DATA SHEET

A51EAL155X
“Black Line FX” colour picture tube

Product specification
Supersedes data of 1998 Dec 04
File under Display Components, DC01

2000 Jan 21

Philips
Components

PHILIPS

“Black Line FX” colour picture tube

A51EAL155X

FEATURES

- ‘Flatter’ and ‘squarer’ screen
- In-line, hi-bi potential ART (Aberration Reducing Triode) gun
- Mask with corner suspension
- HIGH GLOSS screen finish
- Cd-free phosphors
  - Pigmented deep red
  - Bright sulphide green
  - Highly pigmented sulphide blue
- Quick-heating low-power cathodes
- Soft-flash
- Slotted shadow mask optimized for minimum moiré at 525 and 625 line systems
- Internal magnetic shield
- Internal multipole
- The tube is supplied with a matched hybrid saddle toroidal deflection unit of the AT6035 series which forms a self-converging and raster correction free assembly
- Black Matrix technology
- Dark screen tube with increased EHT for improved contrast/brightness performance.

QUICK REFERENCE DATA

PARAMETER	TYP.	UNIT
Deflection angle	90	deg
Minimum useful screen diagonal	51	cm
Overall length	44.4	cm
Glass transmission	41	%
Neck diameter	29.1	mm
Heater voltage	6.15	V
Heater current	315	mA
Anode voltage	27.5	kV
Focus voltage	31% of anode voltage	
Mass	≈14	kg

Black Line FX

ELECTRICAL DATA

SYMBOL	PARAMETER	MIN.	TYP.	UNIT
Capacitances				
$C_{a(m+m')}$	anode to external conductive coating, including rimband	1600	–	pF
C_{kR}, C_{kG}, C_{kB}	cathode of any gun to all other electrodes	–	5	pF
C_{g1}	grid 1 to all other electrodes	–	17	pF
C_{g3}	grid 3 (focusing electrode) to all other electrodes	–	6	pF
Heating				
V_f	heater voltage at average beam current: indirect AC (preferably mains or line frequency) or DC	–	6.15	V
I_f	heater current	–	315	mA
Resistance				
R_{rim}	resistance between rimband and external conductive coating	50	–	MΩ

ELECTRO-OPTICAL DATA

PARAMETER	VALUE
Electron gun system	unitized triple-aperture electrodes; aberration reducing triode
Focus method	electrostatic
Focus lens	hi-bi potential
Deflection method	magnetic
Deflection angles	
diagonal	90°
vertical	78°
horizontal	60°

OPTICAL DATA

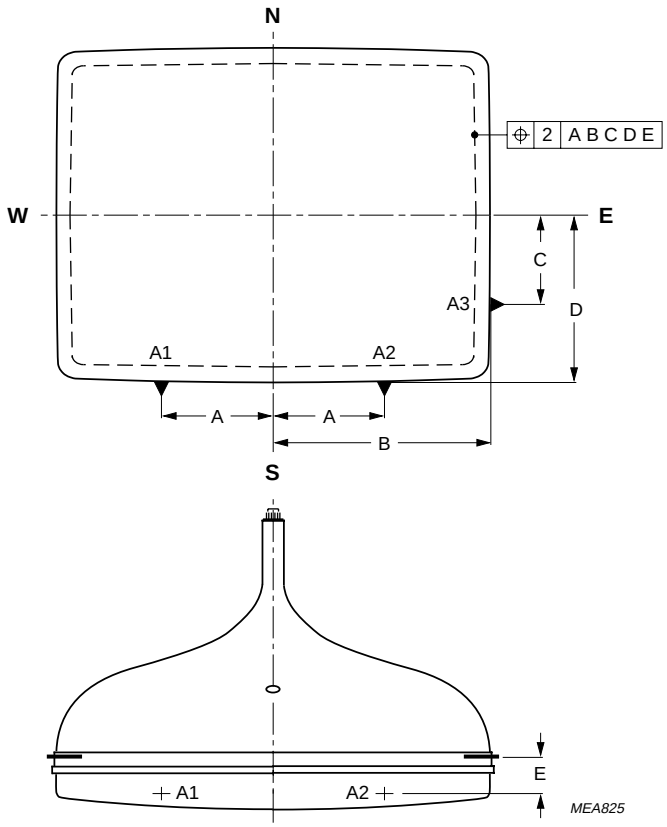
PARAMETER	VALUE
Matrix	black opaque material, PVP technology
Screen	metal-backed vertical phosphor stripes; phosphor lines follow glass contour
Screen finish	high gloss
Nominal useful screen dimensions	
diagonal axis	509.8 mm
horizontal axis	411.2 mm
vertical axis	308.9 mm
area	1270 cm^2
Phosphor alignment	see Fig.1
Phosphors	
red	pigmented europium activated rare earth
green	bright Cd-free sulphide type
blue	highly pigmented sulphide type
Persistence	medium short
Centre-to-centre distance of identical colour phosphor stripes at centre of screen	≈0.78 mm
Light transmission of face glass at centre of screen	41%
Luminance at centre of screen; note 1	79 cd/m^2
Contrast	>20.1 dB

Note

1. Tube settings adjusted to produce white D (x = 0.313, y = 0.329), focused raster, current density 0.4 $\mu A/cm^2$.

Colour coordinates

COLOUR COORDINATE	x	y
Red	0.630	0.330
Green	0.300	0.610
Blue	0.155	0.065



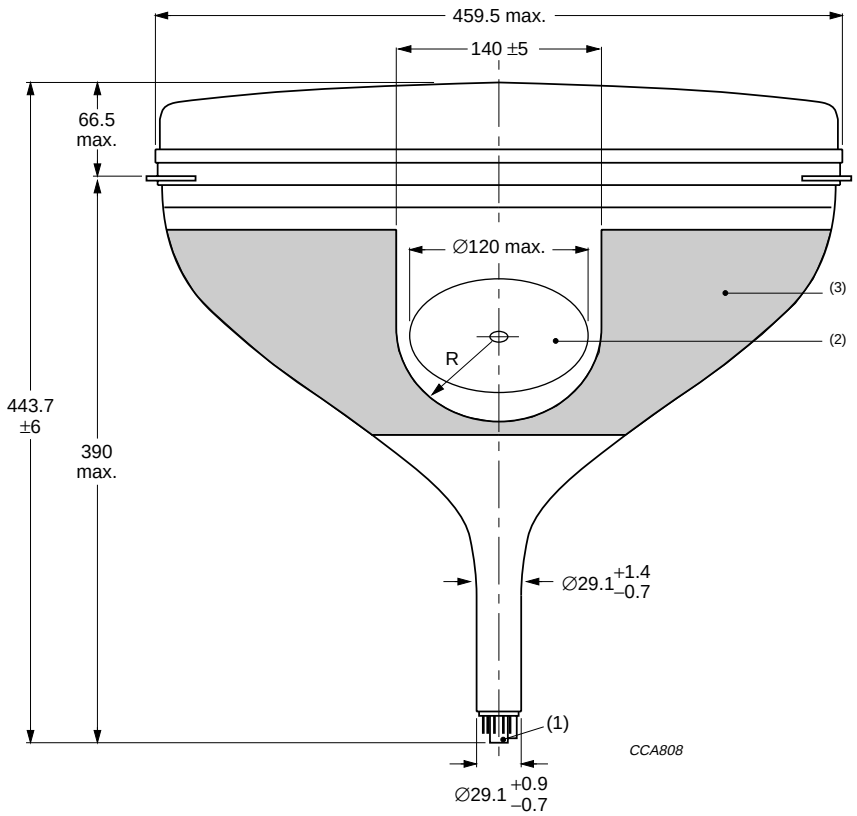
A = 171.7 mm.
B = 223.7 mm.
C = 115.6 mm.
D = 173.9 mm.
E = 23.5 mm.

Fig.1 Phosphor alignment.

MECHANICAL DATA

See Figs 2 to 12.

PARAMETER	VALUE
Overall length	443.7 ±6 mm
Bulb dimensions	
diagonal	<546.1 mm
horizontal	<455.6 mm
vertical	<359.6 mm
Neck diameter; note 1	29.1 +1.4/–0.7 mm
Base	JEDEC B10-277
Anode contact	small cavity contact JEDEC J1-21; IEC 60067-III-2
Mounting position	anode contact on top
Implosion protection	shrunk-on rimband with integral mounting lugs
Mass	≈14 kg



Dimensions in mm.

(1) The socket for this base should not be rigidly mounted; it should have flexible leads and be allowed to move freely. After mounting of the tube in the cabinet note that the position of the base can fall within a circle, having a diameter of max. 50 mm concentric with an imaginary tube axis.

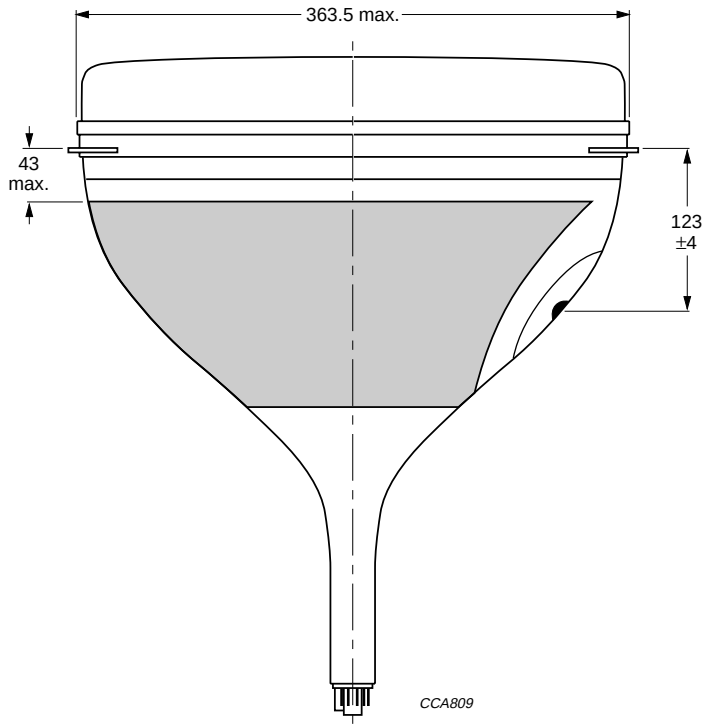
(2) To clean this area, wipe only with a soft lint-free cloth.

(3) Configuration of the outer conductive coating may vary but will contain the contact area as shown.

Fig.2 Tube dimensions; top view.

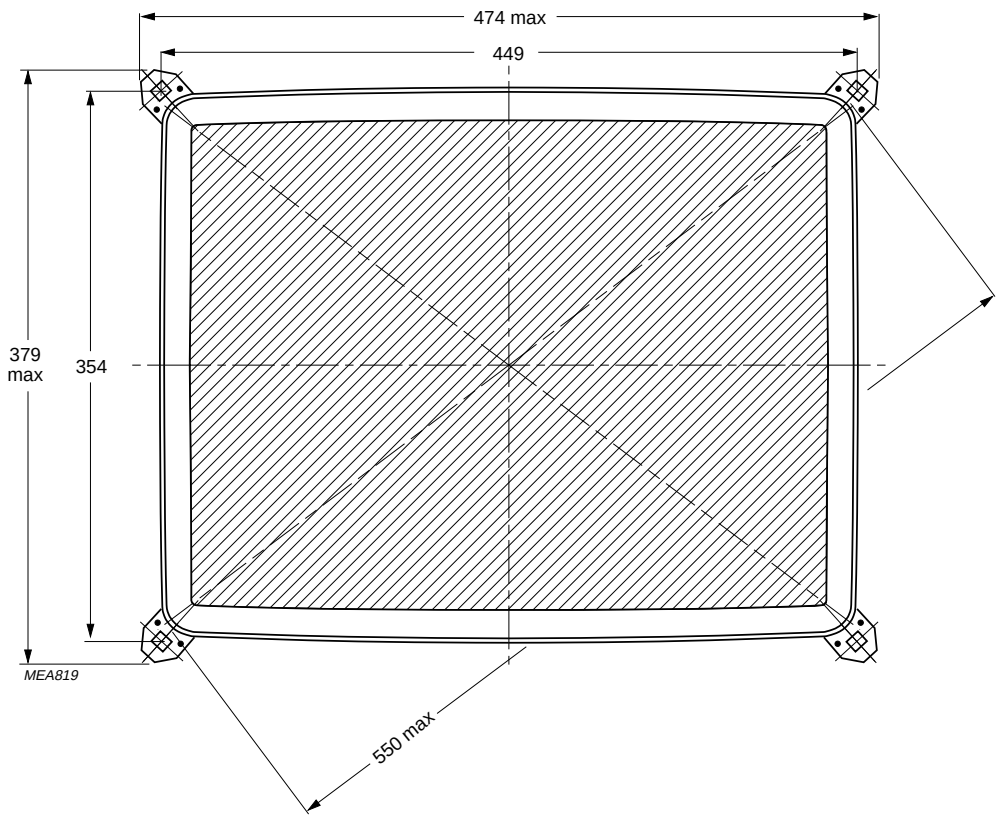
Note

1. In the region of 78.5 mm from the neck end, the maximum diameter is 30 mm.



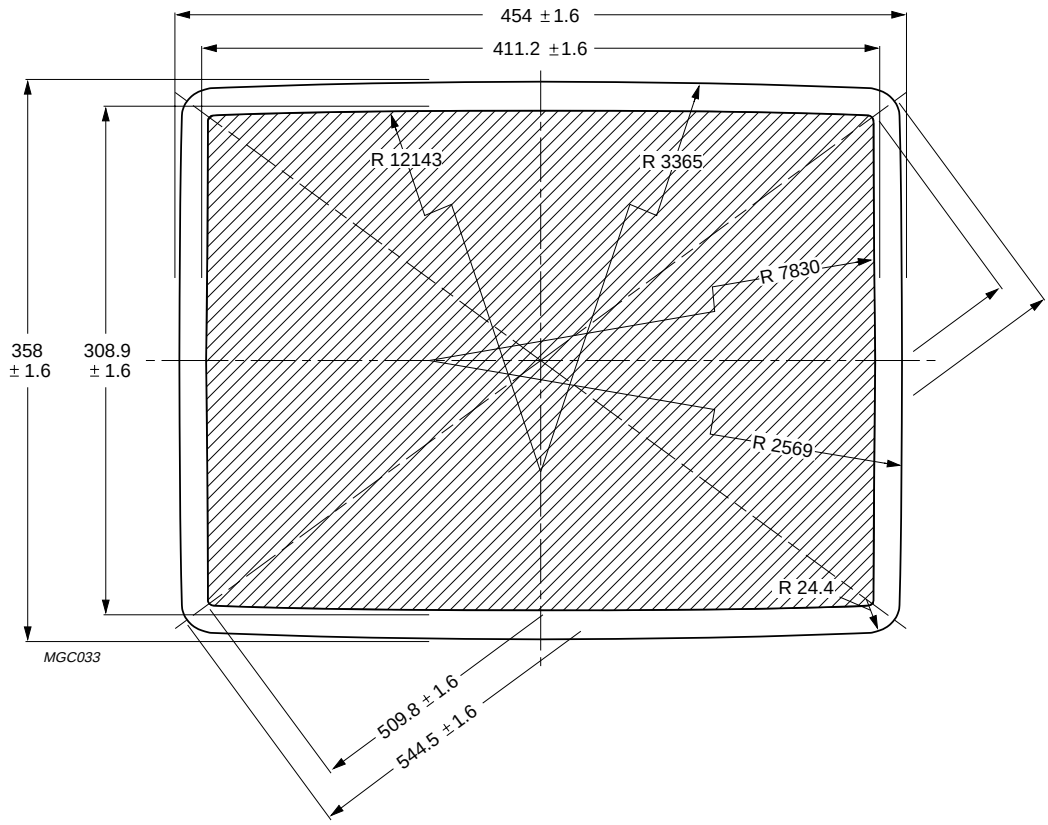
Dimensions in mm.

Fig.3 Tube dimensions; side view.



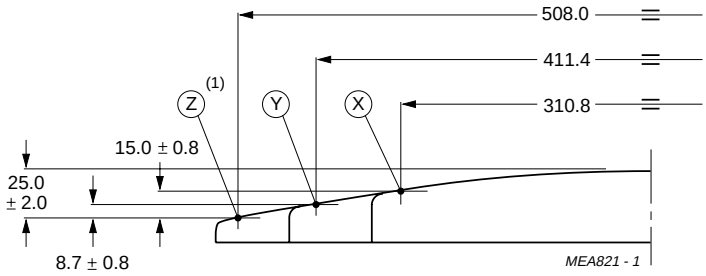
Dimensions in mm.

Fig.4 Tube dimensions; front view.



Dimensions in mm.

Fig.5 Phosphor and screen dimensions.



Dimensions in mm.

(1) Coordinates for Z-point: X = 203.2, Y = 152.4.

The X, Y and Z reference points are located on the outside surface of the face plate on the minor, major and diagonal screen axis respectively.

The distance Z from any point on the screen to the centre can be calculated using the following formula:

$$Z = (A_1 \times X^{B_1}) + (A_2 \times Y^{B_2}\sqrt{\ }) + (A_3 \times X^{B_3} \times Y^{B_4})$$

Where:

$A_1 = 2.33161 \times 10^{-4}$

$A_2 = 2.50647 \times 10^{-4}$

$A_3 = -9.31800 \times 10^{-11}$

$B_1 = 2.1$

$B_2 = 2.1$

$B_3 = 1.84082$

$B_4 = 2.65536$

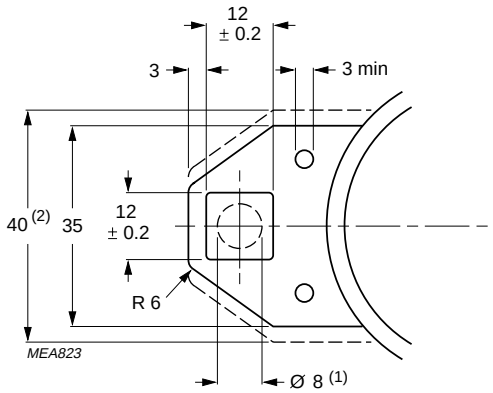
Fig.6 Screen reference points.

Sagittal heights measured with respect to the end of the diagonal axis of the nominal useful screen

NOMINAL USEFUL SCREEN (NUS)			3 mm INSIDE NUS			5 mm OUTSIDE NUS		
COORDINATES		SAGITTAL HEIGHT	COORDINATES		SAGITTAL HEIGHT	COORDINATES		SAGITTAL HEIGHT
X (mm)	Y (mm)	(mm)	X (mm)	Y (mm)	(mm)	X (mm)	Y (mm)	(mm)
0.0	0.0	25.1	0.0	0.0	24.3	0.0	0.0	26.5
0.0[1]	154.5	15.2	0.0	151.5	14.8	0.0	159.5	15.9
20.0	154.5	15.1	20.0	151.5	14.7	20.0	159.5	15.8
40.0	154.4	14.8	40.0	151.4	14.3	40.0	159.4	15.4
60.0	154.4	14.1	60.0	151.4	13.7	60.0	159.4	14.8
80.0	154.2	13.1	80.0	151.2	12.7	80.0	159.2	13.8
100.0	154.1	11.9	100.0	151.1	11.5	100.0	159.1	12.6
120.0	153.9	10.3	120.0	150.9	9.9	120.0	158.9	11.0
140.0	153.7	8.4	140.0	150.7	7.9	140.0	158.7	9.1
160.0	153.5	6.1	160.0	150.5	5.7	160.0	158.5	6.9
180.0	153.2	3.5	180.0	150.2	3.1	180.0	158.2	4.3
200.0	152.9	0.6	200.0	149.9	0.2	200.0	157.9	1.4
203.9[2]	152.8	0.0	201.0	149.8	0.0	208.8	157.7	0.0
204.0	150.0	0.3	–	–	–	–	–	–
204.3	130.0	2.4	201.3	130.0	2.0	209.3	130.0	2.9
204.6	110.0	4.1	201.6	110.0	3.8	209.6	110.0	4.6
204.9	90.0	5.5	201.9	90.0	5.2	209.9	90.0	6.1
205.1	70.0	6.7	202.1	70.0	6.4	210.1	70.0	7.2
205.2	50.0	7.5	202.2	50.0	7.2	210.2	50.0	8.0
205.3	30.0	8.1	202.3	30.0	7.8	210.3	30.0	8.6
205.4	10.0	8.3	202.4	10.0	8.1	210.4	10.0	8.8
205.4[3]	0.0	8.4	202.4	0.0	8.1	210.4	0.0	8.9

Notes

1. End of short axis.
2. End of diagonal axis.
3. End of long axis.

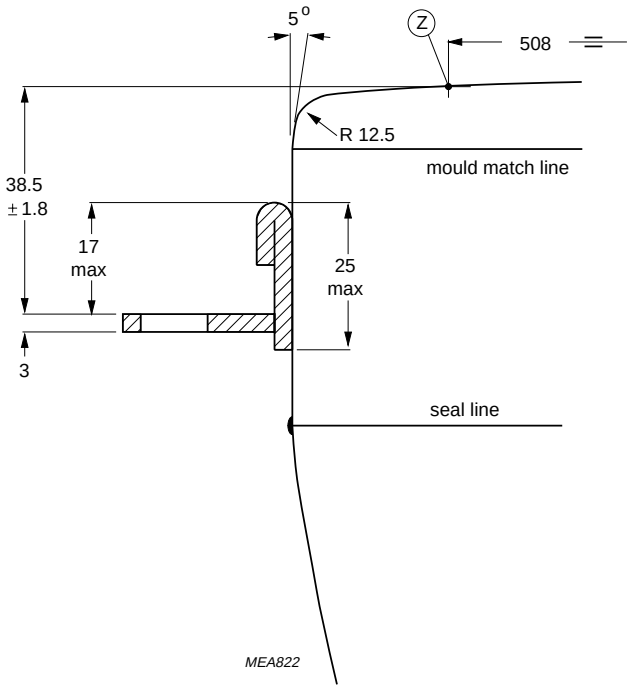


Dimensions in mm.

(1) The position of the mounting screw in the cabinet must be within a circle of 8 mm diameter drawn around the true geometrical positions, i.e. the corners of a rectangle of 354.0 mm × 449.0 mm.

(2) Minimum space to be reserved for mounting lug in cabinet.

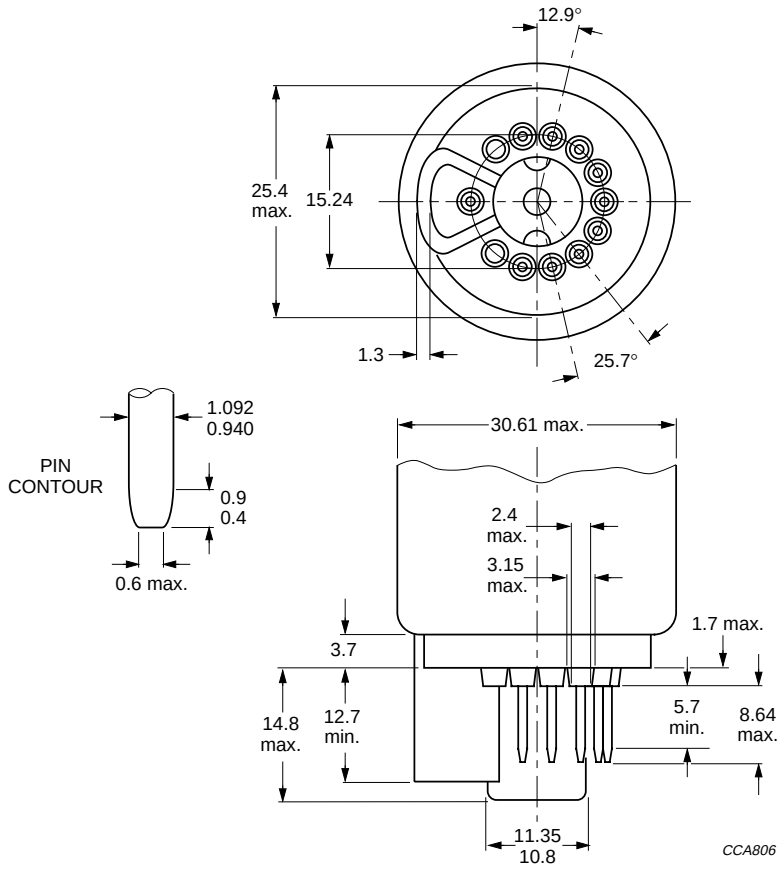
Fig.7 Lug dimensions.



Dimensions in mm.

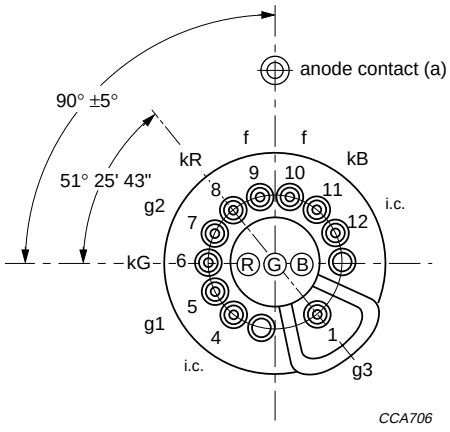
The displacement of any lug with respect to the plane through the three other lugs is max. 1.3 mm. This deviation is incorporated in the tolerance of ±1.8 mm.

Fig.8 Lug position.



Dimensions in mm.

Fig.9 Base JEDEC B10-277.



i.c. = internally connected and not to be used.

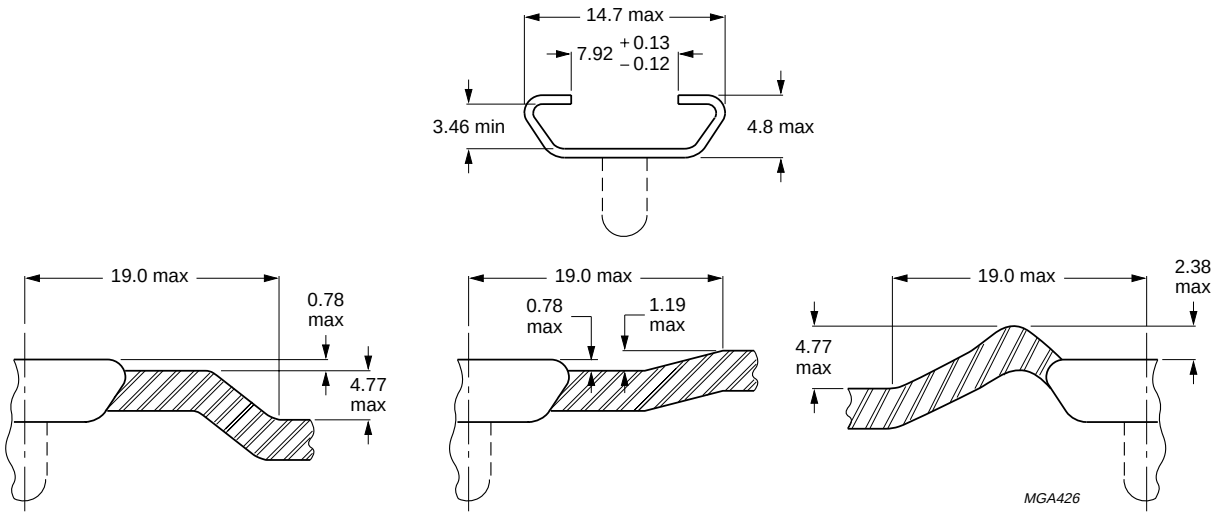
Fig.10 Pin arrangement.

Remarks: to Figs 9 and 10.

The socket for this base should not be rigidly mounted, it should have flexible leads and be allowed to move freely. After mounting the tube in the cabinet, note that the position of the base can fall within a circle, having a diameter of max. 40 mm concentric with an imaginary tube axis.

The mass of the mounting socket assembly should not exceed 150 g.

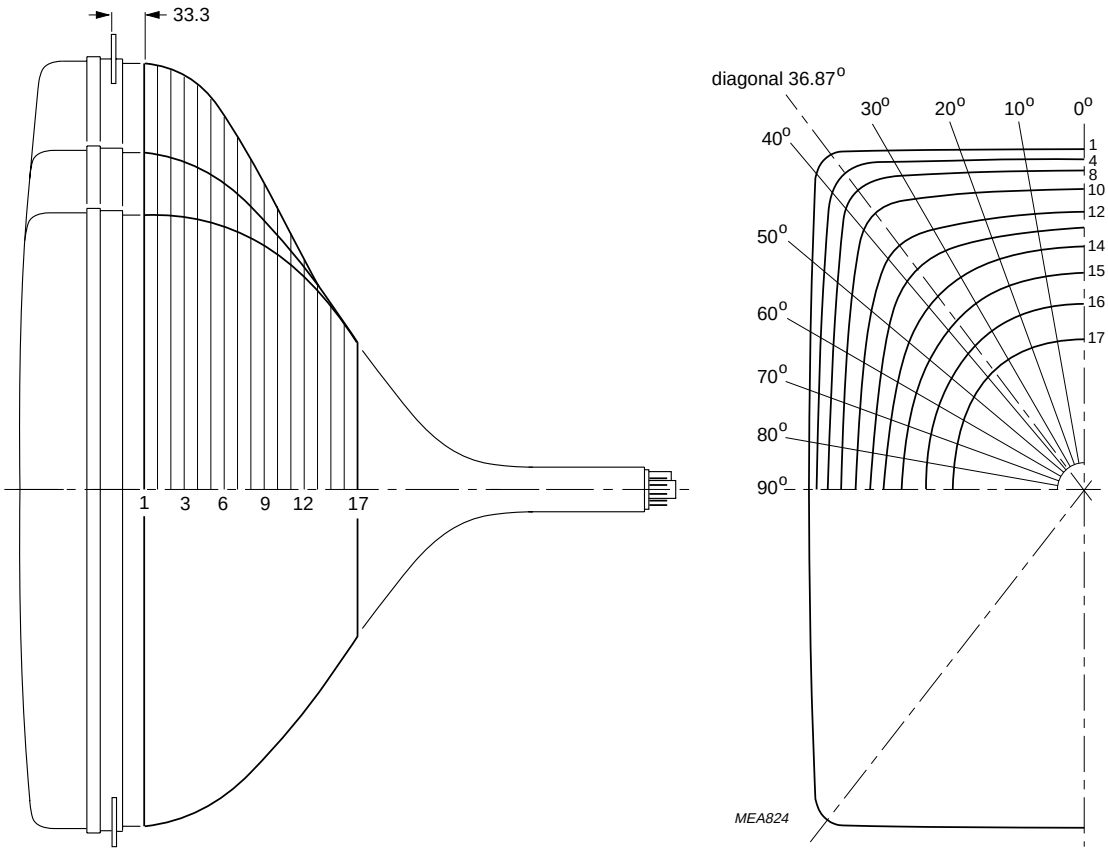
Maximum permissible torque on the tube neck is 0.04 Nm.



Dimensions in mm.

Fig.11 Cavity cap JEDEC J1-21, IEC 60067-III-2.

Cone contour



Dimensions in mm.

Fig.12 Maximum cone contour.

Cone contour data

SECTION	NOMINAL DISTANCE FROM SECTION 1 (mm)	MAXIMUM DISTANCE FROM TUBE AXIS (mm)										
		0°	10°	20°	30°	36.87°	40°	50°	60°	70°	80°	90°
1	0.0	225.7	228.9	239.1	257.6	271.8	267.2	227.9	203.1	187.9	179.6	177.0
2	10.0	224.6	227.7	237.7	255.9	270.0	265.3	226.7	201.9	186.8	178.6	175.9
3	20.0	221.8	224.8	234.3	251.1	264.3	259.6	222.9	198.9	184.2	176.1	173.5
4	30.0	218.1	220.9	229.6	244.5	254.7	250.6	217.9	195.1	180.9	173.1	170.6
5	40.0	213.8	216.4	224.1	236.5	243.1	239.6	212.0	190.9	177.3	169.9	167.5
6	50.0	208.7	211.0	217.7	227.5	231.3	228.4	205.6	186.3	173.6	166.5	164.2
7	60.0	202.6	204.5	210.0	217.5	219.5	217.0	198.5	181.0	169.3	162.6	160.5
8	70.0	195.1	196.8	201.3	206.9	207.6	205.4	190.3	175.1	164.4	158.3	156.3
9	80.0	186.2	187.6	191.4	195.6	195.4	193.5	181.3	168.4	158.9	153.3	151.5
10	90.0	175.6	176.9	180.1	183.3	182.8	181.1	171.4	160.7	152.5	147.6	146.0
11	100.0	163.6	164.6	167.4	169.9	169.2	167.9	160.4	151.9	145.2	141.0	139.6
12	110.0	150.3	151.3	153.8	155.7	154.7	153.6	147.9	141.7	136.6	133.4	132.3
13	120.0	136.4	137.3	139.3	140.4	139.5	138.6	134.5	130.3	126.8	124.6	123.9
14	130.0	122.1	122.8	124.4	124.9	124.0	123.3	120.7	118.2	116.1	114.7	114.3
15	140.0	107.5	107.7	108.2	108.6	108.4	108.2	107.0	105.7	104.5	103.8	103.5
16	150.0	92.6	92.3	92.3	92.6	92.8	92.9	92.9	92.6	92.1	91.6	91.4
17	159.5	78.1	78.1	78.1	78.1	78.1	78.1	78.1	78.1	78.1	78.1	78.1

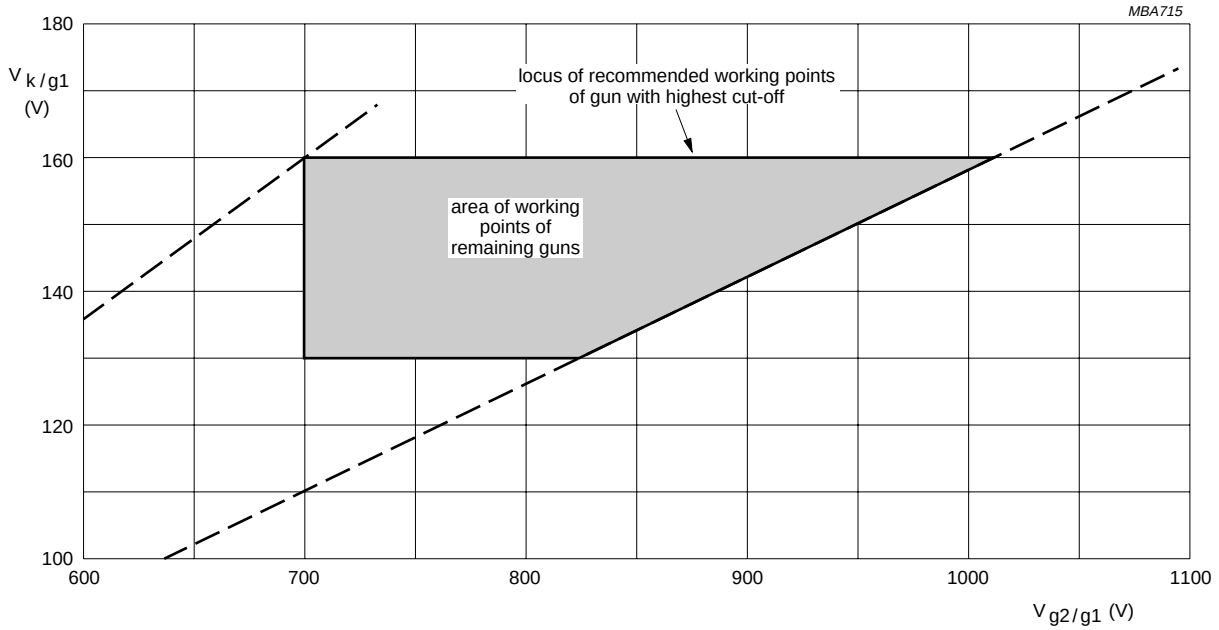
HANDLING

During shipment and handling the tube should not be subjected to accelerations greater than 350 m/s^2 in any direction (at pulse ≤10 ms).

OPERATING DATA

The voltages are specified with respect to grid 1.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$V_{a,g4}$	anode voltage	at full screen load	–	27.5	–	kV
V_{g3}	grid 3 (focus electrode) voltage		8.0	–	9.1	kV
V_{g2}	grid 2 voltage	for spot cut-off voltage V_k = 160 V	700	–	1020	V
V_f	heater voltage	tube operating	–	6.15	–	V



Grid 2 voltage (V_{g2}) adjusted for highest gun spot cut-off voltage V_k = 160 V.

Remaining guns adjusted for spot cut-off by means of cathode voltage.

V_{g2} range: 700 to 1020 V.

V_k range: 130 to 160 V.

Adjustment procedure:

Set cathode voltage (V_k) for each gun at 160 V; increase the grid 2 voltage (V_{g2}) from approximately 700 V to the value at which one of the colours becomes just visible. Now decrease the cathode voltage of the remaining guns so that the other colours become visible.

Fig.13 Spot cut-off design chart.

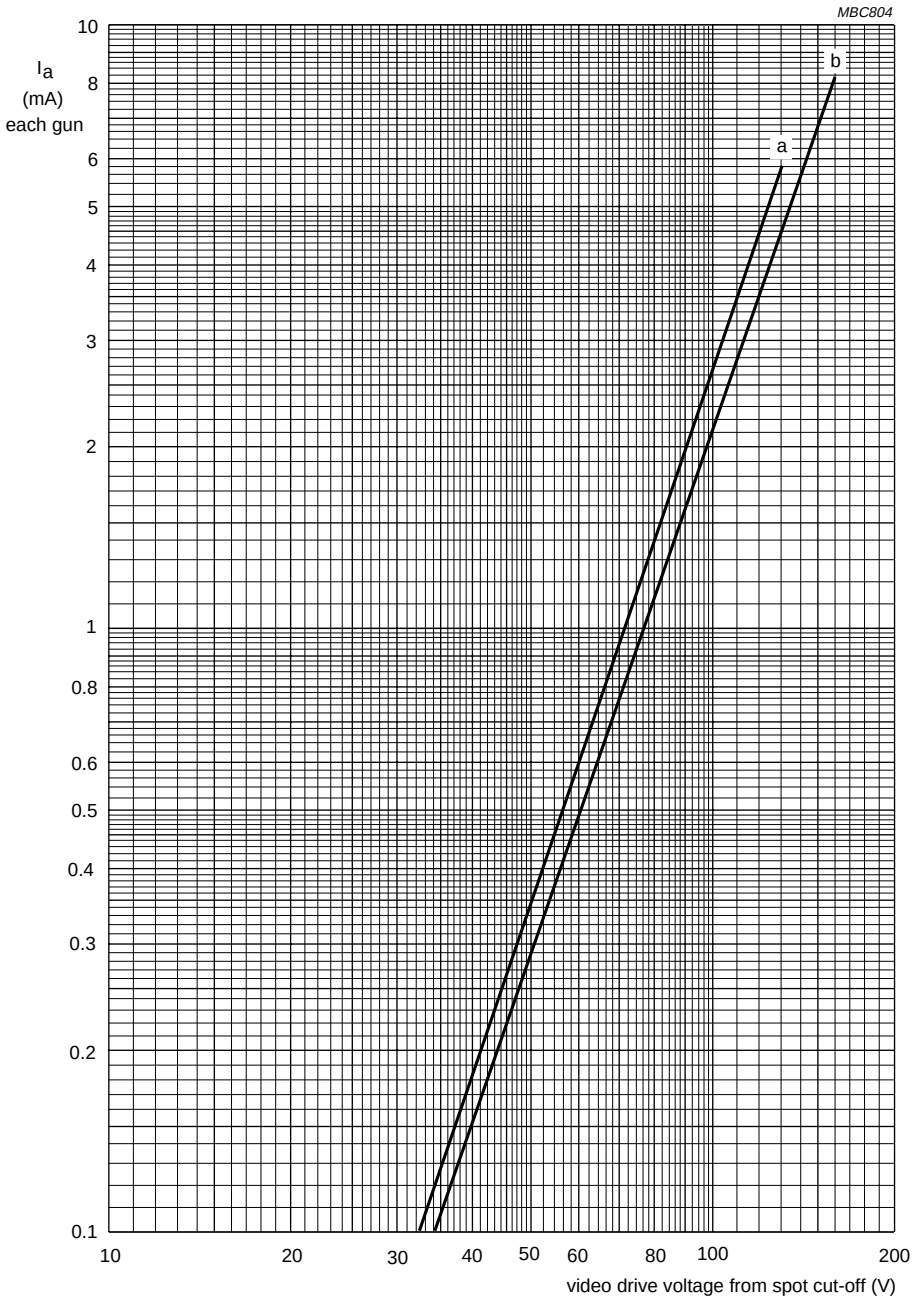
CHASSIS DESIGN VALUES

The values are valid for anode voltages between 22 and 29.5 kV. The voltages are specified with respect to grid 1.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
V_{g3}	grid 3 (focus electrode) voltage as a percentage of anode voltage		29	–	33	%
V_{g2} and V_k	grid 2 voltage and cathode voltage	for visual extinction of focused spot	see Fig.13			
ΔV_k	difference in cut-off voltage between guns in any tube		lowest value >80% of highest value			
V_f	heater voltage	tube operating	–	6.15	–	V
	video drive characteristics		note 1 and Fig.14			
I_{g3}	grid 3 (focus electrode) current		–2	–	+2	μA
I_{g2}	grid 2 current		–2	–	+2	μA
I_{g1}	grid 1 current	under cut-off conditions	–2	–	+2	μA
R_{ins}	insulation resistance	each cathode to grid 1 and heater	50	–	–	MΩ
Anode currents to produce white of 6500 K + 7 MPCD (CIE coordinates: x = 0.313; y = 0.329)						
PERCENTAGE OF THE TOTAL ANODE CURRENT SUPPLIED BY EACH GUN (TYPICAL)						
	red gun		–	39	–	%
	green gun		–	31	–	%
	blue gun		–	30	–	%
RATIO OF ANODE CURRENTS						
	red gun to green gun		1.05	1.25	1.45	
	red gun to blue gun		1.10	1.40	1.70	
	blue gun to green gun		0.80	0.90	1.00	

Note

1. For optimum picture performance it is recommended that the cathodes are not driven below +1 V with respect to grid 1.



V_f = 6.15 V.
$V_{a,g4}$ = 27.5 kV.
V_{g3} adjusted for focus.
V_{g2} (each gun) adjusted to provide spot cut-off for V_k = 130 V (curve a) and V_k = 160 V (curve b).

Fig.14 Typical cathode drive characteristics.

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 60134). Voltages are specified with respect to grid 1.

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
$V_{a,g4}$	anode voltage	notes 1 and 2	22(3)	31.0(4)	kV
I_a	long-term average current for three guns	note 5	–	1000	μA
V_{g3}	grid 3 (focus electrode) voltage		–	11	kV
V_{g2}	grid 2 voltage	note 6	–	1200	V
V_f	heater voltage	note 7	5.7	6.6(4)	V
Cathode voltage					
V_k	positive	operating	–	250	V
		during blanking	–	400	V
V_k	positive operating cut-off		–	200	V
V_k	negative		–	0	V
V_{kp}	negative peak		–	–2	V
Cathode to heater voltage					
V_{kf}	positive		–	250	V
V_{kfp}	positive peak		–	300	V
V_{kf}	negative		–	–135	V
V_{kfp}	negative peak		–	–180	V
Circuit values					
R_{g3}	grid 3 circuit resistance		–	70	MΩ
R_{g2}	grid 2 circuit resistance		–	7	MΩ
R_{g1k}	grid 1 to cathode circuit resistance (each gun)		–	750	kΩ

Notes

1. During adjustment on the production line this value is likely to be surpassed considerably. It is therefore strongly recommended to first make the necessary adjustments for normal operation without the picture tube.
2. The picture tube does not emit X-radiation above 1 μSv/h when operated at 31.0 kV and 1.5 mA.
3. Operation of the tube at lower voltages impairs the luminance and resolution and may impair the convergence.
4. This value is an absolute maximum.
5. The short-term average anode current should be limited by circuitry to 1500 μA.
6. During adjustment on the production line maximum 1500 V is permitted.
7. For maximum cathode life and optimum performance it is recommended that the heater supply is designed for 6.15 V at average beam current, for most applications this equals 6.3 V at zero beam current. **The heater supply source impedance must not be less than 2 Ω.**

BEAM CENTRING

Maximum centring error is 4 mm in any direction after colour purity, static convergence and horizontal centre line correction (measured with deflection coils at nominal position).

FLASHOVER PROTECTION

The high voltages used with this tube (absolute max. 31.0 kV) may produce internal flashovers. Soft-flash technology limits these flashover currents to approximately 60 A offering higher reliability, optimum circuit protection and component savings.

Primary protective circuitry using properly grounded spark gaps and series isolation resistors (preferably carbon composition) is still necessary to prevent tube damage. The spark gaps should be connected to all picture tube electrodes (except the tube heaters) at the tube socket in accordance with Fig.15. No other connections between the outer conductive coating and the chassis are permissible. The spark gaps should be designed for a maximum breakdown voltage at the focus electrode (g_3) of approximately 11.5 kV ($1.5 \times V_{g3}$ max. at $V_{a,g4}$ = 27.5 kV) and at the other electrodes of 1.5 to 2 kV at the lowest operating atmospheric pressure.

The values of the series isolation resisters should be as high as possible (min. 1.5 kΩ) without causing deterioration of circuit performance. The resistors should be able to withstand an instantaneous surge of 20 kV for the focus circuit and 12 kV for the remaining circuits without arcing.

Additional information is available on request.

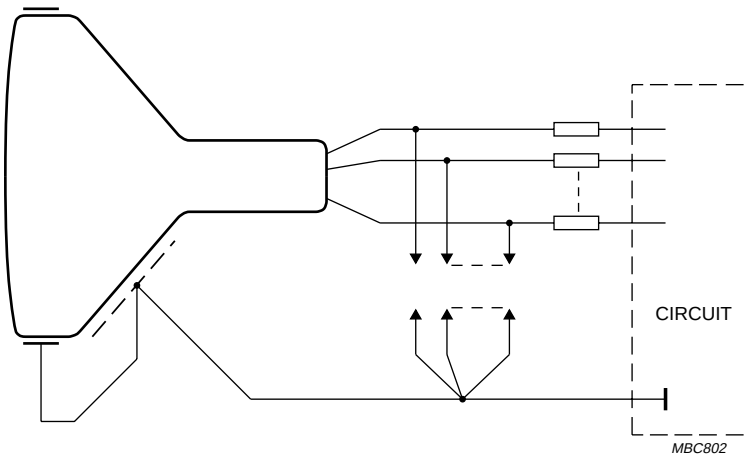
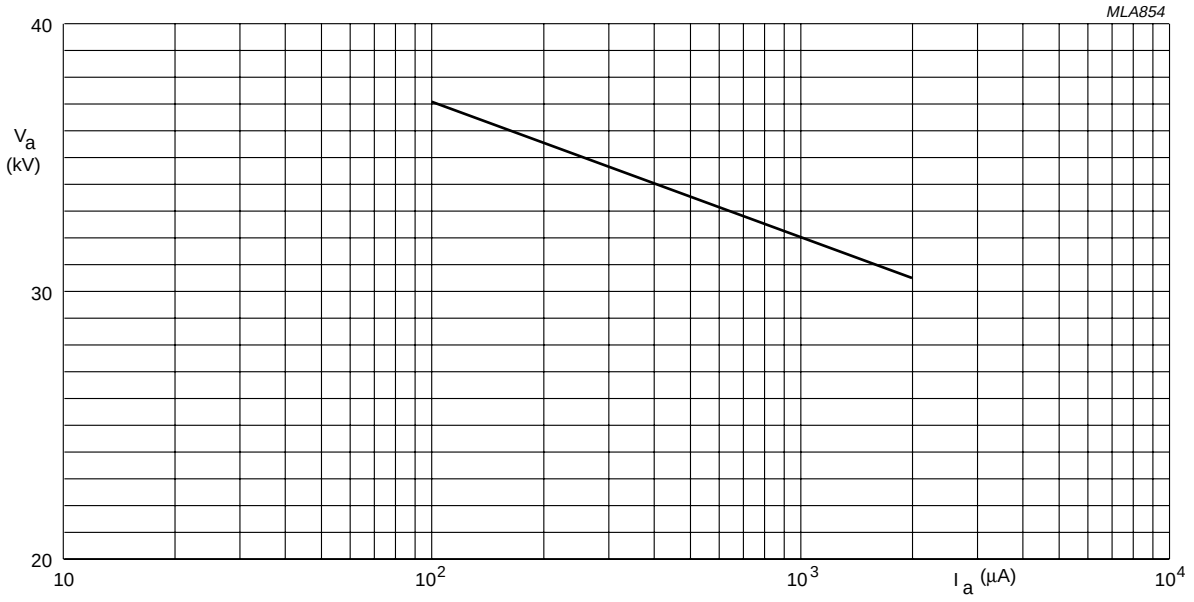


Fig.15 Flashover protection circuit.

X-RADIATION

The tube does not emit X-radiation above 1 μSv/h when operated at 31.0 kV and 1.5 mA.



The X-radiation emitted will also not exceed 1 μSv/h for anode voltage and current combinations shown in the iso-exposure-rate limit curve.

Fig.16 1 μSv/h iso-exposure-rate limit curve.

DEGAUSSING

The picture tube is provided with an internal magnetic shield. This shield and the shadow mask with its suspension system may be provided with an automatic degaussing system, consisting of a single coil mounted on the cone of the picture tube.

For proper degaussing an initial peak magnetomotive force (MMF) of 700 ampere-turns is required. This MMF has to be gradually decreased with a maximum of 25% per half period, using appropriate degaussing circuitry. At an initial peak MMF of >900 ampere-turns, the MMF has to be gradually decreased with a maximum of 30% per half period. In the steady state, no significant MMF should remain in the degaussing coil (≤0.36 ampere-turns). Switch-off is permitted at a peak MMF of ≤8 ampere-turns.

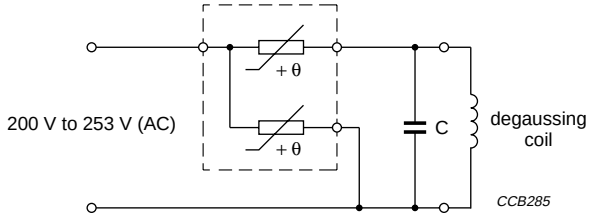
To prevent beam landing disturbances by horizontal frequency currents induced in the degaussing coils, these coils should be shunted by a capacitor of sufficiently high value.

If single-phase power rectification is employed in the TV circuitry, provision should be included to prevent asymmetric distortion of the AC voltage applied to the degaussing circuit due to high DC inrush currents.

An example of a degaussing circuit and coil data is given in Fig.17 and Table "Degaussing coil data".

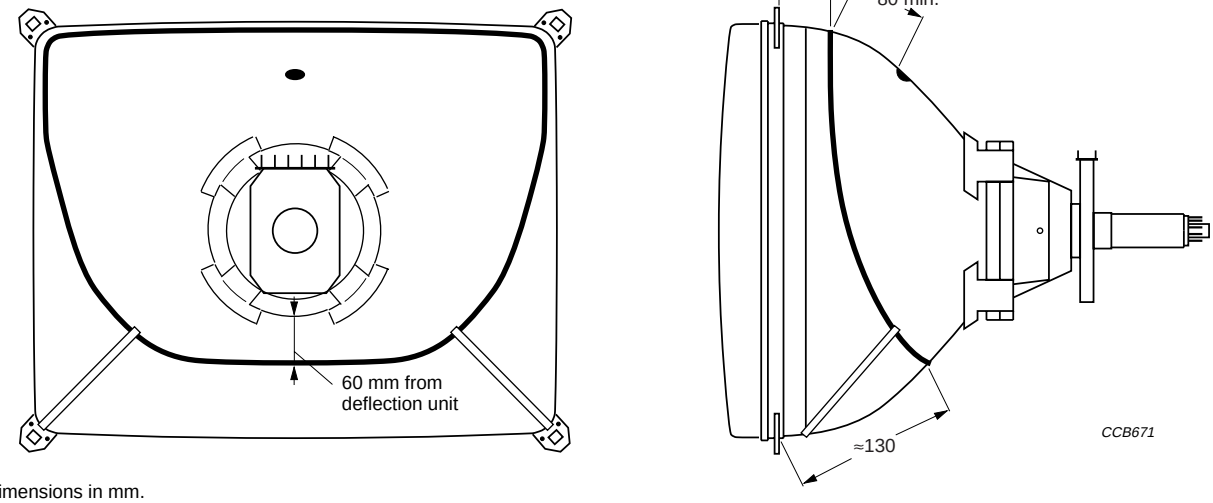
Degaussing coil data

PARAMETER	TYP.	UNIT
Circumference	139	cm
Number of turns	115	
Copper wire diameter	0.355	mm
Resistance	27.5	Ω
PTC thermistor	2322 662 96616	



C = 100 nF.

Fig.17 Degaussing circuit using dual PTC thermistor.



Dimensions in mm.

Fig.18 Position of degaussing coil on the picture tube.

DEFINITIONS

Data sheet status	
Objective specification	This data sheet contains target or goal specifications for product development.
Preliminary specification	This data sheet contains preliminary data; supplementary data may be published later.
Product specification	This data sheet contains final product specifications.
Limiting values	
Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 60134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.	

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Philips Components – a worldwide company

Australia: Philips Components Pty Ltd., HOMEBUSH,
Tel. +61 2 9704 8141, Fax. +61 2 9704 8139

Austria: Österreichische Philips Industrie GmbH, WIEN,
Tel. +43 1 60 101 12 41, Fax. +43 1 60 101 12 11

Belarus: Philips Office Belarus, MINSK,
Tel. +375 172 200 924/733, Fax. +375 172 200 773

Benelux: Philips Components B.V., EINDHOVEN, NL,
Tel. +31 40 25 90 772, Fax. +31 40 25 90 777

Brazil: Philips Components, SÃO PAULO,
Tel. +55 11 3841 2338, Fax. +55 11 829 1849

Canada: Philips Electronics Ltd., SCARBOROUGH,
Tel. +1 416 292 5161, Fax. +1 416 754 6248

China: Philips Company, SHANGHAI,
Tel. +86 21 6354 1088, Fax. +86 21 6354 1060

Denmark: Philips Components A/S, COPENHAGEN V,
Tel. +45 3329 3333, Fax. +45 3329 3905

Finland: Philips Components, ESPOO,
Tel. +358 9 615 800, Fax. +358 9 615 80510

France: Philips Composants, SURESNES,
Tel. +33 1 4099 6161, Fax. +33 1 4099 6493

Germany: Philips Components GmbH, HAMBURG,
Tel. +49 40 2489-0, Fax. +49 40 2489 1400

Hong Kong: Philips Hong Kong, KOWLOON,
Tel. +852 2784 3000, Fax. +852 2784 3003

India: Philips India Ltd., MUMBAI,
Tel. +91 22 4930 311, Fax. +91 22 4930 966/4950 304

Indonesia: P.T. Philips Development Corp., JAKARTA,
Tel. +62 21 794 0040, Fax. +62 21 794 0080

Ireland: Philips Electronics (Ireland) Ltd., DUBLIN,
Tel. +353 1 7640 203, Fax. +353 1 7640 210

Israel: Rapac Electronics Ltd., TEL AVIV,
Tel. +972 3 6450 444, Fax. +972 3 6491 007

Italy: Philips Components S.r.l., MILANO,
Tel. +39 2 6752 2531, Fax. +39 2 6752 2557

Japan: Philips Japan Ltd., TOKYO,
Tel. +81 3 3740 5135, Fax. +81 3 3740 5035

Korea (Republic of): Philips Electronics (Korea) Ltd., SEOUL,
Tel. +82 2 709 1472, Fax. +82 2 709 1480

Malaysia: Philips Malaysia SDN Berhad,
Components Division, PULAU PINANG,
Tel. +60 3 750 5213, Fax. +60 3 757 4880

Mexico: Philips Components, EL PASO, U.S.A.,
Tel. +52 915 772 4020, Fax. +52 915 772 4332

New Zealand: Philips New Zealand Ltd., AUCKLAND,
Tel. +64 9 815 4000, Fax. +64 9 849 7811

Norway: Philips Components, STOCKHOLM,
Tel. +46 8 5985 2000, Fax. +46 8 5985 2745

Pakistan: Philips Electrical Industries of Pakistan Ltd., KARACHI,
Tel. +92 21 587 4641-49, Fax. +92 21 577 035/+92 21 587 4546

Philippines: Philips Semiconductors Philippines Inc.,
METRO MANILA, Tel. +63 2 816 6345, Fax. +63 2 817 3474

Poland: Philips Poland Sp. z.o.o., WARSZAWA,
Tel. +48 22 5710 000, Fax. +48 22 5710 001

Portugal: Philips Portuguesa S.A.,
Philips Components: LINDA-A-VELHA,
Tel. +351 1 416 3160/416 3333, Fax. +351 1 416 3174/416 3366

Russia: Philips Russia, MOSCOW,
Tel. +7 95 755 6918, Fax. +7 95 755 6919

Singapore: Philips Singapore Pte Ltd., SINGAPORE,
Tel. +65 350 2000, Fax. +65 355 1758

South Africa: S.A. Philips Pty Ltd., JOHANNESBURG,
Tel. +27 11 470 5911, Fax. +27 11 470 5494

Spain: Philips Components, BARCELONA,
Tel. +34 93 301 63 12, Fax. +34 93 301 42 43

Sweden: Philips Components, STOCKHOLM,
Tel. +46 8 5985 2000, Fax. +46 8 5985 2745

Switzerland: Philips Components AG, ZÜRICH,
Tel. +41 1 488 22 11, Fax. +41 1 481 7730

Taiwan: Philips Taiwan Ltd., TAIPEI,
Tel. +886 2 2134 2900, Fax. +886 2 2134 2929

Turkey: Türk Philips Ticaret A.S., UMRABIYE/ISTANBUL,
Tel. +90 216 522 18 00, Fax. +90 216 522 18 14

United Kingdom: Philips Components Ltd., DORKING,
Tel. +44 1306 512 000, Fax. +44 1306 512 345

United States:

- Philips Components, SAN JOSE, CA,
  Tel. +1 408 570 5600, Fax. +1 408 570 5700
- Philips Display Components, ANN ARBOR, MI,
  Tel. +1 734 996 9400, Fax. +1 734 761 2776
- Philips Discrete Ceramics, EL PASO, TX,
  Tel. +1 877 250 5996 / +1 915 860 3267, Fax. +1 915 860 3270
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  Tel. +1 877 433 77483, Fax. +1 770 992 0725

Yugoslavia (Federal Republic of): Philips Components, BELGRADE,
Tel. +381 11 3341 299, Fax. +381 11 3342 553

Internet:

- Discrete and Ferrite Ceramics: www.acm.components.philips.com
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For all other countries apply to:
Philips Components, Building BAE-1, P.O. Box 218, 5600 MD EINDHOVEN,
The Netherlands, Fax. +31 40 27 22 599

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