Germanium Detector

User's Manual

9231358A 10/98

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The information in this manual describes the product as accurately as possible, but is subject to change without notice.

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CANBERRA

DP ØØØ25 (4" Snout)

DETECTOR SPECIFICATIONS AND PERFORMANCE DATA

Specifications

DETECTOR MODEL GUL0110P **SERIAL NUMBER** 07034956

CRYOSTAT MODEL 7935-2F/S **PREAMPLIFIER MODEL** 2008S

The purchase specifications, and therefore the warranted performance, of this detector are as follows:
(Electric cooling may degrade performance by as much as 10%.)

Energy	5.9 keV	122 keV	1332 keV
Resolution [eV (FWHM)]	150	550	

Cryostat description (if special) Flange type MAC having a 1" Ø X 4" long endcap

Physical Characteristics

Active diameter 11.3 mm
Active area 100 mm^2
Thickness 10 mm
Distance from window 5 mm
Cryostat window thickness 0.025 mm
Cryostat window material Beryllium

Electrical Characteristics

Depletion voltage (-)300 V dc
Recommended bias voltage (-)500 V dc
Reset rate at recommended bias 0.3 sec (Reset preamp only)
Preamplifier test point voltage at recommended bias ----- V dc (RC preamp only)

Resolution and Efficiency

With amp time constant of 12 Microseconds

*** See attached supplemental data sheet for performance details**

Isotope	^{55}Fe	^{57}Co	^{57}Co	^{60}Co	Peak to Bkgd.
Energy (keV)	5.9	6.4*	122	1332	
FWHM (eV)	123		494		
FWTM (eV)	230		912		

*Substitutes for ^{55}Fe in some cases where ^{55}Fe peaks are not well separated.

Cool Down Time 4 Hours Cryostat Liquid Nitrogen Consumption Rate <1.2 Liters per Day

Tested by: Peter Elmer Date: 07/31/03

Approved by: Stephen Bishop Date: 07/31/03

Supplemental Data Sheet

Argonne National Labs
Order ACK# 82404A

Detector Model: GUL0110S
Cryostat Model: 7935-2F/S
Preamplifier Model: 2008S (HRR)
Serial Number: 07034956

Detector Specifications:

Amplifier Shaping Time (uSec)	Energy Resolution at 5.9 keV 1k CPS Rate (eV FWHM)	100k CPS Rate (eV FWHM)
12	150	---
6	160	---
3	170	---
0.25	275	325
0.125	300	350

Measured Test Results:

Amplifier Shaping Time (uSec)	Energy Resolution at 5.9 keV 1k CPS Rate (eV FWHM)	100k CPS Rate (eV FWHM)
12	123	---
6	128	---
3	142	---
0.25	267	268
0.125	294	297

Revised 1/20/99

INSTRUCTIONS

HIGH RATE RESET PREAMP
(For Single-element Detectors)

General Description

The High Rate Reset Preamplifier makes use of a low capacitance FET having a built-in transistor switch to discharge it. Compared to resistive feedback and conventional Transistor Reset Preamplifiers it has better transient response (no light-induced spurious effects).

Circuit Description

Refer to the block diagram. The preamplifier comprises a charge sensitive input stage (A1) followed by an inverting voltage amplifier (A2). A comparator (A3) drives the reset transistor when the output of the first stage reaches an upper limit of approximately 2.5 volts. The comparator is biased so that the output returns to about 2.5 volts before it resets. Amplifier A2 inverts and amplifies this signal so that the signal output is a negative going signal on a negative ramp which ranges from about +5 to -5 volts.

Comparator A4 monitors a temperature sensor in the associated cryostat and provides a H.V. Inhibit signal in case of detector warm-up. Monostable M1 provides an Inhibit Pulse to gate off the associated ADC during the amplifier overload recovery period. A rear panel control adjusts the width of this pulse.

Physical

The preamplifier circuit is built using surface-mount technology. The P.C. board is mounted in an aluminum case with a 7 pin miniature tube socket at the front which engages the cryostat electrical feedthrough. An eighth connection is located in the center of this socket. The rear panel contains the BNC connectors for Signal Output, Test Input, H.V. Inhibit and Reset Inhibit. In addition there is an SHV connector for detector bias voltage and a 9-pin D connector for preamplifier power.

Controls and Adjustments

The only external control is a rear panel potentiometer (RV9) for Reset Inhibit pulse width. This control sets the inhibit pulse width appropriately to gate off the ADC during the amplifier overload recovery period following reset.

The internal controls are optimized at the factory for the detector with which it is used. Should it be replaced or swapped with another preamplifier, the following controls may require re-adjustment: Refer to the preamplifier layout.

RV1 Drain Current

Affects ramp range and noise slope (noise vs. input capacitance) and controls FET temperature which also affects noise.

RV2 Risetime

Adjust this potentiometer to prevent oscillation of the first stage should it be unstable.

RV4 Output Offset

Can be used to adjust the offset voltage of the output stage amplifier. This is usually of no concern as the output is differentiated by the main shaping amplifier.

RV5 FET Substrate

Biases the FET for proper operation and minimum noise.

RV6 H.V. Inhibit

Trims the H.V. Inhibit circuit to match the temperature sensor.

RV8 Restore Drive

Controls current to reset transistor thus affecting reset time and ramp range.

RVH FET Heater (optional)

Supplies power to a FET heater for independent control of FET temperature.

Set-up and Tuning

Tuning of systems involving several detectors requires time for FET temperatures to stabilize so this can be an iterative process. Tuning of a single preamplifier or one preamplifier out of several in a system is somewhat more straightforward. The following is a simple procedure which brings the preamplifier to an optimum tune. Use a short amplifier time constant for set-up. This will make it easier to see a change in noise level which should be measured at the amplifier output. Ramp range, ramp rate and reset time are measured at the preamplifier output.

A. Set RVH to the factory setting given on the test data sheet. Measure heater voltage at pin 4 on the cryostat connector.

B. Turn RV1 fully counterclockwise.

C. Set RV2 and RV8 at mid-range.

D. Apply bias to detector.

E. Adjust RV5 to establish the minimum ramp rate.

F. Adjust RV2 if preamp output oscillates.

G. Adjust RV5 counterclockwise until the ramp rate begins to increase. Measure the substrate voltage at SK6-3. Turn RV5 clockwise to reduce the substrate voltage by .75V.

H. Iteratively adjust RV1 and RV8 to achieve the following conditions:

Ramp Range ≈ 5 - 10 volts

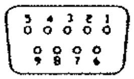
Reset Time - minimum

Noise – minimum

I. Repeat step G.

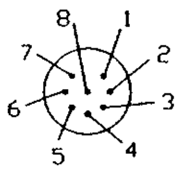
J. H.V. Inhibit Trim

With detector cold adjust RV6 until H.V. Inhibit shuts down the H.V. Supply. (This is factory set for Canberra H.V. Power Supply compatibility.) Then turn RV-6 about 2 ½ turns clockwise beyond the position at which the H.V. Supply is enabled.



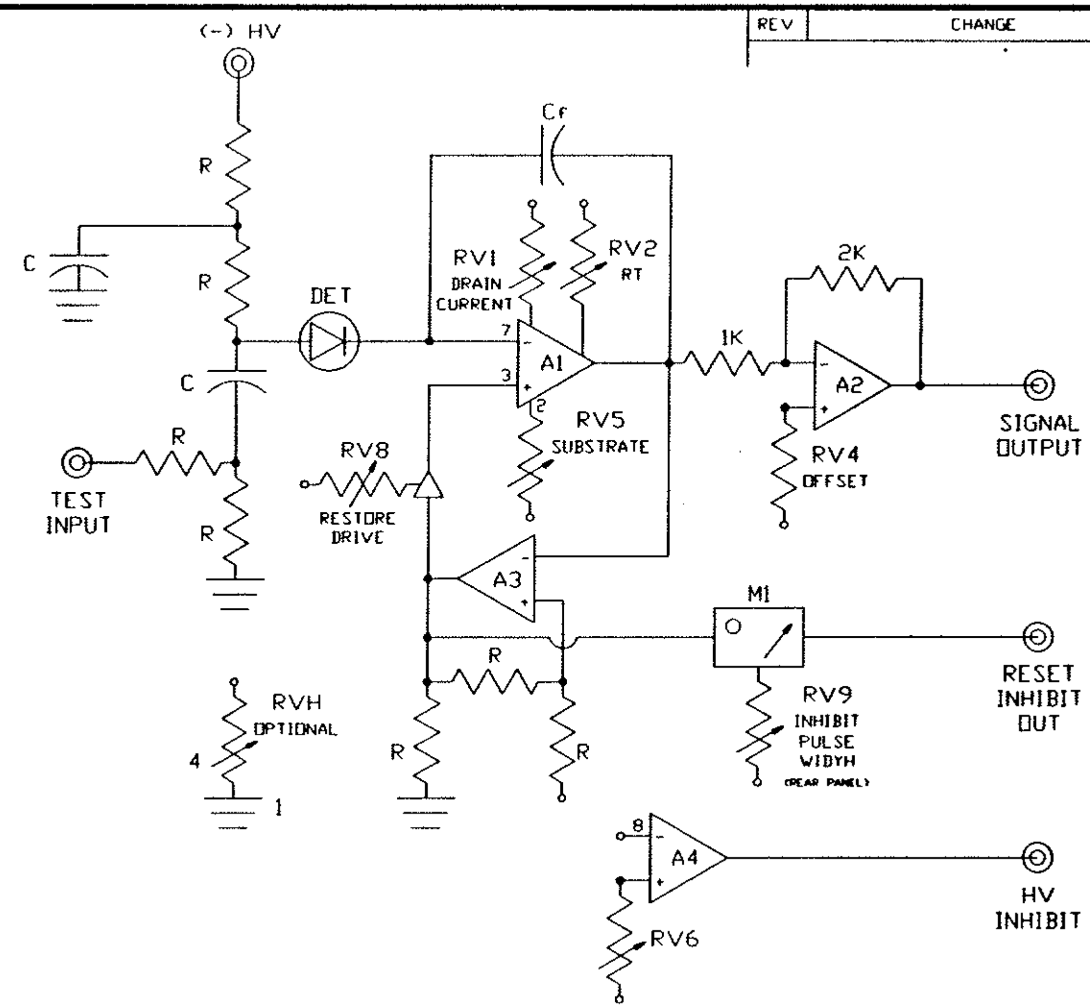
WIRING SIDE

D-9 WIRING		
PIN NO.	WIRE COLOR	DESCRIPTION
1	BLACK	GROUND
2	------	------
3	------	------
4	RED	+12V
5	------	------
6	WHITE	-24V
7	BLUE	+24V
8	------	------
9	GREEN	-12V



8-PIN FEEDTHRU

WIRING SPECIFICATIONS AS VIEWED FROM OUTSIDE CRYOSTAT	
PIN NO.	DESCRIPTION
1	HEATER GND
2	SUBSTRATE
3	INJECTOR
4	HEATER
5	DRAIN
6	SOURCE
7	FEEDBACK
8	TEMP SENSOR



REV	CHANGE	ECN	BY	DATE	APPD

UNLESS OTHERWISE SPECIFIED

TOLERANCES: DECIMAL ONE PLACE ---- TWO PLACE ---- THREE PLACE ---- ANGULAR ---- HOLES .250 & UNDER +.003 -.001 OVER .250 +.005 -.001 FLATNESS .001 PER LINEAR INCH

REMOVE BURRS, BREAK SHARP EDGES & CORNERS

MATERIAL ----------

FINISH ----------

HRR USED ON

DRAWN HG DATE 1/20/99

CHK'D

APPD MECH

APPD ELEC

NEXT ASSY B202285

2008/s PREAMP

SCALE ~ DO NOT TEMPLATE DRAWING

CANBERRA
MERIDEN, CONNECTICUT

DRAWING NO. B202284 REV.

SHT 1 OF 1

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IMPORTANT SAFETY CONSIDERATIONS

READ CAREFULLY

There are three potential hazards in the use and handling of Ge detectors that must be recognized and properly dealt with to avoid the risk of personal injury.

High Voltage

Ge detectors may operate at bias voltages of 5000 V dc or more. Always be sure that detectors are properly grounded (through the SHV coaxial cable ground to a properly grounded Power Supply/NIM Bin). Also use extreme caution when adjusting internal preamplifier controls to avoid contact with the high voltage circuit.

Liquid Nitrogen

LN_2 can cause frostbite if not handled properly. Avoid skin contact with LN_2 or with surfaces cooled by LN_2. Read manual Section 6.1 for more detailed instruction on LN_2 hazards.

Vacuum Failure - Overpressurization

When a cryostat exhibits signs of catastrophic vacuum failure, such as heavy moisture or ice formation on the surfaces, extremely high LN_2 loss rate, and so forth, the adsorber (molecular sieves or charcoal), which normally maintains vacuum, may be virtually saturated.

When allowed to warm up, the adsorber will outgas and the pressure in the cryostat will rise. Canberra cryostats and Dewars sold by Canberra have a pressure relieving seal-off valve which is designed to prevent dangerous levels of pressurization.

The pressure rise, however, can be high enough to break or break loose beryllium windows and/or end-caps. A frozen or ice clogged seal-off valve may fail to relieve pressure, resulting in dangerous levels of pressurization.

Precautions

For these reasons use extreme caution in handling cryostats with symptoms of catastrophic vacuum failure. When you do have to handle them, take the following precautions:

1. Stop using the failed unit immediately. Do not allow it to warm up until additional steps are taken to prevent damage or injury due to overpressurization.

2. Drape a heavy towel or blanket over the end-cap and point the end-cap away from personnel and equipment. If the unit is in a shield, close the shield door.

3. Call the factory for further instructions if the incident occurs during working hours.

4. If it is impractical to keep the unit cold until advice is available from the factory, keep the end-cap covered with a heavy towel or blanket and place the unit in a restricted area in a container (corrugated cardboard, for example). If the unit is in a shield, let it warm up in the shield with the door closed.

5. After the unit has warmed up, cautiously check for overpressurization (outwardly bulging end-caps or windows). If there are no signs of pressure, the unit may be shipped to the factory for repair. Consult the factory for shipping information.

1. INTRODUCTION

Germanium detectors are semiconductor diodes having a P-I-N structure in which the Intrinsic (I) region is sensitive to ionizing radiation, particularly X rays and gamma rays. Under reverse bias, an electric field extends across the intrinsic or depleted region. When photons interact with the material within the depleted volume of a detector, charge carriers (holes and electrons) are produced and are swept by the electric field to the P and N electrodes. This charge, which is in proportion to the energy deposited in the detector by the incoming photon, is converted into a voltage pulse by an integral charge-sensitive preamplifier.

Because germanium has a relatively low band gap, these detectors must be cooled in order to reduce the thermal generation of charge carriers (thus reverse leakage current) to an acceptable level. Otherwise, leakage current induced noise destroys the energy resolution of the detector. Liquid nitrogen, which has a temperature of 77 °K, is the common cooling medium for such detectors. The detector is mounted in a vacuum chamber which is attached to or inserted into a LN_2 Dewar. The sensitive detector surfaces are thus protected from moisture and other contaminants.

1.1. TYPES OF Ge DETECTORS

Canberra makes a wide variety of detector types which are described in this instruction manual. Figure 1.1 illustrates the various detector geometries that are available from Canberra, and the energy range they cover. Figure 1.2 depicts their significant performance characteristics. Consult Section 2 for detailed descriptions and performance ranges of each type.

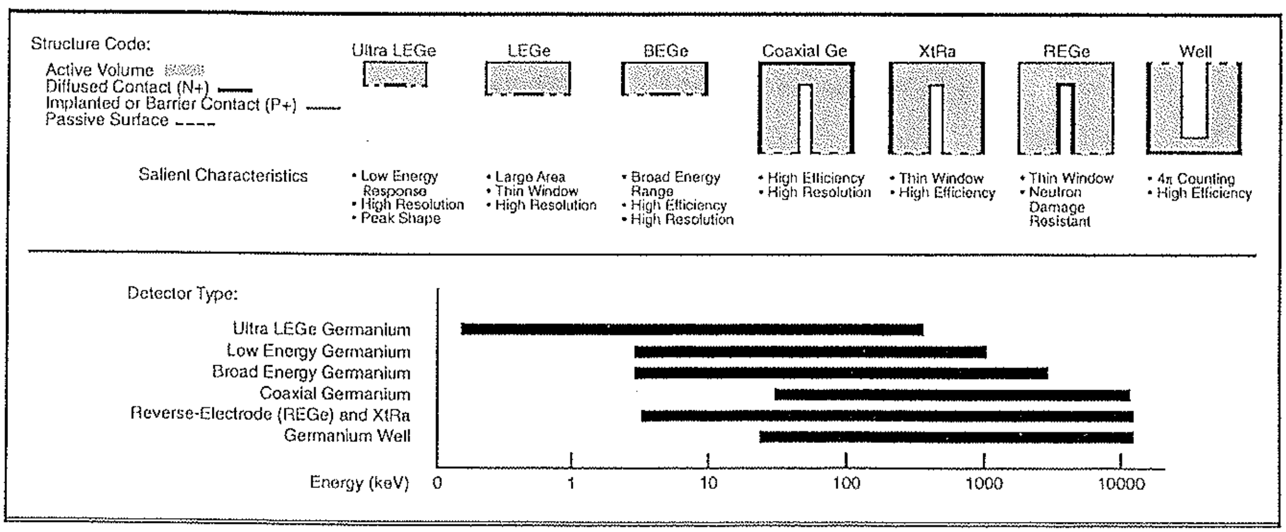
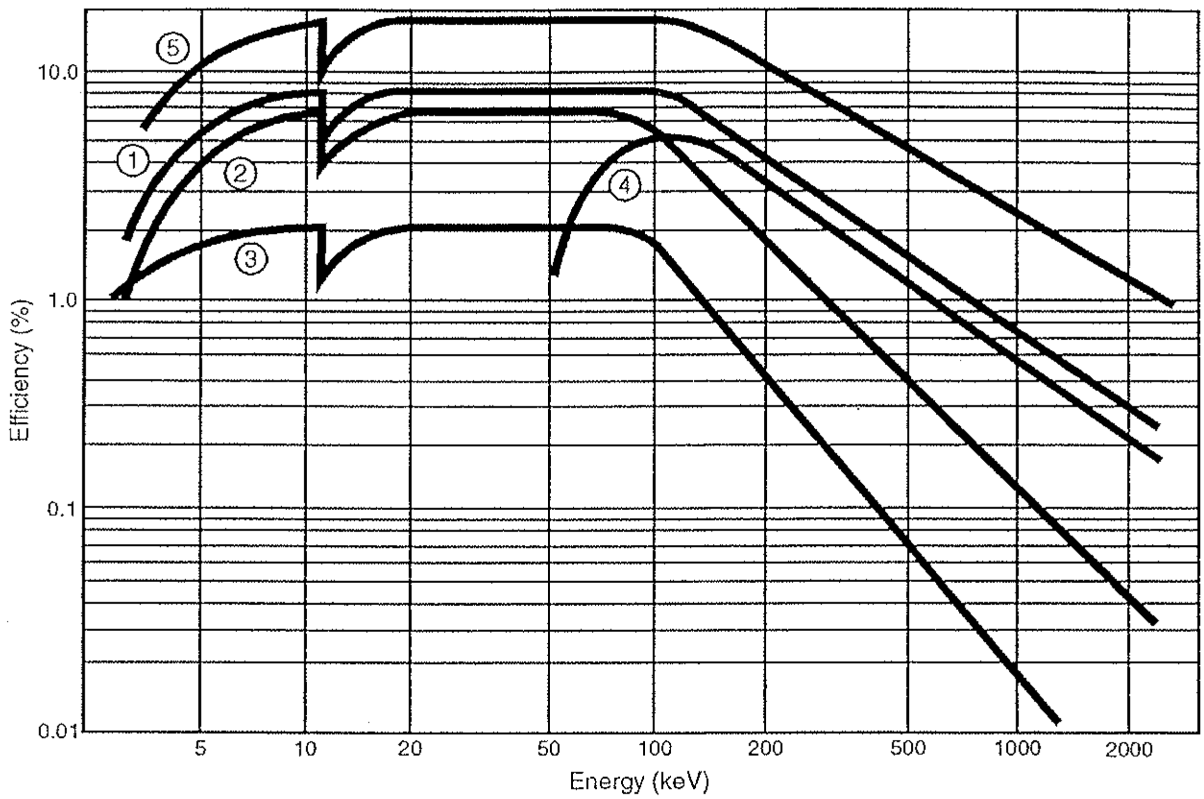


Figure 1.1 Detector Geometries



Typical absolute efficiency curves for various Ge detectors
with 2.5 cm source to end-cap spacing

Code:
(1) REGe, 15% Relative Efficiency
XtRa, 15% Relative Efficiency
(2) LEGe, 10 cm^2 x 15 mm thick
(3) LEGe, 200 mm^2 x 10 mm thick
(4) Coaxial Ge, 10% Relative Efficiency
(5) BEGe, 5000 mm^2 x 30 mm thick

Figure 1.2 Typical Absolute Efficiency Curves
The notch in the efficiency curves at 11.1 keV is caused by excitation of the Ge K-shell by incoming photons and subsequent escape of a significant percentage of the K-shell X rays.

1.2. CRYOSTAT

A cryostat consists of a vacuum chamber which houses the detector element plus a Dewar (double wall vacuum-insulated vessel) for the liquid nitrogen cryogen. In some cases, the detector chamber and Dewar are permanently connected. These are called "integral" cryostats. "Dipstick" cryostats have a detector vacuum chamber with a dipstick-like cold finger which is inserted into the neck of the Dewar.

The detector element is held in place by a holder, which is electrically isolated from but thermally connected to a copper cold finger. The cold finger transfers heat from the detector assembly to the liquid nitrogen reservoir. The detector holder is held in place by an anti-microphonic stabilizer. The detector holder as well as the outer vacuum jacket or "end-cap" are thin to avoid attenuation of low energy photons. The holder is generally made of aluminum and is typically 1 mm thick. The end-cap, is also generally made of aluminum. It is typically 1.5 mm thick. The detector element face is located typically 5 mm from the end-cap so caution should be used to avoid pushing the end-cap in against the detector assembly. Two popular types of cryostats are illustrated in Figure 1.3.

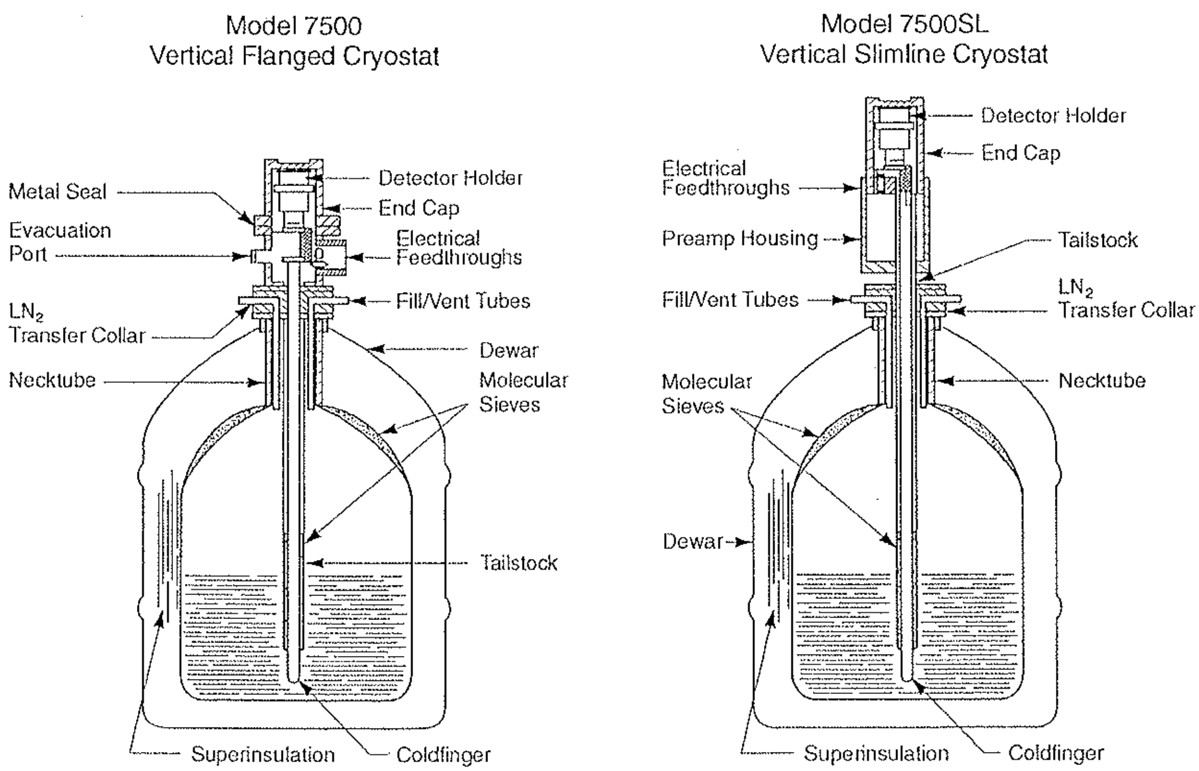


Figure 1.3 Two Types of Cryostat

1.3. PREAMPLIFIER DESCRIPTION

There are two basic types of preamplifiers in use on Ge detectors. These are charge sensitive preamplifiers that employ either dynamic charge restoration (RC feedback) or reset charge-restoration methods to discharge the integrator. The reset may be done with pulsed light from an LED (Pulsed Optical) or with a transistor switch (Transistor Reset).

1.3.1 RC Feedback Preamplifiers

The block diagram in Figure 1.4 describes the conventional RC feedback preamplifier. Charge from the detector is collected on the input node, unbalancing the first stage amplifier which has a capacitor as the feedback element (with a resistor in parallel). The amplifier balance is restored when the output changes by the amount necessary to inject the opposite charge on node A through the feedback capacitor. The transfer function is thus:

$$V_o = \frac{Q_{in}}{C_f}$$

The high value resistor (R_f) discharges the feedback capacitor (C_f) with time constant R_fC_f. The energy rate limit of the preamplifier is inversely proportional to feedback resistor value as is shown in Figure 1.5.

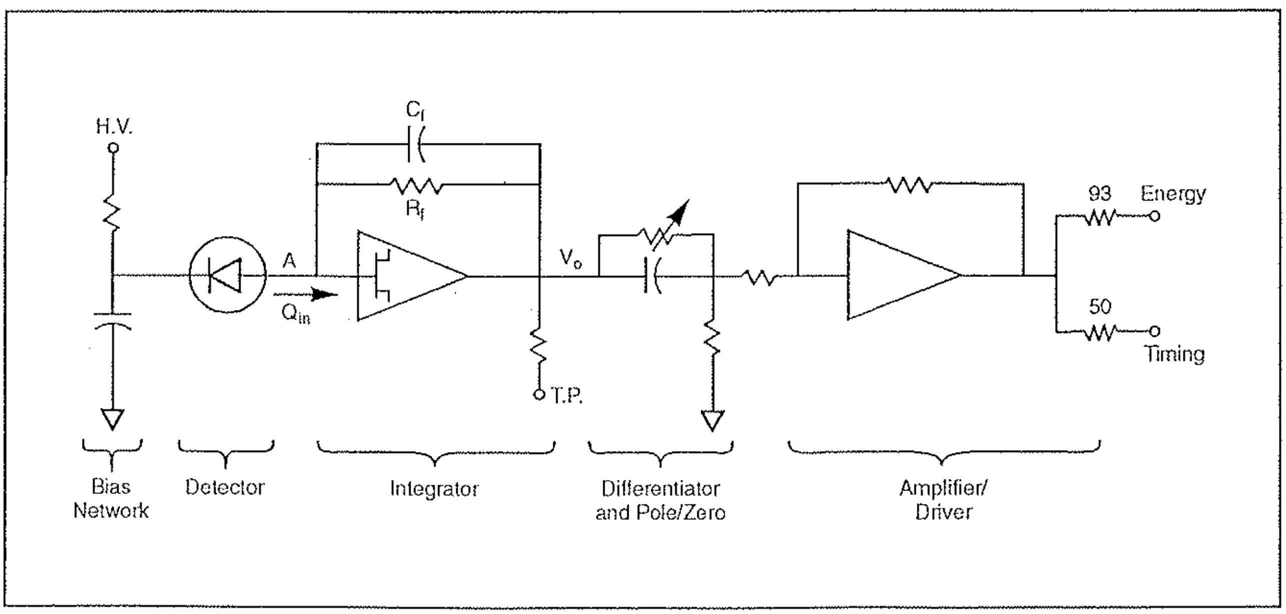


Figure 1.4 Typical RC Feedback Circuit

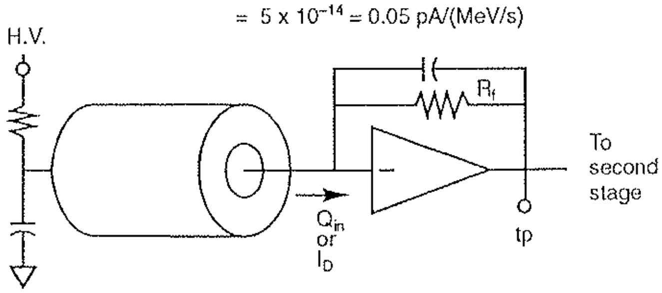
Charge carriers produced by Ge per unit energy deposited = 1/2.98

$$\text{Detector Current} = \text{Energy Rate}\left(\frac{eV}{s}\right) \times \frac{\text{charge (Q)}}{\text{energy (eV)}} \times 1.6 \times 10^{-19}\,\frac{\text{Coulombs}}{Q}$$

Charge per charge carrier

$$\frac{\text{Detector Current (A)}}{\text{Energy Rate (MeV/s)}} = 10^{6} \times \frac{1.6 \times 10^{-19}}{2.98}$$

$$= 5 \times 10^{-14} = 0.05\ \text{pA/(MeV/s)}$$



$V_{tp} = I_D \times R_f$
Assuming $V_{tp} = 20$ V (max)

$$\text{Energy Rate Limit (MeV/s)} = \frac{400\,000}{R\ \text{(Gigohms)}}\ \text{MeV/s}$$

For 2 Gigohms - Limit is 200 000 MeV/s
For 0.5 Gigohms - Limit is 800 000 MeV/s

The energy rate limit of R.C. preamplifiers is a function of feedback resistor value (R_f) and dynamic range.

Figure 1.5 Preamplifier Rate Limit

The output from the integrator is differentiated and passed along to an amplifier/driver which has selectable gain. The output is split and sourced with 50 and 93 ohms for the Timing and Energy outputs, respectively.

1.3.2 Pulsed Optical (PO) Reset Preamps

The feedback resistor in RC Preamps is a source of noise. For low energy detectors where electronic noise is a major contributor to resolution, elimination of the feedback resistor is desirable. With no feedback resistor, the preamplifier output is a step function and successive steps build up to the limit of the amplifier output range. Refer to Figure 1.6.

The preamplifier is then reset by firing an LED in close proximity to the FET chip discharging the FET and resetting the circuit to its initial condition. A monostable circuit generates a gating pulse of variable duration which can be used to gate off the ADC during the reset/recovery interval if necessary to reduce spurious counts in the system.

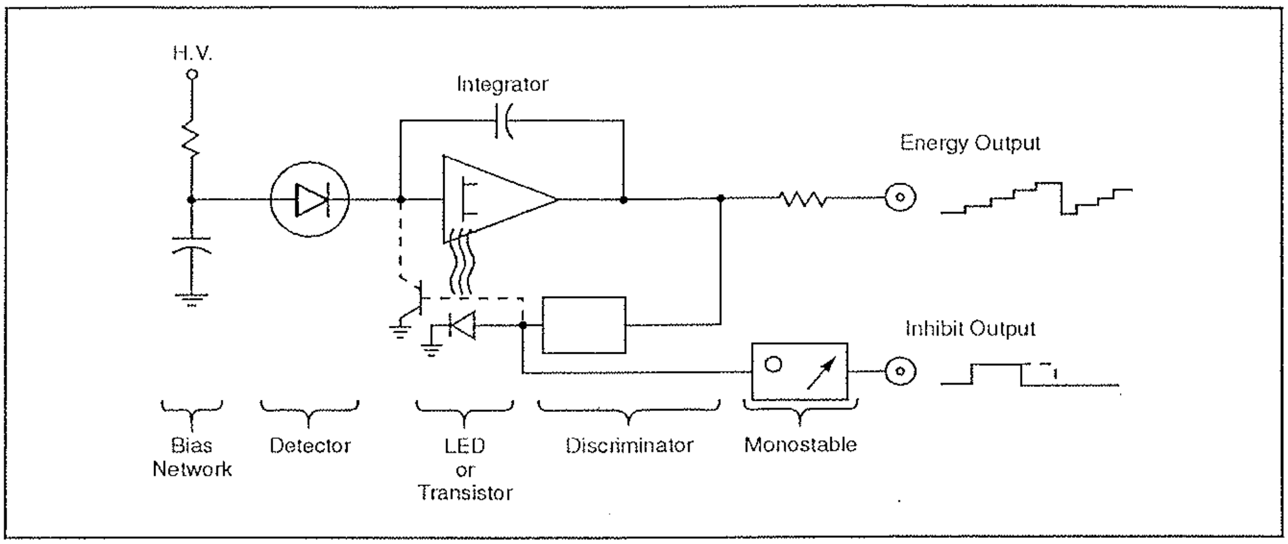


Figure 1.6 Pulsed Optical/Transistor Reset
Preamp Circuit

1.3.3 Transistor Reset Preamps

RC preamps can lock up when they are operated at high energy rates (see Figure 1.5). The transistor reset preamp (TRP) virtually eliminates lock-up since it is capable of discharging the integrator quickly (< 2 μs) and without long-term transients following reset. The PO preamp and the TRP have very nearly the same block diagram but the TRP is designed for detectors operating at high energy rates while the PO preamp is better with ultra-low noise low energy detectors.

1.4. WARM UP SENSOR AND HV INHIBIT

Newer detectors may be equipped with an internal temperature sensor and associated circuitry which can be used to disable the bias supply in case of accidental warm up of the detector. This function is also provided by a separate LN_2 monitor, such as Canberra's Model 1786.

In either case, the reason for having such protection is as follows: When a detector warms up, the molecular sieves, which normally acts as a vacuum pump or adsorber, will release the gases that it accumulated or pumped when cold. The resultant pressure rise can lead to an electrical discharge in the high voltage circuitry within the cryostat and thus damage the FET in the preamplifier.

The Model 1786 senses the liquid nitrogen level in the Dewar and provides an advance warning so that LN_2 can be replenished before the detector begins to warm up. The internal sensor cannot react until it warms up, so while this affords adequate protection to the FET, it may not prevent down time should a refill not take place immediately.

1.5. ENVIRONMENTAL CONSIDERATIONS

Germanium detectors are designed and manufactured for use indoors and for use outdoors under limited conditions, as described in the individual detector's specifications sheet. The detectors conform to Installation Category I and Pollution Degree II standards.

1.5.1 Temperature Range

The environmental temperature range for LN_2 cooled detectors is 5 °C to 40 °C. Electrically cooled detectors may be subject to other limits. See the relevant sections of this manual for these limitations.

1.5.2 Humidity Range

Up to 95% relative humidity – non-condensing. Note that Be and polymer windows are readily damaged by moisture condensation. Humidity must be controlled so that moisture does not condense on windows.

2. DETECTOR DESCRIPTIONS

This section will describe the characteristics of the major types of germanium detectors:

- The Ultra-LEGe Detector
- The Low Energy (LEGe) Detector
- The Coaxial (Coax) Germanium Detector
- The Reverse Electrode (REGe) Detector
- The Extended Range (XtRa) Germanium Detector
- The Ge Well Detector
- The Broad Energy Germanium (BEGe) Detector

2.1 ULTRA-LEGe DETECTOR

The Canberra Ultra-LEGe detector extends the performance range of Ge detectors down to a few hundred electron volts, providing resolution, peak shape, and peak-to-background ratios once thought to be unattainable with semiconductor detectors. The Ultra-LEGe retains the high-energy efficiency intrinsic to germanium detectors because of the high atomic number (Z) and thus covers a wider range of energies than any single-photon detector on

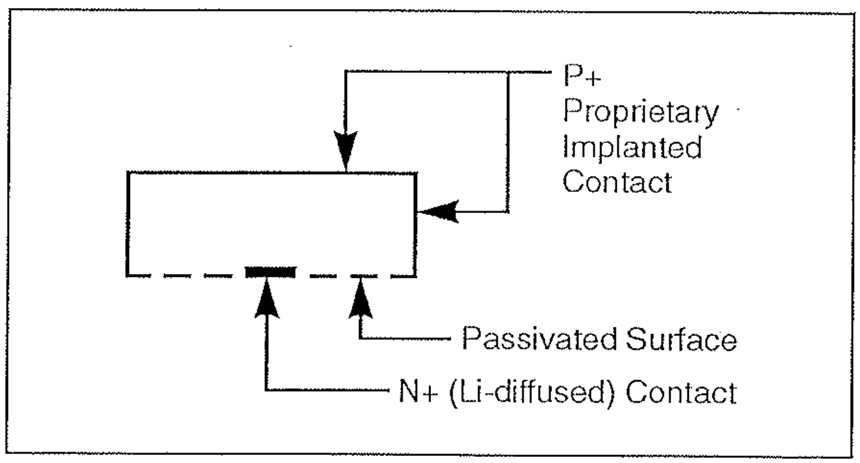


Figure 2.1 Ultra-LEGe Detector Cross Section

the market.

To take full advantage of the low energy response of the Ultra-LEGe, Canberra offers the option of a polymer film cryostat window. This polymer window is a multilayer film which is supported by a ribbed silicon support structure. The film spans silicon ribs that are about 100 microns apart and 0.3 mm thick and act as a collimator accordingly. On horizontal cryostats,

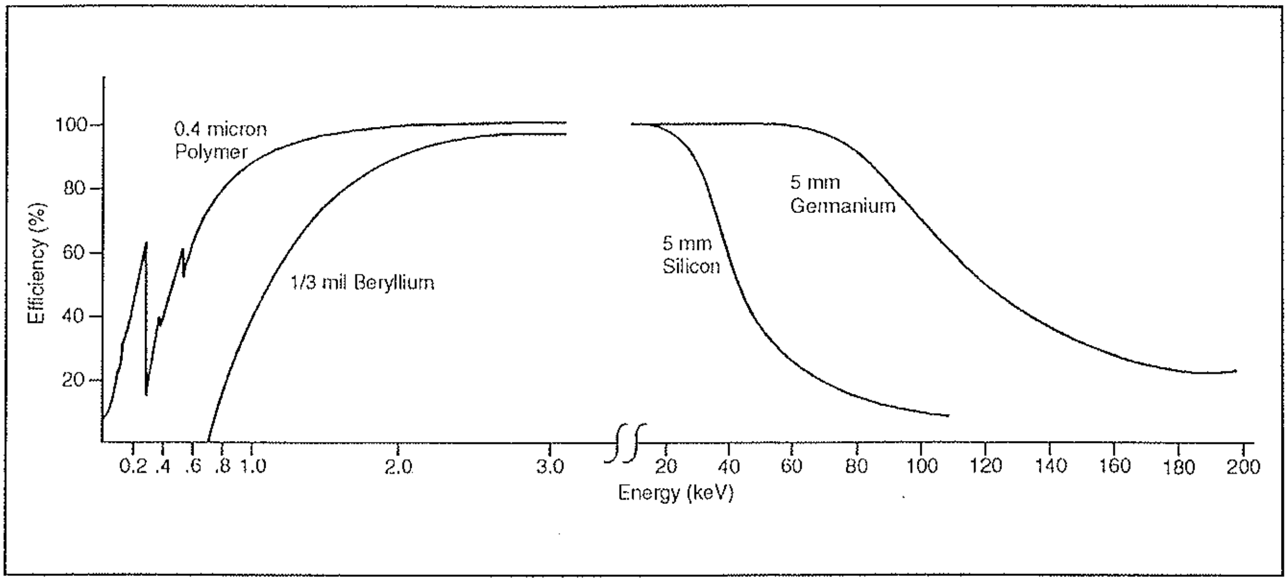


Figure 2.2 Comparison of Window Transmission and Detector Efficiency

the support rib orientation can be chosen by designating the appropriate window model-number suffix: V for vertical ribs and H for horizontal ribs. The support structure is 80% open so the effective detector area is reduced by 20% from the total area. The total film thickness is about 3400 Å, 400 Å of which is an aluminum layer which reduces sensitivity to ambient light. Detectors having polymer windows must be operated in a darkened environment, nevertheless.

2.2 LOW ENERGY Ge DETECTOR (LEGe)

The Low Energy Germanium Detector (LEGe) offers major advantages over conventional planar or coaxial detectors in many applications. The LEGe detector is fabricated with a thin contact on the front face. The rear is of less than full area (Figure 2.3). Thus the capacitance of the detector is less than

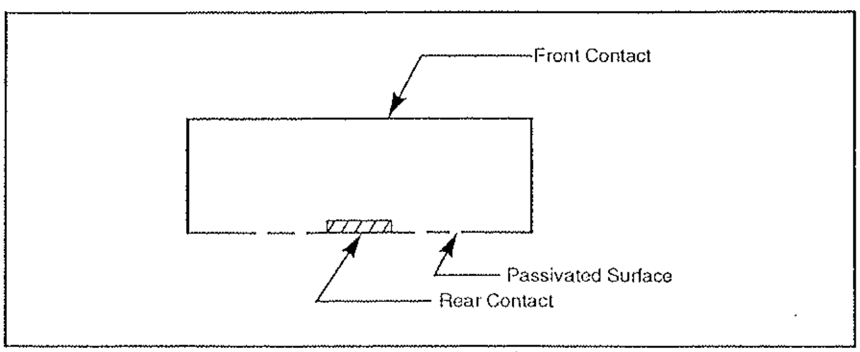


Figure 2.3 LEGe Detector Cross Section

that of a planar device of similar size.

Since preamplifier noise is a function of detector capacitance, the LEGe affords lower noise and consequently better resolution at low and moderate energies than any other detector geometry. Unlike grooved planar detectors, there is virtually no dead germanium beyond the active region. This, and the fact that the side surface is charge collecting rather than insulating, results in fewer long-rise time pulses with improved count rate performance and peak-to-background ratios.

The LEGe detector is available with active areas from 0.5 cm^2 to 38 cm^2 or more and with thicknesses ranging from 5 to 30 mm. The efficiency curve given in Figure 2.4 illustrates the performance of a typical LEGe detector.

To take full advantage of the low energy response of this intrinsically thin window detector, the LEGe is usually equipped with a thin Be window.

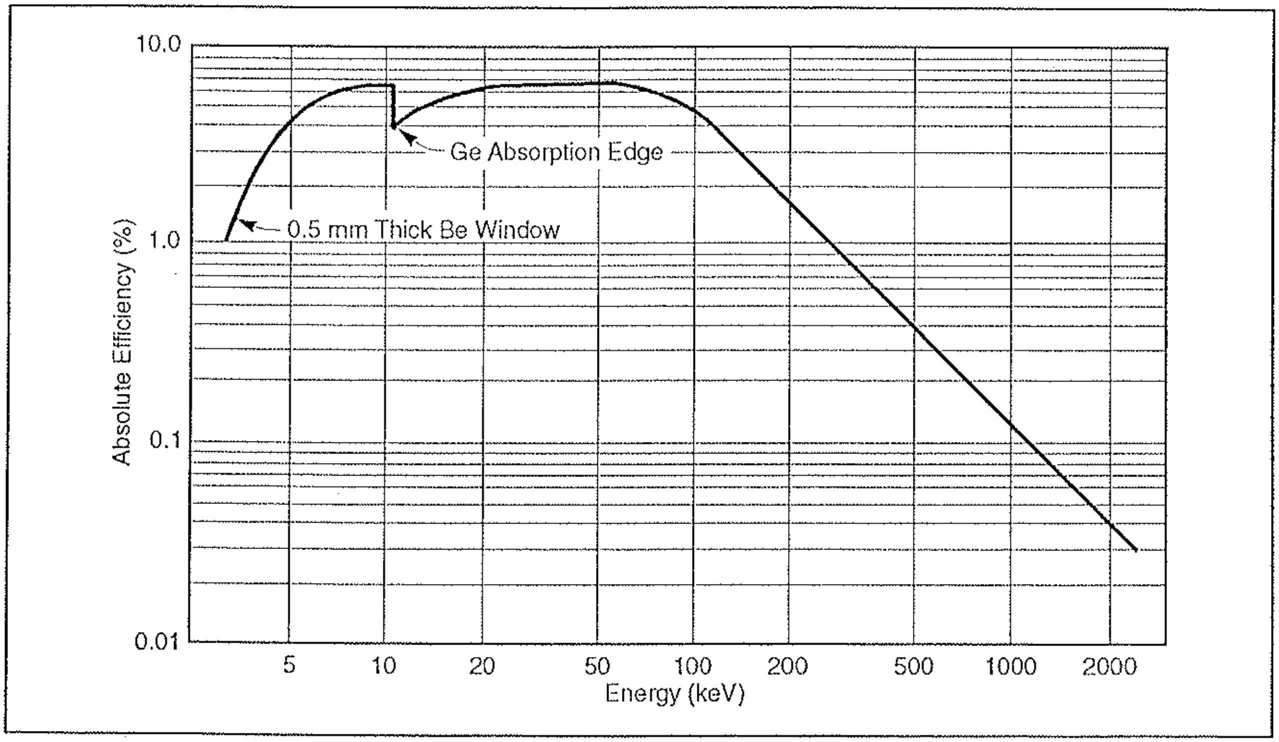


Figure 2.4 Model GL1015 LEGe Detector Efficiency Curve With 2.5 cm Detector-Source Spacing

2.3 COAXIAL Ge DETECTOR

The conventional coaxial germanium detector is often referred to as Pure Ge, HPGe, Intrinsic Ge, or Hyperpure Ge. Regardless of the superlative used, the detector is basically a cylinder of germanium with an n-type contact on the outer surface, and a p-type contact on the surface of an axial well (Figure 2.5).

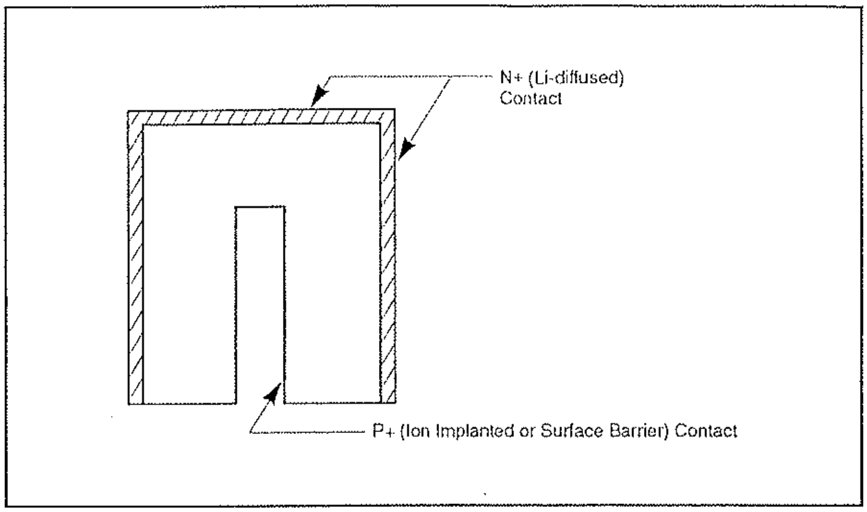


Figure 2.5 Coaxial Ge Detector Cross Section

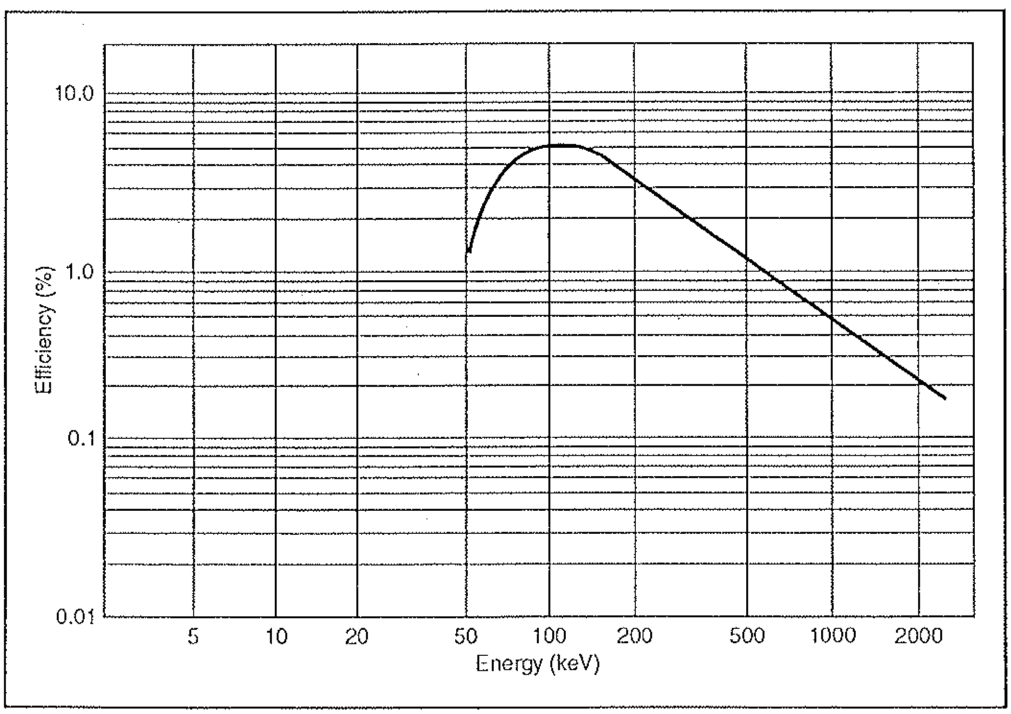


Figure 2.6 Model GC1020 Coaxial Detector Efficiency
Curve With 2.5 cm Detector-Source Spacing

The germanium has a net impurity level of only about 10^{10} atoms/cc so that with moderate reverse bias, the entire volume between the electrodes is depleted, and an electric field extends across this active region. Photon interaction within this region produces charge carriers which are swept by the electric field to their collecting electrodes where a charge sensitive preamplifier converts this charge into a voltage pulse proportional to the energy deposited in the detector.

The n and p contacts or electrodes are typically diffused lithium and implanted boron respectively. The outer n-type diffused lithium contact is about 0.5 mm thick. The inner contact is about 0.3 microns thick. A surface barrier may be substituted for the ion-implanted contact with equal results.

The Canberra Coaxial Ge detector can be shipped and stored without cooling. Like all germanium detectors, however, it must be cooled when it is used to avoid excessive thermally generated leakage current. Furthermore, the lithium diffused outer contact will increase in thickness if the detector is kept warm for extended periods (months or years). This will affect the efficiency of the detector, particularly at low energies.

2.4 REVERSE-ELECTRODE Ge DETECTOR

The Reverse-Electrode detector (REGe) is similar in geometry to other coaxial germanium detectors with one important difference. The electrodes of the REGe are opposite from the conventional coaxial detector in that the p-type electrode (ion-implanted boron) is on the outside, and the n-type contact (diffused lithium) is on the inside (Figure 2.7). There are two advantages to this electrode arrangement – window thickness and radiation damage resistance.

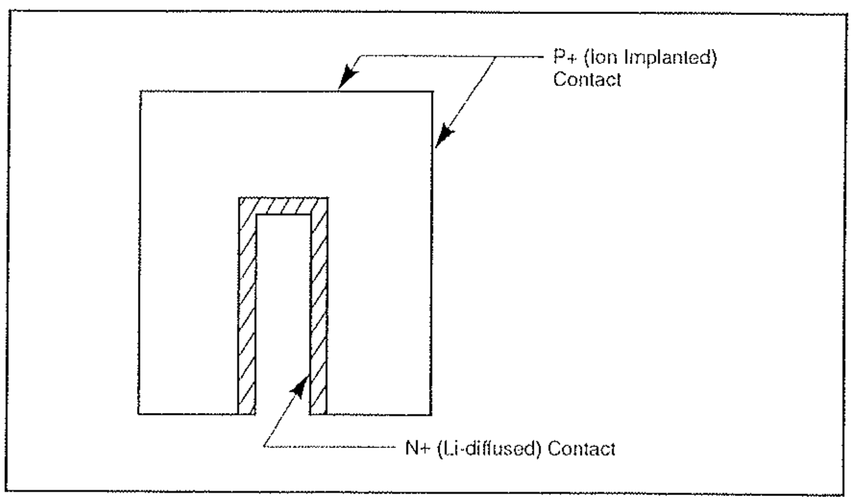


Figure 2.7 REGe Detector Cross Section

The ion-implanted outside contact is extremely thin (0.2 μm) compared to a lithium-diffused contact. This, in conjunction with a thin cryostat window, extends the energy response down to about 5 keV, giving this detector a dynamic range of 2000:1. Needless to say, this dynamic range exceeds the 100:1 offered by most analysis systems so the detector is unlikely to be covering the range of 5 keV to 10 MeV at once.

The radiation damage resistance properties of the REGe detector come about for the following reason. It has been found that radiation damage, principally due to neutrons or charged particles, causes hole trapping in germanium. Unlike the case of the conventional coaxial detector, holes are collected by the outside electrode of the REGe detector.

Since a much greater amount of the active detector volume is situated within a given distance of the outside contact than of the inside contact, it follows that, on average, holes have less distance to travel if they are attracted to the outside contact than if they are attracted to the inside contact. With less distance to travel, they are less likely to be trapped in radiation damaged material. The extent of the improved resistance to radiation damage depends on other factors, of course, but experimental evidence suggests that the REGe detector may be 10 times as resistant to damage as conventional Coaxial Ge detectors.

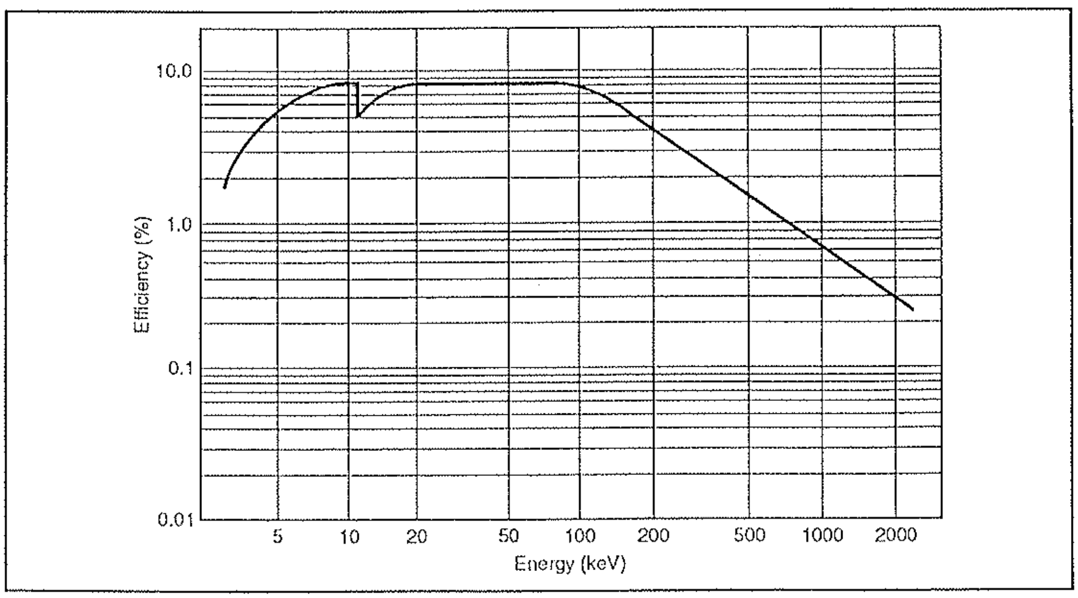


Figure 2.8 Model GR1520 REGe Detector Efficiency Curve With 2.5 cm Detector-Source Spacing

2.5 EXTENDED RANGE Ge DETECTOR

The Canberra XtRa is a coaxial germanium detector having a proprietary thin-window contact on the front surface which extends the useful energy range down to 5 keV. Conventional coaxial detectors have a lithium-diffused contact typically between 0.3 and 1.0 mm thick.

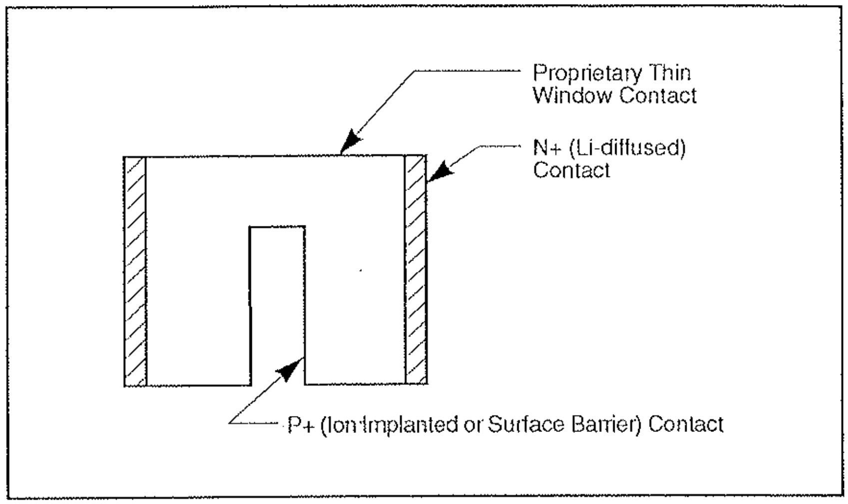


Figure 2.9 XtRa Detector Cross Section

This dead layer stops most photons below 40 keV or so, rendering the detector virtually worthless at low energies. The XtRa detector, with its exclusive thin entrance window and with a beryllium cryostat window, offers all the advantages of conventional standard coaxial detectors such as high efficiency, good resolution, and moderate cost along with the energy response of the more expensive Reverse Electrode Ge (REGe) detector.

The response curves (Figure 2.10) illustrate the efficiency of the XtRa detector compared to a conventional Ge detector. The effective window thickness can be determined experimentally by comparing the intensities of the 22 keV and 88 keV peaks from ^{109}Cd. With the standard 0.5 mm Be window, the XtRa detector is guaranteed to give a 22 to 88 keV intensity ratio of greater than 20:1.

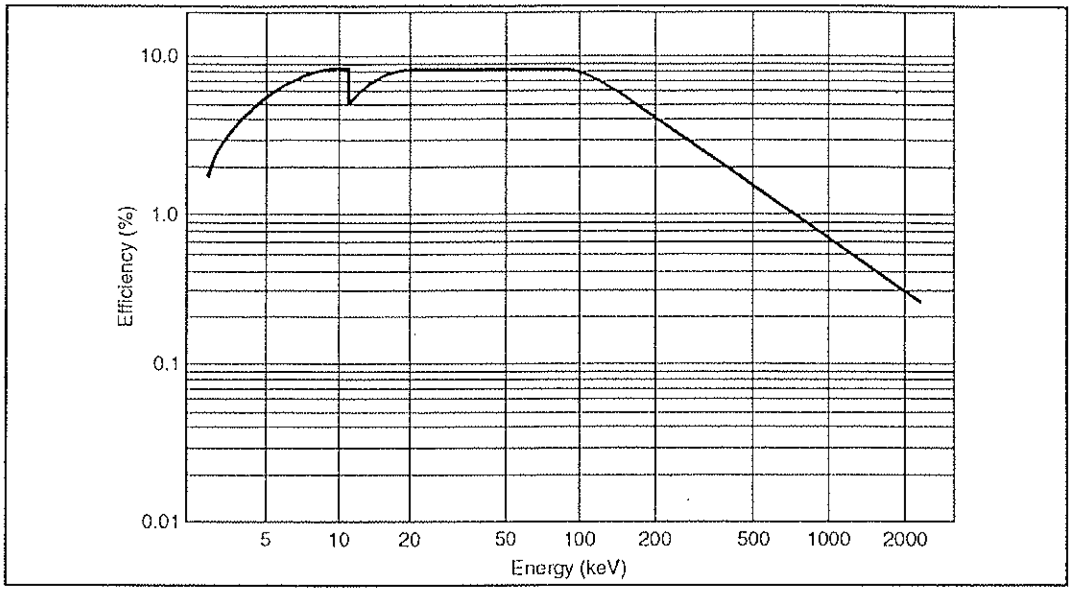


Figure 2.10 Model GX1520 XtRa Detector Efficiency Curve With 2.5 cm Detector-Source Spacing

2.6 Ge WELL DETECTOR

The Canberra Germanium Well Detector provides maximum efficiency for small samples because the sample is virtually surrounded by active detector material. The Canberra Well detector is fabricated with a blind hole rather than a through hole, leaving at least 5 mm of active detector thickness at the bottom of the well. The counting geometry therefore approaches 4π.

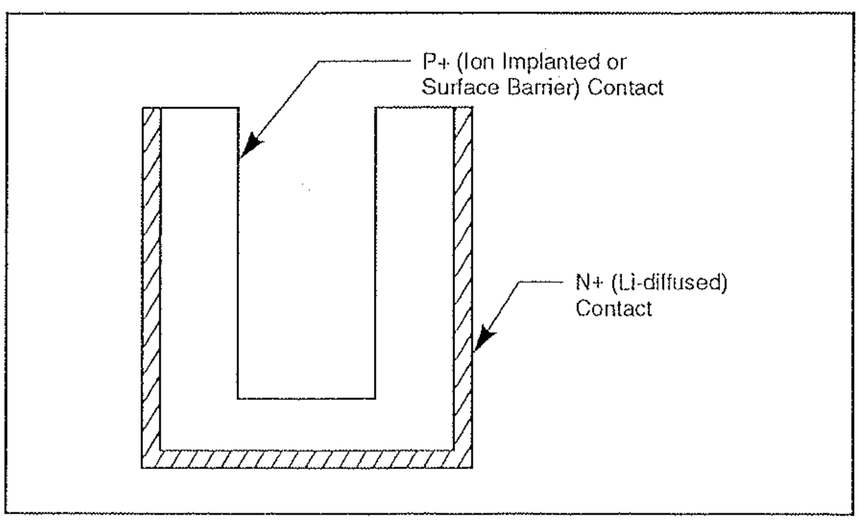


Figure 2.11 Ge Well Detector Cross Section

Germanium Well Detectors are made from high-purity germanium and can therefore be shipped and stored at room temperature without harm. Unlike lithium-drifted detectors, high-purity germanium detectors may be cycled repeatedly between LN_2 and room temperature with no compromise in performance.

The cryostat end cap and well are fabricated from aluminum with a thickness of 0.5 mm in the vicinity of the well. The ion-implanted or surface barrier contact on the detector element is negligibly thin compared to 0.5 mm of aluminum so these detectors have intrinsically good low energy response.

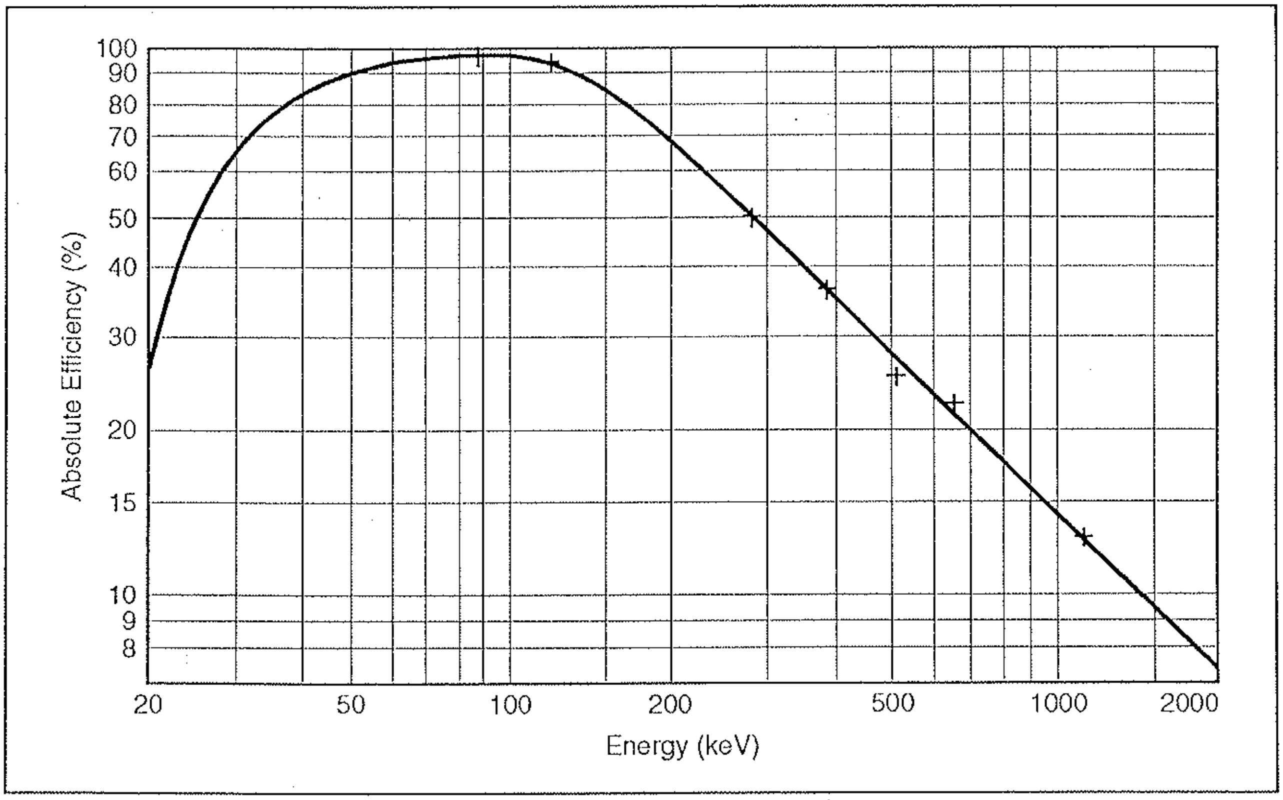


Figure 2.12 Model GCW2522 Ge Well Detector Efficiency Curve (With the Source at the Bottom of the Well)

2.7 BROAD ENERGY GE DETECTOR

The Canberra Broad Energy Ge (BEGe) Detector covers the energy range of 3 keV to 3 MeV. The resolution at low energies is equivalent to that of our Low Energy Ge Detector and the resolution at high energy is comparable to that of good quality coaxial detectors.

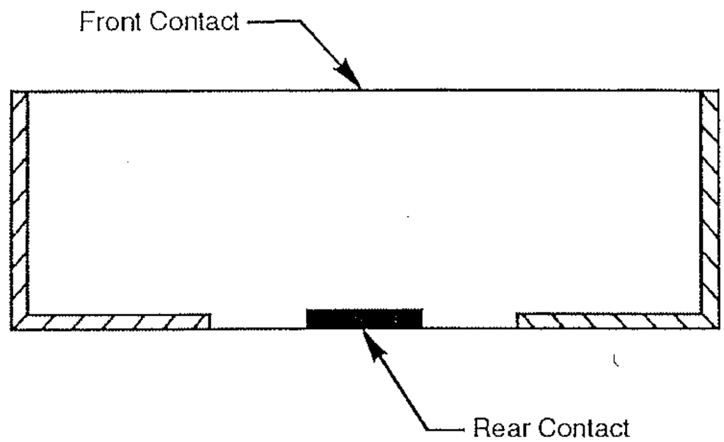


Figure 2.13 BEGe Detector Cross Section

Most importantly, the BEGe has a short, fat shape which greatly enhances the efficiency below 1 MeV for typical sample geometries. This shape is chosen for optimum efficiency for real samples in the energy range that is most important for routine gamma analysis.

In addition to higher efficiency for typical samples, the BEGe exhibits lower background than typical coaxial detectors because it is more transparent to high energy cosmogenic background radiation that permeates above ground laboratories and to high energy gammas from naturally occurring radioisotopes such as ^{40}K and ^{208}Tl (Thorium).

In addition to routine sample counting, there are many applications in which the BEGe Detector really excels. In internal dosimetry the BEGe gives the high resolution and low background need for actinide lung burden analysis and the efficiency and resolution at high energy for whole body counting. The same is true of certain waste assay systems particularly those involving special nuclear materials.

The BEGe detector and associated preamplifier are normally optimized for energy rates of less than 40 000 MeV/sec. Charge collection times prohibit the use of short amplifier shaping time constants. Resolution is specified with shaping time constants of 4-6 microseconds typically.

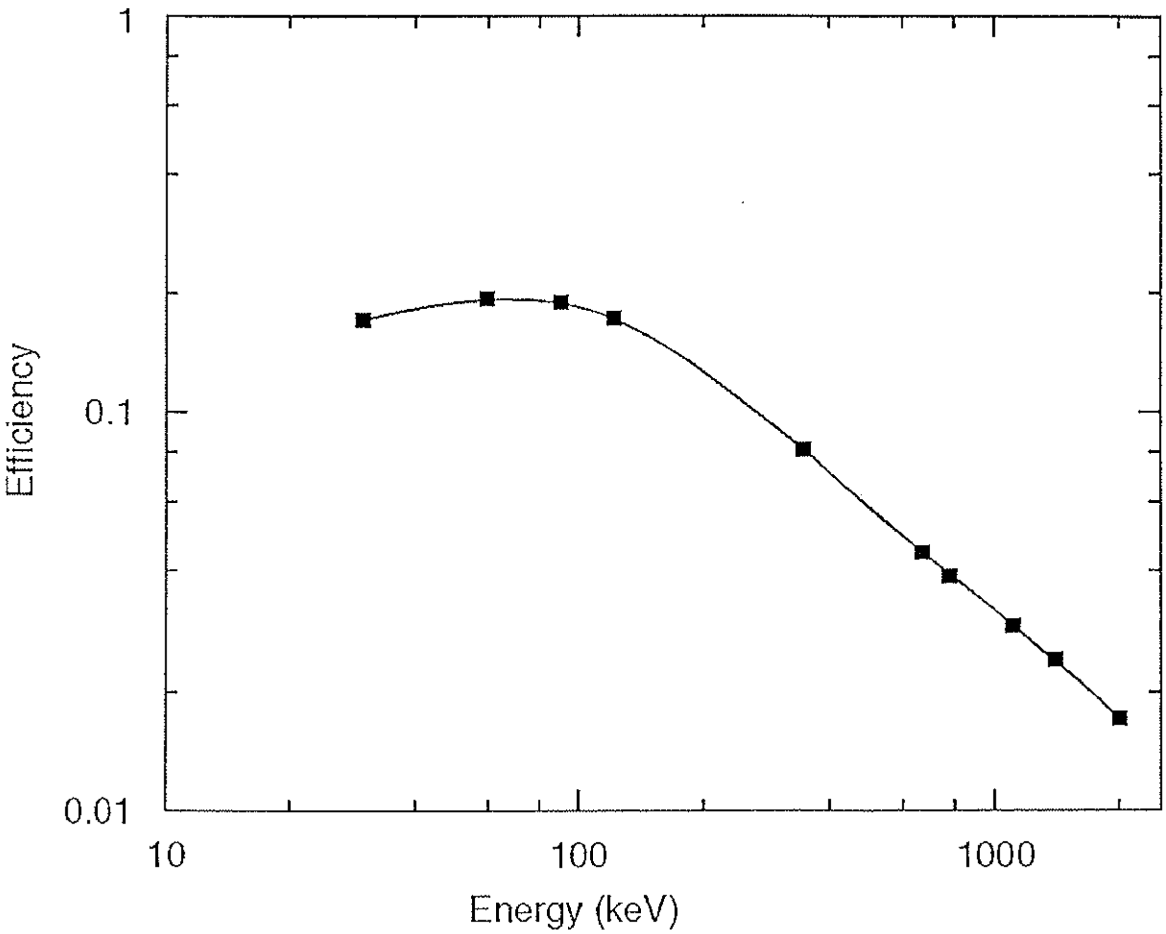


Figure 2.14 Absolute efficiency of BE5030
for a source measuring 74 mmdiameter by 21 mm thick located on the detector end cap.

3. CRYOSTAT DESCRIPTIONS

There are three types of cryostats in two basic styles and in many sizes. This variety can be broken down as follows:

- Types: Dipstick, Integral, All Attitude Portable, Electrically Cooled
- Styles: Flanged (traditional), Slimline
- Sizes: From 1 liter capacity to 50 liter capacity
- Orientations: Horizontal, Vertical, Variable

In addition, special cryostats or variations on the above are available. Instructions for these units are covered in supplements to this manual found in the envelope on the last page if they are necessary.

Precaution

Most cryostats (the 7500 and 7600 are the exceptions) are equipped with Viton O-ring Seals that are permeable to light gases such as helium. Helium is not pumped effectively by the molecular sieves or charcoal adsorber used to maintain vacuum. The epoxy used to bond beryllium, carbon composite, and polymer windows is also permeable. While permeability (as opposed to leaks) is not generally a problem (the atmospheric abundance of helium is quite low) care should be taken to avoid exposing cryostats to high concentrations of helium for extended periods.

3.1. FLANGED AND SLIMLINE STYLES

Refer to Figure 1.3 for a description of these two cryostat styles.

3.2. DIPSTICK CRYOSTAT

Dipstick cryostats consist of a detector chamber having a dipstick-like cold finger which is inserted into a liquid nitrogen Dewar for cooling. The Dewar and the detector chamber have separate vacuum systems including adsorber material which help maintain good vacuum in both over the lifetime of the product. A basic dipstick cryostat is illustrated in Figure 3.1

3.2.1 Dipstick Dewar

Most dipstick cryostats use a 30 liter Dewar. The loss rate of the Dewar alone is typically 0.5 to 0.7 liters/day. Faulty Dewars of this type cannot be repaired but can be replaced in the field at moderate cost.

3.2.2 Fill and Vent Collar

Dipstick cryostats are equipped with a silicone rubber collar which holds the dipstick in place in the Dewar's neck. This collar has interchangeable tubes for fill and vent and has provisions for an LN_2 sensor of the type used with LN_2 monitors, such as the Canberra Model 1786. A clamp ring is used on some dipstick cryostats to provide mechanical stability.

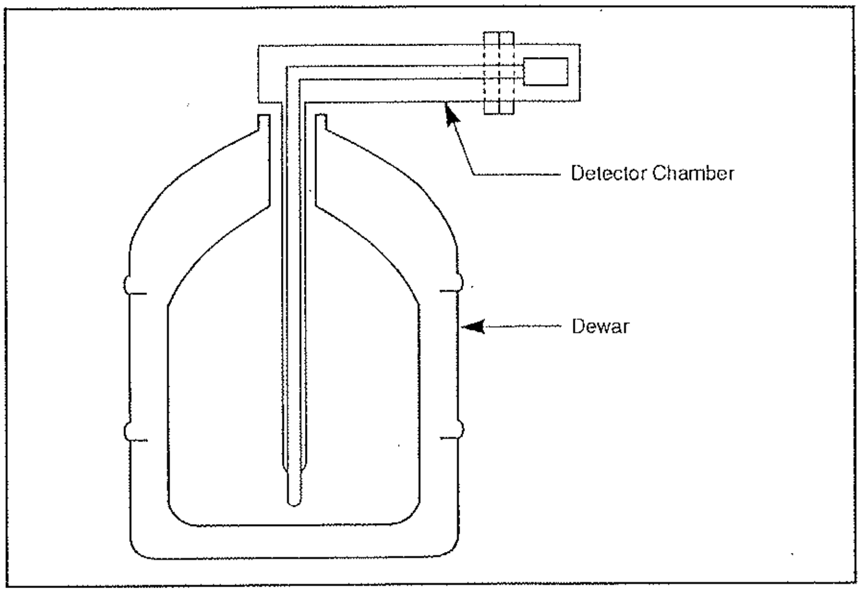


Figure 3.1 Typical Dipstick Cryostat Cross Section.

3.3. INTEGRAL CRYOSTAT

Integral cryostats have a common vacuum chamber for the Dewar and detector. Unlike the dipstick type, the detector chamber and Dewar cannot be separated without breaking vacuum. A basic integral cryostat is shown in Figure 3.2.

3.3.1 Integral Swivel-Head Cryostat

This version of the integral cryostat has a rotary vacuum seal which allows the detector chamber to be rotated 180°, affording multiple geometries without moving the cryostat or warming it up.

Rotating Seal

The rotating joint is outfitted with two O-rings to minimize the chance for leaks. The inner O-ring is under constant compression. The outer O-ring is compressed by a knurled ring nut which can be tightened to retard rotation of the head. It should not be necessary to loosen this nut to any great degree to allow rotation of the head and it would be undesirable to do so. There are mechanical stops which prevent rotation just beyond the normal 180° operating range. These stops cannot be defeated without catastrophic results.

Operation

The head can be rotated with the detector either warm or cold with the following procedure:

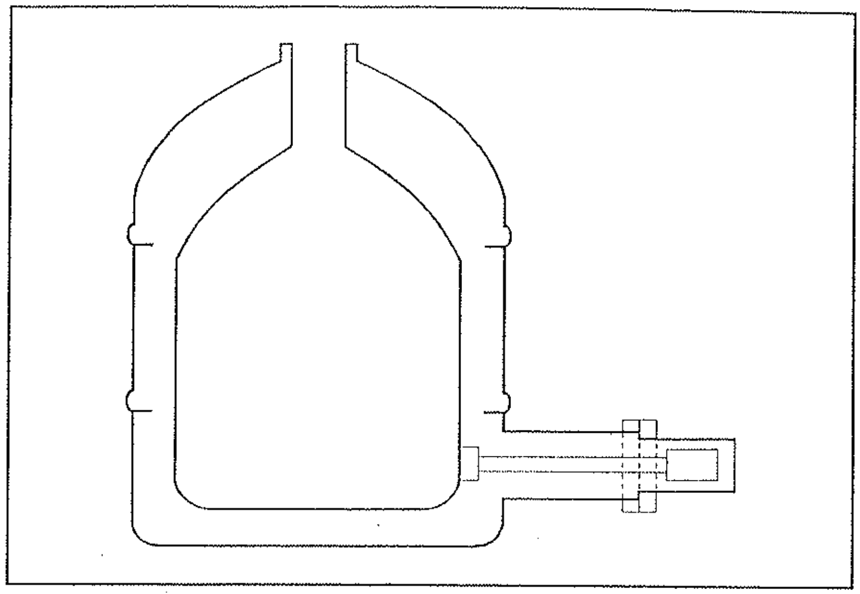


Figure 3.2 Typical Integral Cryostat
Cross Section

1. Turn off the Detector Bias and allow one minute for the bias network to discharge fully.
2. Loosen the ring nut just slightly.
3. Rotate the head to the desired orientation. Do not allow the ring nut to turn with the head.
4. Tighten the ring nut "hand tight". Pliers or wrenches should not be necessary.

3.4. MULTI-ATTITUDE CRYOSTAT (MAC)

Canberra's standard portable multi-attitude cryostats have twin fill/vent ports which allow the units to operate in any orientation. The arrangement of the fill and vent ports is illustrated in Figure 3.3. These units are available in several sizes, with holding times of one to five days.

With the detector horizontal, either tube can vent. With the detector facing down, tube one vents. With the detector facing up, tube two vents. See Section 6.4 for more information on the MAC.

3.4.1 Single Port Portable Cryostats

Portable all-attitude cryostats may also have a single port. These units have a neck tube that extends to the center of the Dewar and as long as the liquid level remains below the end of the tube (i.e., half-full maximum) the port can vent and the cryostat will work normally. For a given overall Dewar size, this

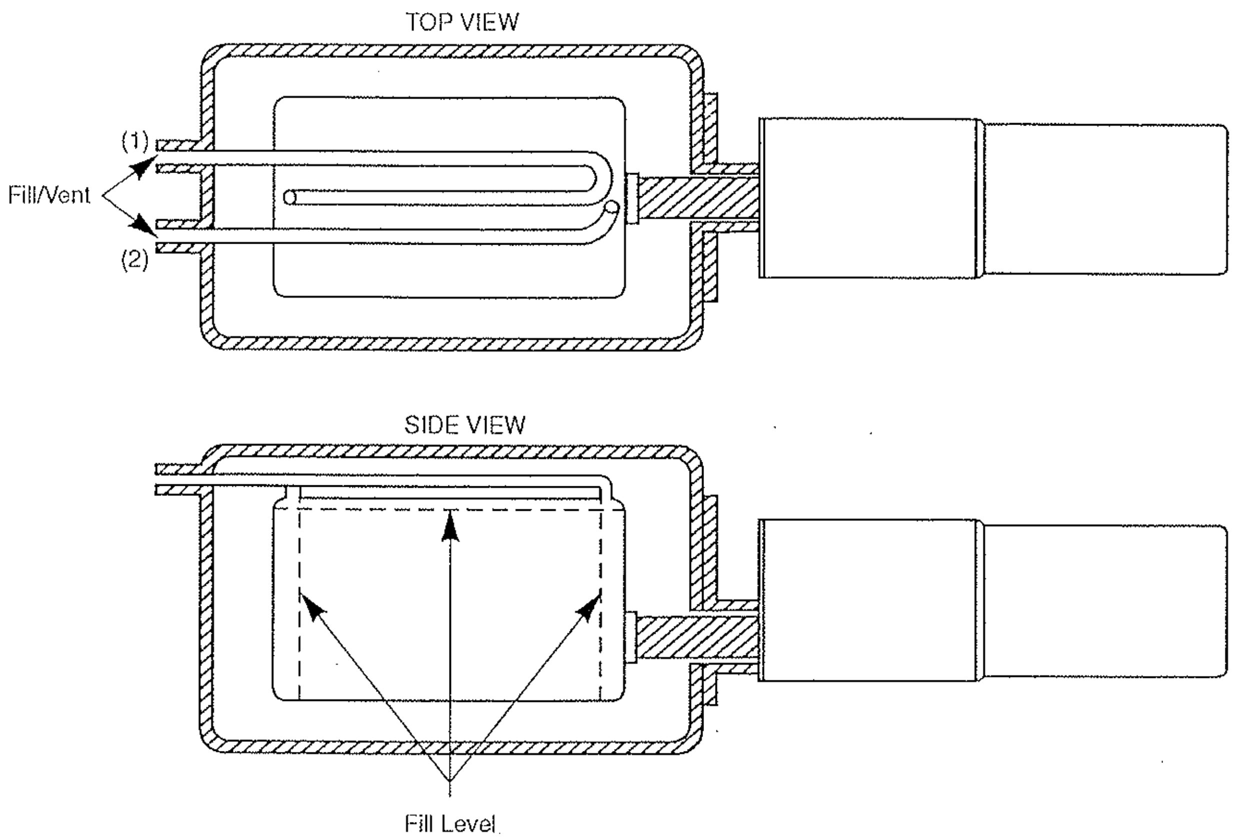


Figure 3.3 Typical Multi-Attitude (MAC) Cryostat Cross Section

type of cryostat has about one half the holding time of the standard MAC. See Figure 3.4 for details.

3.4.2 Detachable Cradle Assembly

The MAC is shipped with a carrying cradle which can be removed if the unit is to be installed in a fixed apparatus for any reason. To detach the cradle, remove the screws holding the rear plate to the handle and to the base, then remove the rear plate and slide the detector backwards taking care to feed the cables through the front plate along with the snout. Refer to Figure 3.5.

The detector cradle is equipped with a cableway fore and aft, so that the pigtail cables from the preamplifier and the extender cables supplied separately may be retained in a convenient and safe orientation. The cable retainer is a split grommet made of plastic.

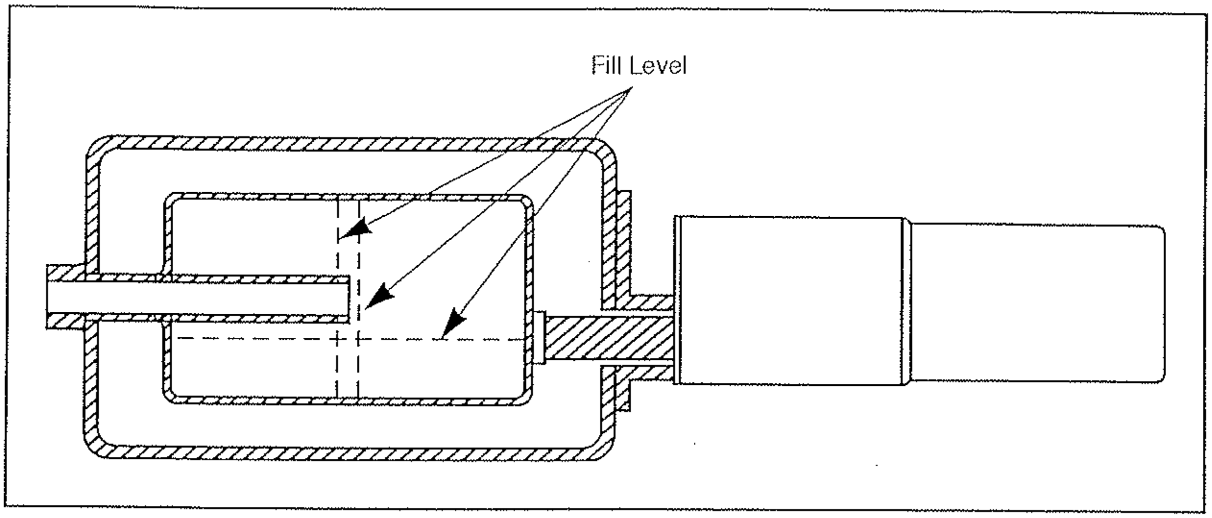


Figure 3.4 Typical Single Port MAC Cross Section

To install the cables, the grommet must first be removed from the cableway. The grommet is snapped over the cable bundle and the cables are inserted in the cableway. The grommet is then pressed into the cableway with the split facing the inside.

The MAC cradle is also equipped with a clamp to secure the extender cable, so that they will not stress the smaller pigtail cables. This clamp, or some other means, must be employed to prevent damage to the miniature coaxial cables in the pigtail cable assembly.

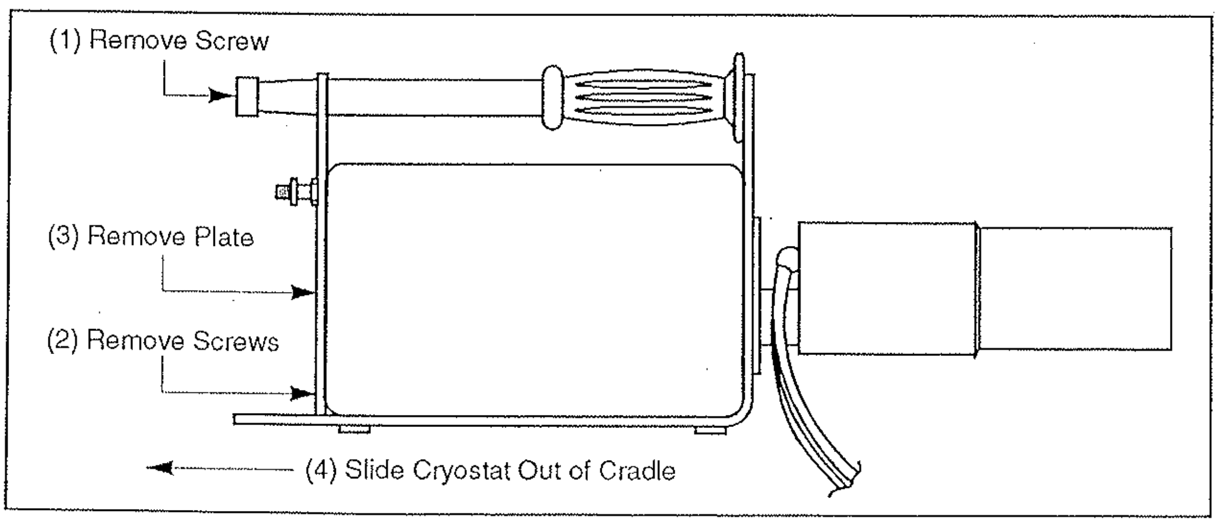


Figure 3.5 Cradle Assembly

Flanged versions of the MAC have a conventional (non slimline) preamplifier with bulkhead connectors which do not require strain relief.

3.5. CONVERTIBLE CRYOSTAT

The Canberra Convertible Cryostat, as the name suggests, is a cryostat which can be converted from one configuration to another without factory intervention. This is made possible by providing a sealed detector chamber which engages a cold finger receptacle. The receptacle can be built into a Dewar as in the case of portable or integral style systems, or inserted in the neck tube of a Dewar as in the case of dipstick style systems. In this way a single detector chamber may be operated with a variety of Dewars/receptacles to meet changing needs of the customer.

3.5.1 Principle of Operation

The detector chamber is a sealed vacuum system. The Dewar and/or dipstick assembly is also a sealed vacuum system. These sub-systems work more or less as traditional systems work. The novel aspect of the Canberra convertible cryostat is the transition coupling which joins the two sub-systems. This transition coupling involves close-fitting coaxial tubing – the inner tube being the detector chamber cold finger jacket and the outer tube being the inner wall of the receptacle. Because of the carefully chosen length and close spacing of these members, there is little heat transfer along the axis, despite the fact that the coupling operates at atmospheric pressure with one end at LN_2 temperature and the other at room temperature. The result is that convertible cryostats exhibit LN_2 loss rates only 0.1 to 0.2 liters/day above that of their conventional counterparts.

3.5.2 Physical Configuration

The detector chamber is shown in cross section in Figure 3.6. The cold finger protrudes slightly from the shroud and is surrounded by a thin-wall vacuum jacket. The chamber is evacuated and sealed by means of a seal-off valve (not shown) built into the base. Vacuum is maintained by an adsorber (not shown) attached to the cold finger assembly. The detector holder and preamplifier front end are located in the vacuum chamber but are not shown in this illustration for reasons of simplicity and clarity.

A set screw in the lug attached to the base of the detector chamber is used to hold the detector chamber firmly in place in the mating receptacle.

Dipstick Cold-Finger Receptacle

The business end of the dipstick cold-finger receptacle is also shown in cross section in Figure 3.6. Here you see the thin-wall vacuum jacket which receives the cold finger assembly. At the bottom of the receptacle is the copper heat sink into which the copper cold finger fits. Thermal joint compound is used to provide good thermal conduction and to prevent galling of these metal surfaces.

The dipstick assembly fits into a Dewar and is held in place by a collar assembly which has ports for LN_2 and a liquid level monitor.

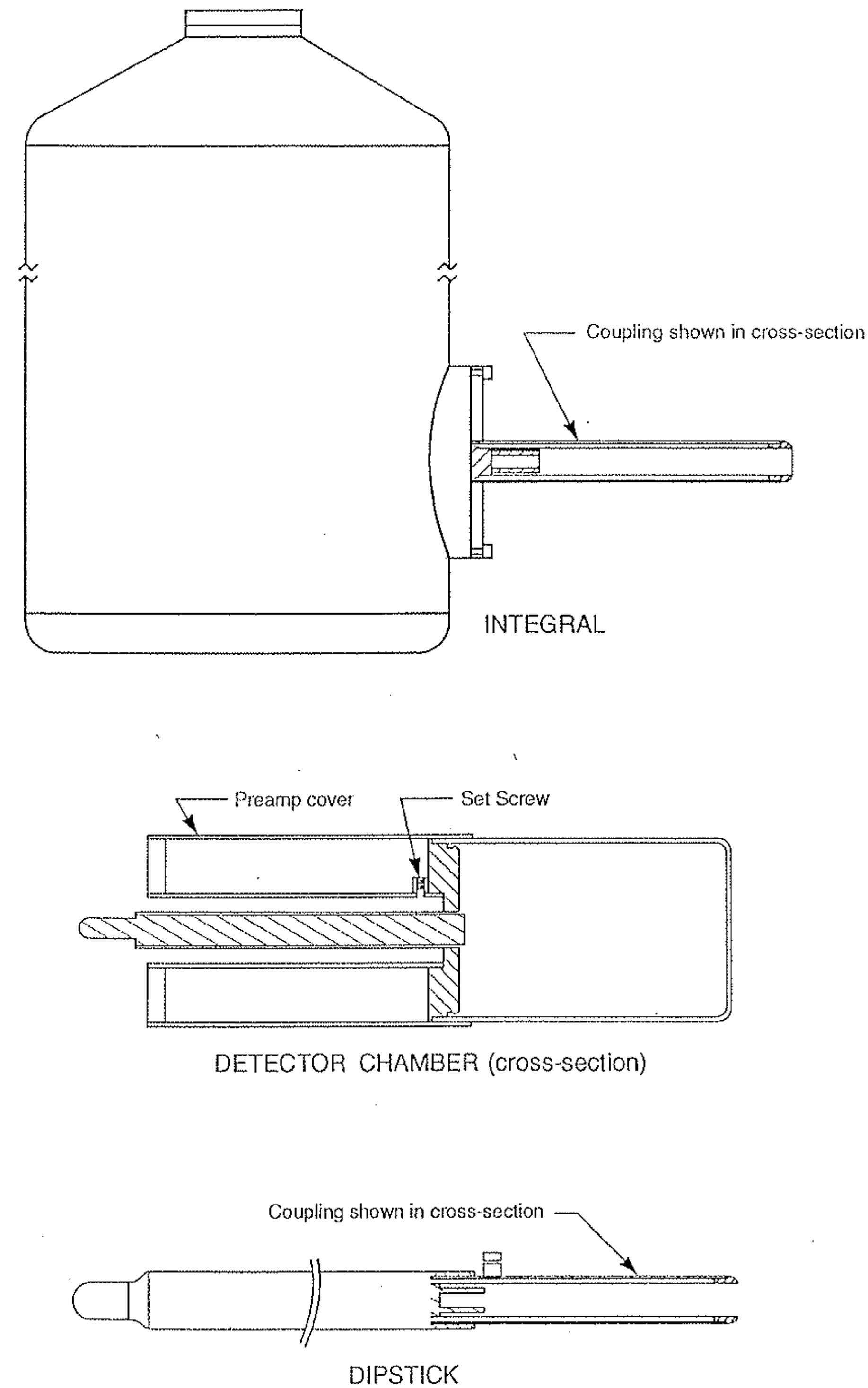


Figure 3.6 Convertible Cryostat

The dipstick is evacuated and sealed by means of a seal-off valve which is shown. Vacuum is maintained by an adsorber located in the bottom of the dipstick assembly.

3.5.3 Changing Configurations

Before engaging or disengaging a detector chamber from a cryostat, both must be at room temperature. Allow the following warm-up times for various cryostat types:

Cryostat Type	Warm-up Time	Conditions
Dipstick	24 Hours	Dipstick removed from Dewar
Integral	24 Hours	Empty liquid – Dewar on side with neck plug removed
Portable	48 Hours	Empty liquid
Cryolectric	24 Hours	Power off

Disengaging Chamber

To disengage the detector chamber from the cryostat, follow these three steps. You'll need a small Phillips-head screwdriver and the $^{3}/_{32}$-inch hex key wrench supplied with the cryostat.

1. Remove screws holding preamp cover to base of preamplifier and slide cover forward exposing the base of the detector chamber.
2. Using the hex key wrench, loosen the set screw holding the detector chamber to the receptacle (see illustration).
3. Gently twist the detector chamber and pull it away from the receptacle.

Engaging Chamber

To remount the detector chamber on the cryostat, follow these seven steps. You'll need a small Phillips-head screwdriver and the $^{3}/_{32}$-inch hex key wrench supplied with the cryostat.

1. Inspect the receptacle and make sure it is both clean and dry. Use a flashlight to check the copper heat sink at the bottom of the receptacle.

2. Inspect the cold finger. Be sure it is free of burrs and dents.

5\. Ensure that both the copper heat sink and the copper cold finger are coated with white thermal joint compound. The compound should coat mating copper surfaces only, not the stainless steel tubing.

4\. Gently slide the capsule over the receptacle until you feel the copper parts mesh. Rotate the detector chamber back and forth to ensure good mating of the surfaces, leaving the detector chamber at the desired angle.

5\. Gently tighten the set screw to lock the detector chamber in place.

6\. Reinstall the preamp cover.

7\. Cool the detector down and wait the prescribed time before testing.

3.6. CRYOLECTRIC CRYOSTAT

The Canberra Cryolectric Cryostat is no longer in production. Consult the factory for information.

3.7. FREOLECTRIC CRYOSTAT

The Canberra Freolectric Cryostat is no longer in production. Consult the factory for information.

3.8. CRYOSTAT OPTIONS

There are wide varieties of cryostat options and features, the most common of which are described below.

3.8.1 Optional Windows

Most Planar, LEGe, XtRa and REGe detectors are equipped with a beryllium (Be) window to enhance sensitivity for low energy photons. Also a carbon composite window is used by Canberra as an alternative to beryllium on low background applications and polymer windows (see Figure 2.2) are used on Ultra-LEGe detectors. Curves showing the transmission characteristics of various windows are shown in Figure 3.7.

Be Window – Care and Handling

Thin Be windows may be damaged easily. Windows of 0.25 mm (10 mils) thickness, or less, should not be touched. The window can be damaged by moisture condensation; keep it clean and dry at all times.

The detector should not be stored or operated in a humid environment. If moisture condenses on the Be window during normal operation, either the humidity is too high or the detector has a vacuum problem.

During cool-down or warm-up cycles when the molecular sieves outgas, some condensation may appear. This is normal. It should go away as soon as the molecular sieves repump the system.

NOTE Damage to Be windows caused by physical abuse or harsh environments is not covered by the warranty.

Polymer Window – Care and Handling

Description:

The Canberra polymer window is only 3400 Å thick including 400 Å of aluminum. Considering that the polymer window is only about 1/25th as thick as 1/3 mil beryllium, it is an amazing device as it withstands atmospheric pressure and is helium leak tight. Not surprisingly, however, the window can be damaged easily if it is not handled properly and protected from the environment. Listed below are characteristics of the window as well as precautionary measures which should be taken to protect it.

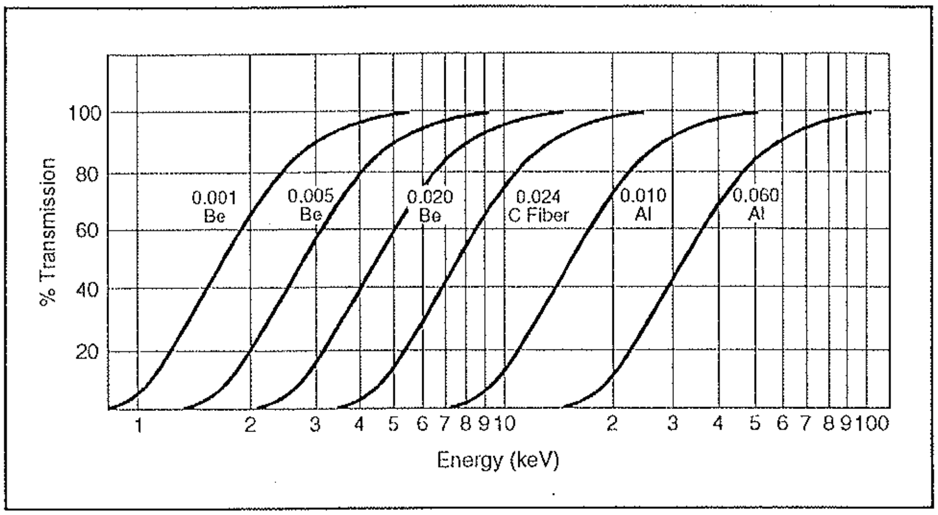


Figure 3.7 Window Transmission Characteristics

The polymer window is a multilayer film supported by a ribbed silicon support structure. The film spans thin silicon ribs which are about 100 µm apart and about 0.3 mm thick. Therefore, the window exhibits a fairly tight collimation effect for photons entering at angles which are not parallel to the ribs. Also the window area is not oversized compared to the detector area so additional collimation is involved here. The ribs are about 20 µm wide so the window has about 80% "open" area.

The aluminum layer is not thick enough to block all light so the detector should be operated in the dark or in very subdued lighting. Ge detectors are very sensitive to infrared radiation and they may show effects of IR even without the presence of visible light.

Precautions:

1. Do not touch the window surface with *anything*, not even a cotton swab or soft brush. Physical abrasion can easily cause damage to the aluminum layer. It is also good to protect the window from dust and other small particles. Under certain circumstances they can abrade the surface and cause leaks.
2. Always avoid applying pressure to the ribbed side of the window (back pressure). The window is very strong when pressure is applied to the film side but very weak if pressure is applied to the ribbed side.
3. When evacuating a detector on which the window is mounted, it is best to pump down slowly to reduce the shock to the window. When venting a vacuum chamber on which the detector is mounted, you should vent very slowly to prevent flying particles from hitting and damaging the window.
4. Avoid any physical shock to the window, such as bumping or jarring the detector.
5. Never subject the window to temperatures higher than 35 °C.

6. Protect the window from moisture and from exposure to corrosive atmosphere. The aluminum layer is attacked by moisture and by acid fumes.
7. Keep the protective cover on the window whenever the detector is not in use, especially when the detector is being moved or when someone is working around the detector. Be very careful when placing test sources near the detector. This is the most common way of breaking windows in our experience.
8. If (or when) a window breaks, warm up the detector immediately and allow the inside of the detector to defrost and dry out before returning the detector to the factory for repair. This can be facilitated by removing the end cap.

Note: Damage to polymer windows is not covered by warranty.

3.8.2 Extended End-caps

The standard end-cap length for most Ge detectors is 7 to 10 cm (3-4 in.). Optional end-caps may reach lengths of 30 cm (12 in.) or more. Detectors so equipped may show increased cool-down time and increased microphonics because of the added cold finger and wire length between the detector and preamplifier. They also require special care in handling to avoid mechanical damage.

3.8.3 Remote Detector Chambers (RDC)

The remote detector chamber (RDC) option provides for external shielding just behind the detector element. The diameter and length of the neck joining the RDC to the cryostat vary depending on the application. A typical RDC configuration is shown in Figure 3.8.

3.8.4 Cold Finger Extension

Standard Dipstick Detectors may be equipped with a cold-finger extension up to 10 cm in length. This allows the dipstick to be inserted through the floor of a shield between the detector chamber and the Dewar without sacrificing working volume of the Dewar. Such an arrangement is shown in Figure 3.9.

Standard Detectors are not designed to be elevated more than 10 cm (4 in.) from the Dewar neck, so the Dewar must be moved up as close as possible to the bottom of the shield.

3.8.5 Special Preamp Hardware

To fit detectors having flanged cryostats into shields of moderate size, special preamp hardware can be used. This hardware generally provides a means of attaching the preamp to the cryostat so that the preamp protrudes a minimum amount from the detector axis.

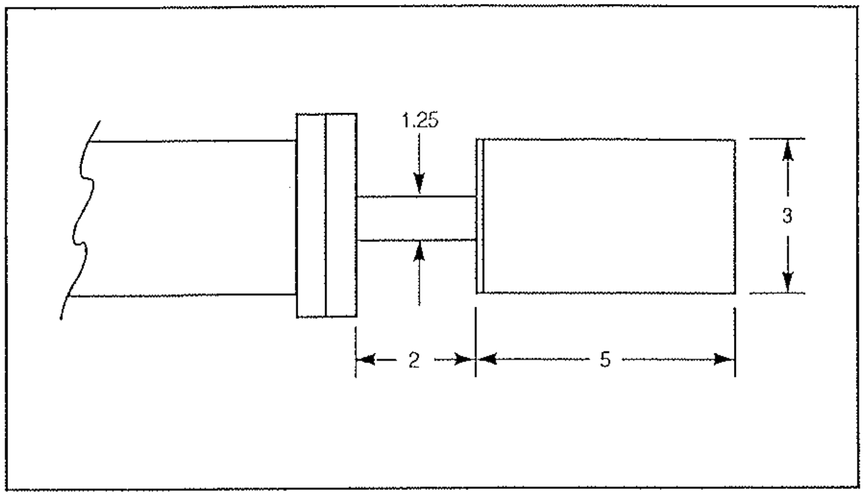


Figure 3.8 Typical RDC Configuration
Dimensions in inches (mm)

3.8.6 Ultra-Low Background Materials

Although the materials used in cryostats are checked for abnormal levels of radioactive impurities, the hardware contribution to background can be improved by careful, time-consuming selection of expensive, often exotic materials. The normal materials used in cryostat construction are classified as low background. Materials that are specially selected or chosen optionally are classified as ultra-low background materials. This choice is usually negotiated with the end-user for each application.

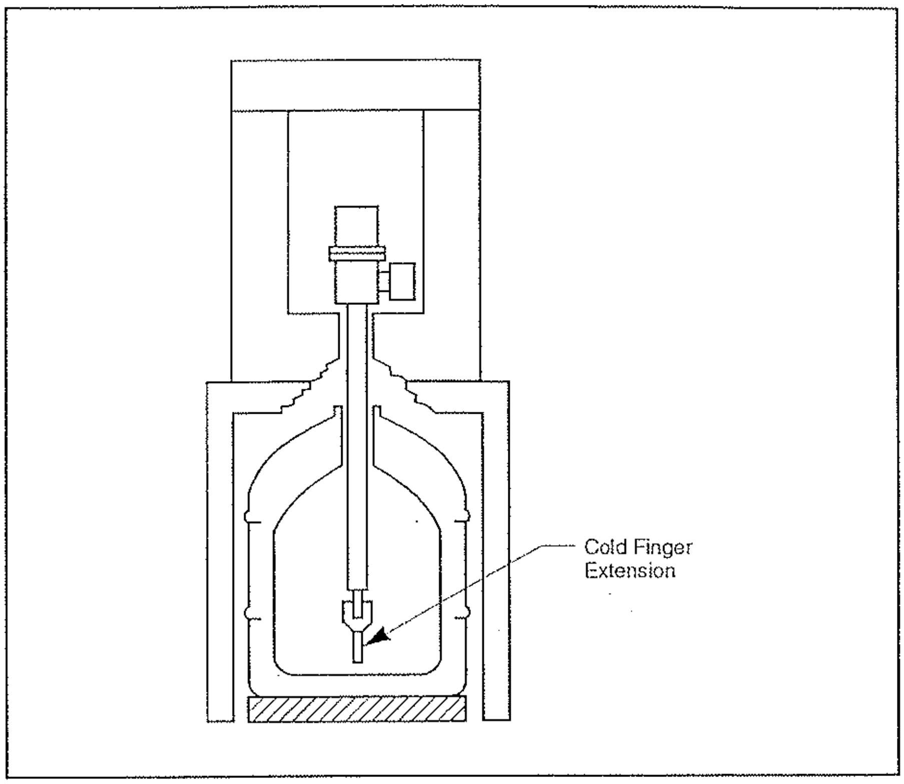


Figure 3.9 Cold Finger Extension

3.9. CRYOLECTRIC II CRYOSTAT

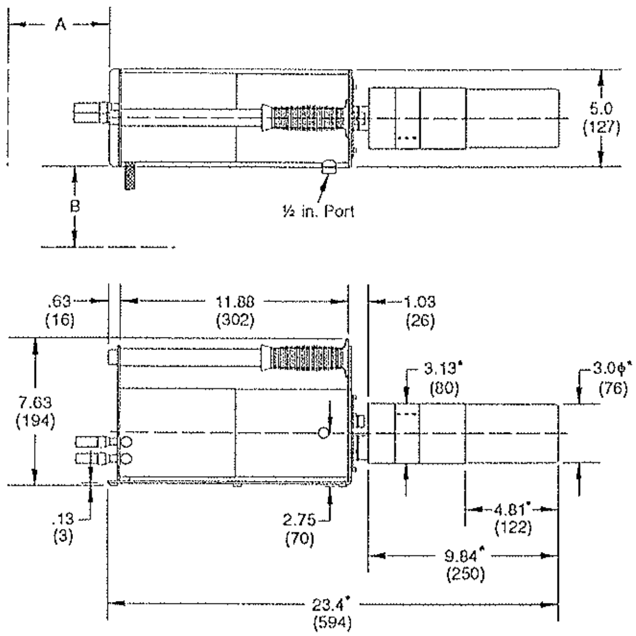
The Canberra Cryolectric II Cryostat is a refrigerating system for cooling semiconductor detectors. The system comprises a compressor which operates on electric power and a cold head which is built into a detector assembly. The compressor and cold head are connected by flexible metal refrigerant hoses. The refrigerant is a proprietary CFC-Free mixture of gases, one component of which is flammable. Each system contains less than 100 grams of the flammable component which allows it to be shipped by air freight. A manufacturers safety data sheet (MSDS) is available from Canberra for the asking. Refer to Figure 3.10 for more information.

3.9.1 Detector Assembly Description

The detector assembly comprises a detector chamber and the cold head or heat exchanger which receives the compressed refrigerant from the compressor. The detector assembly is packaged in a carrier similar to that used with our MAC (Multi-Attitude Cryostat). The refrigerant hose connections are hidden behind a metal shroud that slides over the cold head body for access.

Orientation

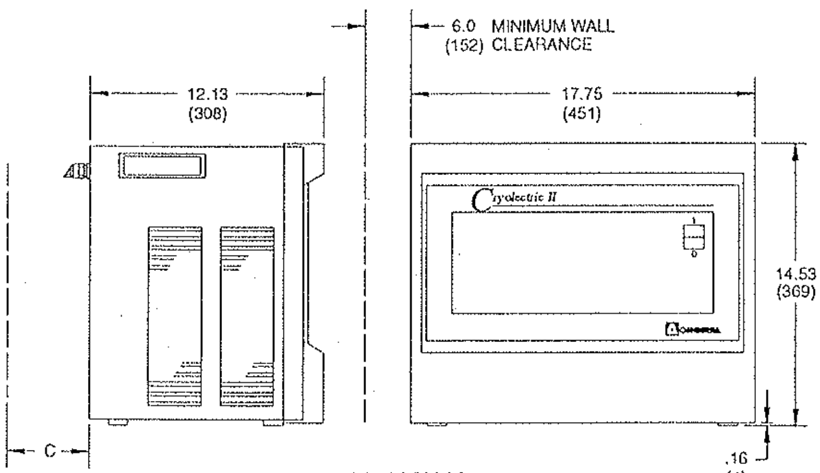
The detector assembly is designed to operate in any orientation. Care should be taken not to put undue stress on the refrigerant hoses. These hoses can be bent in a radius of 15 cm (6 in.) but they *must not* be twisted on their axis.



MINIMUM WALL CLEARANCE			
HOSE CONFIG.	A	B	C
RIGHT ANGLE AT COLD HEAD	0	6.0 (152)	10.0 (254)
RIGHT ANGLE AT COMPRESSOR	6.0 (152)	0	6.0 (152)

COLD HEAD

*End-cap diameter and length shown for detectors of less than 40% efficiency.



COMPRESSOR

Figure 3.10 Cryolectric II Dimensions

Dress the lines so that they are relaxed rather than taut to avoid transmitting vibrations from the compressor the cold head.

3.9.2 Compressor Unit Description

The compressor is a sealed unit of the conventional refrigeration type. A schematic of the compressor unit is shown in Figure 3.11. Since cold head temperatures are very low it is important that the lubricating oil be removed from the refrigerant stream. The compressor unit has an oil separator to provide this function. Care must be exercised to keep oil from migrating to places it cannot be tolerated.

CAUTION The compressor unit must be *upright* and *level* (within 10 degrees) during operation. The compressor unit must not be tilted more than 30 degrees at any time. If the compressor unit is suspected of being tilted (during transport, for example), allow it to remain upright overnight before operating it.

3.9.3 Refrigerant Hoses Description

The detector assembly, the hoses, and the compressor unit are all precharged at the factory. These units may be connected together at the factory or they may be shipped separated. All fittings are self-sealing (Aeroquip Couplings) which are designed to be attached and detached without loss of refrigerant. Care must be exercised, however, as improper procedures can lead to refrigerant leaks.

Vibration Damper

A vibration damper (lead block) may be supplied to stop compressor vibration from getting to the cold head. If needed, attach the damper to the hoses near the cold head.

3.9.4 Unpacking, Inspection and Pressure Check

The Cryolectric II is shipped from the factory in one box. The compressor is at the bottom and the detector chamber is on top. The two are separated by foam packing material. The gas lines may or may not be connected. Lift the detector chamber and the compressor out of the box together if they are attached. Be careful not to stress the gas lines and keep the compressor unit upright at all times.

Inspect all components for damage. If there is physical damage to any of the components notify Canberra immediately.

WARNING When handling pressurized gas lines and other pressurized equipment always use eye protection. Keep the unit away from flames and sparks until it can be determined that there are no refrigerant leaks.

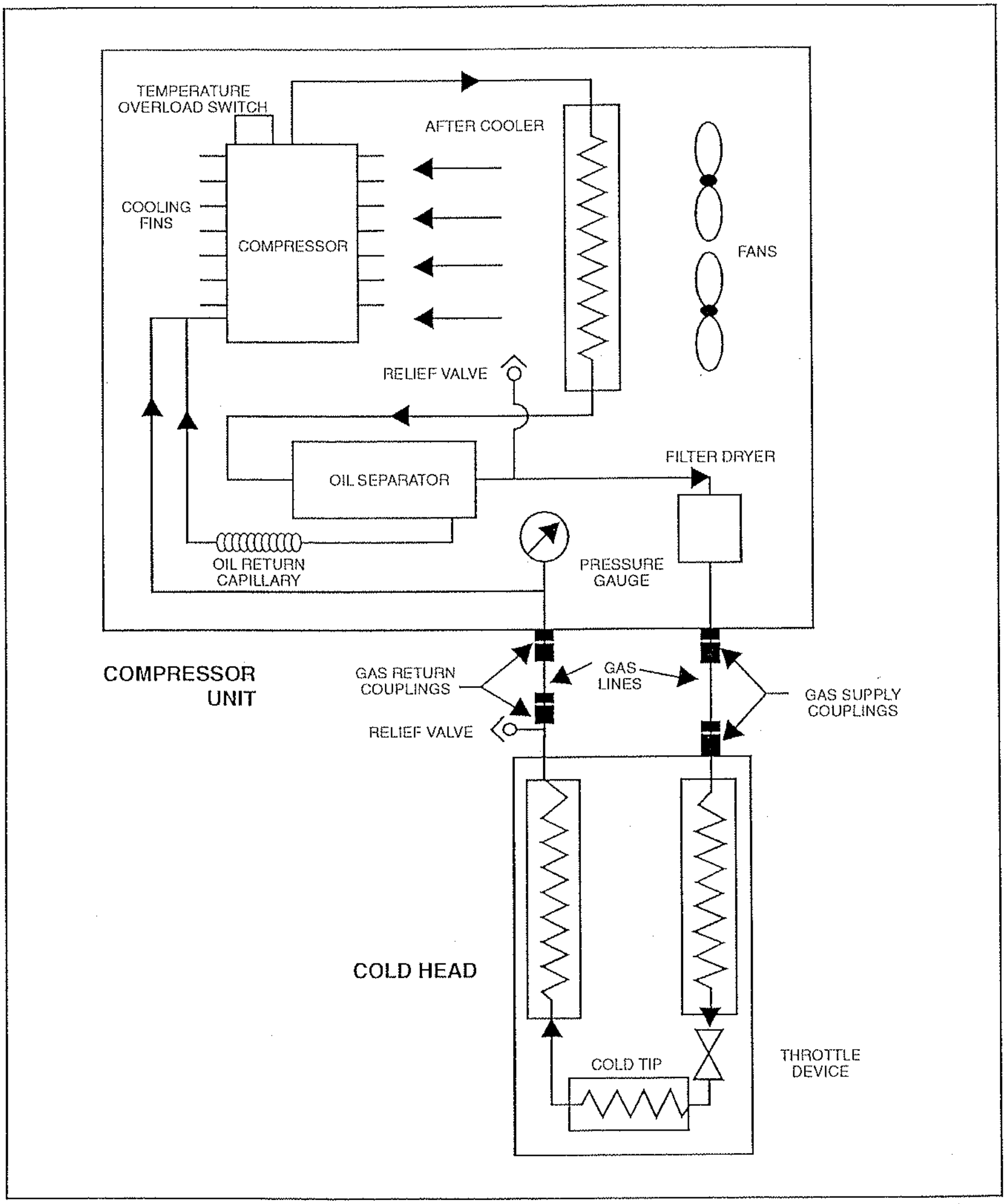


Figure 3.11 Cryolectric II Schematic Diagram

CAUTION Do not tip the compressor more than 30 degrees to avoid oil flow into places it doesn't belong. This can cause system contamination and compressor failure. When received it is best to allow the compressor unit to sit upright and level overnight so that any oil that may have been displaced during shipment can return to the compressor.

NOTE: Retain the shipping container for reuse in case the detector needs to be shipped again.

1. Check the pressure gauge on the rear of the compressor unit after all components have reached equilibrium temperature. The pressure should be within the range shown in Table 3.1 or Table 3.2.
2. The compressor unit will either be shipped from the factory set up for the voltage specified on the purchase order (in which case the voltage requirements will be listed on a tag attached to the power cord) or the compressor will have a voltage selection plug in the power connector assembly with the voltage shown in the window. The voltage choices are 100, 115, 220 and 240 V at 50-60 Hz. Remove this plug by pressing sideways on the detent. Reinstall this plug with the appropriate voltage shown in the window.

Table 3.1 Systems with Flex Lines

Gas Line Length (ft)	Gas Line Charge Pressure (psig)	Compressor Charge Press. (psig)*	System Charge Press. (psig)*
0 to 10	275	275	275
11 to 15	235	275	265
16 to 25	215	275	255
26 to 50	200	275	240

*Tolerance is +5 psig / -25 psig

Table 3.2 Systems with Copper Lines			
Gas Line Length (ft)	Gas Line Charge Pressure (psig)	Compressor Charge Press. (psig)*	System Charge Press. (psig)*
0 to 25	275	275	275
26 to 40	250	275	270
41 to 60	225	275	260
61 to 85	210	275	250
86 to 120	200	275	240
121 to 150	1990	275	235
*Tolerance is +5 psig / -25 psig			

Note: The pressure changes with ambient temperature. The data given in these tables applies at an ambient temperature of 21 °C (70 °F). The pressure increases by about 48 kPa (gauge) per °C (about 1 psig/°F).

3.9.5 Assembly (Gas Line Attachment)

Ignore this section if the system was shipped from the factory with the gas lines attached to compressor and cold head.

WARNING When handling pressurized gas lines and other pressurized equipment, always wear eye protection.

WARNING Never apply heat to a pressurized gas line or other pressurized equipment.

CAUTION Do not crimp the gas lines. Repeated attempts to bend and reposition the gas lines can damage them.

Tools required: 16 mm (5/8 in.) and 20 mm (3/4 in.) open-end wrenches.

1. Decide whether the right angle hose end will be attached to the compressor unit or to the cold head. The right angle ends must be attached first, as shown in Figure 3.12, to ensure that they will exit the unit at the correct angle.
2. All fittings are equipped with protective dust plugs or caps. Do not remove these plugs and caps until you are ready to connect the fittings together.
3. Remove the screw beneath the plastic foot at the rear of the detector assembly and slide the shroud forward to reveal the fittings. For easier access to the fittings, particularly if the right angle fittings are used on the cold head, remove the rear plate of the carrier.
4. Place the system components in the same relative orientation (not necessarily the same places) that you wish them to have in operation. Remember the bend radius of the gas lines is about 6 inches (15 cm) minimum.
5. Remove the dust caps from the right angle hose ends and from the mating fittings.

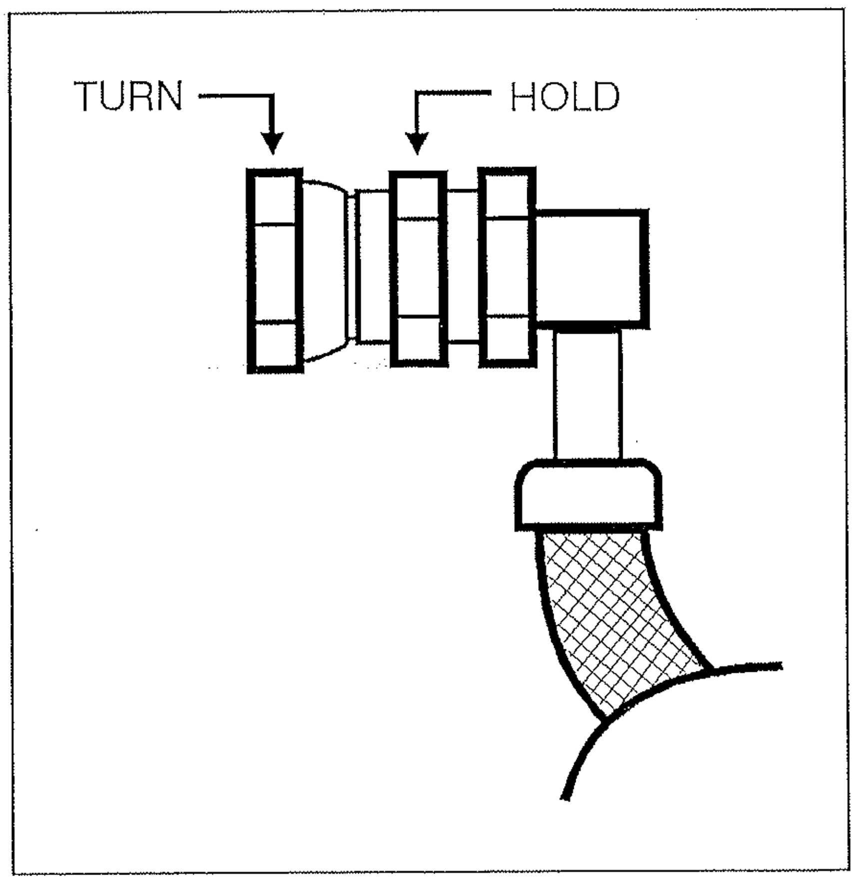


Figure 3.12 Connecting the Right Angle Hose End

WARNING Use caution when connecting and disconnecting the gas lines so that gas does not escape. The fittings must be properly aligned and unstressed for proper engagement. Work in a ventilated area that has no ignition sources nearby.

WARNING Use two wrenches when connecting or disconnecting gas line couplings to avoid loosening the bulkhead coupling. Gas pressure can project the coupling with considerable force.

CAUTION Check the condition of the gasket seal on the plug portion of each coupling. Be sure the gasket is in place and that both the fittings are clean and free of damage. Check the threads and remove any metal slivers or debris that could get into the seal.

NOTE: Keep the caps and plugs in a clean, dry container for future use. If the system is disassembled use them to protect the fittings.

6. Connect the supply and return hoses to their respective fittings using two wrenches to prevent the hose from turning. Observe the markings so as not to mix up the two lines. Tighten to 13-16 newton-meters (10-12 ft-lbs).
7. Dress the lines between the compressor and the detector assembly. Put the detector assembly in the orientation in which it will be used.
8. Remove the remaining hose plugs one at a time and attach the hoses to their respective fittings taking care not to twist the hoses. They should be relaxed - not under torsional stress. Use two wrenches to prevent twisting the hoses. Tighten to 13-16 newton-meters (10-12 ft-lbs).
9. Check the static charge pressure for the entire system and record on the first line in the chart below.

Pressure		
Date	Static	Operational

10. Lift the compressor unit and place it on 10-15 cm (4-6 in.) high blocks at either end to provide access to the bottom of the unit. (Do not tilt the compressor.) Locate three bolts heads in the bottom of the housing near the left side and remove these bolts which secure the compressor during shipment. Save these bolts for reuse in case the compressor unit is shipped again. Remove the blocks and lower the compressor to the floor.

11. The system is now ready for operation. Observe the space requirements necessary for proper ventilation of the compressor. (Figure 3.10)

3.9.6 Operation

1. Plug the power cord into a power outlet with the appropriate voltage and current rating. To avoid ground loops this outlet should be the same one that serves the signal processing electronics which will be used with this detector.

2. Turn on the compressor.

3. After the prescribed cool-down time (see the serial/number tag on the detector), begin checking the detector in accordance with the detector instructions.

4. After several hours of operation record the operational pressure. Check it periodically for several weeks to ensure there are no leaks. The operational pressure is normally around zero psig.

3.9.7 Operation with Power Controller

Electrically powered detectors are subject to partial warm-up when power outages occur. The Cryolectric II will restart automatically when power is restored following an outage. If the power has been off for more than a few minutes the detector may have started to warm-up and if it is re-cooled before it warms up completely, there is a chance that the leakage current will be excessive because of outgassing of the molecular sieve and the adsorption of the outgassing product on the detector surfaces.

The fix for this condition is a complete warm-up followed by re-cooling. The Model 7901-1 Power Controller is an option which prevents automatic restart if power is off for more than a selected interval (3-30 minutes). With this option, no operator intervention is required for short outages, but for long outages manual restart is required. This means that partial warm-ups can be avoided.

Follow the instructions supplied with the Power Controller if it is to be used with the system.

3.9.8 Stopping the Compressor

Turn the power switch to off to stop the compressor.

WARNING During operation liquified refrigerant is present in the system. Never disconnect any part of the refrigerant containing system until the entire system has been turned off and has reached room temperature. Allow 8 hours for warm-up. Failure to do so can lead to over-pressurization and venting.

3.9.9 Restarting the Compressor

Like many refrigeration compressors, the 7903 many not restart properly after a short (<1 minute) power interruption. Restarting immediately may lead to a blown fuse inside the compressor. Refer to Figure 3.13, the compressor's wiring diagram.

3.9.10 Maintenance

No periodic maintenance is required for the Cryolectric II.

Compressor

If the compressor is operated in a dirty environment, however, dust may accumulate on the grilles at the rear and side and the condenser may also become clogged. If this happens, use a vacuum cleaner with a brush nozzle and carefully remove the dust and dirt. Be sure the compressor is turned off and unplugged before opening the case.

Cold Head

The cold head has no moving parts and is thus expected to exhibit little wear in operation. The cold head/cryostat vacuum may deteriorate in time, however, which can prevent automatic restarting if the unit is shut down. See the next section, "Re-Evacuation Procedure" for the procedure to be used.

Incremental Gas Charge Procedure

There can be some loss of gas charge through the self-sealing fittings especially if the hoses are connected and disconnected repeatedly. If the static pressure falls below the levels (including the tolerance) listed in Tables 3.2 or 3.3, it may be necessary to replenish the refrigerant.

A simple means of topping off systems with refrigerant is available from Canberra or from the refrigerator manufacturer, APD Cryogenics. Instructions and 500 cc disposable bottles of the refrigerant with the proper fitting are available from Canberra or from the refrigerator manufacturer, APD Cryogenics. If the static system pressure is above 1400 kPa (200 psig) one or two of these bottles will bring the system pressure back into the operating range.

A two-bottle kit including instructions and MSDS can be ordered by part number 25040-14. The suffix (-14) designates the type of gas. In the unlikely event that your system is charged with a different gas, the gas type is identified on a tag attached to the gas fittings at the time of delivery.

3.9.11 Re-evacuation Procedure

Vacuum is maintained in the Cryolectric II cold head/detector chamber by means of molecular sieves, a material which adsorbs gas molecules when cooled. Although the capacity of the molecular sieves is quite large, it releases most of the adsorbed gas when allowed to warm up as when the unit is turned off. If this gas load is excessive, the Cryolectric II may not cool down again automatically when power is restored.

Depending on the detector size, the outgassing rate, the time since manufacture, the presence of a highly conductive gas, such as helium, in the environment, and other factors, the detector may require re-evacuation. In most cases the period between re-evacuations is expected to be greater than 12 months.

Re-evacuation can be done in the field by qualified personnel using the equipment and procedures described here.

Equipment Required

This describes the minimum requirements for a vacuum pump station (Figure 3.14). A high vacuum pump is preferred if one is available. An LN_2 trapped helium leak detector is an ideal pump station.

- Two-stage rotary vane mechanical vacuum pump
  1. Pump speed > 25 liters/minute (0.9 cfm).
  2. Ultimate pressure < 400 kPa (3 X 10-3 torr).
- Foreline filter (to reduce backstreaming)
- Thermocouple vacuum gauge
- Flexible metal hose and manifold assembly

Evacuation Procedure

To evacuate the Cryolectric II cold head/detector chamber, follow this procedure.

1. Allow the detector to warm up completely by turning off power to the compressor 24 hours before working on the system.
2. Locate the evacuation port. It is about 16 mm diameter by 16 mm long (5/8 in. x 5/8 in.) with a red silicone rubber cover. Use port on the side of the cold head if there is one. Otherwise, use the port located on the flange behind the preamplifier. To access this port, remove the preamplifier from the head.
3. Removing the Preamplifier (only if the side port is not available).

a. Remove the two screws holding the preamplifier cover in place and remove the cover by sliding it carefully over the end cap.

b. Disconnect the low voltage connector (black multi-pin) and the H.V. connector (gray single-pin) from the cryostat feed-throughs.

c. Using a hex key wrench, remove the two screws holding the preamplifier to the cryostat body. These screws are located beneath the preamplifier.

d. Using a hex key wrench, remove the two screws holding the rear panel/clamp together.

e. Now the preamplifier assembly can be removed.

4. Remove the evacuation port cover and clean the vacuum grease out of

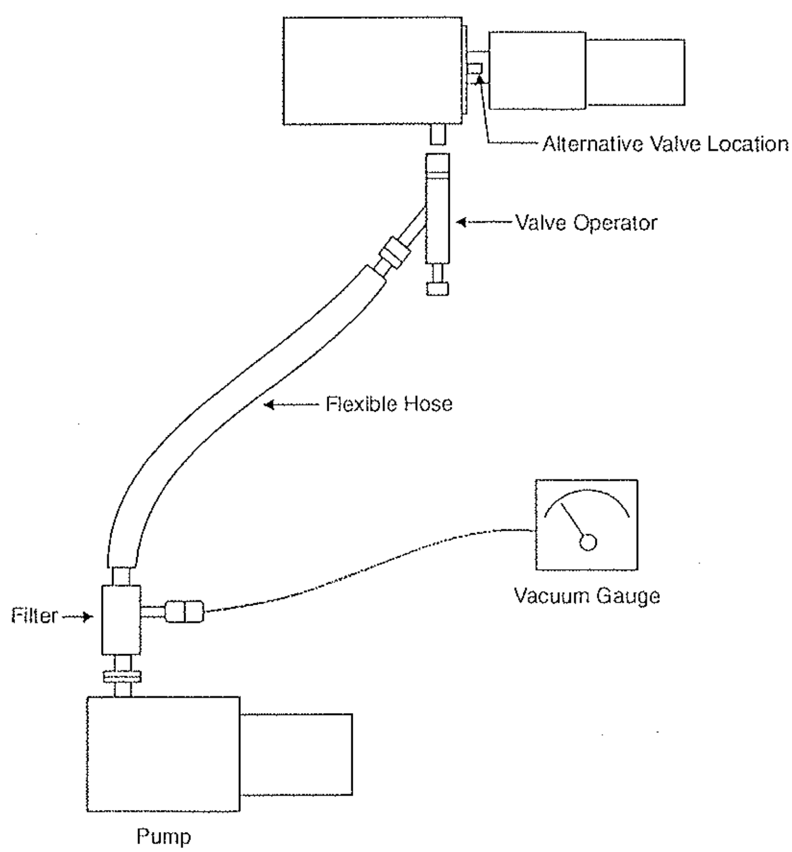
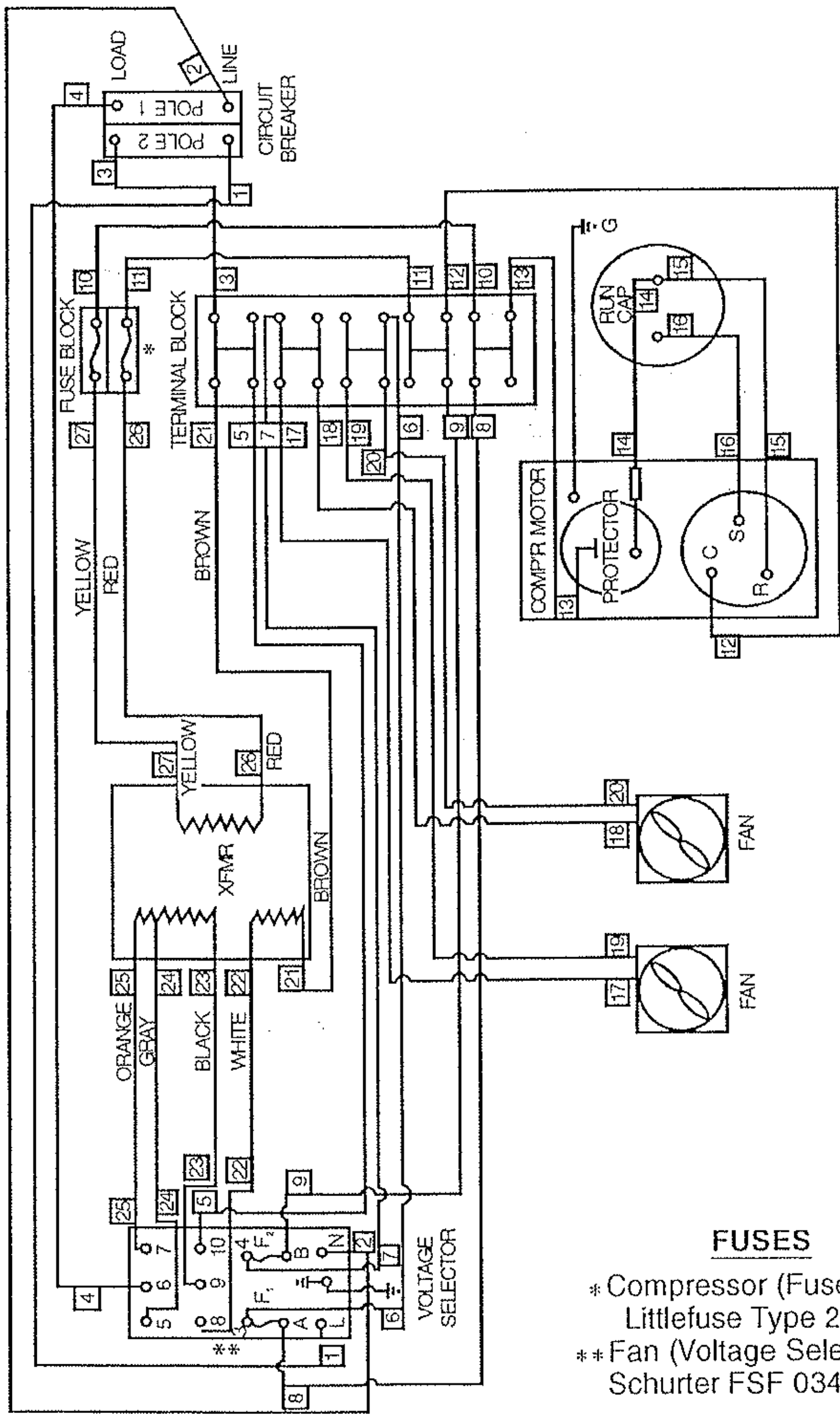


Figure 3.13 Pump Station

the port area using lint-free paper towels or swabs.

5. Attach the valve operator to the evacuation port and tighten. Do not engage the valve plug at this time.
6. With the vacuum pump connected to the valve operator by means of the flexible metal hose, as shown in Figure 3.14, turn on the vacuum pump and the vacuum gauge.
7. Observe the pressure on the vacuum gauge drop from atmospheric pressure to near zero. This should happen within five minutes or so. If it does not drop quickly or if it does not reach near zero levels, check all connections to achieve the correct performance before proceeding.
8. Engage the seal-off valve plug by pushing valve handle inward and turning it clockwise a few turns.
9. Withdraw the handle, pulling the plug out of the valve seat.
10. Watch the manifold pressure rise as the vacuum chamber is opened to the vacuum pump.
11. Continue pumping for two hours. The pumping station should exhibit no signs of a gas load after this amount of time. If it does there may be a leak requiring factory service.
12. When evacuation is complete, push the operator handle in to reseat the valve plug. Hold the handle in while turning it counterclockwise to release the plug, then pull the handle back out. (You must use your sense of touch to tell whether the plug has been released from the valve operator.)
13. Turn off the vacuum pump and vacuum gauge and detach the valve operator.
14. Fill the evacuation port with a small quantity of silicone vacuum grease.
15. Reassemble the system to restore operating conditions.



FUSES

* Compressor (Fuse Block)
Littlefuse Type 218010 (10A)

** Fan (Voltage Selector)
Schurter FSF 034.1516 (1A)

Figure 3.14 Cryolectric II Compressor Wiring Diagram

4. PREAMPLIFIER DESCRIPTIONS

There are several types and models of preamplifiers in use depending on the application. The typical usage is as given in Section 4.1.

The preamplifer manual included in the back of this manual has information on the specific preamp used with this detector.

4.1 PREAMP FEATURES

Preamp Models	Significant Features	Detector Types
2002C, 2002CSL	Cooled FET Warm up/HV Inhibit	Coaxial, REGe, XtRa, LEGe
2008, 2008SL	Pulsed Optical	Ultra-LEGe, LEGe
2002CP, 2002CPSL	Set up for low capacitance detectors	LEGe
2101P 2101N	Transistor Reset Transistor Reset	Coaxial REGe
2002CC	Convertible	Coaxial, REGe

4.2 H.V. INHIBIT CIRCUIT ADJUSTMENT

If the H.V. Inhibit circuit trips and there are no other symptoms indicating a fault (low LN_2, high loss rate, coolness of cryostat, moisture accumulation, low compressor pressure (off), or high detector leakage current), the circuit may need adjustment. Portable detectors should be vertically upright for this adjustment.

Refer to LN Monitor Board Schematic Diagram.

With H.V. *off*, measure the voltage between pins 5 and 6 on comparator A1B. Adjust RV1 until the yellow LED comes on, then turn RV1 in the opposite direction until the green LED comes on. Continue until the voltage between pins 5 and 6 is 50 mV.

5. UNPACKING AND REPACKING

When you first receive your detector, please follow the instructions in section 5.1 for unpacking the detector. Be sure to save all packing materials for possible reshipment.

If you should ever need to return the detector to Canberra for service, please repack the detector for shipment following the instructions in Section 5.2.

5.1. UNPACKING

Remove the cryostat from the box by lifting it vertically by the Dewar handle(s). If the detector has been transported in a cold environment, allow it two hours to come to room temperature before proceeding. This will prevent undue moisture accumulation on sensitive parts of the system.

Remove the cord holding the dipstick to the Dewar and/or holding the plastic bag to the detector chamber. Remove the plastic bag covering the detector chamber and inspect the entire detector system for mechanical damage.

If there is evidence of shipping damage contact the carrier, file a claim for damages, and notify Canberra of the nature and extent of the damage.

Horizontal dipstick cryostats have a plastic foam pillow which cradles the horizontal detector chamber to prevent bending of the dipstick during shipment. This pillow can be removed by cutting the cord or tape securing it to the Dewar's neck.

5.2. PACKING FOR RE-SHIPMENT

Keep all of the packing materials with the original shipping container in case the detector should be shipped to the factory for service or elsewhere for use. We cannot be responsible for shipping damage incurred after initial delivery of the detector or if a detector is returned for in warranty service with improper packing.

Detectors properly prepared for shipment are shown in Figure 5.1.

Dipstick cryostats may be returned to the factory without a Dewar. In this case the dipstick must be packed carefully so it will not be damaged in shipment. Even then there is a greater chance of shipping damage because the smaller packages tend to be handled with less care, and the preferred upright orientation will not be respected.

5.2.1 Pack Detectors Warm

Allow detectors to warm up completely before packing in well-insulated containers. Foam in-place packing material is an excellent insulator. Cold detectors packed in this material are so well insulated that the external cryostat hardware including the sensitive vacuum seals may be cooled to a very low temperature as heat is transferred to the cold inner hardware. If the packing container is well ventilated, this should not be a problem.

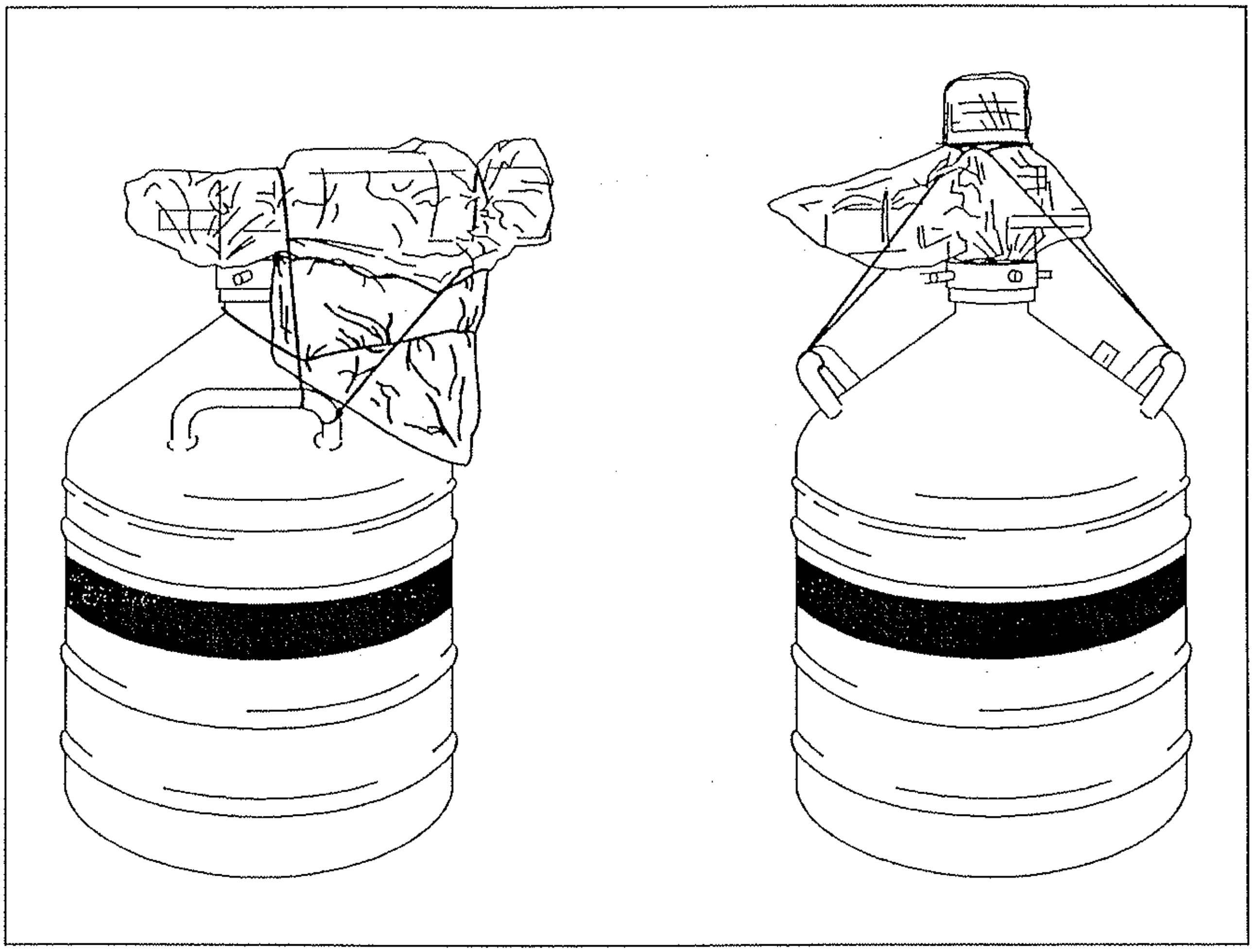


Figure 5.1 Detectors Prepared for Shipment

6. FILLING WITH LIQUID NITROGEN (LN_2)

Before attempting to fill your detector with liquid nitrogen, be sure to read and follow the Warnings and Cautionary Statements listed in Section 6.1

The remaining subsections deal with filling a specific type of cryostat:

- Dipstick Cryostats – Section 6.2
- Integral Cryostats – Section 6.3
- Multi-Attitude Cryostats – Section 6.4

Section 6.5, Temperature Cycling, describes the precautions to be taken if it becomes necessary to temperature cycle your detector

6.1. HANDLING LIQUID NITROGEN

Always handle liquid nitrogen carefully! Its extremely low temperature can produce frostbite!

WARNING!

Liquid nitrogen's temperature is minus 196 °C (77 °K).

Contact with exposed skin can cause severe frostbite!

When spilled on a surface, the LN_2 tends to cover the surface completely and intimately and therefore to rapidly cool a large area.

Protect Your Eyes

The gas issuing from the liquid nitrogen is also extremely cold and can produce frostbite. Delicate tissues such as those of the eyes can be damaged by an exposure to these cold gases which is too brief to affect the skin of the hands or face.

Stand clear of boiling and splashing liquid and its issuing gas. Boiling and splashing always occur when charging a warm container or when inserting warm objects into the liquid. Always perform these operations slowly to minimize boiling and splashing.

Never allow any unprotected part of your body to touch uninsulated pipes or vessels containing liquefied nitrogen: the extremely cold metal may stick fast and tear the flesh when you attempt to pull away from it.

Use tongs to withdraw objects immersed in liquid and handle the tongs and the object carefully. In addition to the hazard of frostbite or skin sticking to cold materials, objects that are soft and pliable at room temperatures usually become very hard and brittle at the temperatures of these liquids and are very easily broken.

Wear Protective Clothing

Protect your eyes with a face shield or safety goggles (safety spectacles without side shields do not give adequate protection).

Always wear gloves when handling anything that is, or may have been, in contact with liquid. Insulated gloves are recommended but leather gloves may also be used. The gloves should fit loosely so that they can be thrown off quickly if liquid should spill or splash into them.

When handling liquids in open containers, it is advisable to wear high-top shoes. Trousers (which should be cuffless if possible) should be worn outside the shoes.

Ventilate the Area

Always handle liquid nitrogen in well-ventilated areas to prevent excessive concentrations of gas.

WARNING!

High concentrations of nitrogen gas in an enclosed area can cause suffocation!

Handle liquid nitrogen only in a well ventilated area.

Never dispose of liquid in confined areas or places where others may enter. Excessive amounts of nitrogen gas in the air reduce the concentration of oxygen and can cause asphyxiation. The gas being colorless, odorless and tasteless cannot be detected by the human senses and will be inhaled as if it were air.

Cloudy Vapor

The cloudy vapor that appears when a liquefied gas is exposed to the air is condensed moisture, not the gas itself. The issuing gas is invisible.

6.2. DIPSTICK CRYOSTATS

Canberra dipstick cryostats are equipped with a fill and vent collar which enables them to be filled without moving the detector chamber. The modern version of this collar is made of silicone rubber which forms a gas-tight seal between the Dewar and detector chamber. The collar is fitted with two identical, thin wall, 9.5 mm (3/8 in.) diameter stainless steel tubes, either of which may be used for filling from a storage Dewar at medium pressure, 40-80 kPa (gage) (6-12 psig). The unused tube serves as a vent for N2 gas that is evaporated during the filling operation. This tube can be fitted with a hose to direct the gas away from the sensitive preamplifier and electrical feedthrough area.

The collar is also equipped with a port for an LN_2 level sensor, such as that used with a Model 1786 LN_2 Monitor.

Transfer of LN_2 from a Dewar to a cryostat by means of a low pressure withdrawal device is illustrated in Figure 6.1.

6.2.1 Warming Up the Dipstick Detector

Should a dipstick detector require a warm up cycle, it is best to remove the dipstick from the Dewar. Loosen the clamp ring if the cryostat is so equipped and slide the dipstick carefully upward. Keep the dipstick either vertically upright or horizontal at all times. *Never* invert a dipstick cryostat.

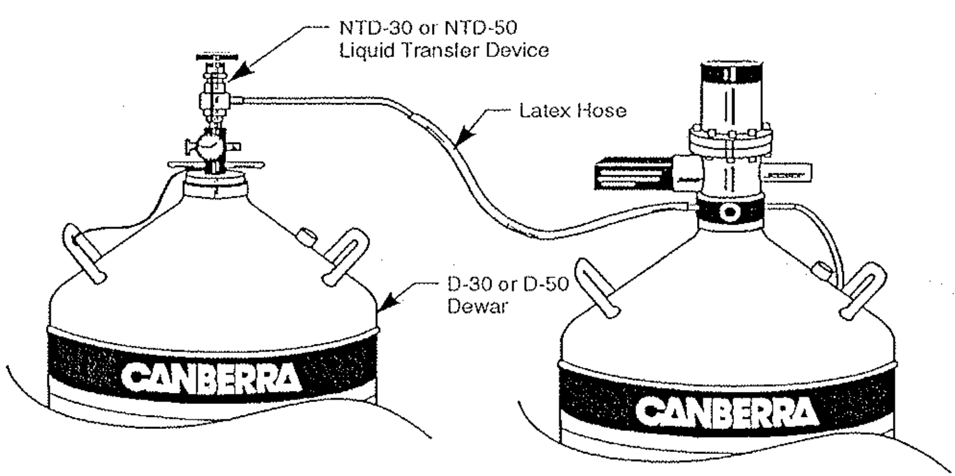


Figure 6.1 LN2 Transfer

If the Dewar is to be emptied, first remove the silicone rubber collar and then pour the contents of the Dewar into another LN_2 container.

Check for and remove any water that may appear in the bottom of the Dewar after it warms to room temperature. The Dewar will warm much more quickly if it is turned on its side to establish convection currents.

A dipstick detector will usually warm up in 12-16 hours (overnight) if it is removed from its Dewar first.

6.3. INTEGRAL CRYOSTATS

Integral cryostats generally have an open neck tube of 40-65 mm (1.5 to 2.5 in.) diameter. Liquid nitrogen can thus be poured directly into these cryostats or can be pumped in from a pressurized container. Be careful not to spill LN_2 on the detector chamber or the preamplifier as components therein may be damaged by the extreme cold temperatures.

The neck-plug should be replaced immediately after refilling as it will prevent ice formation in the neck tube, it will keep foreign matter from falling in, and it will increase LN_2 holding time by forcing the cold LN_2 boil-off gases to the neck-tube surface, thereby reducing heat loss by neck-tube conduction.

If an external LN_2 monitor is used with a integral cryostat, the sensor is usually wired to a BNC connector located in the neck plug. A check on the LN_2 monitor can be made by holding the LN_2 sensor tip just above liquid level until a response is obtained. The monitor must react with the sensor inside the Dewar – pulling it out to verify operation cannot guarantee proper operation because of the extreme difference in temperatures.

6.3.1 Warming Up the Integral Detector

Integral cryostats may be warmed up by first pouring the contents into another LN_2 container and then turning the Dewar on its side without the neck plug. In this orientation most integrals will warm up within 24 hours.

Check carefully and remove any water that may appear in the bottom of the warm Dewar. If allowed to remain, the resultant ice can cause hissing and noise in the detector system.

6.4. MULTI-ATTITUDE CRYOSTATS (MACS)

The MAC should be filled from a source of LN_2 which is at low pressure: ≤165 kPa (gage) (24 psig). A D-50 Dewar equipped with a low pressure withdrawal device (Model NTD-50) is available from Canberra for this purpose. Standalone 160-240 liter pressurized Dewars are also available.

If liquid at high pressure is used, the vaporization that occurs when the pressure is reduced to atmospheric (flash-off) will cause a substantial amount of LN_2 to be blown through the MAC and it will be difficult if not impossible to fill it to capacity. In addition, the Dewar inner could be damaged by high pressure transfer of LN_2.

6.4.1 Fill and Vent Connections

The fill and vent connections are 1/8 NPT male fittings. While hard fittings can be used to transfer the LN_2, it is more convenient to use flexible latex hose which simply stretches over the fittings. The hose can be forced over the hex nut and secured on both sides of the hex nut by a nylon tie-wrap or cord. The hose must not cover the entire nipple as this can lead to excess cooling of the Dewar external hardware.

CAUTION

The Fill and Vent Ports can be damaged by excessive force when attaching or detaching hoses with metal fittings.

Always use a wrench to prevent excess torque on the nipple. See Figure 6.2.

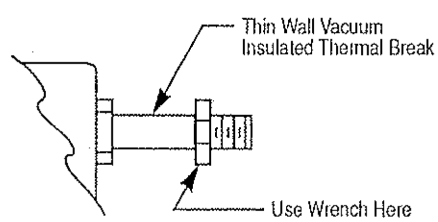


Figure 6.2 Fill/Vent Port Connector

The transfer line should be as short as practical, no more than 1 m (3 feet) is ideal. It should be kept away from the detector and preamplifier chamber to prevent moisture accumulation on these delicate parts. The transfer line should be insulated for the same reasons.

The vent line should be directed away from personnel to avoid injury. It should be sufficiently long to vaporize any liquid blow-by or overflow, or it should be directed into a reservoir which can contain it safely. A Dewar is a satisfactory reservoir.

6.4.2 Filling Orientation

The fill and vent ports exchange roles depending on the orientation of the detector. The given designators apply to the unit when it is oriented horizontally, which is recommended. When the fill and vent ports are pointing downward, the given designations also apply. However, when the ports point upward, the roles are reversed, i.e., the port designated vent is the fill port and vice versa. See Figure 6.3 for construction details.

Please note that the MAC does not have exactly the same LN_2 capacity in every orientation, so some spillage can occur when the unit is filled in one orientation and changed to another. This is normal.

The capacity is usually greater when the MAC is horizontal. If filled in this orientation, you can expect to lose some liquid when changing to uplooking or downlooking orientations.

Port Cover

Another effect to be aware of is percolation, which can occur if the MAC is jarred or shaken. To reduce this effect and to decrease the LN_2 loss rate in some orientations, MACs are equipped with a port cover which blocks the fill port. The cover also directs the vent gas away from the vent port, thus preventing snow or ice formation on the vent port. The right hand port should be blocked when the detector is down looking and the left hand port should be

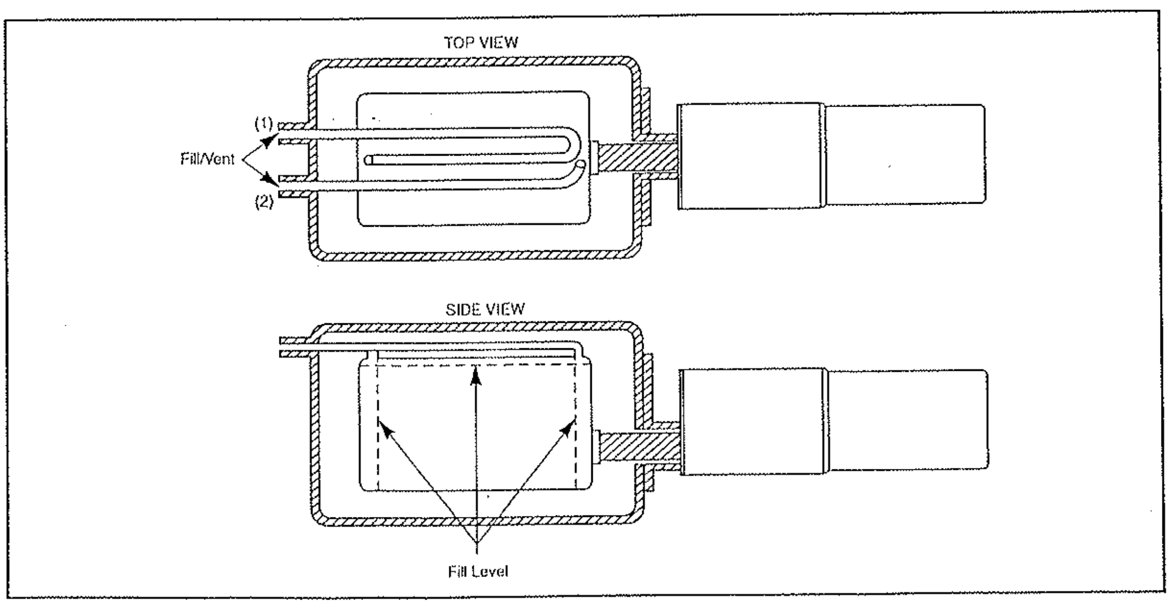


Figure 6.3 MAC Port Construction

blocked when the detector is up looking. A nipple and hose are provided to direct nitrogen gas and spillover liquid away from the user.

Install the cover in the appropriate orientation when the detector is horizontal, then change the orientation. Spillage and loss rate will be minimized if you do this properly.

6.4.3 Cool-Down Time

Typical detectors will cool down sufficiently within 2-6 hours of filling. The LN_2 loss rate will be extraordinarily high during the cool-down period so the MAC should be topped off with LN_2 a few hours after the initial filling.

6.4.4 Warming Up

A MAC can be emptied quickly by orienting it with the end-cap pointing upwards and blocking the vent port. Under this condition the boil-off gases cannot escape and will thus force most of the LN_2 out of the fill port. Use a hose to direct the LN_2 into another LN_2 container.

Because the MAC cannot be emptied as readily as can an open-mouth Dewar, the natural time required for complete warm up is quite long. To ensure that the detector undergoes a complete warm-up cycle once warm up has begun, purge the detector with dry nitrogen gas.

Do NOT purge with air or with N_2 having significant water vapor content.

To do this, the same considerations should be given to the fill and vent ports as outlined in Section 6.4.2. However, the dry nitrogen gas should be forced into the vent port rather than the fill port. An overnight purge at 3 to 5 liters/minute should be sufficient to complete the warm-up cycle. Without a purge warm up may take up to 48 hours.

6.5. TEMPERATURE CYCLING

Ge detectors, unlike Ge(Li) detectors which fail on warm up, can withstand repeated and prolonged periods of room temperature storage. While it is only reasonable to expect a detector to last longer if it is kept cold at all times, with certain specific and important precautions, no serious compromise in life time will result from temperature cycling.

Temperature cycling can even be a remedy for certain problems that may occur in the use of Ge detectors. The important precautions are given below.

6.5.1 Turn Bias Off During Warm Up

A detector should not be allowed to warm up with bias applied. When a detector warms up, the molecular sieves outgas and pressure within the cryostat rises. If electrical discharge occurs as a result of this increased pressure, the sensitive detector surfaces and the preamplifier can be damaged. A Canberra

Model 1786 LN_2 Monitor can be used to disable the bias supply when the LN_2 drops below a satisfactory level. Some detectors are equipped with a built-in Warmup Sensor/HV Inhibit circuit which provides an inhibit signal to the HV power supply.

6.5.2 Complete Warm Up

It can take more than 24 hours for a detector to warm up completely and several hours to cool down thoroughly. When a warm-up cycle has begun, the detector should be allowed to warm up fully before being cooled down again. Otherwise some of the residual gases that are absorbed by the detector surfaces may be frozen there. If the detector warms up completely, the molecular sieves will tend to pump the system clean when the detector is recooled. If a detector is inadvertently cooled after partial warm up, a full warm up cycle will likely restore any lost performance. A complete temperature cycle is often prescribed as a fix for performance problems.

Dipstick cryostats (removed from Dewar), Integral cryostats (on side without neck plug), and electrically cooled cryostats (power off) will warm up in 12-24 hours. MACs may take longer, especially if the LN_2 is not purged completely at the start.

6.5.3 Prevent Moisture Accumulation

As noted in section 6.5.1, when a detector warms up, the molecular sieves which maintain vacuum in the cryostat outgas and pressure within the cryostat rises. Under this condition, the outside of the cryostat will be cooled by the internal hardware until it, too, reaches room temperature. Therefore, it is normal for a cryostat to be cold during warm up and to a lesser extent upon cool down (on cool down the molecular sieves usually get cold and begin pumping before the internal hardware cools down fully).

Moisture which accumulates during temperature cycling should be removed. If humidity in the environment is excessive, moisture may accumulate during normal operation. Environmental humidity should be decreased to prevent both the short term (leakage current in HV circuit/feedthrough) and long term (corrosion) effects of moisture accumulation.

6.5.4 Precautions – Vacuum Failure

When a cryostat exhibits signs of catastrophic vacuum failure, such as heavy moisture or ice formation on the surfaces, extremely high LN_2 loss rate, and so forth, the adsorber (molecular sieves or charcoal), which normally maintains vacuum, may be virtually saturated.

When allowed to warm up, the adsorber will outgas and the pressure in the cryostat will rise. Canberra cryostats and Dewars sold by Canberra have a pressure relieving seal-off valve which is designed to prevent dangerous levels of pressurization.

The pressure rise, however, can be high enough to break or break loose beryllium windows and/or end-caps. A frozen or ice clogged seal-off valve may fail to relieve pressure, resulting in dangerous levels of pressurization.

Precautions

For these reasons use extreme caution in handling cryostats with symptoms of catastrophic vacuum failure. When you do have to handle them, take the following precautions:

1. Stop using the failed unit immediately. Do not allow it to warm up until additional steps are taken to prevent damage or injury due to overpressurization.

2. Drape a heavy towel or blanket over the end-cap and point the end-cap away from personnel and equipment. If the unit is in a shield, close the shield door.

3. Call the factory for further instructions if the incident occurs during working hours.

4. If it is impractical to keep the unit cold until advice is available from the factory, keep the end-cap covered with a heavy towel or blanket and place the unit in a restricted area in a container (corrugated cardboard, for example). If the unit is in a shield, let it warm up in the shield with the door closed.

5. After the unit has warmed up, cautiously check for overpressurization (outwardly bulging end-caps or windows). If there are no signs of pressure, the unit may be shipped to the factory for repair. Consult the factory for shipping information.

7. SETUP AND TEST

The significant specifications of Ge detectors are few in number, and detectors are not complex instruments, so it is possible to verify the performance of a detector with relative ease – provided that the proper equipment is available and correct procedures are used. The equipment used in conjunction with a Ge detector must be of the right type and in good working order to ensure good system performance. Likewise, the procedures must reflect the standards of the manufacturer or there will be unexplained differences in performance between tests in the factory and in the field.

7.1. EQUIPMENT REQUIRED

The Setup and Test section assumes that the test equipment listed here is available. For efficiency measurements, the ^{60}Co source should be calibrated to NIST standards.

- Ge Detector, Cryostat, and Preamplifier
- NIM Bin and Power Supply – C.I. Model 2000 or Equivalent
- Amplifier – C.I. Model 2026 or Equivalent
- MCA – with 8192 ADC Range, 4096 Memory, and Digital Readout
- Detector Bias Supply – C.I. Model 3106D, or Equivalent or Model 3102D for bias of 2000 volts or less.
- Voltmeter (Analog or 3-1/2 digit)
- Oscilloscope – 50 MHz bandwidth, 5 mV/div.
- Sources as in Table 7.1

Table 7.1 Test Sources

Detector Type	^{60}Co	^{57}Co	^{55}Fe	^{109}Cd
Coaxial	P	S		
REGe	P	S		S
XtRa	P	S		S
LEGe		S	P	
Ultra-LEGe		S	P	
Well	P	S		
BEGe	S	P	S	

Where P = Primary source and S = Secondary source