Changes “Other Than Inconsequential” Require These Additional Reviews:

Radiological Controls:
Central Radcon Organization

USQ #GCX-2

CHANGE HISTORY (≤ LAST 5 REV-MODS )

<table>
<thead>
<tr>
<th>Rev-Mod</th>
<th>Release Date</th>
<th>Justification</th>
<th>Summary of Changes</th>
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<tr>
<td>C-1</td>
<td>08/10/2017</td>
<td>Inconsequential change</td>
<td>Update Records Section to comply with writer’s standard.</td>
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<tr>
<td>C-0</td>
<td>08/14/2014</td>
<td>Periodic Review</td>
<td>Minor changes made to procedure to conform to Writers Standard. Removed Warning to coincide with the downgrading of the JHA to GHA.</td>
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<tr>
<td>B-0</td>
<td>05/19/2011</td>
<td>Periodic Review</td>
<td>No changes made to procedure.</td>
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Figure 1 - O-Ring Locations and Part Number

Figure 2 - Connection to CAM Rotameter and Vacuum Relief Valve with Pig/Detector Disconnected from Flow Loop

Figure 3 - High Voltage Trigger Board Component Layout

Figure 4 - High Voltage Trigger Board Schematic

Figure 5 - Logic Board Component Layout
1.0 PURPOSE AND SCOPE

1.1 Purpose

To provide instructions for a safe, uniform method for calibrating and optimizing the Eberline Beta Model AMS-3 Breathing Air Monitor.

1.2 Scope

This procedure involves the Eberline Beta Model AMS-3 Continuous Air Monitor (CAM) that is being used exclusively to monitor Breathing Air.

2.0 INFORMATION

NONE

3.0 PRECAUTIONS AND LIMITATIONS

3.1 Personnel Safety

3.1.1 Lockouts, tagouts, or over-tagging requirements shall be performed in accordance with DOE-0336, Hanford Site Lockout/Tagout Procedure, as applicable.

3.2 Radiation and Contamination Control

3.2.1 Work in radiological areas will be performed using a radiological work permit following review by Radiological Control per the ALARA Work Planning procedure TFC-ESHQ-RP_RWP-C-03.

3.2.2 Handle radioactive sources with extreme care; keep covered and protected at all times when not in use.
4.0 PREREQUISITES

4.1 Special Tools, Equipment, and Supplies

The following supplies may be needed to perform this procedure:

- Oscilloscope, 4 MHZ minimum band width
- Two pulse generators, Eberline MP-1/MP-2, or equivalent
- Two digital multimeters
- Flowmeter or rotameter
- Vacuum gauge or digital manometer or equivalent
- Stop watch
- Resistor, 500 to 1000 ohms, ½ Watt minimum, as required
- Vacuum source
- Vacuum grease.

NOTE - The following sources are applicable for use on the Eberline Beta Air Monitors listed in this procedure, and are identified as source specific on Data Sheets. Based on source decay, duplicate sources listed may not be released by Radiological Control.

- Sources are to be obtained from the Source Custodian (usually Health Physics office). Sources are to be signed out and signed back in when returned at completion of the task.

4.1.1 National Institute of Standards and Technology (NIST) traceable sources of the following types:

- $^{90}$Sr(Y) 10,000 to 40,000 dpm (4.50E-3 μCi to 1.80E-2 μCi)
- $^{99}$Tc 11,000 to 50,000 dpm (4.95E-3 μCi to 2.25E-2 μCi)
- $^{137}$Cs 0.4 to 2.0 μCi Beta-Gamma source.
- $^{60}$Co 0.8 to 1.2 μCi Beta-Gamma source.

(Use only until the 0.4 to 2.0 μCi $^{137}$Cs is available).
4.1 Special Tools, Equipment, and Supplies (Cont.)

<table>
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<tr>
<th>Isotope</th>
<th>Activity Range (dpm)</th>
<th>Activity Range (μCi)</th>
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<tr>
<td>$^{99}$Tc</td>
<td>4,000 to 6,000 dpm</td>
<td>$1.80 \times 10^{-3}$ μCi to $2.70 \times 10^{-3}$ μCi</td>
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<tr>
<td>$^{99}$Tc</td>
<td>40,000 to 60,000 dpm</td>
<td>$1.80 \times 10^{-2}$ μCi to $2.70 \times 10^{-2}$ μCi</td>
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<tr>
<td>$^{99}$Tc</td>
<td>400,000 to 600,000 dpm</td>
<td>$1.80 \times 10^{-1}$ μCi to $2.70 \times 10^{-1}$ μCi</td>
</tr>
<tr>
<td>$^{99}$Tc</td>
<td>1,200,000 to 1,800,000 dpm</td>
<td>$5.41 \times 10^{-1}$ μCi to $8.11 \times 10^{-1}$ μCi</td>
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<tr>
<td>$^{137}$Cs</td>
<td>28,000 to 42,000 dpm</td>
<td>$1.26 \times 10^{-2}$ μCi to $1.89 \times 10^{-2}$ μCi</td>
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<tr>
<td>$^{90}$Sr(Y)</td>
<td>25,600 to 38,400 dpm</td>
<td>$1.15 \times 10^{-2}$ μCi to $1.73 \times 10^{-2}$ μCi</td>
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4.1.2 $^{60}$Co non-NIST 1.0 to 100 mR/hr (V-Block, stick, or block) gamma source as verified by a contact measurement with calibrated ion chamber.

4.2 Field Preparation

4.2.1 **ENSURE** M&TE equipment is within calibration.

4.2.2 **IF** potential for radiological contamination exists, **PERFORM** equipment survey prior to beginning maintenance.
5.0 PROCEDURE

NOTE - Section 5.1 is performed prior to disassembly OR removing CAM from cabinet.

5.1 AMS-3 Pre-Calibration Efficiency Check

5.1.1 IF not already on, TURN CAM on AND
ENSURE the background subtract switch is on.

5.1.2 WAIT five (5) minutes AND
RECORD As-Found background meter reading (cpm) on Data Sheet.

5.1.3 IF background >100 cpm, DECONTAMINATE the detector.

5.1.4 INSTALL NIST traceable beta source into the filter holder (minimum 3000 dpm) THEN
WAIT one (1) minute.

5.1.5 CALCULATE the efficiency using the equation given below by plugging in the following values:
- Meter count rate
- Background from Step 5.1.2
- Source activity

\[
EFF = \frac{Gross \ (cpm) - Background \ (cpm)}{Source \ Activity \ (dpm)} \times 100
\]

5.1.6 RECORD the As-Found calculated percent (%) efficiency on Data Sheet.

5.1.7 CONNECT M&TE air flow measurement device to CAM.

5.1.8 ENERGIZE pump AND ADJUST flow on CAM to indicate 60 lpm.

5.1.9 RECORD As-Found air flow reading on Data Sheet (if necessary, conversion from cfm to lpm is as follows: 1 cfm = 28.32 lpm.)

5.1.10 IF As-Found (calculated) efficiency is not within ±20% of efficiency noted on CAM Cal Sticker for that isotope AND/OR
RECORDED air flow is not within ±10% of M&TE reading, NOTIFY RadCon engineering as to deficiency.
5.2 Preliminary Check and Inspection

NOTE - For units equipped with chart recorder, all readings are algebraic average of indications on chart paper.

5.2.1 WRITE serial number on inside of instrument and cover.

5.2.2 CHECK that there is no physical damage or loose screws/parts.

NOTE - Figure 1 can be used to show O-Ring part number and location.

5.2.3 REMOVE chamber and chamber plug "O" rings.

5.2.4 CLEAN "O" ring grooves.

5.2.5 LUBE new "O" rings, THEN INSTALL in chamber and chamber plug grooves.

5.2.6 WHEN flow chamber and chamber plug service is complete, RECORD on Data Sheet.

5.2.7 ENSURE spacer pins in the flow chamber, are in the correct position.

5.2.8 ASSEMBLE detectors/flow chamber in unit.

5.2.9 CLEAN AND SERVICE chart recorder, AND RECORD on Data Sheet.

5.2.10 IF no built in chart recorder exists in unit, RECORD N/A in the "Clean and Service Recorder" section of the Data Sheet.
5.3 Check Rotameter

NOTE - Figure 2 is used as a reference for connection to CAM rotameter and vacuum relief valve with PIG/detector disconnected from flow loop.

5.3.1 DISCONNECT tubing from sample chamber outlet.

5.3.2 CONNECT test equipment to CAM rotameter and vacuum source.

5.3.3 SET the M&TE rotameter flow as close as possible to 60 liters per minute.

5.3.4 CHECK that the CAM rotameter indicates value stated on Data Sheet.

5.3.5 RECORD M&TE rotameter check on Data Sheet.

5.3.6 IF rotameter is out of tolerance, PERFORM the following:

5.3.6.1 NOTIFY FWS.

5.3.6.2 OBTAIN a new rotameter from FWS.

5.3.6.3 REPLACE rotameter.

5.3.6.4 REPEAT Section 5.3.
5.4 Calibrate Vacuum Relief Valve

5.4.1 SET flow as close as possible to 60 liters per minute indication on M&TE flowmeter.

5.4.2 BLOCK inlet to M&TE flowmeter.

5.4.3 ADJUST vacuum relief valve to relieve at value specified on Data Sheet on M&TE vacuum gauge/manometer AND RECORD As-Left value on Data Sheet.

5.4.4 REMOVE vacuum to CAM.

5.4.5 REMOVE test equipment.

5.4.6 CONNECT tubing to sample PIG.
5.5 Perform Leak Test

5.5.1 ENSURE CAM rotameter flow is SET as close as possible to 60 liters per minute.

5.5.2 BLOCK (SLOWLY) inlet to PIG.

5.5.3 ENSURE CAM rotameter indicates no flow.

5.5.4 IF no flow is indicated, RECORD on Data Sheet AND GO TO Section 5.6.

5.5.5 IF flow is indicated, CHECK for leaks.

5.5.6 IF leak is detected, REPAIR.

5.5.6.1 IF there is still a leak, STOP AND NOTIFY FWS AND REPEAT Steps 5.5.1 through 5.5.5.
5.6 Count Rate Meter Calibration

NOTE  Chart is to be used as primary readout if unit has recorder, otherwise use meter.

5.6.1 ENSURE power to CAM is off.

5.6.2 SET high voltage disable switch to CAL position (or ON position if so labeled).

5.6.3 RECORD As-Found readout indication in As-Found section of Data Sheet.

5.6.4 IF As-Found readout indication is within tolerance, RECORD As-Found readout indication in the As-Left section of the Data Sheet AND GO TO Step 5.6.6.

5.6.5 ADJUST mechanical ZERO of meter AND RECORD final readout indication in As-Left section of Data Sheet.

5.6.6 POWER UP CAM.

5.6.7 CONNECT pulse generator to MAIN SIGNAL connector located on back of CAM.

5.6.8 SET pulse amplitude to negative (-) 600 mV, not to exceed (-) 1 V.

5.6.9 SET pulse generator frequency output to 100K counts per minute (within 99K to 101K counts per minute).
5.6 Count Rate Meter Calibration (Cont.)

5.6.10 CONNECT oscilloscope to output of A5-B, Pin 8 test point, same point as left side of R15.

5.6.11 RECORD As-Found pulse width on Data Sheet.

5.6.12 IF As-Found pulse width is within tolerance, RECORD As-Found pulse width, in the As-Left section of the Data Sheet AND

GO TO Step 5.6.14.

5.6.13 ADJUST pulse width (R13) to value specified on Data Sheet AND

RECORD pulse width in the As-Left section of the Data Sheet.

5.6.14 CONNECT digital multimeter to the Recorder output 0-10mV on rear of instrument.

NOTE - CAMs equipped with a 4 to 20 mA analog output may require a 500 to 1000 ohm resistor in series with an ammeter connected across analog output terminal. Output could be either mA or mV, depending on CAM setup.

- It may take up to ten minutes for readout to stabilize. Instability and unusual length of time to stabilize should be noted in COMMENTS section of Data Sheet.

5.6.15 SET pulse generator output per the Data Sheet AND

RECORD output (digital multimeter values) for each pulse generator output setting in As-Found section of Data Sheet.

5.6.16 IF As-Found output readings are within tolerance, RECORD As-Found output readings in the As-Left column of the Data Sheet AND

GO TO Section 5.7.

5.6.17 SET pulse generator to minimum count rate specified on Data Sheet AND

ADJUST ZERO control (R26), until CAM readout indicates same value as input from pulse generator (counts per minute).
5.6 Count Rate Meter Calibration (Cont.)

5.6.18 IF mA is out of tolerance as specified on Data Sheet, ADJUST ZERO control on Action Pak.

5.6.19 SET pulse generator to maximum count rate specified on Data Sheet AND ADJUST SPAN control (R28), as necessary, until CAM readout indicates same value as input from pulse generator (counts per minute).

5.6.20 IF mA is out of tolerance as specified on Data Sheet, ADJUST SPAN control on Action Pak.

5.6.21 SET pulse generator to count rates specified on Data Sheets AND RECORD digital multimeter values in the As-Left section of the Data Sheet.
5.7 Subtraction Calibration

5.7.1 CONNECT pulse generator No. 1 to MAIN SIGNAL connector.

5.7.2 CONNECT pulse generator No. 2 to SUBTRACTION SIGNAL connector.

5.7.3 ADJUST pulse generator No. 2 output to obtain a pulse width between 1 and 50 microseconds and an amplitude between (-)600 mV and (-)1 V.

5.7.4 PLACE background subtraction switch in OFF position.

5.7.5 SET pulse generator No. 1 output to 100K counts per minute (99 to 101K counts per minute).

5.7.6 SET pulse generator No. 2 output to 80K counts per minute (79 to 81K counts per minute).

5.7.7 PLACE background subtraction switch in ON position AND RECORD As-Found Background Subtract value in the As-Found section of the Data Sheet.

5.7.8 IF As-Found Background Subtract value is within tolerance as specified on Data Sheet, RECORD As-Found value in the As-Left section of the Data Sheet AND GO TO Section 5.8.

5.7.9 ADJUST subtraction adjustment (R14) until readout is within tolerance specified on Data Sheet AND RECORD value in the As-Left section of the Data Sheet.
5.8  Alarm Delay

5.8.1  IF CAMs is not equipped with light and bell, CONNECT the light and bell wires to test setup in shop, OTHERWISE CONNECT the light and bell wires to the cover for testing

5.8.2  TURN alarm set control fully clockwise.

5.8.3  SET pulse generator to produce readout reading greater than 100 counts per minute.

5.8.4  TURN alarm set control fully counterclockwise AND START timing.

5.8.5  RECORD time duration it takes for alarm to actuate in the As-Found section of the Data Sheet.

5.8.6  IF As-Found time duration to actuate alarm is within tolerance, RECORD As-Found time duration in the As-Left section of the Data Sheet AND GO TO Section 5.9.

NOTE - Figure 5 provides component layout on logic board to identify adjust pots on logic board.

5.8.7  ADJUST delay pot R-33 on logic board for time delay per the Data Sheet.

5.8.8  REPEAT Steps 5.8.1 through 5.8.5 until time duration is in tolerance AND RECORD time duration value in the As-Left section of the Data Sheet.
5.9 External Alarm Verification

5.9.1 IF CAMs is not equipped with light and bell, CONNECT the light and bell wires to test setup in shop, OTHERWISE

CONNECT the light and bell wires to the cover for testing

5.9.2 PLACE CAM in alarm condition by rotating alarm set control fully counterclockwise.

5.9.3 CHECK that alarm bell and rotating beacon operate AND

RECORD on Data Sheet.

5.9.4 USING a multimeter, ENSURE the high alarm contacts C and NC (on rear of panel) are OPEN AND

RECORD on Data Sheet.

5.9.5 PRESS alarm acknowledge pushbutton (located on front panel).

5.9.6 ENSURE alarm bell is deactivated AND

RECORD on Data Sheet.

5.9.7 DISCONNECT alarm bell and beacon from CAM.

5.9.8 REMOVE pulse generators.

5.9.9 CONFIRM the green COUNTING lamp (located on front of panel) turns OFF within 30 to 60 seconds AND

RECORD on Data Sheet.
5.9 **External Alarm Verification (Cont.)**

5.9.10 **CONFIRM** the red FAIL lamp (located on front of panel) turns ON within 30 to 60 seconds **AND**

**RECORD** on Data Sheet.

5.9.11 **USING** a multimeter, **ENSURE** the fail alarm contacts C and NC (on rear of panel) are **OPEN** **AND**

**RECORD** on Data Sheet.

5.9.12 **PLACE** switch to OPERATE position (OR OFF position, if so labeled).

5.9.13 **CONFIRM** the red FAIL lamp is OFF.

5.9.14 **CONFIRM** the green COUNTING lamp is ON.
5.10 GM Tube Quality Check

5.10.1 **PLACE** background subtraction switch in OFF position.

5.10.2 **PLACE** gamma source (10 to 100 mR/hr) $^{60}$Co near detector on top of CAM behind air inlet pipe or on side at bottom, adjacent to inlet pipe.

5.10.3 **OBSERVE** for one minute reading indicated on CAM recorder/indicator or remote output (with digital multimeter).

5.10.4 **PLACE** background subtraction switch in ON position.

5.10.5 **OBSERVE** for 30 seconds to one minute the reading indicated on CAM recorder/indicator or remote output (with digital multimeter).

5.10.6 **CONFIRM** background subtraction circuit causes a reading less than value observed in Step 5.10.3.

5.10.7 **PLACE** background subtraction switch in OFF position.

5.10.8 **REMOVE** Gamma source.

**NOTE** - Use of 1 microcurie $^{60}$Co source or 0.4 to 2.0 microcurie $^{137}$Cs source is permissible if High Range $^{99}$Tc source IS NOT available.

5.10.9 **REMOVE** filter holder plug **AND**

**PLACE** near detector, applicable source capable of driving count rate readout off scale on high side.

5.10.10 **CONFIRM** that the count rate readout goes off scale on high side and remains there until source is removed.

**OR**

**IF** count rate readout “does not” go off scale, **NOTIFY** FWS **AND**

**OBTAIN** further direction.
5.11 Radiological Calibration

5.11.1 REMOVE holder from PIG.

5.11.2 PLACE source specified on Data Sheet in holder facing detector.

5.11.3 PLACE holder in PIG.

5.11.4 PLACE background subtraction switch to ON position.

5.11.5 OBSERVE countrate indicated for five minutes AND CALCULATE counting efficiency using following equation:

\[
EFF = \frac{\text{Gross (cpm)} - \text{Background (cpm)}}{\text{Source Activity (dpm)}} \times 100
\]

5.11.6 RECORD counting efficiency and counts per minute value observed (of specified source) on Data Sheet, efficiency must be a minimum of the value specified on Data Sheet, IF not NOTIFY FWS AND OBTAIN further direction.

5.11.7 REPEAT Steps 5.11.1 through 5.11.6 using other sources specified by Data Sheet.

5.11.8 RECORD counting efficiencies on efficiency sticker (or efficiency tag) AND ATTACH efficiency sticker (or efficiency tag) to front of CAM.

5.11.9 RECORD source serial numbers, expiration date and activity value on the Data Sheet.

5.11.10 REMOVE all radiological sources from CAM.

5.11.11 IF CAM “does not” have an installed recorder, GO TO Step 5.12.9.
5.12 Test Run

5.12.1 PLACE source in detector chamber, capable of generating indications of between 100 counts per minute and 80K counts per minute on recorder.

5.12.2 PLACE CAM in operation.

5.12.3 OPERATE CAM minimum of two hours.

5.12.4 IF CAM chart reading and recording operation function test properly, RECORD on the Data Sheet AND GO TO Step 5.12.5.

5.12.4.1 IF not, NOTIFY FWS AND OBTAIN further direction.

5.12.4.2 REPAIR AND REPEAT Sections 5.6 and 5.12, as necessary.

5.12.5 REMOVE test section of chart after completion of test.

5.12.6 RECORD date and CAM serial number on chart section.

5.12.7 ATTACH chart section to Data Sheet.

5.12.8 REMOVE source(s).

5.12.9 IF CAM IS NOT equipped with heater, GO TO Section 5.13.

NOTE - Heater system has 30 second response time.

5.12.10 ENSURE heater thermostat is set for 40°F by visual inspection of thermostat dial.
5.12 Test Run (Cont.)

NOTE -  Heater surface temperature will not likely reach temperatures that could burn due to the 30 second response time, heat ramping and the ability of the craft to discern quickly whether the elements have been energized.

- FREEZE-IT spray applied directly to the skin could cause aerosol burns. Care should be taken to ensure nozzle is properly aimed before discharging.

5.12.11 **SPRAY** thermostat's temperature bulb with "FREEZE IT" spray **AND**

**OBSERVE** heater turns ON and OFF by feeling near heater for temperature changes.

5.12.12 **IF** heater does not function properly, **NOTIFY** FWS **AND**

**OBTAIN** further direction.

5.12.13 **INSPECT** for wire damage and abnormal discoloring due to overheating.
5.13 Restoration

5.13.1 IF any problems were encountered with calibration, INFORM FWS.

5.13.2 ENSURE Test Equipment has been disconnected and removed.

5.13.3 ENSURE Test Equipment information and calibration status are recorded on Data Sheet.

5.13.4 ENSURE instrument, equipment, or system restoration by observing indications, alarms and computer points are consistent with expected conditions.

5.13.5 ATTACH calibration sticker to CAM.

5.13.6 NOTIFY Operations that testing is complete and system may be returned to desired configuration.

5.14 Acceptance Criteria

Acceptance Criteria has been met when Steps in this procedure have been satisfactorily performed and As-Left values meet the specifications and tolerance(s) per the Data Sheet.

5.15 Review

5.15.1 INFORM Shift Manager and FWS test is complete.

5.15.2 FWS REVIEW AND ENSURE the following:

- ENSURE RadCon is notified if As-Found Efficiency is NOT within ±20% or As-Found Air Flow is NOT within ±10% of M&TE reading per Step 5.1.10.
- Completed Data Sheets meet the acceptance criteria.
- Comments sections are filled out appropriately.
- Work requests needed as a result of this procedure are identified and generated.
- Work request number(s) of any work documents generated as a result of this procedure, are recorded in the Comments/Remarks section of the Data Sheet.

NOTE - The following step only applies to breathing air CAMs.

5.15.3 IF any As-Found reading is not within the specified tolerance, NOTIFY Radiological Engineering.
5.16 Records

This procedure is performed within a work package, as such, the procedure in its entirety will be maintained as a record per the Work Control process.

The identified record custodian is responsible for record management in accordance with TFC-BSM-IRM_DC-C-02 or other applicable requirements.
Figure 1 - O-Ring Locations and Part Number

O-Ring 1, part # ORBN 2135
O-Ring 2, part # ORBN 2135
O-Ring 3, part # ORBN 2133
O-Ring 4, part # ORBN 2031
O-Ring 5, part # ORBN 2040
Figure 2 - Connection to CAM Rotameter and Vacuum Relief Valve with Pig/Detector Disconnected from Flow Loop
Figure 3 - High Voltage Trigger Board Component Layout

Notes:
1. Q301 is available in two case styles. Both are shown.
2. R319 value has been changed from 51K Ohm to 27K Ohm for the AMS 3-1.
Figure 4 - High Voltage Trigger Board Schematic

NOTES:
1. ALL RESISTORS ARE 1/4 WATT EXCEPT AS NOTED.
2. NOMINAL VALUE. R302 MAY BE SELECTED TO IMPROVE OPERATION.
3. CAPACITOR VALUES ARE IN MICROFARADS.
4. XXX INDICATES A VOLTAGE LEVEL. LOW VOLTAGE ARE MEASURED
   WITH 10 MEGOHM VOM. THE 900 VOLT POINT MUST BE
   MEASURED WITH 1000 MEGOHM OR GREATER INPUT IMPEDANCE METER.
5. R319 VALUE IS 27K IN THE AMS-3-1.

OPTIONAL HIGH VOLTAGE SWITCH DISABLE
NOTES:

1. K1 AND K2 ARE IN SOCKETS ON THE REVERSE SIDE OF THE BOARD.
2. NUMBERED TERMINALS ARE SCHEMATIC REFERENCED WIRE CONNECTIONS.
3. A13 AND A14 ARE USED FOR THE OPTIONAL COMPUTER OUTPUT.
4. THE JUMPER SHOWN PROVIDES FOR THE ALARM RELAYS TO PULL IN ON ALARM.
   FOR DROP OUT ON ALARM (FAIL SAFE) JUMPER THE UPPER TWO TERMINALS SHOWN.