



302 Tenth Street  
Troy, NY 12180  
USA  
Phone: 518.272.3565  
Fax: 518.272.3585  
www.chart-ind.com

### Data Sheet 2s241K Cryocooler

The 2s241K is a low vibration, no maintenance, highly reliable, acoustic Stirling (pulse tube) cryocooler for applications requiring cooling loads up to 220 watts at 77k. Each unit is driven by two of Qdrive's renowned STAR linear reciprocating motors with clearance seal pistons, providing wear free operation with no lubrication required. These compact systems are ideal not only for laboratory use but also for military and aerospace applications.

Qdrive's design is completely absent of cold moving parts or seals, eliminating maintenance that is required of most other technologies. The dual opposed motor/piston design within the pressure wave generator (PWG) is naturally balanced, reducing vibration and noise. If vibration at the cooled point is of concern Qdrive's remote head system (FAR) separates the PWG from the coldhead via a flexible transfer line and isolates the coldhead from any moving parts. To improve power consumption and increase versatility, each cooler is designed to be adjusted "on-the-fly" to match varying cooling load requirements. These advantages are accompanied by competitive pricing in both small and large quantities, making them ideal not only for laboratory use but also for HTS, medical, liquefaction, military and aerospace applications.



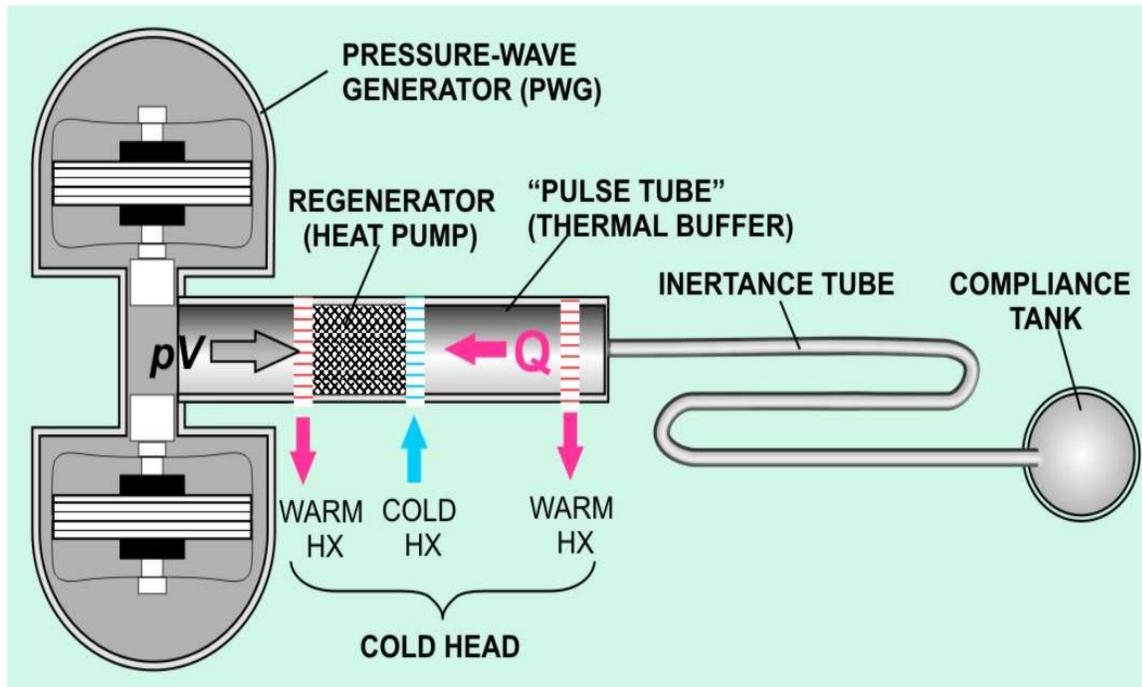
Figure 1: 2s241K Cryocooler with CL, DE, XW options



Figure 2: 2s241 Remote Coldhead

## Operating Principle

The base cryocooler unit consists of a pressure wave generator driven by patented STAR linear reciprocating motors and an acoustic Stirling (pulse-tube) coldhead. The acoustic Stirling coldhead consists of a warm heat exchanger, a regenerator, a cold heat exchanger, a thermal buffer tube, a hot heat exchanger, an inertance tube, and compliance tank. Figure 3 below is shown as an inline configuration for clarity, but the actual coldhead is “folded over” at the cold heat exchanger to create a salient cold zone.



**Figure 3: Thermoacoustic (pulse tube) Diagram**

- 1) Pressurized helium gas is cyclically compressed and expanded relative to the mean pressure (charge pressure) by the pistons of the PWG.
- 2) With each forward stroke of the pistons, the gas moves through the aftercooler, or warm heat exchanger, where heat is removed. The gas parcel continues through the regenerator, which precools it before reaching the cold heat exchanger.
- 3) As the gas moves toward the cold heat exchanger, gas in the acoustic network (thermal buffer tube, hot heat exchanger, reservoir) also moves in the same direction. Even as the driven gas stops advancing, when the pistons reach their upper limits, the network's gas continues moving, driven by its own inertia in the high-speed inertance tube. This acts like a virtual piston, moving away from the cold exchanger, which expands the gas in that area. As it expands, it gathers heat from the surroundings (the area or substance to be cooled).
- 4) The pistons begin withdrawing and helium then moves back through the regenerator and aftercooler. Still delayed by its inertia, the gas in the network follows and the cycle begins again.
- 5) The cryocooler motors and heat exchangers are cooled by local air, water, or an optional closed water loop that consists of a reservoir, a pump, and a liquid-to-air heat exchanger.

## Specifications

### General:

Model 2S241K cryocooler generates approximately 200-220 watts rated cooling output @ 77K from approximately 5000 watts electrical input, rejecting to 20 C water, as shown in Figure 4. Exterior surfaces are mainly constructed of anodized aluminum or stainless steel. The coldhead is mounted via a vacuum flange with dimensions as defined in Figure 5. Unit is powered by two STAR™ 1s241M motors, each capable of 2 kW (mechanical) output at 60 Hz, mounted nose-to-nose in a common vessel at mean pressure. Both motors use clearance seal pistons on our Commuter™ flexure suspension. Piston stroke is rated at 20mm, with a maximum rating of 24mm, and controlled by the input power electronics. Instrumentation, automatic temperature control, water-cooling, and drive electronics are optionally available.

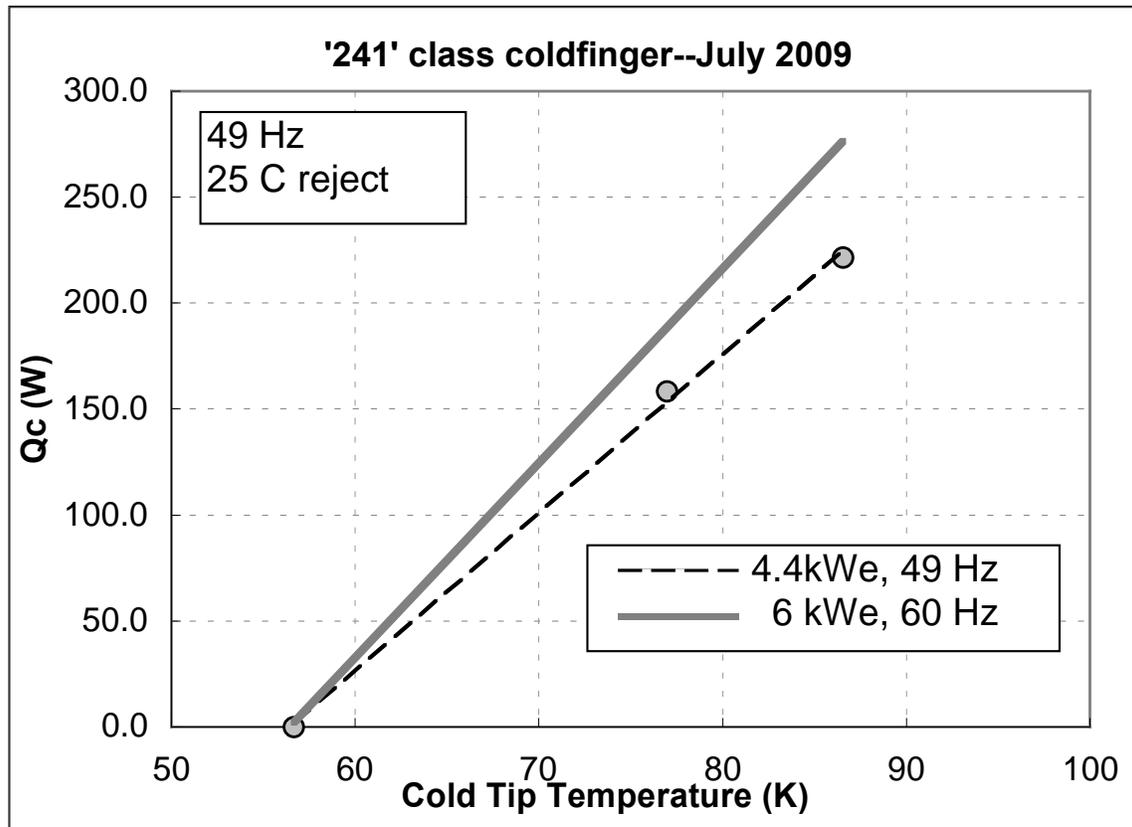


Figure 4: Approximate Cooling Load Curve with Rigid Transfer Line

Materials of construction: 300 series stainless and anodized aluminum in most non-electromagnetic parts. All vessel components are constructed in accordance with applicable ASME Vessel Code requirements, but are NOT stamped.

Mounting (basic cryocooler only without enclosure): Mounting pad 14" x 9.19" (35.56mm x 23.34mm). Lifting eye mounts on each side of housing. Refer to Figure 6 PWG drawing.

Connections (Internal Charge Gas): Connection dimensional details to be agreed upon. 1/4 inch Swagelok tube fitting is provided for evacuation, filling, or connection of working fluid (99.999 helium).

**NOTE: METRIC FITTINGS CAN BE SUPPLIED AT NO EXTRA COST IF REQUESTED**

Dimensions: Drive: 438mm wide (excluding power & instrument connections), 741mm long and 360mm high. Vacuum flange NW300 or equivalent. See Figure 5 and Figure 6 for complete dimensions.

Weight (PWG and Coldhead): approximately 150kg (system & ship weight to be determined). Additional options add mass.

Motor Rating (subject to change as required):

- 2000 x 2 kWe nominal at 60 Hz, 20 mm stroke
- Core Impedance @ 208VAC winding: 1.0 ohm DC, (10 @ 60 Hz)
- Stator Inductance @ 208VAC winding: 26mH
- Nominal BL product @ max voltage winding: 60-65 N/Ampere
- Rated Voltage/Current: 208 VAC 1ø rms @ 60 Hz / 14 Ampere rms (0.8 power factor)
- Intrinsic Stiffness: 130-135 kN/m (approximate)
- Damping, Rm: 24 N-s/m (approximate)

Motor Mechanical:

- SS720 multi-strap suspension
- M-19 laminated stator construction
- FeNdB magnets
- Stroke limit 24 mm (20 mm operation must be centered within 2 mm)
- Moving mass 4 kg (approximately)

Piston & Gas Management:

- Clearance seals, Rulon buffers
- Inertance balance tube for drift management
- Bolted vessel for 3.0 MPa maximum allowable working (mean) pressure operation

Thermal Management:

- Direct conductive motor cooling to external liquid cooling loop in parallel with coldhead aftercooler (coolant supply & pump optional with -CL option)
- 12 litre/minute required flow for full load. Less than 300 kPa pressure drop (internal)

Safety Management (power supplies, readouts and controls not included)

- Accelerometer to monitor PWG vibration
- Two (2) motor temperature sensors
- Two (2) Micro-Epsilon "VIP" piston position transducers (<0.5% linearity, -5C to 80C temperature range) with BNC connector shielded outputs (110VAC in required)

NOTE: MONITORING OF THE SAFETY MANAGEMENT DEVICES IS REQUIRED TO MAINTAIN WARRANTY

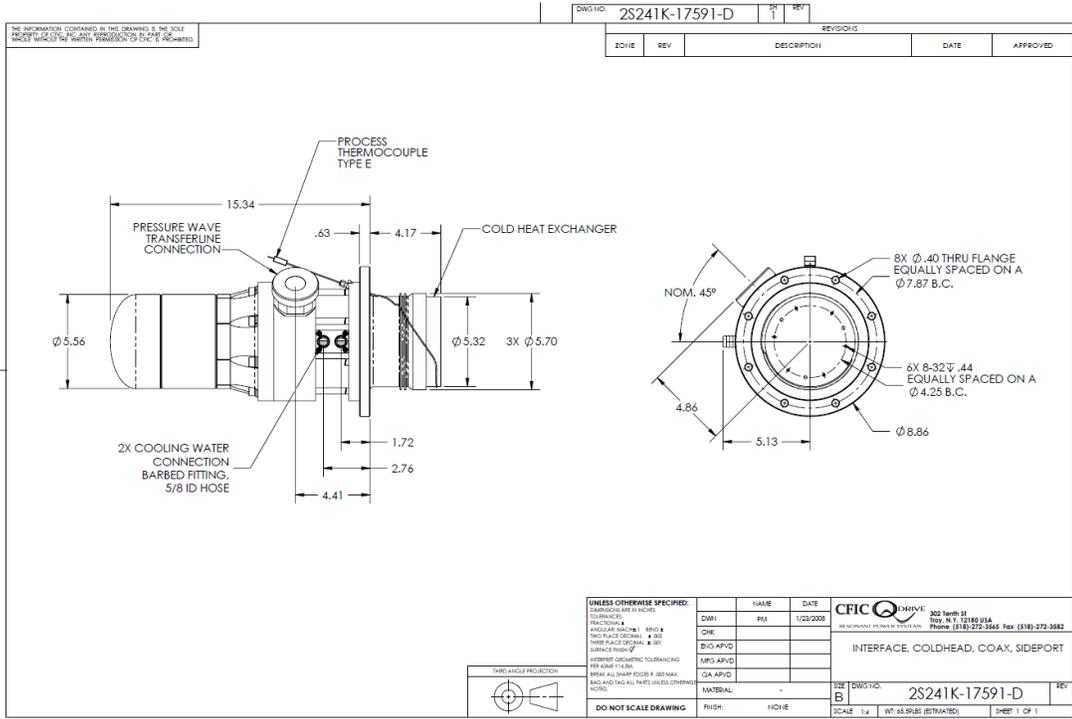


Figure 5: Remote Cold Head

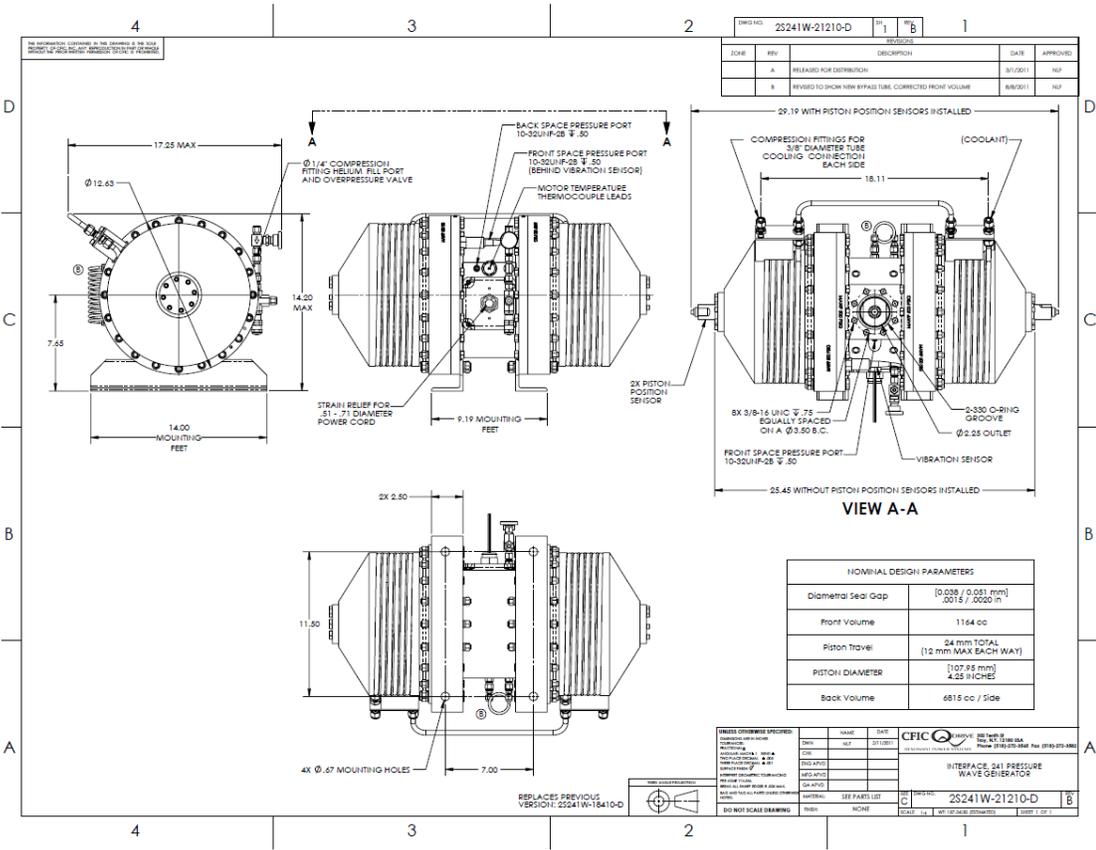


Figure 6: Pressure Wave Generator

## **OPTIONS:**

### **Optional Driver Electronics Package (-DE option):**

- IGBT-based switching vector-type inverter AC power supply (85-90% efficiency at full load)
- 200-240V 1-phase or 3-phase 50/60Hz input
- 42A continuous capacity
- 25-100 Hz frequency range
- Current Limit (voltage foldover)
- Thermal overload, short-circuit latching breaker
- Air cooled NEMA-1/IP-20 enclosure-panel controls for frequency and amplitude adjustment
- Face-mount digital metering for voltage, current, frequency

### **Optional Pressure Switch (-PS option)**

- ENDEVCO piezo dynamic pressure tap at connection port (<2% error, <1 deg shift, +/-5V out)
- Typically used only at the PWG level for research applications

### **Optional Liquefier/Subcooler Load (-LX option)**

- Single-pass, flow-through inert-fluid 2<sup>nd</sup> stream heat exchanger/condenser
- Inlet and outlet fittings to be determined by buyer. No storage dewar provided
- Vacuum insulated cold parts and process fluid connections

### **Optional Closed-Loop Cooling System (-CL option)**

- Integrated liquid-air interface, eliminates user water supply & hookups
- 1/10 hp, 15 gpm @ 1 foot head, epoxy-coated circulating pump (110VAC)
- 24" x 24" four row copper tube fin coil, with multiple 250 cfm fans & guard (110 VAC)
- Coolant fill port. Water supplied, antifreeze required for service below 0 C
- May reduce cooling power at ambient temperatures greater than 20C

### **Optional Enclosure (-XW custom option)**

- AVAILABLE ONLY TOGETHER WITH-DE OPTION (CL, IP can be fitted also)
- Anodized or powder-coated metal enclosure for splash water-resistance and shipping
- On wheels, but also suitable for forklift transport
- Approximate dimensions 24W x 36H x38L inch, including DE, CL options

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All specifications are the most accurate representation of product at time of offering, subject to change without notice. Purchaser is responsible to verify details of interface requirements.