



**TELEDYNE**  
ADVANCED POLLUTION INSTRUMENTATION  
A Teledyne Technologies Company

## **INSTRUCTION MANUAL**

# ***MODEL 702 PRECISION CALIBRATOR***

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## SAFETY MESSAGES

Your safety and the safety of others is very important. We have provided many important safety messages in this manual. Please read these messages carefully.

A safety message alerts you to potential hazards that could hurt you or others. Each safety message is associated with a safety alert symbol. These symbols are found in the manual and inside the instrument. The definition of these symbols is described below:



GENERAL WARNING/CAUTION: Refer to the instructions for details on the specific danger.



CAUTION: Hot Surface Warning.



CAUTION: Electrical Shock Hazard.



Technician Symbol: All operations marked with this symbol are to be performed by qualified maintenance personnel only.

### CAUTION

**The instrument should only be used for the purpose and in the manner described in this manual.**

**If you use the instrument in a manner other than that for which it was intended, unpredictable behavior could ensue with possible hazardous consequences.**



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# 1 INTRODUCTION

The Teledyne API Model 702 Precision Calibrator is a low-cost, simple, light-weight calibrator and is intended to be used as a single- or dual-point transfer medium.

The basic unit is a two-gas dilution system.

An optional ozone generator can be supplied to support GPT calibration.

The M702 has one ZERO AIR or diluent IN connection, two GAS IN connections, one dilution ratio, two ozone and GPT concentrations (if installed), one CAL GAS OUT connection.

When the two cylinders of the same gas are connected with the appropriate concentrations, the M702 will produce two concentrations, such as “precision” (20% URL) and “span” (80% URL) as well as “zero”.

Both cylinders will be diluted by the same ratio.

Alternatively, if two cylinders of different gases are connected, then the M702 will produce one concentration of each gas, each diluted by the same ratio.

## NOTE

**The M702 has been checked out at the factory and meets all of our test criteria. However, during shipment, regulator settings may have shifted. Check the flows using NIST-Traceable flow standards before using the M702. See Section 9.2 for flow verification.**



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## 2 WARRANTY

### WARRANTY POLICY (02024D)

Prior to shipment, Teledyne API equipment is thoroughly inspected and tested. Should equipment failure occur, Teledyne API assures its customers that prompt service and support will be available.

### COVERAGE

After the warranty period and throughout the equipment lifetime, Teledyne API stands ready to provide on-site or in-plant service at reasonable rates similar to those of other manufacturers in the industry. All maintenance and the first level of field troubleshooting is to be performed by the customer.

### NON-TELEDYNE API MANUFACTURED EQUIPMENT

Equipment provided but not manufactured by Teledyne API is warranted and will be repaired to the extent and according to the current terms and conditions of the respective equipment manufacturers warranty.

### GENERAL

During the warranty period, Teledyne API warrants each Product manufactured by Teledyne API to be free from defects in material and workmanship under normal use and service. Expendable parts are excluded.

If a Product fails to conform to its specifications within the warranty period, Teledyne API shall correct such defect by, in Teledyne API's discretion, repairing or replacing such defective Product or refunding the purchase price of such Product.

The warranties set forth in this section shall be of no force or effect with respect to any Product: (i) that has been altered or subjected to misuse, negligence or accident, or (ii) that has been used in any manner other than in accordance with the instruction provided by Teledyne API or (iii) not properly maintained.

**THE WARRANTIES SET FORTH IN THIS SECTION AND THE REMEDIES THEREFORE ARE EXCLUSIVE AND IN LIEU OF ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR PARTICULAR PURPOSE OR OTHER WARRANTY OF QUALITY, WHETHER EXPRESSED OR IMPLIED. THE REMEDIES SET FORTH IN THIS SECTION ARE THE EXCLUSIVE REMEDIES FOR BREACH OF ANY WARRANTY CONTAINED HEREIN. TELEDYNE API SHALL NOT BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF OR RELATED TO THIS AGREEMENT OF TELEDYNE API'S PERFORMANCE HEREUNDER, WHETHER FOR BREACH OF WARRANTY OR OTHERWISE.**

**TERMS AND CONDITIONS**

*All units or components returned to Teledyne API should be properly packed for handling and returned freight prepaid to the nearest designated Service Center. After the repair, the equipment will be returned, freight prepaid.*

### 3 SPECIFICATIONS

Table 3-1: M702 Specifications

Flow measurement accuracy	± 1% FS
Flow control repeatability	± 1% FS
Flow stability (7 days)	1%
Diluent flow range	1 to 3 SLPM
Diluent pressure required	35-50 psig
Gas flow range	10 to 50 ccm
Gas pressure required	35-50 psig
Dilution ratio	20:1 to 300:1
Diluent input ports	1
Gas input ports	2
Ozone generator	Current regulated temperature controlled mercury vapor lamp
Ozone concentration range	50 ppb (@ 1 SLPM); 4 ppm (maximum)
Ozone adjustment resolution	5 ppb
Ozone preset values	2 (independent)
Ozone stability (7 days)	3%
Front panel controls	Diluent pressure with gauge Gas pressure with gauge Gas select buttons (Cyl 1/Cyl 2/NONE) Diluent (ON/OFF) Ozone select (Preset 1/Preset 2/OFF) Ozone preset adjustment Power (ON/OFF)
Rear panel controls	Gas select (Cyl 1/Cyl 2/NONE) Diluent (ON/OFF) Ozone select (Preset 1/Preset 2/OFF)
Rear panel status outputs	Gas selection (Cyl 1/Cyl 2/NONE) Temp OK Diluent (ON/OFF) Ozone preset (Preset 1/Preset 2/OFF)

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Rear panel pneumatic connections	GAS IN (2 1/8" stainless unions) DILUENT IN (1/4" brass union) CAL GAS OUT (1/4" stainless steel union)
Tubing	Use Stainless Steel Tubing and Fittings for NH <sub>3</sub> Analyzers (Option for NH <sub>3</sub> Analyzers)
Mounting	Bench (standard) Rack (optional) Suitcase-handle (optional)
Ambient temperature range	5 to 40°C
Dimensions	5.25 H x 17 W x 23.5" DEEP (133 x 432 x 597 mm)
Weight	29 lbs. (13.1 Kg)
Power	100 V 50/60 Hz 115 V 60 Hz 220 V 50/60 Hz 230 V 50 Hz 240 V 50 Hz 100 Watts
Peripheral equipment support	Source gas cylinder with dual stage regulator, 35-50 psig; Teledyne API Model 701 Zero Air Module or other source of zero air (3 SLPM @ 35-50 psig)
Environmental Conditions	Installation Category (Over Voltage Category) II Pollution Degree 2

## 4 DESCRIPTION

See Figure 4-1 (assembly drawing) and Figure 4-2 (pneumatic diagram).

Zero air, or diluent, enters the M702 at the rear panel union labeled ZERO AIR IN. The air is controlled (ON/OFF) by a normally closed solenoid valve which is actuated by the DILUENT push button on the front panel. When the valve is open, the gas is admitted to the temperature-controlled precision pressure regulator in the oven.

The air flow is controlled by the regulated gas pressure against the fixed restrictor in the oven. You control the regulator secondary pressure with the DILUENT PRESSURE knob on the front panel, observing the pressure on the front panel DILUENT pressure gauge. See Chapter 9 regarding flow calibration.

Calibration gas from one or two certified cylinders enters the rear panel at the ports marked CYL 1 and/or CYL 2. Flow is controlled (ON/OFF) by manifold-mounted normally closed solenoid valves, one valve for CYL 1 and one valve for CYL 2. The two CYL valves are connected so that you may use either gas, neither, but not both at once. You control the Gas flow by adjusting the GAS PRESSURE regulator and observing the GAS PRESSURE gauge on the front panel.

The pressure regulators and restrictors are contained inside the oven which is maintained at 50°C making the flows immune to the effects of ambient temperature.

In the BASIC M702 (no OZONE/GPT option) the GAS and DILUENT streams are combined at a tee and conducted to the rear panel CAL GAS OUT union.

### 4.1 Ozone/GPT Option

If the OZONE/GPT option is installed, the DILUENT is split through two parallel restrictors. A low flow passes through the ozone generator then mixes with the GAS (for GPT, the GAS will be Nitric Oxide) at the entrance to the reaction chamber.

The Ozone reacts stoichiometrically with the NO (which must be in excess) in the reaction chamber to form NO<sub>2</sub> with some NO remaining.

#### NOTE

**Ensure that NO production is 10% more than O<sub>3</sub>.**



The remainder of the DILUENT combines with the reacted product at the exit of the reaction chamber and dilutes the NO/NO<sub>2</sub> to the desired concentration.

The combined product leaves the M702 through the rear panel CAL GAS OUT bulkhead union.

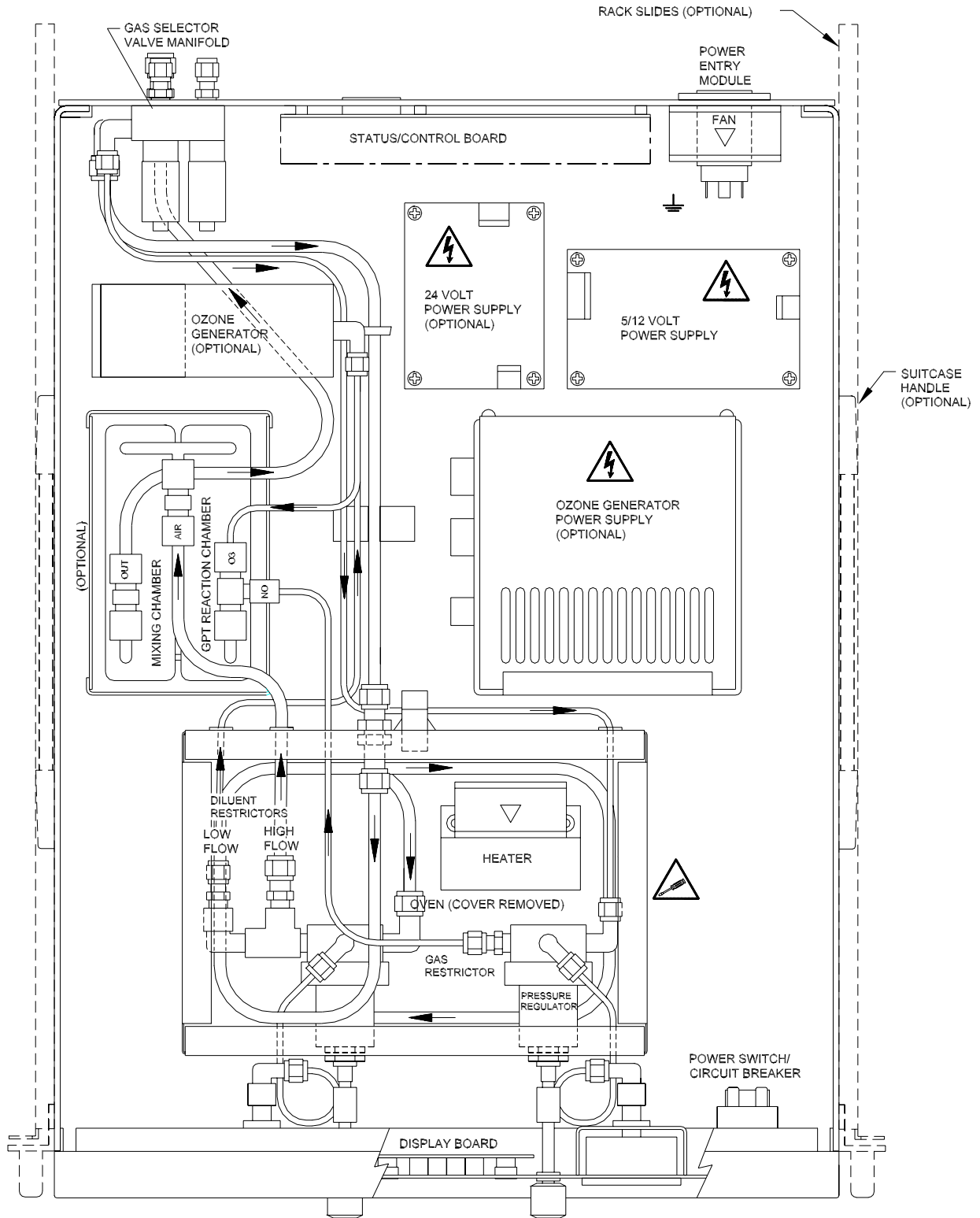
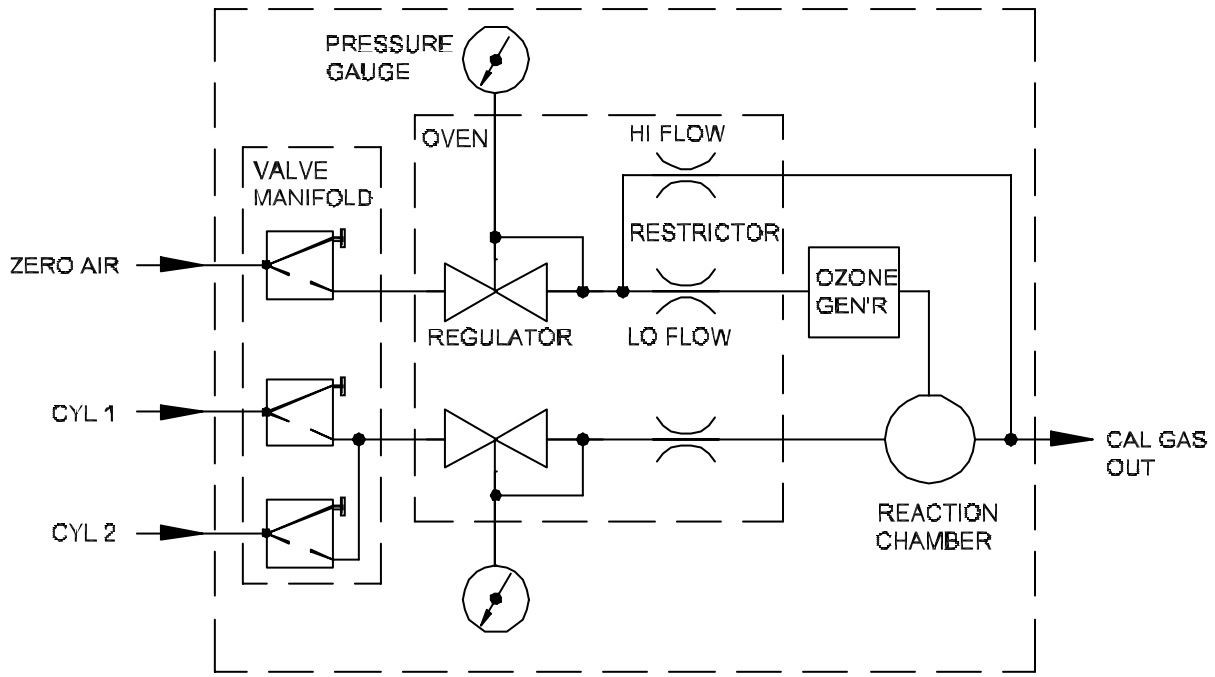
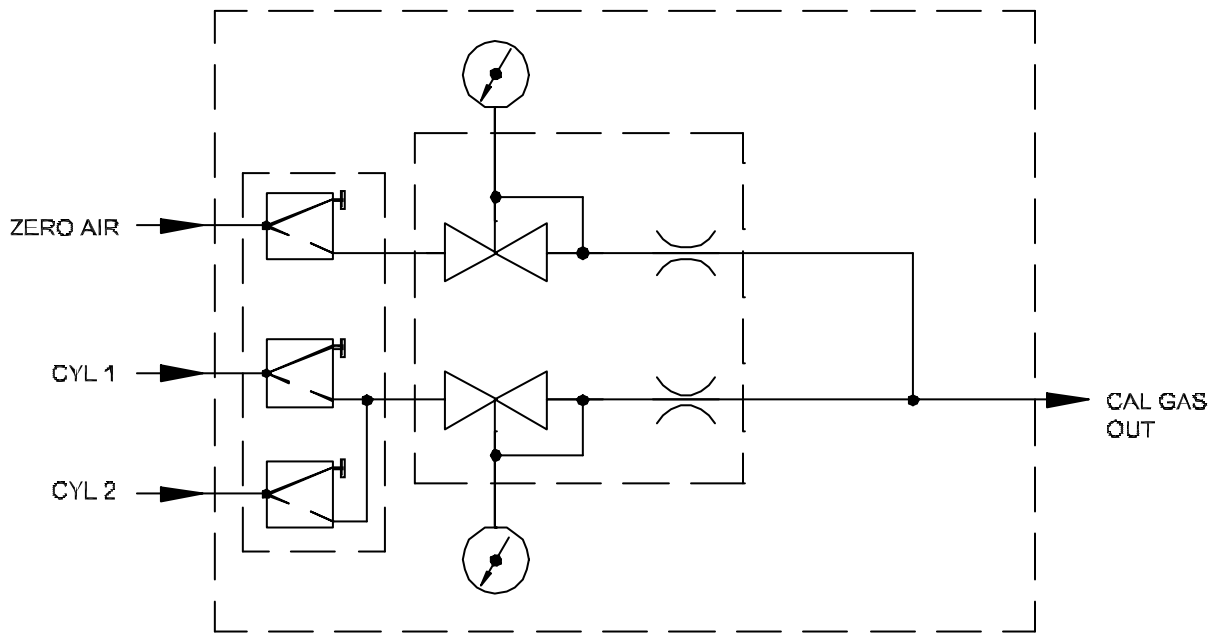


Figure 4-1: Assembly





WITH OPTIONS: OZONE & GPI



BASIC; SIMPLE GAS DILUTION

Figure 4-2: Pneumatic Diagram

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## 5 FRONT PANEL

The front panel contains all the controls needed to operate the M702 Calibrator. See Figure 5-1.

### 5.1 Power

Combination power switch and circuit breaker controls power to all of the M702 functions and protects against current overload.

### 5.2 Diluent

Alternate-action push-button switch turns on and off the ZERO AIR IN (or DILUENT IN) solenoid valve.

### 5.3 Cyl 1

Alternate-action push-button switch turns on and off the CYL 1 solenoid valve.

### 5.4 Cyl 2

Alternate-action push-button switch turns on and off the CYL 2 solenoid valve.

- CYL 1 or CYL 2 or neither may be selected. The logic will not allow both to be selected at the same time.

- \* These functions may be also controlled by remote contact closure through the CONTROL IN terminal strip on the rear panel. (See Section 6.4.)

- \*\* The status of these functions may be read remotely through the STATUS OUT terminal strip on the rear panel. (See Section 6.5.)

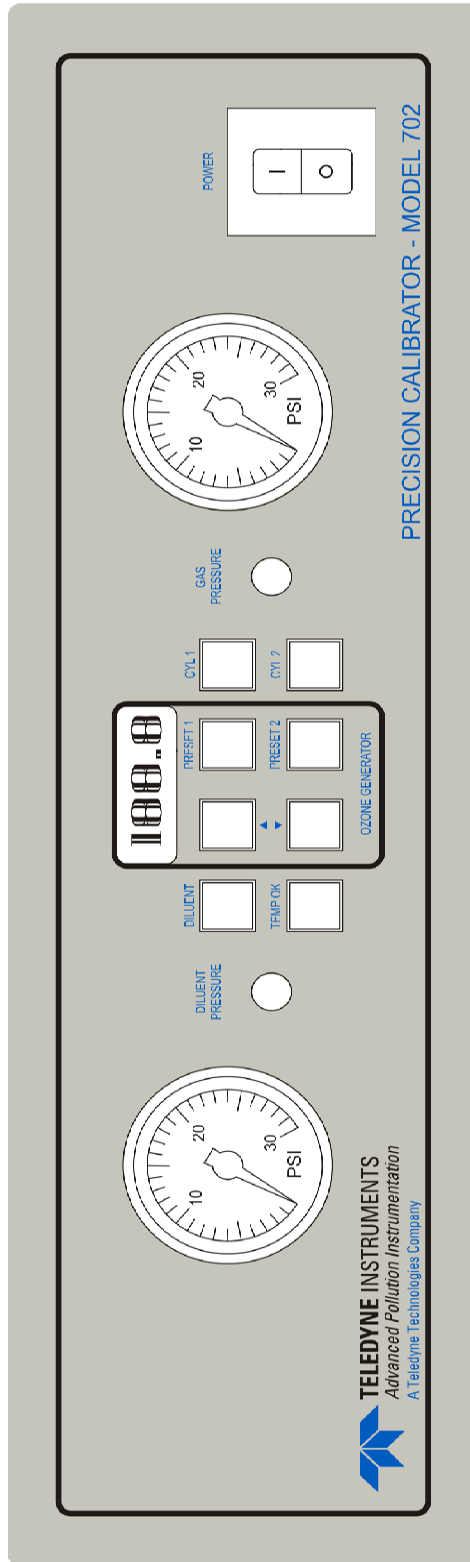


Figure 5-1: Front Panel

## 5.5 Diluent Pressure

The Diluent Pressure knob controls the diluent pressure regulator; clockwise to increase. The regulator secondary pressure is displayed on the adjacent pressure gauge. The pressure gauge will read zero when the DILUENT valve is off.

### CAUTION

**Do not exceed 50 PSIG or the M702 pressure gauge and regulator can be damaged.**



## 5.6 Gas Pressure

The Gas Pressure knob controls the Gas pressure regulator; clockwise to increase. The regulator secondary pressure is displayed on the adjacent pressure gauge. The regulator and pressure gauge are common to CYL 1 and CYL 2. The pressure gauge will read zero when neither CYL 1 nor CYL 2 is selected.

### CAUTION

**Do not exceed 50 PSIG or the M702 pressure gauge and regulator may be damaged.**



Remember to keep the pressure gauge in the upper half of its range for best resolution and control.

## 5.7 Preset 1 \* \*\*

The alternate action push-button switch selects the #1 drive voltage setting of the Ozone Generator.

## 5.8 Preset 2 \* \*\*

The alternate action push-button switch selects the #2 drive voltage setting of the Ozone Generator.

## 5.9 Digital Display

Displays the Ozone Generator current setting in percentage units from zero to 100. Will read zero if neither PRESET 1 nor PRESET 2 is selected.

Serves as “power on” indicator.

Displays “M702” and self-check items on start-up.

See Chapter 11 for setting Ozone concentration.

## 5.10 Up/Down Buttons

These push-buttons raise or lower the drive voltage setting of the Ozone Generator. The buttons operate on PRESET 1 or PRESET 2, whichever is presently selected.

The buttons have a built-in slow/fast mode.

The selected value will automatically store 5 seconds after the last push-button action.

## 5.11 Temp OK \*\*

Indicator shows when the oven temperature is at the 50°C set-point.

## 6 REAR PANEL

All connections, electrical and pneumatical are made at the M702 rear panel. See Figure 6-1.

### 6.1 Zero Air In

(1/4" BRASS swage-type union)

Use CLEAN 1/4" OD PFA (or similar) tubing.

The zero air or "diluent" source must be able to produce 1 to 3 SLPM at 35 - 50 psig.

### 6.2 Cyl 1 (or CYL 2) IN

(1/8" STAINLESS STEEL swage-type unions)

Use CLEAN 1/8" OD STAINLESS STEEL tubing.

**CAUTION**

**Do not use plastic tubing between the cylinder regulator and the M702. Use stainless steel.**



The gas cylinder or other source must produce 10 to 50 ccm at 35 - 50 psig.

**CAUTION**

**Do not exceed 50 PSIG at the cylinder regulator.**



## 6.3 Cal Gas Out

(1/4" STAINLESS STEEL swage-type union)

Connect the CAL GAS OUT port of the M702 to the analyzer sample manifold with CLEAN 1/4" OD PFA (or similar) tubing.

**CAUTION**

**The sample manifold must be properly vented. The USEPA suggested vent criteria is shown in Figure 8-1.**





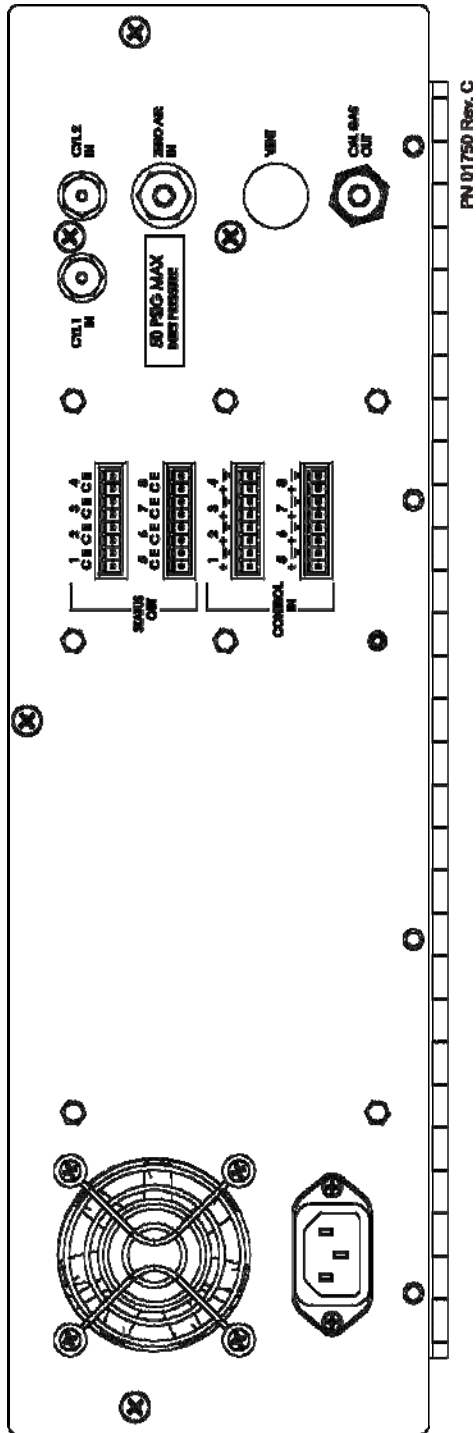


Figure 6-1: Rear Panel

## 6.4 Remote Control

Five functions may be remotely controlled through the CONTROL IN terminal strip.

CONTACT PAIR	FUNCTION
#1	DILUENT VALVE
#2	CYL 1 VALVE
#3	CYL 2 VALVE
#4	OZONE PRESET 1
#5	OZONE PRESET 2

These require a contact closure. Current is 30 mA.

## 6.5 Status Out

Seven functions may be remotely monitored for ON/OFF state through the STATUS OUT terminal strip.

CONTACT PAIR	FUNCTION
#1	DILUENT VALVE
#2	CYL 1 VALVE
#3	CYL 2 VALVE
#4	OZONE PRESET 1
#5	OZONE PRESET 2
#6	TEMPERATURE OK
#7	SYSTEM OK

These are uncommitted emitter/collector pairs and will sink 5 mA.

See Figure 6-2 for examples.

## 6.6 Power

Use an approved three-wire grounded power cord.

At 115 VAC, 60 Hz, the M702 draws 2.0 Amps.

At 230 VAC, 50 HZ, the M702 draws 1.0 Amp.

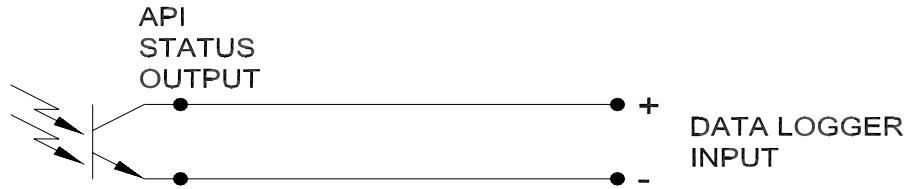
**CAUTION**

**Be sure that the power cord is properly grounded.**

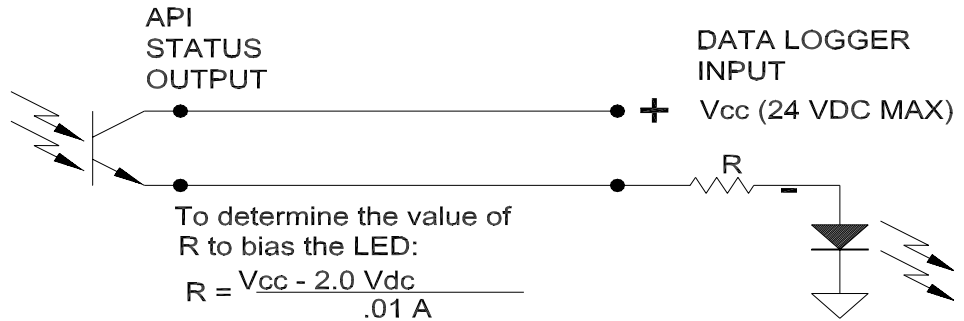


## 6.7 Remote Control/Status Out

1. If the datalogger inputs are "TTL", then the configuration of the status output should be:-



2. If the datalogger inputs are driven by current (eg., input LED of an optocoupler), then the configuration of the status output should be:-



3. If the datalogger supplies a voltage (eg., 24 Vdc) and expects to see the voltage during a closure, then the configuration of the status output should be:-

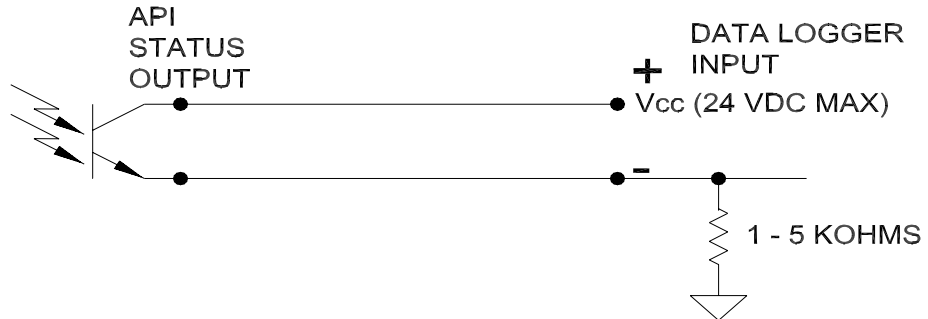


Figure 6-2: Status Output Configuration

## 6.8 Cooling Fan

The cooling fan draws air in and requires at least 3" (75 mm) of clearance for proper operation.

## 7 GETTING STARTED

### 7.1 Unpacking

Verify that there is no shipping damage.

If there are signs of damage, immediately contact the shipper, then Teledyne API.

Remove the cover and check for damage inside, particularly the glass GPT reaction chamber.

Check the line voltage decal on the rear panel. Verify that it matches your local power. (The M702 is not frequency-sensitive.)

### 7.2 Installation

See Figure 4-1.

The basic M702 has four rubber feet for bench-top mounting.

If the M702 is to be rack-mounted, the rubber feet must be removed. This is easily done from under the chassis, using a philips screwdriver.

The rack-mounting option is designed for a standard 19" RETMA rack.

When installing the M702, check the following points:

1. At least 3" (75mm) clearance at the back of the M702 for proper fan operation.
2. At least 3" (75mm) at each side for proper ventilation.
3. Adequate support for the weight: 30 lbs (14 Kg).
4. Access at the rear for making pneumatic and electrical connections.
5. Access at the front for control and adjustments.

#### "CE" NOTE

**When the M702 is operating, the cover must be in place and all cover screws must be tightened. Otherwise the M702 may exceed "CE" standards for electromagnetic radiation.**



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## 8 STARTING FOR THE FIRST TIME

### 8.1 First Turn-On

1. Remove the M702 cover.
2. Remove the oven cover.
3. Turn on the front panel POWER SWITCH.
  - a) The digital display should come on, displaying “API” and then carrying out a rapid self-check.
  - b) The rear panel cooling fan should start.
  - c) The oven heater fan should start.
  - d) The oven heater should be getting warm.
4. Replace the oven cover.
5. After 30 minutes, the TEMP OK light on the front panel should come on, indicating that the oven is up to 50°C.
6. Leave the M702 cover off until all leak checks have been done. Refer to Section 8.3.

### 8.2 Cylinder Connection

**CAUTION**

**Make sure that the area is well ventilated.**



If this is the first time that the gas cylinder and regulator have been connected to the M702:

1. Attach the cylinder regulator to the cylinder and tighten.
2. Attach the 1/8” stainless steel tubing to the regulator and tighten.  
**DO NOT ATTACH THE TUBING TO THE M702.**

**CAUTION**

**Use clean 1/8" stainless steel tubing.**



**CAUTION**

**Do not use plastic tubing. It may burst. With nitric oxide cylinders, atmospheric oxygen can permeate plastic tubing and oxidize NO to NO<sub>2</sub>.**



3. Close the regulator shut-off valve.
4. Open the cylinder valve.
5. Check the regulator for leaks using bubble solution.
6. Tighten if necessary.

**CAUTION**

**If the regulator still leaks, turn off the cylinder valve immediately, find the cause of the leak. (missing washer?)**



7. To prevent ambient air from flowing through the cylinder, thoroughly flush the cylinder regulator several times, as follows:
  - a) Close the regulator shut-off valve.
  - b) Open the cylinder valve.
  - c) Turn the cylinder regulator up to 35-50 psig.

**CAUTION**

**Do not exceed 50 PSIG at the cylinder regulator.**



- d) Close the cylinder valve.
- e) Open the regulator shut-off valve to vent the regulator contents.
- f) Repeat this once or twice more and then leave the regulator shut-off valve closed.
- g) Connect the stainless steel tubing to the M702 rear panel CYL 1 IN union and tighten.

**CAUTION**

**With nitric oxide cylinders, do not allow air to enter the regulator after purging. Oxygen will form NO<sub>2</sub> with the NO.**





## 8.3 Leak Checking

1. Open the cylinder valve and the regulator valve.
2. Check for leaks at the:
  - a) M702 rear panel union,
  - b) inlet valve manifold and
  - c) inlet valves, using bubble solution.
3. Cap the rear panel CAL GAS OUT union.
4. Push the CYL 1 button on the M702 front panel to open the CYL 1 valve.
5. Set the cylinder regulator to 35-50 psig.

**CAUTION**  
**Do not exceed 50 PSIG.**



6. Set the M702 GAS regulator to 30 psig.
7. Close the regulator shut-off valve.
8. Observe the front panel GAS pressure gauge.
9. If the gauge falls more than 2 psi in 5 minutes, there is an unacceptable leak.
10. Find the leak, using bubble solution. (It is probably a loose fitting)
11. Similarly, check the CYL 2 channel.
12. Connect the zero air (or diluent) supply to the M702 rear panel DILUENT IN union using clean ¼" PFA (or similar) tubing. (PFA (or similar) tubing is easier to work than stainless steel tubing and the consequences of burst tubing are not hazardous).
13. Set the zero air supply pressure at 35-50 psig.
14. Open the DILUENT valve by pushing the DILUENT button.
15. Adjust the DILUENT regulator to 30 psig.
16. Close the DILUENT shut-off valve by pushing the DILUENT button.
  - a) If the pressure drops more than 2 psi in 5 minutes, there is an unacceptable leak.
  - b) Find the leak and tighten the offending fitting.
17. Replace the M702 cover and tighten all cover screws.
18. Remove cap from CAL GAS OUT union.

**"CE" NOTE**

**When the M702 is operating, the cover must be in place and all cover screws must be tightened. Otherwise the M702 may exceed "CE" standards for electromagnetic radiation.**



## 8.4 Connecting the M702 to the Analyzer

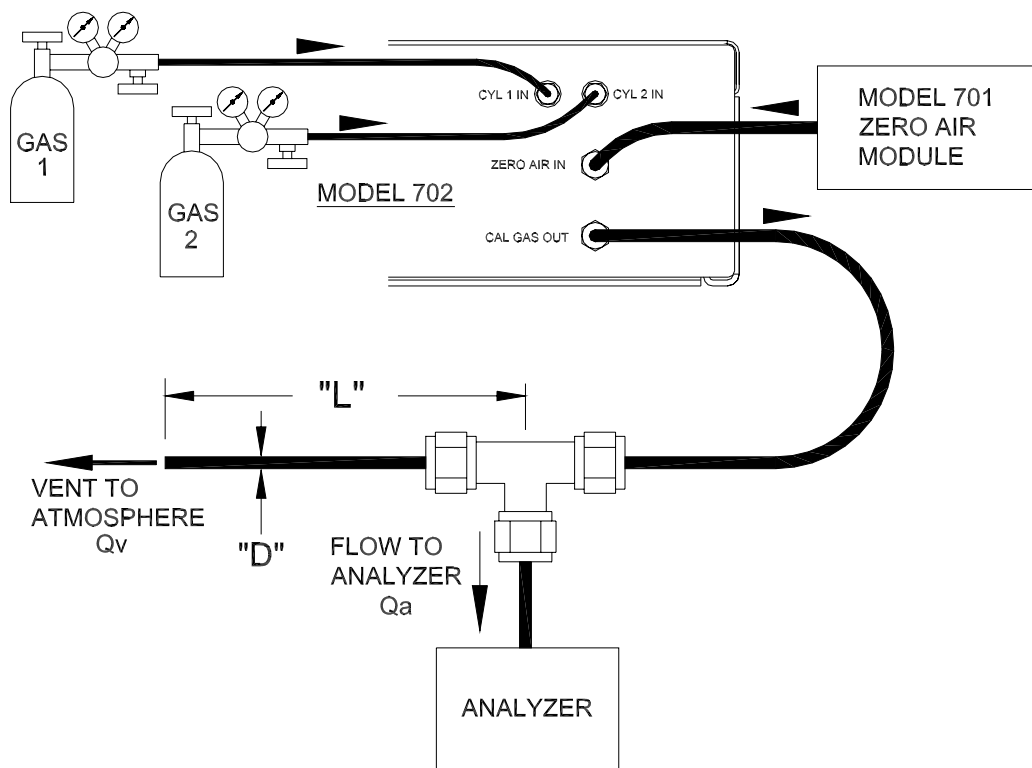
When you connect the M702 SPAN GAS OUT port to the analyzer(s) to be calibrated, it is very important that the analyzer sample inlet pressure be the same as the normal sampling pressure.

Figure 8-1 illustrates the USEPA-suggested criteria for designing the sampling manifold.

**CAUTION**

**The M702 does not have a built in vent. The vent should be a part of the manifold and should be as close as possible to the analyzer sample inlet. There must be only one vent in the manifold. See Figure 8-1.**





Note that the analyzer is connected to the "leg" of the Tee and the vent is connected to the "run" of the Tee.

For minimum back-diffusion through the vent and for minimum back-pressure in the manifold, the following relationship should be met:

$$Q_v \times L / Q_a \times D = 500$$

where;

- Q<sub>v</sub> is the flow in the vent (cc/min)
- Q<sub>a</sub> is the flow to the analyzer (cc/min)
- L is the length of the vent (inches)
- D is the inside diameter of the vent (inches)

Example:

- Analyzer flow = 500 cc/min
- Vent flow = 1000 cc/min
- D = .188 inches
- L = 48" approximately

**NOTE: For NH<sub>3</sub> Analyzers, keep all external tubing and fittings as short as possible. Ensure that the tubing and fittings are stainless steel and must be conditioned for 24 hours prior to use for each gas.**

Figure 8-1: Sample Manifold Venting

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## 9 SETTING DILUTION FLOWS

### CAUTION

We recommend that the M702 be set and kept at one flow for GAS and one flow for DILUENT.



### 9.1 Recommendations

While it is possible that the M702 can be used as a multi-point calibrator, WE DO NOT RECOMMEND IT.

The following compounding errors for a given flow can add up to as much as 10% inaccuracy:

1. Reading the pressure gauge during flow calibration.
2. Plotting the graph of flow versus pressure gauge reading.
3. Reading the graph.
4. Setting the pressure.

If you do use the M702 as a multi-point calibrator, you MUST re-verify the flows after each flow change using an NIST-traceable standard.

The flow standard can be a mass flow meter, a soap-film meter or a positive displacement piston meter; as long as it has can be traced to an NIST standard.

We recommend that, after you measure the flows, you CONSIDER THE REGULATOR TO BE LOCKED and that you use the pressure gauge as an ON/OFF indicator only.

The pressure regulators are more stable and repeatable when they are operating at the upper part of the range so we recommend that you set the GAS and DILUENT pressures on the M702 front panel to at least 15 psig, higher if you can.

The same rule applies with your flow measurement standard. It is more accurate when operated in the upper half of its range.

With the standard M702:

1. At 30 psig the DILUENT flow about 3000 sccm, nominal, and the GAS flow about 50 sccm, nominal.
2. At 15 psig the DILUENT flow about 1400 sccm nominal, and the GAS flow about 18 sccm, nominal.

Note:

1. Flow is not linear with pressure.
2. Flows will be different at its same pressure for different gases.

We recommend that you choose cylinder concentrations to support:

1. DILUENT FLOW between 1400 and 3000 sccm and
2. GAS FLOW between 18 and 50 sccm.

## 9.2 Verifying Flows

### 9.2.1 Diluent Flow

1. Connect the Zero Air Generator (Teledyne API Model 701) to the ZERO AIR IN port.
2. Set the Zero Air Generator output pressure to 35-50 psig.
3. Connect an NIST-traceable flow measurement device (mass flow meter, soap-film flowmeter or dry piston flowmeter) to the rear panel CAL GAS OUT port.  
ENSURE THAT THE PORT IS NOT VENTED.
4. The flowmeter should have a useful range of 1000 to 3000 ccm.
5. Press the front panel DILUENT button to open the air valve.
6. Check that the CYL 1 and CYL 2 buttons are NOT depressed.
7. Select a diluent pressure by adjusting the DILUENT PRESSURE regulator knob.
8. Measure the corresponding flow.
9. Adjust the diluent pressure until the desired flow is obtained.
10. Note the diluent pressure and use as an indication of flow.

### 9.2.2 Gas Flow

**CAUTION**

**Ensure to use stainless steel tubing between the cylinder regulator and the M702.**



1. Connect the gas cylinder to the rear panel CYL 1 IN (or CYL 2 IN) port.
2. Set the cylinder regulator secondary pressure to 35-50 psig.
3. Connect an NIST-traceable flow measurement device (mass flow meter, soap-film flowmeter or dry piston flowmeter) to the rear panel CAL GAS OUT port.
4. The flowmeter should have a useful range of 10 to 100 ccm.
5. Press the front panel CYL 1 (or CYL 2) button to open the gas valve.
6. Check that the DILUENT and CYL 2 (or CYL 1) buttons are not depressed.

7. Select a gas pressure by adjusting the GAS PRESSURE regulator knob.
8. Measure the corresponding flow.
9. Adjust the gas pressure until the desired flow is obtained.
10. Note the gas pressure and use as an indication of flow.

### **9.2.3 Corrections for NPT (Normal Temperature & Pressure)**

No NPT corrections are necessary.

The M702 is a DILUTION calibrator where the gas flow is divided by the diluent flow, i.e., it is ratiometric. The ambient temperature and pressure effects are same for both gas and diluent and the effects are self-canceling.

## 9.2.4 Example

Say you want to set a span gas of 450 ppb and require at least 1000 ccm to support your analyzer.

Start with the DILUENT flow at 2000 ccm and the cylinder flow at 20 ccm.

From the following equations:

$$\text{Gas concentration out (ppb)} = \frac{1000 \times \text{Cyl gas(ppm)} \times \text{Cyl flow(ccm)}}{\text{Cyl flow(ccm)} + \text{Diluent flow(ccm)}}$$

$$\text{Cylinder gas flow (ccm)} = \frac{\text{Diluent flow(ccm)}}{[1000 \times \text{Cyl gas(ppm)} / \text{Gas out(ppb)}] - 1}$$

$$\text{Cylinder concentration} = \frac{\text{Gas out(ppb)} \times [\text{Cyl flow(ccm)} + \text{Diluent flow(ccm)}]}{1000 \times \text{Cyl flow(ccm)}} \text{ (ppm)}$$

Taking the example from above:

$$\text{Cyl gas concentration (ppm)} = \frac{450\text{ppb} \times [20\text{ccm} + 2000\text{ccm}]}{1000 \times 20\text{ccm}} = 45.4\text{ppm}$$

Cylinder gas concentration should be 40 to 50 ppm.

## 9.3 Improving Response Times

### 9.3.1 Single Channel Dilution (Without Ozone or GPT)

After the M702 Calibrator has been switched from ZERO to SPAN or vice versa, or the SPAN concentration has been altered, there is necessarily a delay, or response time, before the final gas concentration is stable.

You will see a small improvement in response time by using the following technique WHEN ONLY ONE OF THE TWO “CYL” PORTS IS CONNECTED.

1. When going from DILUENT to CYL (ZERO to SPAN).
  - a) Open the active CYL port.
  - b) Open the unused CYL port FOR A SECOND OR TWO.
  - c) This flushes DILUENT from the inlet manifold and replaces it with CYL gas.
2. When going from CYL to DILUENT (SPAN to ZERO).
  - a) Close the active CYL port, Open the unused CYL port FOR A SECOND OR TWO.



- b) This flushes CYL gas from the inlet manifold and replaces it with ZERO air.
3. When going from one CYL to the other.
  - a) Unfortunately, this condition requires that both CYL ports are used and so a second port is not available for venting.

### 9.3.2 With Ozone and GPT

With the Ozone Generator and GPT options installed, the response time will be longer because there is more surface area to condition to a new concentration.

You will reduce the response time by preconditioning the surfaces as follows:

When going from ZERO to OZONE or GPT ( $\text{NO} + \text{O}_3 = \text{NO} + \text{NO}_2$ ):

1. Turn on the M702 Ozone or GPT.
2. Wait for 20 to 30 minutes for the M702 and the manifold to condition.
3. Switch the Analyzer valve to the Span state.

When the calibration sequence is complete:

1. Switch the M702 back to Zero Air.

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## 10 SETTING UP OZONE GENERATION

The OZONE option adds an ozone generator, a glass reaction chamber and a second air flow control restrictor.

### NOTE

**When using NH<sub>3</sub> gas, do not turn on the ozone at the same time the NH<sub>3</sub> gas is flowing. This will cause NH<sub>3</sub> salt to build up and flow problems will occur.**



From the DILUENT regulator, air flows through two restrictors in parallel. One is a low-flow restrictor which controls the flow through the ozone generator and the other is a high-flow restrictor which controls the downstream dilution air. The DILUENT pressure gauge indicates the TOTAL flow of the two restrictors.

Select the ozone-generating lamp current from the front panel by means of the PRESET 1 and PRESET 2 buttons. As implied, the PRESET buttons select one of two preselected ozone lamp currents.

You may alter the PRESET values by means of the UP/DOWN buttons. Refer to Section 10.1.

There are two methods of varying the ozone concentration:

1. By selecting PRESET 1 or PRESET 2, or
2. by altering the PRESET values.

(Varying the diluent flow is NOT RECOMMENDED as mentioned earlier.)

The usual preset ozone concentrations are:

1. 0.20 ppm•LPM and
2. 0.80 ppm•LPM.

(Refer to Appendix A for the Check Out Sheet in the back of this manual for the exact values.)

For example:

1. PRESET 1 set at 0.20 ppm•LPM (200 ppb at 1000 ccm)  
gives a concentration of 100 ppb at 2000 ccm.  
(the diluent flow set up in the above dilution example).
2. PRESET 2 set at .80 ppm•LPM  
gives a concentration of 400ppb at 2000 ccm.

## 10.1 To Adjust A Preset Value

1. Press PRESET 1 button (or PRESET 2).
2. Press the UP or DOWN button until the desired concentration is shown in the display.
3. Wait 5 seconds for the new value to be stored.
4. The allowable range of ozone concentrations is 0.05 to 4 ppm•LPM.  
(50 to 4000 ppb at 1000 ccm or 25 to 2000 ppb at 2000 ccm)

## 10.2 Verifying Ozone Concentration

Ozone concentration accuracy is NOT critical for GPT work.

However, if you intend to use the M702 as an OZONE TRANSFER DEVICE, you MUST independently verify the ozone concentration accuracy.

**CAUTION**

**It takes about an hour to reach ozone stability.**



## 11 SETTING UP GPT

This option includes the Ozone option (with glass reaction chamber).

By setting the correct flows and concentrations of nitric oxide, ozone and diluent, the nitric oxide (NO) is stoichiometrically oxidized by ozone (O<sub>3</sub>) to nitrogen dioxide (NO<sub>2</sub>) using the EPA-approved Gas Phase Titration technique.

The USEPA prescribes specific rules for GAS PHASE TITRATION of NO to NO<sub>2</sub>.

### NOTE

**Prior to performing GPT, ensure to flow zero air through the instrument after using NH<sub>3</sub> gas.**



### 11.1 Basic Equations

The basic equations are:

$$[\text{NO}_x] \text{ out} = [\text{NO}] \text{ cyl} \times (\text{QNO} / (\text{QNO} + \text{QO}_3 + \text{QAIR}))$$

$$[\text{NO}_2] \text{ out} = [\text{O}_3] \times (\text{QO}_3 / (\text{QNO} + \text{QO}_3 + \text{QAIR}))$$

$$[\text{NO}] \text{ out} = [\text{NO}_x] - [\text{NO}_2]$$

where:

$$[\text{NO}_x] \text{ out} = \text{NO}_x \text{ concentration at CAL GAS OUT [ppm]}$$

$$[\text{NO}] \text{ cyl} = \text{NO concentration in the cylinder [ppm]}$$

$$[\text{NO}_2] \text{ out} = \text{NO}_2 \text{ concentration at the CAL GAS OUT [ppm]}$$

$$[\text{NO}] \text{ out} = \text{NO concentration at the CAL GAS OUT [ppm]}$$

$$[\text{O}_3] = \text{Ozone concentration into the reaction chamber [ppm]}$$

$$\text{QNO} = \text{NO flow from the cylinder (LPM)}$$

$$\text{QO}_3 = \text{Ozone flow into the reaction chamber (LPM)}$$

$$\text{QAIR} = \text{Dilution air flow into the reaction chamber (LPM)}$$

The  $\text{NO} + \text{O}_3 \Rightarrow \text{NO}_2 + \text{O}_2$  reaction is slow and limitations must be observed to ensure a complete reaction.

Generally, the NO concentration in the reaction chamber should be high and the residence time should be long but not too long or ozone will be reduced by excessive surface contact.

The two criteria are:

1. Residence time in the reaction chamber  $t = < 1.2$  minutes
2. NO concentration x residence time  $[NO] \times t = > 2.75$  ppm•minutes

where:

$$t = \text{residence time in the reaction chamber} \\ = \text{reaction chamber volume} / (Q_{NO} + Q_{O_3}) \text{ (minutes)}$$

$[NO]$  = NO concentration in the reaction chamber [ppm]

$$= [NO]_{\text{cyl}} \times (Q_{NO} / (Q_{NO} + Q_{O_3})) \text{ ppm}$$

In the Model 702 Calibrator, the criteria are easy to maintain because the critical factors have been pre-calculated.

1. The reaction chamber volume is 136 cc.
2. Use an NO cylinder concentration of 50 ppm•([NO] cyl)
3. Set the NO cylinder flow at 20 ccm•(QNO)
4. Set the ZERO AIR flow at 2000 ccm.

The O<sub>3</sub> flow (QO<sub>3</sub>) will be approximately 200 ccm and the dilution air (QAIR) will be approximately 1800 ccm.

The DILUENT regulator flow restrictors in the M702 automatically split the diluent flow (QGPT); approximately 10% through the Ozone generator (QO<sub>3</sub>) and the remainder to downstream dilution (QAIR). The resulting high O<sub>3</sub> concentration helps ensure a rapid and complete reaction with the NO.

The total of QO<sub>3</sub> and QAIR will be as accurate as your ZERO AIR flow verification.

Using the above values, the criteria are met, as follows:

$$\text{Reaction time} = 136 \text{ cc} / (20 + 200 \text{ ccm}) = 0.62 \text{ minutes} (< 1.2 \text{ minutes})$$

$$[NO] \text{ reaction chamber;} = 50 \text{ ppm} \times 20 \text{ ccm} / (20 + 200 \text{ ccm}) = 4.55 \text{ ppm}$$

$$\text{Product of } [NO] \text{ and } t, 0.62 \text{ minutes} \times 4.55 \text{ ppm} = 2.82 \text{ ppm}\cdot\text{minutes}$$

$$(> 2.75 \text{ ppm}\cdot\text{minutes})$$

## 11.2 Set-Up

GPT is generally used to calibrate NO<sub>x</sub> analyzers having a primary range of 500ppb (0.5 ppm). With this in mind, we suggest the following set-up.

$$[\text{NO}]_{\text{cyl}} = 50 \text{ ppm}$$

$$\text{QNO} = 20 \text{ ccm (CYL pressure approx. 15 psig)}$$

$$\text{QO}_3 = 200 \text{ ccm}$$

$$\text{QAIR} = 1800 \text{ ccm}$$

$$\text{QGPT} = 200 + 1800 = 2000 \text{ ccm (DILUENT pressure approx. 15 psig)}$$

$$[\text{NO}_x]_{\text{out}} = 50 \times 20 / (20 + 2000) = 0.495 \text{ ppm at 2020 ccm total flow.}$$

With the O<sub>3</sub> turned OFF, the gas at the CAL GAS OUT union would be read by an NO<sub>x</sub> Analyzer as:

$$\text{NO}_x = 495 \text{ ppb, NO} = 495 \text{ ppb, NO}_2 = 0$$

In PRESET 1, the normal ozone specific output is 0.2 ppm•LPM.

For a total flow of 2000 ccm, the Ozone concentration is:

$$\frac{0.2 \times 1000 \times 1000}{2000 + 20} = 99 \text{ ppb}$$

$$\text{NO}_x = 495 \text{ ppb, NO} = 495 - 99 = 396 \text{ ppb, NO}_2 = 99 \text{ ppb.}$$

In PRESET 2, the normal ozone specific output is 0.8 ppm•LPM.

For a total flow of 2000 ccm, the Ozone concentration is:

$$\frac{0.8 \times 1000 \times 1000}{2000 + 20} = 396 \text{ ppb}$$

$$\text{NO}_x = 495 \text{ ppb, NO} = 495 - 39 = 99 \text{ ppb, NO}_2 = 396 \text{ ppb.}$$

## 11.3 Converter Efficiency

These NO<sub>x</sub>, NO and NO<sub>2</sub> figures are predicated on a 100% efficient converter in the NO<sub>x</sub> analyzer.

Refer to the Teledyne API Model 200A NO<sub>x</sub> ANALYZER instruction's manual for determining converter efficiency.



## 12 TROUBLESHOOTING

Table 12-1: M702 Troubleshooting

Problem	Probable Cause	Corrective Action
Power light does not come on.	Unplugged power cord.	Plug in power cord at both ends.
	Incorrect line voltage.	Refer to Table 3-1 for the correct line voltage.
	Tripped power switch/circuit breaker.	Untrip power switch/circuit breaker.
	5/15 VDC power supply failed.	Replace power supply.
Oven temperature light does not come on after 30 minutes.	Unplugged oven power cord.	Plug in oven power cord.
	Heater is open (it has infinite resistance).	Replace with a new heater. Resistance should be 550 $\Omega$ .
	Thermistor is open or shorted.	Replace with a new thermistor. Resistance should be 30 K $\Omega$ at 25°C and 11K $\Omega$ at 50°C.
Pressure regulator does not respond.	Pressure source not connected.	Ensure that the pressure source is connected to the intake.
	Selector valve is off.	Turn on the selector valve.
	Failed selector valve.	Replace the selector valve.
Regulated pressure is too low.	Pressure at intake too low.	Refer to Section 8.3 for leak checking.
	Leak.	Refer to Section 8.3 for leak checking.
No ozone output.	UV lamp failed.	Replace UV lamp.
	Ozone generator power supply failed.	Replace ozone generator power supply.
	24 VDC power supply failed.	Replace the 24 VDC power supply.

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## 13 MAINTENANCE

**NOTE**

The operations outlined in this chapter are to be performed by qualified maintenance personnel only.



**CAUTION**

Do not loosen any tubing connection while pressure is applied to the M702.



**CAUTION**

Even though the front panel power switch is off, there is line voltage present at the power entry terminals, power switch thermals and on the control board.

For added safety, remove the power cord from the rear panel receptacle.



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## 14 EXPENDABLES

The Model 702 does not require any expendables.

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# APPENDIX A

Table A-1: Model 702 Check Out Sheet

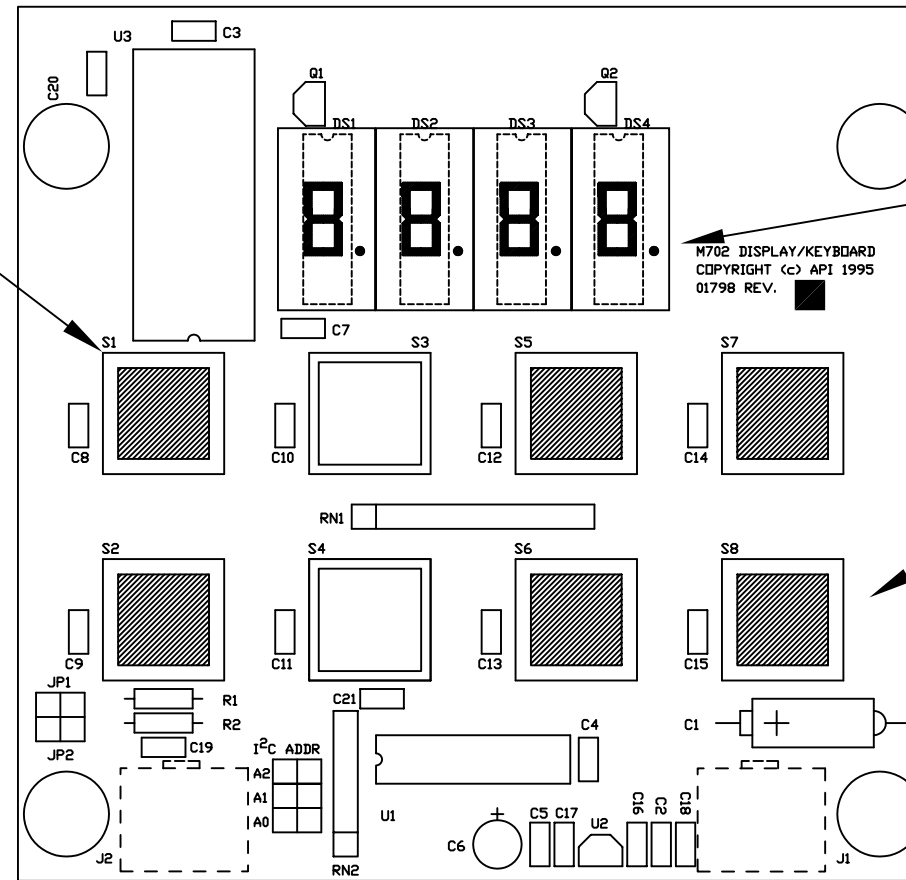
<b>CHECK OUT SHEET MODEL 702</b>	
SERIAL NUMBER _____	DATE _____ BY _____
LINE POWER? _____	( _____ VAC/ _____ HZ)
PROM # _____	
APPEARANCE _____	OK
LEAK-CHECK _____	OK
FANS RUNNING? _____	YES
<b>TEMPERATURES</b>	
OVEN _____	(48-50°C)
OZONE GENERATOR _____	(48-52°C)
<b>FLOWS</b>	
DILUENT (@ 15 PSIG) _____	CCM
(Mass flow meter S/N _____)	
GAS (@ 15 PSIG) _____	CCM
(Mass flow meter S/N _____)	
DILUTION RATIO (DILUENT/GAS) _____	:1
TOTAL FLOW (DILUENT + GAS) _____	CCM
<b>OZONE CONCENTRATIONS</b>	
PRESET 1 (@ 15 PSIG DILUENT FLOW) _____	PPM.
(PPM x FLOW LPM) _____	PPM•LPM
PRESET 2 (@ 15 PSIG DILUENT FLOW) _____	PPM.
(PPM x FLOW LPM) _____	PPM•LPM

**Table A-2: Model 702 Electrical Schematics**

<b>Part No.</b>	<b>Name</b>
01798	Assembly, keyboard/display PCA
01799	Diagram, keyboard/display PCA
02280	Assembly, Rear Panel
02281	Diagram, Rear Panel
0290100	M702 Standard Version-Interconnect Drawing
0290101	M702 03 Option Version-Interconnect Drawing



PIN 1: UPPER LEFT  
HAND CORNER FOR  
ALL SWITCHES  
S1-S8



DECIMAL POINT DOWN

△ 4 8PL

NOTES:

- 1 △ NON-ILLUMINATED SWITCHES: S3, S4 (PIN 1: UPPER LEFT HAND CORNER)
- 2 △ ILLUMINATED SWITCHES: S1, S2, S5, S6, S7, S8 (PIN 1: UPPER LEFT HAND CORNER)
- 3 △ J1, J2 ARE INSTALLED ON THE SOLDER SIDE
- 4 △ SWITCHES S1-S8 MUST BE SOLDERED ON AFTER MACHINE CLEANING, USING A ROSIN BASED FLUX AND REMOVED BY AN ALCOHOL BASED SOLVENT.

8/22/01  
8.23.00

C: ADDED NOTE 4.  
B: CLARIFY LOCATION OF PIN 1

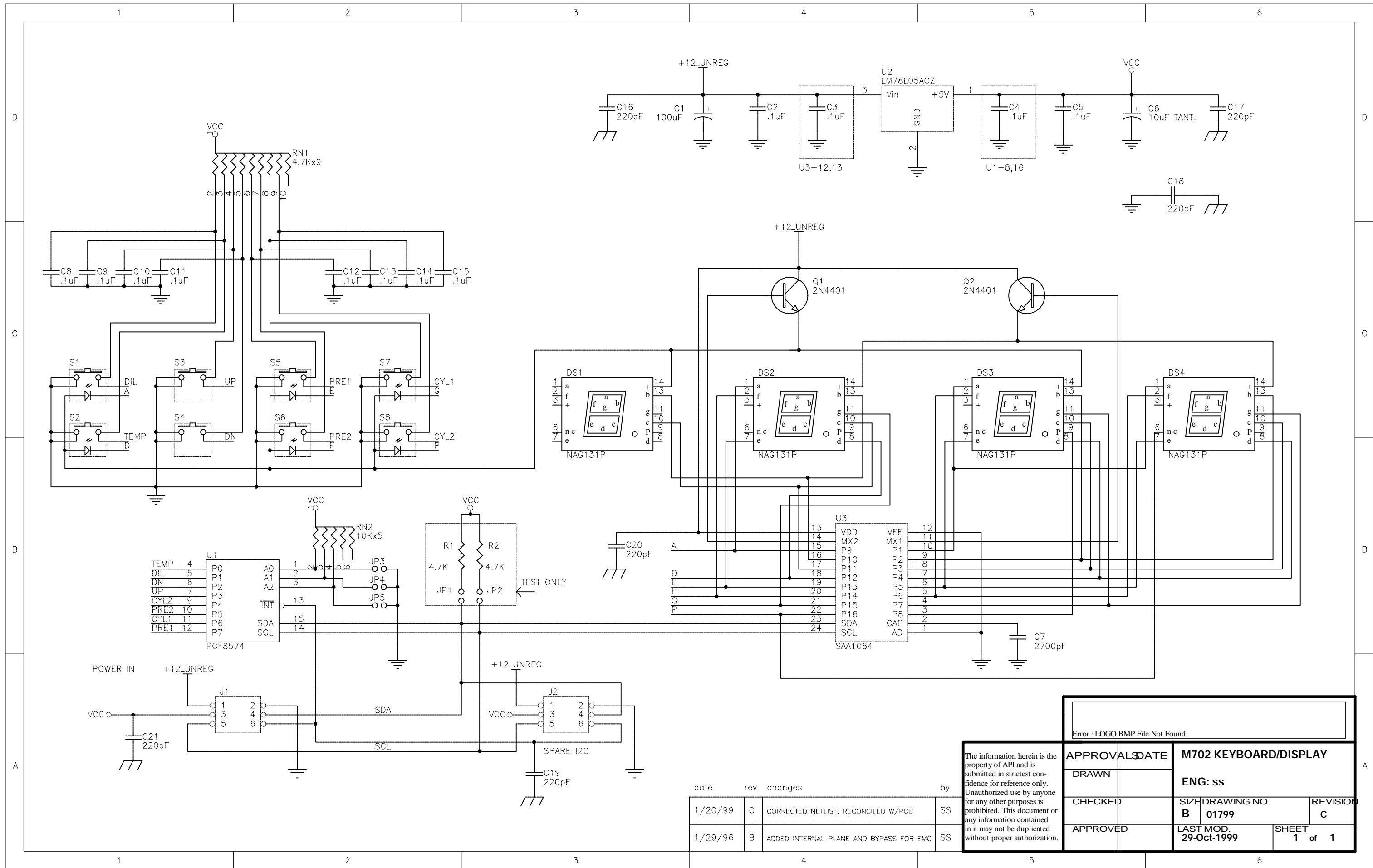
KV  
RH

4.18.97		A: INITIAL RELEASE	RH
DATE	ECR#	DESCRIPTION OF CHANGE	BY

TOLERANCES	
X±	XXX±
XX±	

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<b>API</b>		ADVANCED POLLUTION INSTRUMENTATION INC. SAN DIEGO, CA.	
APPROVALS	DATE	PCA, KEYBOARD/DISPLAY M702	
DRAWN			
CHECKED			
APPROVED			
DO NOT SCALE DRAWING		SIZE △	DRAWING NO. 01798
		SCALE	REVISION C
			SHEET 1 OF 1

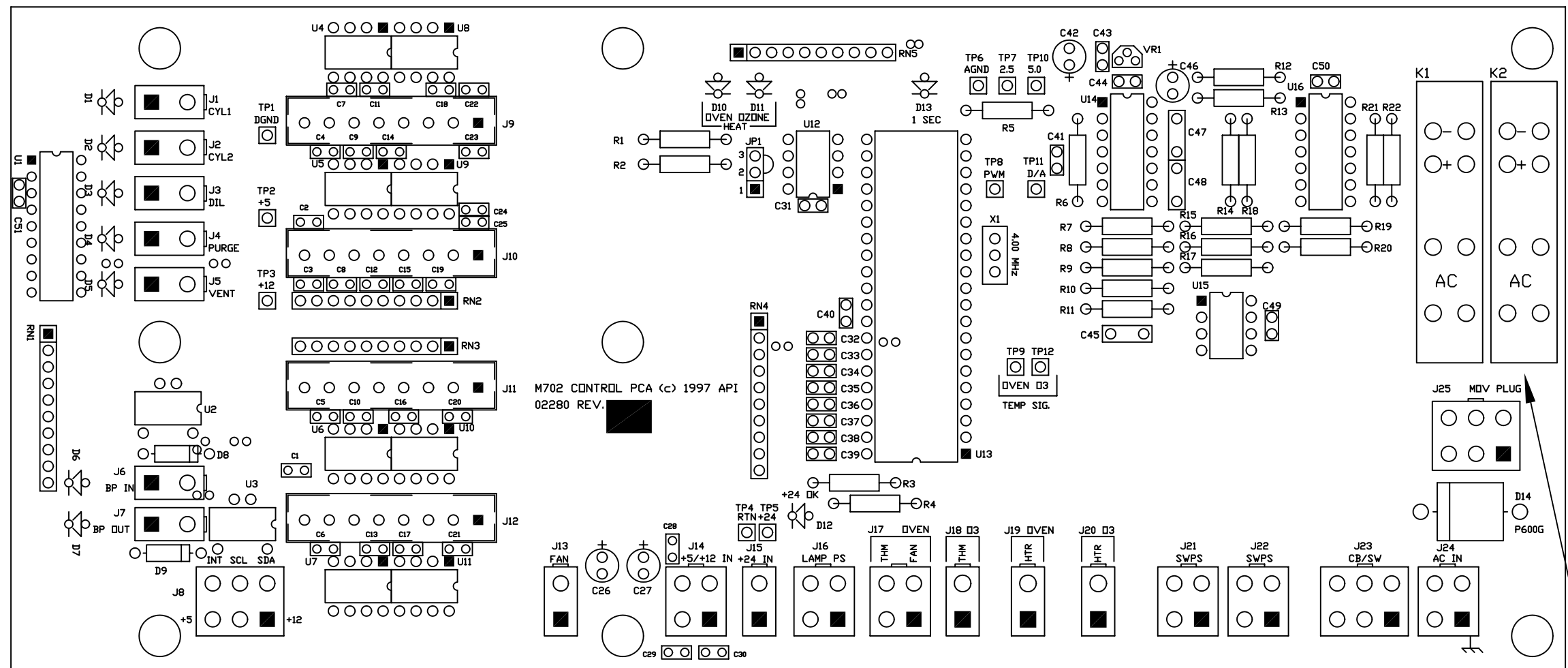


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APPROVALS	DATE	M702 KEYBOARD/DISPLAY	
DRAWN		ENG: ss	
CHECKED		SIZE	DRAWING NO.
APPROVED		B	01799
		LAST MOD.	REVISION
		29-Oct-1999	C
		SHEET	1 of 1

date	rev	changes	by
1/20/99	C	CORRECTED NETLIST, RECONCILED W/PCB	SS
1/29/96	B	ADDED INTERNAL PLANE AND BYPASS FOR EMC	SS



NOTES:

- 1) J9, 10, 11, 12 INSTALLED ON SOLDER SIDE
- INSTALL K1,K2 AFTER MACHINE WASH

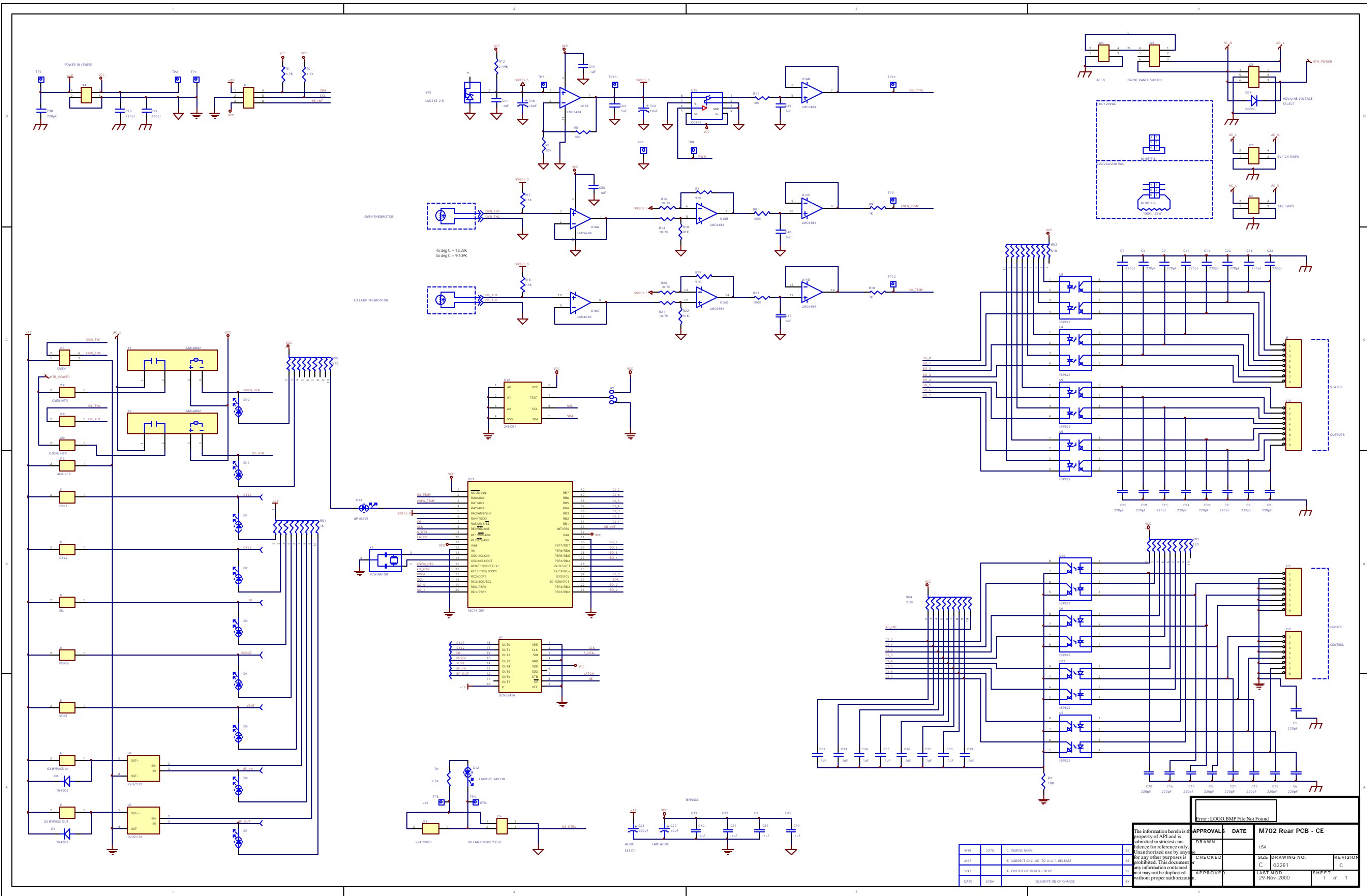
10/04/01	1841	C: ADDED NOTE 2	KV
5.9.97		B: DELETED REV A NOTES	RH
4.18.97		A: INITIAL RELEASE	RH
DATE	DCN#	DESCRIPTION OF CHANGE	BY

**TOLERANCES**  
 X±      XXX±  
 XX±

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ADVANCED POLLUTION INSTRUMENTATION INC.  
 SAN DIEGO, CA.

APPROVALS	DATE	PCA, REAR PANEL-M702	
DRAWN		DRAWING NO. 02280	REVISION C
CHECKED			
APPROVED		SCALE	SHEET 1 OF 1
DO NOT SCALE DRAWING			



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APPROVAL	DATE	M702 Rear PCB - CE
DRAWN	USA	
CHECKED		SIZE
APPROVE		DRAWING NO. C. 02281
		REVISION C.
		LAST MOD. 29-Nov-2000
		SHEET 1 of 1

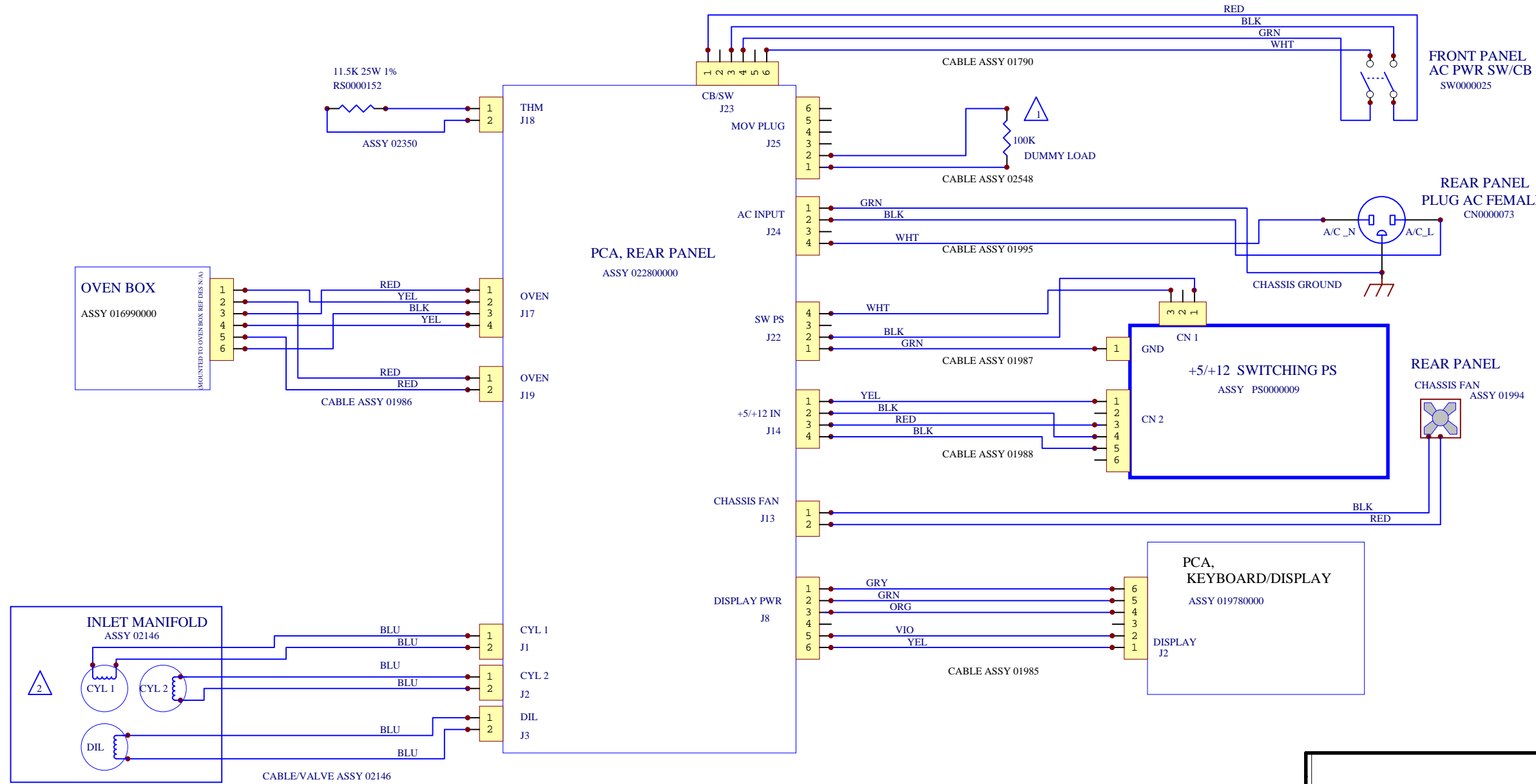
REV	DATE	DESCRIPTION OF CHANGE
1	2/21/00	C. WINDOW REV
2	2/21/00	B. CORRECT D12, D16 TO 10K & 1.5 RELEASE
3	1/21/00	A. PROTOTYPE BUILD - 10 PC
4	1/21/00	

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M702 STANDARD VERSION

NOTES:

- 1 USE 100K FOR 220-240VAC  
USE 22AWG WIRE FOR 110VAC
- 2 CYL 1, CYL 2, AND DIL ARE VALVES, PART NUMBER VA000023



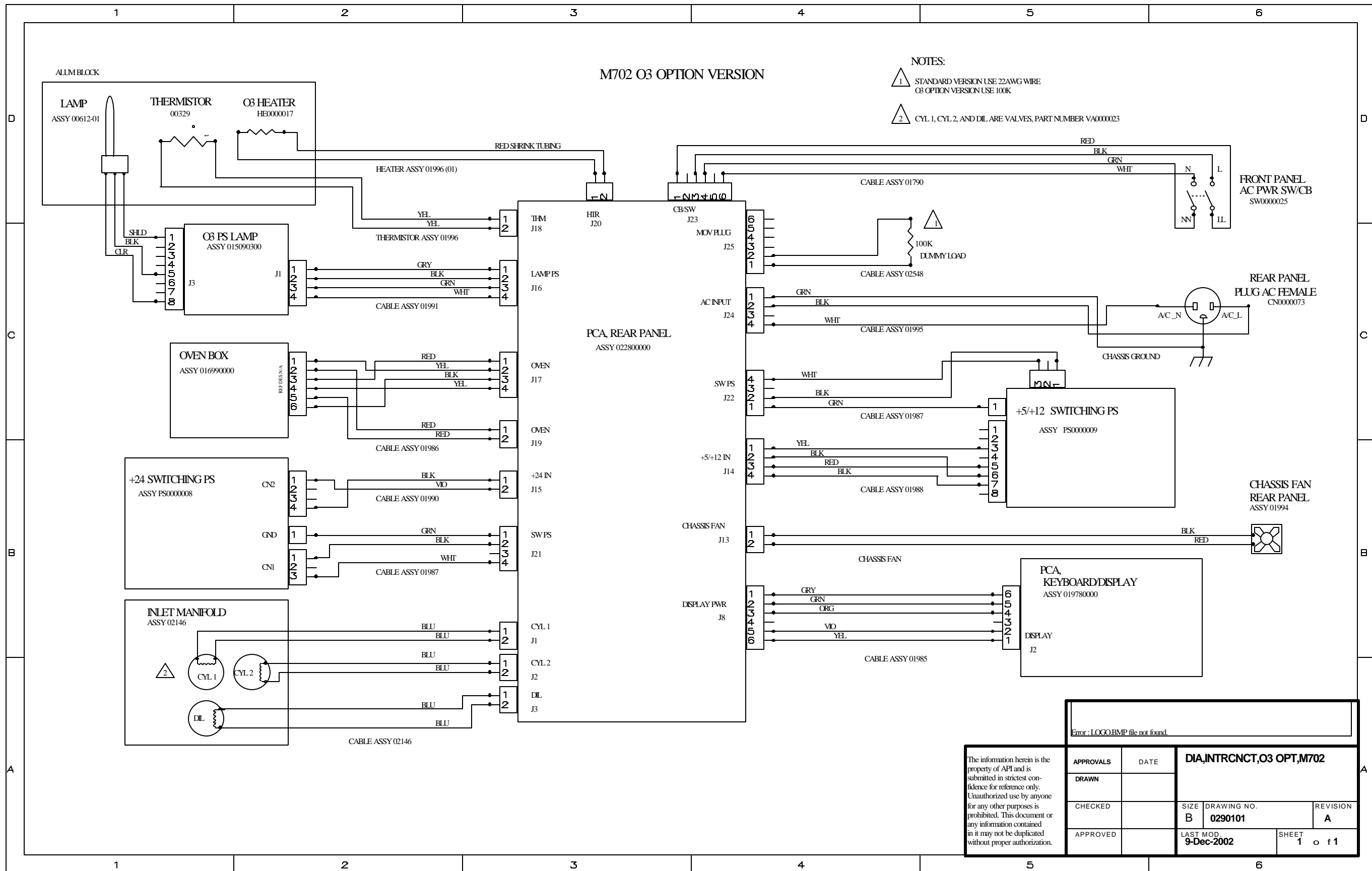
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APPROVALS		DATE	<b>DIA,INTRCNCT,STD,M702</b>	
DRAWN			SIZE	REVISION
CHECKED			B	A
APPROVED			DRAWING NO. 02901	
LAST MOD. 1-Aug-2001			SHEET 1 of 1	

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M702 O3 OPTION VERSION

- NOTES:
- 1 STANDARD VERSION USE 22AWG WIRE  
O3 OPTION VERSION USE 100K
  - 2 CYL 1, CYL 2, AND DIL ARE VALVES, PART NUMBER VA000023



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APPROVALS	DATE	<b>DIA,INTRCNCT,O3 OPT,M702</b>	
DRAWN		SIZE	DRAWING NO.
CHECKED		B	0290101
APPROVED		REVISION	A
		LAST MOD.	SHEET
		9-Dec-2002	1 of 1

## APPENDIX B – M702 SPARE PARTS & EXPENDABLES

**NOTE**

Use of replacement parts other than those supplied by API may result in non-compliance with European standard EN 61010-1.

- 02046 - List, Spare Parts, M702
- 05825 - List, Recommended Spares Stocking Levels, M702

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## M702 Spare Parts List

Part Number	Description
003290000	Thermistor Assembly (885-071600)
005940300	ASSY, OZONE GENERATOR, M702
006120200	ASSY, OZONE GEN LAMP w/PIGTAIL (BIR)
015090300	ASSY, O3 GEN LAMP POWER SUPPLY, M700/702
017980000	PCA, KEYBOARD/DISPLAY, M702
018490100	GAUGE, PRESSURE, 30 PSI, M702
018540000	Pressure Regulator, Zero Air, M702
018540100	Pressure Regulator, Gas, M702
019800101	ASSY, FLOW RESTRICTOR,1/8,SS,50CCM, M702
019800201	ASSY, FLOW RESTRICTOR,1/8,B,250CCM, M702
019800301	ASSY, FLOW RESTRICTOR,1/4,B,3000CCM,M702
024710000	ASSY, TUBING, CLEAR FEP 1/8" (TU1), 6FT
024760000	ASSY, TUBING, TU0000011, 6FT
024780000	ASSY, TUBING, CLEAR FEP 1/4" (TU18), 6FT
028240000	GPT Reaction Volume
FA0000012	Fan, 12VDC, M702
FL0000001	Sintered Filter (002-024900)
HE0000017	Heater, Reaction Cell, 12W
KIT000068	Retrofit, M702 12/5 VDC Power Supply Replacement
PS0000008	PWR SUPPLY, SWITCHING, 24VDC, M702
PS0000014	PWR SUPPLY, SWITCHING,5.2V 12V -5V, M702
SW0000025	SWITCH, POWER, CIRC BREAK, VDE/CE *
VA0000023	Valve, Gas Shut-off
VA0000025	Valve, Zero Air shut-off

# Recommended Spare Parts Stocking Levels

## Model 702

Recommended Spare Parts List: Standard

Part Number	Description	1	2-5	6-10	11-20	21-30
003290000	THERMISTOR, BASIC (VENDOR ASSY)(KB)		1	2	2	2
017980000	PCA, KEYBOARD/DISPLAY, M702				1	1
018490100	GAUGE, PRESSURE, 30 PSI, M702	1	1	2	4	4
018540000	PRESSURE REGULATOR, AL, M702			1	1	2
018540100	PRESSURE REGULATOR, SS, M702			1	1	2
019800101	ASSY, FLOW RESTRICTOR,1/8,SS,50CCM, M702				1	1
019800201	ASSY, FLOW RESTRICTOR,1/8,B,250CCM, M702				1	1
KIT000068	REPLACEMENT, SWITCHING PS, 12/5VDC, M702			1	2	2
VA0000023	VALVE, MANIFOLD, 2-WAY CLIPPARD		1	2	2	4
VA0000025	VALVE, SS, 12VDC, 2WAY(KB)				1	1

Recommended Spare Parts List: To Upgrade from PN 039550200 Relay Board  
(M100E: Use KIT000207, M100E Relay Retrofit)

Part Number	Description	1	2-5	6-10	11-20	21-30
028240000	REACTION CHAMBER, GPT, M700, M702 (KB)				1	1
FA0000012	FAN, BRUSHLESS, 12VDC, 60MM (KB)	1	1	1	2	2

Recommended Spare Parts List: For 240V Operation, Use PN 055100200

Part Number	Description	1	2-5	6-10	11-20	21-30
HE0000017	HTR, 12W/120V (50W/240V), CE AP (KB)			1	1	1

Recommended Spare Parts List: With O<sub>3</sub> Option Installed

Part Number	Description	1	2-5	6-10	11-20	21-30
005940300	ASSY, OZONE GENERATOR, M702				1	1
006120200	ASSY, OZONE GEN LAMP w/PIGTAIL (BIR)		1	1	2	2
015090300	ASSY, O3 GEN LAMP POWER SUPPLY, M700/702			1	1	2
019800301	ASSY, FLOW RESTRICTOR,1/4,B,3000CCM,M702				1	1
028240000	REACTION CHAMBER, GPT, M700, M702 (KB)				1	1

Recommended Spare Parts List: With IZS, ZS Option Installed

Part Number	Description	1	2-5	6-10	11-20	21-30
PS0000008	PWR SUPPLY, SWITCHING, 24VDC, M702			1	2	2