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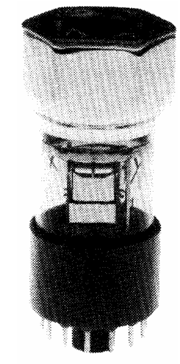
S83020F, S83020FM1, S83020FM2 Photomultipliers

60-mm Hexagonal 10-Stage, Head-On PMTs



BURLE S83020F, -Ml, and-M2 are 60-millimeter hexagonal, 10-stage photomultiplier tubes. Each employs a potassium-cesium-antimonide (bialkali) photocathode and a "teacup" first dynode followed by a hybrid box-and-grid/circular-cage dynode structure. The first dynode is similar in appearance to a truncated paraboloid. Interposed between the photocathode and the first dynode is a washer-like electrode that serves to focus the photoelectron stream. This structure affords increased efficiency in collecting photoelectrons from all regions of the useful photocathode with resulting improvements in pulse height resolution capability.

These tubes were designed primarily for application to medical diagnostic systems of the Anger camera type. However, they are expected to be useful also in general scintillation-counting applications and in the detection and measurement of low-level light events in the blue region of the spectrum.

S83020F has a permanently-attached base; S83020FM1 a temporary base; and S83020FM2 flying leads with no base. In cases where prospective production volume justifies the necessary tooling expense, BURLE is prepared to provide devices with permanently-attached Voltage Divider Networks as defined by customer specification.

General Data

Faceplate:
- Material…………… Schott B270 Glass or Equivalent
- Cross-section………………………….. Plano-Plano
- Thickness……………………………. 3.18+/- 0.38 mm
- Index of refraction @ 436 nm………………….. 1.523

Photocathode:
- Type……………. Semi-transparent K-Cs-Sb (Bialkali)
- Spectral response……………………… See **Figure 1**
- Wavelength of maximum response………. 370 nm

Dynodes:
- Number……………………………………………. 10
- Secondary-emitting surface:
  - Dynode No. 1…………………… Alkali-Antimonide
  - Dynodes No. 2-8………………… Beryllium-oxide
  - Dynodes No. 9-10…………… Proprietary material
- Structure…… "teacup" + box-and-grid + circular-cage

Weight (Approximate)…………………………… 165 gm

Socket………………………………….. BURLE AJ2283

Absolute Maximum Ratings[1]

Limiting Values

DC Supply Voltage:

Between anode and cathode……………	1700	V
Between anode and dynode No.10……	300	V
Between adjacent dynodes………………	300	v
Between dynode no.1 and cathode……	600	V

Average Anode Current:

Averaged over any 30 second interval…..	0.1	mA

Temperature:

Storage……………………………	-40 to + 70	°C
Operation…………………………….	See Note 2	

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Test Parameters and Limits

In order to insure that BURLE Photomultipliers consistently meet exacting performance standards, each device is subjected to a series of tests that verify that its operating parameters conform to normal expectations for the tube type. Although the conditions under which these tests are performed may or may not duplicate operating conditions in particular applications, long experience has shown that a tube satisfying the criteria indicated below can be expected to perform satisfactorily in a variety of applications.

Power supply voltage (E = 1100 Volts unless otherwise noted) is applied to the tube's electrodes via a Voltage Divider Network (VDN) in accordance with the distribution listed in Table 1. Ambient temperature is approximately 22 degrees C.

Test Parameter	Min.	Typ.	Max.	Units
Cathode Responsivity[3]…	8.6	10..0	--	µA/inc.lm
Anode Responsivity[4]…..	0.35	0.95	1.55	A/inc.lm
Anode Dark Current[5]…...	--	1.0	10.0	nA
Pulse Height (^{57}Co)[6]……	40	210	360	mV
Pulse Ht. Resl'n(^{57}Co)[6]….	--	9.1	9.7	%
Count Rate Stability[7]…….	-3	--	+3	%

Typical Performance Characteristics

The following information is provided in order that customers may predict the typical performance of a tube of this type in an application where TEST PARAMETER data may not be directly relevant. This material has been derived from TEST PARAMETER values and from special evaluations conducted in BURLE's Application Engineering Laboratory. This information is supplied for guidance only and is not intended to supersede the limiting ranges given in the TEST PARAMETER section.

Unless otherwise indicated, the power supply voltage (F) is applied to the tube's electrodes via a Voltage Divider Network (VDN) in accordance with the distribution listed in Table 1.

Parameter	Typ.	Units
Cathode Responsivity @ 370 nm…………….	103	mA/W
Cathode Quantum Efficiency @ 370 nm…….	34.5	%
Multiplier Gain @ 1100 V[8]……………………..	95000	--
Gain Exponent[9]…………………………………	6.65	--
Gain versus E…………………………………….	**See Figure 2**	
Anode Dark Current versus E[10]………………..	**See Figure 3**	
Anode Current Linearity[11]……………………….	**See Figure 4**	
Cathode Current Linearity versus Temp……..	**See Figure 5**	
Anode Responsivity Temp. Coefficient……….	**See Figure 6**	
Anode Dark Current versus Temperature[10]….	**See Figure 7**	
Peak-to-Valley Ratio[12]………………………….	3.2	--
Sensitivity to External Magnetic Fields[13]……..	21	%
Anode Pulse:[14]		
Rise Time……………………………………..	XXX	ns
Fall Time………………………………………	XXX	ns
FWHM…………………………………………	XXX	ns
Transit Time…………………………………	XXX	ns
Transit Time Spread[15] ………………………	XXX	ns

1. In accordance with the Absolute maximum rating system as defined by the Electronic Industries Association Standard RS-239A, formulated by the JEDEC Electron Tube Council.
2. In general, these types can be operated successfully over the temperature range specified for Storage. However, the user should be aware that performance may be affected by operating temperature changes. See, for example, **Figures 5, 6, and 7**; which show the effect of temperature on effective Cathode Current Linearity, Anode Responsivity, and Anode Dark Current, respectively.
3. Under the following conditions: Light from a tungsten filament lamp operated at a color temperature of 2856 K is transmitted to the cathode through a blue filter (Corning C.S. No. 5-58, polished to 1/2 stock thickness). The value of flux on the filter is 0.1 millilumen and 300 volts is applied between cathode and all other electrodes connected as anode.

   Cathode Responsivity = Cathode Current/Incident Flux
4. Under the following conditions: Light from a tungsten filament lamp operated at a color temperature of 2856 K is transmitted to the cathode through a blue filter (Corning C.S. No. 5-58, polished to 1/2 stock thickness). The value of flux on the filter is 10 microlumens and test voltage (E) is 1100 volts.

   Anode Responsivity = Anode Current/Incident Flux
5. Anode dark current is measured at an ambient temperature of 22 degrees C. The test is conducted without special pre-conditioning in the dark, although care is taken to avoid excessive exposure to room lighting prior to test. Using conditions as described in Note 4, applied voltage is adjusted to obtain an anode current of 15 micro-amperes, after which light is extinguished and dark current measured. For a typical tube, Gain is approximately 150,000 under these conditions.
6. Power supply voltage during this test is 1100 volts. The test is conducted with a gamma-ray source of sufficient intensity to produce between 5K and 15K counts per second from the device under test when positioned on the back side of the scintillator and along its principle axis. The scintillator is an encapsulated 2" long x 2" diameter NaI(Tl) crystal identified as BURLE No. 2004 or equivalent. The faceplate end of the scintillator is coupled to the faceplate of the photomultiplier by a coupling fluid such as mineral oil or equivalent The anode of the photomultiplier is connected to a shunt RC network whose time constant is 10 +/- 2 microseconds and to the input of a charge-sensitive preamplifier, Nuclear Data Model 520 or equivalent. A multi-channel analyzer (MCA) characterizes scintillation events in terms of an amplitude histogram as illustrated in **Figure 10**, on which are defined Pulse Height and Pulse Height Resolution. Pulse height is given in millivolts developed across a hypothetical load consisting of a capacitance of 100 picofarads shunted by a resistance of 100 kilohms.
7. A light emitting diode (LED) is employed as a light source. The LED is driven by a suitable pulse generator so as to produce an anode pulse equivalent in amplitude and shape to that due to ^{57}Cobalt excitation of BURLE Scintillator No. 2004 or equivalent. Following operation for at least 10 seconds at a LED pulse rate of 4000 Hertz, pulse height is measured and recorded as PH_i. The LED pulse rate is changed to 40000 Hertz and the pulse height is immediately measured and recorded as PH_f. Count Rate Stability is defined as follows:

   $CRS = 100 \times (PH_f - PH_i)/PH_i$

   Note - This test is conducted on a periodic sampling basis.

8. Gain (Current Amplification) is defined as:

   Gain = Anode Responsivity/Cathode Responsivity

9. The relationship between multiplier gain and power supply voltage (E) may be expressed as follows:

   Gain = C x E^a

   where C = a constant and ^{a} = the gain exponent

10. In contrast to the case of Anode Dark Current specified under **Test Parameters and Limits**, data for this curve is taken following a minimum of 12 hours preconditioning in complete darkness. This avoids excitation of spurious dark current by ambient room lighting.

11. The photocathode is illuminated by a square light pulse of approximately 500 nanosecond duration. Introduction of successive values of optical attenuation into the input light path allows determination of the peak pulse anode current at which space charge effects cause deterioration of the normally linear light-in/ current-out function. In designing a voltage divider network, precautions must be taken to maintain the appropriate voltage distribution in the presence of high average and/or high peak anode current values. This subject is treated in the BURLE Photomultiplier Handbook (TP-136) under the section titled "Photomultiplier Applications -Applied Voltage Considerations". Also in this section is a discussion on extending the linear operating range to higher levels of peak pulse anode current, using a so-called Tapered Divider. As a general rule of thumb, one may anticipate that careful choice of the "tapering" function should roughly double the peak pulse anode current at which linearity degrades to a given level.

12. The tube under test is exposed to a very low level of illumination such that photoelectrons are produced with temporal separation at a rate of approximately 10,000 per second. Power supply voltage is adjusted to obtain a gain of approximately one million. A multi-channel analyzer (MCA) characterizes single-electron signal events in terms of an amplitude histogram or spectrum as illustrated in **Figure 11,** on which is defined Peak-to-Valley Patio. Also shown is the spectrum due to noise events in complete darkness, the contribution of which is included in the Peak-to-Valley value reported.

13. A magnetic field of 0.7 Gauss (approximating the earth's magnetic field), with flux lines perpendicular to the long axis of the unshielded tube under test, is rotated about the tubes axis in increments of 30 degrees. Using an appropriate light stimulus, the anode signal from the tube is recorded at each magnetic field orientation. Magnetic sensitivity is defined as follows:

    MFS = (Max. Signal - Mi Signal)/(Mean Signal)

    The effect of the magnetic environment in which a tube is operated is greatly reduced by suitable magnetic shielding. For example, a 0.004" thick close-fitting magnetic shield of high permeability material, covering all glass surfaces other than the faceplate, will typically reduce the MFS value by approximately one order of magnitude.

14. The photocathode is fully illuminated by a delta-function light pulse of approximately 1 nanosecond duration and of intensity sufficient to create an anode current pulse of approximately x milliamperes (peak value). Power supply voltage during the test is xxxx volts. Rise and Fall Times, the FWHM value, and Transit Time are as defined on **Figure 12**. For estimating the effect of power supply voltage on these parameters, the following empirical relationship may be used:

    Parameter Value = C x E^b

    where C = a constant and ^{b} = -0.5 to -0.7

15. The photocathode is fully illuminated by a delta-function light pulse of approximately 1 nanosecond duration. Power supply voltage during the test is xxxx volts. Transit Time Spread is defined as the full-width-half-maximum of the distribution of Transit Times about the mean Transit Time, observed over a period of time encompassing a series of illumination events. This parameter is sensitive to the number of photoelectrons created during each event, increasing in value as the photoelectron count decreases. The value given applies to approximately xxx photoelectrons.

Table 1

Voltage to be Provided by Divider	
Between	**8.33% of Supply Voltage (E) Multiplied By:**
Cathode and Focus Electrode	1.8
Focus Electrode and Dynode No.1	0.2
Dynode No.1 and Dynode No.2	1.0
Dynode No.2 and Dynode No.3	1.0
Dynode No.3 and Dynode No.4	1.0
Dynode No.4 and Dynode No.5	1.0
Dynode No.5 and Dynode No.6	1.0
Dynode No.6 and Dynode No.7	1.0
Dynode No.7 and Dynode No.8	1.0
Dynode No.8 and Dynode No.9	1.0
Dynode No.9 and Dynode No.10	1.0
Dynode No.10 and Anode	1.0
Cathode and Anode	12.0

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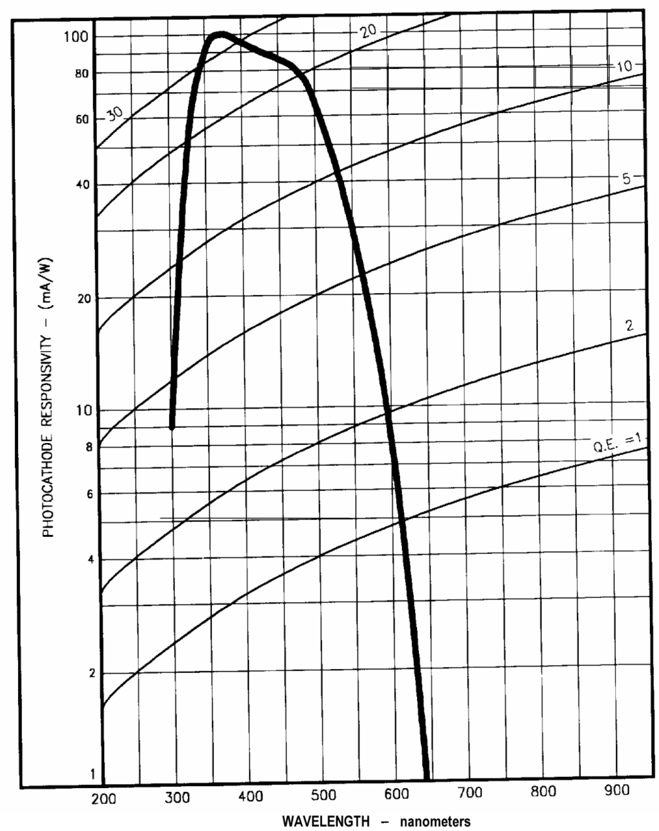

Figure 1 - Typical Photocathode Spectral Response Characteristics

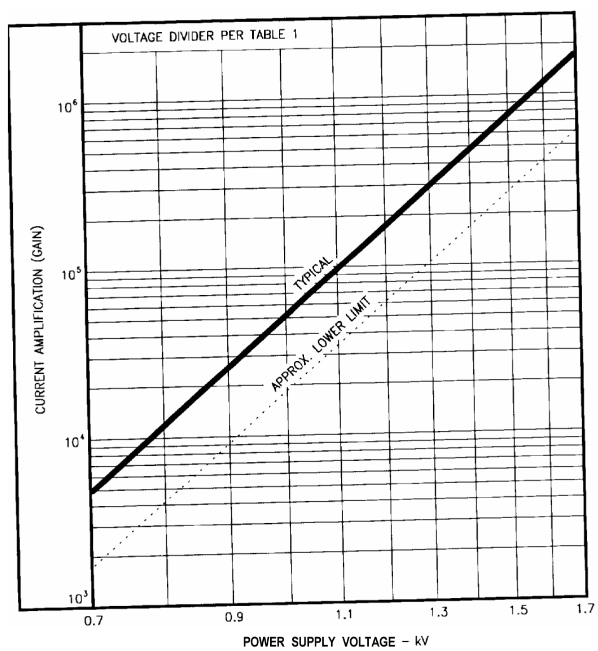

Figure 2 – Typical Current Amplification Characteristic

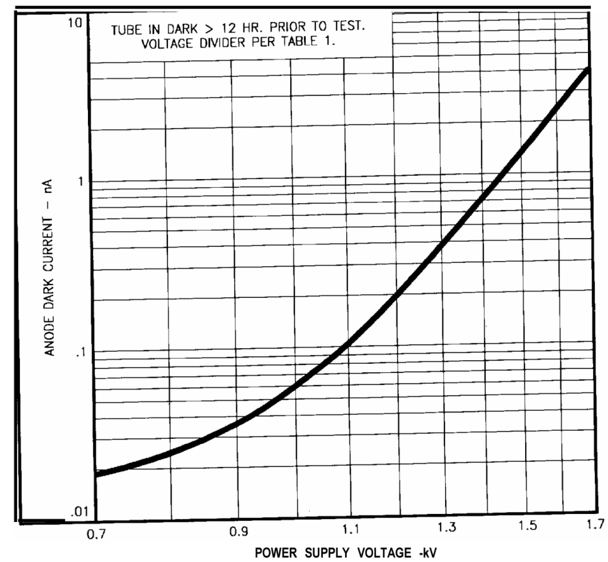

Figure 3 - Typical Anode Dark Current Characteristic

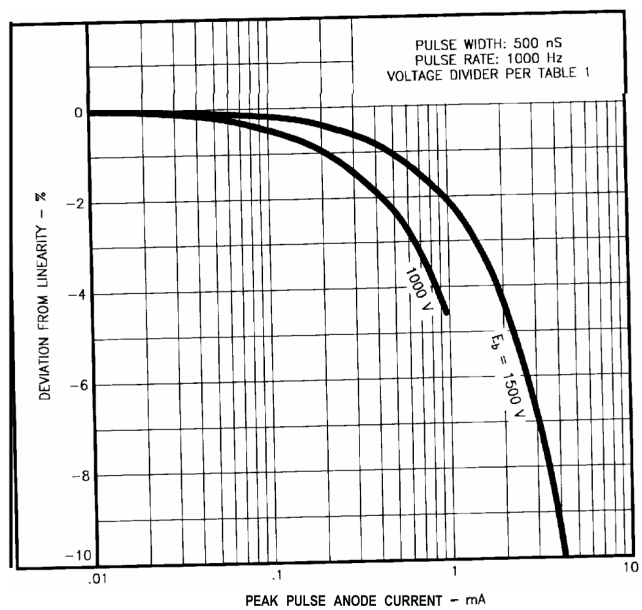

Figure 4 - Typical Anode Current Linearity Characteristics

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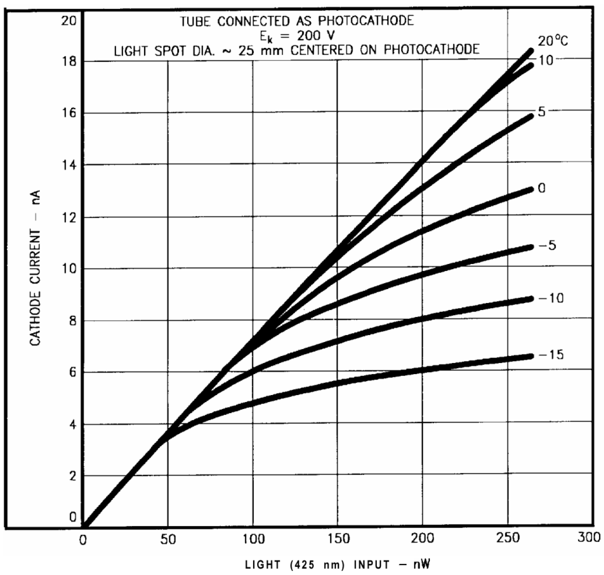

Figure 5 - Typical Cathode Current Linearity Characteristic Showing Effect of Operating Temperature

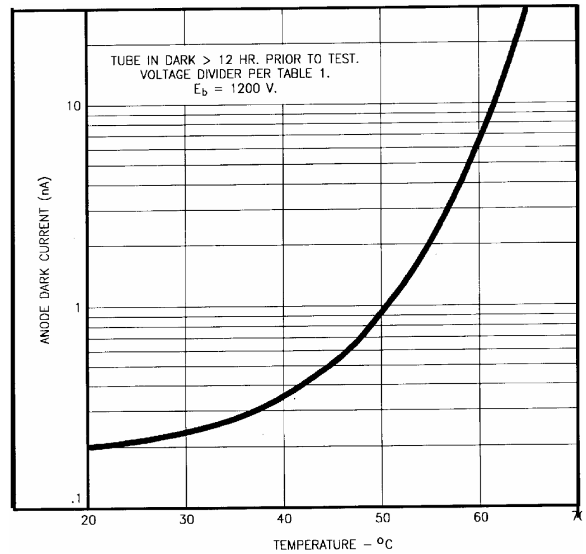

Figure 7 - Typical Effect of Operating Temperature on Anode Dark Current

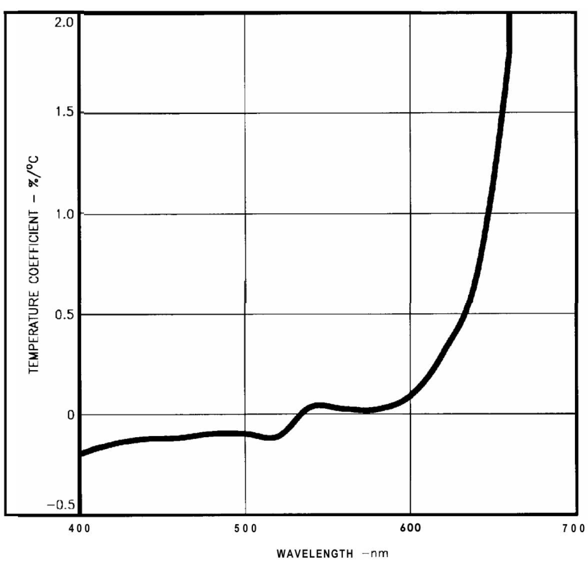

Figure 6 - Typical Anode Responsivity Temperature Characteristic

Warning-Personal Safety Hazards
Electrical Shock - Operating voltages applied to this device present a shock hazard.

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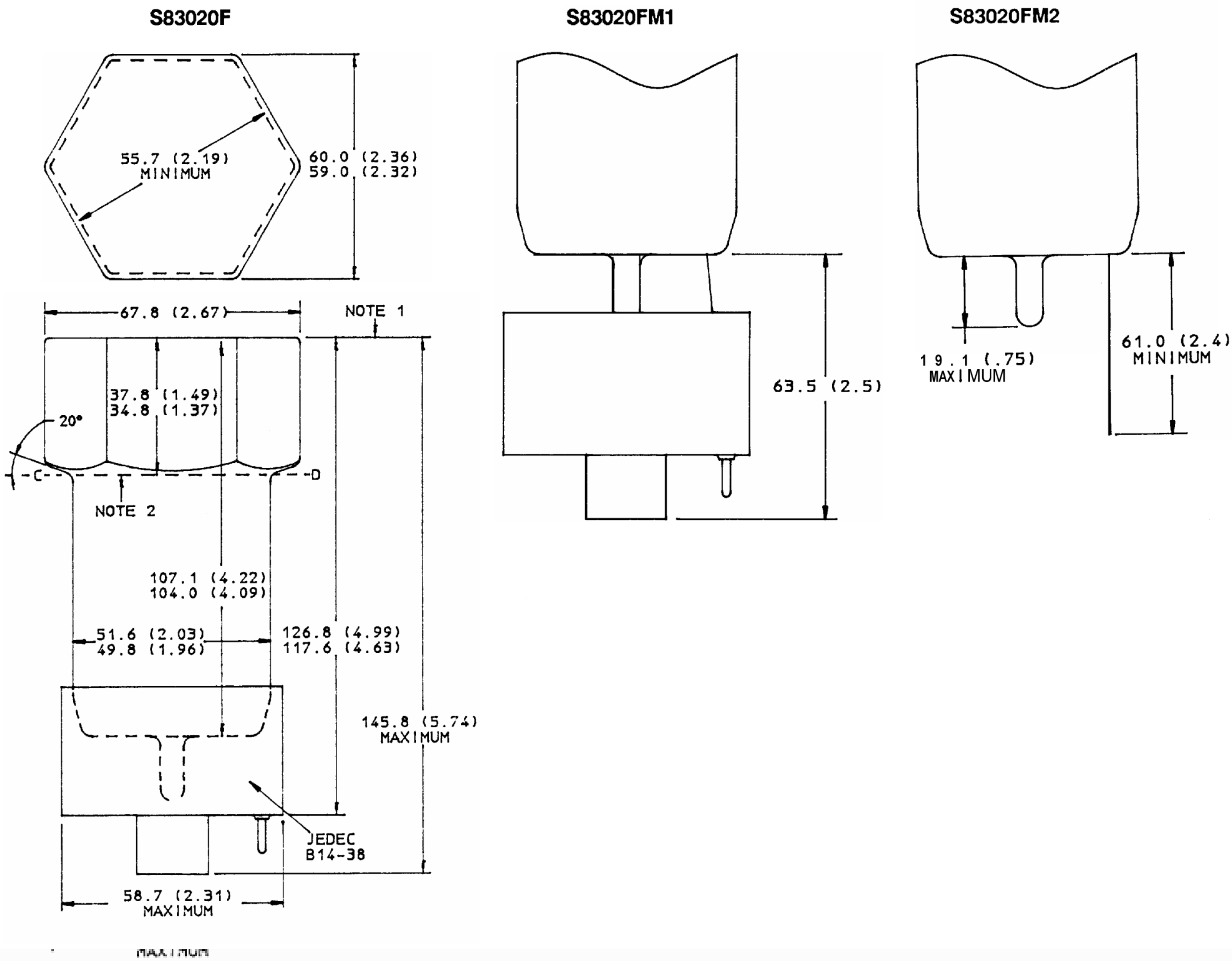


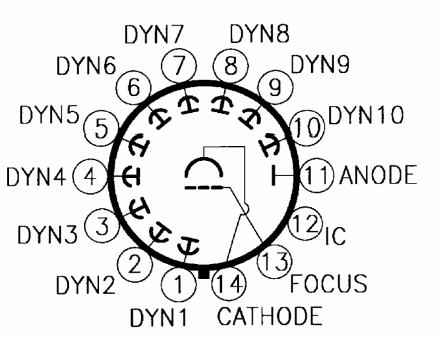
Dimensions are in millimeters unless otherwise stated. Dimension in parentheses are in inches and are derived from the basic inch dimensions. (One inch = 25.4 mm).

Note 1 - Deviation from flatness not to exceed 0.25 mm (0.01 inch) from peak to valley.

Note 2 - The C-D reference line is defined by the points where a 57.2 mm (2.25 in) wide “U” gauge, held parallel to the faceplate, contacts the bulb/neck transition.

Figure 8 - Dimensional Outlines

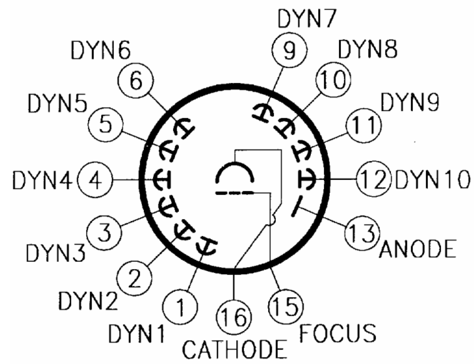
S83020F, S83020FM1



IC – INTERNAL CONNECTION, DO NOT USE

Bottom View

S83020FM2, S83020FM1 (base removed)



STEM LEADS 7, 8, & 14 ARE CLIPPED SHORT
CATHODE LEAD IDENTIFIED BY DOT ON STEM GLASS

Bottom View

Pin 1: Dynode No. 1
Pin 2: Dynode No. 2
Pin 3: Dynode No. 3
Pin 4: Dynode No. 4
Pin 5: Dynode No. 5
Pin 6: Dynode No. 6
Pin 7: Dynode No. 7
Pin 8: Dynode No. 8
Pin 9: Dynode No. 9
Pin 10: Dynode No. 10
Pin 11: Anode
Pin 12: Internal Connection, Do Not Use
Pin 13: Focusing Electrode
Pin 14: Photocathode
Base Pin Connections

Pin 1: Dynode No. 1
Pin 2: Dynode No. 2
Pin 3: Dynode No. 3
Pin 4: Dynode No. 4
Pin 5: Dynode No. 5
Pin 6: Dynode No. 6
Pin 7: Clipped Short
Pin 8: Clipped Short
Pin 9: Dynode No. 7
Pin 10: Dynode No. 8
Pin 11: Dynode No. 9
Pin 12: Dynode No. 10
Pin 13: Anode
Pin 14: Clipped Short
Pin 15: Focusing Electrode
Pin 16: Photocathode
Stem Lead Connections

Figure 9 - Base Pin and Stem Lead Connections

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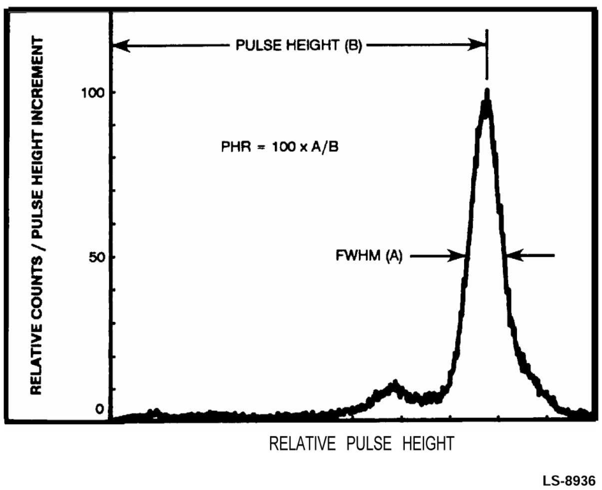

Figure 10 - Definitions, Pulse Height and Pulse Height Resolution

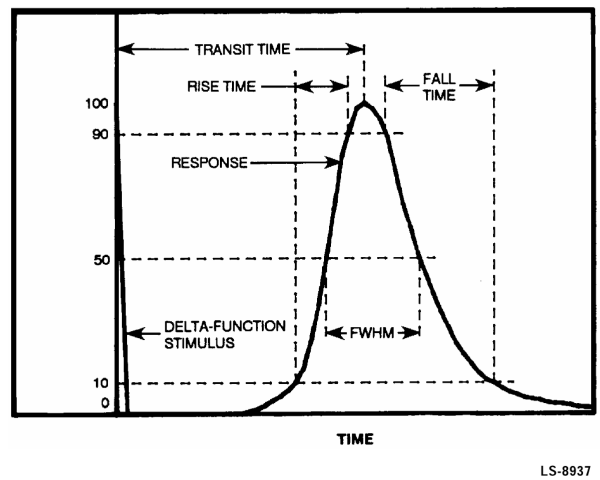

Figure 12 - Definitions, Anode Pulse Timing Parameters

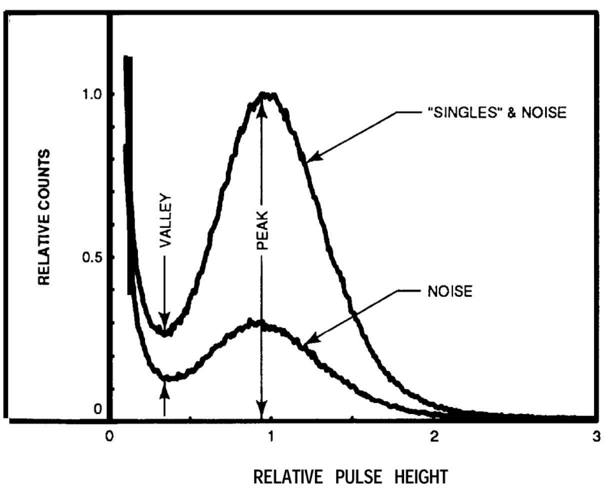

Figure 11 - Definition, Peak-to-Valley Ratio, Single Photoelectron Pulse Height Distribution