

**PULSED KLYSTRON AMPLIFIER
E37202**

E37202 is a C-band high-power pulsed amplifier klystron designed for linear accelerators. The E37202 delivers 50MW peak output power in 2.5 μ s pulse width with a power gain of more than 50 dB and with an efficiency of more than 40%. Output power is extracted through two WR-187 standard waveguides in parallel. However one port output is possible with the specific power combiner. The electron beam is focused by the series-coil electro-magnet VT-68926B. An Sc-doped dispenser cathode is employed, ensuring high reliability and long tube life.



GENERAL DATA CHARACTERISTICS ⁽¹⁾

| Electrical | Min. | Typ. | Max. | Units |
|--|-----------|------|-------|--------------------------|
| Frequency | --- | 5712 | --- | MHz |
| Heater Voltage ⁽³⁾ | --- | --- | 110 | V |
| Heater Current ⁽³⁾ | --- | --- | 5.5 | A |
| Heater Current (Surge) ⁽³⁾ | --- | --- | 7 | A |
| Heater Warm-up Time | 60 | --- | --- | min |
| Peak Beam Voltage ⁽⁴⁾ | --- | --- | 370 | KV |
| Peak Cathode Current | --- | --- | 344 | A |
| Peak RF Drive Power ⁽⁵⁾ | --- | --- | 500 | W |
| Peak RF Output Power ⁽¹⁾ | --- | --- | 50 | MW |
| Beam Perveance | --- | 1.53 | --- | μ A/V ^{3/2} |
| Efficiency ⁽¹⁾ | 40 | --- | --- | % |
| Gain ⁽¹⁾ | 50 | --- | --- | dB |
| Average RF Output Power | --- | --- | 6.5 | kW |
| Pulse Width (Beam Voltage) ⁽⁶⁾ | --- | --- | 6.2 | μ s |
| Pulse Width (RF Output Power) ⁽⁷⁾ | --- | --- | 2.5 | μ s |
| Pulse Repetition Rate | --- | --- | 60 | pps |
| Load VSWR | --- | --- | 1.2:1 | --- |
| Ground | Tube Body | | | |

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| Physical | Min. | Typ. | Max. | Units |
|---|------|--------------|------|--|
| Mechanical | | | | |
| Dimensions | | | | See outline drawing |
| Height | | Approx. 1450 | | mm |
| Net Weight ⁽⁸⁾ | | Approx. 300 | | kg |
| Mounting Position | | | | Vertical, Cathode down |
| Cathode | | | | Dispenser cathode (Scandate impregnated cathode) |
| Ion Pump ^{(2) (9)} | | 8 | | L/sec. |
| Focusing Electromagnet ^{(10) (11)} | | | | Canon Electromagnet VT-68926B |
| RF Power Combiner | | | | Integrated Canon Power Combiner |
| X-ray Shields ⁽¹²⁾ | | | | Canon X-ray Shield Kit VT-69122 |
| Connection | | | | |
| Heater/Cathode | | | | One MULTI-CONTACT Pin Plug SP4N |
| Heater | | | | Two MULTI-CONTACT Pin Plugs SP3N |
| RF Input | | | | Coaxial, Type N Receptacle |
| RF Output | | | | RIKEN DESY Type Flange Output Waveguide WR-187 ⁽¹³⁾⁽¹⁴⁾ |
| Ion Pump | | | | Coaxial, SHV-R |
| Cooling | | | | |
| Cathode | | | | Oil |
| Collector | | | | Water ^{(15) (16)} |
| Flow Rate | 30 | --- | --- | L/min |
| Pressure Drop | --- | --- | 0.2 | MPa |
| Coolant Pressure | --- | --- | 1.0 | MPa |
| Inlet Coolant Temperature | 5 | --- | 40 | °C |
| Inlet/Outlet Connector | | | | 1 inch Swaegelok Connectors or Two NITTO KOHKI SP Couplers "6P" ⁽¹⁷⁾ |
| RF Output Waveguide | | | | Water ^{(15) (16)} |
| Flow Rate | 2 | --- | --- | L/min |
| Pressure Drop | --- | --- | 0.05 | MPa |
| Coolant Pressure | --- | --- | 1.0 | MPa |
| Inlet Coolant Temperature | 5 | --- | 40 | °C |
| Inlet/Outlet Connector | | | | 8 mm Swagelok Connectors |
| Environmental | | | | |
| Temperature (Operating) | 0 | --- | 40 | °C |
| Humidity (Operating) | | | | Non condensing (%) |

ABSOLUTE RATINGS ⁽¹⁾⁽¹⁸⁾

| | Min. | Max. | Units |
|--|------|------------------------|--------|
| Frequency | 5707 | 5717 | MHz |
| Heater Voltage ^{(3) (19)} | --- | 110 | V |
| Heater Current ^{(3) (19)} | --- | 5.5 | A |
| Heater Current (Surge) ⁽³⁾ | --- | 7 | A |
| Heater Warm-up Time | 60 | --- | min. |
| Peak Beam Voltage ^{(4) (20)} | --- | 370 | kV |
| Peak Inverse Beam Voltage ⁽²¹⁾ | --- | 40 | kV |
| Peak Cathode Current ^{(22) (23)} | --- | 344 | A |
| Peak Inverse Cathode Current | --- | 40 | A |
| Peak RF Drive Power ^{(5) (24)} | --- | 500 | W |
| Peak RF Output Power | --- | 51 | MW |
| Average RF Output Power | --- | 7.7 | kW |
| Collector Dissipation | --- | 35 | kW |
| Pulse Width (Beam Voltage) ⁽⁶⁾ | --- | 6.2 | μs |
| Pulse Width (RF Output Power) ⁽⁷⁾ | --- | 3.0 | μs |
| Pulse Repetition Rate | --- | 60 | pps |
| Load VSWR ⁽²⁵⁾ | --- | 1.5:1 | |
| Coolant Flow (Collector) ⁽¹⁶⁾ | 30 | --- | L/min. |
| Coolant Flow (RF Output Waveguide) ⁽¹⁶⁾ | 2 | --- | L/min. |
| Inlet Coolant Temperature | 5 | 40 | °C |
| Coolant Pressure (Collector) ⁽¹⁵⁾ | --- | 1.0 | MPa |
| Coolant Pressure (Waveguide) ⁽¹⁵⁾ | --- | 1.0 | MPa |
| Ion Pump Voltage ⁽²⁾ | 3.1 | 3.9 | kV |
| Waveguide Pressure ⁽¹⁴⁾ (Vacuum) | --- | 1.3 x 10 ⁻⁵ | Pa |
| | (--- | 1.0 x 10 ⁻⁷ | Torr) |
| Environmental Temperature | 0 | 40 | °C |
| Environmental Humidity | 0 | 90 | % |

TYPICAL OPERATION
(Example)

| | | Units |
|-------------------------------|------|---------|
| Frequency | 5712 | MHz |
| Heater Voltage | 82 | V |
| Heater Current | 4.2 | A |
| Peak Beam Voltage | 361 | kV |
| Peak Cathode Current | 326 | A |
| Peak RF Drive Power | 285 | W |
| Peak RF Output Power | 50.9 | MW |
| Efficiency | 43.3 | % |
| Gain | 52.5 | dB |
| Pulse Width (Beam Voltage) | 4.8 | μ s |
| Pulse Width (RF Output Power) | 2.5 | μ s |
| Pulse Repetition Rate | 60 | pps |

ACCESSORIES **(Option)**

Included with the tube

| | |
|-------------------------------------|----------|
| Ion Pump Magnet | VT-69062 |
| X-ray Shield for klystron collector | VT-69048 |
| Power Combiner | --- |

Not delivered with the tube as Option

| | |
|-------------------------------------|-----------------|
| Focusing Electromagnet | VT-68926B |
| Ion Pump Power Supply | VT-69009 Series |
| High Voltage Cable | VT-69035 Series |
| X-ray Shield Kit | VT-69122 |
| Lifting Attachment | VT-69131 |
| Pulse Transformer Oil Tank Assembly | VT-61181 |

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 |
| 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 thyatron triggering signal.

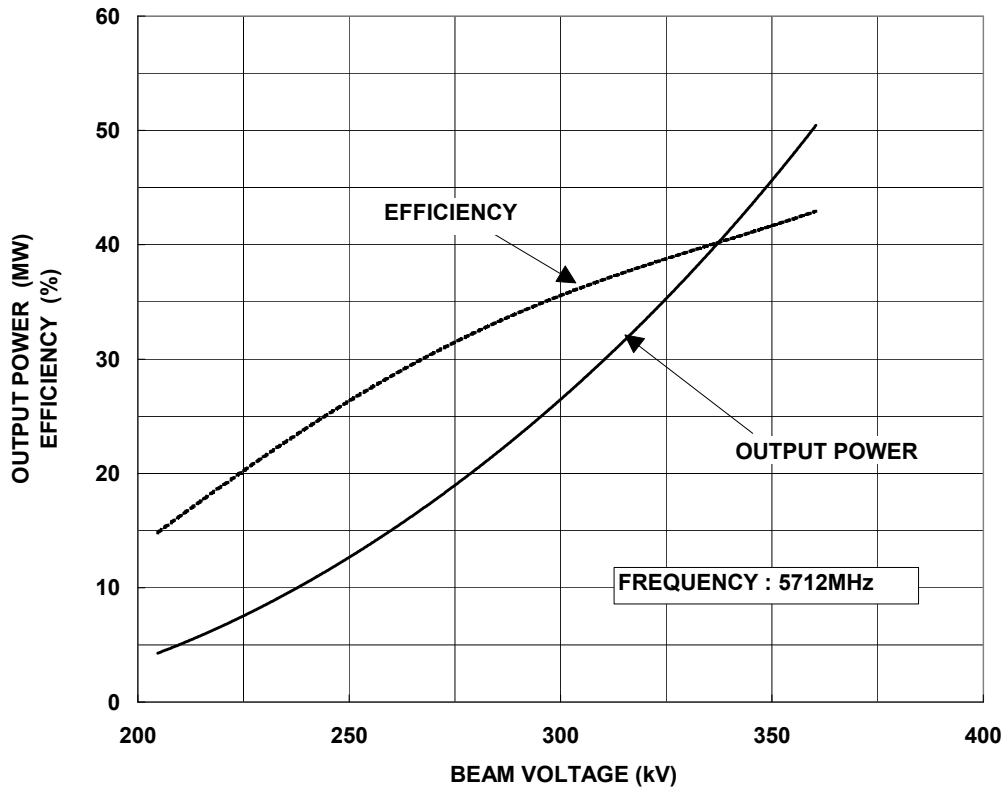
--- The "pulse-to-pulse" action speed indicates that the monitoring device must detect the first single irregular pulse and interlock system must cut off the next pulse to the irregular pulse detected. For this purpose, peak measuring devices and comparators with references, which can be adjustable,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

Notes

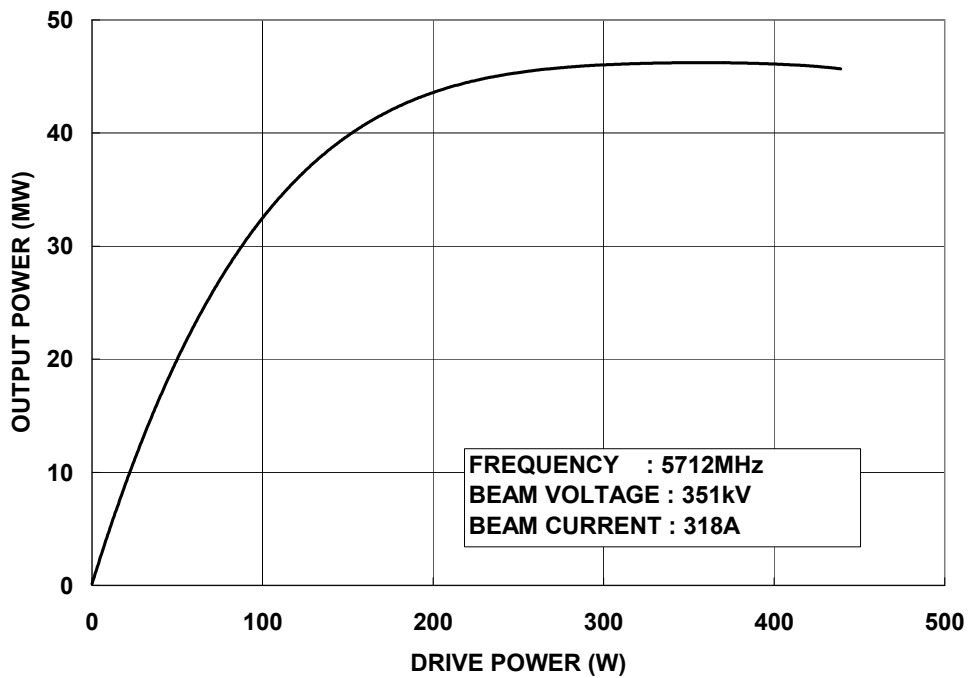
- (1) All voltages except heater voltage and ion pump voltage are referenced to the cathode. The ion pump voltage is referenced to the tube body. The tube body must be firmly connected to the ground.
- (2) An ion pump shall be an integral part of each tube. This ion pump shall operate at +3500Vdc +/- 400Vdc from a high impedance power supply capable of delivering 10mA. For normal tube operation, the ion pump current shall be less than 10 μ Adc. 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 7 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) Measured the tube with collector X-ray shields.
- (9) Interlock should be provided to prevent application of beam voltage, unless the ion pump current is less than the normal operating value.
- (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 $\pm 5\%$ 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 radiation can be deduced down to 30 μ Sv/h measured at 1 meter from the tube axis, when the klystron is operated with the specific focusing electromagnet VT-68926B and X-ray shield kits VT-69048. X-ray radiation can be deduced down to 6 μ Sv/h measured at 1 meter from the tube axis around the X-ray shields of VT-69122, when the klystron is operated with the VT-68926B ,VT-69048 and X-ray shield kits VT-69122. 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 waveguides shall be operated in vacuum.
- (14) Interlocks should be provided to prevent application of rf drive power, unless the pressure in the output power waveguide is less than 1.3×10^{-5} Pa (1×10^{-7} Torr).
- (15) By de-ionized low conductivity water. The maximum inlet water pressure shall not exceed 1.0 MPa (10 kgf/cm²).
- (16) 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.
- (17) NITTO KOHKI SP COUPLER "6P" is compatible with HANSEN plug quick connector "6HK-LL6-K31".
- (18) 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.
- (19) Interlock should be provided to prevent application of a beam voltage unless the heater voltage and the heater current are within $\pm 5\%$ of prescribed value, and have been applied for the period of time specified in Note(3).
- (20) 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.
- (21) Interlocks should be provided to prevent application of beam voltage, unless inverse beam voltage is less than the Absolute Ratings value.
- (22) 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.
- (23) Interlocks should be provided to prevent the application of beam voltage, unless inverse cathode (beam) current is less than the specified value.
- (24) The tube shall not be damaged when operated at maximum rated RF drive power when the beam voltage removed.
- (25) Output power is measured under a load VSWR 1.2:1.0 maximum.

TYPICAL CHARACTERISTICS

TYPICAL SATURATED OUTPUT CHARACTERISTICS

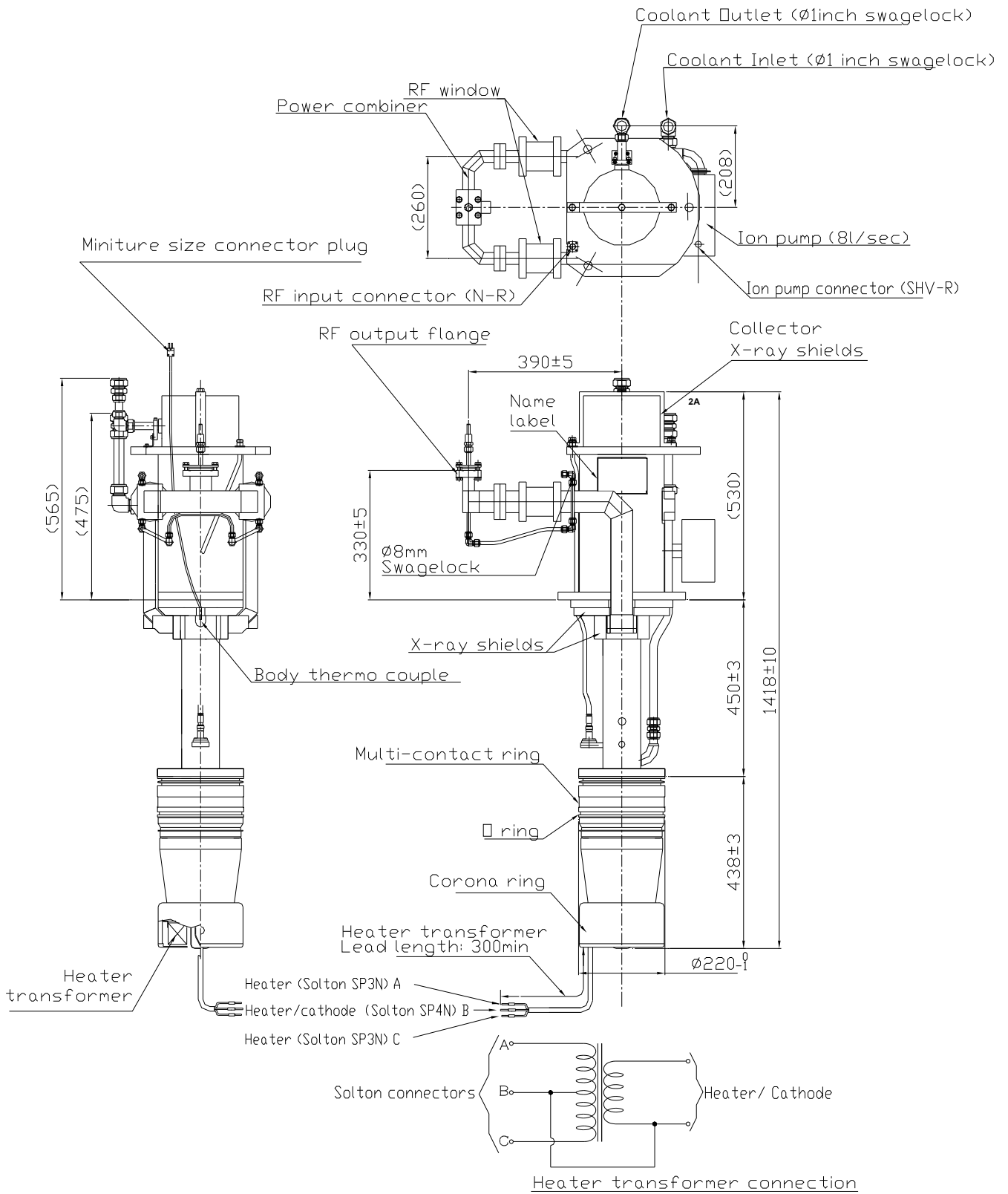


TYPICAL TRANSFER CHARACTERISTICS



DIMENSIONAL OUTLINE OF THE E37202 KLYSTRON

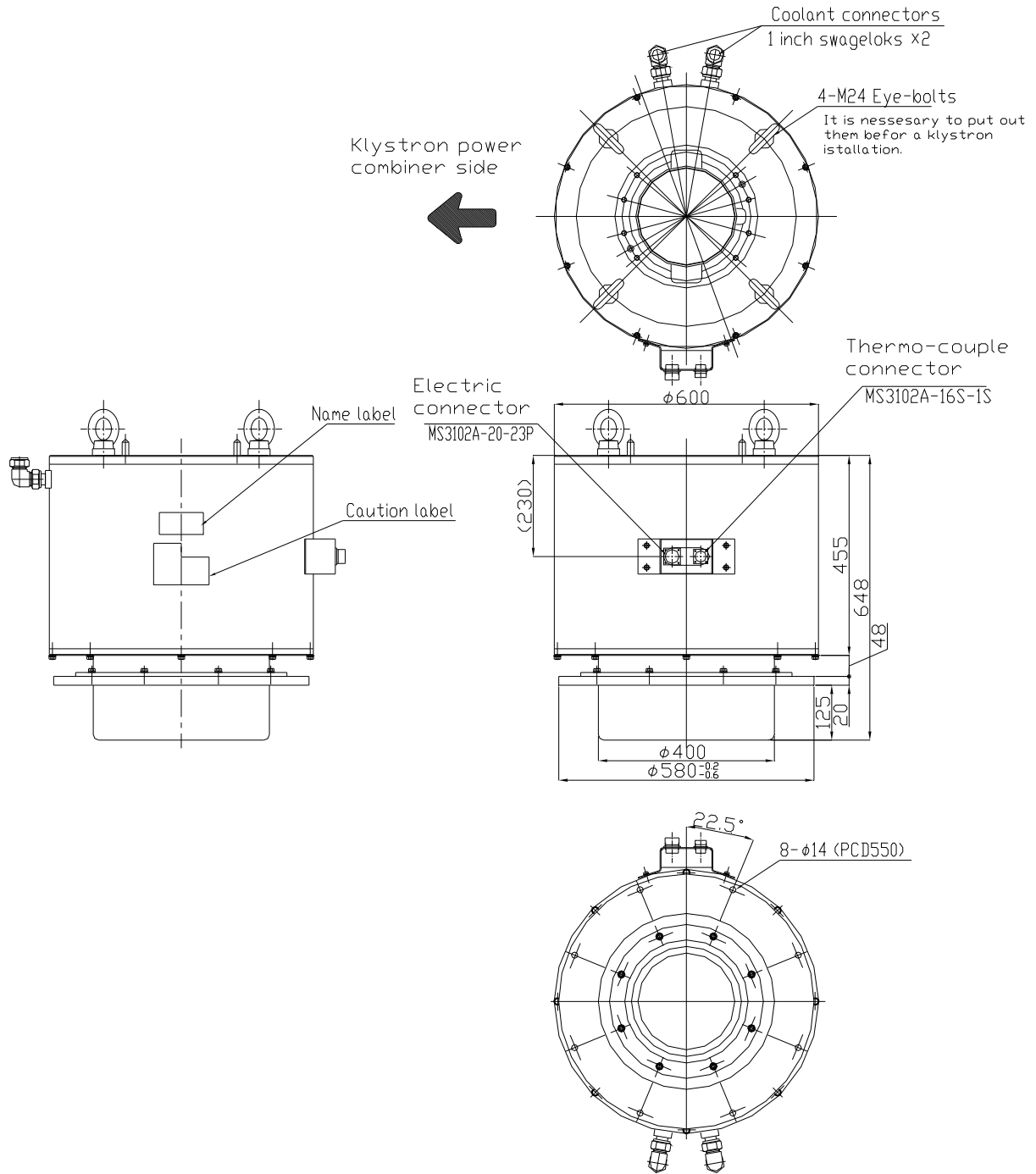
Unit: mm



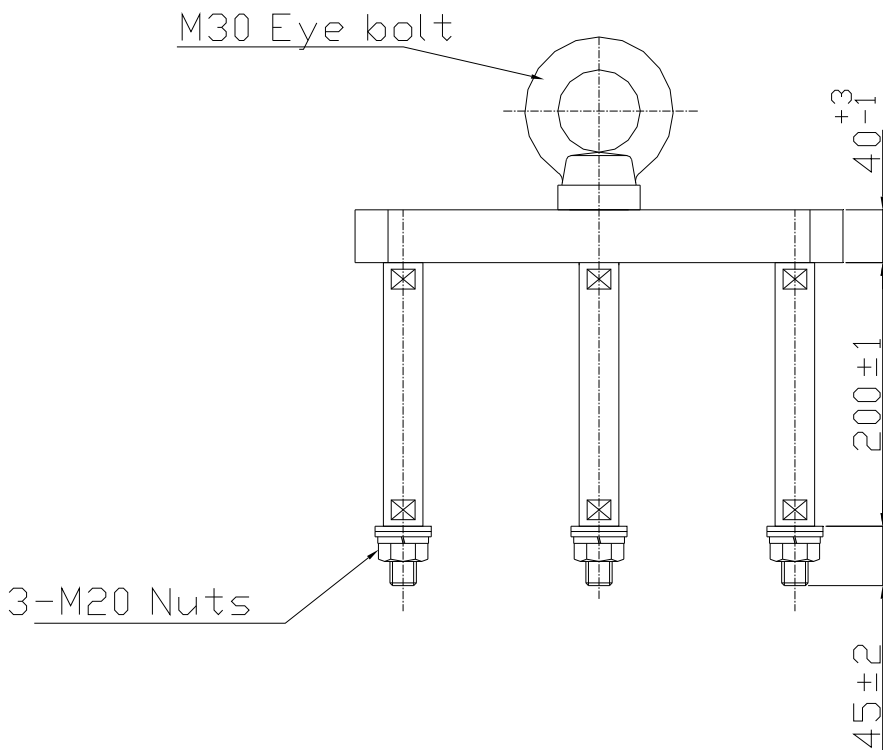
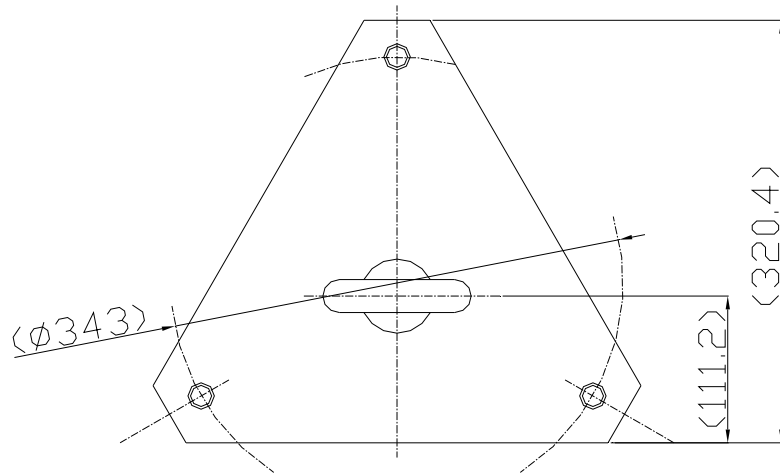
VT-68926B OUTLINE DRAWING

Unit: mm

Weight: approx. 850kgf

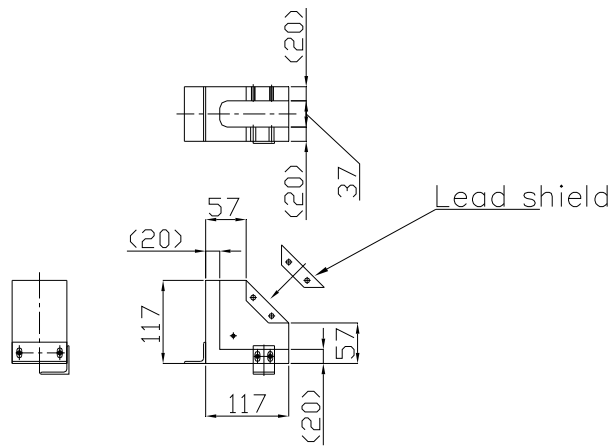
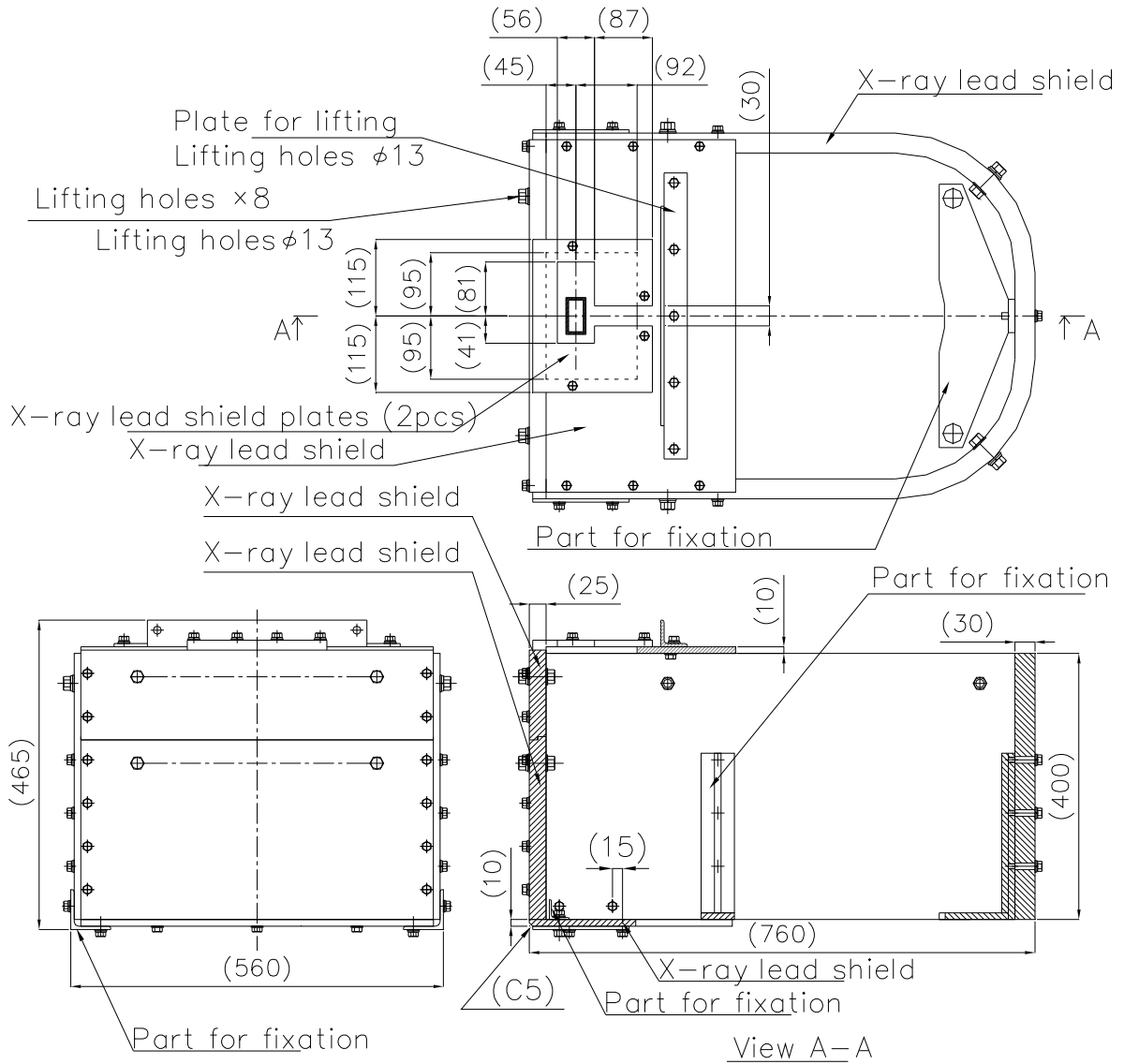


VT-69131 OUTLINE DRAWING



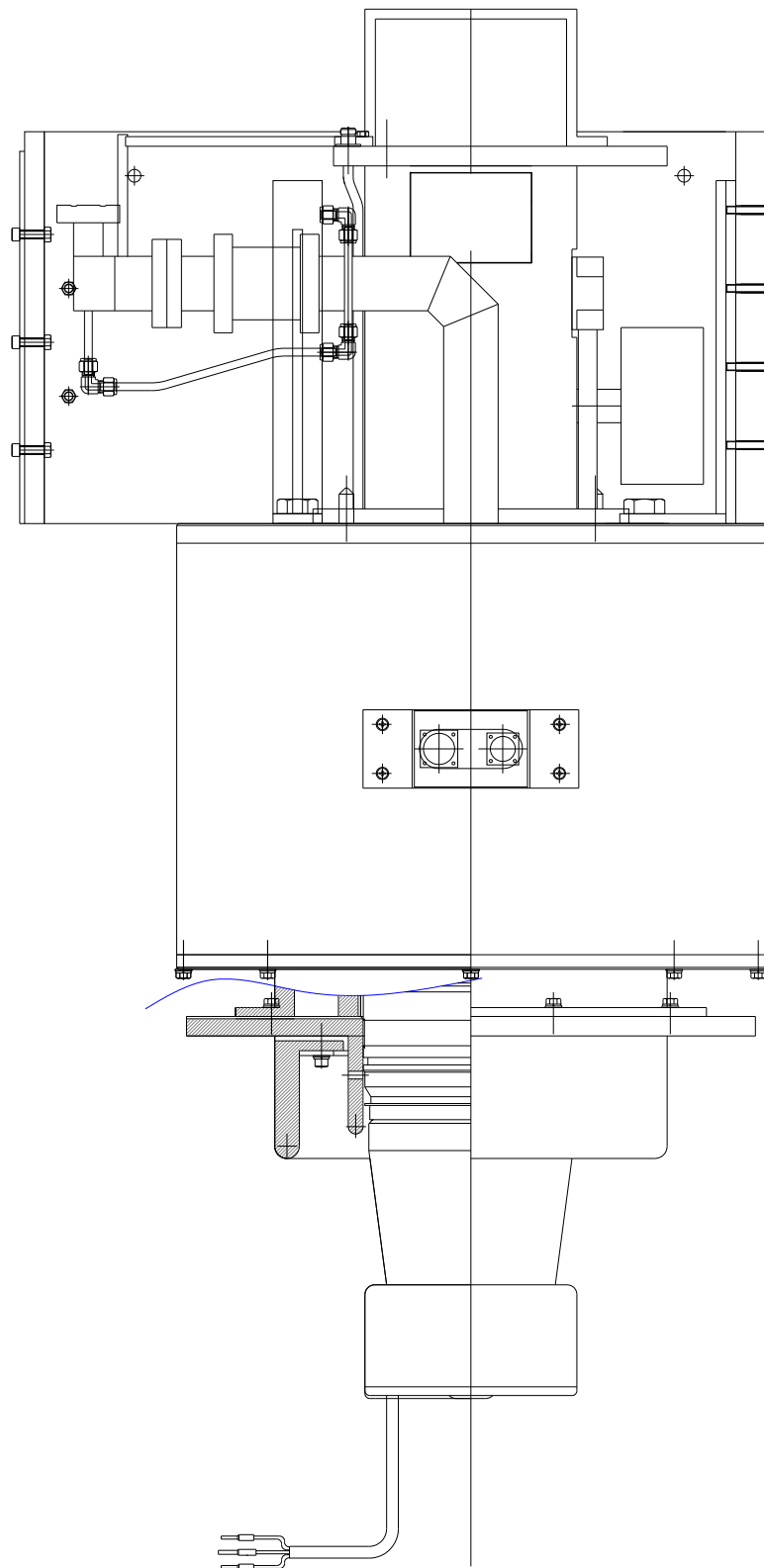
VT-69122 OUTLINE DRAWING

Weight: approx. 400kgf



X-ray shields around coolant connectors

**OUTLINE DRAWING OF
KLYSTRON with ELECTRO MAGNET AND X-RAY SHIELDS**



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Product scope is referred to the following URL. <https://etd.canon/eng/company/quality.htm>.