



MAST/KEYSTONE
Model 727-5
OZONE MONITOR

Operation and Instruction Manual

Mast/Keystone
2200 Dickerson Rd
Reno, Nevada 89503
Tel: (866) 574-6360/(775) 324-2799
Fax: (866)574-6395/(775) 324-5375
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GENERAL

The **Mast/Keystone Ozone Monitor 727-5** UV absorption ozone photometer is enclosed entirely in a cabinet 50.8 x 27.9 x 13.3 centimeters (20 x 11 x 5.25 inches) and weighs 6.4 kilograms (14 pounds). Ozone concentration readings are digitally displayed on the front panel over the range 0.00 to 9.99 ppm.

Sample gas is continually supplied to the sample chamber by a self-contained pump and sample handling system. The intensity of the UV beam traversing the 35.5 centimeter sample cell (11 centimeter in the high concentration model) is attenuated in proportion to the concentration of ozone in the sample as prescribed by Beer's Law. This signal is detected and electronically processed for presentation by the readout system.

A reference subsystem provides a good degree of stability by correcting for source intensity, optical path transmittance, and detector response changes. Self-zeroing and interference removal is accomplished by comparison of sample and reference readings.

SPECIFICATIONS

RANGE	0- 10 PPM
AUTO CONTROL	+ 5%
LOWER DETECTABLE LIMIT	.02 PPM
INCREMENTAL SENSITIVITY	.01 PPM
ACCURACY	±4% (Based on Beer's Law)
PRECISION (REPEATABILITY)	±1% or ±2nd Digit, <i>WHICHEVER IS GREATER</i>
FLOW RATE	2 LPM NOMINAL
LINEARITY 1	% up to 2ppm 4% at 10 PPM (Based on Beer's Law)
TEMPERATURE RANGE	2 C to 99 C (36 F to 210 F)
POWER	110V, 50/60 HZ, 100 Watts (220V A.C. Available)

<u>OUTPUT</u>	
DIGITAL	0.00 to 9.99 PPM

<u>CABINET</u>	<u>BENCH MOUNT</u>
WIDTH	27.9 CM (11 inches)
HEIGHT	13.3 cm (5.25inches)
DEPTH	80.8 cm (20 inches)
WEIGHT	6.4 kilo (14 lbs)

INSTALLATION and OPERATION

Installing a **Mast/Keystone 727-5 Ozone Monitor** consists of making a connection to the air to be sampled, a power connection and, if desired, a computer connection. A surge protector and 350-watt battery backup should be connected to the instrument by the client/purchaser for best performance.

An air sample connection should be made with 1/4 inch CD Teflon Tubing (supplied with monitor). Remove the nut on the inlet bulkhead connector and slip it over the end of the tube. Insert this into the connector marked "INLET" and tighten the nut finger tight. This connector is on the rear of the chassis; is off-white in color; and made of the material, kynar, a fluoroplastic which does not react with ozone and which is very similar to Teflon. Here the user will encounter one of the controversies regarding the measurement of ozone--the question of the use of input sample filters.

Since the *Mast/Keystone* analyzer is an optical instrument, particulate can cause an interference. However, since ambient particulate levels change gradually over a period of time, the referencing circuit eliminates this problem. At very high particulate levels (500 ug/m³) we calculate an interference, after reference, of only a few PPB if the particulate is in the sub-micron range; and no interference if it is greater than a micron.

NOTE: Cigarette smoking should be prohibited near the instrument and the inlet tube.

In addition to being a potential interferent, particulate could accumulate in the optics to the point where insufficient light would be transmitted. This would necessitate more frequent cleaning of the optical system but would not cause long term errors in the data, again because of the referencing system.

Although it is not a typical situation, there is the possibility that the ambient air being sampled would have enough large particulate in it that some of the particulate would become lodged in the Teflon solenoid valve used in the referencing system. Under these circumstances, it would be advisable to use a particulate filter.

It has been determined that a .5 or 1.0 micron Teflon filter will not degrade the ozone concentration in an air sample if the filter is clean. But, if the dirt builds up on the filter, it will destroy some of the ozone in the sample. Therefore, if a filter is to be used, it must be changed regularly and should be held in a Teflon filter holder. Some people feel that filter maintenance may not be reliably performed and that this will put an unknown factor into the data. They prefer to monitor without the use of a filter. If a filter is used, all calibrations should be done with the filter in line so that any effect the filter may have on the sample will be included in the span.

Sample air should be drawn through a standard glass or Teflon manifold with enough flow to ensure that the sample residence time is less than 10 seconds. The sampling system should make provision for a water drop out or some provision to ensure that water (rain) cannot enter the system. It should be placed as far as possible from any vent lines or any source that could contaminate the sample.

The exhaust should be prevented from reentering the sample system. However, when measuring high ozone concentrations from an ozone chamber or other source, exhausting the sample outside the working area or using a charcoal filter at the outlet is recommended.

ELECTRICAL CONNECTION

The instrument is designed to operate on standard, single phase AC power, 50 to 60 hertz and 105 to 125 volts. A three-conductor power cable is supplied with the instrument. Installation of a UPS battery backup and surge protector of 350 watt minimum capacity is advised.

HAZARD WARNING:

Operating the instrument without a third wire ground is a dangerous electrical practice!!!!



COMPUTER CONNECTION

A USB connector is provided to allow the user to log ozone and temperature levels into a computer spreadsheet. Standard USB cables are available through *Mast/Keystone* or local vendors. The *Mast/Keystone 727-5 Ozone Monitor* is provided with a program on CD for connecting to the customer PC which will place the data in Microsoft Excel. The computer used for this purpose must have the following:

Windows XP 1997 or higher, such as Vista

Microsoft Excel – any version

Framework 3.5

40 MB free space on PC hard disk

512 MB RAM Memory

Internet Connection (*optional*)

Installation of Mast/Keystone Software:

Insert the **Mast/Keystone 725-5 Ozone Monitor** software CD into the computer, whether you are connected to the internet or not. Continue with the instructions on the following page.

HAVE internet connection:

1. Open CD
2. Execute the program installer
3. Click "**Next**"
4. Select the **Install Program** folder and click "**Next**"
5. Click "**Next**"
6. Click "**Close**"

Do NOT have internet connection

1. Open CD
2. In the folder **Framework 3.5**, execute the "dotnetfx35.exe" setup file
3. Execute the program installer
4. Click "**Next**"
5. Select the **Install Program** folder and click "**Next**"
6. Click "**Next**"
7. Click "**Close**"

Use of the Mast/Keystone 727-5 Ozone Monitor Software

1. Click on the "**MastDev Ozone Terminal Software**"
2. Click on "**Port Settings**" and select the **serial port to be used**
3. Select the **Bit Rate** of **19200**
4. Click "**OK**"
5. Click "**Open COM Port**"
6. Browse to the desired folder in which to save your results, enter a file name of the Excel document to be created and click "**OK**"
7. Once the test has been completed click "**Close COM Port**", depending on your computer, the file will try to open
8. Click "**Exit**" to close

Enter a file name in Excel that will be used to save the data. Wait until the test terminates.

TURN ON OR OFF

Connect the instrument as previously described and push on (or off) the red-lighted power switch. The front display panel will light up a few moments after power is applied. If the instrument seems to be giving bad or irregular data, push the power switch off and on. Read the next section on "WARMUP".

WARM-UP

The instrument should be given 30 minutes to warm-up from the time it is first turned on. During this time, the displayed readings fluctuate by several PPM. This is normal and is caused by lamp and photo diode warm-up.

MACHINE REST

If the monitor will not be used to collect data for an extended period of time, turning it off will extend the life of the ozone filter and the UV source. To put the machine at rest, simply push the power button so that the red-light turns off.

OPERATING IN TEST MODE

1. Set up the test mode for O₃ amounts and duration
2. Select air pump "ON"
3. Select lamp "ON"
4. Select Test (T1 to T3)

OPERATION IN O₃ LEVEL AUTO-HOLD

1. Set up O₃ level with auto-hold
2. Select air pump "ON"
3. Select lamp "ON"

MAINTENANCE

It is recommended that the *Mast/Keystone 727-5 Ozone Monitor* be returned annually to *Mast/Keystone* for maintenance and calibration. The list of items cleaned and/or serviced and inspected for performance follows:

1. Filter
2. Pump diaphragm and pump head
3. Particulate filters (if used)
4. Cleaning of UV sensor tube

FILTER

A loss in sensitivity of the *Mast/Keystone 727-5 Ozone Monitor* is probably due to leaks in the sample handling system or a defective filter. A total lack of sensitivity is probably due to a faulty valve or pump. Replacing the filter is recommended every 12 months.

PUMP DIAPHRAGM AND HEAD

The pump diaphragm should be checked at least every 12 months, or whenever there is reason to suspect the instrument is malfunctioning. Check the pump head at this time to make sure the check valves are operating correctly. Both the diaphragm and the valves should be cleaned and any particulate found should be removed. Air should move through each port in only one direction. If the sampling system is functioning correctly, a definite suction will be felt when a finger is placed on the inlet port. (This check is normally performed at the annual calibration.)

PARTICULATE FILTER (Optional)

The particulate filter (*not a carbon filter*) should be replaced annually. If the ambient air is extremely dusty, the filter should be changed more often. If the instrument reads higher after installing a new filter, the time between changes should be decreased. As well, if the sample flow rate increases after changing the filter, the frequency of change should be modified.

UV SENSOR TUBE

1. Remove the absorption tube from the optical bench.
2. Look through it at a light source. If it is dirty, clean it with a window cleaner solution.
3. Dry the tube with a paper tissue, pulling it through with a small gauge wire. Blow compressed air through it to remove particulates.
4. Clean the quartz windows using a cotton swab on a stick. (If the absorption tube is quite dirty, it may be necessary to take the optical bench apart and clean the quartz windows with the same window cleaner solution used above. Wear rubber gloves or finger cots to avoid smudges or fingerprints on the windows.)

TROUBLESHOOTING AND REPAIR

Much troubleshooting can be done on the basis of understanding how the monitor works. Following is a functional description. There are three basic subsystems in the monitor. They are optical, gas flow, and electronic.

Optical:

1. *Lamp* - The UV source is a low pressure, cold cathode, mercury vapor lamp with 92% of its output concentrated at the 253.7 nm emission line, where absorption by ozone is maximized. Emission at wavelengths shorter than 200 nm is eliminated by a vycor optical filter around the light. Presence of the vycor filter prevents any emission at 185 nm, an emission line which generates ozone.
2. *Detector* - The detector is a "solar blind" cesium telluride vacuum diode with a broad passband centered near 253.7 nm. The total optical selectivity of the lamp and detector together is such that better than 99.5% of the detector current is due to 253.7 nm light.
3. *Cell* - The optical cell is a 35.5 cm chamber consisting of a kynar-coated aluminum or glass tube and a quartz window to isolate the gas physically from the lamp and detector.

Gas Flow:

1. *Ozone Filter* - The ozone filter is a plastic inline container filled with paper that is treated with activated carbon. The sample going into the filter is preserved intact except for the ozone.
2. *Gas Switch* - The gas switch is a dual input-single output Teflon diaphragm valve. It is operated by a plunger actuated by a 24 VDC solenoid that is turned on and off by a signal from the electronic subsystem timing circuitry. It is connected to the ozone filter in such a way as to perform the function of diverting the gas sample through the filter or sending it directly to the optical cell.
3. *Pump* - The pump, which pulls sample through the optical cell is a brushless D.C. diaphragm type. The pumping section consists of a Teflon-coated synthetic rubber diaphragm, housed in a molded plastic casing directly driving the motor shaft by a connecting rod-crank assembly. Motor and crank pin bearings are double shielded ball bearings lubricated for the life of the unit. Valves are of the self-biasing fiberglass fabric reinforced synthetic rubber type. The drive motor is a 24 volt D.C. magnetically commutated type. At 24 volts, the pump is capable of 15 inches of water vacuum at 2.5 liters per minute, more than adequate for the monitor's requirements.
4. *Fittings and Tubing* -- In order to maintain sample integrity, all fittings and tubing in contact with ozone-containing sample are Teflon or kynar. Kynar is a fluoroplastic, off-white in color, with chemical properties similar to Teflon but superior in mechanical strength. All other fittings are nylon and tubing is tygon.

Several items and repair operations can be carried out successfully by the consumer's personnel. However, this instrument can be quite difficult to analyze and repair in regard to some of the fine detail of the electronics. For that reason, it is strongly recommended that the consumer contact **Mast/Keystone** before attempting a repair.

The more information communicated to the **Mast/Keystone** staff, the better the situation can be judged. Please consider the following prior to contact:

1. Note all symptoms and any conditions under which they occur such as history, sampling site, time of day, temperature, last calibration, other pollutants, etc.
2. Note the serial number of the instrument and the operating time period since the last maintenance operation.
3. Note any and all action consumer personnel may have pursued with regard to the current problem.
4. Note any adaptation consumer personnel may have made with regard to this specific instrument.
5. Check the solenoid valve. In many instruments this valve will make an audible click when it closes. If it does not, place fingers on the blue solenoid cover. When closing, operator should feel a thump as the valve closes. In some instruments, the thump occurs when the solenoid opens as well.

Repair and Replacement:

All repairs and replacement should be made with the power cord removed.

UV Lamp Replacement: To remove the lamp, unplug the white, three-wire connector and pass it through the hole in the side of the chassis next to the lamp holder. Loosen the set screw on the lamp holder and remove the amp. To replace the lamp, reverse the procedure. Changing the UV Lamp will require re-calibration of the monitor.

Filter Replacements:

To remove the filter, loosen the plastic nuts on the connecting tubes. Remove the filter. In replacing the filter, make sure the tube nuts are all the way on the tubes and the tubes are well into the connecting fittings. Tighten the nuts.

Solenoid Replacement:

Remove filter. Remove the two screws on the underneath side of the chassis, loosen the fitting nuts on the inlet and outlet side of the valve, and disconnect the white connector. Remove the solenoid. Remove the fittings from the valve. To replace the solenoid, avoid turning the fittings in all the way to the last thread. To do so will distort the valve body.

Packing for Shipment:

Prior to packaging, inspect the instrument to ensure that the cover and other mechanical parts are securely fastened and that the gas ports at the rear are covered.

Use the original shipping carton and packing material, making sure the instrument is wrapped in heavy paper or plastic and three (3) inches of filler material surrounds it, including the top and bottom. Take precautions against mechanical damage, excessive humidity, negligent handling, etc. If the packaging is deemed inadequate, the returned instrument will be returned in a new shipping box for which the customer will be billed.

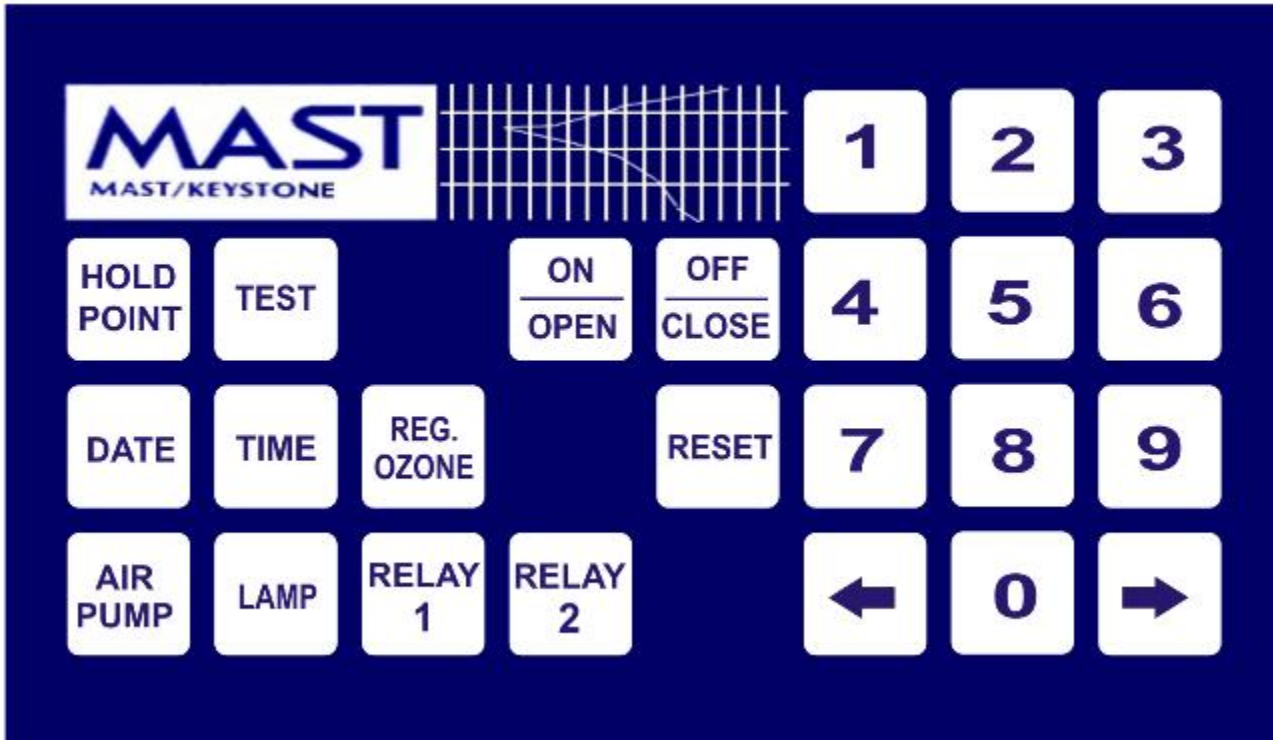
The shipping carton should be appropriately labeled with *"Scientific Instrument"*, *"Fragile"*, *"This Side Up"*, and *"Handle with Care"* warnings. *Mast/Keystone* will not assume any costs for damages incurred during shipping unless the instrument is *appropriately* returned in the original shipping carton and all of the above precautions are taken.

Always insure the instrument or parts being returned for its/their full value!

OPERATION

CONTROLS

The front panel controls of the *Mast/Keystone 727-5 Ozone Monitor* consist of an on/off switch and a tactile keypad used for the various operations the unit is capable of performing.



FUNCTIONS

- « = LAST (backup to previous digit, only available when entering multidigit numbers)
 » = NEXT (enters and accepts information, go to next function)
 ON = HIGH (turns function on)
 OFF = LOW (turns function off)
 RESET = TEST

Note: When setting multidigit numbers, the active digit is indicated by a comma to the right of it. Operator must set all active digits.

MAIN SCREEN

DISPLAYS = PPM: 0.00 00C HR/MIN
 HOLD: OFF(ON) DD/MM/YY

DEFINITIONS = PPM: 0.00 = PARTS PER MILLION OZONE (O₃)
 EXAMPLE: PPM: 0.50
 00C = TEMPERATURE IN CENTIGRADE FROM OVEN
 TEMPERATURE PROBE
 HR/MIN = TIME IN 24-HOUR CLOCK
 DD/MM/YY = DATE BY DAY/MONTH/YEAR

HOLD POINT - Allows operator to set ozone regulator level.

DISPLAY = AUTO HOLD OFF
 = ON OFF EXIT »

ACTIVE SWITCHES	=	EXIT »	=	GO TO NEXT FUNCTION
	=	ON	=	TURN FUNCTION ON
	=	OFF	=	TURN FUNCTION OFF

SELECT "ON"

DISPLAY	=	AUTO HOLD
		SET LEVEL 0.00

ACTIVE SWITCHES	=	ANY NUMBER	=	WILL PLACE NUMBER INTO SET LEVEL
	=	«NEXT or PRIOR »	=	WILL MOVE TO NEXT NUMBER OR NEXT (PRIOR) FUNCTION (if any numbers are skipped, program will be left unchanged)

EXAMPLE - If 0.50 ppm ozone concentration in the chamber is desired, the entry would be 050. If 50 is entered, the program will wait for the last number.

TIME - Allows operator to set time. **Note:** The system uses a 24-hour clock. Two digits must be used when entering this data. Example: To obtain a 2:00 pm time, enter 14. To obtain a 1:00 am time, enter 01.

DISPLAY	=	SET TIME 00:00:00
		24 hours HH:MM:SS

ACTIVE SWITCHES	=	ANY NUMBER	=	WILL SET NUMBER INTO MEMORY
	=	» NEXT	=	GO TO NEXT NUMBER OR FUNCTION
	=	LAST «	=	WILL BACK UP 1 DIGIT IF POSSIBLE

ERROR MESSAGES	=	TIME ERROR	=	AUTO RETURN TO SET TIME – IN 5 SECONDS
			=	AUTO RETURN TO MAIN SCREEN

DATE - Allows operator to set date. Two digits must be used when entering this data. Example: To set the month of February, enter 02.

DISPLAY	=	SET DATE 00/00/00	
		DD/MM/YY	
ACTIVE SWITCHES	=	ANY NUMBER	= WILL SET NUMBER INTO MEMORY
	=	» NEXT	= GO TO NEXT NUMBER OR FUNCTION
	=	LAST «	= WILL BACK UP 1 DIGIT IF POSSIBLE
ERROR MESSAGES	=	DATE ERROR	= AUTO RETURN TO MAIN SCREEN

LAMP - Used to power UV ozone generating lamp functions in *Mast/Keystone 03 Generator*.

DISPLAY	=	UV LAMPS OFF (or ON)	
	=	ON OFF EXIT »	
ACTIVE SWITCHES	=	» EXIT	= GO TO NEXT FUNCTION OR EXIT MODE
	=	ON	= SETS FUNCTION = ON
	=	OFF	= SETS FUNCTION = OFF
			= AUTO RETURN TO MAIN SCREEN

(In older model generators, the generator lamp must be powered manually from the generator front panel.)

AIR PUMP - Used to power air pump functions in *Mast/Keystone 03 Generator*.

DISPLAY	=	AIR PUMP OFF (or ON)	
	=	ON OFF EXIT	
ACTIVE SWITCHES	=	EXIT »	= GO TO NEXT FUNCTION OR EXIT MODE
	=	ON	= SETS FUNCTION = ON
	=	OFF	= SETS FUNCTION = OFF
			= AUTO RETURN TO MAIN SCREEN

(In older model generators, the generator lamp must be powered manually from the generator front panel.)

RELAY 1 - Used to power *Mast/Keystone Dynamat* functions.

DISPLAY	=	RELAY 1 DYNAMAT OFF (or ON)	
	=	ON OFF EXIT	
ACTIVE SWITCHES	=	EXIT »	= GO TO NEXT FUNCTION OR EXIT MODE
	=	ON	= SETS FUNCTION = ON
	=	OFF	= SETS FUNCTION = OFF
			= AUTO RETURN TO MAIN SCREEN

RELAY 2 - Used to power AUX RELAY functions in *Mast/Keystone 03 Generator*.

DISPLAY	=	RELAY 2 AUX OFF (or ON)	
	=	ON OFF EXIT	
ACTIVE SWITCHES	=	EXIT »	= GO TO NEXT FUNCTION OR EXIT MODE
	=	ON	= SETS FUNCTION = ON
	=	OFF	= SETS FUNCTION = OFF
			= AUTO RETURN TO MAIN SCREEN

REGULATE OZONE (REG. OZONE) - Allows operator to manually set ozone regulator position.

DISPLAY	=	REGULATOR VALVE	
	=	ON OFF EXIT	
ACTIVE SWITCHES	=	EXIT »	= GO TO NEXT FUNCTION
	=	ON	= OPENS REGULATOR SEVERAL STEPS TO INCREASE OZONE CONCENTRATIONS IN CHAMBER
	=	OFF	= CLOSES REGULATOR SEVERAL STEPS TO DECREASE OZONE CONCENTRATIONS IN CHAMBER
	=		= INACTIVE

TEST – Allows operator to store and use up to three different sets of pre-programmed test parameters.

DISPLAY	=	T1 T2 T3 EXIT »	
ACTIVE SWITCHES	=	1,2,3 EXIT »	= SELECTS TEST
SELECT T1			
DISPLAY	=	TEST 1 ON OFF « CONFIG EXIT »	
ACTIVE SWITCHES	=	ON OFF CONFIG EXIT	= STARTS PREPROGRAM TEST 1 = STOPS PREPROGRAM TEST 1 = EXITS MODE = OPENS CONFIGURATION PROGRAMMING = RETURNS TO MAIN MENU
SELECT "CONFIG"			= CONFIGURES TEST PROCEDURE
DISPLAY		TEST 1A PPM: 0.00 DURATION: 00: 00	
ACTIVE SWITCHES	=	ANY NUMBER « PREVIOUS NEXT »	= ALLOWS USER TO SET OZONE AMOUNT AND DURATION TIME IF WARMUP TIME IS DESIRED FOR OVEN, USE SECTION A OF THE PROGRAM = USED TO CHANGE OZONE AMOUNT OR DURATION TIME = USED TO CHANGE OZONE AMOUNT OR DURATION TIME
DISPLAY	=	TEST 1B PPM: 0.00 DURATION: 00: 00	
ACTIVE SWITCHES	=	ANY NUMBER « PREVIOUS NEXT »	= ALLOWS USER TO SET OZONE AMOUNT AND DURATION TIME = USED TO CHANGE OZONE AMOUNT OR DURATION TIME = NEXT FUNCTION
DISPLAY	=	TEST 1C PPM: 0.00 DURATION: 00: 00	
ACTIVE SWITCHES	=	ANY NUMBER « PREVIOUS NEXT »	= ALLOWS USER TO SET AMOUNT OF OZONE = USED TO CHANGE OZONE AMOUNT = NEXT FUNCTION

DISPLAY = TEST 1D PPM: 0.00
DURATION: 00: 00

ACTIVE SWITCHES = ANY NUMBER = ALLOWS USER TO SET AMOUNT OF OZONE
« PREVIOUS = USED TO CHANGE OZONE AMOUNT
NEXT » = NEXT FUNCTION/EXIT TO MAIN SCREEN

At this point, the Mast/Keystone 727-5 Ozone Monitor automatically exits to Main Screen.

REPEAT PROCEDURES ABOVE FOR T2 AND T3

TEST – To run preprogrammed Test Mode T1 (T2, T3)

DISPLAY = T1 T2 T3
EXIT »

SELECT = 1 = FOR T1 TEST

DISPLAY = T1 ON OFF

SELECT = ON = TO START T1 TEST

DISPLAY = TEST SCREEN
PPM:0.00 OOC HR/MIN
T1A 0.00 DATE

EXITING TEST EARLY

SELECT TEST

DISPLAY = TEST T1 T2 T3
« CONFIG
EXIT »

SELECT T1

SELECT = TEST 1 ON OFF
« CONFIG
EXIT »

SELECT = OFF
AUTO RETURN TO MAIN SCREEN