CX2593X
Oil Cooled, Deuterium Filled
Four-Gap Metal/Ceramic Thyratron

The data to be read in conjunction with the Hydrogen Thyratron Preamble.

ABRIDGED DATA

Hollow anode, deuterium-filled, four-gap thyratron, with metal envelope suitable for switching high peak and average power at high pulse repetition rates with >50% current reversal.
The cathode heater and reservoir must be operated from independent power supplies.
The CX2593X must be used in conjunction with Teledyne Te2v resistor box MA942A. Resistor box settings and/or reservoir heater voltage can be adjusted within the specified limits to obtain the maximum thyratron gas pressure consistent with the required voltage hold-off.

Peak forward anode voltage	-	120 kV max
Peak forward anode current	-	20 kA max
Peak reverse anode current	-	10 kA max
Average anode current	-	10 A max
Peak output power	-	1000 MW max

GENERAL DATA

Electrical

Cathode	-	Barium aluminate impregnated tungsten
Cathode heater voltage (see note 1)	-	6.3 ± 5%
Cathode heater current	-	90 A
Reservoir heater voltage (see notes 1 and 2)	-	6.3 ± 5%
Reservoir heater current	-	7.0 A
Tube heating time (minimum)	-	10 min
Anode to gradient grid capacitance	-	45 pF
Gradient grid to grid 2 capacitance	-	50 pF

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Mechanical

Seated height	-	450 mm max
Clearance required below mounting flange	-	75 mm min
Overall diameter (mounting flange)	-	152.4 mm nom
Net weight	-	14.4 kg approx.
Mounting position	-	See note 3
Tube connections	-	See outline

Cooling

The tube must be cooled by total liquid immersion, for example in force-circulated transformer oil (see Teledyne Te2v Technical Reprint No. 108 'The cooling of oil-filled electrical equipment, with special reference to high power line-type pulse generators' by G. Scoles). Care must be taken to ensure that air is not trapped inside the tube end cover.

PULSE MODULATOR SERVICE

MAXIMUM AND MINIMUM RATINGS

These ratings cannot necessarily be used simultaneously, and no individual rating must be exceeded.

Anode		Min	Max	
Peak forward voltage (see note 4)	.	-	120	kV
Peak inverse anode voltage	.	See note 5		
Peak forward anode current	.	-	20	kA
Peak reverse anode current	.	-	10	kA
Average anode current	.	-	10	A
Rate of rise of anode current	.	See notes 6 and 7		

Triggering

The CX2593X must be triggered with two independent pulses, in accordance with the recommendations below.

Grid 2		Min	Max	
Unloaded grid 2 drive pulse voltage (see note 8)	.	1000	2000	V
Grid 2 pulse duration	.	1.0	-	µs
Rate of rise of grid 2 pulse (see notes 7 and 9)	.	10	-	kV/µs
Grid 2 pulse delay (see note 10)	.	0.5	3.0	µs
Peak inverse grid 2 voltage	.	-	450	V
Loaded grid 2 bias voltage	.	-50	-200	V
Impedance of grid 2 drive circuit (see note 11)	.	50	200	Ω

Grid 1 – Pulsed		Min	Max	
Unloaded grid 1 drive pulse voltage	.	600	2000	V
Grid 1 pulse duration	.	2.0	-	µs
Rate of rise of grid 1 pulse	.	1.0	-	kV/µs
Peak inverse grid 1 voltage	.	-	450	V
Loaded grid 1 bias voltage	.	See note 12		
Peak grid 1 drive current (see note 13)	.	5.0	100	A

Cathode		Min	Max	
Heater voltage	.	6.3 ± 5%		V
Heating time	.	10	-	min

Reservoir		Min	Max	
Heater voltage (see note 1)	.	6.3 ± 5%		V
Heating time	.	10	-	min

Environmental		Min	Max	
Ambient air temperature	.	0	+40	°C

CHARACTERISTICS

		Min	Typ	Max	
Critical DC anode voltage for conduction	.	-	7.0	10.0	kV
Anode delay time (see note 14)	.	-	200	350	ns
Anode delay drift time (see note 15)	.	-	15	25	ns
Time jitter (see note 16)	.	-	3.0	5.0	ns
Recovery time	.	See note 17			
Cathode heater current (at 6.3 V)	.	80	90	100	A
Reservoir heater current (at 6.3 V)	.	6.0	7.0	8.0	A

NOTES

1. The cathode heater and the reservoir heater must be supplied from independent power supplies. **The common connection for these two supplies is the pair of yellow sleeved leads, not the cathode flange.**
   N.B. The tube will suffer irreversible damage if the cathode flange is connected as the common point.
   The cathode heater supply must be connected between the cathode flange and the cathode heater leads (yellow sleeves), the reservoir heater supply must be connected between the cathode heater leads (yellow sleeves) and the reservoir heater lead (red sleeve), see Fig. 1. In order to meet the jitter specification, it may be necessary in some circumstances that the cathode heater be supplied from a DC source.

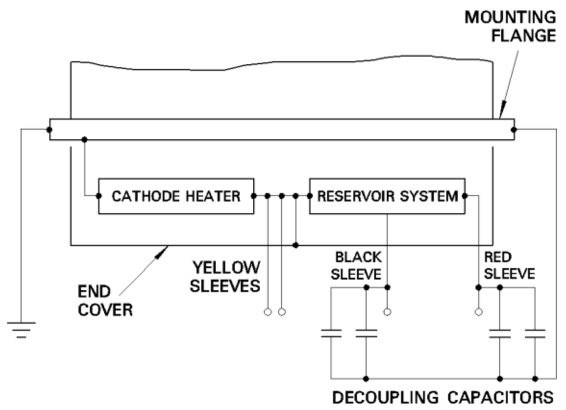


Fig. 1 CX2593X base connections

Care should be taken to ensure that excessive voltages are not applied to the reservoir heater circuit from the cathode heater supply because of high impedance cathode heater connections. For example, in the worst case, an open circuit heater lead will impress almost double voltage on the reservoir heater, especially on switch-on, when the cathode heater impedance is minimal. This situation can be avoided by ensuring that the two supplies are in anti-phase. The reservoir heater circuit must be decoupled with suitable capacitors, for example, a 1 µF capacitor in parallel with a low inductance 1000 pF capacitor.
   The heater supply systems should be connected directly between the cathode flange and the heater leads. This avoids the possibility of injecting voltages into the cathode and reservoir heaters. At high rates of rise of anode current, the cathode potential may rise significantly at the beginning of the pulse, depending on the cathode lead inductance, which must be minimised at all times.

2. CX2593X gas pressure may be altered using Teledyne Te2v resistor box type MA942A. The CX2593X **must** be used in conjunction with the MA942A. The resistor box must be connected between the reservoir gas pressure control lead (black sleeve) and the cathode heater lead (yellow sleeve). Gas pressure may be increased by increasing the resistor box settings from their initial recommended values which are marked on the gas pressure control lead. The gas pressure may be increased to a value consistent with the required forward hold-off voltage. Additional variations in gas pressure can be achieved by altering the reservoir power supply voltage within the specified range.

3. The tube must be fitted using its mounting flange. The preferred orientation is with the tube axis vertical and anode uppermost; mounting the tube with its axis horizontal is permissible. The tube should not be mounted with its axis vertical and cathode uppermost.

4. The maximum permissible peak forward voltage for instantaneous starting is 100 kV and there must be no overshoot. 120 kV is the maximum level to which the thyratron has been conditioned. For pulse modulator service, a maximum peak forward anode voltage of 100 kV is recommended unless command charge is used to minimise the voltage hold-off period for the thyratron. A 30 minute DC hold-off test at 100 kV is carried out during manufacture.

5. Due to the bidirectional switching capability of the tube, the presence of any reverse voltages will result in reverse current.

6. The ultimate value which can be attained depends to a large extent upon the external circuit. The rate of rise of current can be well in excess of 100 kA/µs.

7. This rate of rise refers to that part of the leading edge of the pulse between 10% and 90% of the pulse amplitude.

8. Measured with respect to cathode.

9. A lower rate of rise may be used, but this may result in the anode delay time, delay time drift and jitter exceeding the limits quoted.

10. The last 0.25 µs of the top of the grid 1 pulse must overlap the corresponding first 0.25 µs of the top of the delayed grid 2 pulse.

11. During both the drive pulse period and during recovery when the current flow is reversed.

12. DC negative bias voltages must not be applied to grid 1. Grid 1 is pulse driven and the potential of grid 1 may vary between -10 V and +5 V with respect to cathode potential during the period between the completion of recovery and the commencement of the succeeding grid pulse.

13. The optimum grid 1 pulse current is the maximum value which can be applied without causing premature commutation. This value is variable depending on gas pressure, maximum forward anode voltage, grid 2 negative bias voltage, peak current and repetition rate.

14. The anode delay time for this thyratron is the time interval between the instant when the unloaded control grid voltage passes cathode potential and the instant when anode conduction takes place.
    It is measured during the manufacturing test at a pulse modulator test voltage of 85 kV. Please note that the anode delay time value may change when the operating parameters of this thyratron are varied.

15. The anode delay time drift is the change in the anode delay time during a specified period of operation of the tube.
    The anode delay time drift is measured during the thyratron's manufacturing test at a pulse modulator test voltage of 85 kV over a period of approximately 5 hours of operation.
    Please note that the anode delay time drift value may change when the operating parameters of this thyratron are varied.

16. A time jitter of less than 1 ns can be obtained if the cathode heater voltage is supplied from a DC source.
    The time jitter is a measurement of the short-term variation in the anode firing time. It is defined as the pulse-to-pulse variation measured over a period of 5 secs at the 50% level of the anode current pulse or the anode voltage waveform with reference to any constant level on the unloaded control grid pulse voltage rise.
    It is measured during the manufacturing test at a pulse modulator test voltage of 85 kV. Please note that the time jitter value may change when the operating parameters of this thyratron are varied.

17. The amount of time available for thyratron recovery must be maximised by circuit design. Command charging techniques are recommended because this thyratron has a long recovery time (>100 µs) due to the gradient grid drift spaces. The amount of time required for recovery is affected by gas pressure, peak current, pulse duration and load mismatch, all of which may keep the thyratron in a conducting state.

HEALTH AND SAFETY HAZARDS

Teledyne Te2v thyratrons are safe to handle and operate, provided that the relevant precautions stated herein are observed. Teledyne Te2v does not accept responsibility for damage or injury resulting from the use of electronic devices it produces. Equipment manufacturers and users must ensure that adequate precautions are taken. Appropriate warning labels and notices must be provided on equipment incorporating Teledyne Te2v devices and in operating manuals.

High Voltage

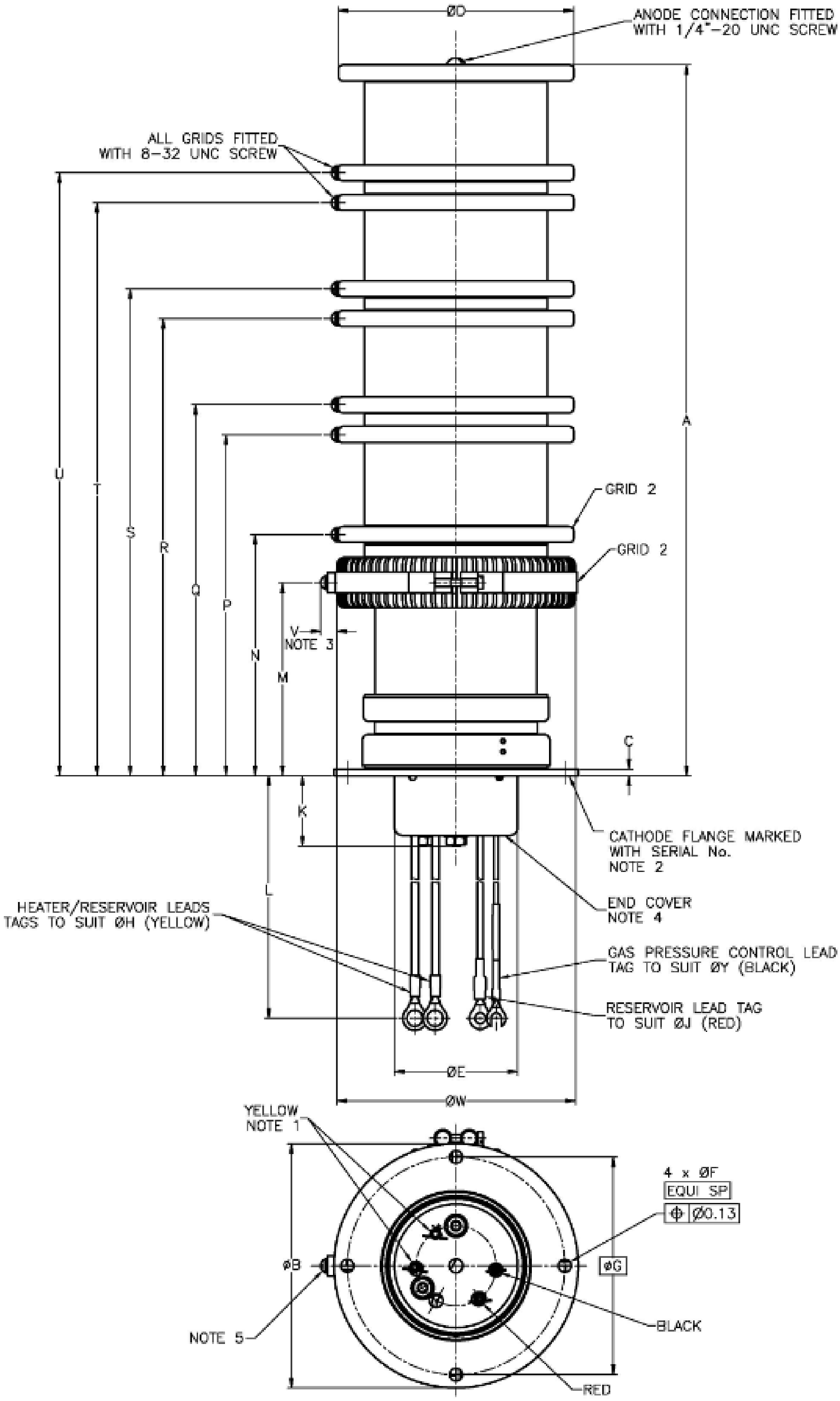
Equipment must be designed so that personnel cannot come into contact with high voltage circuits. All high voltage circuits and terminals must be enclosed and fail-safe interlock switches must be fitted to disconnect the primary power supply and discharge all high voltage capacitors and other stored charges before allowing access. Interlock switches must not be bypassed to allow operation with access door open.

X-Ray Radiation

All high voltage devices produce X-rays during operation and may require shielding. The X-ray radiation from hydrogen thyratrons is usually reduced to a safe level by enclosing the equipment or shielding the thyratron with at least 1.6 mm (1/16 inch) thick steel panels.
Users and equipment manufacturers must check the radiation level under their maximum operating conditions.

OUTLINE

(All dimensions without limits are nominal)



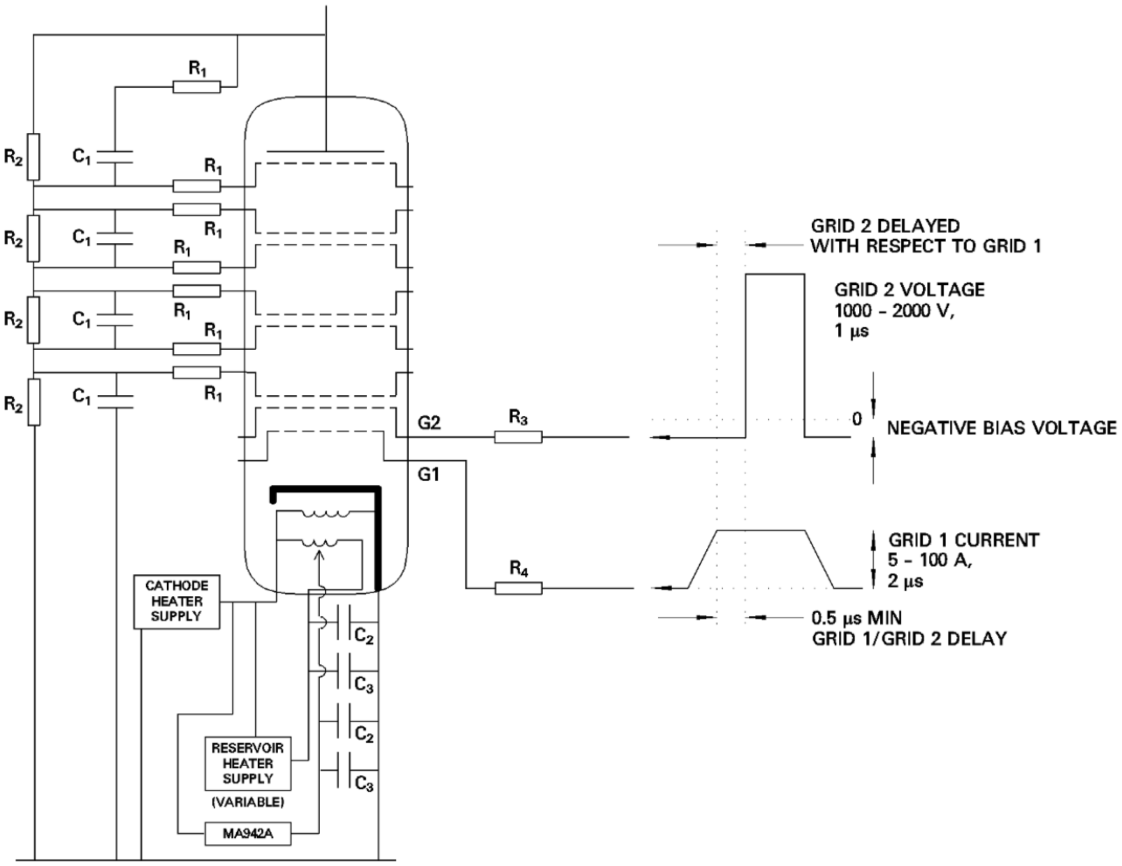
Ref	Millimetres	Inches
A	450.00 max	17.717 max
B	152.40 ± 0.25	6.000 ± 0.010
C	4.35 max	0.171 max
D	147.00 ± 3.00	5.787 ± 0.118
E	78.00 max	3.071 max
F	8.00	0.315
G	135.74	5.344
H	9.50	0.374
J	6.00	0.236
K	60.00 max	2.632 max
L	343.00 ± 6.35	13.504 ± 0.250
M	122.00 ± 6.00	4.803 ± 0.236
N	152.00 ± 6.00	5.984 ± 0.236
P	214.00 ± 6.00	8.425 ± 0.236
Q	232.50 ± 6.00	9.154 ± 0.236
R	286.00 ± 6.00	11.260 ± 0.236
S	304.50 ± 6.00	11.988 ± 0.236
T	358.00 ± 6.00	14.094 ± 0.236
U	376.50 ± 6.00	14.826 ± 0.236
V	15.00 max	0.591 max
W	152.40 ± 3.00	6.000 ± 0.118
X	36.00 max	1.417 max
Y	6.00	0.236

Inch dimensions have been derived from millimetres

Outline Notes

1. These two leads must be connected in parallel to the same terminal of the heater transformer.
2. The mounting flange is the connection for the cathode and cathode heater return.
3. This dimension also applies to the clamping screws and lugs.
4. The end cover is at heater potential and must not be grounded.
5. The terminal screws are in line with the hole in the mounting flange to within ±6.35 mm.

SCHEMATIC DIAGRAM



R_1	=	470 Ω to 1 kΩ 2.5 W vitreous enamelled wirewound resistors.
R_2	=	5 to 20 MΩ high voltage resistors with a power rating consistent with forward anode voltage.
R_3	=	Grid 2 series resistor. 12 W vitreous enamelled wirewound is recommended, of an impedance to match the grid 2 drive pulse circuit.
R_4	=	Grid 1 series resistor. 12 W vitreous enamelled wirewound is recommended, of an impedance to match the grid 1 drive pulse circuit.
C_1	=	500 pF capacitors with a voltage rating equal to the peak forward voltage.
C_2, C_3	=	Reservoir protection capacitors with a voltage rating ≥500 V;
C_2	=	1000 pF low inductance (e.g. ceramic),
C_3	=	1 µF (e.g. polycarbonate or polypropylene).

Components R_3, R_4, C_2 and C_3 should be mounted as close to the tube as possible.