PULSED KLYSTRON AMPLIFIER
E3765,A

Customizes klystrons to meet all specific performance requirements. E3765,A is an S-band high power amplifier klystron designed for industrial linear accelerators. The E3765,A klystron delivers 5.0MW peak output power in 11.5μs pulse duration. Output power is extracted through WR284 standard waveguide. The electron beam is focused by a series-coil electromagnet. The focusing electromagnet VT-68934,E is available.

GENERAL DATA CHARACTERISTICS (1)

Electrical (2)	Min.	Typ.	Max.	Units
Frequency	---	2856	---	MHz
Heater Voltage (3)	---	---	18	V
Heater Current (3)	---	---	18	A
Heater Current (Surge) (3)	---	---	20	A
Cathode Warm-up Time	30	---	---	min
Peak Beam Voltage (4)	---	---	140	kV
Peak Cathode Current	---	---	104	A
Peak RF Drive Power (5)	---	---	120	W
Peak RF Output Power	---	5.0	5.5	MW
Collector Dissipation	---	---	125	kW
Efficiency	38	---	---	%
Gain	46	---	---	dB
Average RF Output Power	---	---	36	kW
Pulse Width (Beam Voltage) (6)	---	---	13.5	μs
Pulse Width (RF Output Power) (7)	---	---	11.5	μs
Pulse Repetition Rate	---	---	550	pps
Load VSWR	---	---	1.2:1	---
Ground		Tube Body		

Physical	Min.	Typ.	Max.	Units
Mechanical				
Dimensions			See outline drawing	
Height		Approx. 1300		mm
Net Weight		Approx. 100		kg
Mounting Position			Vertical, Cathode down	
Cathode			Impregnated Cathode	
Ion Pump (2) (8) (9)	2			L/sec.
Focusing Electromagnet (10) (11)			Canon Electromagnet VT-68934,E	
X-ray Shields			Canon X-ray Shielding Kit VT-69169 (12)	
Connection				
Heater/Cathode			Mate with SOCKET	
Heater			Mate with SOCKET	
RF Input			Coaxial, Type N receptacle	
RF Output			WR-284 (13), CRP-284F(EIA) flange	
Ground			Tube Body	
Ion Pump			Coaxial, HN-R	
Cooling				
Cathode	Oil			
Collector	Water (14) (15)			
Flow Rate	100	---	---	L/min
Pressure Drop			0.49	MPa
Coolant Pressure	---	---	0.98	MPa
Inlet Coolant Temperature	4	---	40	°C
Inlet/Outlet Connector	1 inch Swagelok			
Body	Water (14) (15)			
Flow Rate	18	---	---	L/min
Pressure Drop			0.39	MPa
Coolant Pressure	---	---	0.78	MPa
Inlet Coolant Temperature	4	---	40	°C
Inlet/Outlet Connector	1/2 inch Swagelok			
Window	Water (14) (15)			
Flow Rate	5	---	---	L/min
Pressure Drop			0.29	MPa
Coolant Pressure	---	---	0.49	MPa
Inlet Coolant Temperature	4	---	40	°C
Inlet/Outlet Connector	10 mm Swagelok			
Environmental				
Temperature	0	---	40	°C
Humidity	0	---	90	%

ABSOLUTE RATINGS (1)(16)

	Min.	Max.	Units
Frequency	2854	2858	MHz
Heater Voltage (3) (17)	---	18	V
Heater Current (3) (17)	---	18	A
Heater Current (Surge) (3)	---	20	A
Cathode Warm-up Time	30	---	min.
Peak Beam Voltage (4) (18) (24)	---	140	kV
Peak Beam Inverse Voltage (19)	-20	---	kv
Peak Cathode Current (20) (21)	---	104	A
Peak RF Drive Power (5) (22)	---	120	W
Peak RF Output Power	---	5.5	MW
Average RF Output Power	---	36	kW
Collector Dissipation	---	125	kW
Pulse Width (Beam Voltage)(6) (24)	---	13.5	µs
Pulse Width (RF Output Power)(7)	---	11.5	µs
Pulse Repetition Rate	---	550	pps
Load VSWR (23)	---	1.4:1	
Coolant Flow (Collector) (15)	100	---	L/min.
Coolant Flow (Body) (15)	18	---	L/min.
Coolant Flow (Window) (15)	5	---	L/min.
Inlet Coolant Temperature	4	40	°C
Coolant Pressure (Collector) (14)	---	0.98	MPa
Coolant Pressure (Body) (14)	---	0.78	MPa
Coolant Pressure (Window) (14)	---	0.49	MPa
Ion Pump Voltage	3.2	3.8	kV
Environmental Temperature	4	40	°C
Environmental Humidity	0	90	%

TYPICAL OPERATION

		Units
Frequency	2856	MHz
Heater Voltage	12.6	V
Heater Current	9.5	A
Peak Beam Voltage	135	kV
Peak Cathode Current	89	A
Peak RF Drive Power	70	W
Peak RF Output Power	5.1	MW
Efficiency	42	%
Gain	48.6	dB
Pulse Width (Beam Voltage)	13.5	µs
Pulse Width (RF Output Power)	10.5	µs
Pulse Repetition Rate	400	pps

ACCESSORIES
(Option)

Not included with the tube as Option

Focusing Electromagnet	VT-68934,E
Ion Pump Power Supply	VT-69009 Series
High Voltage Cable	VT-69035 Series
X-ray Shield Kit	VT-69169
Lifting Attachment	VT-69219

Electromagnet VT-68934,E

GENERAL DATA CHARACTERISTICS [1]

Electrical	Min.	Typ.	Max.	Units
Power supply: (Constant current DC power supply: Current stability +/-2% and below)				
Solenoid current				
Main coil	-	36	40	Adc
Counter coil	-	18	30	Adc
Solenoid voltage				
Main coil	-	130	160	Vdc
Counter coil	-	2	5	Vdc

Mechanical	Min.	Max.	Units
Dimension	See outline drawing		
Height	Approx. 490		mm
Net weight	Approx. 450		kg
Electrical connection	Terminal block		
Temperature interlock signal output	-		
Cooling; Water cooling [14] [15]			
Flow rate	10	-	L/min
Pressure drop	-	0.29	MPa
Water pressure	-	0.78	MPa
Water inlet temperature	4	40	ºC
Water connector (In)	PT1/2 inch female		
Water connector (Out)	PT1/2 inch female		
Environment			
Temperature	5	40	ºC
Humidity	0	75	%

ABSOLUTE RATINGS [1][16]

	Min.	Max.	Units
Solenoid current			
Main coil	-	42	Adc
Counter coil	-	32	Adc
Solenoid voltage			
Main coil	-	160	Vdc
Counter coil	-	5	Vdc
Coil case voltage		1500	Vdc
Flow rate	10	-	L/min
Water pressure	-	0.78	MPa
Water inlet temperature	4	40	ºC
Temperature	4	40	ºC
Humidity	0	90	%

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	Pulse-to-pulse
Beam current	max. A	Klystron high voltage	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 (SF_6)	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
Electromagnet 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 +/-300Vdc 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 20 A. This value of heater voltage shall be maintained for at least 30 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) X-ray shields are required to operate the klystron. The Canon X-ray shielding kit is available.

(13) The output waveguide shall be operated in SF_6.

(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 provide 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.

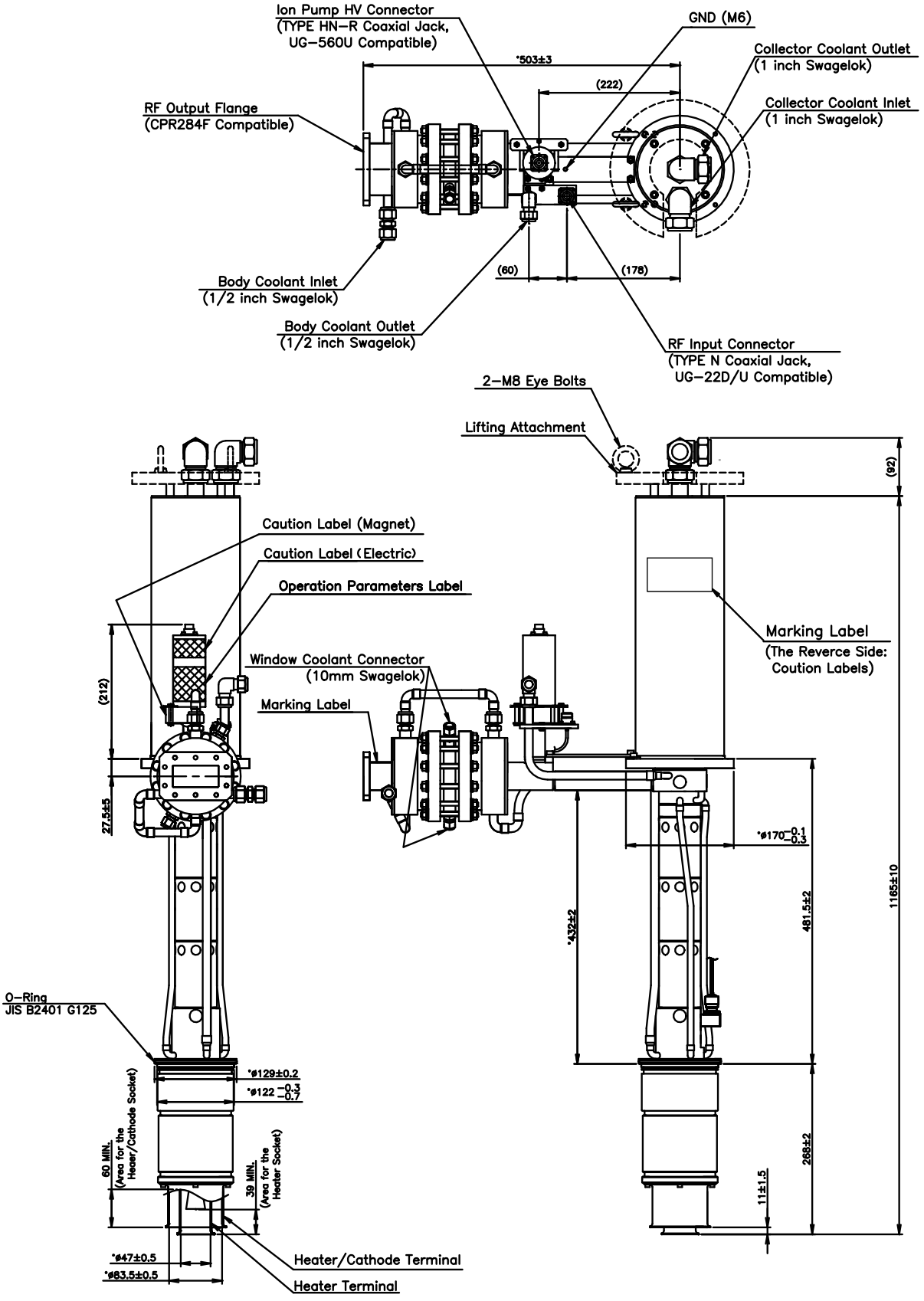
(24) We confirm high-voltage durability of the electron gun under the condition of the long pulse operation (13.5μs, 137kV) by using the following equation at the factory test.

$$epy = 137 \times (tp(epy) / 13.5)^{-0.3} ,$$

where, epy and tp(epy) are applied voltage at the high-voltage test and pulse width of beam voltage by using the power supply at the factory, respectively. Applied voltage at high-voltage test will be 171kV in case of 6.5μs pulse width.

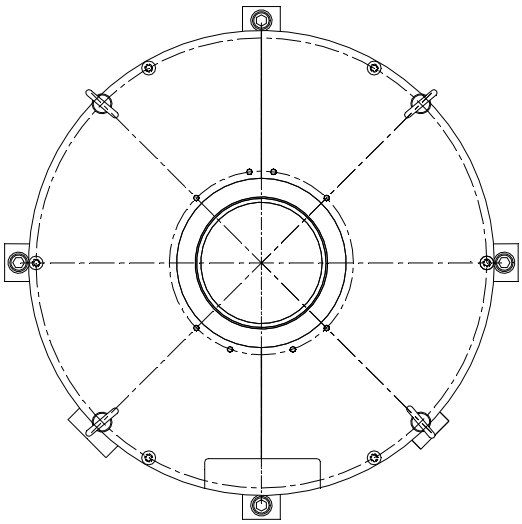
DIMENSIONAL OUTLINE OF THE E3765,A KLYSTRON

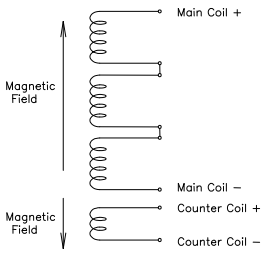
Unit : mm

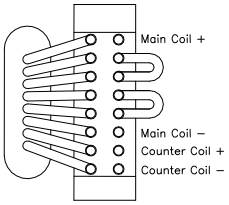


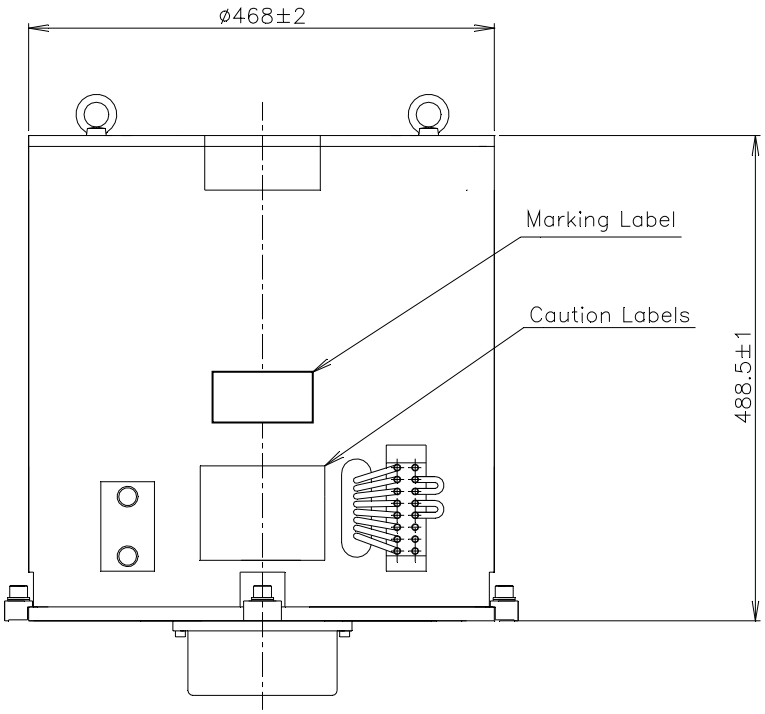
OUTLINE DRAWING OF THE VT-68934,E

Unit: mm



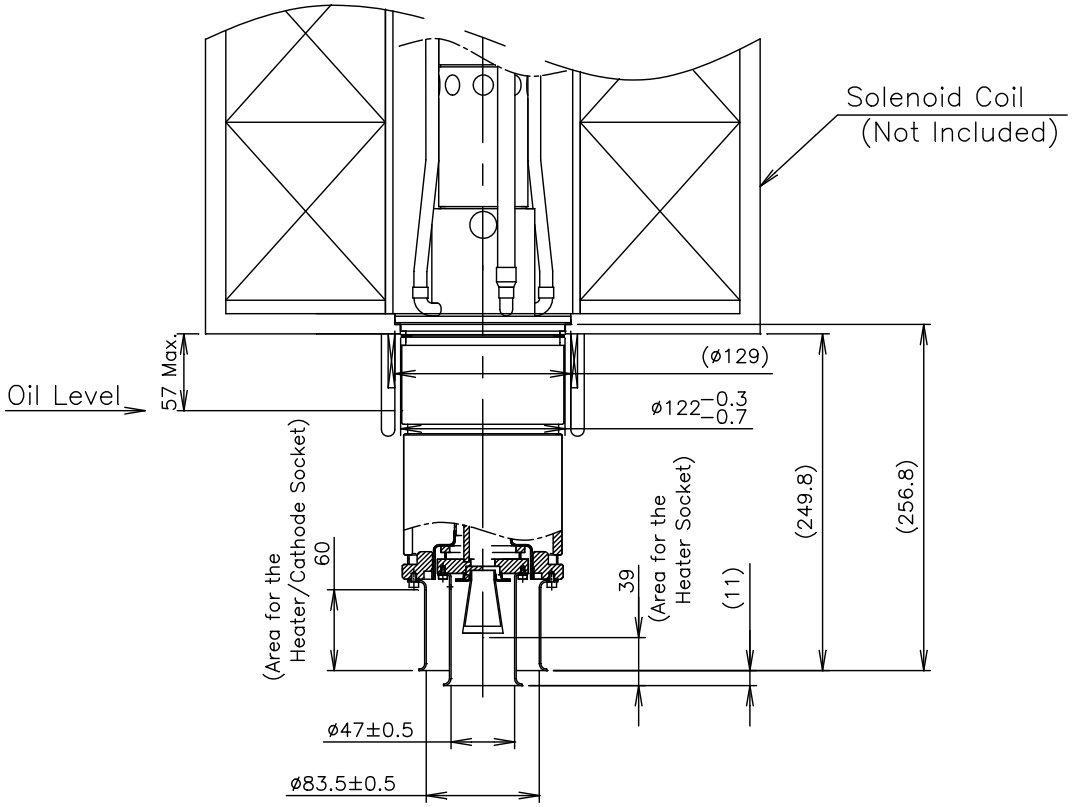






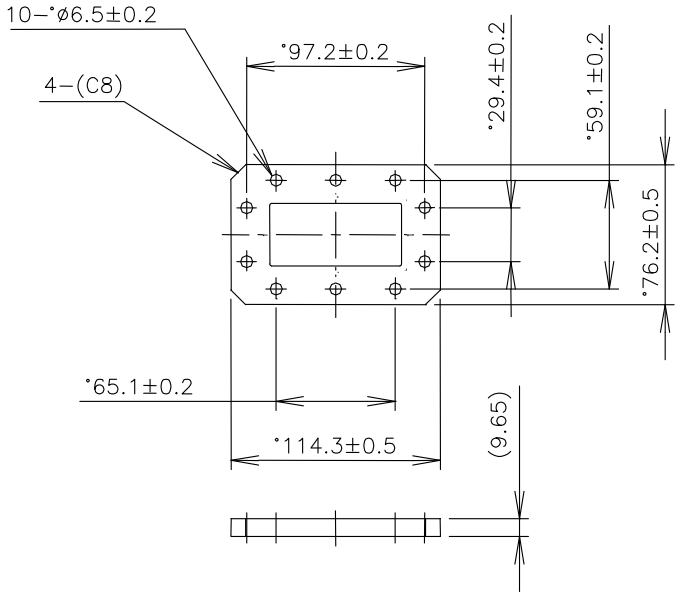
DETAIL DRAWING OF THE HEATER/CATHODE TERMINAL

Unit: mm



DIMENSIONAL DRAWING OF OUTPUT FLANGE

Unit: mm



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