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## Product Information

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# ULTRA-HIGH POWER X-RAY GENERATOR SUPRE-X1.5A

## 1. Introduction

An ultrahigh-powered X-ray generator (Model SUPRE-X1.5A) has been developed recently by Rigaku.

This X-ray generator is capable of yielding the world's highest X-ray output of up to 60 kV and 1500 mA. It also includes many additional salient features not found in conventional X-ray generators.

In its development, design emphasis was placed on

- 1) compactness
- 2) improved operational productivity
- 3) energy conservation.

Regarding compactness, all components are reduced in size without losing simplicity and ease of operation. The tube housing section of the SUPRE-X1.5A is roughly one-fourth of the vacuum volume of its predecessors, the RU1500 and RU-1000. In the case of the RU models, the X-ray beam height is above eye-level, making the optical system alignment and sample mounting somewhat troublesome. The SUPRE-X1.5A beam height is less than 1.52 meters above the floor to facilitate adjustment and measurement. Furthermore, when compared to the RU-1500, the floor "footprint" area and the weight have been reduced by 20 percent and 30 percent, respectively.

Operational productivity has substantially improved by the use of a computer for full system control and status monitoring. For instance, traditionally the X-ray tube aging has been handled manually with the operator gradually increasing the load to the X-ray tube target while monitoring the vacuum level. With the new system, an automatic mode allows unattended aging so that the load is automatically increased according to a preset load cycle. Should electron discharge occur for some reason during this automatic mode aging a built-in resetting function would restore the original load conditions automatically while moni-



toring the situation. Efficient aging can be made accordingly. It is also possible to switch over to the conventional manual mode, if desired.

Efforts for energy savings are embodied in the following ways. The cooling water recirculation system employed in the SUPRE-X1.5A has a heat-exchanging capacity of about 120,000 kcal/hr. This means, however, that an overabundance of heat dissipation capacity would be used when the generator is run at low power. To cope with this waste of energy, a cascade operation chilling system is adopted

such that the chiller unit is divided into seven subunits. The number of subunits running is controlled by the computer according to the load applied to the anode. In addition, when only the vacuum system is operating, another water recirculating pump of smaller capacity is used to avoid unnecessary power consumption.

The concept of energy saving is also incorporated into the operation of the rotating anode, itself. Previously, the anode was rotated at a constant high speed regardless of the applied load. In the present system, the initial setting of the rotating anode speed is determined by the limits of the applicable load. The variable rotation speed for the anode on this manner has led to a prolonged service life of such components as the magnetic fluid seal, the water seals, bearings, etc, in addition to energy conservation.

## 2. Features

### 1) Rotating Anode

The rotating anode used is 320 mm in diameter and runs at a maximum of 10,000 RPM. The target materials of the anodes manufactured at this time are Cu and Mo.

A mechanical seal is used for the cooling water seal. With the modifications to speed controls, these water seals can be used for several thousand hours with no need for replacement. (assessment of actual lifetimes is still ongoing.)

The magnetic fluid seal has a moderate vacuum level (approximately  $10^{-1}$  Pa) applied in the middle of the seal section aimed at averaging the pressure applied to the respective seal stages. This is designed to improve seal lifetime.

Using the fine focus optics, the position of the electron beam that hits the target surface is made to deviate from the center. Two power supplies are used for one single target so that simultaneous operation of both a normal focus and fine focus can be made with maximum load.

### 2) Cathode

Five different cathodes are available for multi-purpose utilization of the system. Each cathode is designed in a cassette form as with the RU300 and RU-200 X-ray generators to facilitate removal and

replacement. Designed for  $6^\circ$  takeoff angles, the tungsten filament and cathode assemblies are:

1 x 1 mm:	for 90 kW maximum power
0.1 x 10mm:	for 18 kW maximum power
0.3 x 0.3 mm	for 12 kW maximum power
0.1 X 0.1 mm:	for 4 kW maximum power

A single dimension, 0.1 x 10 mm for 18 kW operations, is also available in LaB<sub>6</sub>. This cathode is specifically designed for improved output in conjunction with EXAFS experiments.

### 3) Power

Two power supplies, 90 kW and 18 kW, are incorporated in the system. Each of the power supplies can be used independently and combined with different kinds of cathodes. Each power supply is of a high-frequency type and their maximum outputs are 60 kV-1500 mA and 60 kV-300 mA, respectively.

The use of the high-frequency power supplies has minimized the ripple effect (to less than 1% at maximum loads). As a result, approximately 20% greater intensities are attainable when compared to conventional X-ray generators using commercial power supplies.

## 3. Applications

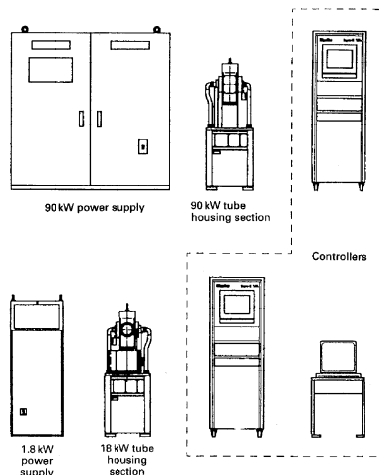
1) The SUPRE-XI.5A features a 60 kV1500 mA, 90 kW output. It is literally an amazingly high power X-ray generator of the world's top level.

A "high output X-ray source" is in strong demand in line with today's research trends toward diversification, sophistication, and specialization. Against such a backdrop of needs, the SUPRE-XI.5A displays high performance capabilities in quality control of silicon semiconductors, development of new materials, etc., as the system permits real-time observation of X-ray diffraction data on a television monitor.

2) The system will be indispensable, showing excellent promise for such research fields where measurements of extremely weak diffracted X-rays and scattered X-rays.

3) Real-time analysis of "dynamic behavior" of materials can now be studied in very short times.

## 4. System Configuration



## 5. Specifications

### 1) X-ray tube housing section (common to 90 kW and 18 kW use)

- X-ray rotation anode

Anode diameter:	320 mm
Anode rotation speed:	10,000 rpm (max.)
Vacuum seal:	Magnetic fluid seal
Anode driving:	Inverter control system

- Vacuum system

Oil rotary pump:	250 lit/min
Turbomolecular pump:	1000 lit/sec
Vacuum gauge:	Ionization gauge
Partial pressure system using a vacuum seal	

- Electron gun
  - 90 kW: 1 x 1 mm
  - 18 kW: 0.1 x 10 mm
  - 18 kW: 0.1 x 10 mm (LaB<sub>6</sub> cathode)
  - 12 kW: 0.3 x 0.3 mm
  - 4 kW: 0.1 X 0.1 mm (all at 6° take-off angle)

### 2) Power supply section

- 90 kW power supply

Input power supply:	3-phase 400 V AC. 120 kVA
Max. rating:	90 kW, 60 kV, 1500 mA
Tube voltage:	10 to 60 kV in steps of 1 kV

Tube current:	10 to 1,500 mA in steps of 1 mA
Stability:	Within ±0.05%/8 hrs (for both tube voltage and tube current)
Ripple percent:	Within 1% (at maximum load)

- 18 kW power supply

Input power supply:	3-phase 200 V AC, 24 kVA
Max. rating:	18 kW, 60 kV, 300 mA
Tube voltage:	10 to 60 kV in steps of 1 kV
Tube current:	10 to 300 mA in steps of 1 mA
Stability:	Within ±0.01%/8hrs (for both tube voltage and tube current)
Ripple percent:	Within 1% (at maximum load)

### 3) Heat exchanger

Feed water temp.:	10°C
Water temp. variation:	±2.5°C
Feed water flow rate:	280 lit/min
Heat load capacity:	115,000kcal/hr
Power consumption	3-phase 200 V AC, 124 kVA