_{90} - M_0}{M_0} \times 100\ (\%)$$

where M_0 is the magnification in 1mm diameter area in the center, and M_{90} is the magnification at a point of 90% of the input surface filed-of-view from the center.

6. DQE (Detection Quantum Efficiency)

By obtaining the S/N ratio for input and output signals of an X-ray image intensifier using gamma rays (^{241}Am at 59.5 keV), DQE is defined as follows:

$$\text{DQE} = \frac{(S/N)^2_{OUT}}{(S/N)^2_{IN}} \times 100\ (\%)$$

Hamamatsu uses the photon counting method to measure DQE. Unlike conventional bandpass filtering thchniques, this method ensures reliable values not dependent on the frequency bandwidth.

7. Background

The background is the luminance of a phosphor screen under operating conditions with the X-ray turned off.

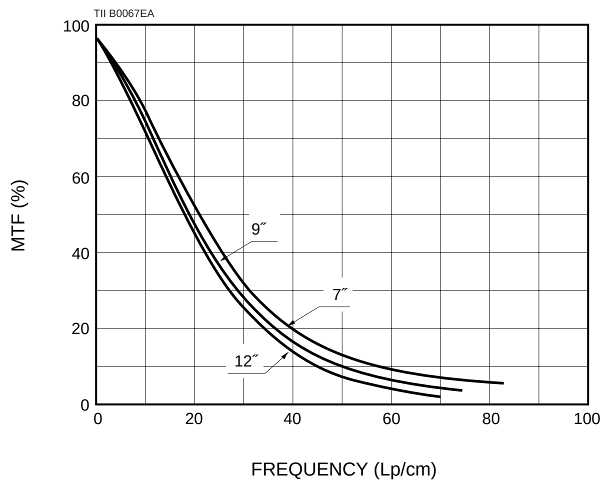
8. Measurement Instruments

Dose Meter: Victoreen Model 500
Luminance Meter: Spectra Pritchard Photometer, Photo Research Model 1980

Type No.	Features	Input Window: Effective Diameter Typ. (mm)	Input Window: Detecting Phosphor Screen Material	Input Window: Window Material / Thickness	Output Window: Effective Diameter Min. (mm)	Output Window: Viewing Phosphor Screen Material	Output Window: Window Material	Typical Supply Voltage (Vac ± 10 %)	Limiting Resolution: Center Typ. (Lp/cm)	Conversion Factor Gx: Typ. (cd/m² / µC/kg•s)	Conversion Factor Gx: Typ. (cd/m² / mR/s)	Contrast Ratio Typ.	DQE Typ. (%)	Distortion Typ. (%)	Weight Typ. (kg)	Type No.
6-inch Type																
V3732P	Dual Field Type (6”-4”)	150	CsI	Al 1mmt	14.5 ± 0.5	P-20	Borosilicate Glass	100 (50/60 Hz)	46	700	180	20:1	60	5	12.5	**V3732P**
		105							60	—	—	—		—		
9-inch Type																
V2465P	Triple Field Type (9”-6”-4.5”)	213	CsI	Al 1mmt	20.0 ± 0.5	P-20	Borosilicate Glass	100 (50/60 Hz)	44	1400	350	25:1	60	5	20	**V2465P**
		155							50	—	—	—		—		
		115							60	—	—	—		—		
V5914P	Single Field Type	220	CsI	Al 1mmt	20.0 ± 0.5	P-20	Borosilicate Glass	100 (50/60 Hz)	44	1100	280	25:1	60	5.5	20	**V5914P**
12-inch Type																
V3733P	Triple Field Type (12”-9”-7”)	293	CsI	Al 1mmt	62.0 ± 0.5	P-20	Borosilicate Glass	100 (50/60 Hz)	70	180	45	35:1	60	10	37	**V3733P**
		235							75	—	—	—		—		
		185							83	—	—	—		—		
16-inch Type																
V5213P	Quadruple Field Type (16”-12”-9”-7”)	360	CsI	Al 1mmt	62.0 ± 0.5	P-20	Borosilicate Glass	100 (50/60 Hz)	55	250	65	35:1	60	14.5	53	**V5213P**
		293							65	—	—	—		—		
		235							70	—	—	—		—		
		185							80	—	—	—		—		

Figure 4: Spatial Modulation Transfer Function (MTF) (at Center)

V3733P



V5213P

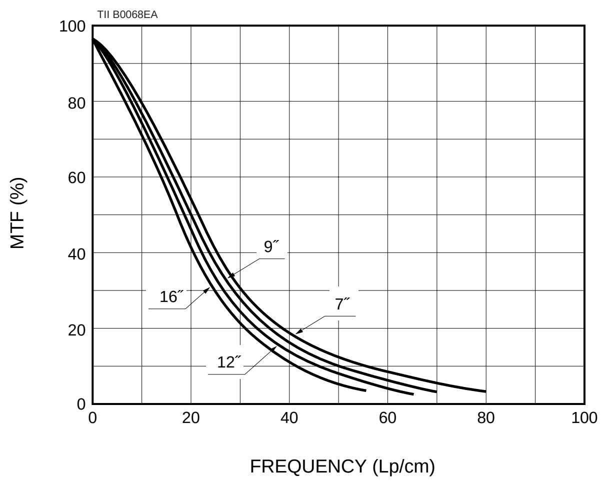


Figure 5: Phosphor Decay Characteristics

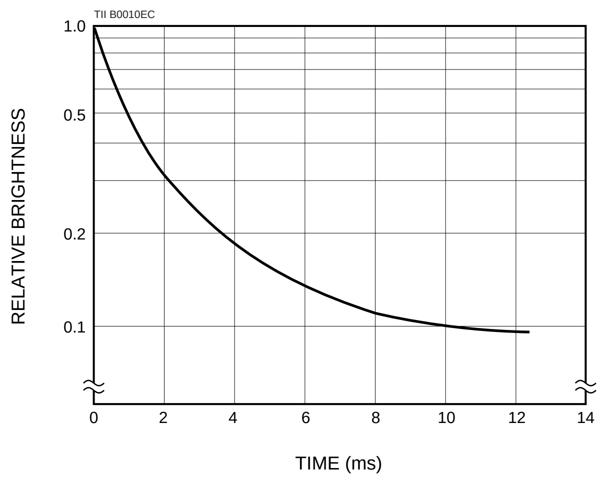
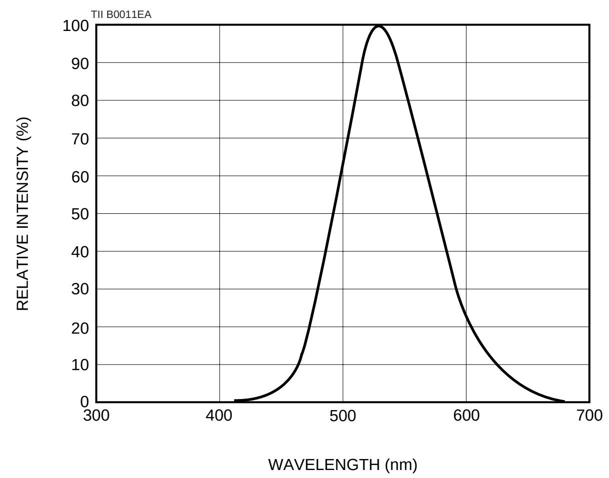
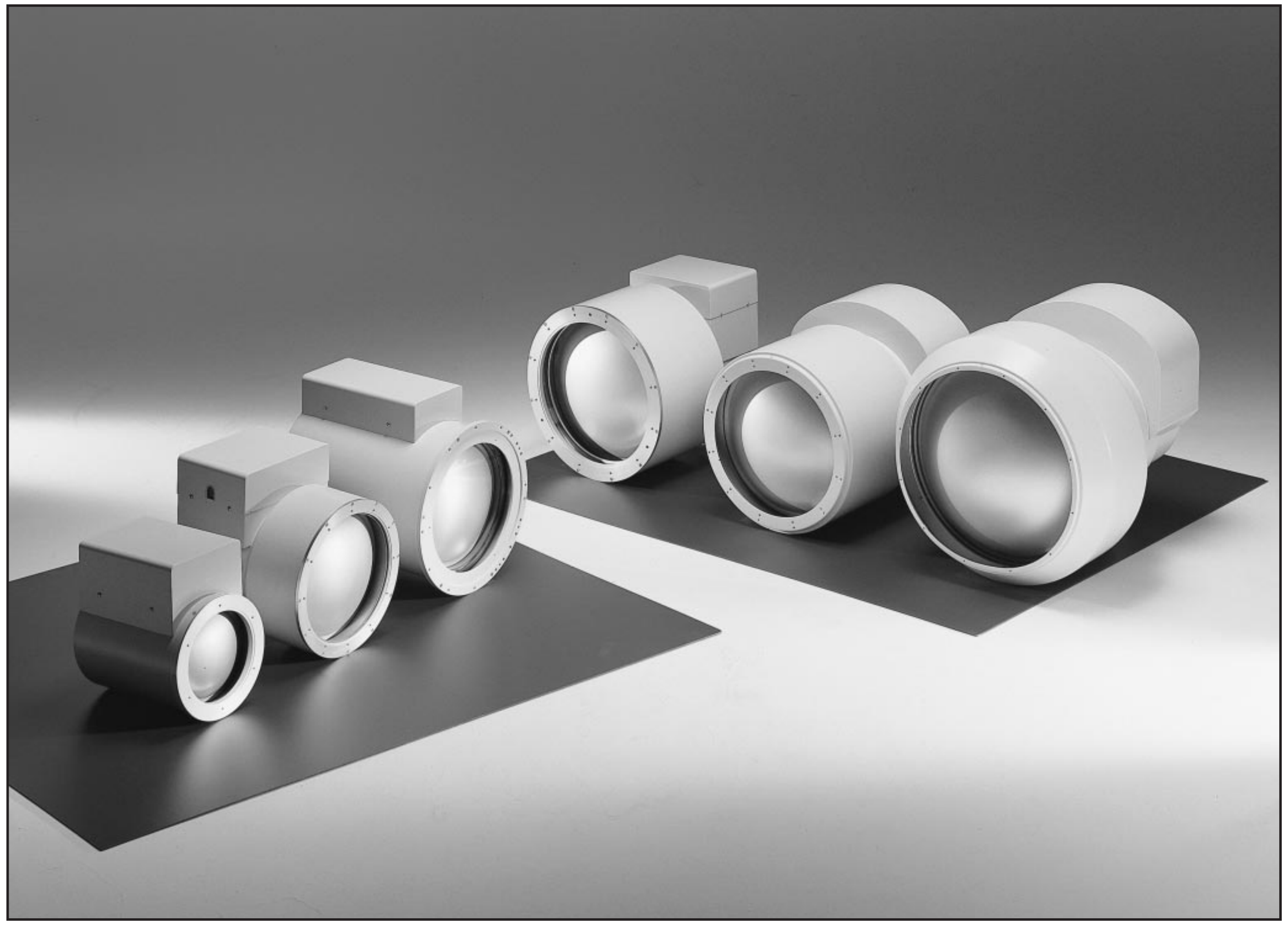


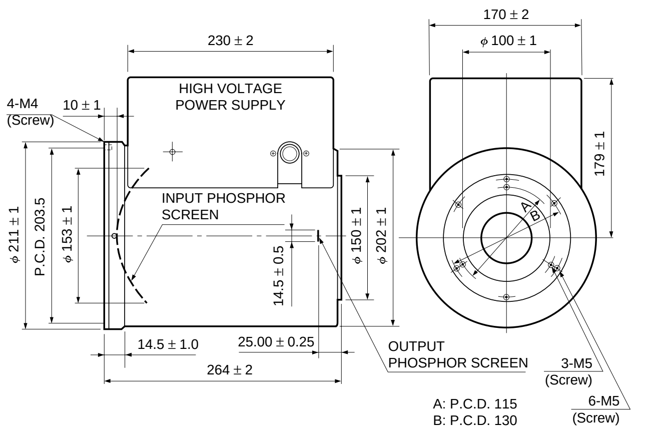
Figure 6: Phosphor Spectral Emission (P-20)





Dimensional Outlines (Unit: mm)

V3732P



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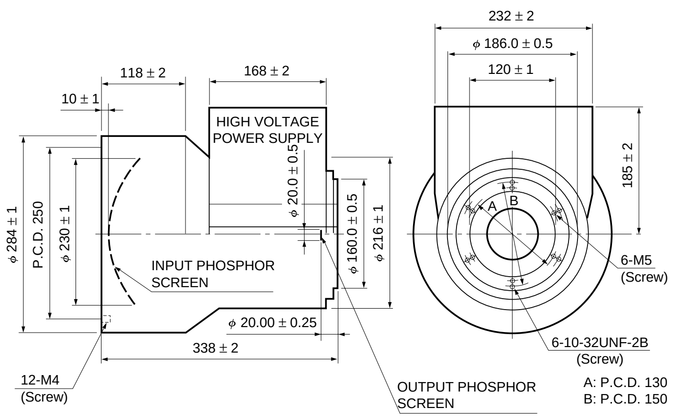
V2465P



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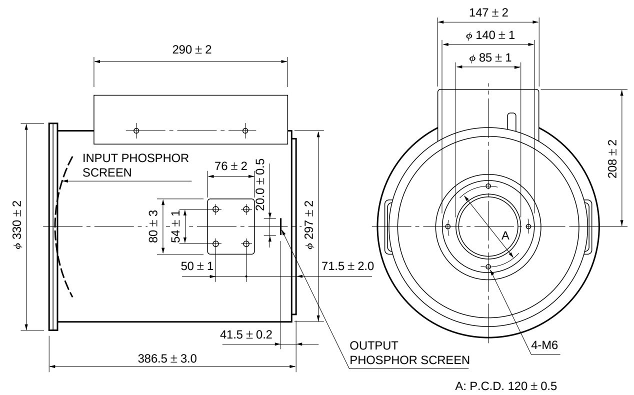
V5914P



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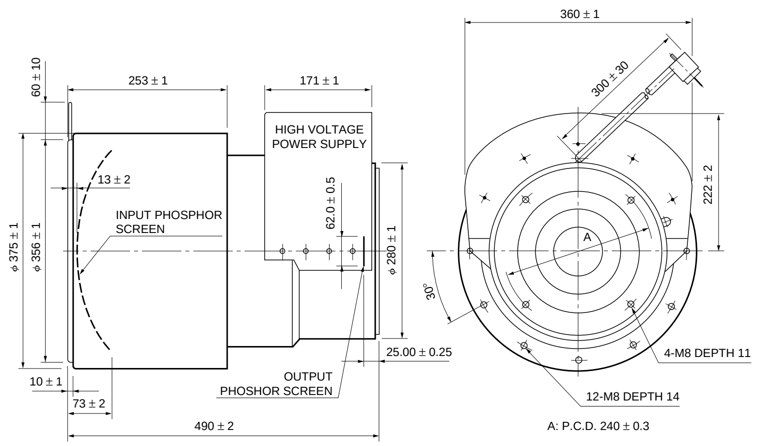
V3733P



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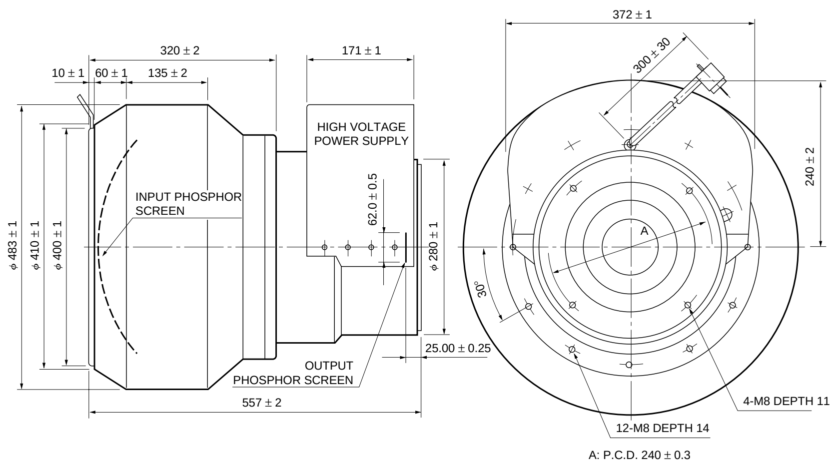
V5213P



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X-RAY IMAGE INTENSIFIERS

CAUTIONS

An X-ray image intensifier is a glass vacuum tube. This glass tube can easily break if damaged or if shock is applied. Please use caution and wear a protective mask when handling this tube.

The output window is optically clean and should never be touched with bare hands.

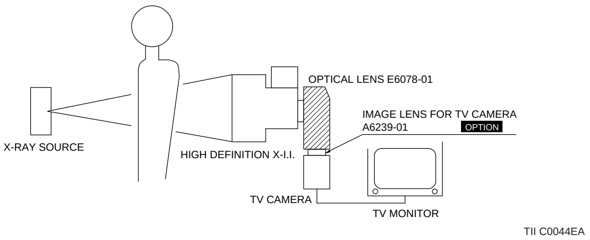
An X-ray image intensifier uses high voltage (25-30 kV). Never open the case and touch the inside with the hands to avoid electrical shock. Also use caution concerning the ambient temperature and humidity.

WARRANTY

Hamamatsu X-ray image intensifiers are warranted for one year from date of purchase or 1,000 hours of operation, whichever comes first.
This warranty is limited to product replacement within the warranty period. This warranty does not cover damage caused by natural disaster, operational error or exceeding the various ratings. Please ask our sales office for further details.

OPTION

E6078-01 is optical lens unit and exclusively designed for the high defintion X-ray Image Intensifier (V3733P and V5213P) to make an image transfer from the tube to a camera-unit effectively.



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