ANHVPS-10: How to Specify an X-Ray HVPS That Holds the Beam Still

A customer guide to X-ray high voltage power supply selection: voltage, current, ripple, regulation, arc protection, operating mode, filament supply, and tube compatibility

Quick answer: To specify an X-ray HVPS, do not ask only for a kV number. Define the voltage range, current or power, ripple, regulation, stability, arc protection, operating mode, filament or mA control, interface, interlock, mechanical format, and tube/load compatibility. This application note helps potential ATI customers prepare that specification before requesting a quote.

Customer question	Practical specification answer	Information to give ATI
What should I specify before asking for an X-ray HVPS quote?	Specify voltage range, polarity, output current or power, ripple, regulation, stability, operating mode, duty cycle, interface, protection, enclosure, cable/tube arrangement, and floating filament supply needs.	Target kV/mA/W, X-ray tube model if known, load capacitance/cable length, line input, ambient range, analog/digital interface, safety interlock, and regulatory constraints.
Why is kV not enough?	The selected kV sets beam energy, but beam usefulness depends on how tightly the X-ray high voltage power supply holds that kV during exposure, warm-up, line/load change, pulsing, and arc events.	Required image, spectrum, dose, thickness, or inspection repeatability; acceptable ripple; acceptable drift; and whether the process is continuous, pulsed, or gated.
What makes an X-ray generator power supply different from a generic HV supply?	An X-ray generator power supply must handle tube behavior: arc protection, short-circuit protection, interlock logic, fault reporting, mA control, filament isolation, and tube/cable compatibility.	Tube current control method, filament voltage/current, grounding scheme, exposure sequence, arc-recovery expectation, connector/cable requirement, and service environment.

1. What an X-ray HVPS must do

An **X-ray HVPS**, or X-ray high voltage power supply, is the energy-control subsystem that lets an X-ray tube behave like an instrument rather than a spark-making science project. The programmed kV establishes the electron acceleration field between cathode and anode; that field affects photon spectrum, penetration, exposure behavior, and measurement repeatability. Radiopaedia defines kVp as the peak potential applied to the X-ray tube, and radiography teaching material from SUNY Upstate explains that changing tube voltage changes X-ray output and beam energy in practical imaging examples. [1] [2]

For a customer selecting an **X-ray generator power supply**, the better question is not simply “Can it reach 70 kV?” The better question is “Can it hold the X-ray beam steady while the tube warms up, load current changes, the input line moves, the system pulses, or the tube arcs?” A tooth, alloy sample, battery cell, weld, food package, or CT reconstruction never sees the front-panel promise; it sees the full beam history.

Key rule: First choose voltage, current, power, and polarity. Then specify the behaviors that protect image quality, spectrum repeatability, tube life, and system uptime: ripple, regulation, stability, arc recovery, interlock, interface, floating filament supply, and tube compatibility.

2. Why kV is not enough: camera megapixels versus a steady photograph

Selecting an X-ray power supply only by kV is like selecting a camera only by megapixels. The number is important, but it does not guarantee a sharp photograph. A high-resolution camera on a vibrating tripod still makes a blurred image; the tripod is the stability, ripple, regulation, and emission-control system that keeps the picture from smearing. Likewise, a nominally correct X-ray tube voltage can still produce unstable image density, drifting XRF intensity, inconsistent thickness readings, or reconstruction artifacts if the voltage ripple, drift, load regulation, line regulation, or emission control are poor.

The engineering analogy is a beam governor. Nominal kV aims the X-ray beam; the HVPS regulation loop holds it inside a narrow energy corridor. Gusts that push the beam out of that corridor include AC ripple, input-line variation, tube-current changes, warm-up drift, ambient temperature, pulsed load behavior, cable capacitance, and arc events. Good X-ray HVPS selection means specifying the corridor, not only the destination.

Specification trap: “70 kV” names the destination. Ripple, regulation, drift, load behavior, line behavior, polarity, and arc recovery define whether the beam stays on the road long enough to make a useful image or spectrum.

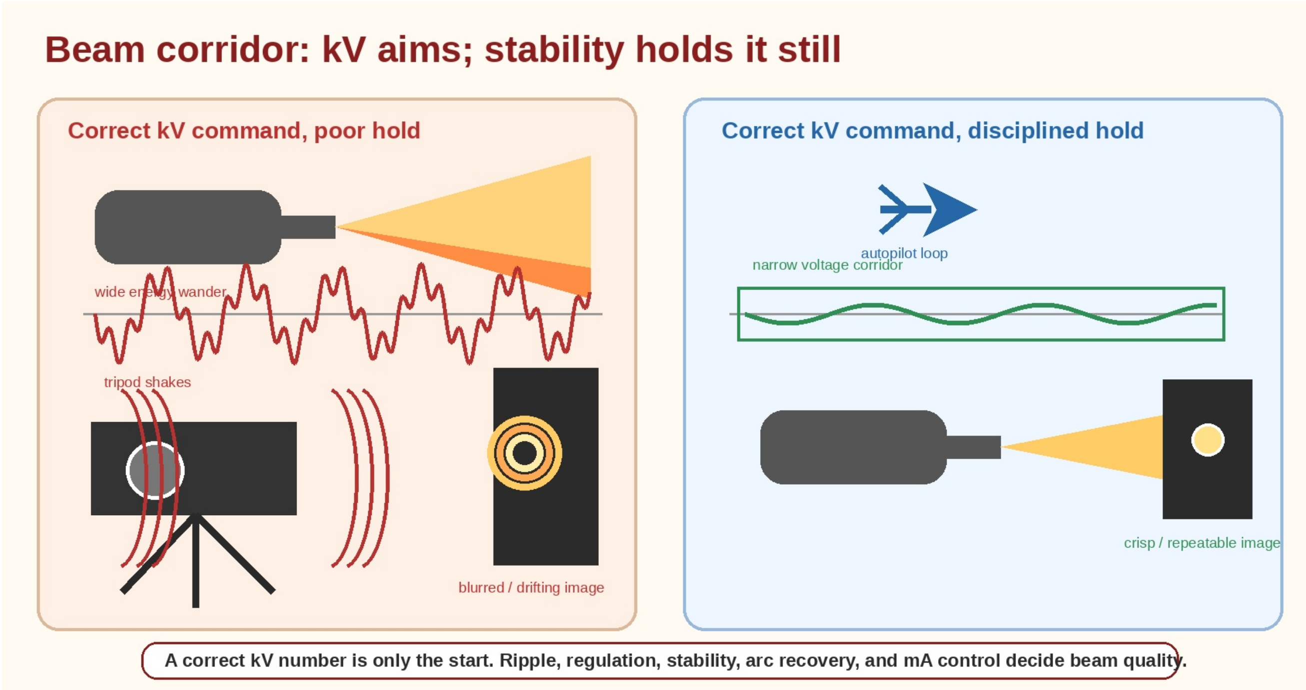

Figure 1. A correct kV command is only the starting point. The X-ray high voltage power supply must keep the beam inside a narrow corridor during the exposure, scan, spectrum acquisition, or production measurement.

3. Specification vocabulary: separate five different errors

“High stability” is useful only after it is converted into measurable terms. A supply can have low voltage ripple and still drift during warm-up. It can have good warm-up behavior and still move with ambient temperature. It can look excellent at one bench load and then shift when X-ray tube current, input line, cable length, or grounding changes. One generic stability number is not a specification; it is a hiding place.

Specification term	What it means in an X-ray power supply	How customers should specify it
Voltage ripple	Fast AC variation riding on the DC output. It can lower effective/mean beam energy during part of the cycle; in imaging it behaves like vibration, and in XRF it can modulate line intensity.	State peak-to-peak or RMS value, measurement bandwidth, operating voltage/current, divider/probe method, line condition, and cable/load configuration.
Warm-up drift	Slow output movement after high voltage is enabled as references, dividers, thermal mass, emission control, oil or encapsulation, and control electronics settle.	State initial condition, warm-up time, ambient temperature, load current, and final acceptance window such as ppm/hr or percent/hr.
Temperature coefficient	Output movement per degree C as the HV divider, reference, enclosure, and insulation system respond to ambient and self-heating.	State ppm/degC or percent/degC, temperature range, thermal soak method, load, and whether the number is typical or maximum.
Load regulation	Output change caused by X-ray tube current changes. This is where a supply that looks good at no load may fail in the real tube.	State current range, step size, allowed voltage deviation, recovery time, cable/tube arrangement, and continuous or pulsed operating mode.
Line regulation	Output change caused by AC or DC input variation. It matters when an OEM system shares input power with motors, heaters, computers, or other noisy loads.	State input range, line-frequency or DC-bus condition, allowed output change, and whether performance is guaranteed during exposure or only after settling.

Ripple is not only a cosmetic wiggle on a voltage trace. It can lower effective or mean beam energy during part of the cycle, which helps explain why ripple changes XRF line intensity, dose, image contrast, and exposure repeatability even when the nominal kVp command looks correct. [3] [4]

Design rule: Never accept the phrase “high stability” by itself. Ask which error is being limited, under which load, over which temperature, across which bandwidth, and after which warm-up time.

When comparing X-ray HVPS datasheets, customers should look for the conditions behind the numbers. Useful specifications state whether ripple is peak-to-peak or RMS, what bandwidth was used, what divider or probe measured the output, what voltage and current were present, what temperature range was tested, and whether the value is typical or maximum. Without conditions, a beautiful number may not survive contact with the tube.

4. Application examples: the same error creates different customer pain

Public product examples show that X-ray HVPS products occupy several specialized lanes. Advanced Energy lists compact XRG70 modules from 25 to 70 kV at 70 W; Matsusada lists X-ray power supplies from 30 to 160 kV with small modules and rack systems up to 4 kW; Spellman's XRV industrial X-ray generator family spans 160 to 450 kV at 1.8 to 6 kW. [5] [6] [7] The table below translates those practical voltage ranges into customer consequences.

Application	Typical X-ray HVPS range and polarity note	Where it is used	Why the specification matters
XRF analyzer / compact source	25–70 kV, ~0.1–2 mA, 5–100 W class; confirm tube polarity	Benchtop XRF analyzers, coating thickness gauges, RoHS screening, material sorting, compact analytical instruments.	Voltage ripple and drift change line intensity and calibration transfer. The customer sees false chemistry drift, re-standardization, and weak repeatability.
Dental X-ray / small imaging	60–100 kV, ~1–10 mA, 100 W–1 kW class; confirm tube polarity	Intraoral dental, panoramic/cephalometric subsystems, small-animal imaging, education and laboratory imaging. IAEA notes intraoral dental equipment commonly uses 60–70 kV and 3.5–8 mA. [8]	Regulation, exposure repeatability, and filament/mA control affect image tone, contrast, dose consistency, and retakes.
Industrial X-ray inspection	80–160 kV, ~1–67 mA, 0.6–4 kW class; confirm positive/negative/bipolar need	Electronics, batteries, packages, welds, castings, tires, plastics, food/package inspection, and process monitoring.	Load regulation, arc recovery, and uptime determine whether a defect is real or the source moved. Poor control causes false rejects, missed defects, and production-line recalibration.
NDT / CT / high-power generator	160–450 kV, mA range, 1.8–6 kW class; confirm polarity and grounding	Large castings, aerospace NDT, security scanning, industrial CT, dense assemblies, and research imaging.	Stability, pulsed behavior, dose consistency, and generator recovery affect voxel consistency, penetration margin, reconstruction artifacts, and acceptance tests.

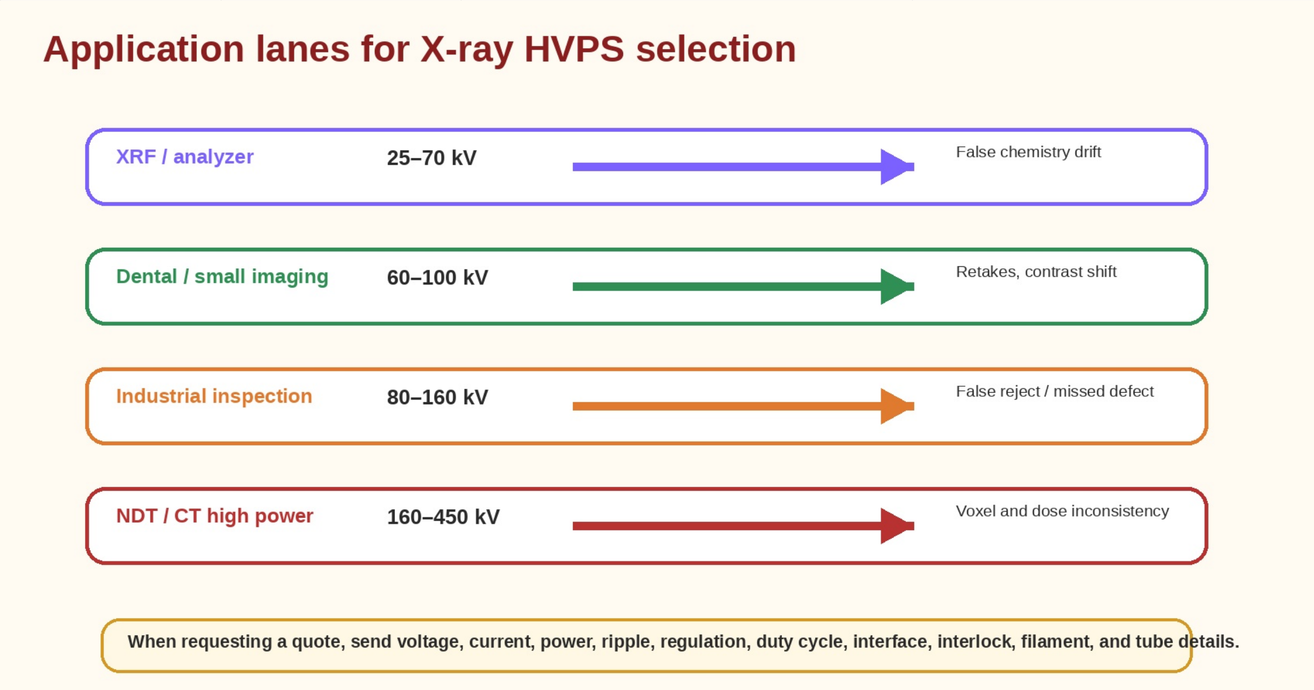

Figure 2. Common customer request lanes for X-ray HVPS selection. Dental X-ray, XRF analyzer, industrial X-ray inspection, NDT, and CT systems punish instability in different ways, so the specification should name the real consequence and the required polarity.

5. Arc protection and arc recovery: ask what happens after the spark

Real X-ray tubes can arc. A supply that reaches voltage on a calm bench but cannot detect, limit, recover, and report arc events is not a mature X-ray generator power supply. Arc protection affects tube lifetime, image uptime, operator confidence, warranty exposure, and OEM service cost.

The right analogy is a fire drill. The first job is fast detection. The second job is energy limiting, so one spark does not become a destructive event. The third job is controlled arc recovery: no excessive overshoot, no repeated hunting, no silent fault, and no mystery behavior that leaves the system integrator guessing. In a serious X-ray HVPS specification, arc recovery belongs beside ripple, regulation, and stability.

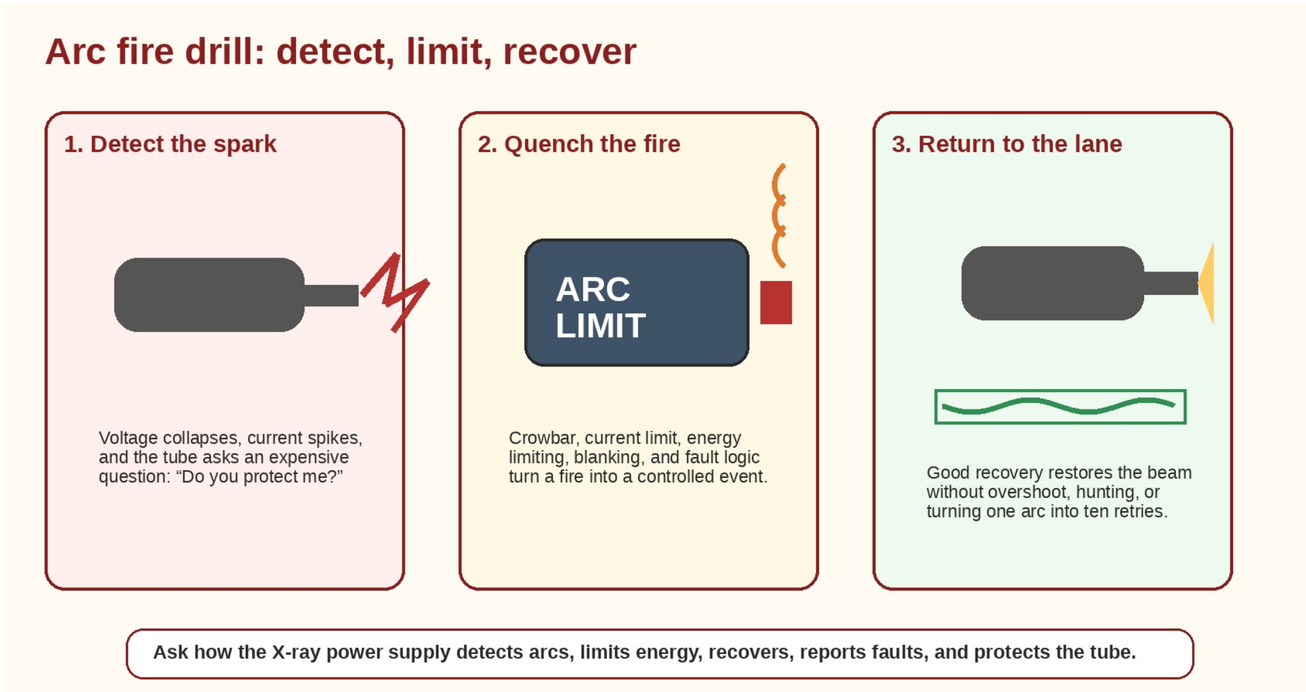

Figure 3. Arc handling protects the tube, image, uptime, and warranty. A professional X-ray power supply detects the spark, limits energy, reports the event, and returns to the voltage lane in a controlled way.

6. Operating mode: continuous, pulsed, capacitor charging, and filament control

Before choosing an OEM X-ray power supply, identify the operating mode. Continuous imaging and process inspection behave like a lighthouse: the customer wants quiet, reliable light over time. Pulsed X-ray systems behave more like a camera flash: stored energy, pulse width, droop, jitter, recharge time, and repetition rate become central. A capacitor charging power supply is not just a DC supply with a capacitor nearby; it is an energy-delivery subsystem whose charge voltage, energy per pulse, recharge time, peak current, end-of-charge accuracy, and recovery behavior shape the exposure sequence.

The filament supply is equally important. High voltage accelerates electrons, but the filament/emission system controls how many electrons are available. For real X-ray tube use, customers should ask whether the design needs a floating filament supply, integrated filament control, tube mA feedback, emission stabilization, warm-up sequencing, and isolation compatible with the tube. In a grounded-anode tube, the cathode and filament assembly can float at full cathode potential, so the filament supply and related sense circuitry must be isolated for the full operating kV, not only for the few volts that heat the filament. Without this, the system may own a high-voltage module but still lack a controlled X-ray generator.

Warning: Do not treat a floating filament as a low-voltage accessory. In many X-ray tubes it rides on the high-voltage cathode node, so isolation rating, emission-loop behavior, warm-up sequence, and arc survival must be part of the HVPS specification.

Operating-mode detail	Specify before quote	Why customers care
Continuous DC	kV/mA range, duty cycle, ripple, drift, cooling, cable/load capacitance.	Keeps density, spectrum, and thickness readings from wandering during long exposures or production runs.
Pulsed or capacitor charging	Pulse width, repetition rate, droop, jitter, charge voltage, energy per pulse, recharge time, and peak current.	Prevents weak flashes, timing errors, dose variation, and reconstruction artifacts.
Floating filament/mA loop	Filament voltage/current, mA feedback, warm-up sequence, full-kV isolation rating, and arc survival.	Turns a high-voltage module into a controlled X-ray generator rather than a lonely kV source.

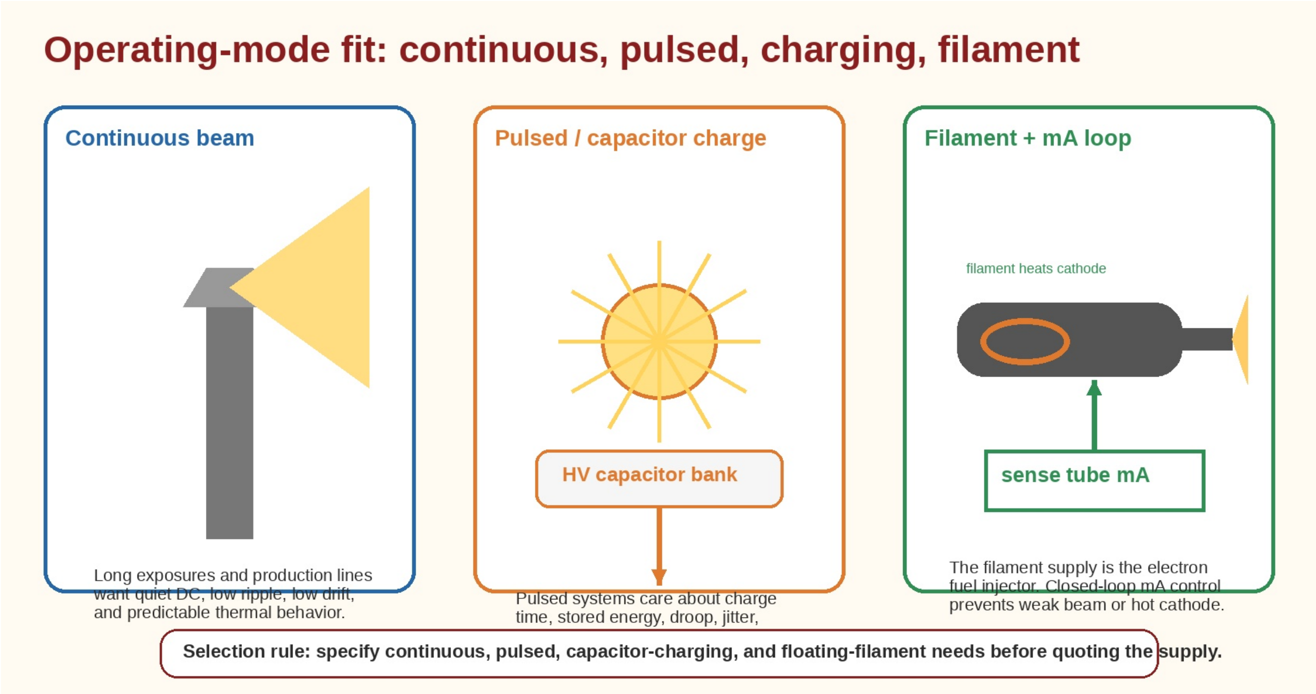

Figure 4. Choose the operating mode before choosing the box. Continuous DC, pulsed operation, capacitor charging, and floating-filament/mA control are different X-ray HVPS requirements.

7. What to send ATI when requesting a custom or OEM X-ray HVPS

A good request for quote helps ATI recommend the right configuration quickly. Instead of asking only for a “70 kV power supply,” describe the X-ray tube, voltage, current, power, application, duty cycle, ripple target, regulation target, interface, interlock, filament requirement, cable length, grounding scheme, enclosure, cooling, and expected environment. A complete specification prevents overbuying, underbuying, and late redesign.

When requesting a quote	Typical customer lane	Details that help ATI recommend the right X-ray HVPS configuration
30 kV, 1–2 mA class	XRF analyzer heads, compact X-ray sources, education/lab fixtures, small material-analysis instruments.	Required ripple, analog set/monitor signals, interlock logic, arc/short/overload protection, connector style, cable length, and measurement bandwidth.
50 kV, 1–2 mA class	XRF, coating gauges, small cabinet inspection, low-density materials, compact OEM instruments.	USB/RS-485/Ethernet or analog interface preference, repeatability requirement, mechanical envelope, cooling, grounding, and installation environment.
70 kV, ~1 mA class	Dental X-ray subsystems, small imaging heads, and compact analyzer-class products.	Exposure timing, mA regulation, floating filament supply requirement, safety interlock behavior, warm-up drift target, and tube compatibility.
100 kV, 0.5–1 mA class	Higher-penetration cabinet inspection, process monitoring, plastics, food/package inspection, and electronics assemblies.	Arc recovery, load regulation, cable guidance, duty cycle, fault reporting, enclosure/interface needs, and acceptance-test method.

Interface and protection details also matter. Many OEM systems need 0–5 V or 0–10 V analog set/monitor signals, RS-232/RS-485/USB/Ethernet digital interface options, enable/inhibit input, interlock chain, fault output, current monitor, voltage monitor, arc count, and clear recovery behavior. These are not cosmetic features; they determine how easily the X-ray HVPS becomes part of the customer’s instrument.

8. X-ray power supply selection checklist

Use the following checklist before comparing suppliers or sending an RFQ. The goal is not to make the specification longer for fun; the goal is to prevent the one missing line that later becomes image drift, unstable chemistry, a damaged tube, or a field-service visit.

Question to answer before selection	Good specification	Risk if ignored
What voltage, current, power, and polarity are actually required?	Nominal kV, adjustment range, positive/negative/bipolar polarity, mA or W, tube model, and load configuration are stated.	Overspecified cost, underspecified penetration, wrong-polarity tube mismatch, weak flux, or inadequate duty cycle.

Question to answer before selection	Good specification	Risk if ignored
How stable must the X-ray beam be?	Ripple, warm-up drift, tempco, load regulation, and line regulation are given as separate limits with measurement conditions.	A single vague “high stability” claim hides the error that will ruin the image, spectrum, or measurement.
How should arcs and faults be handled?	Arc detection, energy limiting, recovery time, retry behavior, short protection, overload, over-temperature, interlock, and fault output are specified.	Tube damage, downtime, nuisance trips, unsafe service conditions, or unexplained OEM field failures.
Is the operating mode continuous, pulsed, or capacitor-charging?	Duty cycle, pulse width, repetition rate, charge voltage, energy per pulse, droop, recharge time, peak current, and stored-energy limits are defined.	The selected supply may reach kV but fail the exposure sequence.
Does the X-ray tube need filament or mA control?	Floating filament supply, filament voltage/current, emission loop, mA monitor, full-kV isolation rating, and warm-up behavior are documented.	The HVPS becomes only a voltage source while the customer still lacks a controlled electron source.
How will the OEM system control and monitor the supply?	Analog interface, digital interface, Ethernet/USB/RS-232/RS-485 needs, monitors, inhibits, interlocks, and fault codes are listed.	Integration delays, missing diagnostics, and field service confusion.

9. Closing rule: specify the beam, not only the box

A high-voltage X-ray power supply is not selected correctly when the kV number looks right. It is selected correctly when the voltage, current, ripple, regulation, stability, protection, operating mode, filament supply, interface, and tube compatibility match the application. Dental X-ray, XRF analyzer, industrial X-ray inspection, NDT, CT, and OEM source designs all need the same discipline, but they emphasize different failure modes.

Final customer rule: Do not buy only a “kV box.” Specify the X-ray beam you need, the disturbances it must survive, the tube it must protect, and the signals your system must control and monitor. Then the image, spectrum, thickness reading, or reconstruction can be about the object under test—not about the power supply trying to improvise.

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