PULSED KLYSTRON AMPLIFIER E3730A

E3730A is an S-band high-power pulsed amplifier klystron designed for linear accelerators. The E3730A delivers 50MW peak output power in 4 μs pulse width with a power gain of more than 50 dB and with an efficiency of more than 42%. Output power is extracted through a WR-284 standard waveguide. The electron beam is focused by the series-coil electro-magnet VT-68922. An Sc-doped dispenser cathode is employed, ensuring high reliability and long tube life.

GENERAL DATA CHARACTERISTICS (1)

Electrical	Min.	Typ.	Max.	Units
Frequency	---	2856	---	MHz
Heater Voltage (3)	---	---	20	V
Heater Current (3)	---	---	20	A
Heater Current (Surge) (3)	---	---	40	A
Heater Warm-up Time	60	---	---	min
Peak Beam Voltage (4)	---	---	325	KV
Peak Cathode Current	---	---	400	A
Peak RF Drive Power (5)	---	---	500	W
Peak RF Output Power (1)	---	---	50	MW
Beam Perveance	---	2.0	---	$\mu A/V^{3/2}$
Efficiency (1)	42	---	---	%
Gain (1)	50	---	---	dB
Average RF Output Power	---	---	10	kW
Pulse Width (Beam Voltage) (6)	---	---	6.7	μs
Pulse Width (RF Output Power) (7)	---	---	4.0	μs
Pulse Repetition Rate	---	---	50	pps
Load VSWR	---	---	1.2:1	---
Ground		Tube Body		

Physical	Min.	Typ.	Max.	Units
Mechanical				
Dimensions			See outline drawing	
Height		Approx. 1400		mm
Net Weight		Approx. 280		kg
Mounting Position			Vertical, Cathode down	
Cathode			Dispenser cathode (Scandate impregnated cathode)	
Ion Pump (2) (8) (9)	8			L/sec.
Focusing Electromagnet (10) (11)			Canon Electromagnet VT-68922	
X-ray Shields (12)			Canon X-ray Shield Kit VT-69064	
Connection				
Heater/Cathode			Spring Contact Rods	
Heater			Spring Contact Rod	
RF Input			Coaxial, Type N Receptacle	
RF Output			SLAC type Flange "Female" Output Waveguide WR-284 (13)	
Ion Pump			Coaxial, HN-R	
Cooling				
Cathode	Oil			
Collector	Water (14) (15)			
Flow Rate	30	---	---	L/min
Pressure Drop	---	---	0.3	MPa
Coolant Pressure	---	---	1.0	MPa
Inlet Coolant Temperature	5	---	35	°C
Inlet/Outlet Connector		NITTO KOHKI “SP-type COUPLER” “4P” for the inlet, “4S” for the outlet		
RF Output Waveguide	Water (14) (15)			
Flow Rate	2	---	---	L/min
Pressure Drop	---	---	0.05	MPa
Coolant Pressure	---	---	1.0	MPa
Inlet Coolant Temperature	5	---	35	°C
Inlet/Outlet Connector	1/4 inch Swagelok			
Environmental				
Temperature (Operating)	0	---	40	°C
Humidity (Operating)		Non condensing		(%)

ABSOLUTE RATINGS (1)(16)

	Min.	Max.	Units
Frequency	2855	2857	MHz
Heater Voltage (3) (17)	---	20	V
Heater Current (3) (17)	---	20	A
Heater Current (Surge) (3)	---	40	A
Heater Warm-up Time	60	---	min.
Peak Beam Voltage (4) (18)	---	325	kV
Peak Inverse Beam Voltage (19)	---	100	kV
Peak Cathode Current (20) (21)	---	400	A
Peak Inverse Cathode Current	---	55	A
Peak RF Drive Power (5) (22)	---	1000	W
Peak RF Output Power	---	52	MW
Average RF Output Power	---	10.5	kW
Collector Dissipation	---	35	kW
Pulse Width (Beam Voltage)(6)	---	6.7	µs
Pulse Width (RF Output Power)(7)	---	4.0	µs
Pulse Repetition Rate	---	50	pps
Load VSWR (23)	---	1.4:1	
Coolant Flow (Collector) (15)	30	---	L/min.
Coolant Flow (RF Output Waveguide) (15)	2	---	L/min.
Inlet Coolant Temperature	5	35	°C
Coolant Pressure (Collector) (14)	---	1.0	MPa
Coolant Pressure (Waveguide) (14)	---	0.4	MPa
Ion Pump Voltage (2)	3.1	3.9	KV
Waveguide Pressure (13) (Vacuum)	---	6.7×10^{-5}	Pa
	(---	5.0×10^{-7}	Torr)
Environmental Temperature	0	40	°C
Environmental Humidity	0	90	%

TYPICAL OPERATION
(Example)

		Units
Frequency	2856	MHz
Heater Voltage	18	V
Heater Current	18	A
Peak Beam Voltage	312	kV
Peak Cathode Current	362	A
Peak RF Drive Power	365	W
Peak RF Output Power	51	MW
Efficiency	45	%
Gain	51	dB
Pulse Width (Beam Voltage)	6.5	μs
Pulse Width (RF Output Power)	4.0	μs
Pulse Repetition Rate	50	pps

ACCESSORIES
(Option)

Included with the tube

Ion Pump Magnet	VT-69062
X-ray Shield for klystron collector	VT-69063

Not delivered with the tube as Option

Focusing Electromagnet	VT-68922
Ion Pump Power Supply	VT-69009 Series
High Voltage Cable	VT-69035 Series
X-ray Shield Kit	VT-69064
Lifting Attachment	VT-69065
Sealing Gasket (for waveguide flange)	VT-69045
Pulse Transformer Oil Tank Assembly	VT-61169

KLYSTRON AND EQUIPMENT PROTECTION

The protective devices mentioned below must be provided. They must be connected that a defect in any one of them will prevent operation of the tube. Whenever possible, an indicating light should show the reason for protective action.

Characteristics	Type	Point of action	Action speed
Oil level	min. F	Klystron high voltage	Medium
Ion pump current	max. A	Klystron high voltage	Fast
Tube water flow	min. F	Heater supply	Medium
Tube water temperature	max. F	Heater supply	Medium
Heater voltage	min. max. A	Klystron high voltage	Medium
Heater current	min. max. A	Klystron high voltage	Medium
Beam voltage	max. A	Klystron high voltage	Medium and Pulse-to-pulse
Beam current	max. A	Klystron high voltage	Medium and Pulse-to-pulse
Klystron inverse voltage	max. F	Klystron high voltage	Pulse-to-pulse
Klystron inverse current	max. F	Klystron high voltage	Pulse-to-pulse
Waveguide pressure (Vacuum)	max. F	RF drive or Klystron high voltage	Fast
Waveguide SWR	max. F	RF drive or Klystron high voltage	Pulse-to-pulse
Electromagnet current	min. max. A	Klystron high voltage	Medium
Electromagnet water flow	min. F	Electromagnet supply	Medium
Electromagnet water temperature	max. F	Electromagnet supply	Medium

--- "F" indicates a device designed for operation at a rated value.

--- "A" indicates a device which operating point is adjustable according to the individual characteristics of each tube.

--- "S" indicates a device which operating point is specified by the equipment manufacturer.

--- The "medium" action speed indicates the monitoring system can be based on average value measurements.

--- The "fast" action speed indicates the klystron high voltage must be cut off as soon as possible. Usually this can be done by cutting off the thyratron triggering signal.

--- The "pulse-to-pulse" action speed indicates that the monitoring device must detect the first single irregular pulse and interlock system must cut off the next pulse to the irregular pulse detected. For this purpose, peak measuring devices and comparators with references, which can be adjustable, are necessary.

Notes

(1) All voltages except heater voltage and ion pump voltage are referenced to the cathode. The ion pump voltage is referenced to the tube body. The tube body must be firmly connected to the ground.

(2) An ion pump shall be an integral part of each tube. This ion pump shall operate at +3500Vdc +/- 400Vdc from a high impedance power supply capable of delivering 10mA. For normal tube operation, the ion pump current shall be less than 4μAdc. Because of the size of this tube, it is not abnormal to observe changes in the internal vacuum during storage. To be able to put the stored klystron into operation quickly, the klystron ion pump be operated all the time.

(3) When the heater power is applied to a cold tube, the heater voltage shall be adjusted from zero to prescribed values so that the heater current should not exceed 40 A. This value of heater voltage shall be maintained for at least 60 minutes prior to the application of beam voltage. The liquid coolant flow must be operating whenever the heater power is applied.

(4) The electron gun insulator shall be immersed an insulating oil.

(5) Drive power is defined as the power incident to the klystron.

(6) The beam pulse width (duration) shall be measured between the 75% point of the beam voltage pulse.

(7) The RF pulse width shall be measured between the 3 dB points of the output pulse.

(8) Interlock should be provided to prevent application of beam voltage, unless the ion pump current is less than the normal operating value.

(9) To operate the ion pump, a specific magnet is required. Unless specified in contract, the magnet for the ion pump will be provided with the klystron.

(10) The focusing solenoid must be cooled with water.

(11) Interlocks should be provided to prevent application of beam voltage unless solenoid coil current are within ± 5% of the specified value. Interlocks in the liquid cooling system should prevent the application of solenoid voltage, unless the liquid coolant flow is at, or above the specified minimum flow rate.

(12) Unless specified in contract, X-ray shields will not be provided with the klystron. X-ray radiation can be deduced down to 20 μSv/h measured at 0.3 meter from the surface, when the klystron is operated with the specific focusing electromagnet VT-68922 and X-ray shield kit VT-69064. The value does not mean the X-ray intensity, which is definitely harmless to human body, and does not give any guarantee of X-ray intensity radiated from equipment using the klystron.

(13) The output waveguide shall be operated in vacuum.

(14) By de-ionized low conductivity water.

(15) Interlocks in the liquid cooling system should prevent the application of heater voltage and beam voltage, unless the liquid coolant flow is at, or above the specified minimum flow rate.

(16) Referring to paragraph 6.5 of MIL-E-1G, those values are based on the “absolute system” and should not be exceeded under continuous or transit conditions. A single rate may be the limitation and simultaneous operation at another rating may not be possible. Design values for systems should include a safety factor to maintain operation within ratings under voltage and ion pump voltage and environmental variation.

(17) Interlock should be provided to prevent application of a beam voltage unless the heater voltage and the heater current are within ± 5% of prescribed value, and have been applied for the period of time specified in Note(3).

(18) Interlocks should be provided to prevent application of beam voltage greater than 5% above normal operating value, as well as preventing exceeding the Absolute Ratings.

(19) Interlocks should be provided to prevent application of beam voltage, unless inverse beam voltage is less than the Absolute Ratings value.

(20) Interlocks should be provided to prevent the cathode (beam) current from exceeding values greater than 10% above normal operating values, as well as preventing exceeding the Absolute Ratings.

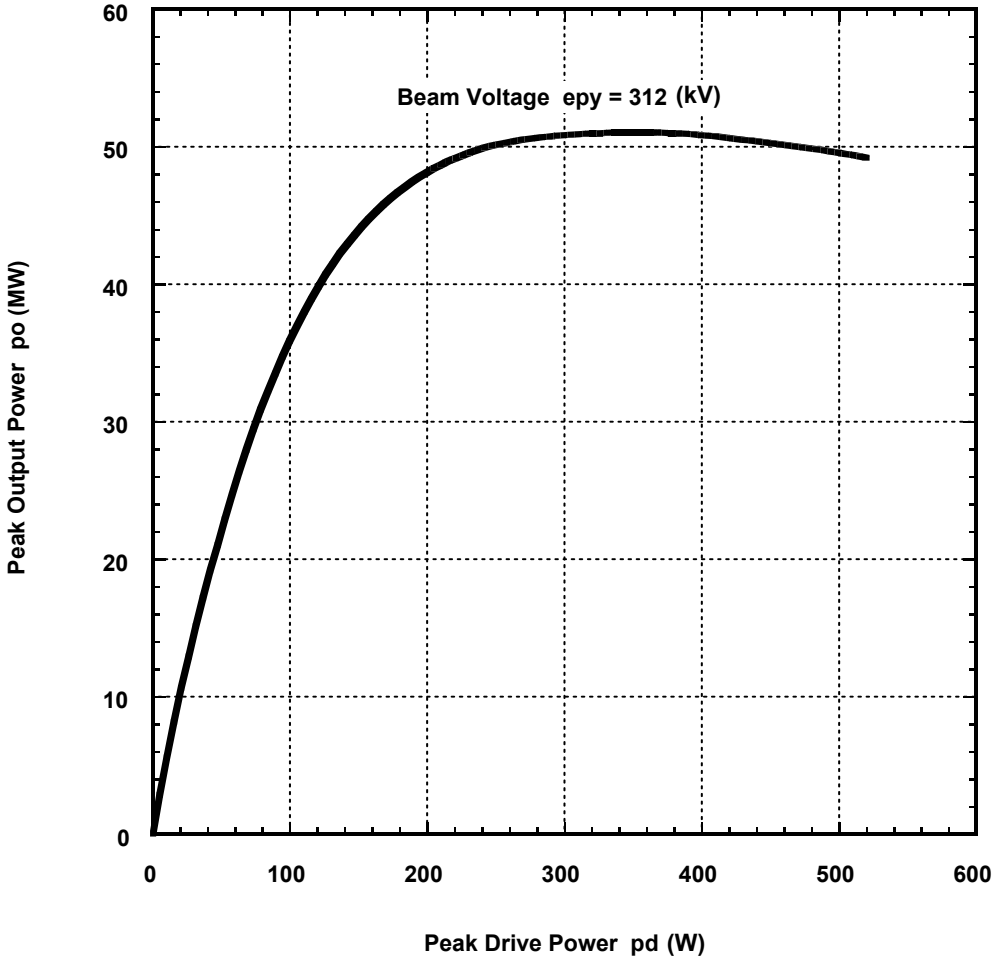
(21) Interlocks should be provided to prevent the application of beam voltage, unless inverse cathode (beam) current is less than the specified value.

(22) The tube shall not be damaged when operated at maximum rated RF drive power when the beam voltage removed.

(23) Output power is measured under a load VSWR 1.2:1.0 maximum.

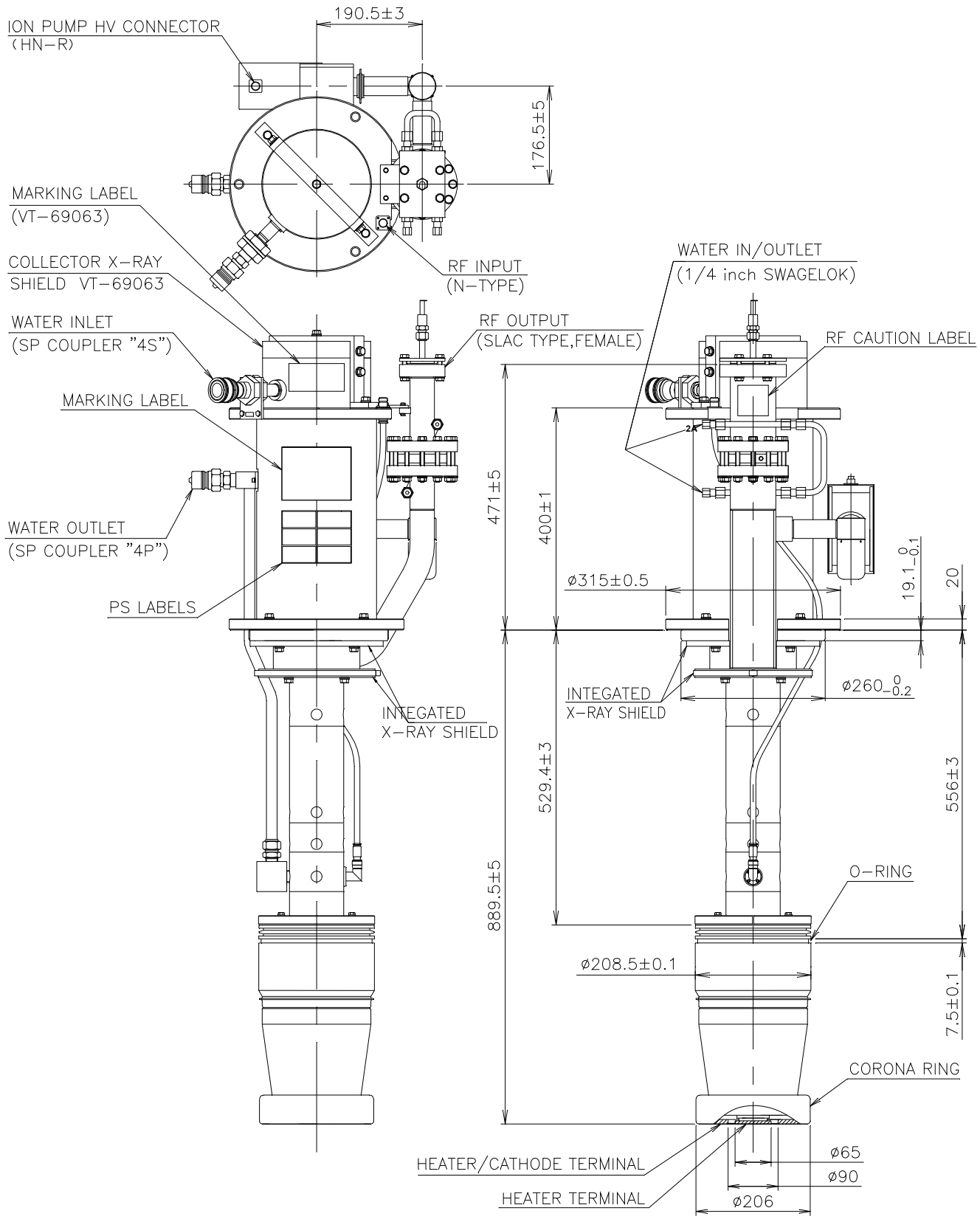
TYPICAL CHARACTERISTICS

TYPICAL POWER TRANSFER CHARACTERISTICS



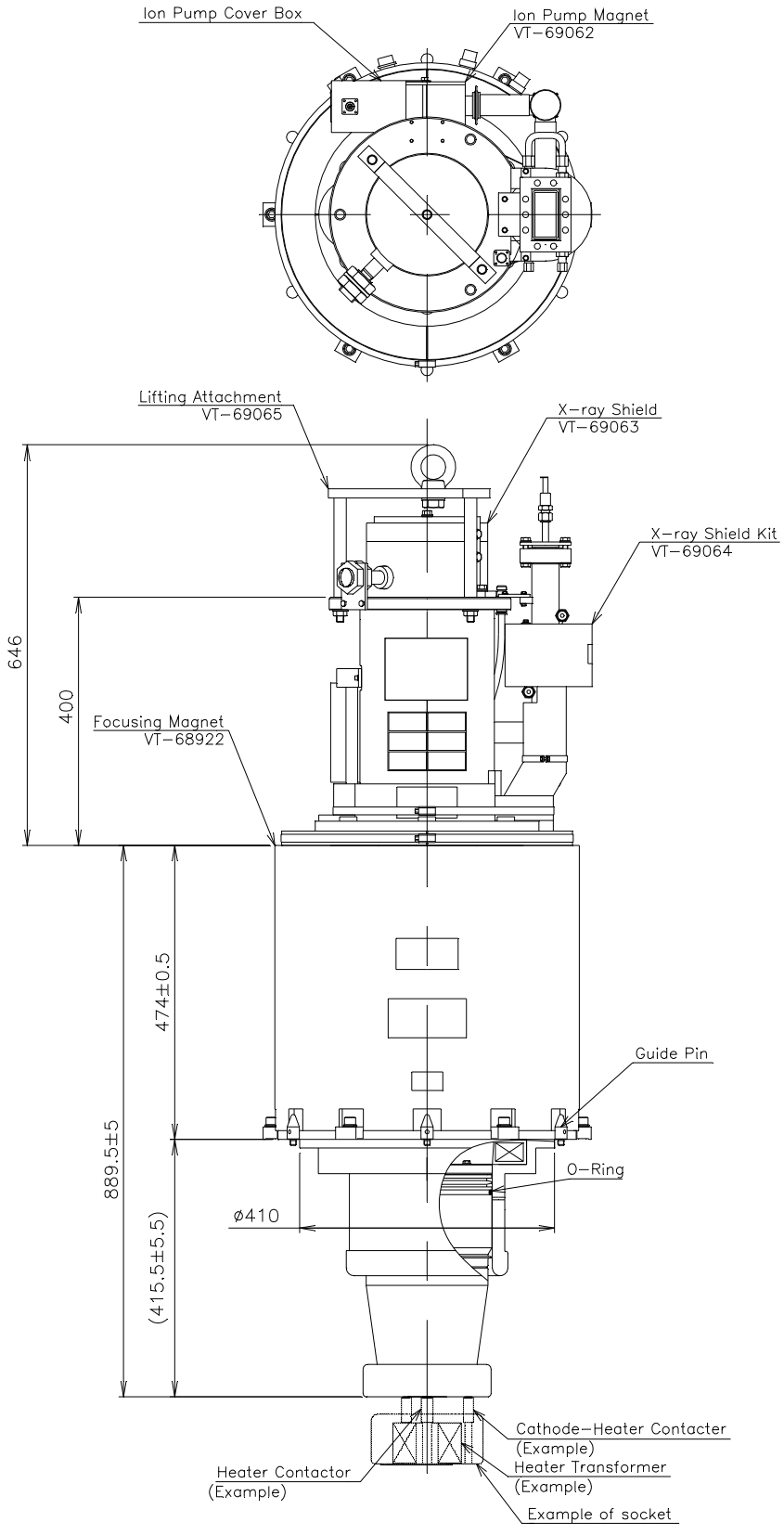
DIMENSIONAL OUTLINE OF THE E3730A KLYSTRON

Unit: mm



CONFIGURATION OF KLYSTRON UNITS

Unit: mm



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