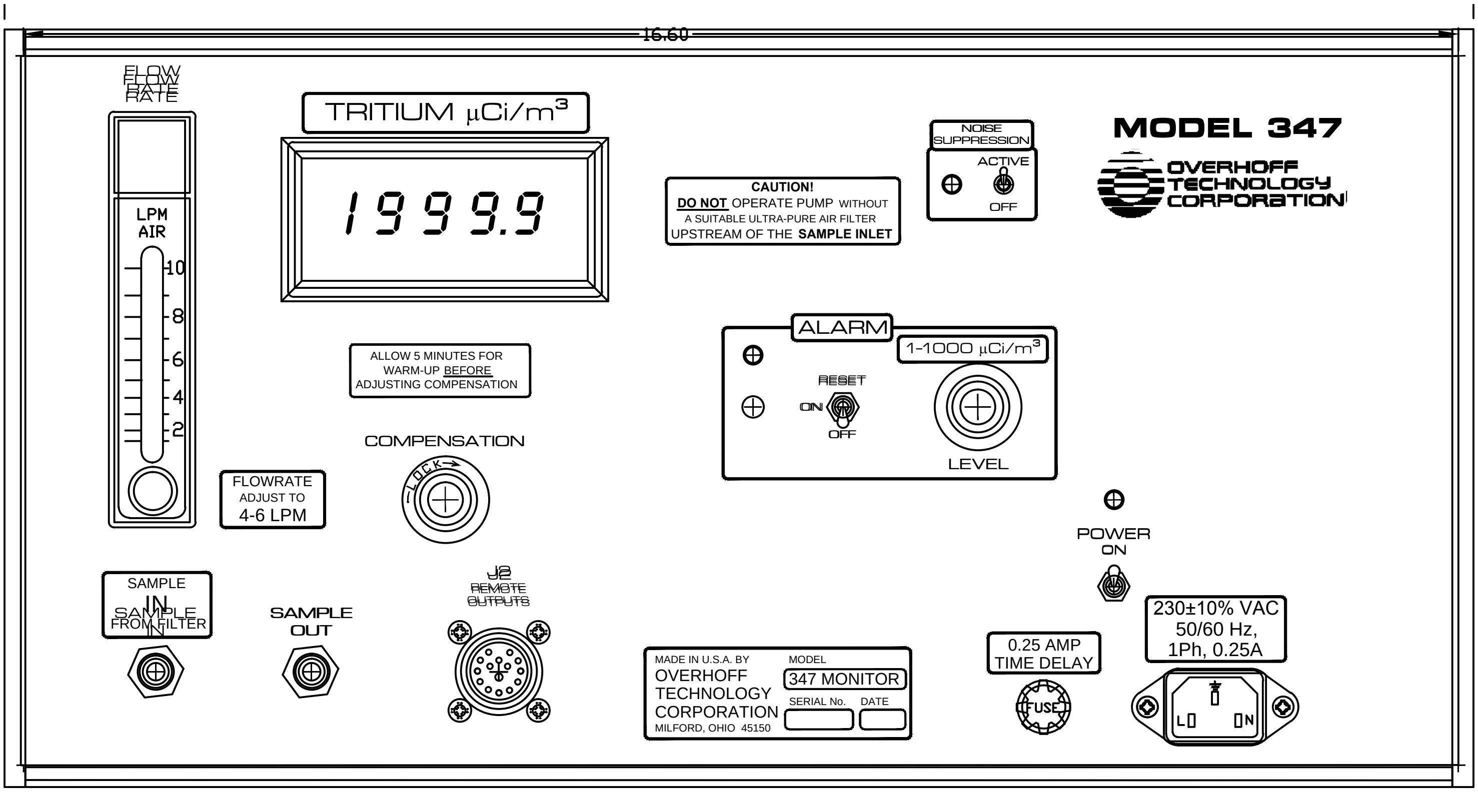
OPERATION/MAINTENANCE MANUAL

TRITIUM MONITOR
MODEL 347

OVERHOFF TECHNOLOGY CORPORATION
1160 US ROUTE 50, MILFORD, OHIO, USA

Tritium Monitor Model 347 in a Table Top Enclosure, Gamma Compensated, Quadruple Ionization Chambers, Digital Measurement Display in μCi, Inhibited Radon Response and a Single Alarm System. Includes an External Pump System with Ultra Pure Filter.

TABLE OF CONTENTS



NOTES:

1. DIMENSIONS ARE INCHES (MILLIMETERS)

2. ALLOW FOR 16" (406mm) OF DEPTH BEHIND FRONT PANEL

3. SAMPLE IN/OUT FITTINGS ARE HOSE BARBS FOR VINYL TUBING, $\frac{5}{16}$" (8mm) OD, $\frac{3}{16}$" (5mm) ID.

FIGURE 1
FRONT PANEL

1.0. GENERAL INFORMATION

1.1. INTRODUCTION

A tritium monitor is an instrument designed to determine the presence and level of radioactive gas (tritium) in air or other gas streams. These monitors may be used to detect radioactive gases in many applications like:

room air
stacks, hoods, or other effluent passages
process piping
glove boxes, and similar.

These monitors are generally calibrated in terms of (micro) Curies per cubic meter though other units can be used as requested (Bequerel, pCi/cm^3, etc.).

The principle of measurement is based on collecting the current that is generated by the radioactive decay (of tritium) inside an ionization chamber. The ionization current is proportional to the concentration of the gas radioactivity, as well as to the specific activity of the radionuclide (tritium) being detected.

A tritium monitor consists of the following parts:

1. An ionization chamber to collect the ionization current.
2. A sampling system to circulate the sample (air) through the ionization chamber.
3. An electrometer to amplify the very weak ionization current.
4. All other associated electronics to process and display the signal.

Ionization chambers respond not only to the airborne radioisotope which circulates through the ionization chamber, but also respond to the presence of external high energy radiation capable of ionizing the air inside. Therefore, ionization chambers will respond to X-rays and gamma radiation as well.

To overcome this effect, Overhoff Technology Corporation (OTC) tritium monitors can be supplied with compensating ionization chambers. Here a second ionization chamber is used to cancel the effects of external radiation upon the measuring ionization chamber. Additional gamma radiation suppression can be accomplished by using lead shielding. OTC tritium monitors are equipped with special circuitry to identify and reject ionization currents that are produced by decaying radon, or other airborne alpha emitting radioisotopes.

1.2. AVAILABLE CONFIGURATIONS

OTC tritium monitors are available in a number of different configurations. Form and size depend upon the application and use.

Portable instruments are battery powered and light weight.

Instruments used for fixed applications employ 19" rackmount enclosures which carry power supplies and signal processing circuits. They may also contain the ionization chamber and electrometer.

Ionization chambers and electrometers are available for remote installation where the "display" enclosure is connected via a shielded ten conductor cable.

1.3. FEATURES

While the basic purpose of the OTC tritium monitor is to measure the presence and level of tritium (or other airborne radioisotopes) the monitors may be supplied with a number of user selected special features.

Your particular instrument, which is described in this manual, has these special features.

1. Measurement range, 0.1 to 1999.9 $\mu Ci/m^3$
2. 0.1 $\mu Ci/m^3$ Resolution
3. Minimum Detectable Activity (MDA) of 0.5 $\mu Ci/m^3$
4. Quadruple ionization chambers with nominal volume of 2 liters each arranged in a cruciform pattern for optimum gamma compensation.
5. External Pump System

1.4. GENERAL DESCRIPTION

This monitor consists of quadruple 2 liter ionization chambers with an integral electrometer coupled to the electronic circuits in the display cabinet. The chambers are mounted internally in the cabinet. The cabinet contains all signal processing, alarm and external interface circuits, read out, and all required power supplies. The measurement ionization chambers serve to collect the current produced as tritium decays radioactively. The compensation ionization chambers are identically constructed, but sealed. It serves to cancel the effects of external gamma fields. The electrometer serves to transform this current into a form and magnitude suitable for display, alarm, and external uses, as the ionization current itself is very weak.

The signal processing circuits serve to reject unwanted signals and to translate the electrometer signal voltage into a form and magnitude suitable for display, alarm and external uses as well.

The alarm circuits provide acoustic and visible signals to denote that a preset level of measurement has been exceeded.

The purpose of the power supply needs no special comment.

1.5. RESPONSE OF IONIZATION CHAMBERS TO RADIATION

1.5.1. SPECIFIC IONIZATION CURRENT

The current generated in an ionization chamber is the result of collecting electrons generated from ionization of gas caused by occurrence of a nuclear event in the gas inside.

The number of ions (magnitude of the current) is influenced by numerous factors like the energy, physical nature and particle range. As a good rule of thumb for beta particles in air one secondary electron (and one positive ion) is formed for every 34 electron volts of energy lost by the primary beta particle as it travels its path.

The Curie is defined as 3.71×10^{10} nuclear decay events per second. The mean energy of tritium decay is 5.69 kev. Therefore it is calculated that 1 Curie of tritium produces an ion current very close to

$$1 \times 10^{-6} \text{ amperes.}$$

A concentration of 1 $\mu Ci/m^3$ of tritium in a chamber of a volume of one liter will thus produce a current of

$$1 \times 10^{-15} \text{ amperes.}$$

It must be remembered that the ionization chamber responds to the quantity of tritium present inside. This is to say that effects due to temperature and pressure may need to be accounted for. Even if a sample of gas is known to contain tritium at a certain concentration, i.e., parts per million or other, it must be remembered that the activity (amount per unit volume) is dependent upon temperature and pressure. The ionization chamber only responds to the quantity of radiation inside.

1.5.2. THE WALL EFFECT

Ionization chambers also exhibit several other peculiarities. The wall effect can be a problem if the track length of the decaying particle is appreciable when compared to the dimensions of the chamber.

For ionization chambers with small linear dimension, if the track of ionized particles is comparatively long (the mean free path), an appreciable part of the energy of the primary particle is simply dissipated in the wall of the ionization chamber. This effect increases as the chamber dimensions shrink, and decreases as the chamber dimensions increase.

In air, atmospheric pressure, the maximum mean free path of a tritium beta particle is of the order of five millimeters, and for chambers with linear dimensions of ten centimeters or greater this "wall" effect becomes negligible.

1.5.3. RECOMBINATION EFFECTS

At high concentrations, another effect takes place.

When the ion population density is high, some of these positive and negative ions will recombine and are lost to the measurement electrode.

This is known as saturation or as stagnation since the effect is more pronounced in corners of the ionization chamber where the potential field gradient is low. The effect can be reduced by increasing the ionization chamber voltage.

For measurements of tritium at very high concentrations, such as are required when working with pure T_2, special chamber geometries are employed, long slender ionization chambers, with relatively large internal ion collecting electrodes and short spacing between the chamber elements enhance field gradients. With even moderate polarization potentials of 100 V or so, such chamber geometries show linear response even to pure tritium streams.

1.5.4. DISCRIMINATION AGAINST ALPHA PULSES

Since the energy of an alpha decay is at least 10,000 times more active than that of a tritium beta event, suppression of alpha pulses is needed in order to distinguish the presence of tritium at low levels. Stable and accurate measurements of tritium for values below 5 $\mu Ci/m^3$ can only be obtained with means to suppress response to alpha decay.

Alpha decay events, as detected in an ionization chamber, are not instantaneous. The special circuitry which recognizes the alpha pulses requires some amount of time to suppress the event. During pulse suppression, the instrument analog circuitry is placed in a "holding" mode, response is frozen during the interval associated with the alpha event. The holding intervals occur at random, but effectively add to the apparent time constant of the electronics. The instrument response becomes slower with increasing radon or gamma noise background. For large background the instrument will even freeze completely, the alpha pulse light will be permanently illuminated.

1.6. CONTAMINATION (PLATE OUT) OF IONIZATION CHAMBERS

Tritium gas will combine with the oxygen and the moisture in the air to form oxide of tritium (HTO or T_2O). Chemically indistinguishable from normal water or water vapor, the tritium oxide will attach itself to the walls of an ionization chamber and bond both physically as well as chemically.

Thus, prolonged exposure to high (or even modesty high) concentrations of tritium will contaminate the walls of the ionization chamber, which will appear as ZERO OFFSET to the displayed measurement. It is possible, but laborious, to decontaminate ionization chambers, but it is often simpler just to replace the chambers with new ones.

1.7. TECHNICAL SPECIFICATIONS

The instrument described in this manual has been designed and constructed for your particular application.

It has been built and tested to the specifications listed on the next pages.

Circuit diagrams and interconnections between parts of the monitor, as well as those leading to user selected remote devices or interfaces, are given at the end of this manual.

Consult the factory for further information, or for application engineering at

1160 US Route 50, P. O. Box 182
Milford, OH 45150-9705, USA
Telephone (513) 248-2400
Facsimile (513) 248-2402
E-Mail Support@Overhoff.com

1.8. PERFORMANCE SPECIFICATIONS

When used for the measurement of airborne tritium gas or vapor (HT, T_2, HTO or T_2O) the following major performance specifications will apply.

1.8.1. MEASUREMENT

RANGE	single, 0.1 to 1999.9 $\mu Ci/m^3$
DISPLAY	4 ½ digit panel meter
ACCURACY	±10 % of reading, 0.5 $\mu Ci/m^3$ whichever is greater
STABILITY AND DRIFT LONG TERM	±1 $\mu Ci/m^3$, ambient temperature, after warm-up
NOISE	<0.5 $\mu Ci/m^3$, 1 sigma, with 20 second time constant
GAMMA COMPENSATION	second ionization chamber pair of equal volumes, mounted in cruciform pattern, serves to cancel effects of external gamma fields
RESPONSE RATE ELECTRONIC	two linear time constants 20 seconds for <80 $\mu Ci/m^3$ 3 seconds for >80 $\mu Ci/m^3$)
WARM-UP TIME	less than 5 minutes required for high voltage power supplies to stabilize

1.8.2. ALARM SYSTEM

ALARM SYSTEM	single level alarm set-point adjustable from 0 to 100.0 $\mu Ci/m^3$
INDICATORS	acoustic signaler
MODE	a. RESET. Alarm will reset if the signal level recedes below the set point. b. ON. Alarm can only be reset if the signal level is below the set point and the Reset function is selected. c. OFF. Prevents any alarm system action.

1.8.3. IONIZATION CHAMBER

VOLUME	measuring: 3200 cm^3 total wetted: 4000 cm^3
ELECTRODE	solid wall electrodes
GASKETS	silicone rubber
PRESSURE	0.1 to 2 atmospheres
PORTS	1/8" N.P.T., fitted with hose barb fittings for 3/16" I.D. vinyl tubing
MATERIALS OF CONSTRUCTION	chamber cans, stainless steel base plate, aluminum

1.8.4.	ENVIRONMENTAL TEMPERATURE	storage: -40° C to +60° C operating: 5° C to +40° C
	HUMIDITY	0 to 95 % R.H.
1.8.5.	FRONT PANEL INTERFACE	J2, bayonet connector uses a MS3116F-14-15P Mating plug see wire list at end of manual
1.8.6.	POWER	230 VAC ±10 %, 50-60 Hz 20 W maximum
	FUSE	.25 A, slow blow, .25" diameter x 1.25" long
1.8.7.	PHYSICAL	
	CABINET	frame constructed of aluminum extrusions front and rear panel are 1/8" thick, aluminum covers are aluminum sheet
	DIMENSIONS	8.75" H x 17.0" W x 16.00" D
	WEIGHT	45 lbs.
1.8.8.	SAMPLE FLOW SYSTEM	
	PRE-FILTER	high efficiency 99.99% at 0.1 microns, filter cartridge Solberg No. HE04
	PUMP	Rubber Diaphragm/Linear Motor Type Medo Model VC0201-E1 Max Pressure: 1.5 psi Max Flow: 20 LPM Operating Voltage: 115 VAC, 50/60 Hz, 0.5 A
	ULTRA PURE FILTER	Teflon membrane on a polypropylene support 2.75" dia x 10" long Part No. 44095K31, mounted in a polypropylene housing
	DIMENSIONS	17.0" Wide x 16.0" Deep x 7.0" High
	WEIGHT	20 lbs
	FLOW METER	Adjustable rotameter, 0 – 10 LPM mounted on front panel of tritium monitor

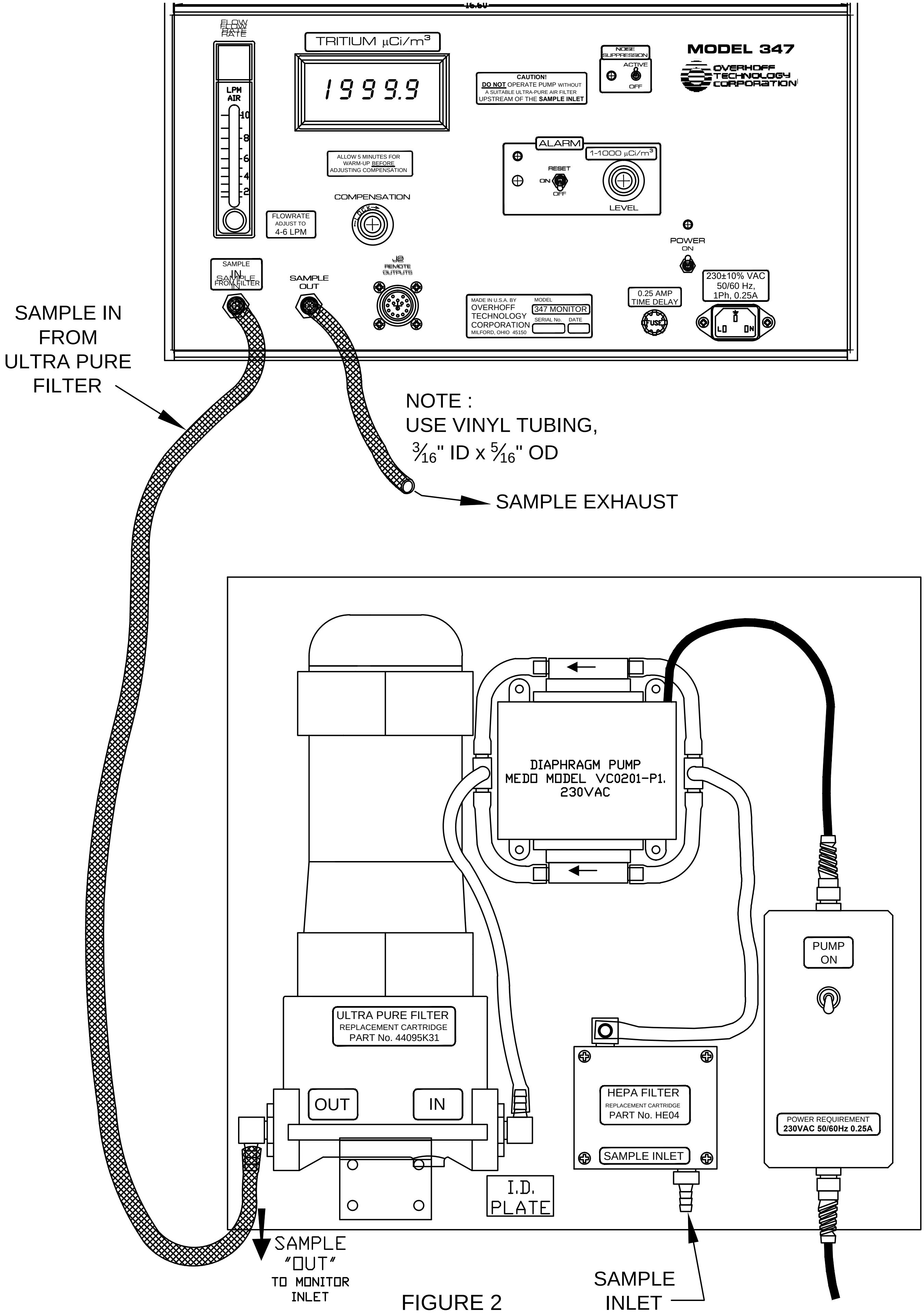


FIGURE 2
HOSE CONNECTIONS

2.0. EQUIPMENT AND INSTALLATION

2.1. EQUIPMENT SUPPLIED

1. Enclosure containing all associated electronics, displays and ionization chamber/electrometer assembly
2. Detachable AC line cord, 8ft (2.5m) long
3. Mating plug for J2 Output Connector, MS3116F-14-15P
4. Operation and Maintenance manual in paper and electronic formats
5. External pump system
6. 3 meters of sniffer hose

2.2. INSTALLATION

NOTE: NOT SUITABLE FOR USE IN A WET LOCATION. NOT SUITABLE FOR USE IN EXPLOSION HAZARD ENVIRONMENTS

The following information is provided to the user to ensure stable and accurate performance.

The cabinet can be located on any flat surface, such as a table top, or, it can be mounted to a wall bracket, or on a small moveable cart. In all cases, the instrument must be protected against vibration, shock, moisture and dirt.

Gamma compensation of this instrument has been designed to correct for normal terrestrial background, and significant artificial gamma background. In the event that the instrument is to be used in the presence of somewhat higher gamma background, the user may wish to construct a lead shield to reduce radiation incident upon the monitor.

ELECTRICAL GROUNDING

The electrical and electronic equipment grounding is often considered only form the viewpoint of hazard and safety. Indiscriminate or excessive grounding may actually enhance the potential of danger and disturb the proper internal operation of the instrument. The electronic circuitry, including logic, adjustment controls, and local and remote displays, are centrally and all inclusively grounded at the ionization chamber module. The circuit system common line is electrically connected to the metal frame or housing of the electrometer module. When signal outputs are connected to remote displays, computer interfaces, or similar devices, it is necessary that no significant ground potential differences exist between the monitor and other equipment. If significant potential ac or dc differences exist, shifts in the instrument “zero” can appear.

THE FOLLOWING IS RECOMMENDED:

1. Make all interconnections. The AC power shall be connected using the flexible line cord provided. Activate total instrument. Allow ten minute “warm-up”. Adjust zero if needed.

2. Attach remote connections (devices) and verify <u>absence</u> of change in zero.

If the zero has changed, check for ground loops and spurious ac or dc potential differences from one location to the other.

Select a site for the instrument, turn off the main power switch and the switch for the pump.
Attach all remote equipment with the wiring as supplied by OTC, or as designed locally for interface or remote alarms. Refer to 2.3.1. for important information.

2.2.1. PRECAUTION, SAMPLE FLOW SYSTEM

A high efficiency dust filter must always be installed at the input of the measuring ionization chamber. Failure to include a dust filter will cause debris build-up in the chamber and the monitor will behave erratically. Monitors placed into lines carrying pure dust free process gases are an exception to the dust filter rule.

A flow rate of 5 liters per minute is recommended for this instrument. Too low a flow rate causes sluggish response. Too high flow rates induce significant pressure changes within the ionization chamber, which shifts it out of proper calibration.

2.3. OPERATION

After ensuring that the instrument is installed, and that the pneumatic system is checked, all in conformance to the preceding instructions, the following steps are suggested.

1. Locate and turn OFF the mains power switch.
2. Select the OFF position of the alarm mode toggle switch.
3. Adjust the alarm level to full scale.
4. Select active mode for noise suppression
5. Attach mains line cord
6. Turn mains power switch ON.
7. Warm up five minutes minimum. Adjust the compensation potentiometer to obtain a ZERO reading on the meter.
8. Adjust the alarm set point potentiometer.
9. Switch the alarm mode toggle to the ON position.
10. Allow instrument to settle for up to ten minutes.
11. Activate the external pump, set flow meter needle valve for desired flow rate (typically 3 to 6 liters per minute).
12. Instrument is now in service.

2.3.1. INSTALLATION OF REMOTE OR ANCILLARY SYSTEMS

A front panel bayonet connector provides many connections for remote meter display, alarm relay contacts. A wire list for these connections is given at the manual's end.

These connections can be made prior to placing the monitor into active duty.

WARNING: CARE MUST BE TAKEN NOT TO CREATE GROUND LOOPS. THE SIGNAL CIRCUIT COMMON OF THE MONITOR IS ELECTRICALLY CONNECTED TO THE FRAME OF THE IONIZATION CHAMBER.

The Level Alarm relay contacts close upon alarm condition and are rated at 0.25 amps, 100VDC or 60VAC. The alarm relay operates in the fail-safe mode. The relay is energized with the instrument in a "NO ALARM" state.

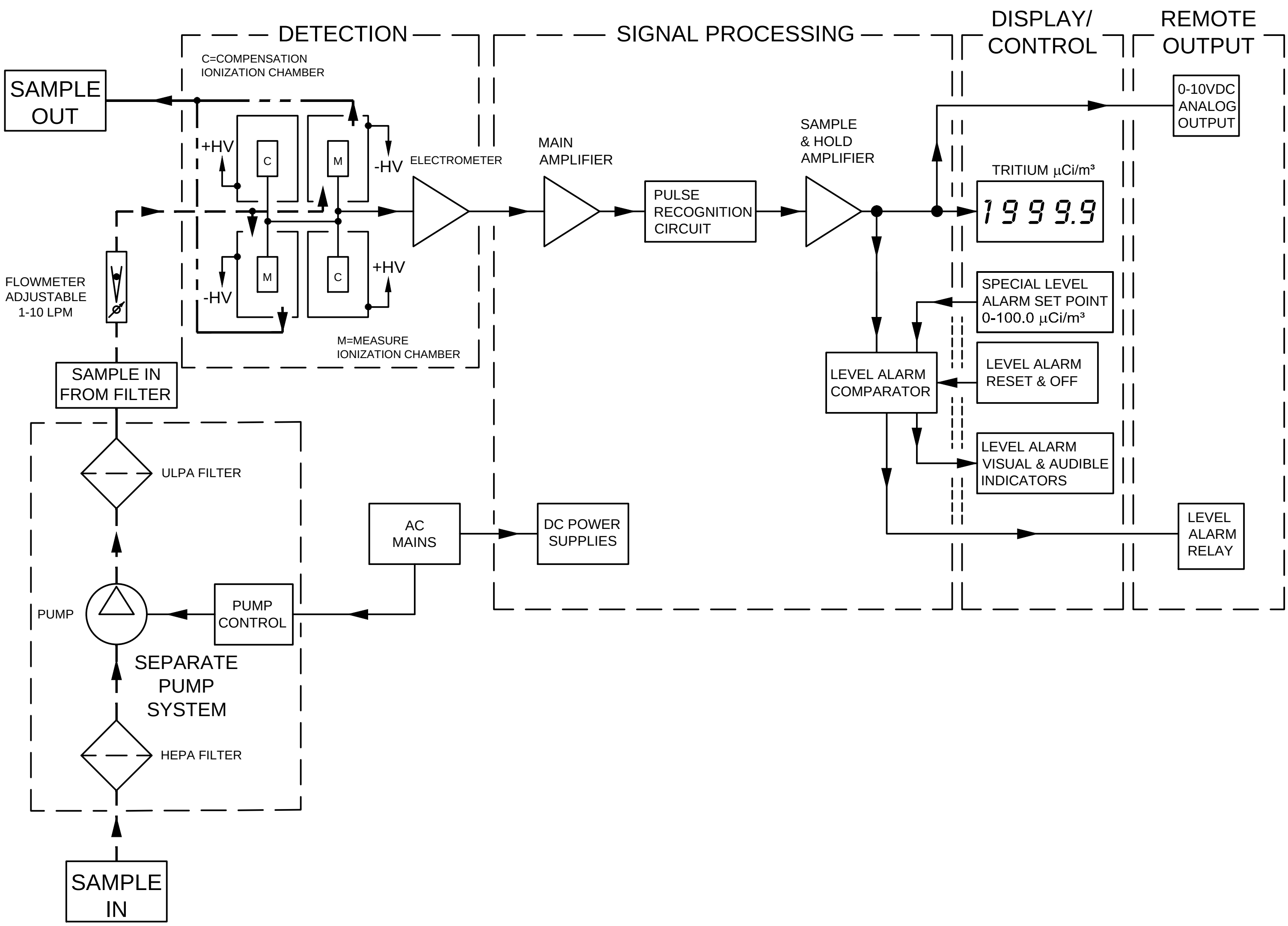


FIGURE 3
BLOCK DIAGRAM
OVERHOFF TECHNOLOGY CORPORATION
MODEL 347 TRITIUM MONITOR

3.0. INSTRUMENT ARCHITECTURE, DESCRIPTION

3.1. GENERAL

This section contains a simplified basic description of the functioning of the individual components of this monitor. The description is provided as background information for the user, engineer, or technician responsible for service and calibration.

3.2. PNEUMATIC

The pneumatic system of the monitor is comprised of the dust filter, ionization chamber and pump.

3.2.1. DUST FILTERS

A high efficiency particulate air (HEPA) filter should be used in order to reduce pressure drops to practical minimums. This type of filter acts to remove particulates and ions to a high degree of efficiency. Large particles are removed mechanically. Small particles and ions are removed electrokinetically through triboelectric action.

3.2.2. IONIZATION CHAMBER

The ionization chamber serves to segregate the positive and negative charges arising from nuclear decay. In principle, the current collected by the ion (or electron) collecting electrode is linearly proportional at the transducer, to the gas activity.

The wall of the measurement chamber is at a negative potential with respect to the collecting rod. The wall attracts positive ions and the collecting rod collects electrons. The ionization chamber, the collecting rod and the electrometer preamplifier are mechanically rigid and massively designed so that microphonic and piezo-electric effects are minimized. These effects disturb proper alpha pulse detection.

3.2.3. PUMP

The pump is located upstream of the ionization chamber. Excessively large flow rates should be avoided since they may lead to appreciable pressure drops in the ionization chamber with a consequent loss in accuracy of measurement. Too low a flow rate will result in sluggish response.

3.3. CIRCUIT DESCRIPTION

CAUTION: This instrument has not been designed for indiscriminate opening or disassembly of the internal parts. It contains highly sensitive semiconductors which are destroyed by even the slightest electrostatic discharge.

3.3.1. IONIZATION CHAMBERS

In its simplest form, an ionization chamber is an enclosed volume with two electrodes. Voltage is applied between the electrodes, generating an electric field which will segregate and collect electric charges which are created by nuclear events occurring inside the chambers. Nuclear events may consist of ionization of air molecules by external or internal alpha, beta or gamma radiation.

The OTC monitors are designed to measure tritium. Activity of tritium decay is such that a concentration of 1 $\mu Ci/m^3$ in a volume of 1 liter will generate an ionization current of about 10^{-15} amperes. This is a very weak current.

Alpha pulses from naturally occurring radon, are much more energetic. They can produce short current bursts of up to 10^{-13} coulombs during decay, and therefore appear as large noise “spikes” which can seriously impair tritium measurement.

Gamma radiation also has a strong effect. In an ionization chamber, in air, a gamma radiation field of 1 mr/hr will create the same amount of ionization as 90 $\mu Ci/m^3$ of tritium.

A tritium monitor, in order to measure to low concentrations, should respond only to tritium and be immune to alpha or gamma radiation. For this purpose, a second ionization chamber system has been included to balance out any ionization current contribution from external gamma radiation.

In the 347 series instrument, the two ionization chambers are arranged side by side. This provides good gamma compensation in all directions, especially for fields incident parallel to the front or rear panel of the instrument.

Several hundred volts polarizing potential is supplied to the ionization chambers. A negative voltage is applied to the measurement chambers, and a positive voltage of equal amplitude is applied to the compensation chambers.

3.3.2. ELECTROMETER

Also known as a transimpedance amplifier, it serves the purpose of converting the extremely feeble ionization current into a voltage suitable for further signal processing and measurement display.

The heart of the electrometer consists of a specially selected ultra high impedance semiconductor device which has been chosen both for ultra low internal current leakage as well as long term d.c. stability. The semiconductors used in the 347 instrument are suitable for measurement of currents as low as 10^{-16} amperes.

In all 300 series instruments, the electrometer is directly attached to the ionization chamber pairs and is protected by solid metal. This configuration helps to reduce effects from vibration.

3.3.3. SIGNAL PROCESSING AMPLIFIER

The signal processing amplifier converts the output of the electrometer signal into a 0 - 10 V signal for driving the panel meter, the alarm system and remote signal outputs.

Proprietary circuitry is used for the recognition and elimination of transient signals due to alpha pulses generated by radon decay or due to passage of high energy cosmic rays.

This circuitry is active in the 0-60 $\mu Ci/m^3$ range, and is disabled for all higher activities in order to increase speed of response where it is most needed. The electronic time constant is typically 20 for activities below 60 $\mu Ci/m^3$, but drops to 5 seconds or less for all higher activities.

A "compensation" potentiometer has been included to null offsets indicated on the display.

3.3.4. ALARM CIRCUITS

This monitor is equipped with a single independent signal alarm. The set point can be set for any value 0-100.0 $\mu Ci/m^3$ by means of a ten turn potentiometer located on the front panel.
Once activated, the alarm system becomes latched, remaining active until reset or disabled by the mode control switch, which has three positions:

- RESET, this deactivates the alarm system provided that the measurement signal level is less than the alarm set point
- ON - Alarm system ready
- OFF - this prevents any alarm system action.

1. The signal alarm activates an acoustic signal and a visual red LED.
2. The alarm may be switched ON or OFF.
3. The alarm will continue to operate until manually RESET even if the displayed signal has receded below the set point.
4. The alarm has relay interface connections on the front panel J2 connector.

3.3.5. POWER SUPPLIES

All power supplies are fully regulated. Low voltage (±15 V) supplies are used through out to power the semiconductor circuitry. The polarization potential for the ionization chambers, nominally ±150 V are fully regulated, noise and ripple free.

4.0. CALIBRATION

INTRODUCTION

Calibration (or verification) of tritium monitors can be accomplished by three different methods. The object is to make sure that the instrument displays reading which correctly corresponds to the activity of the tritium laden gas stream passing through the ionization chamber.

Each method has advantages and disadvantages.

The direct method involves the introduction of tritium in an exactly known concentration and adjusting the monitor to read correctly. The second method, is to expose the ionization chamber to a gamma flux of known (repeatable) intensity. The third method is to simulate the ionization current by introducing a known electric current directly into the electrometer.

The tritium monitor is brought into proper calibration by adjustment of a trimmer potentiometer included for this specific purpose.

FIRST METHOD

To ensure traceability to National Standards, the first method is generally mandated by government authorities. This method is time consuming, and is quite difficult to perform with precision. This method is, however, useful as a "type" test, and can serve as a basic accurate calibration from which the gamma response (the second method) can be cross correlated.

SECOND METHOD

Uses an external gamma field, a field strength of 1 mr/h should produce a meter reading of 90 $\mu Ci/m^3$. A standard instrumentation calibration gamma range facilities can be used.

THIRD METHOD

All OTC ionization chamber - electrometer modules carry a BNC receptacle to which a precisely calibrated ultra high resistor can be attached. Using Ohm's law, and knowing the volume of the ionization chamber, a voltage value can be calculated for a properly simulated ionization current.

4.1. FIRST METHOD, TRITIUM GAS CALIBRATION

The first method involves the injection of tritium into the ionization chambers in an amount that will produce an accurately predictable concentration. The tritium monitor calibration potentiometer is then adjusted to make the measurement display coincide with the predicted gas concentration.

In order to do this, one needs a source of tritium gas with a known activity and knowledge of effective volumes of ionization chambers and all other volumes involved.

Gas sources are normally found to be tritium gas calibrators (consisting of a lecture bottle filled with tritiated methane at a known activity, plus pressure regulators, valves and an accurately known sample chamber). The calibrator enables one to inject tritium at a calculated activity into a loop comprising the ionization chamber and calibrator.

Documentation furnished with the calibrator will provide data concerning the STP activity of the bottled gas.

This is the activity in Curies (or milliCuries) of 1 cubic centimeter of gas at a standard pressure of 760 Hg at 0º C.

Instructions with detailed procedure for use are supplied with gas calibrators. A table for the determination of decay factors is usually included. The half life of tritium is about 12.33 years.

Some general hints can be given.

It is important that the calibration sample be well circulated through the entire calibration system loop.

Adequate time should be allowed for the system pressure and temperature to come to equilibrium, and that no excess pressure is built up.

The inclusion of a previously calibrated “master” or “reference” tritium monitor the sampling loop is highly recommended.

The calibration can actually be repeated for several levels of tritium activity. This is not done in order to verify the linearity of the tritium monitor (which is highly linear) but to ensure that the calibration process itself is free from subtle errors.

If several monitors all require calibration, it is permissible to connect them all at once in a loop.

4.2. SECOND METHOD, GAMMA CALIBRATION

Ionization chambers are often used for direct gamma detection and measurement. The ionization chambers used for the measurement of radioactive gases are similarly sensitive to gamma radiation.

With access to a certified gamma range, calibration facility, tritium monitors can be calibrated using the relationship

1 mr/hr yields the same ionization current as 90 $\mu Ci/m^3$ of tritium.

CAUTION: The ion current resulting from irradiation with gamma rays is a function of the TOTAL MASS inside the chamber. When performing gamma calibration, it is important to always note the ambient temperature and pressure as changes in these variables will alter the gamma response in accordance with normal gas laws.

4.2.1. CALIBRATION VERIFICATION USING A SMALL GAMMA CHECK SOURCE

For purposes of periodic verification of calibration of a tritium monitor one may use a small laboratory gamma check source of a type which is commonly used for G-M counters or other survey instruments. A 1 mCi radium needle is also handy.

If a tritium monitor has previously been calibrated by any other method, gas, gamma, or electrical, its response may be checked by using the small check source.

The source is placed at a defined location relative to the ionization chamber, and the monitor response is observed.

This source is used as a quick and simple check, returning the source to the defined spot should always produce the same instrument response, provided, of course, temperature and pressure variations are taken into account.

4.3. THIRD METHOD - ELECTRICAL EQUIVALENCE METHOD (FACTORY METHOD)

The third method involves the use of a substitution for the ionization current. In the early 60's George Soudain at Toulouse University France, determined that an activity of 1 $\mu Ci/m^3$ of tritium produces an ion current of 0.995×10^{-15} A per liter. By knowing the ionization chamber's true volume, one can calculate the monitor display for any simulated current.

While this method is of primary interest for calibration at high levels, since it is obviously undesirable to work with high levels of radioactive gases, electrical calibration is certainly valid for all levels of measurement.

In practice, a known current is injected into the electrometer in substitution for an ionization current. With a known value for this current, the instrument is adjusted to display the calculated reading equivalent to ionization from gas or photons (gamma).

4.4. GAS METHOD, PRACTICAL PROCEDURE

The following steps are to be taken in sequence:

1. Aquatint yourself with the contents of the calibrator manual

2. Flush the ionization chamber to ensure that it contains no moisture and radioactive gas.

3. Attach suitable plumbing for tritium injection of a known activity. A gas calibrator consisting of a tank (lecture bottle) containing tritiated gas of a known concentration (certified to national standards) together with a system of pressure gauges and accurately known standard volumes can be used to inject tritium into the ionization chamber under calibration.

4. Activate the monitor

5. Allow 5 minutes for “warm up”

6. Turn the COMPENSATION potentiometer until the panel meter indicates ZERO.

7. Inject tritium gas in order to provide an activity of at least 100 $\mu Ci/m^3$ (the higher the better).

   Calculating the activity produced by using the gas calibrator involves knowledge of the concentration of the contents of the tritium tank, quantity of tritium injected into the system, and the total volume of the system which includes all wetted volumes. This includes those of the entire ionization chamber system (inside chamber and ion trap), tubing or piping connections, pump volume, and any of the calibrator.

8. Remove the cover to the calibration control. Insert a small screw driver and adjust the electrometer trimmer potentiometer until the monitor displays the correct reading.

9. Replace the cover for the potentiometer.

4.5. DIRECT GAMMA CALIBRATION **NOT APPLICABLE**

Due the cruciform arrangement of the ionization chambers, the 347 tritium monitor **CANNOT** be directly calibrated using a photon (gamma) source of radiation.

GAMMA CHECK SOURCE VERIFICATION, is the preferred method of using a gamma source.

SEE 6.2. FOR PROCEDURE OUTLINE.

NOTE: Take note of the ambient temperature and atmospheric pressure. These factors should be taken into account when using a gamma source.

4.6. ELECTRICAL CALIBRATION, PRACTICAL PROCEDURE (FACTORY METHOD)

Based upon the relationship that the electrical activity of 1 Curie of tritium generates an ionization current of 1×10^{-6} A, we calculate that for a chamber of 3.2 liters, we can expect a response equivalent to

1 $\mu Ci/m^3$ for every 3.2×10^{-15} A.

A BNC socket is located on the side of the electrometer, the center conductor of which is connected to the ion collecting electrode via a reed relay.

A standard ultra high megohm resistor, encapsulated into a BNC plug, is attached to the BNC socket and a known voltage is applied to the input end of the resistor.

The value of the resistor is engraved onto the BNC case, or is otherwise recorded.

Thus, knowing the voltage, and the resistance, it is simple to calculate the current, and to calculate the expected panel meter display.

In order to perform this electrical calibration, the following steps may be performed.

1. Zero the monitor.
2. Attach the standard high meg resistor (typically of the order of 1×10^{12} Ω nominal value) to the electrometer BNC socket.
3. Attach a variable source of voltage between the hook end of the BNC resistor and the chassis of the electrometer base plate (ground).
4. Monitor this voltage with a calibrated voltmeter.
5. Using Ohm's law, calculate the expected panel meter display.
6. Adjust the calibration potentiometer as required.

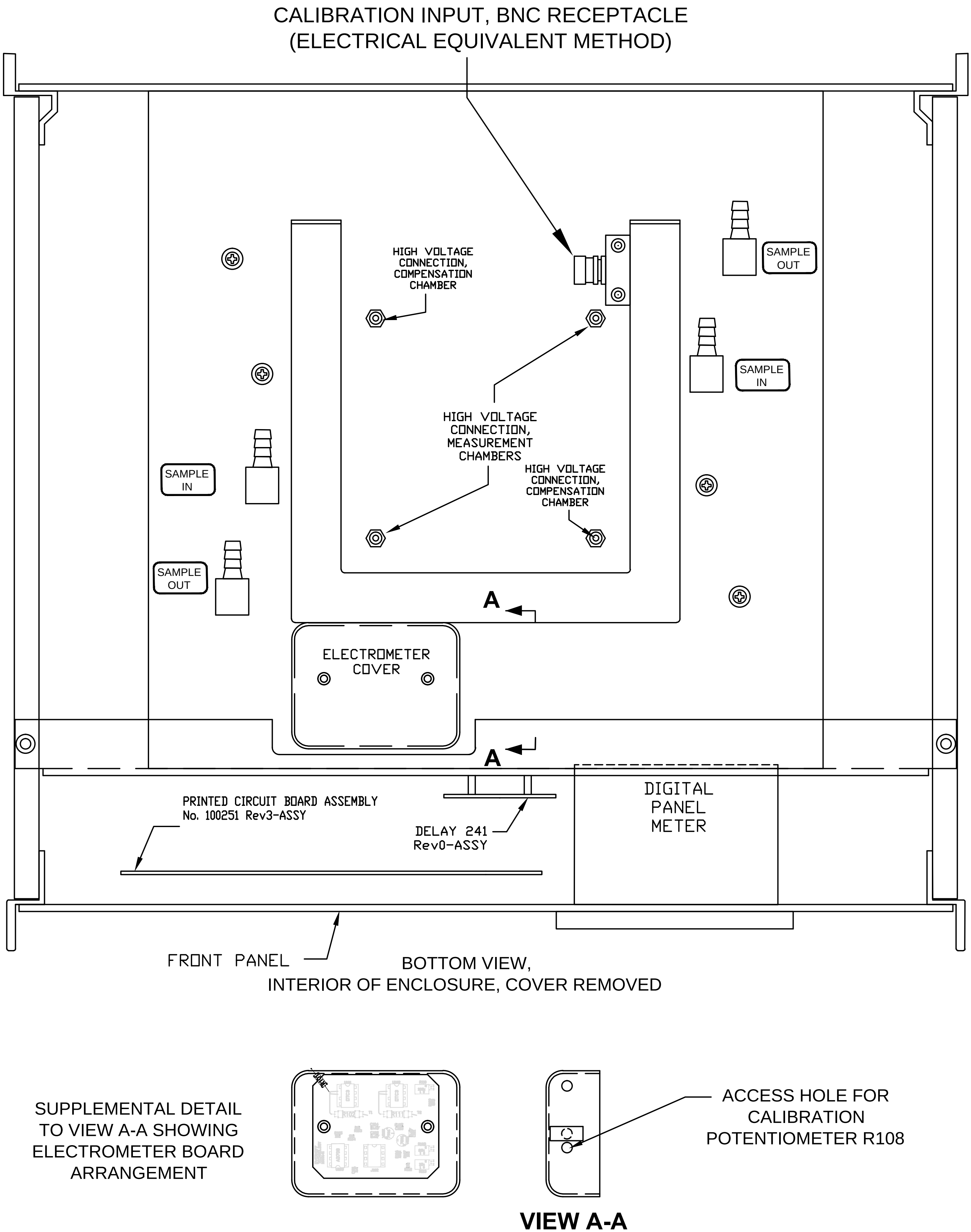


FIGURE 4
CALIBRATION INPUT AND ADJUSTMENT

4.7. EVIDENCE OF MALFUNCTION, PERIODIC CALIBRATION

Good practice indicates that instrument performance and calibration be verified at periodic intervals. Log books should be kept, data should include items such as

- Date
- Test method
- Test results
- Identity of worker

OTC tritium monitors have been designed to be highly stable, and response variations from test to test should be minor. Only small calibration changes should ever be needed.

Large apparent changes in calibration, or in instrument behavior, are indicative of malfunction or component failure.

Contamination of the ionization chambers by dirt, moisture or plated out tritium can cause erratic behavior, and shifts in "ZERO" reading. Malfunctioning defective, or failed electronic components can also create large apparent changes in calibration.

If malfunction is suspected, the instrument must first be reconditioned or repaired. The monitor should only be recalibrated once it has been assured that it is in working condition.

Consult the factory for repair, maintenance or any work which entails service beyond the subjects covered in this manual.

Call, email or fax the factory and request engineering service assistance.

OVERHOFF TECHNOLOGY CORPORATION
Telephone (513) 248-2400
Facsimile (513) 248-2402
Email: support@overhoff.com

5.0. REPAIR AND TROUBLESHOOTING

Repair of the tritium monitor is, in general, restricted to replacement of modules.

The complete instrument or faulty modules should be returned to the factory (Overhoff Technology Corporation) for repair, after which they will be returned to the customer.

Repair of defective wiring or connections, as well as faulty relays or fuses, may be undertaken by the user's technical personnel, after thorough review of the descriptive information obtained by contacting the factory.

Listed below are a number of faults that may be remedied by simple removal and replacement procedures.

5.1. ELECTRICAL

1. POWER LOSS: the pilot LED is dark.

   ACTION: Check fuses and incoming line power.

2. DAMAGED RELAY

   ACTION: First remedy the cause of the damage, then replace the relay.

3. PANEL METER READS NEGATIVE

   Probable Cause: Moisture in sampling line.

   ACTION:
   1. Dry out all sampling lines, pump and other tubing with stream of dry air, do not exceed a flowrate of 25 LPM and maintain normal flow direction, otherwise the pump will be damaged. Replace dust filter.
   2. Replace entire ionization chamber assembly

   Contact the factory for replacement parts, or return the instrument for factory service.

4. ERRATIC READING

   Contact factory.

5. SIGNIFICANT CHANGE IN CALIBRATION

   Contact factory.

7. METER READS OFF SCALE

PROBABLE CAUSE: Electronic failure.

ACTION: Contact factory, or replace printed circuit board

8. MALFUNCTION OF ALARM SYSTEM

PROBABLE CAUSE:
1. Defective relay.
2. Defective electronics.

ACTION:
1. Replace relay.
2. Replace printed circuit board.

5.2. MECHANICAL

1. LOW FLOW

POSSIBLE CAUSE:
1. Plugged sample lines.
2. Very dirty dust filter.
3. Defective pump.

ACTION: Determine cause and correct as needed.

6.0. MAINTENANCE

Overhoff 347 series instruments have been designed for many years of trouble free service. Very little maintenance is required, but some periodic attention may be necessary.

Pump life is in excess of 10,000 hours of actual use; ensuring that the instrument is operated only with dust filters in line preserves its life.

When not in use, the monitor should be stored in a cool dry environment.

6.1. OPERATOR MAINTENANCE

The following operational checks may be performed at daily, weekly or monthly intervals to suit.

Inspect dust filter for excessive dust build up. Check the flow rate. Does the pump have sufficient flow when 10ft of the sniffer hose is connected to the inlet of the dust filter?

GAMMA CHECK, If a tritium monitor has previously been calibrated, a low intensity gamma radiation source check can be used as a quick verification of monitor performance. On the top surface of the instrument case towards the front which is the defined location for "**GAMMA CHECK**". When using the identical gamma check source, at the defined spot, it should always produce the same instrument response, provided, of course, temperature and pressure variations are taken into account. This source check may be performed at a frequency of your choice, it could be daily, weekly or monthly. We recommend a low intensity gamma check source of the type which is commonly intended for G-M counters or other survey instruments. For example; a 10 micro Curie, Cesium-137 check source should be sufficient for a monitor reading of 5-10 DAC.

- **IMPORTANT:** Do not adjust the calibration when performing a gamma check.
- Manipulate the alarm set point potentiometer to verify correct functioning of the alarm.
- Adjust the compensation potentiometer to indicate zero on the panel meter. If the instrument is suspected of DRIFT, the zero reading may be verified. This should be done by an instrument engineer or technician.

6.2. SUPERVISORY MAINTENANCE

The following tasks are the responsibility of the supervisory engineering staff.

1. Calibration verification is to be performed at yearly intervals, or as otherwise specified.
2. Response checks (in case of need for cursory verification of the operational status of the ionization chambers and of the whole system), of the system may be tested by using a low strength gamma radiation check source. This must be done under the strict supervision of a health physicist. The gamma source is brought into proximity of each ionization chamber and the response is observed.

6.3. FACTORY MAINTENANCE

A determination that the system appears to have suffered a functional failure should require that the factory be notified. The manufacturer, if required, will supply engineering assistance via telephone or in person.

Should it appear to be necessary to return the instrument to our factory, authorization for the return must be obtained from Overhoff Technology Corporation prior to shipping. In-freight charges will be borne by the customer.

OVERHOFF TECHNOLOGY CORPORATION
Telephone (513) 248-2400
Facsimile (513) 248-2402
Email: support@overhoff.com

7.0. STORAGE

The equipment may be stored indefinitely in any storage place with the following environmental conditions:

Temperature:	-40º C - +60º C
Humidity:	0 - 95 % R.H.
Atmospheric:	should be free of corrosive vapors or liquids

During temporary or extended storage make sure that the gas ports to the ionization chambers and all electrical connectors be protected from moisture or contamination.

It is best to seal ports and connectors by wrapping them with adhesive tape or use small plastic bags and elastic bands.

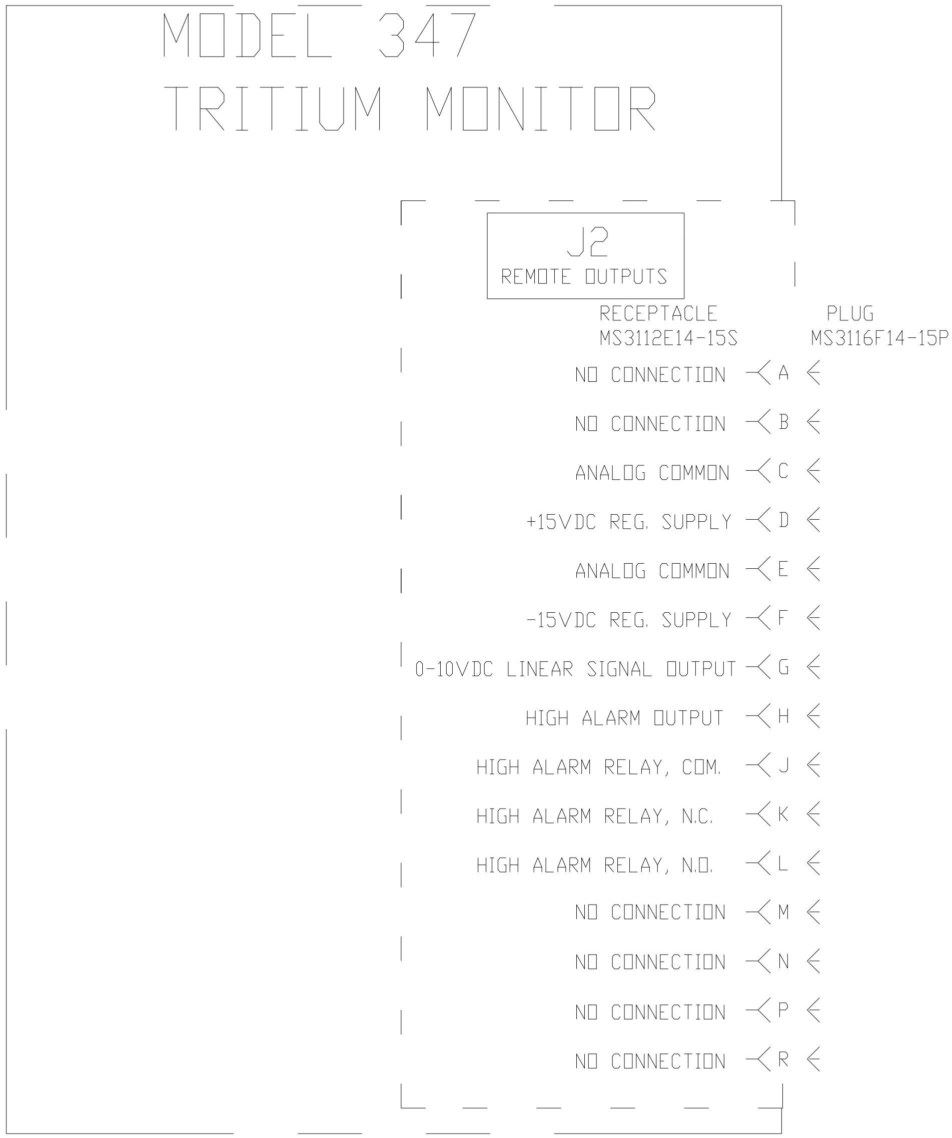
8.0. WARRANTY

All instruments built by Overhoff Technology Corporation are warranted to perform as claimed.

Defective components or workmanship of the instrument will be corrected free of charge for parts and/or labor within a one year period from date of delivery. Non-performance of the instrument as a result of negligence on behalf of the customer is not covered by this warranty.

Should it appear to be necessary to return the instrument to our factory, authorization for the return must be obtained from Overhoff Technology Corporation prior to shipping. In-freight charges will be borne by the customer.

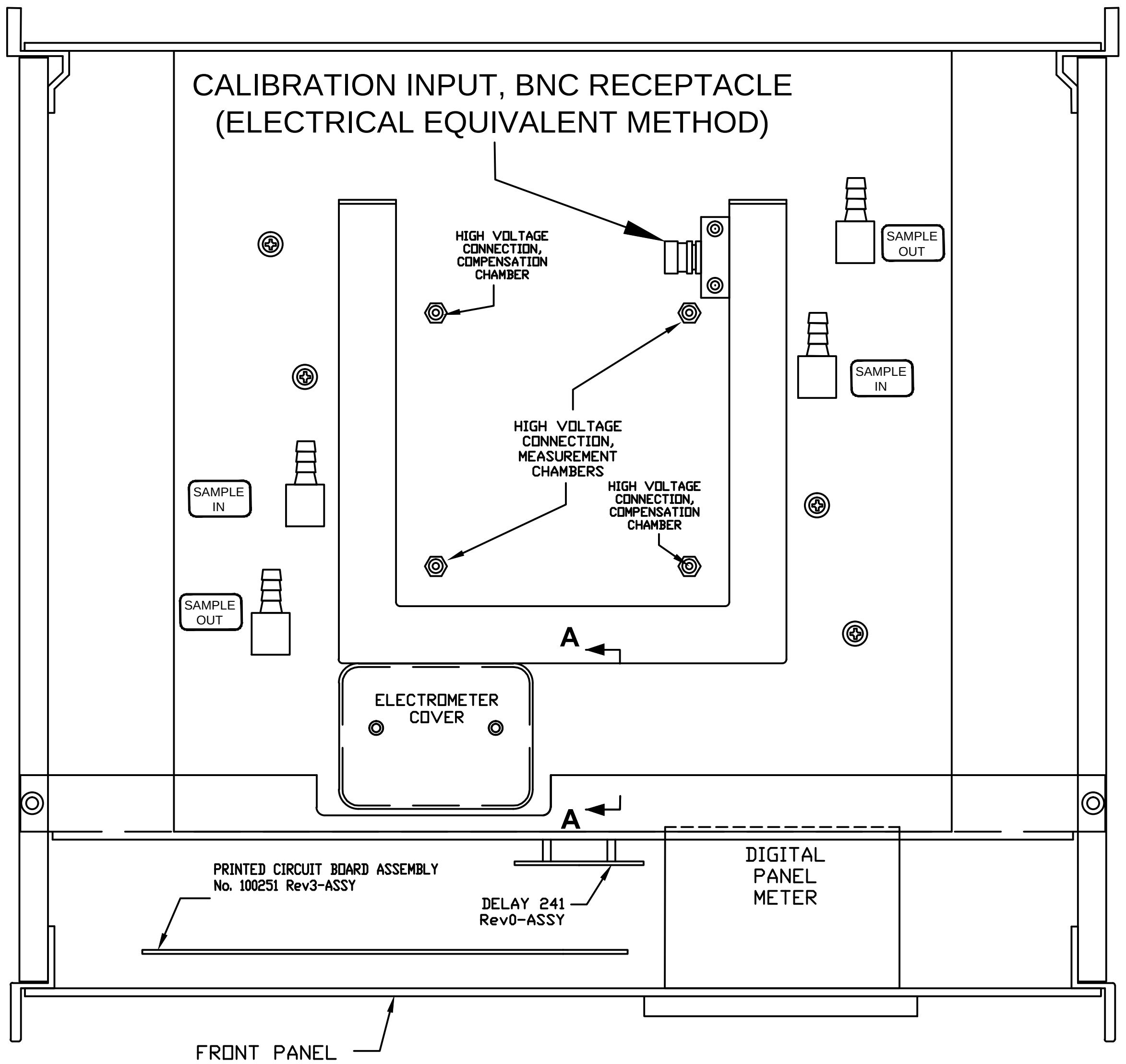
9.0 WIRE LIST, REMOTE CONNECTOR J2



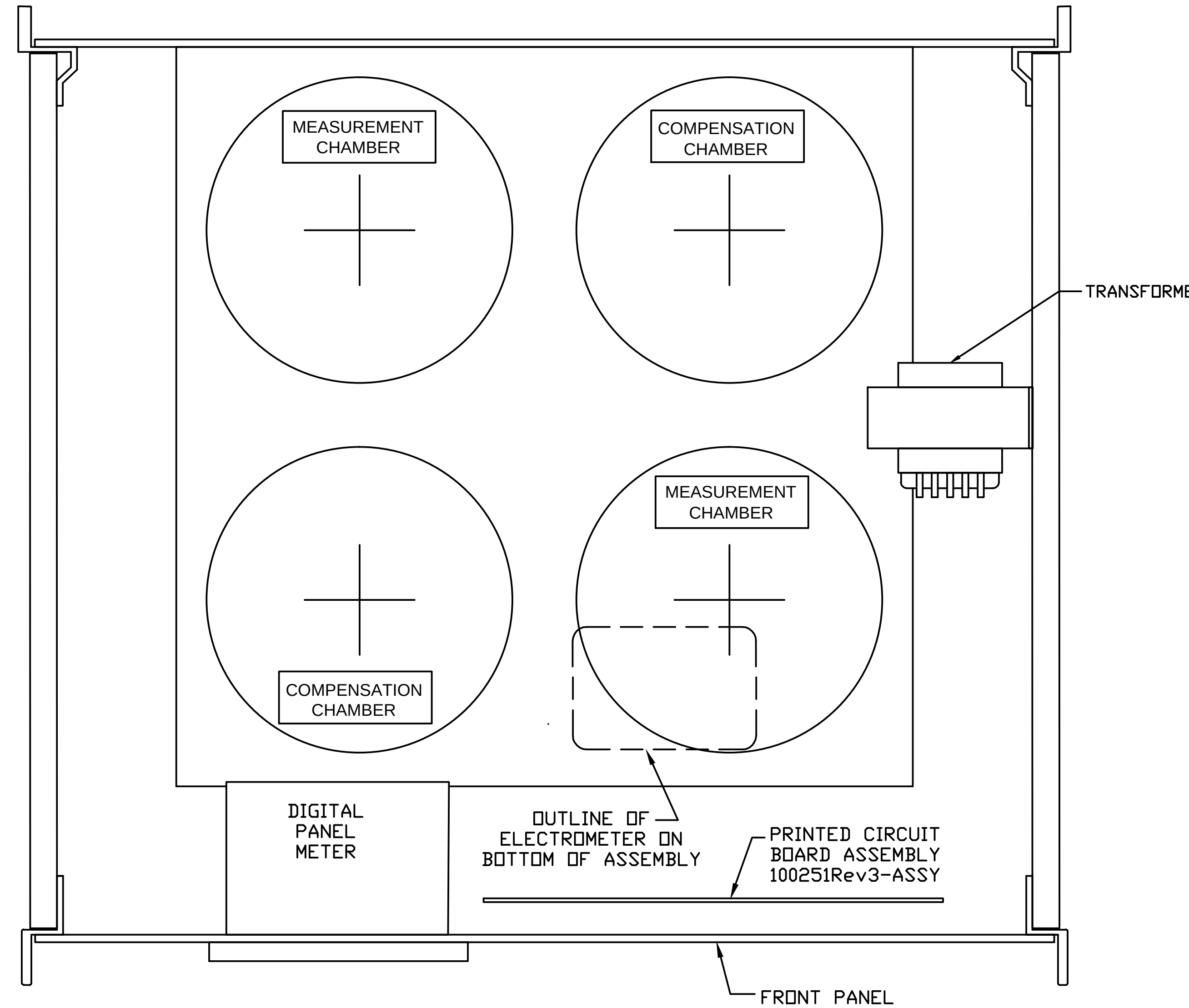
10.0 DRAWINGS/DIAGRAMS

DRAWING NUMBER	DESCRIPTION
1020943-4122-1	Ionization Chamber Assembly
1021201-4122-2	Pump System
1021342-4122-1 Sheet 1 of 2	Front Panel, Model 347
1021342-4122-1 Sheet 2 of 2	Interior Layout, Model 347
WD-347-4122-1	Wiring Diagram

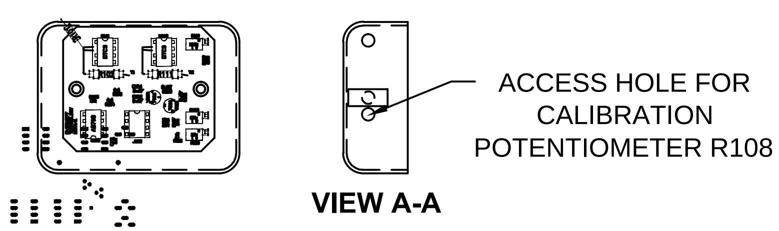
REVISIONS			
REV	DESCRIPTION	APPROVED	DATE
1	REWORK PER CUSTOMER REQUEST FOR μCi/m³ UNITS OF MEASURE	DW	5-6-15



BOTTOM VIEW,
INTERIOR OF ENCLOSURE, COVER REMOVED



TOP VIEW

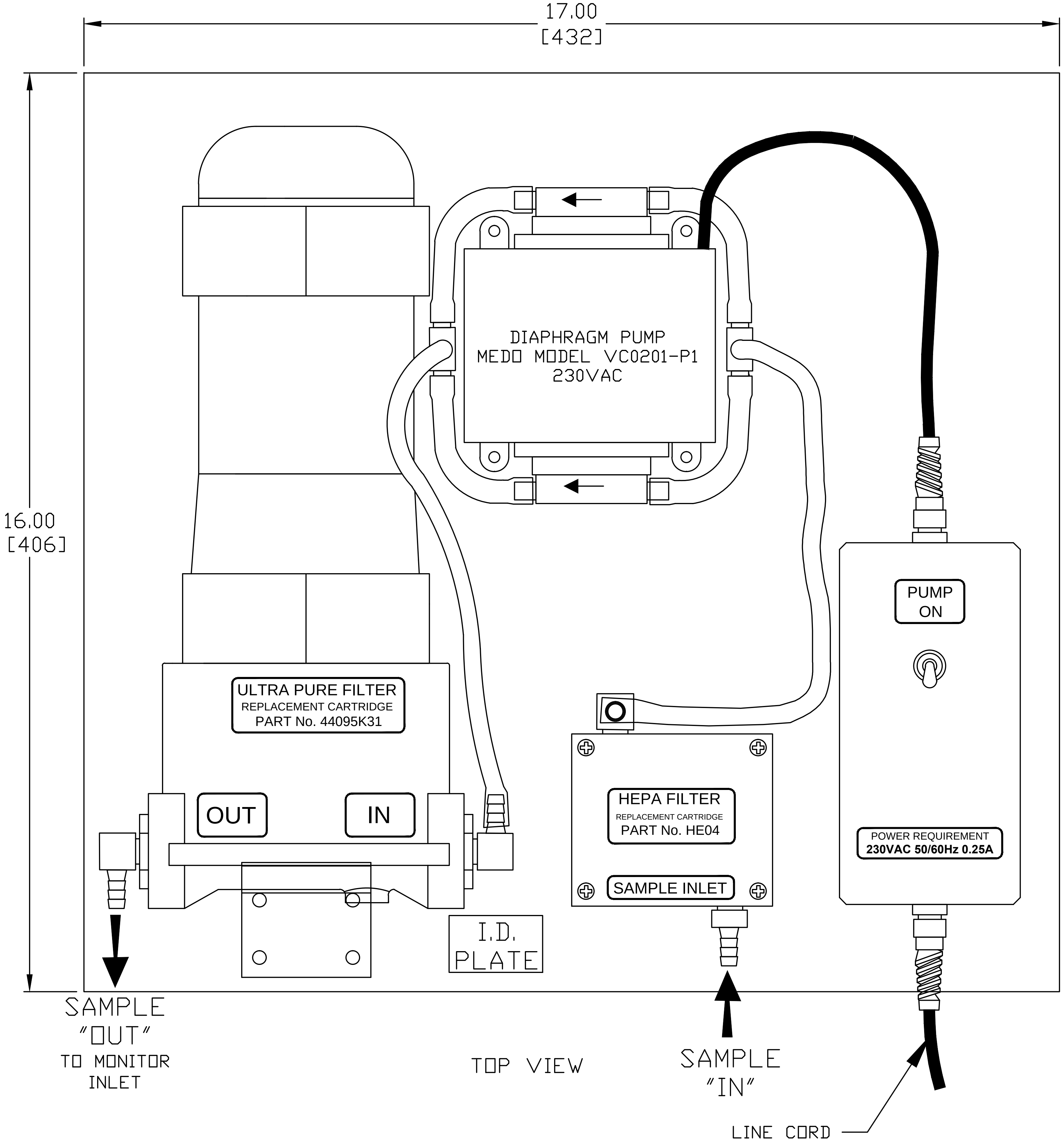


VIEW A-A

SUPPLEMENTAL DETAIL
TO VIEW A-A SHOWING
ELECTROMETER BOARD
ARRANGEMENT

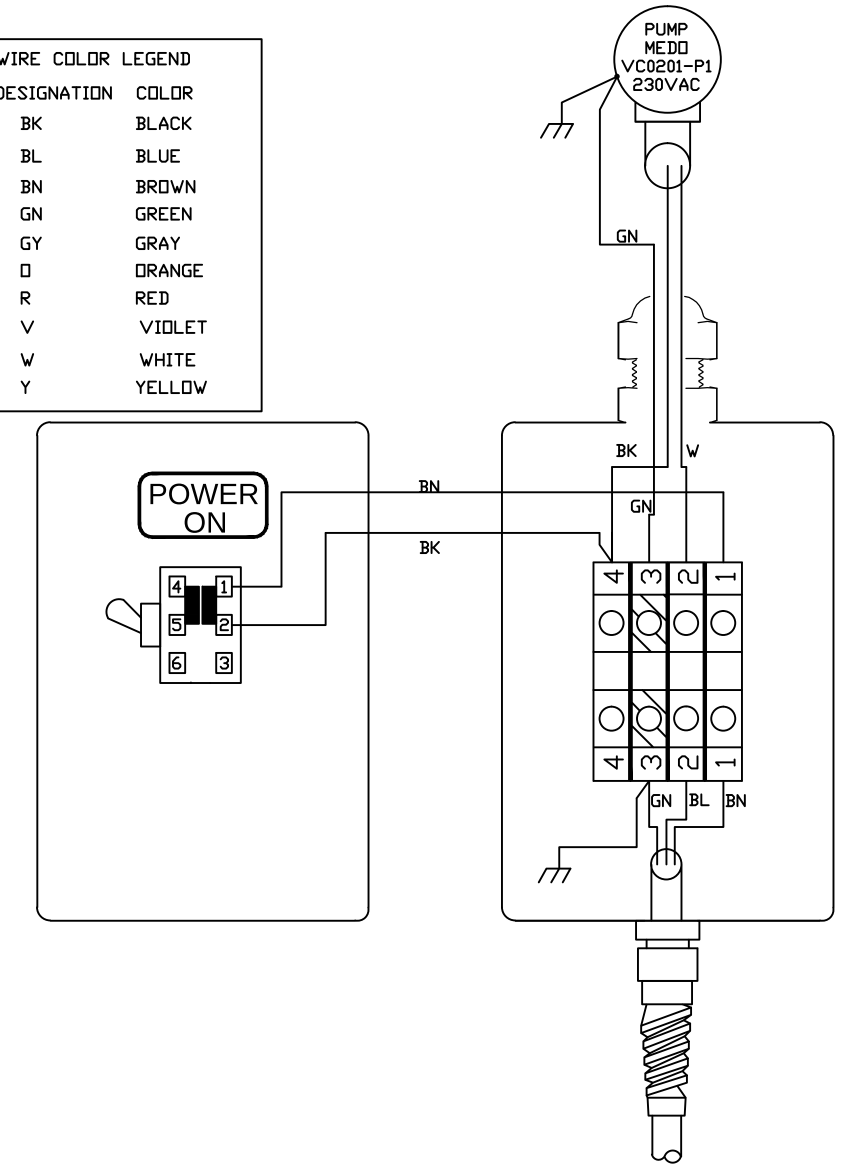
MODEL 347 TRITIUM MONITOR		**OVERHOFF TECHNOLOGY CORPORATION** MILFORD, OHIO 45150 U.S.A.			
		MODEL 347 230V, INTERIOR VIEW			
DRAWN I.WIBBENMEYER	DATE 12-09-13	SIZE B	FILE NAME 1021342 .DWG	DWG NO. 1021342	REV 1
APPROVED D. WILLIAMSON	DATE 12-09-13	SCALE .50		SHEET 2 OF 2	

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED
–	–	–	–



WIRE COLOR LEGEND

DESIGNATION	COLOR
BK	BLACK
BL	BLUE
BN	BROWN
GN	GREEN
GY	GRAY
O	ORANGE
R	RED
V	VIOLET
W	WHITE
Y	YELLOW



NOTES:

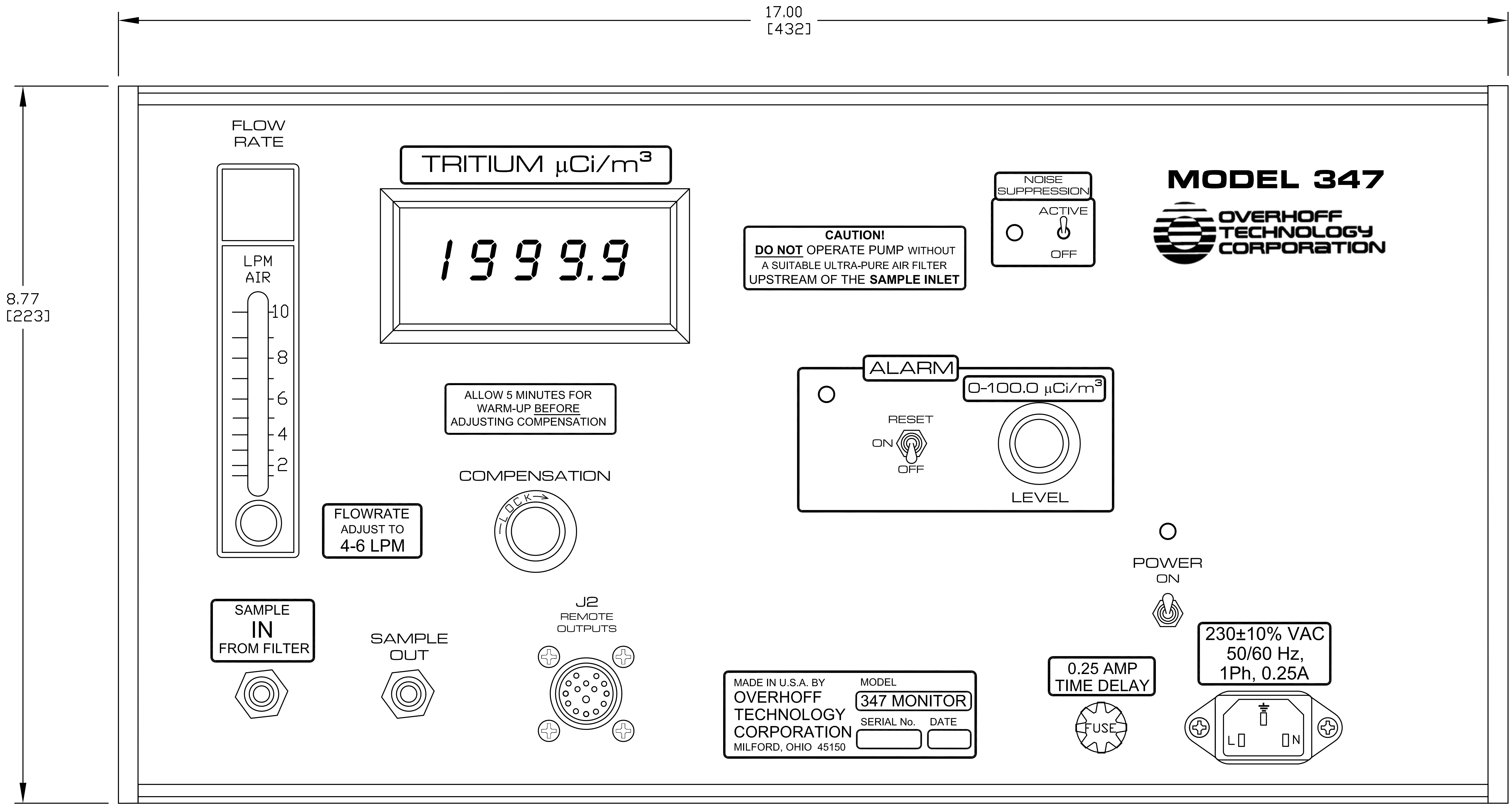
1. DIMENSIONS ARE IN INCHES (MILLIMETERS)
2. OVERALL MAXIMUM HEIGHT IS 6.00" (152mm).
3. REFER TO PNUEMATIC FLOW DIAGRAM, PART OF THE BLOCK DIAGRAM

MODEL 347
TRITIUM MONITOR

OVERHOFF TECHNOLOGY CORPORATION
MILFORD, OHIO 45150 U.S.A.

PUMP (230V) ASSEMBLY FOR
MODEL 347 TRITIUM MONITOR

DRAWN	DATE	SIZE	FILE NAME	DWG NO.	REV
J. CREECH	01-15-16	B	1021201.DWG	1021201	0
APPROVED	DATE	SCALE	.50	SHEET	1 OF 1
D. WILLIAMSON	01-18-16				



NOTES:

1. DIMENSIONS ARE INCHES (MILLIMETERS)
2. ALLOW FOR 16" (406mm) OF DEPTH BEHIND FRONT PANEL
3. SAMPLE IN/OUT FITTINGS ARE HOSE BARBS FOR VINYL TUBING, 5/16" (8mm) OD, 3/16" (5mm) ID.

REV	DESCRIPTION	APPROVED	DATE

REVISIONS

MODEL 347
TRITIUM MONITOR

DRAWN	DATE
I.WIBBENMEYER	12-09-13
APPROVED	DATE
D. WILLIAMSON	12-09-13

OVERHOFF
TECHNOLOGY
CORPORATION

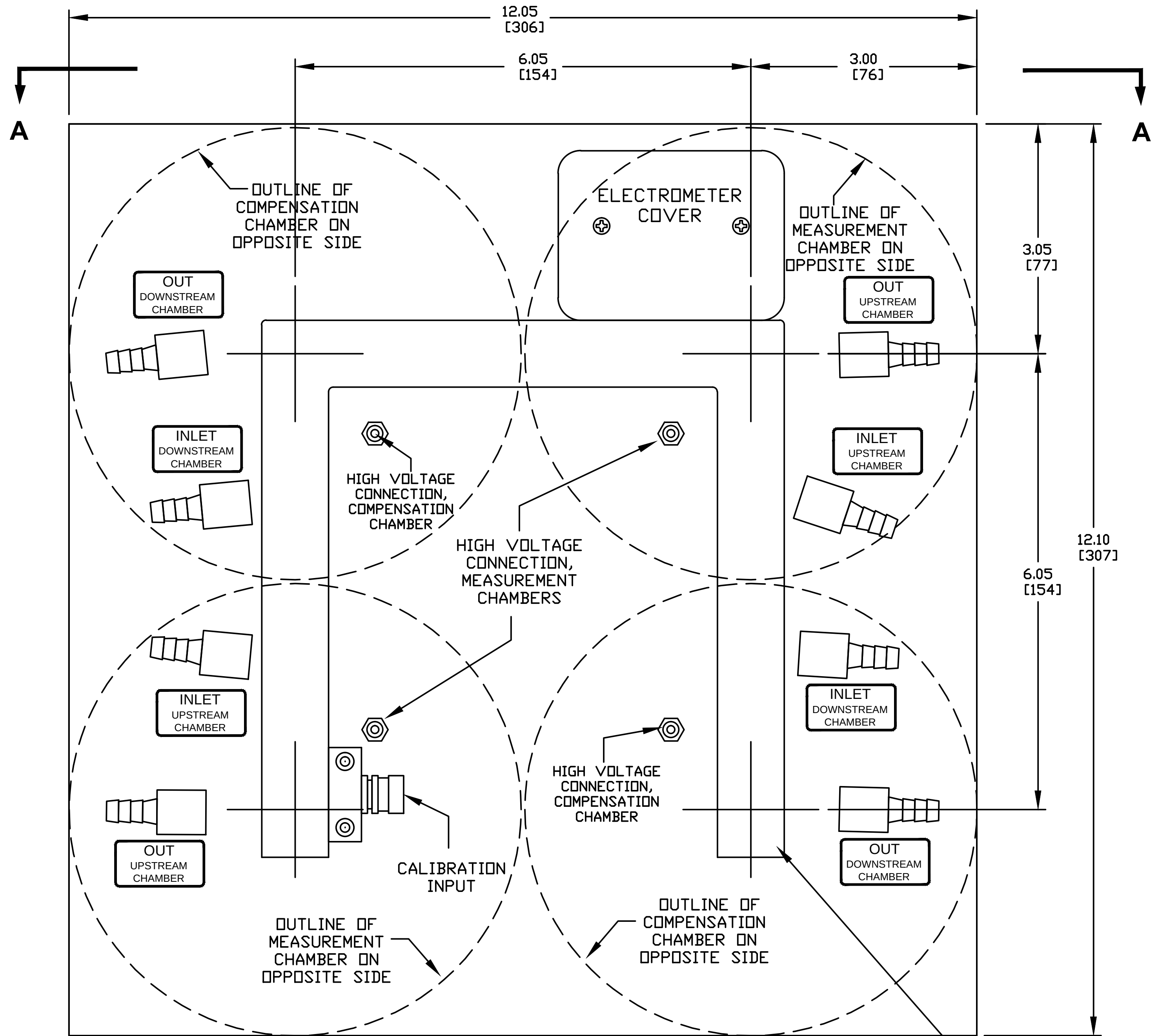
MILFORD, OHIO 45150 U.S.A.

MODEL 347 230V, FRONT PANEL

SIZE	FILE NAME	DWG NO.	REV
B	1021342 .DWG	1021342	0

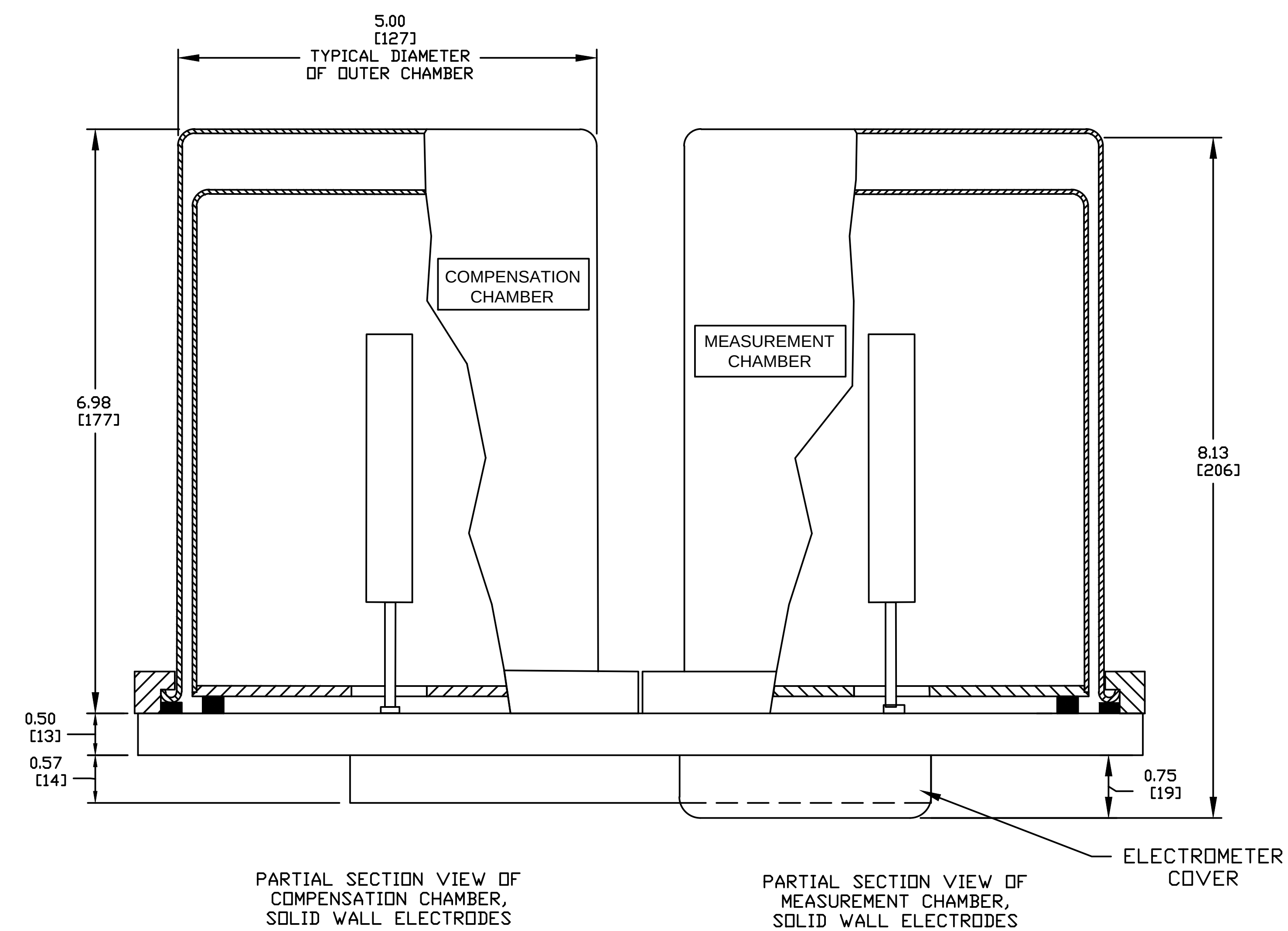
SCALE .80 SHEET 1 OF 2

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED



METAL COVER FOR WIRE USED TO CONNECT ALL FOUR COLLECTING ELCTRODES

BOTTOM VIEW



FRONT, VIEW A-A

NOTES:

1. DIMENSIONS ARE INCHES (MILLIMETERS)

MODEL 347
TRITIUM MONITOR

OVERHOFF TECHNOLOGY CORPORATION

MILFORD, OHIO 45150 U.S.A.

IONIZATION CHAMBER ASSEMBLY,
GAMMA COMPENSATED 2 LITER CHAMBERS
MOUNTED IN A QUADRUPLE/CRUCIFORM ARRANGEMENT

DRAWN	DATE	SIZE	FILE NAME	DWG NO.	REV
I.WIBBENMEYER	12-09-13	B	1020943.DWG	1020943	0
APPROVED	DATE	SCALE	N/S	SHEET	1 OF 1
D. WILLIAMSON	12-09-13				