HAMAMATSU

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Ruggedized High Temperature Photomultiplier Tubes

Introduction

This catalog provides the latest information for Hamamatsu ruggedized high temperature photomultiplier tubes ranging in diameter from 13 mm (1/2") to 51 mm (2"). All listed tubes employ high temperature bialkali photocathode that feature stable operation and long life at temperatures up to 90 °C, 175 °C or 200 °C. The electrode supporting structures have been designed so that tubes can be used in severe environments such as those found in oil well logging, geological exploration, and aerospace applications.
We offer a wide variety of complete assemblies of tubes, sockets, voltage dividers and tube shields which have been quality tested to assure reliable operation.

Applications

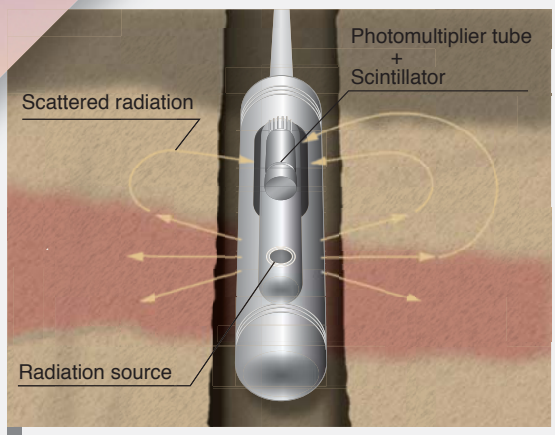
Oil well logging

Geological exploration

Gauge meter

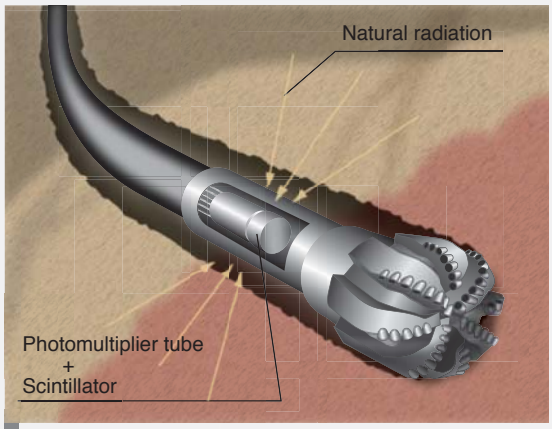
Aerospace research

Oil well logging



Wireline

Measuring scattered radiation in the stratum.



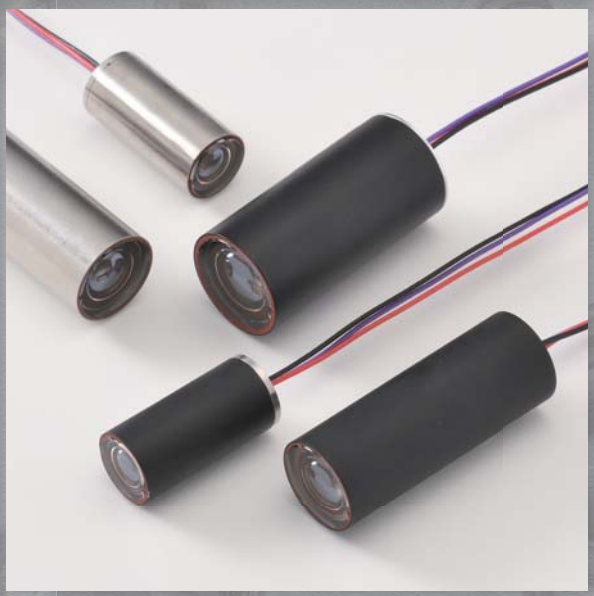
MWD (Measurement While Drilling)
LWD (Logging While Drilling)

Measuring natural radiation inside the rock of the stratum.

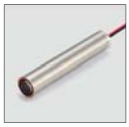
Contents

Index by type number

We select photomultiplier tubes with optimal sensitivity to match your application and operating conditions. We can also design and assemble custom products and devices.



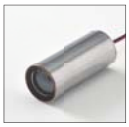
Standard types (Glass tubes)

Diameter	Maximum shock *1	Maximum sine vibration *2	Maximum operating temperature	Temporary base	Button stem	Assembly	Product photos
ϕ13 mm (1/2")	5000 m/s² (500 G)	200 m/s² (20 G)	90 °C	R4177-04	R4177-06	R4177-28	 R4177 / -04  R4177-27 / -28
			175 °C	R4177	R4177-01	R4177-27	 R4177-01 / -06
ϕ19 mm (3/4")	10000 m/s² (1000 G)	300 m/s² (30 G)	90 °C	R3991A-04		R3991A-08 R3991A-28	 R3991A / -04 R3991AH  R3991A-07 / -08
			175 °C	R3991A		R3991A-07 R3991A-27 R3991A-31	 R3991AH-07
			200 °C	R3991AH		R3991AH-07 R3991AH-27 R3991AH-31	 R3991A-27 / -28 / -31 R3991AH-27 / -31
ϕ25 mm (1")	10000 m/s² (1000 G)	300 m/s² (30 G)	90 °C	R1288A-04	R1288A-06	R1288A-08 R1288A-28	 R1288A / -04  R1288A-07 / -08
			175 °C	R1288A	R1288A-01	R1288A-07 R1288A-27 R1288A-31	 R1288AH  R1288AH-07
			200 °C	R1288AH		R1288AH-07 R1288AH-27 R1288AH-31	 R1288A-01 / -06  R1288A-27 / -28 / -31 R1288AH-27 / -31
ϕ28 mm (1-1/8")	5000 m/s² (500 G)	200 m/s² (20 G)	90 °C	R6877A-04	R6877A-06	R6877A-08 R6877A-28	 R6877A / -04  R6877A-07 / -08
			175 °C	R6877A	R6877A-01	R6877A-07 R6877A-27 R6877A-31	 R6877A-01 / -06  R6877A-27 / -28 / -31

Standard types (Glass tubes)

Diameter	Maximum shock *1	Maximum sine vibration *2	Maximum operating temperature	Temporary base	Button stem	Assembly	Product photos
φ38 mm (1-1/2")	5000 m/s² (500 G)	200 m/s² (20 G)	90 °C	R9722A-04	R9722A-06	R9722A-28	 R9722A / -04  R9722A-27 / -28
			175 °C	R9722A	R9722A-01	R9722A-27	 R9722A-01 / -06
φ51 mm (2")	5000 m/s² (500 G)	200 m/s² (20 G)	90 °C		R4607A-06	R4607A-28	 R4607A-01 / -06  R4607A-27 / -28
			175 °C		R4607A-01	R4607A-27	

Highly ruggedized types (Ceramic tubes)

Diameter	Maximum shock *1	Maximum sine vibration *2	Maximum operating temperature	Temporary base	Button stem	Assembly	Product photo
φ19 mm (3/4")	10000 m/s² (1000 G)	500 m/s² (50 G)	175 °C			R8874-01	 R8874-01
φ25 mm (1")	10000 m/s² (1000 G)	400 m/s² (40 G)	175 °C			R13788-01	 R13788-01

Only initial production tubes are tested for these shock and vibration tests.
Test conditions are as follows:
*1 Shock tests: 0.5 ms, 3 impact shocks/direction (6 directions)
*2 Vibration tests: 50 Hz to 2000 Hz, 1 octave/min, 3 sweeps/axis (3 axes)

Test criteria are as follows:

Cathode luminous sensitivity deviation	Less than ±10 %
Anode luminous sensitivity	Less than ±25 %
Anode dark current	Less than 10 times
Visual inspection	Good

Photomultiplier tubes whose type number is shown in **blue** undergo a sine-wave vibration screening test to guarantee operation under vibration. If guaranteed operation under vibration is required, use a photomultiplier tube whose type number is shown in blue in the “Quick reference” table.
Highly ruggedized types (Ceramic tubes) are designed specifically for MWD (Measurement While Drilling) applications. Their operation is guaranteed even under vibration so no sine-wave vibration screening test is performed. (See page 8 for measurement method.)

Sine-wave vibration screening test method for MWD application

The sine-wave vibration screening test is performed by reducing the acceleration from the maximum level by 100 m/s2 (10 G) taking into account the PMT service life. (See Figure 1 for details.)

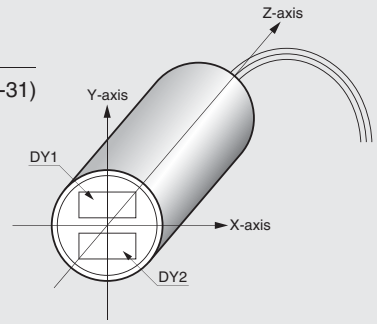
Figure 1 **Sine-wave vibration screening test block diagram for R1288A-31, R1288AH-31, R3991A-31, R3991AH-31, R6877A-31 and an example test data**

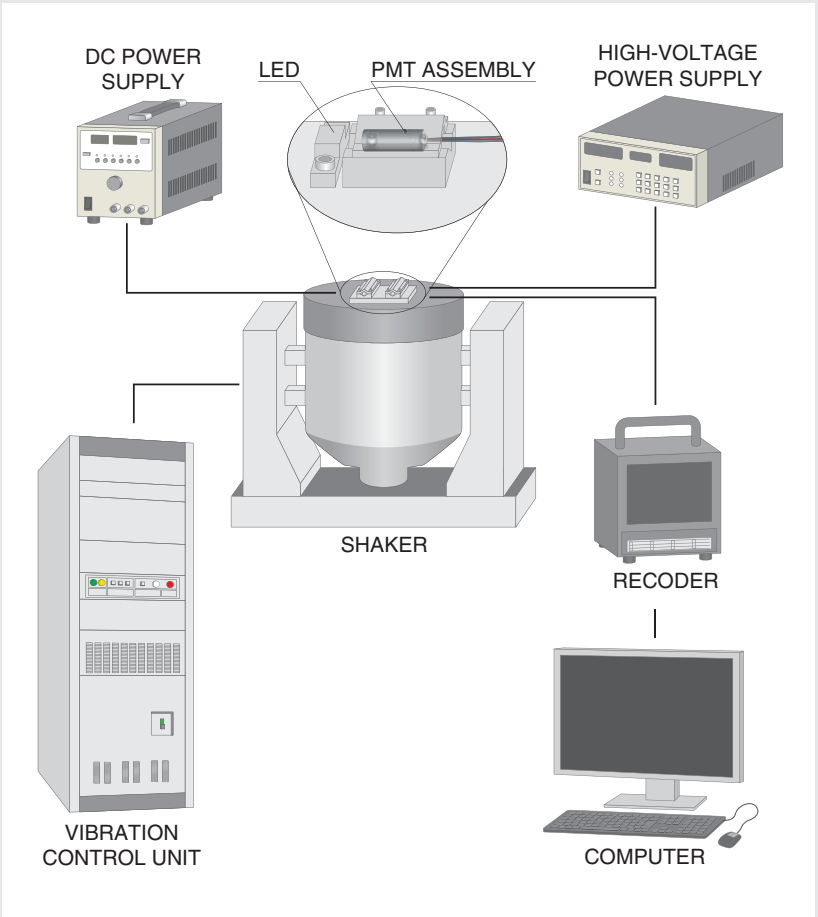
<Screening condition>

Vibration	: Sine wave 200 m/s^2 (20 G) (R1288A-31, R1288AH-31, R3991A-31, R3991AH-31) Sine wave 100 m/s^2 (10 G) (R6877A-31)
Frequency	: 50 Hz to 2000 Hz
Sweep time	: 1 octave/min, 1 sweep/axis (3 axes)
Supply voltage	: -1500 V
Anode output current	: Approx. 2 µA (DC)

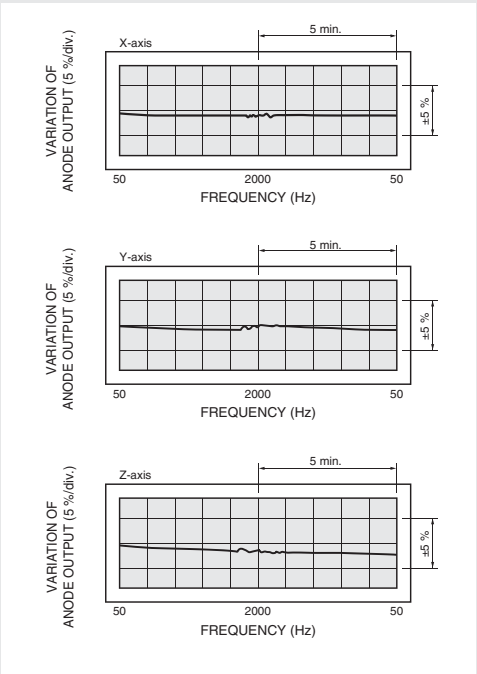
<Judgement>

Anode output variation during the screening test: less than ±5 %





Test data attached prior to shipping



Description for the notes in the following product page:

NOTE 1

① Temperature cycling tests are performed for all 175 °C and 200 °C type tubes. See Figure 2.
② A socket will be supplied with a tube. (Assembly type is excluded.)
③ Screening tests are performed on all R1288A-31, R1288AH-31, R3991A-31, R3991AH-31, R6877A-31 tubes. See Figure 1 on page 8.
④ The voltage distribution ratios are shown in the bottom table of each page.
⑤ Averaged over any interval of 30 s Max..
⑥ These voltages are applied when the anode sensitivity and characteristics are measured.
⑦ The light source is a tungsten filament lamp operated at a distribution temperature of 2856 K.
The light input is 0.01 lm and 150 V are applied between the cathode and all other electrodes connected together as anode.
In the case of blue sensitivity, a blue filter is interposed between the light source and the tube. See Figure 3.
⑧ The light source is a tungsten filament lamp operated at a distribution temperature of 2856 K.
⑨ Measured after 30 min storage in darkness.

NOTE 2

In use of this assembly at +HV potential, the load resistor (R_L) and the high-voltage resistant capacitor (C) must be wired as follows:

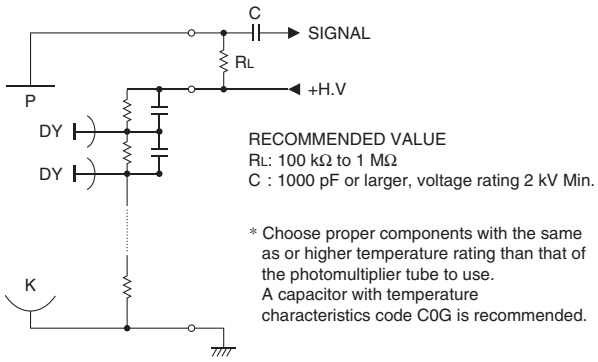
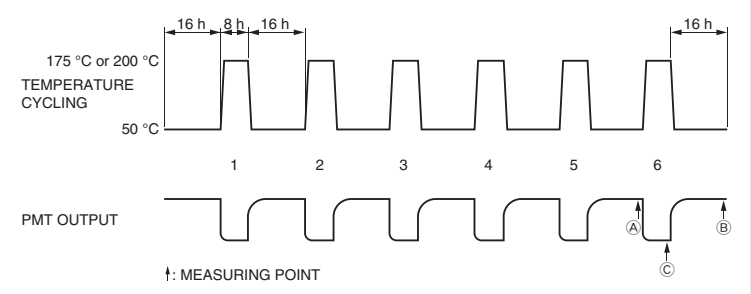
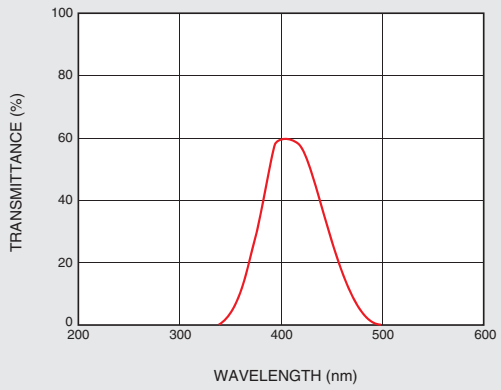


Figure 2 An example of the temperature cycling test chart



NOTE
① Temperature cycling tests are performed for all 175 °C and 200 °C type tubes.
② Temperature rise/down condition 3 °C/min Max.
③ PMT output: $\frac{(Ⓑ-Ⓐ)}{Ⓐ} < 10\ \%$
④ Light source: Blue LED simulating a photo-peak of NaI (Tl) + ^{137}Cs.
The noise edge is checked with an MCA.
PMT noise edge at 175 °C: 60 keV Max. (Measurement at Ⓒ of PMT output)
PMT noise edge at 200 °C: 100 keV Max. (Measurement at Ⓒ of PMT output)

Figure 3 Transmittance of the blue filter



Standard types 13 mm (1/2") dia.

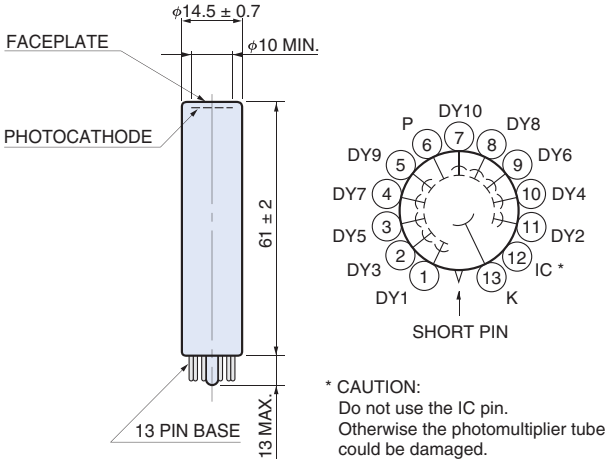
Specifications

Maximum operating temperature (°C)	① Type No.	Base configration	② Socket	Dynode structure / number of stages	③ MWD appl.	Maximum ratings ④ Anode to cathode voltage (V)	Maximum ratings ⑤ Average anode current (mA)	⑥ Anode to cathode voltage (V)		Shock
90	R4177-04	Temporary base	E678-12R	Linear focused / 10	—	1800	0.02	1500	A	5000 m/s² (500 G)
	R4177-06	Button stem	E678-13E							
	R4177-28	Assembly (S/S case)	—				0.01			0.5 ms
175	R4177	Temporary base	E678-12R	Linear focused / 10	—	1800	0.02	1500	A	5000 m/s² (500 G)
	R4177-01	Button stem	E678-13E							
	R4177-27	Assembly (S/S case)	—				0.01			0.5 ms

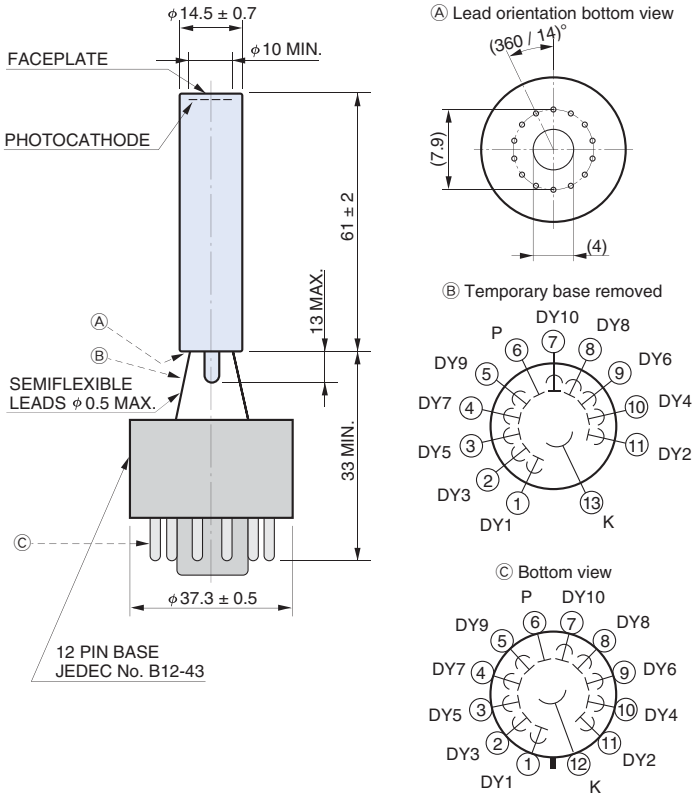
S/S: Stainless steel

Dimensional outlines and basing diagrams (Unit: mm)

R4177-01 / -06



R4177 / -04



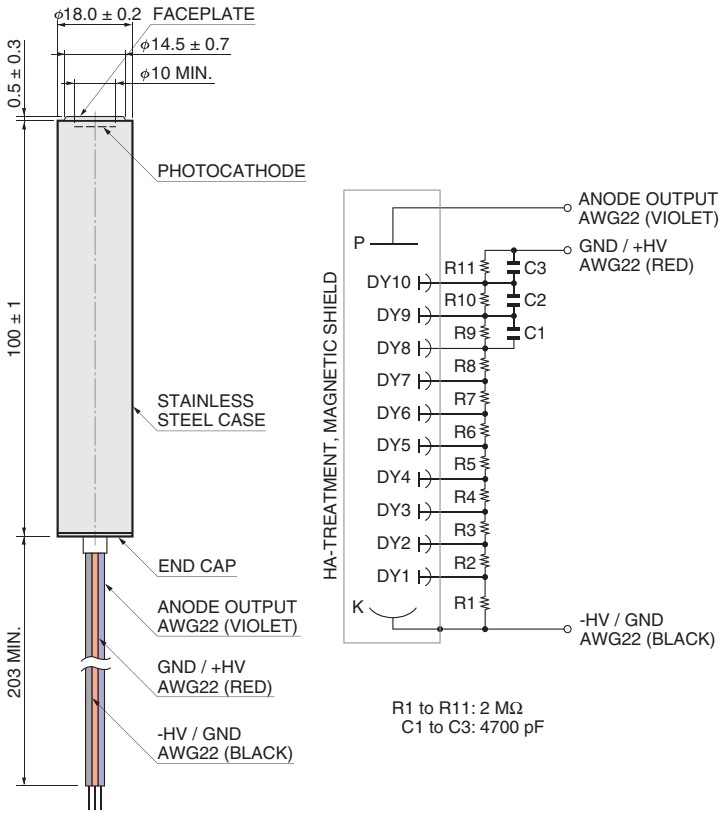
Voltage distribution ratios

Number of stages	Distribution ratio codes	Voltage distribution ratio K: Cathode Dy: Dynode P: Anode											
10	A	K	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	Dy10	P
			1	1	1	1	1	1	1	1	1	1	1

Vibration	Cathode sensitivity ⑦				Anode sensitivity and characteristics					Type No.
	Luminous at 25 °C		Blue sensitivity index at 25 °C		Gain at 25 °C	Luminous ⑧ at 25 °C		Dark current ⓪		
								at 25 °C	at 175 °C	
	Min. (μA/lm)	Typ. (μA/lm)	Min.	Typ.	Typ.	Min. (A/lm)	Typ. (A/lm)	Typ. (nA)	Max. (nA)	Typ. (nA)	
200 m/s^2 (20 G)	20	30	3.0	4.5	5.0 × 10^5	6	15	0.5	10	5 (90 °C)	R4177-04
											R4177-06
											R4177-28
200 m/s^2 (20 G)	20	40	4.0	6.0	5.0 × 10^5	10	20	0.5	10	100	R4177
											R4177-01
											R4177-27

R4177-27 / -28

(See Note 2 on page 9)



R1 to R11: 2 MΩ
C1 to C3: 4700 pF

* Image is for illustration purposes.

Standard types 19 mm (3/4") dia.

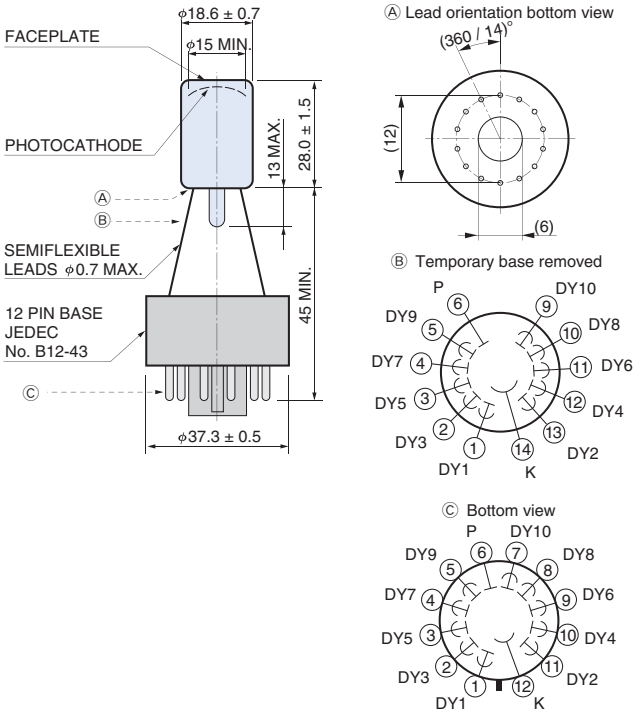
Specifications

Maximum operating temperature (°C)	① Type No.	Base configration	② Socket	Dynode structure / number of stages	③ MWD appl.	Maximum ratings ④ Anode to cathode voltage (V)	Maximum ratings ⑤ Average anode current (mA)	⑥ Anode to cathode voltage (V)		Shock
90	R3991A-04	Temporary base	E678-12R	Circular and linear focused / 10	—	1800	0.02	1500	B	10 000 m/s² (1000 G) 0.5 ms
	R3991A-08	Assembly	—				0.01			
	R3991A-28	Assembly (S/S case)	—							
175	R3991A	Temporary base	E678-12R	Circular and linear focused / 10	—	1800	0.02	1500	B	10 000 m/s² (1000 G) 0.5 ms
	R3991A-07	Assembly	—				0.01			
	R3991A-27	Assembly (S/S case)	—							
	R3991A-31	Assembly (S/S case)	—		YES					
200	R3991AH	Temporary base	E678-12R	Circular and linear focused / 10	—	1800	0.02	1500	B	10 000 m/s² (1000 G) 0.5 ms
	R3991AH-07	Assembly	—				0.01			
	R3991AH-27	Assembly (S/S case)	—							
	R3991AH-31	Assembly (S/S case)	—		YES					

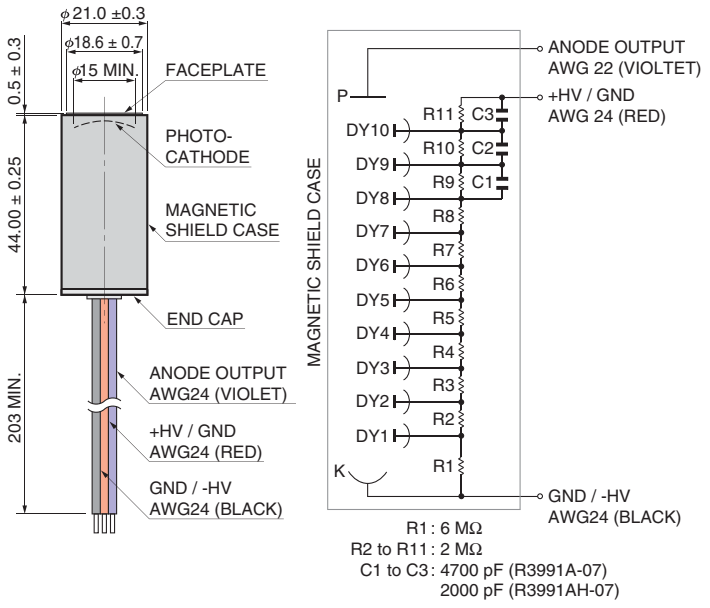
S/S: Stainless steel

Dimensional outlines and basing diagrams (Unit: mm)

R3991A / -04, R3991AH



R3991A-07 / -08, R3991AH-07 (See Note 2 on page 9)



R1 : 6 MΩ
R2 to R11 : 2 MΩ
C1 to C3 : 4700 pF (R3991A-07)
2000 pF (R3991AH-07)

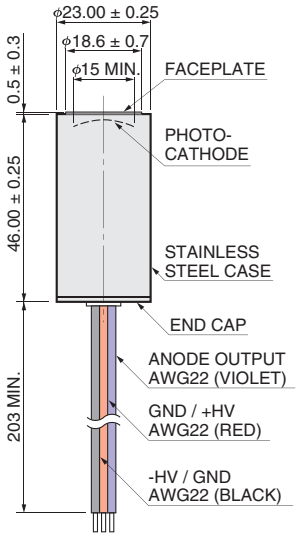
Voltage distribution ratios

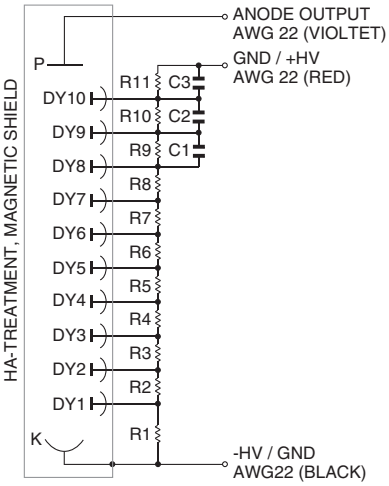
Number of stages	Distribution ratio codes	Voltage distribution ratio K: Cathode Dy: Dynode P: Anode										
10	B	K	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	Dy10	P
		3	1	1	1	1	1	1	1	1	1	1	

Vibration	Cathode sensitivity ⑦				Anode sensitivity and characteristics						Type No.
	Luminous at 25 °C		Blue sensitivity index at 25 °C		Gain at 25 °C	Luminous ⑧ at 25 °C		Dark current ⑨			
								at 25 °C		at 175 °C	
	Min. (μA/lm)	Typ. (μA/lm)	Min.	Typ.	Typ.	Min. (A/lm)	Typ. (A/lm)	Typ. (nA)	Max. (nA)	Typ. (nA)	
300 m/s² (30 G)	20	30	3.0	4.5	3.3 × 10⁵	5	10	0.1	10	10 (90 °C)	R3991A-04
											R3991A-08
											R3991A-28
300 m/s² (30 G)	20	40	4.0	6.0	5.0 × 10⁵	5	20	0.1	10	200	R3991A
											R3991A-07
											R3991A-27
											R3991A-31
300 m/s² (30 G)	30	50	5.0	7.0	5.0 × 10⁵	10	25	0.1	10	2000 (200 °C)	R3991AH
											R3991AH-07
											R3991AH-27
											R3991AH-31

R3991A-27 / -28 / -31, R3991AH-27 / -31

(See Note 2 on page 9)





R1 : 6 MΩ
R2 to R11 : 2 MΩ
C1 to C3 : 4700 pF (R3991A-27 / -28 / -31)
2000 pF (R3991AH-27 / -31)

* Image is for illustration purposes.

Standard types 25 mm (1") dia.

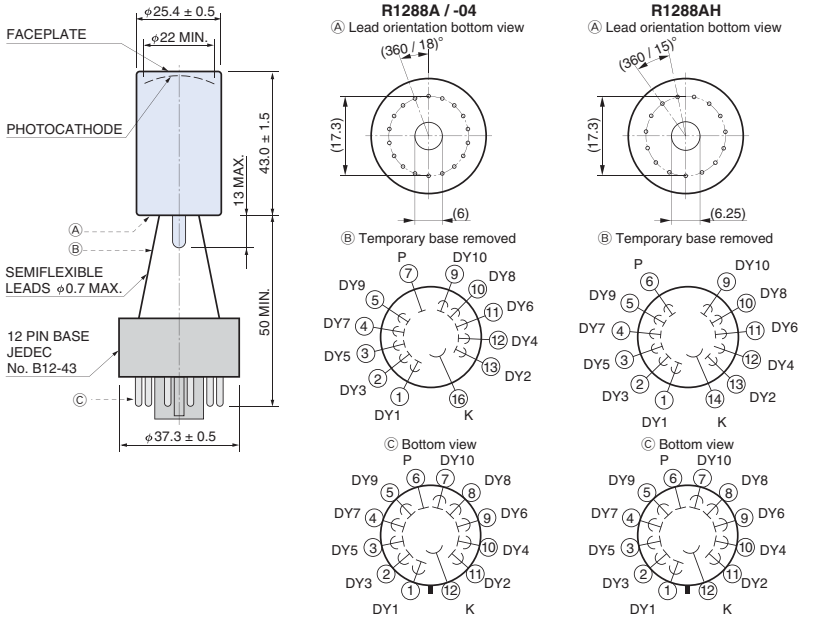
Specifications

Maximum operating temperature (°C)	① Type No.	Base configration	② Socket	Dynode structure / number of stages	③ MWD appl.	Maximum ratings ④ Anode to cathode voltage (V)	Maximum ratings ⑤ Average anode current (mA)	⑥ Anode to cathode voltage (V)		Shock
90	R1288A-04	Temporary base	E678-12R	Circular and linear focused / 10	—	1800	0.02	1500	B	10 000 m/s² (1000 G) 0.5 ms
	R1288A-06	Button stem	E678-14-03							
	R1288A-08	Assembly	—				0.01			
	R1288A-28	Assembly (S/S case)	—							
175	R1288A	Temporary base	E678-12R	Circular and linear focused / 10	—	1800	0.02	1500	B	10 000 m/s² (1000 G) 0.5 ms
	R1288A-01	Button stem	E678-14-03							
	R1288A-07	Assembly	—				0.01			
	R1288A-27	Assembly (S/S case)	—							
	R1288A-31	Assembly (S/S case)	—		YES					
200	R1288AH	Temporary base	E678-12R	Circular and linear focused / 10	—	1800	0.02	1500	B	10 000 m/s² (1000 G) 0.5 ms
	R1288AH-07	Assembly	—				0.01			
	R1288AH-27	Assembly (S/S case)	—							
	R1288AH-31	Assembly (S/S case)	—		YES					

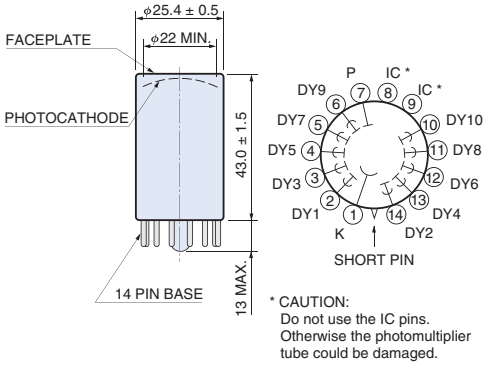
S/S: Stainless steel

Dimensional outlines and basing diagrams (Unit: mm)

R1288A / -04, R1288AH



R1288A-01 / -06



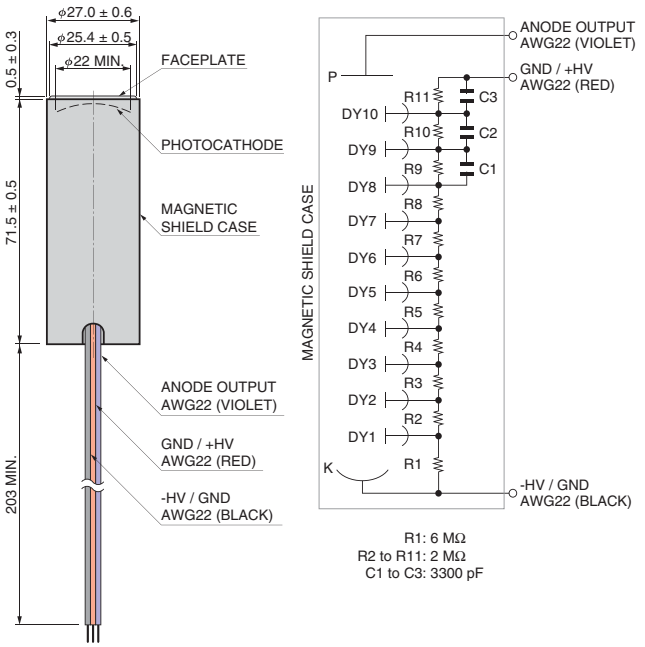
* CAUTION:
Do not use the IC pins. Otherwise the photomultiplier tube could be damaged.

Voltage distribution ratios

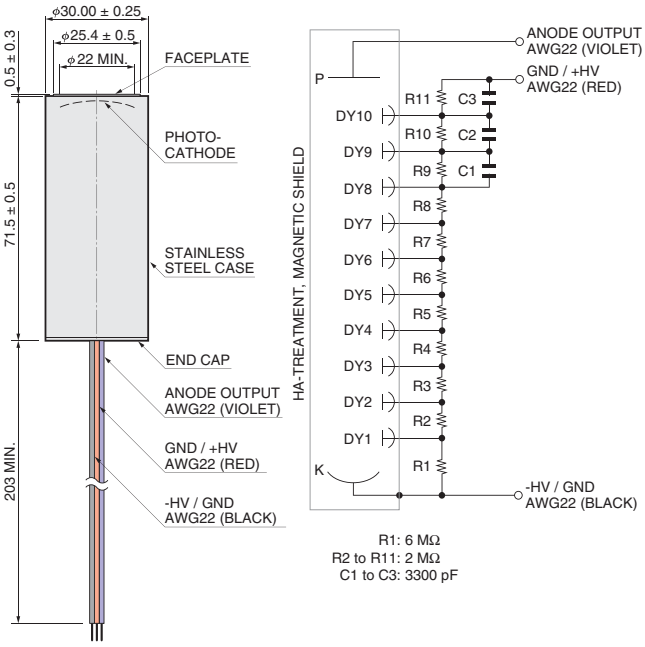
Number of stages	Distribution ratio codes	Voltage distribution ratio K: Cathode Dy: Dynode P: Anode										
10	B	K	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	Dy10	P
		3	1	1	1	1	1	1	1	1	1	1	

Vibration	Cathode sensitivity ⑦				Anode sensitivity and characteristics					Type No.
	Luminous at 25 °C		Blue sensitivity index at 25 °C		Gain at 25 °C	Luminous ⑧ at 25 °C		Dark current ⑨		
								at 25 °C	at 175 °C	
	Min. (μA/lm)	Typ. (μA/lm)	Min.	Typ.	Typ.	Min. (A/lm)	Typ. (A/lm)	Typ. (nA)	Max. (nA)	Typ. (nA)	
300 m/s² (30 G)	20	30	3.0	4.5	3.3×10^5	5	10	0.1	10	20 (90 °C)	R1288A-04
											R1288A-06
											R1288A-08
											R1288A-28
300 m/s² (30 G)	20	40	4.0	6.0	5.0×10^5	8	20	0.1	10	400	R1288A
											R1288A-01
											R1288A-07
											R1288A-27
											R1288A-31
300 m/s² (30 G)	30	50	5.0	7.0	5.0×10^5	10	25	0.1	10	4000 (200 °C)	R1288AH
											R1288AH-07
											R1288AH-27
											R1288AH-31

*R1288A-07 / -08, R1288AH-07 (See Note 2 on page 9)



R1288A-27 / -28 / -31, R1288AH-27 / -31 (See Note 2 on page 9)



* CAUTION: These tubes have open ends potted with silicone.
Do not apply force to this potted portion, or do not fill any additional potting material. Either actions could damage the voltage divider built in.

Standard types 28 mm (1-1/8") dia.

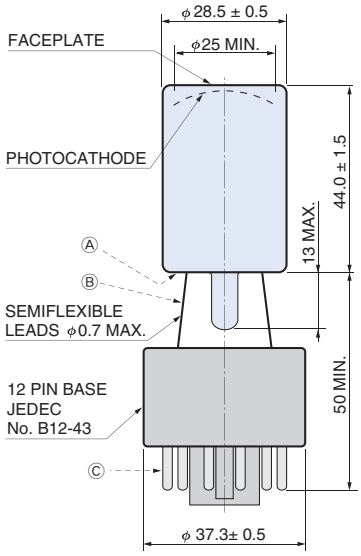
Specifications

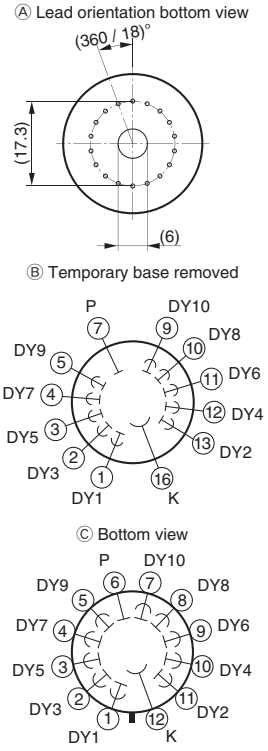
Maximum operating temperature (°C)	① Type No.	Base configration	② Socket	Dynode structure / number of stages	③ MWD appl.	Maximum ratings ④ Anode to cathode voltage (V)	Maximum ratings ⑤ Average anode current (mA)	⑥ Anode to cathode voltage (V)		Shock
90	R6877A-04	Temporary base	E678-12R	Circular and linear focused / 10	—	1800	0.02	1500	B	5000 m/s² (500 G) 0.5 ms
	R6877A-06	Button stem	E678-14-03							
	R6877A-08	Assembly	—				0.01			
	R6877A-28	Assembly (S/S case)	—							
175	R6877A	Temporary base	E678-12R	Circular and linear focused / 10	—	1800	0.02	1500	B	5000 m/s² (500 G) 0.5 ms
	R6877A-01	Button stem	E678-14-03							
	R6877A-07	Assembly	—				0.01			
	R6877A-27	Assembly (S/S case)	—							
	R6877A-31	Assembly (S/S Case)	—		YES					

S/S: Stainless steel

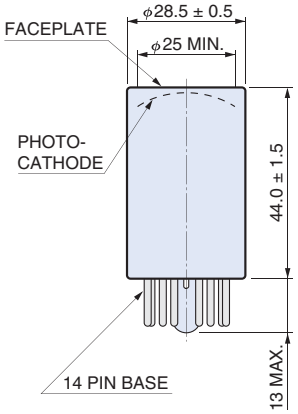
Dimensional outlines and basing diagrams (Unit: mm)

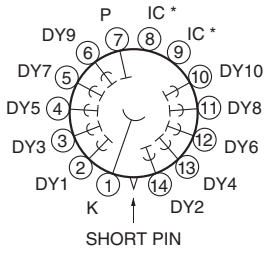
R6877A / -04





R6877A-01 / -06





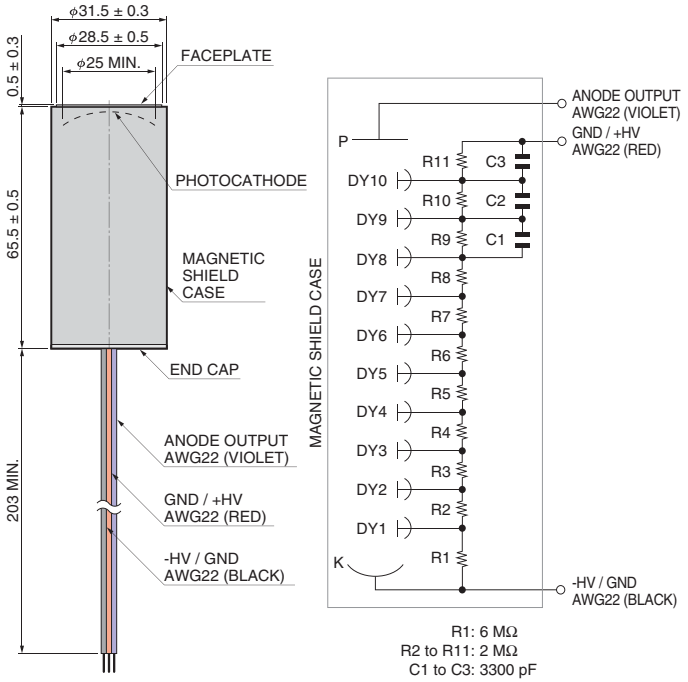
* CAUTION:
Do not use the IC pins.
Otherwise the photomultiplier tube could be damaged.

Voltage distribution ratios

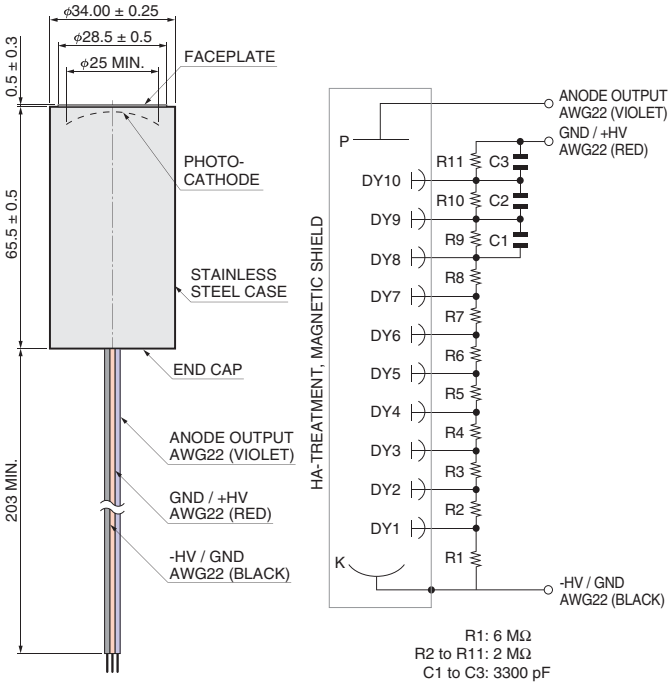
Number of stages	Distribution ratio codes	Voltage distribution ratio K: Cathode Dy: Dynode P: Anode											
10	B	K	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	Dy10	P
		3	1	1	1	1	1	1	1	1	1	1	

Vibration	Cathode sensitivity ⑦				Anode sensitivity and characteristics					Type No.
	Luminous at 25 °C		Blue sensitivity index at 25 °C		Gain at 25 °C	Luminous ⑧ at 25 °C		Dark current ⑨		
								at 25 °C	at 175 °C	
	Min. (μA/lm)	Typ. (μA/lm)	Min.	Typ.	Typ.	Min. (A/lm)	Typ. (A/lm)	Typ. (nA)	Max. (nA)	Typ. (nA)	
200 m/s^2 (20 G)	20	30	3.0	4.5	3.3 × 10^5	5	10	0.2	10	30 (90 °C)	R6877A-04
											R6877A-06
											R6877A-08
											R6877A-28
200 m/s^2 (20 G)	20	40	4.0	6.0	5.0 × 10^5	8	20	0.2	10	500	R6877A
											R6877A-01
											R6877A-07
											R6877A-27
											R6877A-31

R6877A-07 / -08



R6877A-27 / -28 / -31



Standard types 38 mm (1-1/2") dia.

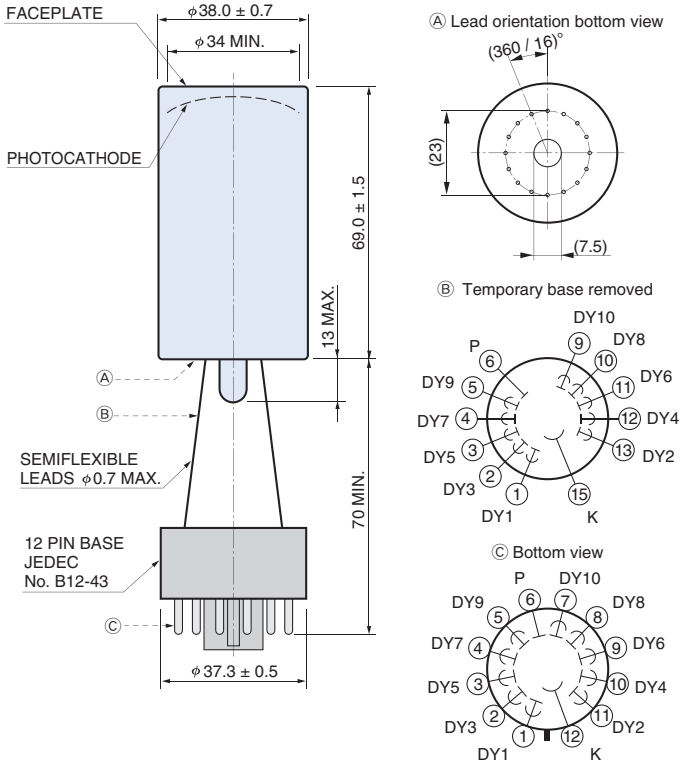
Specifications

Maximum operating temperature (°C)	① Type No.	Base configration	② Socket	Dynode structure / number of stages	③ MWD appl.	Maximum ratings ④ Anode to cathode voltage (V)	Maximum ratings ⑤ Average anode current (mA)	⑥ Anode to cathode voltage (V)		Shock
90	R9722A-04	Temporary base	E678-12R	Circular and linear focused / 10	—	1800	0.02	1500	C	5000 m/s² (500 G)
	R9722A-06	Button stem	E678-14-03							
	R9722A-28	Assembly (S/S case)	—				0.01			0.5 ms
175	R9722A	Temporary base	E678-12R	Circular and linear focused / 10	—	1800	0.02	1500	C	5000 m/s² (500 G)
	R9722A-01	Button stem	E678-14-03							
	R9722A-27	Assembly (S/S case)	—				0.01			0.5 ms

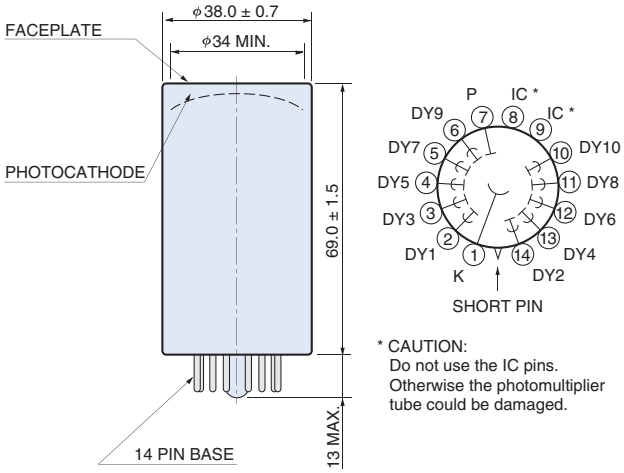
S/S: Stainless steel

Dimensional outlines and basing diagrams (Unit: mm)

R9722A / -04



R9722A-01 / -06



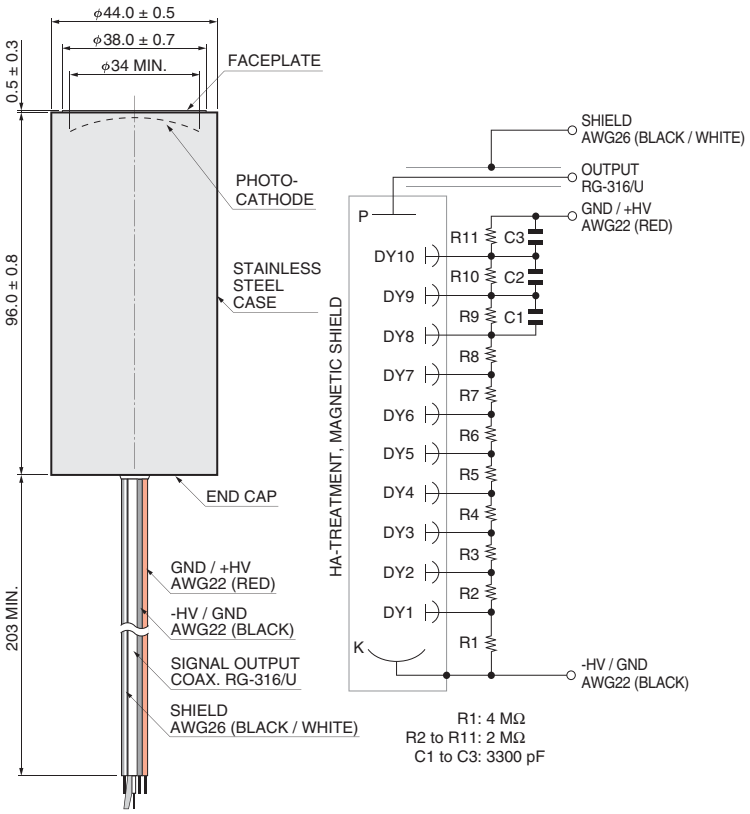
* CAUTION:
Do not use the IC pins.
Otherwise the photomultiplier tube could be damaged.

Voltage distribution ratios

Number of stages	Distribution ratio codes	Voltage distribution ratio K: Cathode Dy: Dynode P: Anode											
10	C	K	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	Dy10	P
		2	1	1	1	1	1	1	1	1	1	1	

Vibration	Cathode sensitivity ⑦				Anode sensitivity and characteristics					Type No.
	Luminous at 25 °C		Blue sensitivity index at 25 °C		Gain at 25 °C	Luminous ⑧ at 25 °C		Dark current ⑨		
								at 25 °C	at 175 °C	
	Min. (μA/lm)	Typ. (μA/lm)	Min.	Typ.	Typ.	Min. (A/lm)	Typ. (A/lm)	Typ. (nA)	Max. (nA)	Typ. (nA)	
200 m/s² (20 G)	20	30	3.0	4.5	3.3×10^5	5	10	0.5	10	40 (90 °C)	R9722A-04
											R9722A-06
											R9722A-28
200 m/s² (20 G)	20	40	4.0	6.0	5.0×10^5	5	20	0.5	10	1000	R9722A
											R9722A-01
											R9722A-27

R9722A-27 / -28



* Image is for illustration purposes.

Standard types 51 mm (2") dia.

Specifications

Maximum operating temperature (°C)	① Type No.	Base configration	② Socket	Dynode structure / number of stages	③ MWD appl.	Maximum ratings ④ Anode to cathode voltage (V)	Maximum ratings ⑤ Average anode current (mA)	⑥ Anode to cathode voltage (V)		Shock
90	R4607A-06	Button stem	E678-15C	Circular and linear focused / 10	—	1800	0.02	1500	C	5000 m/s² (500 G) 0.5 ms
	R4607A-28	Assembly (S/S case)	—				0.01			
175	R4607A-01	Button stem	E678-15C	Circular and linear focused / 10	—	1800	0.02	1500	C	5000 m/s² (500 G) 0.5 ms
	R4607A-27	Assembly (S/S case)	—				0.01			

Highly ruggedized types 19 mm (3/4") dia. / 25 mm (1") dia.

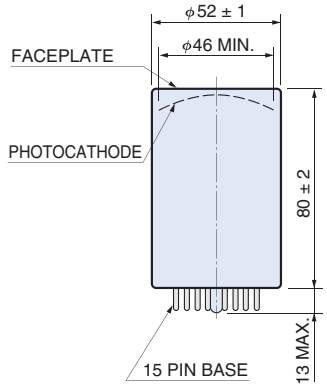
Specifications

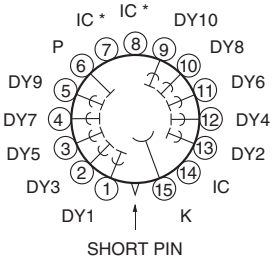
Maximum operating temperature (°C)	① Type No.	Base configration	② Socket	Dynode structure / number of stages	③ MWD appl.	Maximum ratings ④ Anode to cathode voltage (V)	Maximum ratings ⑤ Average anode current (mA)	⑥ Anode to cathode voltage (V)		Shock
175	R8874-01	Assembly (S/S case)	—	Circular and linear focused / 10	YES	1800	0.01	1500	B	10 000 m/s² (1000 G) 0.5 ms
	R13788-01	Assembly (S/S case)	—	Circular and linear focused / 10	YES	1800	0.01	1500	B	10 000 m/s² (1000 G) 0.5 ms

S/S: Stainless steel

Dimensional outlines and basing diagrams (Unit: mm)

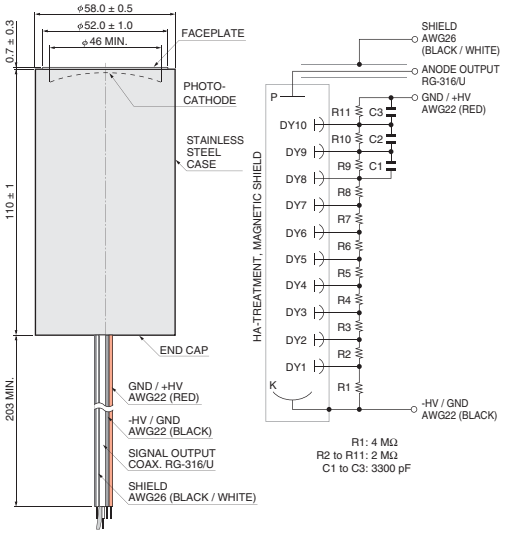
R4607A-01 / -06





* CAUTION:
Do not use the IC pins.
Otherwise the photomultiplier tube could be damaged.

R4607A-27 / -28



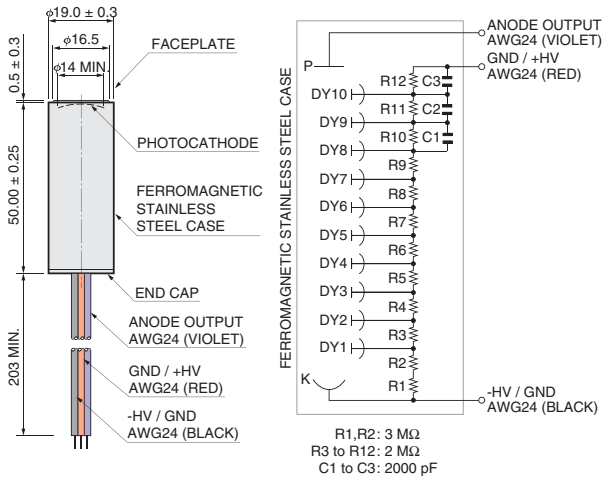
Voltage distribution ratios

Number of stages	Distribution ratio codes	Voltage distribution ratio K: Cathode Dy: Dynode P: Anode											
		K	Dy1	Dy2	Dy3	Dy4	Dy5	Dy6	Dy7	Dy8	Dy9	Dy10	P
10	B	3	1	1	1	1	1	1	1	1	1	1	
	C	2	1	1	1	1	1	1	1	1	1	1	

Vibration	Cathode sensitivity ⑦				Anode sensitivity and characteristics					Type No.
	Luminous at 25 °C		Blue sensitivity index at 25 °C		Gain at 25 °C	Luminous at 25 °C ⑧		Dark current ⑨		
								at 25 °C	at 175 °C	
	Min. (μA/lm)	Typ. (μA/lm)	Min.	Typ.	Typ.	Min. (A/lm)	Typ. (A/lm)	Typ. (nA)	Max. (nA)	Typ. (nA)	
200 m/s² (20 G)	20	30	3.0	4.5	3.3 × 10⁵	5	10	3	50	50 (90 °C)	R4607A-06
											R4607A-28
200 m/s² (20 G)	20	40	4.0	6.0	5.0 10⁵	5	20	3	50	1500	R4607A-01
											R4607A-27

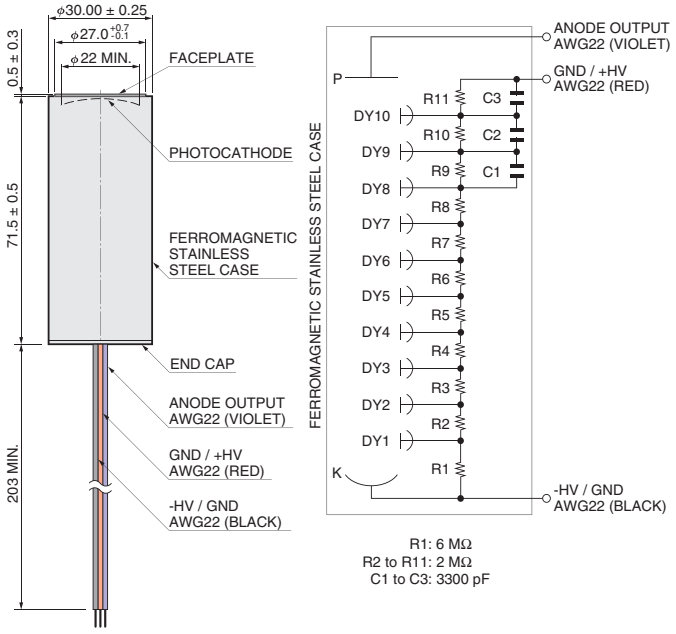
Vibration	Cathode sensitivity ⑦				Anode sensitivity and characteristics					Type No.
	Luminous at 25 °C		Blue sensitivity index at 25 °C		Gain at 25 °C	Luminous at 25 °C ⑧		Dark current ⑨		
								at 25 °C	at 175 °C	
	Min. (μA/lm)	Typ. (μA/lm)	Min.	Typ.	Typ.	Min. (A/lm)	Typ. (A/lm)	Typ. (nA)	Max. (nA)	Typ. (nA)	
500 m/s² (50 G)	20	40	4.0	6.0	5.0 × 10⁵	5	20	0.1	10	150	R8874-01
400 m/s² (40 G)	20	40	4.0	6.0	5.0 × 10⁵	8	20	0.1	10	400	R13788-01

R8874-01



R13788-01

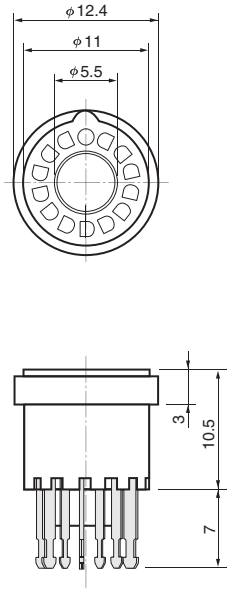
(See Note 2 on page 9)



Sockets

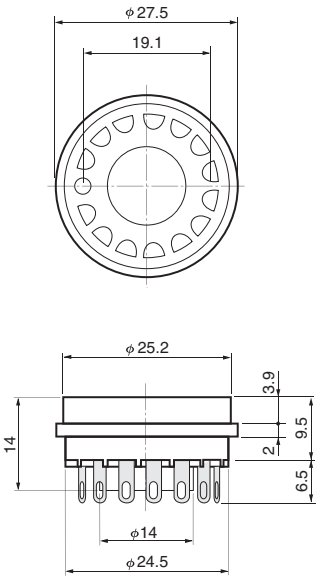
Dimensional outlines (Unit: mm)

E678-13E



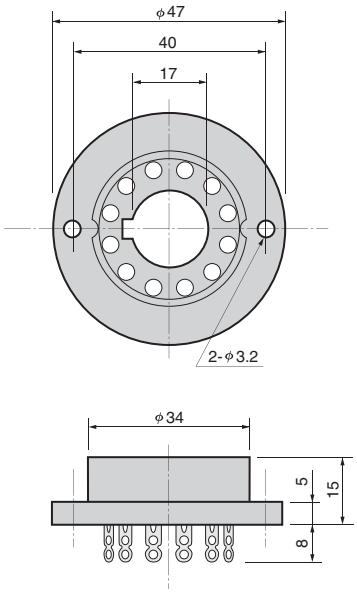
This socket can be used within the PMT operating temperature range.

E678-14-03

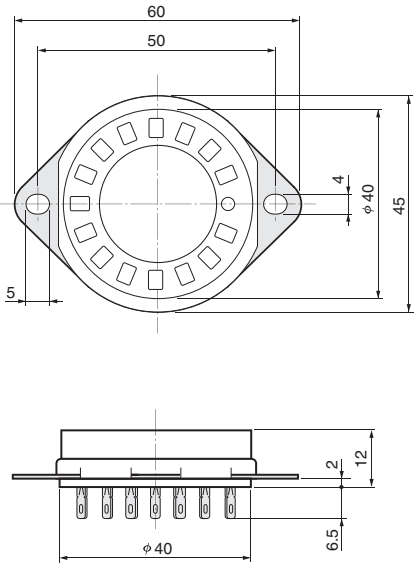


This socket can be used within the PMT operating temperature range.

E678-12R



E678-15C



This socket can be used within the PMT operating temperature range.

Contact pins are gold plated.

1. General characteristics

1-1. General characteristics

Figure 1 Spectral response (Typ.) (175 °C types)

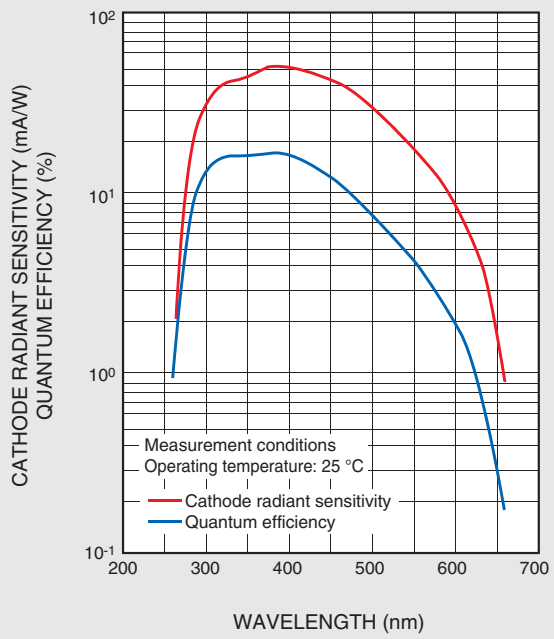


Figure 2 Gain (Typ.)

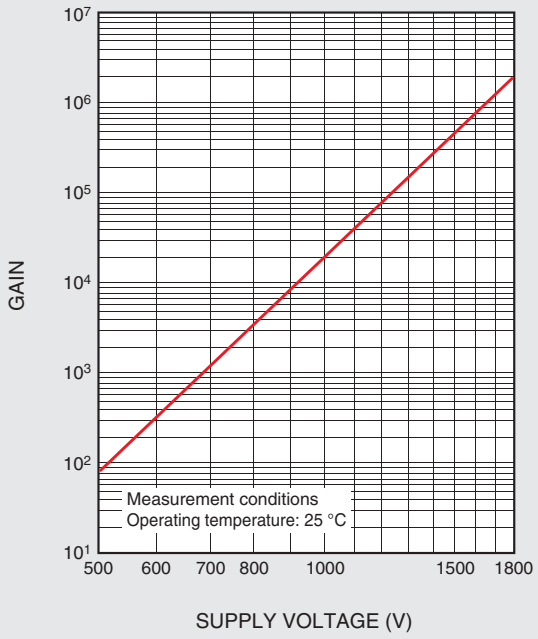


Figure 3 Pulse height vs. temperature (Typ.)

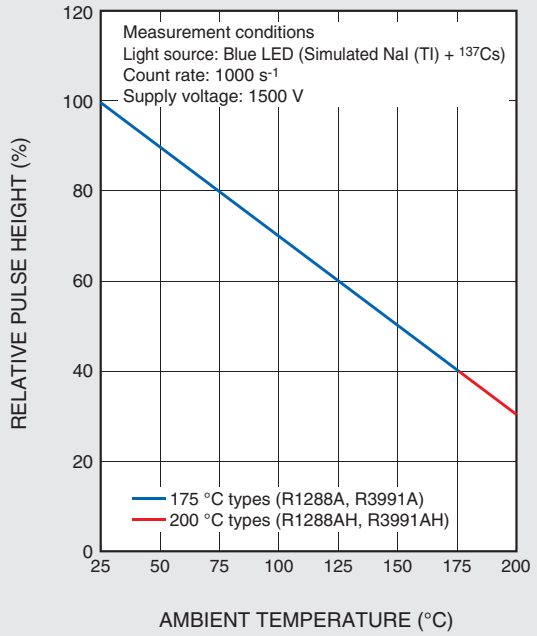


Figure 4 Pulse height resolution vs. temperature (Typ.)

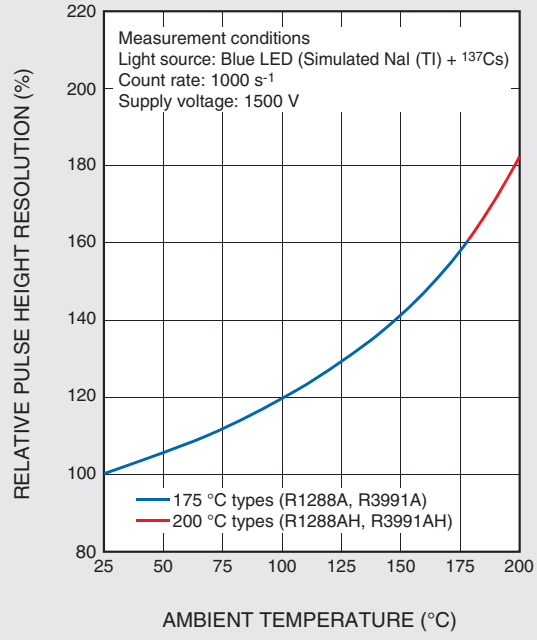


Figure 5 Noise edge vs. temperature (Typ.)

The noise edge (keV) is defined as the point at which a steep rise with a slope greater than 10 %/keV is found on a pulse height distribution by checking the output count change from the photo-peak to the lower energy side.

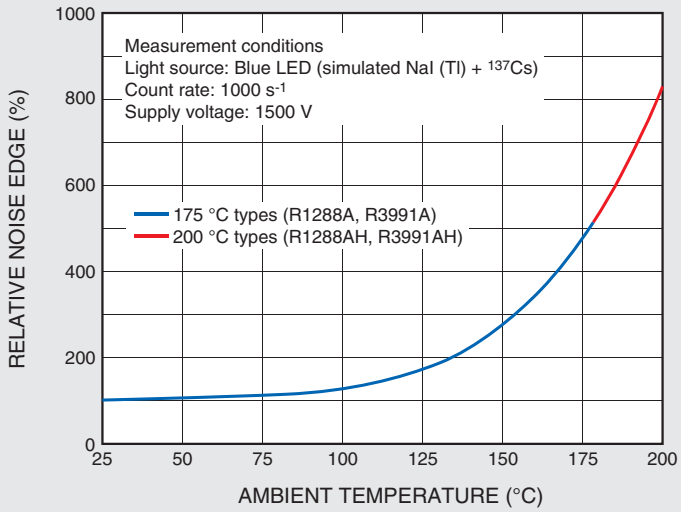


Figure 6 Life characteristics with continuous operation (Typ.) (R1288A)

The expected service life of the 175 °C type is more than 400 hours when operated at 175 °C.

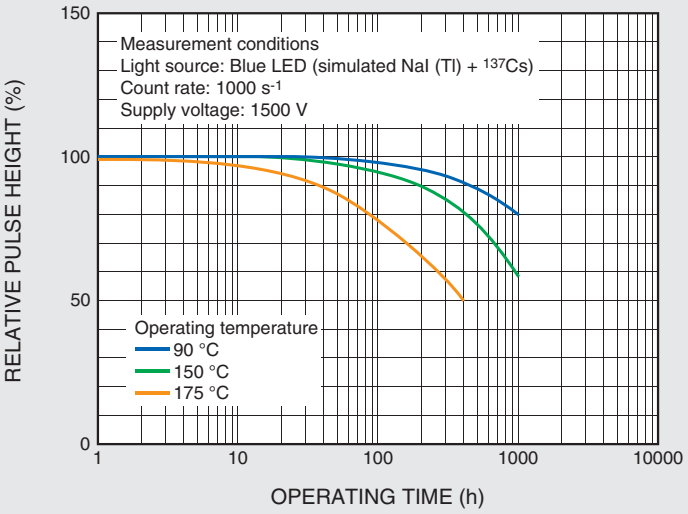
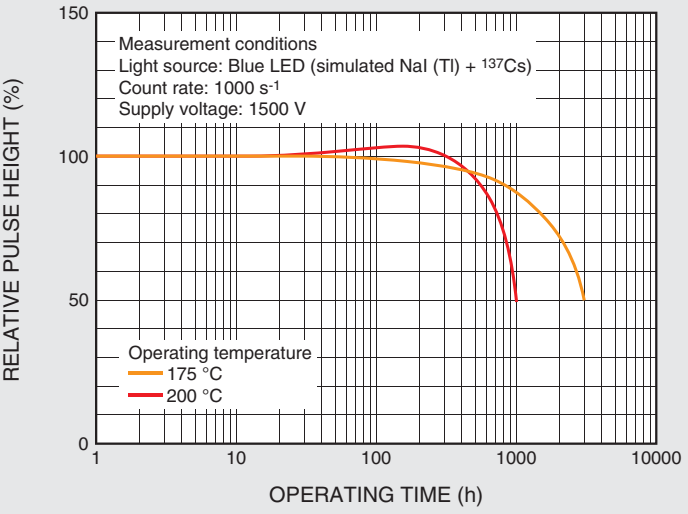


Figure 7 Life characteristics with continuous operation (Typ.)(R1288AH)

The expected service life of the 200 °C type is more than 500 hours when operated at 200 °C.



1-2. LLD during plateau measurement

This section describes the LLD (lower level discriminator) that should be set to make plateau measurements.
First, let us calculate the charge amount per pulse that is output from the photomultiplier tube.
The number of photons emitted from a NaI (Tl) scintillator for high temperature and rugged environments is usually about 20 photons/keV of gamma-ray energy. A conventional NaI (Tl) scintillator produces approximately 40 photons/keV of the gamma-ray energy.
If using ^{137}Cs (gamma-ray energy 662 keV), the number of emitted photons will be about 13 000. It is simply calculated by 662 × 20.
If the photomultiplier tube is used with a ^{137}Cs radiation source, the charge amount per pulse of the photomultiplier tube is obtained as follows:

$$N \times \eta \times \alpha \times \mu \times e = 13\,000 \times 0.15 \times 0.5 \times 5 \times 10^{5} \times 1.6 \times 10^{-19} \approx 80 \text{ pC}$$

N: Number of photons emitted from scintillator per event
η: Photocathode quantum efficiency (assumed to be 15 % at room temperature)
α: Light collection yield of the scintillation light to the photocathode (assumed to be 50 %)
μ: PMT gain
e: Electron charge

As calculated above, the charge amount per pulse obtained using the ^{137}Cs (662 keV) is about 80 pC.
The estimated charge amount obtained under the conditions at 175 °C will therefore be about 30 pC which is about 40 % the charge at room temperature (See Figure 3 on page 23).

Based on these, the LLD should be adjusted to an optimal level, however, in view of the decrease in output during high temperature operation, it is preferable that the LLD be set so that a plateau region can be obtained at a voltage lower than the rated voltage.

For general characteristics when LLD = 1.5 pC, refer to Figures 9 to 11 on page 26.

Since the PMT gain and the emission intensity of scintillators differ from product to product, we advise adjusting the LLD setting as needed to match the actual usage conditions so that the plateau region can be obtained below the rated voltage.
When setting the LLD, we suggest using a capacitor with a known capacitance and a pulse generator in order to calibrate by using the pulse output from the capacitor.

Figure 8 **Plateau test block diagram**

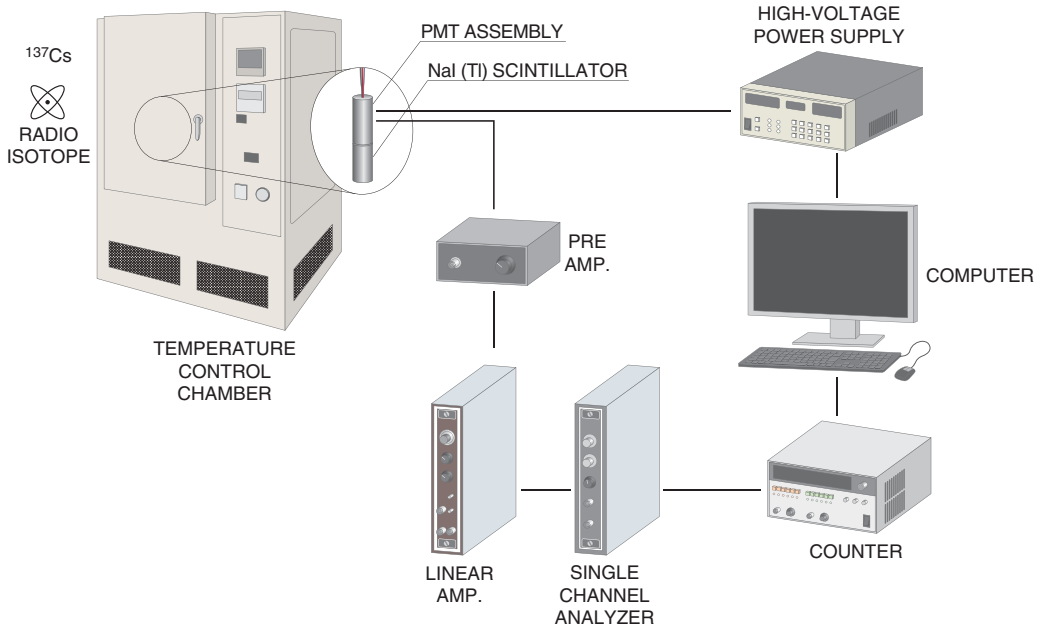


Figure 9 **Plateau characteristics (Typ.) (R1288A, R1288AH)**

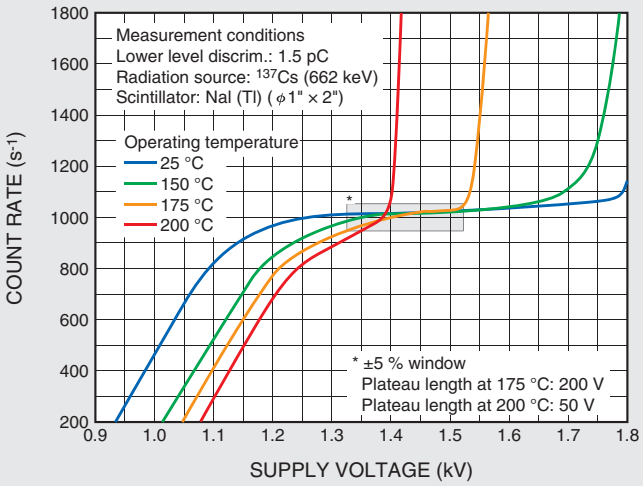


Figure 10 **Plateau characteristics (Typ.) (R3991A, R3991AH)**

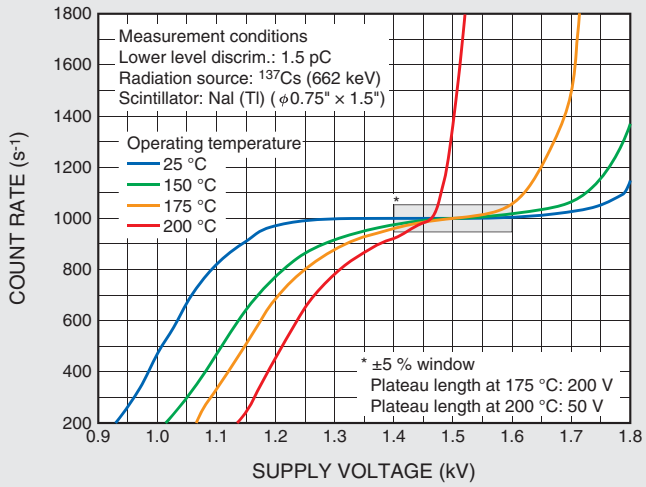
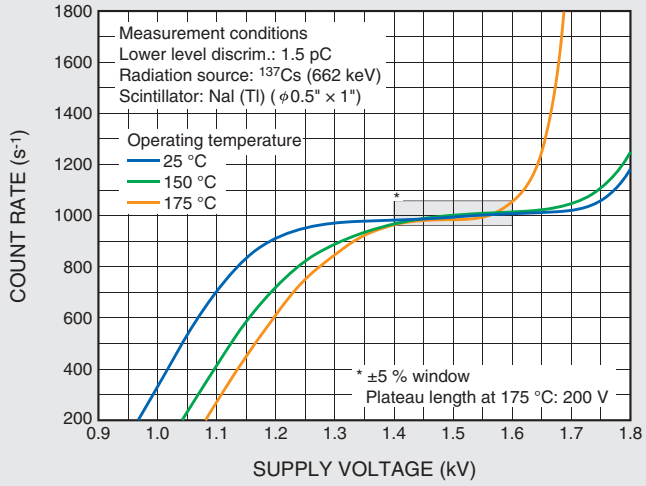


Figure 11 **Plateau characteristics (Typ.) (R8874-01)**

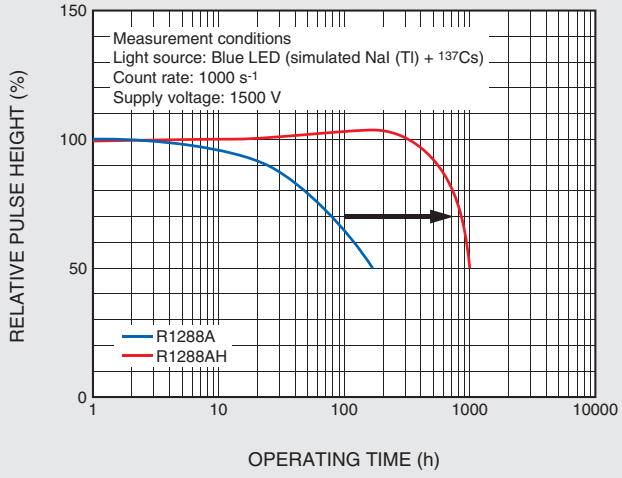


The lower limit of the plateau length measured under the above conditions will be as follows:
Plateau length at 175 °C (±5 % window): 100 V (≈ noise edge 60 keV Max.)
Plateau length at 200 °C (±5 % window): 25 V (≈ noise edge 100 keV Max.)

2. Photomultiplier tubes

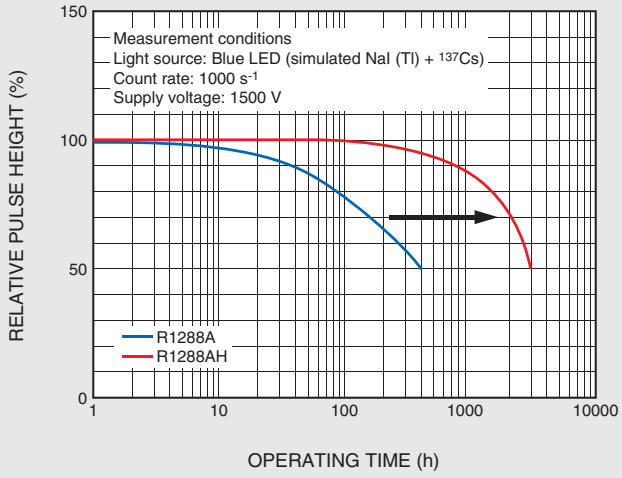
2-1. Long life characteristic

Figure 1 Relative pulse height vs. operating time (Typ.) (Temperature: 200 °C)



Compared to the R1288A, the R1288AH offers less degradation in output and higher stability even during continuous operation at 200 °C.

Figure 2 Relative pulse height vs. operating time (Typ.) (Temperature: 175 °C)



Stability is drastically improved even during continuous operation at 175 °C.

A major factor that determines the service life of photomultiplier tubes operated at high temperatures is the deterioration in photocathode sensitivity which adversely affects the energy resolution. Be aware that increasing the supply voltage can increase the output, but will not improve the energy resolution.

2-2. Comparison of pulse height resolution on different dia. photomultiplier tubes with same sized scintillators

Figure 3 With ϕ 0.75" × 1.5" NaI (Tl) scintillator (Typ.)

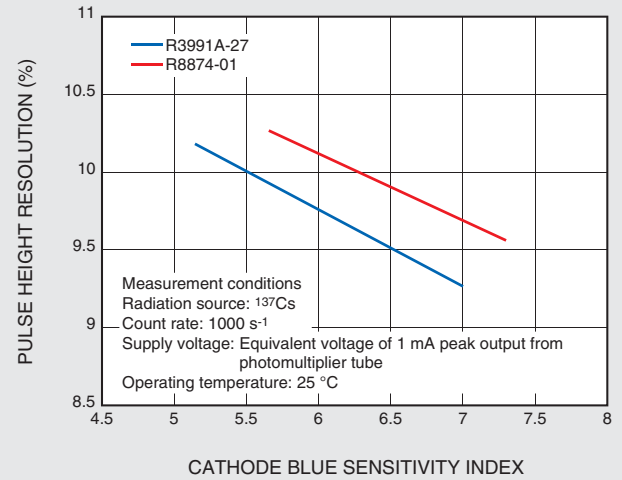
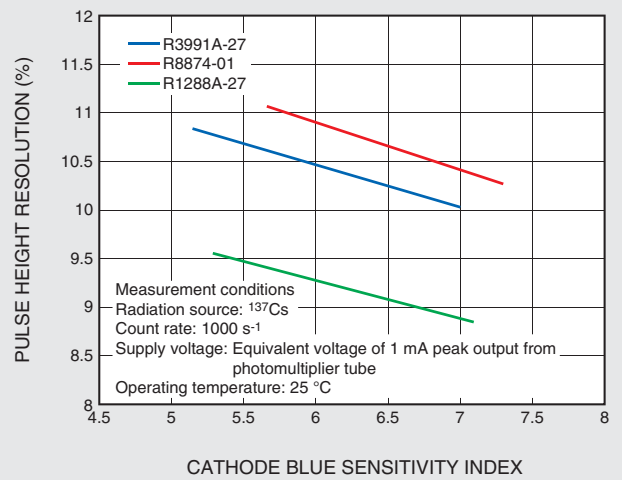


Figure 4 With ϕ 1" × 2" NaI (Tl) scintillator (Typ.)



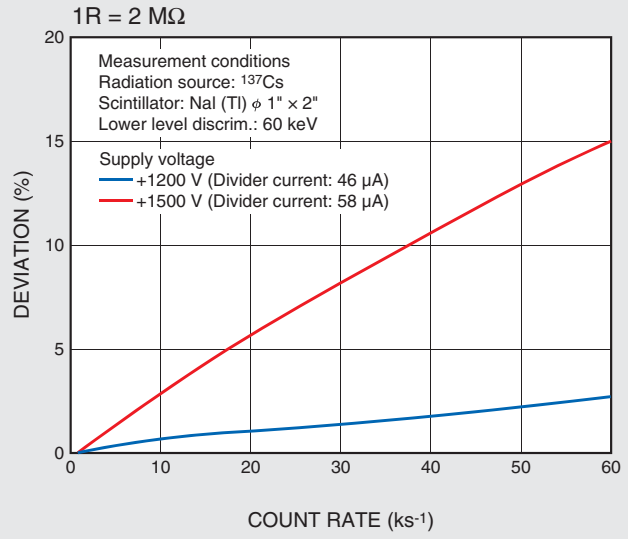
The energy resolution degrades if the outer diameter of the photomultiplier tube is smaller than that of the scintillator being used. So use a photomultiplier tube with an outer diameter equal to or larger than the diameter of the scintillator.

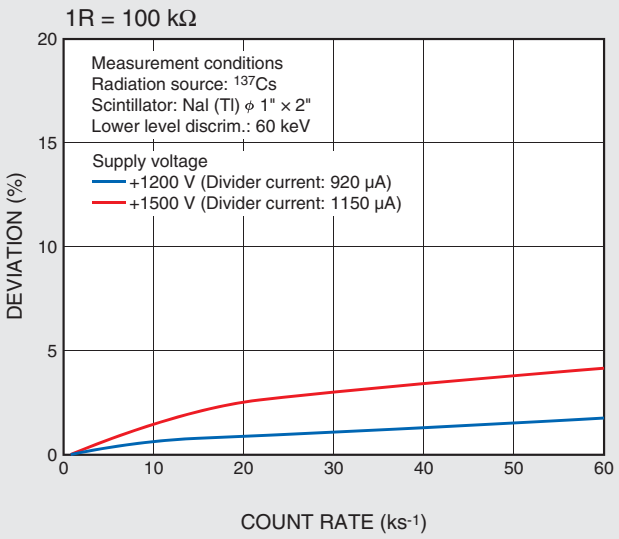
3. Photomultiplier tube assemblies

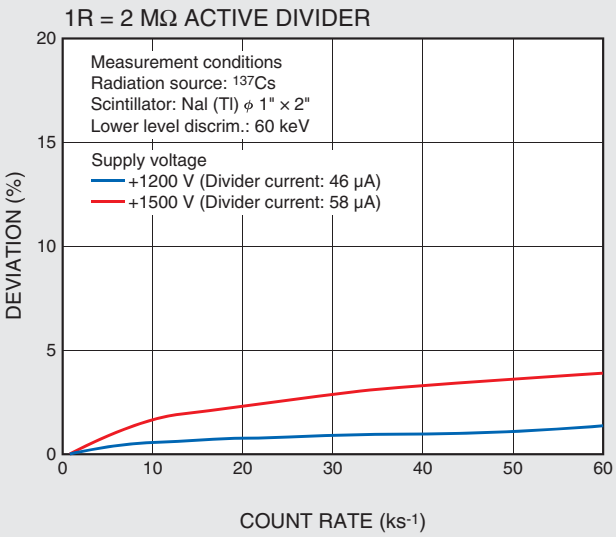
3-1. Count rate characteristics

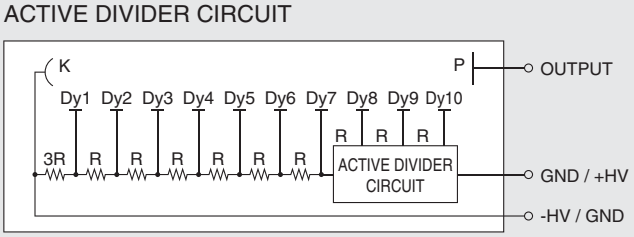
Power consumption is limited in oil well logging equipment.
The voltage divider circuit for operating the photomultiplier tube must have low power consumption. A common method to lower power consumption is to use a high resistance to limit the voltage divider current. However, such a design causes deviation in PMT gain when operated at a high count rate. An active divider circuit is effective in solving this problem. Figure 1 shows count rate characteristics of a R1288A photomultiplier tube measured with active divider circuits of different base resisters (1R = 2 MΩ, 1R = 100 kΩ and 1R = 2 MΩ ACTIVE DIVIDER). Active divider circuits are clearly effective in eliminating gain fluctuations while still limiting the voltage divider current.
If the active divider circuit is required for your application, please contact our sales office nearest you.

Figure 1 **Count rate characteristics (Typ.) (R1288A)**









High-voltage power supply modules C12733-03 / -04

Features

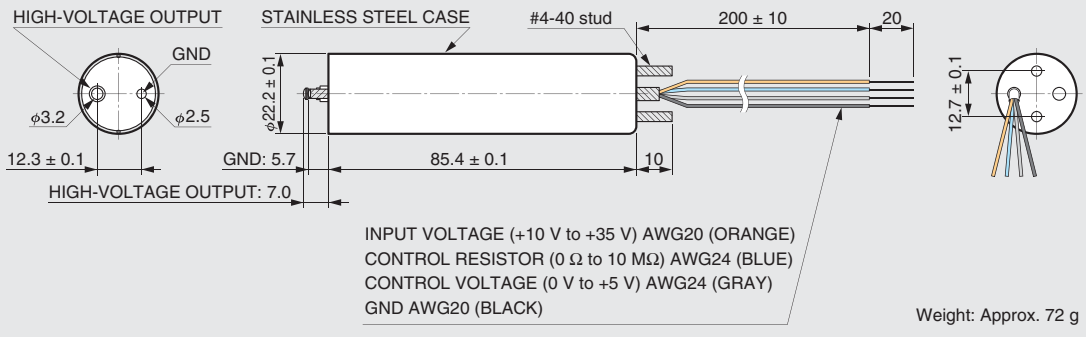
- **Wide operating temperature**
  Operating ambient temperature: -40 °C to +175 °C
- **High reliability for shock / vibration**
  Vibration: 300 m/s² (30 G), Shock: 10 000 m/s² (1000 G)
- **Best match with most of the hamamatsu ruggedized high temperature photomultiplier tube assemblies**

Specifications

Parameters			C12733-03	C12733-04	Unit
Input voltage			+10 to +35		V
Input current Ⓐ	with no load	Max.	30		mA
	with full load	Max.	90		
Variable output voltage range			-500 to -1800	+500 to +1800	V
Specification guaranteed output voltage range			-500 to -1800	+500 to +1800	V
Output current		Max.	90		μA
Line regulation ⒶⒷⒸ		Typ.	±0.2		%
Load regulation against 0 % to 100 % load change Ⓐ		Typ.	±0.1		%
Ripple / Noise (p-p)		Typ.	100		mV
Output voltage control			By external controlling voltage (0 V to +5 V) or external controlling resistor (0 Ω to 10 MΩ)		—
Control voltage input impedance		Typ.	10		kΩ
Output voltage setting (Absolute value)		Typ.	-(500 + controlling voltage x 260)	+(500 + controlling voltage x 260)	V
Output voltage rise time (0 % → 99 %)		Typ.	350		ms
Temperature coefficient		Typ.	±0.005		%/°C
Operating ambient temperature			-40 to +175		°C
Storage temperature			-55 to +70		°C
Storage humidity Ⓓ			Below 80 %		—
Resistance to shock			1000 G, 1/2 sine, 0.5 ms		—
Resistance to vibration			30 G, 10 Hz to 2000 Hz		—
Oscillation frequency		Typ.	15		kHz
Protective function			Over current protection, low input voltage malfunction prevention Ⓔ, transient input voltage fluction prevention		—

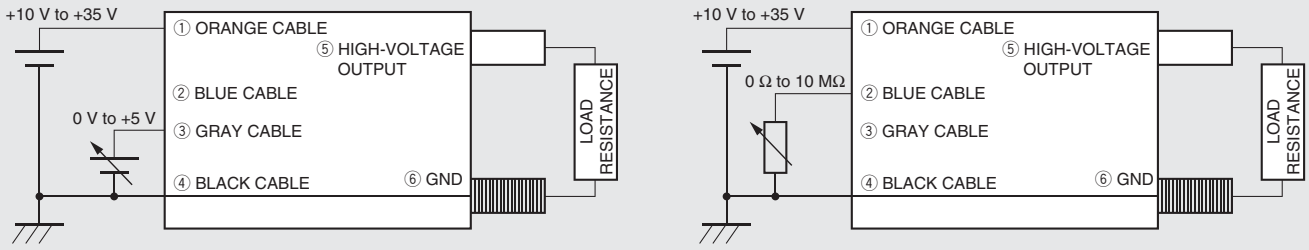
NOTE: Ⓐ At maximum output voltage. Ⓑ At maximum output current.
Ⓒ Larger value of +10 V to +24 V input change or +24 V to +35 V input change.
Ⓓ No condensation.
Ⓔ The low input voltage malfunction prevention function operates below 4 V.

Dimensional outline (Unit: mm)



Weight: Approx. 72 g

Figure 1 Connection diagram



The case is internally connected to ⑥.

Figure 2 Output control response characteristic (Typ.)

C12733-03 / -04 can adjust the high-voltage output by supplying the required control voltage between ③ and ④ or connecting required control resistor between ② and ④.

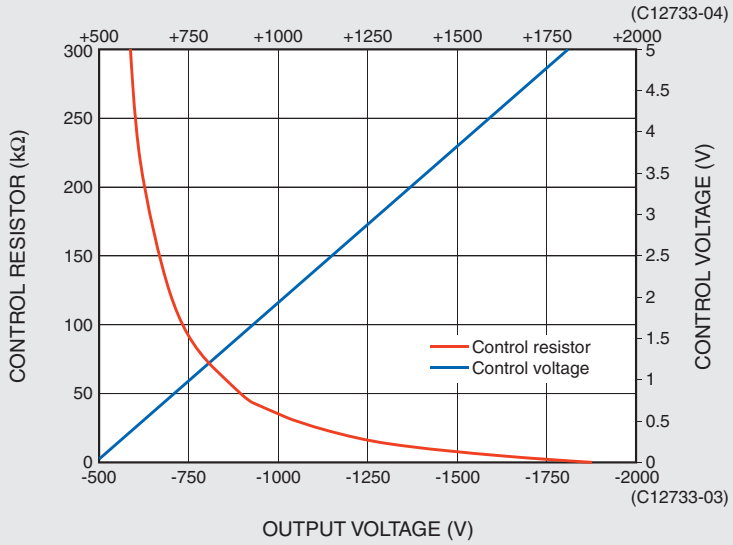
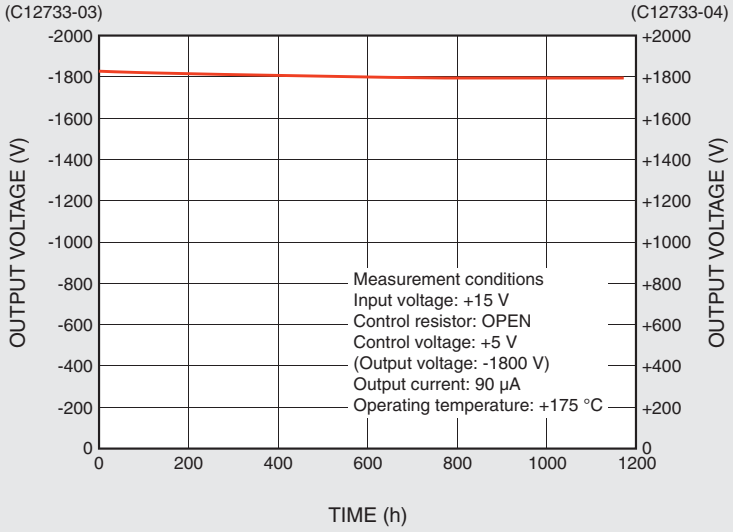


Figure 3 Life characteristics (Typ.)



⚠ WARNING

Take sufficient care to avoid an electric shock hazard

A high-voltage used in photomultiplier tube operation may present a shock hazard. Photomultiplier tubes should be installed and handled only by qualified personnel that have been instructed in handling of high-voltages. Designs of equipment utilizing these devices should incorporate appropriate interlocks to protect the operator and service personnel.

PRECAUTIONS FOR USE

- **Recommend to apply high-voltage all the time at high temperature.**
  It is recommended that a high voltage is applied all the time to the 200 °C type photomultiplier tubes while it is exposed to high temperatures above 175 °C. Leaving the photomultiplier tubes at above 175 °C without any HV bias may degrade the characteristics.

- **Store photomultiplier tube assemblies having internal voltage divider circuits in an environment at temperatures above -30 ˚C.**
  Temporary bases and button stems are designed for temperatures down to -80 °C. (Note that when button stems are inserted in a socket, they must be stored at temperatures no lower than -30 °C.)

- **Handle tubes with extreme care.**
  Photomultiplier tubes have evacuated glass envelopes. Allowing the glass to be scratched or to be subjected to shock can cause cracks.

- **Keep faceplate and base clean.**
  Do not touch the faceplate and base with bare hands. Dirt and fingerprints on the faceplate cause loss of transmittance and dirt on the base may cause ohmic leakage. Should they become soiled, wipe it clean using alcohol.

- **Do not apply force in excess of 200 N to the faceplate of photomultiplier tube assemblies.**

- **Do not expose to strong light.**
  Direct sunlight and other strong illumination may cause damage to the photocathode. They must not be allowed to strike the photocathode, even when the tube is not operated.

- **Handling of tubes with a glass base.**
  A glass base (also called button stem) is less rugged than a plastic base, so care should be taken in handling this type of tube. For example, when fabricating the voltage-divider circuit, solder the divider resistors to socket lugs while the tube is inserted in the socket.

- **Do not use ultrasonic cleaners for cleaning.**

- **Do not use the temporary base with socket in the final product.**
  Attached B12-43 base and E678-12R socket are only for testing purposes and are not guaranteed for long-time operation at high temperature.

  Data and specifications listed in this catalog are subject to change due to product improvement and other factors. Before deciding which types to use in your production equipment, please consult our sales office.

WARRANTY

Hamamatsu photomultiplier tubes and related products are warranted to the original purchaser for a period of 12 months after delivery. The warranty is limited to repair or replacement of a defective product due to defects in workmanship or materials used in its manufacture.
However, even if within the warranty period the warranty shall not apply to failures or damages caused by misoperation, mishandling, modification or accidents such as natural or man-made disasters.
The customer should inspect and test all products as soon as they are delivered.
This warranty shall not apply to photomultiplier tubes used in oil well logging, since they might be subjected to conditions exceeding product specifications. However, if the customer can provide data proving the photomultiplier tubes were used within the specifications, then the warranty may be considered valid in some cases.

DISPOSAL OF PRODUCT

The materials used in some photomultiplier tubes contain beryllium alloy. Please follow the applicable regulations regarding disposal of hazardous materials and industrial wastes in your country, state, region or province.

HAMAMATSU

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- Infrared detectors
- LED
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- X-ray flat panel sensors
- Mini-spectrometers
- Opto-semiconductor modules

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- Photomultiplier tube modules
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- Xenon lamps / Mercury-xenon lamps
- Deuterium lamps
- Light source applied products
- Laser applied products
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