4. Warranty

All valves manufactured by "Pulsed Technologies Ltd." (The Manufacturer) are guaranteed to be free of defects in workmanship, materials and construction and are designed to give satisfactory service when used under normal operating conditions. The Manufacturer guarantees conformity of thyratrons to the parameters specified in item 1.1 of the thyratrons' certificate within a period of 12 months from the date of delivery, confirmed by shipping documents or within a minimum operating time in terms of total switched charge is 5×10^4 Coulomb, either within a filament life of 1000 hours whichever comes first. The above conditions should be considered provided the thyratrons are treated in accordance with the technical parameters stated in the appropriate clause of the thyratrons' certificate.

For valves failing before expiration of operating time 5×10^3 C, a valve may at the option of Manufacturer be replaced free of charge or credited in full, provided that the filament life guaranteed has not expired. For valves failing with a filament life in excess of the initial period up to operating time 5×10^3 C, but less than the total warranty minimum operating life, replacement or credit will be given on pro rata basis determine by the ratio of the unrealised portion of the warranted operating life to the total warranty minimum operating life. The operating life is considered to start when the valve is first put into service, even though it may subsequently be removed and held as a spare.

Conditions of Warranty. The warranty is valid only if the following conditions are met :

1. The valve is supplied direct from the Manufacturer or via an agency, representative or other selling medium authorized by Manufacturer.
2. The valve is operated within the published minimum and maximum ratings, provided that safety devices for protection against overcurrent in terms of average current are fitted and operation time counter is used.
3. The valve is not subjected to any negligence in use, storage, transportation or handling.
4. The decision of Manufacturer on the cause of failure and on the value and form of any applicable allowances is accepted by the customer.
5. Right of access to equipment for the purpose of checking operating conditions is granted to any representative of Manufacturer where Manufacturer may so require.
6. Manufacturer is notified within 30 days of the valve failure.
7. The valve is withdrawn from service as soon as possible after the failure is alleged to have occurred.

5. Claims Information. In case of a premature failure of a thyratron it should be returned to the Manufacturer within 30 days together with the Certificate stating the following information:

Storage time _____

Date of putting into operation _____

Date of failure_____

Specifications of a mode of operation _____

information about operating conditions, cause of failure.

Operating time in the specified mode _____ of hours (total switched charge).

The reasons for removal of a thyratron from operation _____

The items of information are filled_____

(Date, signature)

In case of absence of the filled passport the claim is not accepted.

Individual №_____, Manufacturing date_____

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Tel: +7 (0912) 24-9217, 25-8569, Fax/tel.: +7(0912)24-9238, E-mail: pulsetech@mail.ru
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TDI1-50k/25 THYRATRON
Product Certificate. Certificate of Quality.

Thyratron TDI1-50k/25 (Copper Arc Thyratron, Grounded Grid Thyratron) is manufactured in compliance with КВФМ 433 212.005 Technical Conditions and designed for use as a switch tube in pulse circuits of capacitive storages with subnanosecond and microsecond pulse duration for domestic as well as export delivery.

1. Basic Technical Data.

The thyratron features a compact, stacked ceramic-metal construction, with hydrogen as a buffer gas under the pressure of 20÷60 Pa in operational mode only. Semiconductor high-temperature ignitor is used for triggering the thyratron. Patented dielectric coating protects envelope of the tube against damage in emergency when anode reverse voltage increases for up to 100% of forward voltage. The tube is environmental-friendly product, has internal shield for minimization of X-Ray emission from the region of anode. In TDI1-50k/25H variant the thyratron comprises a hollow anode and is used, for example, for operation in modes with oscillating current, as well as for triggering both from cathode and anode part. Design of the thyratron is covered by Russian Federation patents No 1792207, 1807798, 2300157, 2418339, International Patents PCT/RU2005/000298US, PCT/RU2011/000038, US Patent No.7,825,595 B2.

1.1. Optimal Electrical Parameters.

Parameter	*Value*	*Fact. value*
Peak Anode Voltage, *kV*	2÷20	
Peak Forward Anode Current, *kA*	50	
Pulse Repetition Rate, *Hz*	0.5	
Anode Current 1st half-wave width, *μs* *	2÷3	
Switching Capacity, *μF*	5	
Heater Voltage, *V,* (not less/not more)	3.0/7.0	
Heater Current (at U_{heat} = V), *A,* not more	2.5	
Peak Open Circuit Trigger Voltage, *kV,* (not less/not more)	2.0/6.0	
Peak trigger current, *A,* (not less/not more)	80/150	
Readiness Time, *min*	5	

** - oscillated mode with 2÷3 halfwaves.*

1.2.Absolute ratings (maximus, nonsimultaneous)*

Parameter	***Value***
Peak Forward Anode Voltage, *kV* (Notes 1, 2, 3)	1÷25
Peak Forward Anode Current, *Ib, kA*	100
Maximum anode current rise rate, *A/s* (Note 4)	$3\cdot10^{12}$
Anode current pulse duration, *μs*	0,1÷200,0
Switched energy per shot, *J*	10 000
Anode Dissipation Factor *(Pb=V×A×pps)* (Note 6, 7)	$30\cdot10^9$
Root mean square current, *RMS=* $\sqrt{Ib \times ib}$ *(ib=C·U·f)* (Note 6, 7)	300
Pulse repetition rate, *f, Hz* (Note 5,6)	100
Time Jitter, *ns* (Note 5)	3.0
Rate of rise of ignition voltage pulse, *kV/μs,* not less	5.0
Trigger Current Pulse Duration, *μs*	1÷5

*Notes *Operation of the thyratron when two or more parameters p.1.1 are exceeded simultaneously may be permitted only upon agreement with the Manufacturer.*

(Note1) The dwell time at the peak anode voltage should be minimized in order to minimize pre-firing. For operation at the rated peak forward anode current, the dwell time must be less 0.5 of pulse period, but must not exceed 1 millisecond.

(Note 2) *After thyratron anode current ceases and before the voltage is reapplied to the anode, the anode voltage must be kept between minus (10 -5000) Volts for at least 100 μs to provide for buffer gas deionization.*

(Note 3) *The reverse anode voltage applies for a previously non-conducting tube. Exclusive only of a spike not longer than 25 nanoseconds, the peak reverse anode voltage must not exceed 5 kV during the first 50 microseconds after conduction.*

(Note 4) *The ultimate value depends on the external circuit parameters.*

(Note 5) *Low-energy, high-rate of rise of ignition voltage pulse trigger system by a cable pulse generator (fig.3).*

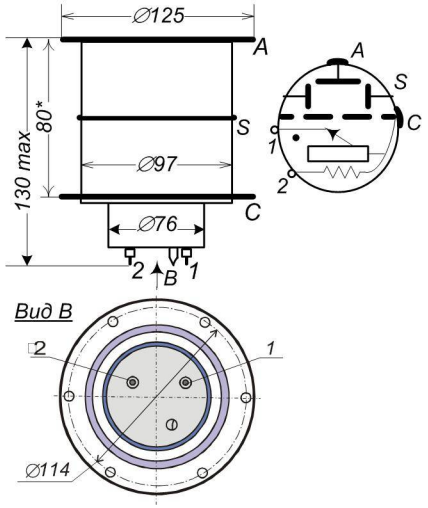
(Note 6) *Pb >10^9 and RMS >50 can be achieved in burst mode only. Burst and pause durations must be agreed with the Manufacturer.*

(Note 7) *Use forced air or liquid (oil) cooling providing Pb and RMS below indicated in p. 1.2.*

1.3. The thyratron operating resource (mode p.1.1) in terms of total switched charge - 10^5 Coulomb.

1.4. Maximum overall dimensions ($\varnothing_{\text{cathode flange}} \times H_{max}$), mm - 125×135.

1.5. Mass - not more than 1.8 kg.



2. A diagram of electrodes connection

A- anode;
S - screen;
C - cathode, a heater
1 - trigger negative signal input lead.
2 - heater (R_{res} ~1Ω);
3 - ignitor lead (+);

ATTENTION! *It is required in all circuits to carefully observe polarity of the ignition voltage applied to the appropriate leads of the ignitor and to provide symmetry of current pick-off from cathode and anode flanges relative to the axis of the device.*
The thyratrons must be handled carefully in order to prevent mechanical effect on the leads 1,2,3 exceeding 8 kgs in an axial direction and 3kgs in direction perpendicular to the axes. It is strictly forbidden to expose the leads 1,2,3 to impacts.

3. Operation Guidelines

3.1. Trigger negative signal is to be applied to the lead 1 of the thyratron. Resistance of ignitor within warranty period is 5÷5000 kOhm.

3.2. Switching sequence: a) apply heater voltage; b) allow the thyratron to warm up for not less than 5 min; c) apply pulsed ignition voltage to the ignitor, rise the anode voltage to the operating level. It is permitted to simultaneously switch on heater and ingition voltages.

3.3. When switching off supply voltages first switch off anode voltage, then all the rest voltages. It is permitted to simultaneously switch off all the supply voltages.

3.4. For ensuring warranty period of operation in modes different from those specified in p.1.1 it is necessary to select a heater voltage depending on the mode of operations of a thyratron. For this purpose during operation with a nominal load, increase of the heater voltage by steps of 0.2÷0.3V from the value specified in the passport staying at each value for 2÷3 minutes before appearance of signs of unstable operation (transition to higher frequency or to continuous discharge). At occurrence of these signs switch off anode voltage, reduce heater voltage by 0.1÷0.2 V and in ~1 minutes switch on anode voltage and keep it for 5-10 minutes. At steady operation fix the given heater voltage. Further it is desirable to repeat this procedure after every total 10^5 C of operation.

3.4. The maximum-allowed temperature of cathode, anode and screen flanges is +100°C. If it is exceeded, a forced air cooling must be used.

3.5. Before operating the thyratron after a long period of storage a training (ageing) in an operational mode within not less than 30 minutes is required. When training the thyratron, anode voltage must be raised gradually by stages 3-5 kV from minimum peak voltage of 5-10 kV up to operating voltage.

Criteria of completion of aging at each step - absence of spontaneous breakdowns within 3-5 minutes.

Recommended Circuits for Ignition Pulse Generator

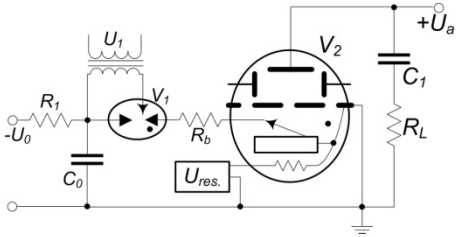


Fig.1. Principal circuit of a triggered spark gap-based ignition pulse generator. The circuit may be used at high operating temperatures (up to 200 °C).
Uo=5kV,
V_1–triggered spark gap RU83;
R_1=10kΩ, R_b= (0÷50) Ω,
C_o= (0.01÷0.2) μF

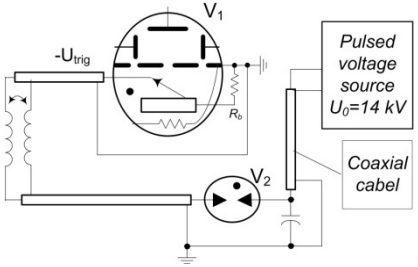


Fig.2. Low-jitter (<5ns), low-energy, trigger system by a cable pulse generator. (*V.A.Gribkov, et al, "Pseudosparks in nanosecond range of its operation: firing, jitter, and disconnection", Journal of Physics D: Appl. Phys.* ***37,*** *2004, 2107–2111).*
V_2- sharpening spark gap;
cable length = 6 m;

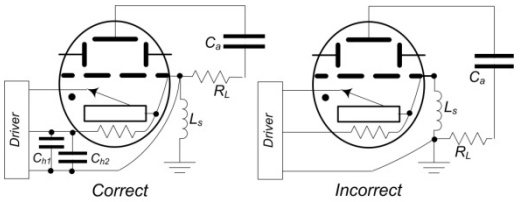


Fig..3. Please make sure that voltage jumps (stray voltage) **Us=|Ls·dI/dt|** in ground circuit should be minimized. For that heating voltage cable must be connected to the thyratron connectors directly. Also load circuit must be connected right to the thyratron cathode and equipment case directly. Cathode of the tube must be connected with equipment case by a minimum length cable (stray inductance $L_s \rightarrow 0$).
C_1, C_2: Reservoir protection capacitors with a voltage rating > 500 V;
C_1 = 1000 pF low inductance (e.g. ceramic), C_2 = 1uF (e.g. polycarbonate).
Components C_1, C_2 should be mounted as close to the tube as possible.