Advanced Research Systems

OPERATION MANUAL

EXPANDERS

MODELS DE-202 AND DE-204

Revision	Date	Initials
Rev 2	10/28/09	RB
Rev 3	5/29/12	ER
Rev 4	11/15/12	ER

Conforms to UL STD 61010-1

Certified to CSA STD C22.2 No 61010-1

Table of Contents

General

ARS Inc. expanders are designed to operate safely with only original ARS Inc. parts and when the installation and servicing are performed in accordance with the instructions in this manual.

CAUTION !

Modification of the equipment without the approval of ARS Inc. will void the warranty.

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Contact ARS Inc. with any questions you have concerning the use or maintenance of this equipment:

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WARNINGS, Cautions, NOTES

Three types of special notices are presented throughout this manual:

WARNINGS CALL ATTENTION TO ACTIONS OR CONDITIONS WHICH CAN RESULT IN INJURY OR DEATH TO PERSONNEL.

CAUTION !

Cautions call attention to actions or conditions which can result in damage to the equipment or abnormal performance.

NOTE

NOTES GIVE IMPORTANT ADDITIONAL INFORMATION, EXPLANATIONS, OR RECOMMENDATIONS.

All warnings, cautions, and notes appear in the text where they are especially applicable. Because of their importance, they are summarized on the following pages:

WARNING

ALWAYS WEAR EYE PROTECTION WHEN HANDLING ANY PRESSURIZED EQUIPMENT.

WARNING

NEVER APPLY HEAT TO ANY PRESSURIZED EQUIPMENT.

WARNING

NEVER USE HELIUM GAS FROM A CYLINDER WITHOUT A PROPER PRESSURE REGULATOR AND PROPERLY RATED TUBING AND FITTINGS.

WARNING

WHEN BREAKING A VACUUM WITH GAS, DO NOT EXCEED ATMOSPHERIC PRESSURE.

WARNING

ALLOW THE EXPANDER TO WARM TO ROOM TEMPERATURE BEFORE DISCONNECTING THE GAS LINES. COLD GAS, IF TRAPPED IN THE EXPANDER, CAN REACH DANGEROUSLY HIGH PRESSURE IF ALLOWED TO WARM.

WARNING

USE 2 WRENCHES TO DISCONNECT GAS LINES FROM THE EXPANDER TO AVOID LOOSENING THE EXPANDER COUPLING.

WARNING

PERMIT ONLY QUALIFIED ELECTRICAL TECHNICIANS TO OPEN ELECTRICAL ENCLOSURES, OR TO PERFORM TESTS WITH THE POWER SUPPLY CONNECTED AND WIRING EXPOSED.

CAUTION !

Before connecting the gas lines to the compressor or expander, check that the face seal ring on the male coupling is in good condition, and that the faces of both mating couplings are clean.

CAUTION !

Never open the vacuum valve when connected to a vacuum pump that is off.

CAUTION !

Verify the electrical supply power frequency matches the frequency on the expander label. The expander is set at the factory for operation at either 50 Hz or 60 Hz.

CAUTION !

Do not get contaminants (particulates, moisture, oils or solvents, etc.) inside the expander.

CAUTION !

Modification of the equipment without the approval of ARS Inc. will void the warranty.

NOTE

KEEP THE DUST CAPS OR PLUGS ON UNUSED GAS COUPLINGS.

NOTE

THE EXPANDER MAY BE NOISY DURING COOLDOWN, BUT THE NOISE LEVEL WILL DECREASE TO A NORMAL MINIMUM AS IT REACHES THE COOLDOWN TEMPERATURE.

NOTE

IT IS PREFERRABLE TO BREAK VACUUM WITH DRY GAS TO MINIMIZE ACCUMULATION OF MOISTURE IN THE VACUUM SPACE. IF THE INSULATING VACUUM IS BROKEN WHEN THE EXPANDER IS COLD, THEN THE OUTSIDE OF THE VACUUM ENCLOSURE WILL FROST OR BECOME WET.

NOTE

USE 2 FILL/VENT FITTINGS, P/N 001075, WITH 1 EACH ATTACHED TO THE SUPPLY (RED) AND RETURN (GREEN) GAS COUPLINGS ON THE EXPANDER.

NOTE

WEAR CLEAN LINTLESS GLOVES. KEEP PARTS, WORK AREA, AND TOOLS CLEAN.

NOTE

DO NOT FIT AN O-RING INTO THE WELD RELIEF GROOVE IN THE WARM FLANGE. O-RINGS ARE TO BE PLACED WHERE SHOWN.

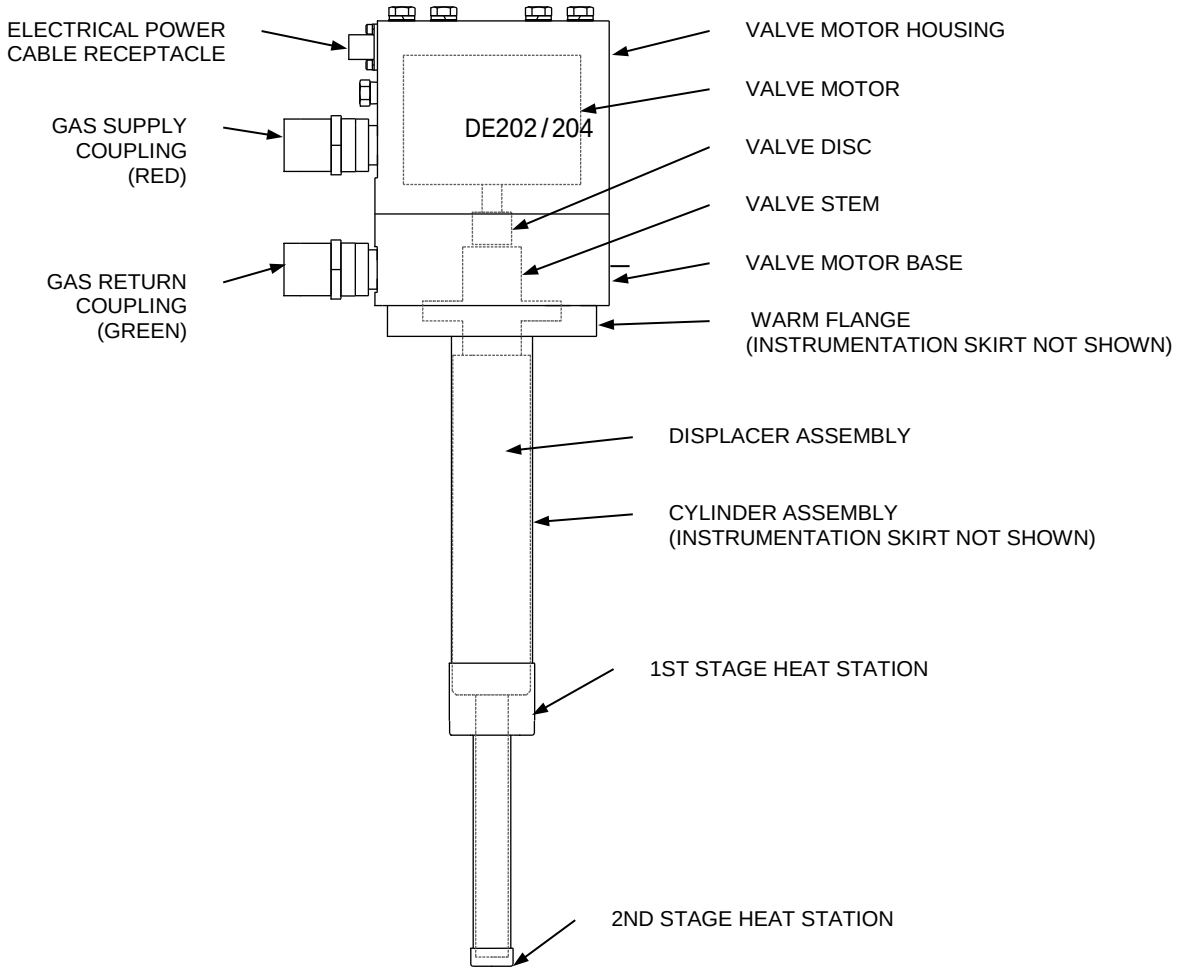
The expander is the part of the closed cycle cryogenic refrigerator that gets cold. It operates on the principle of the Gifford-McMahon refrigeration cycle. It is connected to a compressor by two gas lines and an electrical power cable. One of the gas lines supplies high pressure helium gas to the expander, the other gas line returns low pressure helium gas from the expander.

The compressor provides the necessary helium gas flow rate at the high and low pressure for the expander to convert into the desired refrigeration capacity. The electrical power from the compressor drives a motor which turns a valve disc inside the expander.

The high pressure helium gas flows into the valve motor housing. The rotary valve alternately opens and closes ports in a valve stem in a precisely timed repetitive cycle. First high pressure gas is admitted into the lower portion of the expander. Then the gas is vented to the low pressure return out of the valve motor base and back to the compressor. Inside the lower portion of the expander is a displacer assembly which reciprocates due to the cyclical changes in gas pressure.

The displacer assembly comprises a slack cap coupled to a 1st stage displacer, and the 1st stage displacer is coupled to a smaller diameter 2nd stage displacer. Each displacer stage contains internal regenerative heat exchangers to exchange heat with the gas to maximize the available refrigeration. Seals on the outside of the displacer assembly rub on the inside of a cylinder to minimize gas leakage between the high and low pressures.

The cylinder assembly provides a mounting flange (the warm flange), an instrumentation skirt (not shown), and two levels of refrigeration (the 1st stage and 2nd stage heat stations). The 2nd stage heat station gets coldest. Tapped holes on each heat station are provided for the customer to attach radiant heat shields and/or sample mounts.



Your expander may have a suffix or suffixes at the end of the model number, e.g. DE202/204NB. The following suffixes are defined:

A The 2nd stage can achieve < 9 K.

N The 2nd stage can achieve a minimum temperature < 6.5 K.

P The 2nd stage can achieve a minimum temperature < 5.5 K.

S The 2nd stage can achieve a minimum temperature < 4 K.

T TurboCooler. The 2nd stage has higher cooling power. Generally only provided with the "A" version of the cooler.

Note: All expanders are tested at ARS Inc. and verified to achieve the advertised minimum temperature at the expander 2nd stage heat station, not at the sample.

B The cylinder assembly only, with the displacer assembly and valve motor assembly removed, can be heated to 200 C (475 K) MAX., or to 400 C (675 K) MAX. without instrumentation attached. When assembled (cylinder, displacer and valve motor), the cylinder assembly can be safely heated to 80-100 C (355-375 K) MAX. The valve motor assembly is limited to a 40 C ambient. These expanders have high vacuum "Conflat" flanges on the skirt.

I An expander with o-ring seals on a welded stainless steel instrumentation skirt. The skirt has 3 user feedthrough ports and 1 vacuum pumpout port. These expanders can have the cylinder assembly safely heated to 80-100 C (355-375 K) MAX. The valve motor assembly is limited to a 40 C ambient.

E An expander with o-ring seals on a removable "bolt-on" aluminum instrumentation skirt. The skirt has 3 user feedthrough ports and 1 vacuum pumpout port. These expanders can have the cylinder assembly safely heated to 80-100 C (355-375 K) MAX. The valve motor assembly is limited to a 40 C ambient.

F The cylinder assembly has a flat warm flange, without an instrumentation skirt attached.

G, **K** Special configurations for applications requiring movement of the expander, mounting to the customer's goniometer.

1. Unpack the equipment and inspect it for shipping damage. Check the Tip n Tell for any dropping of the boxes during shipment. Report any shipping damage to the freight carrier and the insurance company.

2. The expander, compressor, and gas lines are shipped pressurized with helium gas at the equalization pressure of the compressor.

3. Attach the accessories to the expander (radiant heat shields, sample holders, vacuum shrouds, etc.) in accordance with your application. Consult Tech Notes available on website for optimal performance.

4. Secure the expander in position with a method suitable to your application. The expander will function in any orientation. Stands are available for mounting the cryostat securely on the optical table or on the floor.

5. Connect the gas lines to the compressor and expander:

⚠WARNING

ALWAYS WEAR EYE PROTECTION WHEN HANDLING ANY PRESSURIZED EQUIPMENT.

⚠WARNING

NEVER APPLY HEAT TO ANY PRESSURIZED EQUIPMENT.

CAUTION !

Before connecting the gas lines to the compressor or expander, check that the face seal ring on the male coupling is in good condition, and that the faces of both mating couplings are clean.

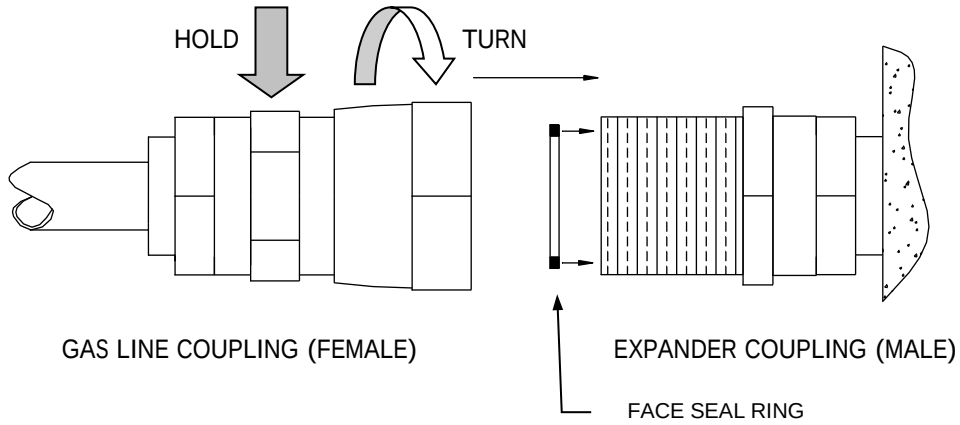
NOTE

KEEP THE DUST CAPS OR PLUGS ON UNUSED GAS COUPLINGS.

5.1. Connect one gas line to the supply gas couplings (high pressure, marked with red tape) at the compressor and expander.

5.2. Connect the other gas line to the return gas couplings (lower pressure, marked with green tape) at the compressor and expander.

5.3 Use two wrenches (provided with the expander) to hold and turn the gas line coupling (female) where shown. Turn until tight.



6. Attach your instrumentation wiring to any connectors provided on the expander skirt in accordance with your application.

7. Connect the expander electrical power cable to the compressor and expander receptacles.

7.1. Expander power source is supplied by the expander power cable. Rated power source is 1 amp, 250 V, 50/60 Hz. Protected by F2, 1 amp, 250 V 3 AG (¼" dia. X 1 ¼" lg.) quick acting little fuse #312001P.

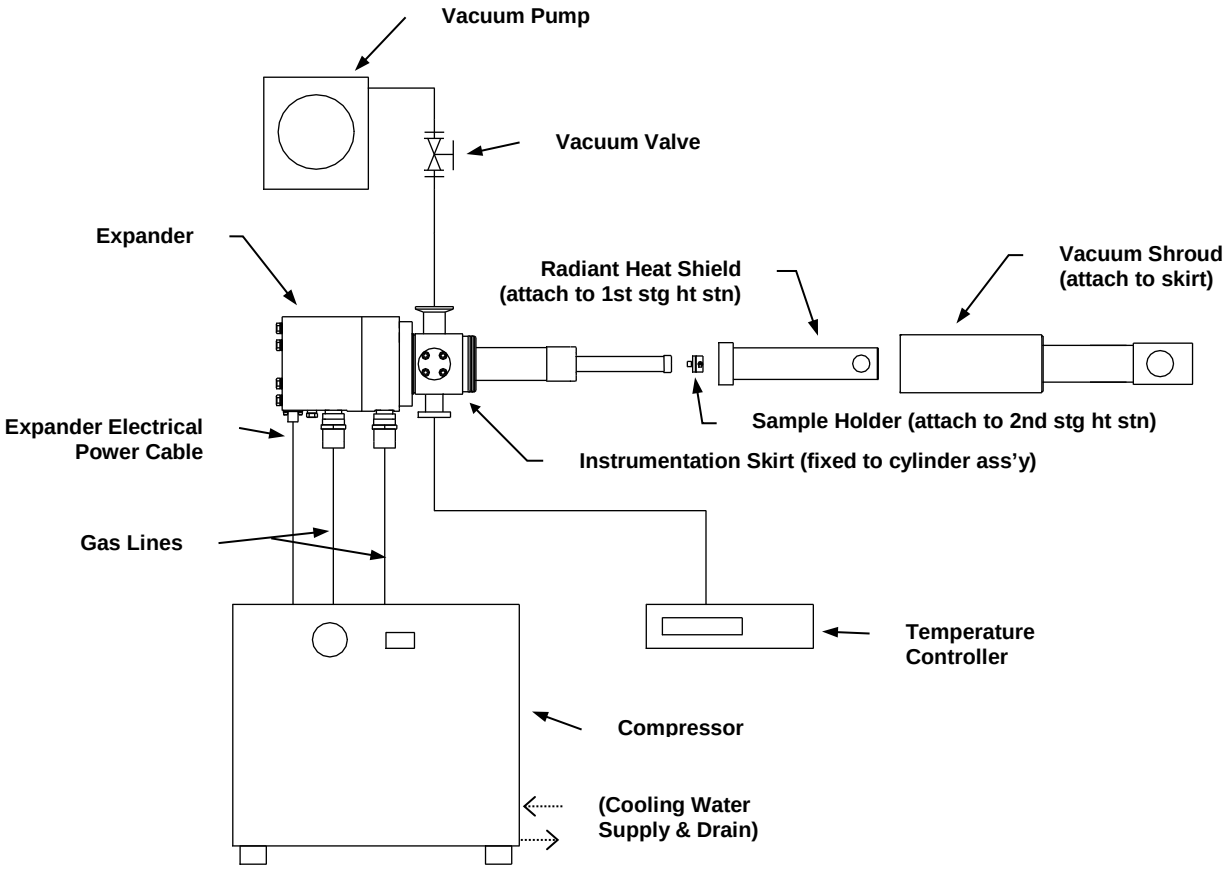
8. Connect the proper electrical power, and if applicable the cooling water supply and drain, to the compressor.

CAUTION !

Verify the electrical supply power frequency matches the frequency on the expander label. The expander is set at the factory for operation at either 50 Hz or 60 Hz.

9. Connect a source of clean vacuum (capable of achieving < 0.01 torr), isolated by a vacuum valve, to the pumpout port provided on the expander skirt.

DE202/204 Expander



Typical setup showing a simple shroud, radiation shield and sample holder

⚠WARNING

10 Make sure there is a pressure relief valve in place to relieve any pressure created in the vacuum shroud from condensed gasses when the system is being warmed up. The double o-ring on the shroud acts as a pressure relief valve only if the shroud is not restrained from decoupling from the expander.

1. Verify that the equalization pressure on the compressor pressure gauge meets the requirement listed on the compressor and/or in the compressor manual. If the pressure is below the minimum, then add helium gas in the manner described in the compressor manual (use only 99.999% ultra-pure helium, dew point < -50 C (-58 F) at 300 psig (2069 kPa)). If necessary, add gas to the expander per the Maintenance section of this manual.

2. Evacuate the expander vacuum shroud or enclosure to < 0.1 torr. Lower vacuum pressure, < 1 E-4 torr, is preferred because it reduces the residual heat load on the expander but requires cleaner vacuum pumps (two stage rotary pump for 1E-4 torr, or turbomolecular pump for higher vacuum, 1E-10 torr are recommended).

CAUTION !

Never open the vacuum valve when connected to a vacuum pump that is off.

   2.1. Close the vacuum valve.

   2.2. Turn on the vacuum pump.

   2.3. Slowly open the vacuum valve.

   2.4. The expander can be started with an insulating vacuum pressure of < 0.1 torr. However, a higher vacuum, 1E-4 torr is preferred for fast cooldown and clean samples.

3. Turn on the compressor, and turn on the cooling water to the compressor, if applicable. The expander will begin to cool down. The noise from the expander should be a regular beat at a frequency approximately 2X the frequency of the electrical supply power.

NOTE

THE EXPANDER MAY BE NOISY DURING COOLDOWN, BUT THE NOISE LEVEL WILL DECREASE TO A NORMAL MINIMUM AS IT REACHES THE COOLDOWN TEMPERATURE.

4. Close the vacuum valve when the vacuum pressure remains < 0.01 torr or the expander has cooled to 150 - 200 K.

5. The cooldown time and minimum temperature achieved will depend upon your application (sample material, size, mass, heat loads).

6. To stop operation, turn off the compressor and turn off the cooling water, if applicable.

1. Turn off the compressor and wait until the expander 2nd stage has warmed to > 273 K (0 C).

2. Break the insulating vacuum in the vacuum shroud or enclosure, and disconnect the vacuum plumbing from the expander.

NOTE

IT IS PREFERRABLE TO BREAK VACUUM WITH DRY GAS TO MINIMIZE ACCUMULATION OF MOISTURE IN THE VACUUM SPACE. IF THE INSULATING VACUUM IS BROKEN WHEN THE EXPANDER IS COLD, THE OUTSIDE OF THE VACUUM ENCLOSURE WILL FROST OR BECOME WET.

⚠WARNING

WHEN BREAKING A VACUUM WITH GAS, DO NOT EXCEED ATMOSPHERIC PRESSURE.

CAUTION !

Never open the vacuum valve when connected to a vacuum pump that is off.

3. Disconnect the electrical power cable.

4. Disconnect any instrumentation cables from the expander.

5. Disconnect the gas lines from the expander:

⚠WARNING

ALLOW THE EXPANDER TO WARM TO ROOM TEMPERATURE BEFORE DISCONNECTING THE GAS LINES. COLD GAS, IF TRAPPED IN THE EXPANDER, CAN REACH DANGEROUSLY HIGH PRESSURE IF ALLOWED TO WARM.

⚠WARNING

NEVER APPLY HEAT TO ANY PRESSURIZED EQUIPMENT.

⚠WARNING

USE 2 WRENCHES TO DISCONNECT GAS LINES FROM THE EXPANDER TO AVOID LOOSENING THE EXPANDER COUPLING.

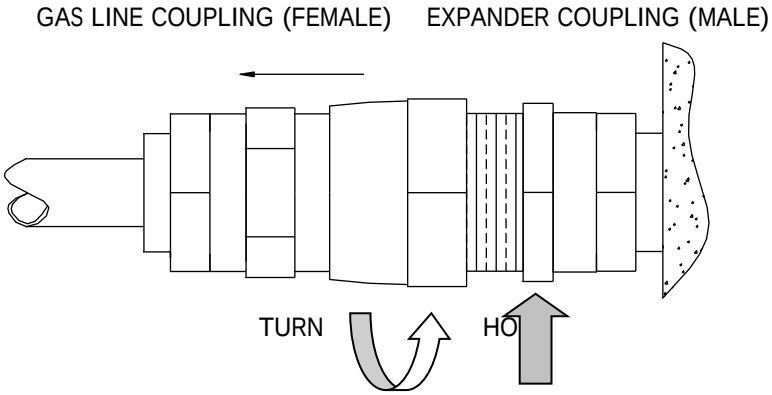
⚠WARNING

ALWAYS WEAR EYE PROTECTION WHEN HANDLING ANY PRESSURIZED EQUIPMENT.

NOTE

KEEP THE DUST CAPS OR PLUGS ON UNUSED GAS COUPLINGS.

5.1. Use 2 wrenches (provided with the expander) to hold and turn the gas couplings where shown:



6. Remove the expander from the application mounting.

The expander normally requires no maintenance until it has been operated for 10,000 hours. By that time the valve disc, valve stem, and displacer seals will have typically worn enough to need replacement. However, depending on the performance you need, this maintenance interval can be extended without damaging the expander.

Also check the compressor manual for any compressor service; some compressors require an adsorber change at 10,000 hours. Adsorbers (in the compressor) must be replaced at recommended interval to minimize the risk of contaminating the cold head.

Contact ARS Inc. for parts, tools, service, or any questions you have concerning the use or maintenance of this equipment. When ordering parts or tools, you must supply the model number and serial number (M/N and S/N) of the expander as marked on the nameplate affixed to the end face of the valve motor assembly. Contact:

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email: ars@arscryo.com

service email: arsservice@arscryo.com

web: www.arscryo.com

The expander is designed to operate safely with only original ARS Inc. parts and when the installation and servicing are performed in accordance with the instructions in this manual.

CHARGING THE EXPANDER WITH HELIUM GAS:

1 Fill the expander with helium gas (use only 99.999% ultra-pure helium, dew point < -50 C (-58 F) at 300 psig (2069 kPa)) to the equalization pressure defined on the compressor and/or in the compressor manual, and per the following:

⚠WARNING

NEVER USE HELIUM GAS FROM A CYLINDER WITHOUT A PROPER PRESSURE REGULATOR AND PROPERLY RATED TUBING AND FITTINGS.

⚠WARNING

ALWAYS WEAR EYE PROTECTION WHEN HANDLING ANY PRESSURIZED EQUIPMENT.

CAUTION !

Before connecting the gas fittings to the expander, check that the face seal ring on the male coupling is in good condition, and that the faces of both mating couplings are clean.

NOTE

KEEP THE DUST CAPS OR PLUGS ON UNUSED GAS COUPLINGS.

NOTE

USE 2 FILL/VENT FITTINGS, P/N 001075, WITH 1 EACH ATTACHED TO THE SUPPLY (RED) AND RETURN (GREEN) GAS COUPLINGS ON THE EXPANDER.

2 Connect fill/vent fittings from the service tool kit to the expander gas supply and return couplings (red and green). Refer to Installation step 4.3 on page 7 for instructions on connecting gas couplings.

3 Connect the expander electrical power cable to the compressor and expander receptacles.

4 Attach the regulated helium gas supply cylinder to the fill fitting attached to the gas supply (red) coupling on the expander using tubing and fittings rated for the gas supply pressure. Use only 99.999% ultra-pure helium with a dew point less than -50 C (-58 F) at 300 psig (2069 kPa).

5 Set the helium supply pressure at 100 psig (690 kPa).

6 Turn on the compressor to power the valve motor and valve disc.

7 Open the helium supply valves on the cylinder, regulator, and both the fill/vent fittings attached to the gas supply and return (red and green) couplings on the expander. Gas will begin to vent out of the return-side vent fitting in a pulsating manner because the valve is alternately admitting/venting gas.

8 Wait 5 seconds, then close the helium gas supply cylinder valve (not the regulator).

9 Watch the regulator pressure gauge. Wait until the pressure decreases to 5-10 psig (30-70 kPa). Then re-open the helium gas supply cylinder valve.

10 REPEAT STEPS 8 AND 9, 9X MORE.

11 Close the valve on the vent fitting on the gas return (green) coupling on the expander.

12 Increase the setting on the helium supply pressure regulator to the equalization pressure defined on the compressor and/or in the compressor manual. Wait 10 seconds.

13 Turn off the compressor.

14 Disconnect the helium gas supply and both fill/vent fittings from the expander. Refer to Removal step 5.1 for instructions on disconnecting gas couplings.

WARNING

USE 2 WRENCHES TO DISCONNECT GAS LINES FROM THE EXPANDER TO AVOID LOOSENING THE EXPANDER COUPLING.

WARNING

ALWAYS WEAR EYE PROTECTION WHEN HANDLING ANY PRESSURIZED EQUIPMENT.

NOTE

KEEP THE DUST CAPS OR PLUGS ON UNUSED GAS COUPLINGS.

19. Re-install and operate the expander. Refer to Installation and Operation sections.
20. Valve motor and its housing are identical for DE202 and DE204; The structure and operation of the expanders for DE202 and DE204 are exactly the same, only differences are the size and the cooling capacity.

The following troubleshooting guide lists the most common problems that can occur. Also check the compressor manual.

⚠WARNING

PERMIT ONLY QUALIFIED ELECTRICAL TECHNICIANS TO OPEN ELECTRICAL ENCLOSURES, OR TO PERFORM TESTS WITH THE POWER SUPPLY CONNECTED AND WIRING EXPOSED.

Problem	Possible Cause(s)	Corrective Action(s)
1. No cooldown - Valve motor does not start when compressor starts	1.1 Expander electrical power cable not connected 1.2 Open circuit in cable 1.3 Defective valve motor 1.4 Blown fuse or tripped circuit breaker in compressor	1.1 Connect the cable; See Installation section of this manual 1.2 Disconnect cable; Check continuity of each wire, and each plug and receptacle pin; Repair/replace cable as necessary 1.3 Check motor for shorts to ground; Check motor for winding resistance (A-B ≈ 2 kΩ, A-C & B-C ≈ 1 kΩ); See wiring schematic at end of this table 1.4 Remove fuse F2, located on compressor's front panel, using a small blade screw-driver (1/4 turn counter-clockwise). Replace with 1 A, 250 V, 3AG (¼" dia X ¼" lg) quick action little fuse 312001P. Reverse procedure to reinstall.
2. No cooldown - Valve motor hums but does not start	2.1 Defective capacitor or resistor 2.2 Defective valve motor 2.3 Open circuit in cable	2.1 Check/replace valve motor capacitor and/or resistor in compressor; See wiring schematic at end of this table 2.2 See 1.3 2.3 See 1.2
3. No cooldown - Valve motor runs	3.1 No or poor insulating vacuum 3.2 Gas line couplings are not fully connected, or are connected wrong 3.3 Compressor gas flow rate inadequate	3.1 Check vacuum system operation and pressure (must be < 1 E-3 torr); Check for vacuum leaks; See Installation and Operation sections of this manual 3.2 Check that gas lines are properly connected between compressor and expander,

		supply-supply and return-return; Check that couplings are fully engaged at both ends; See Installation section of this manual 3.3 Check compressor operating pressures; See compressor manual

Troubleshooting guide continued -

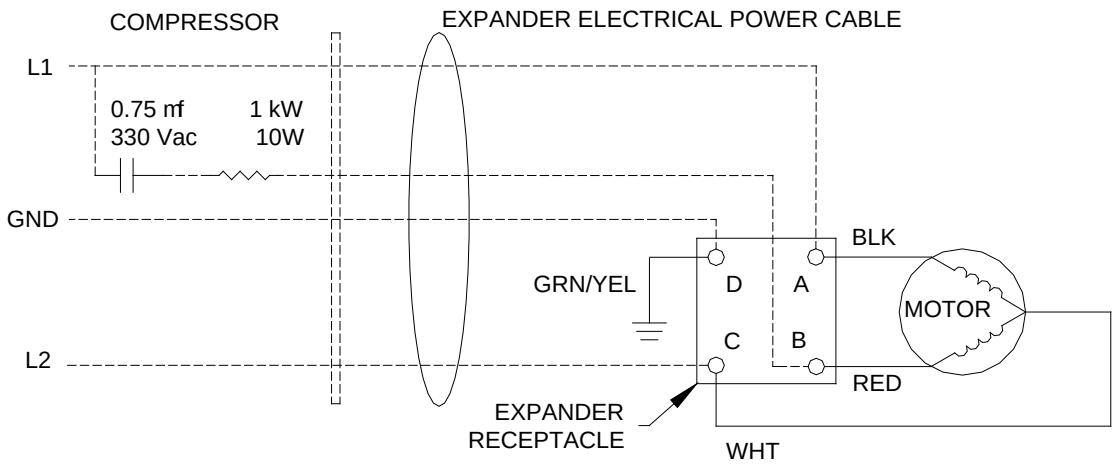
Problem	Possible Cause(s)	Corrective Action(s)
4. Vacuum shroud or enclosure very cold or "sweating"	4. No or poor insulating vacuum	See 3.1
5. Abnormally noisy operation after 15 minutes of cooldown	5.1 Incorrect compressor pressures 5.2 Contaminants in gas 5.3 Electrical power supply frequency incorrect for expander	5.1 See 3.3 5.2 Vent and re-fill gas in entire system (compressor, gas lines, expander); See Maintenance step 18 in this manual; See compressor manual 5.3 Check expander label for required frequency; Check power supply frequency
6. Intermittent on/off operation	6.1 Compressor cycling on/off 6.2 Compressor cooling water not on 6.3 Compressor oil too cold due to cooling water or ambient temperature	6.1 See compressor manual 6.2 Turn on cooling water; See Installation section of this manual 6.3 Decrease water flow rate or increase water temperature; Place compressor in room warmer than 60 F
7. Expander 2nd stage heat station temperature cycling several degrees (> ± 3 K)	7. Contaminants in gas	7. See 5.2
8. Sudden loss of refrigeration capacity	8.1 Loss of insulating vacuum 8.2 Compressor malfunction 8.3 Defective valve motor 8.4 Defective capacitor or resistor	8.1 See 3.1 8.2 See 6.1 8.3 See 1.3 8.4 See 2.1
9. Slow loss of refrigeration	9.1 Small insulating vacuum leak 9.2 Worn displacer seals 9.3 Small expander helium leak	9.1 See 3.1 9.2 See Maintenance section of this manual; A leaking seal will show intermittent streaks of

		black on the displacer near the seal 9.3 Check compressor pressure gauge for loss of pressure; Leak check expander at locations noted in diagram at end of this table using a mass spectrometer helium leak detector probe, or a commercial leak detection solution (dilute soap solution)

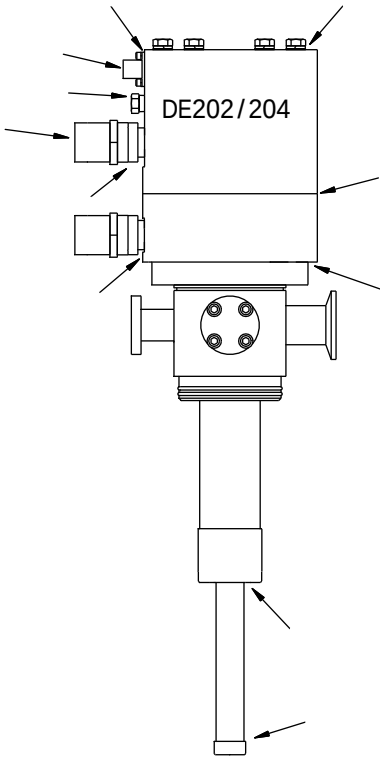
Troubleshooting guide continued -

Problem	Possible Cause(s)	Corrective Action(s)
10. Sample temperature too high Note: All cryostats are tested at ARS Inc. and verified to achieve the advertised minimum temperature at the expander 2nd stage heat station, not at the sample.	10.1 Thermometry problems: Sensor wires not thermally anchored; Sensor not thermally anchored; Sensor wires shorted; Thermocouples not electrically isolated; Heater introducing some heat 10.2 Small insulating vacuum leak 10.3 High radiant heat load on sample 10.4 High conductive heat load on sample 10.5 Sample not thermally anchored	10.1 Securely anchor sensor wires to cold tip; Securely anchor sensor; Check wire insulation; Check for thermal grease shorting exposed sensor or wire contacts; Electrically isolate multiple thermocouple junctions that are attached to the same metal; Reduce applied heater power or unplug heater 10.2 See 3.1 10.3 Close radiant heat shield openings with aluminum foil; Reduce or shield laser or glowing heat sources; 10.4 Minimize heat paths to sample (e.g. minimize quantity and diameter of wires, maximize their length). 10.5 Securely anchor sample to mount and mount to expander 2nd stage heat station; Use indium foil or wire between metal-metal contacts; Choose higher conductivity windows (e.g. sapphire); Use thermal “Cry-Con” grease or silver-filled epoxy between sample and window contacts, but minimize thickness of grease or epoxy layer

VALVE MOTOR WIRING SCHEMATIC
(MOTOR SHAFT ROTATES CLOCK-WISE WHEN FACING SHAFT)



Expander Leak Check Locations -



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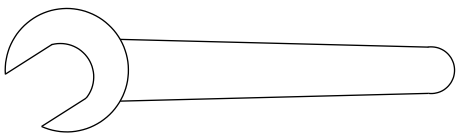
EXPANDER INSTALLATION TOOL KIT (provided with new expander) –

QTY	ARS P/ N	DESCRIPTION
1		1" THIN HEAD SERVICE WRENCH
1		$1\frac{1}{8}$" THIN HEAD SERVICE WRENCH
1		$1\frac{3}{16}$" THIN HEAD SERVICE WRENCH

Typical Service Wrench



FILL/VENT FITTING, ARS P/N 001075 –