SMOKE DETECTORS SENSITIVITY ANALYZER

Model 501-B

USER'S GUIDE

GEMINI SCIENTIFIC CORP.

1122-B ASTER AVENUE, SUNNYVALE, CA 94086
Phone: 408.554.0310
Fax: 408.554.7143
E-mail: Gemini@geminiscientific.com
Web: http://www.geminiscientific.com

Version 3 - May 2004

ANALYZER FOR SMOKE DETECTORS

Model 501-B Aerosol Generator

USER'S GUIDE

Serial No.:

Date Calibrated:

Inspected by:

Sold To:

GEMINI SCIENTIFIC CORP., 1122-B ASTER AVENUE, SUNNYVALE, CA 94086

For technical assistance, please dial *800.582.8882*

Version 3 – May 2004

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Warranty

Gemini Scientific Corp. warrants the instrument described herein to be free from defects in material and factory workmanship for a period of one year, and agree to repair such instruments, which under normal use and service disclose the defect to be the fault of Gemini Scientific Corp.

Gemini Scientific Corp.'s obligation under this Warranty relates to the original purchaser and is limited to a return of the purchase price or at the Gemini Scientific Corp.'s sole discretion, to the repair or replacement of the instrument or any of its parts, which prove to be defective. For this Warranty to be in effect, any material or part alleged to be defective is to be returned to Gemini Scientific Corp. with our prior written approval, fully insured and transportation prepaid by the purchaser, within 12 months from date of delivery.

This Warranty shall not apply to an instrument which has been (I) subjected to misuse, negligence, or accident; (2) connected, installed, operated or adjusted other than in accordance with instructions furnished by the Gemini Scientific Corp.; (3) repaired, modified or serviced by someone not authorized by the Gemini Scientific Corp., so that in our judgment on the performance or reliability of the instrument has been impaired.

We reserve the right to make replacement with equivalent merchandise and to make changes at any time in the specification, design, or construction of the instrument without incurring obligation to make any commensurate changes in units previously delivered.

Gemini Scientific Corp. assumes no liability for consequential or contingent damages for a defective instrument covered by this Warranty, failure of delivery in whole or part, or for any other cause. This Warranty and the writing to which it is attached constitute the understanding of the buyer and seller so that no terms, conditions, or agreement purporting to modify the terms hereof shall be binding unless made in writing and signed by an authorized agent of the home office of the Gemini Scientific Corp.

⚠ WARNING

THE AEROSOL FROM THIS INSTRUMENT MAY BE HARMFUL TO THE HEALTH OF THE OPERATOR IF PRECAUTIONS ARE NOT TAKEN.

The Model 501-B Aerosol Generator/Smoke detector Analyzer generates an aerosol consisting of a refined NF-Grade white mineral oil in air. Aerosol concentration at the discharge point of the hose is adjustable from 0 to 45 mg/m^3 (0 to 6 mg/min). Room air would dilute the discharge quickly. The aerosol smoke is odorless and not visible. Proper precautions to avoid over exposure such as good ventilation and limited discharge time are recommended. Do not hold end of hose close to face during aerosol discharge.

The maximum allowable limit under OSHA (Occupational Safety and Health Administration) regulation in an eight-hour weighted average for oil-based aerosol is 5 mg/m^3. The RUDOL™ White Mineral Oil is approved by the FDA (Food and Drug Administration) for use on skin and incidental food contact.

To reach the OSHA allowable limit, for example, you need to discharge at the maximum concentration rate (6 mg/min) into a non-ventilated 14x12x10 feet room for a period of about 50 minutes. However, in typical testing, very little aerosol is introduced into the room. The normal time per test is only about 30 seconds at 1/4 of the maximum concentration, far below the OSHA safety limit. However, precaution is necessary to avoid situations where exposure can reach above the OSHA limit.

THIS INSTRUMENT SHOULD NOT BE USED IN OR NEAR CONCENTRATED OXYGEN ENVIRONMENTS SUCH AS OXYGEN TENTS OR OPERATING ROOMS IN A HOSPITAL.

THIS EQUIPMENT OPERATES AT VOLTAGE LEVELS THAT CAN BE HAZARDOUS TO OPERATING PERSONNEL.

The Model 501-B Aerosol Generator-Analyzer for Smoke Detectors operates on a rechargeable 12V Ni-Metal Hydride battery. This voltage appears at the serial number label and various other points on the chassis. The power of the instrument should be completely turned off before opening the front panel for filter change or repair. Only qualified personnel, who are familiar with the location of the voltage and the hazards involved, may open the cabinet with power circuit energized. When connecting a new battery, make sure to observe correct polarity. Connect the red positive (+) line to the red positive (+) battery terminal and connect the black negative (-) line to the black negative (-) battery terminal.

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1.0 Introduction

The Gemini 501-B Smoke Detector Analyzer/Aerosol Generator is an instrument ideally suited to measure the sensitivity response of installed smoke detectors. The Generator produces an aerosol with particles size characteristics resembling fire smoke. The range of concentration, between 0 and 45 mg/m^3 or from 0 to 4 %/ft obscuration (UL-268), is sufficient to trigger the alarm thresholds of all *UL-approved* ionization and photoelectric smoke detectors.

The calibration reading for each instrument represents both the UL-268 obscuration standard in (%/ft) and to aerosol mass concentration in (mg/m^3). The calibration reading on the LCD allows the operator to determine the sensitivity of the detector and compare it to the range specified by the manufacturer as printed on the back of each detector.

The instrument can save a considerable amount of time for inspection personnel who must remove detectors from ceiling positions for periodic cleaning or testing. Using the hose, wands, and shroud, test smoke is delivered to the detector without removing it from the ceiling. From the test results, inspectors can decide whether to remove the detector for cleaning or sensitivity adjustment.

The current NFPA 72 Fire Alarm Code (1996) recommends sensitivity inspection of installed detectors within one year after installation and every alternate year thereafter.

2.0 Specifications

Aerosol Characteristics
Particle size
- Number median diameter ..... 0.2 micrometer (um)
- Mass median diameter ..... 0.45 um
- Repeatability ..... ± 5 %

Generation Characteristics
- Test stream flow rate ..... 60 L/min.
- Aerosol flow rate ..... 0 - 4.2 L/min.

Concentration Range
- Adjustable ..... 0 - 40 mg/m3 (0 - 4 %/ft obscuration)
- Reset, concentration ..... ±4%
- Type of aerosol ..... Rudol™ Oil *
- Operating temperature ..... 24 ±3°C (75 ±5°F)

Mechanical Characteristics
- Dimensions, overall ..... 9.5 x 6.5 x 7 in. (24.1x 16.5 x 17.8 cm)
- Weight, approximately ..... 11 lb. (5.0 kg), with battery
- Hose length ..... 5 ft. (1.5 m)

Oil Reservoir Volume ..... approx. 30 ml
Power Requirement ..... 12 V DC, 6.5 Amp-Hr Ni-MH Battery

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*RUDOL oil, a NF-grade white mineral oil, aromatics-free, saturated aliphatic hydrocarbons. Viscosity = 29 centistokes @40 C. Specific gravity = 0.87 @25 °C. RUDOL is a registered trademark of Witco Chemical Corp. It conforms to the FDA-CFR 172.878, which allows for direct skin & food contacts and stabilized with Vitamin E for long shelf life.

3.0 Principles of Operation

3.1 General

The Gemini 501-B Aerosol Generator/Smoke Detector Analyzer operates on the principle of nebulization of a liquid to produce a poly-dispersed micro-sized spray with a relatively large mass median diameter. An impactor reduces the median diameter by selectively removing the larger diameter particles. The remaining aerosol is diluted by a large volume of room air at a constant rate from the blower. Hose and wands carry the aerosol up to a shroud, which covers the test detector at the ceiling.

A dual-head compressor/vacuum diaphragm pump is used in the system. The compressor line provides the air pressure necessary for the operation of the nebulizer. Aerosol output and particle size distribution from the nebulizer is kept constant by maintaining a constant pressure from the compressor. The vacuum line provides suction to vary the aerosol concentration of the test stream by diverting part of the aerosol from the generator. The amount of diversion is controlled by an adjustable valve and measured by a flow meter.

3.2 Main Elements of the Instrument

Figure 1 shows the locations of some of the elements (pages4).

3.2.1. Compressor / Vacuum Pump

The compressor line generates the air pressure necessary to operate the nebulizer.
The vacuum line removes a specified quantity of aerosol using a control valve that varies the final concentration of the aerosol in the test stream. This flow is monitored by a flow meter.

3.2.2. Nebulizer and Nebulizer Reservoir *(Figure 1 (9))*

The nebulizer produces the aerosol from the Rudol liquid using the pressurized air. Calibration of each instrument is based on the particular nebulizer supplied. Therefore, **nebulizer is not interchangeable with other testers with different serial numbers**.

⚠ ***WARNING:*** *Oil for the nebulizer is stored in the 30-ml transparent acrylic nebulizer reservoir. Before storage, oil has to be emptied from the nebulizer reservoir to prevent oil from flowing back into the system, which may damage the electronic components of the tester.*

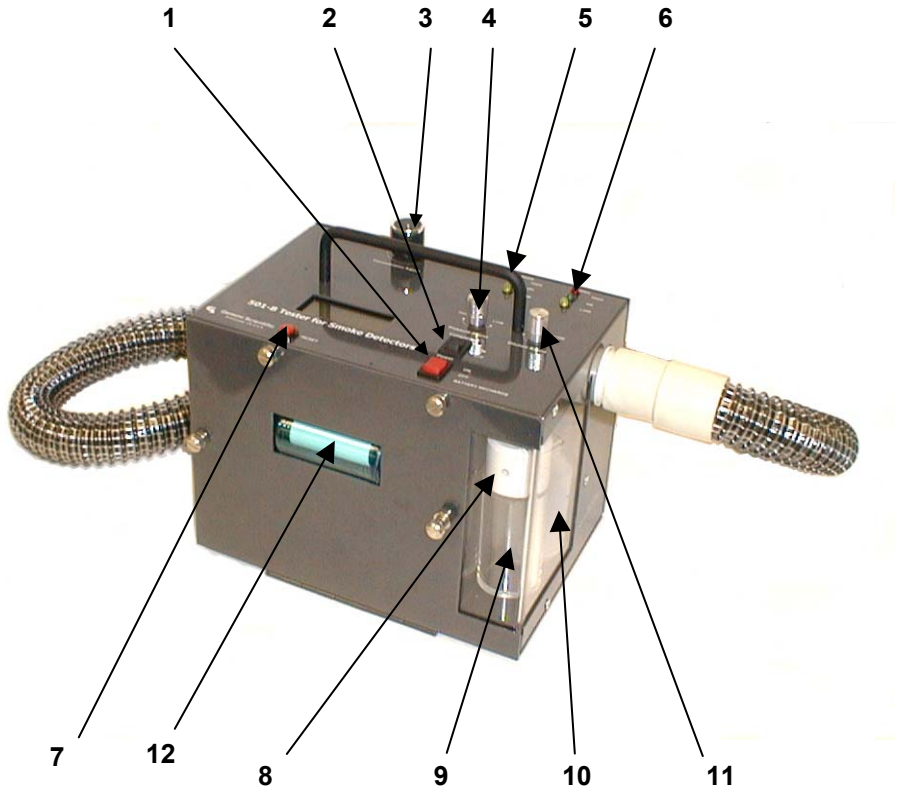


Figure 1, Front View of Model 501-B

1. Function Switch (On / Off / Battery Recharge)
2. Compressor/Pump Switch (On / Off)
3. Concentration Adjust Knob
4. Pressure Adjust Knob
5. Pressure LED Indicator
6. Dilution LED Indicator
7. Timer Reset Button
8. Pressure Line Jet
9. Nebulizer Reservoir
10. Drain Reservoir
11. Dilution Adjust Knob
12. Filter Element

3.2.3. Manifold

The manifold is a central flow-switching chamber, which connects the nebulizer, impactor, vacuum line, drain outlet, and drain reservoir. It is from this chamber that adjustable portions of the aerosol are discarded through the drain and vacuum system while the remainder goes to the final test stream.

3.2.4. Impactor

The impactor, located inside the manifold, consists of a metal disc with 3 small holes. The function of the impactor is to select the aerosol particulate with proper size distributions (smoke sized particles). Do not modify (enlarge or close) any holes on the impactor.

3.2.5. Drain Reservoir (Figure 1 (10))

In order to control the concentration of aerosol in the test stream, varying amounts of aerosol from the nebulizer are pulled by the vacuum into the filter, or by gravity into the drain reservoir. The drain reservoir should be attached to the drain outlet before any testing. In order for the system to work, the drain reservoir should not contain any leakage. The drain reservoir should be emptied when it is about 3/4 full or before storage.

3.2.6. Filters

The disposable filter (blue) on the front panel absorbs all of the excess smoke from the vacuum stream before it enters the vacuum pump. It protects the mass monitor and the vacuum pump.

The filter SHOULD be replaced when the filter element turns red, which is after about 100-150 tests.

3.2.7. Controls

Function Switch (ON/OFF/Battery recharge) The switch should be set at the “OFF” position during storage or between tests. When the switch is set at the “ON” position, the blower will be turned on and the system will be ready. To charge the internal battery, connect the NiMH charger provided and turn the switch to the “Battery recharge” position.

Compressor/Pump Switch (ON/OFF) When the system is ready (Function Switch set at the “ON” position), set the Compressor Switch at the “ON” position will turn on the compressor. Concentration of the aerosol can then be adjusted using the Concentration Adjust knob.

Dilution Adjust. The dilution LED lights (Red, Green, Yellow) indicates the dilution airflow rate. The correct rate is shown by the green light. Red and yellow mean "high" and "low" respectively. To maintain the correct airflow rate, adjust the dilution knob on the right of the top panel until the green light is on. If normal adjustment is not enough, one or a few of the 6 openings in the diffuser located inside the shroud *(the clear plastic bowl)* may have to be enlarged or covered. (See Table 1, Problem Diagnostics, P. 15).

Pressure Adjust The pressure LED lights (Red, Green, Yellow) indicates the compressed air pressure. The correct rate is shown by the green light. Red and yellow mean "high" and "low" respectively. To maintain the correct pressure, turn the pressure adjust knob on the top panel until the green light is on.

Concentration Adjust. Use the concentration adjust valve to adjust the sensitivity reading on your LCD. Turning clockwise will lower the sensitivity readout (smaller amount of smoke output) whereas turning counter-clockwise will increase the sensitivity readout (larger amount of smoke output).

Internal Battery / External Power Source Switch (for newer Models May 2004 or later only) on the left panel. When set at the “INT BAT” internal battery position, the tester will be powered by the internal NiMH battery. When set at the “EXT Power” position, the tester will be powered by an external power source, either through the provided AC Adapter (12VDC output) or any other 12V DC battery. The AC Adapter or an external 12VDC battery must be connected to the “AC Adapter/Ext Battery” jack next to the “INT BAT/EXT Power” switch.

3.2.8. Blower, Hose, Wands, Diffuser, and Shroud

Blower. The blower provides air to dilute the aerosol from the nebulizer. The dilution-air adjust knob controls the flow rate of the dilution air *(See 3.2.7)*.

Hose and wand. Insert the plastic end of the 5-ft., 1-1/2 inch diameter flexible hose to the output port (right side) of the analyzer and connect the other end to the wand and the shroud. An operator using a single-length wand can reach a normal ceiling height of about 8 feet. Additional wands may be coupled to reach ceilings as high as 20 feet. For a 30-feet application, an optional *high-reach kit* is also available. It is a retractable pole that allows you to reach up to 30-feet ceiling.

Wall-mounted detectors testing adaptor Connect one end of the adaptor to the wand and the other end to the diffuser and the shroud. The adaptor can be bent at any arbitrary angle up to 90 degree. This facilitates the testing of wall-mounted smoke detectors.

Shroud. The purpose of the shroud (*the clear plastic bowl)* is to cover the detector so that the aerosol of known concentration is not affected by room air. For good results the edge of the shroud should touch most of the wall surface around the detector.

However, since the test stream is flowing out at a high rate of about 2.1 ft^3/min (60 L/min), room air would not be able to dilute the smoke stream even though the shroud is as much as 1/2 inch away from the wall. For some older models of smoke detectors and duct detectors, a different size of shroud may be needed. Please contact Gemini Scientific for more info.

Diffuser. The diffuser inside the shroud has six holes, which limits the flow rate and distribute the smoke evenly to the detector. It also serves as a connection between the wands and the shroud. Holes on the diffuser may need to be closed or enlarged to attain correct flow rate. *(See 3.2.7)*

Duct detector testing adaptor This optional testing adaptor allows you to test duct detectors.

3.2.9 Temperature

To monitor the aerosol temperature, the temperature probe should be inserted into the small aluminum well on top of the nebulizer. Temperature reading is shown at the lower left corner of the LCD. The sensitivity reading on the LCD is corrected for fluctuations in temperature. However, operating temperature should not be below 70^o F when smoke output is greatly reduced due to the low temperature. Temperature above 90 degree during testing would be fine since the sensitivity is adjusted accordingly.

3.2.10 Exposure Time

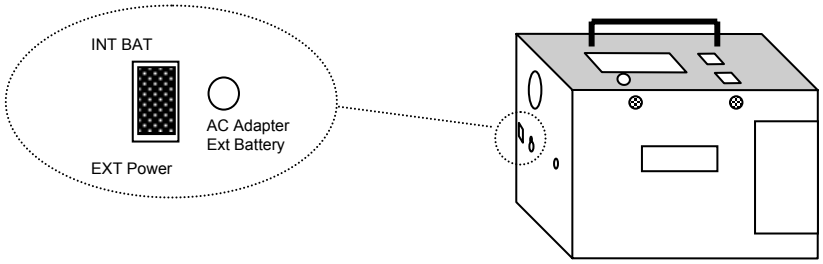
The purpose of the timer is to help the inspector control the smoke exposure time. If the detector does not respond within 30 to 45 seconds after exposure, stop the test. Reset to a higher concentration level for the next test. However, for some brands of detectors (with a longer sampling time), or in borderline cases, 45 to 55 seconds or more of exposure time may be required to find the maximum sensitivity.

How fast the detector responds <u>should not</u> be used to determine the sensitivity of the detector. To avoid nuisance alarm, some detectors are designed to alarm only after exposure to smoke for at least 24 seconds at the proper designated level of concentration. Please refer to the smoke detector manufacturer's specifications and manual for more details.

3.2.11 Operation

The Model 501-B is equipped with a 12 V DC Ni-Metal-Hydride rechargeable battery *(refer to pg. 4 Figure 1).* Newer models *(May 2004 or later Model)* are also equipped with an AC Adapter/External Battery jack that can be connected to the provided AC Adapter (12VDC output) or any 12VDC battery.

I. *Internal Battery operation:*
   1. *(For May 2004 or later Models only)* The Power Source switch on the left panel must be set at “INT BAT” position.
   2. With the internal battery connected, set the Function Switch (1) at the "On" position.
   3. Adjust the dilution LED indicator to (6) “green” position (OK) using the dilution-adjust knob (11).
   4. Set the Compressor Switch (2) at the “ON” position to turn on the compressor.
   5. Under normal conditions, the battery should supply several hours of operation. The battery should be recharged when it fails to maintain its proper function. It is recommended that the battery should be charged the night before any testing. To conserve battery, turn off either the compressor or the whole system at the end of each test.
   6. DO NOT CONTINUE to use the analyzer when the battery is depleted.



II. *External Power operation (For May 2004 or later Models only):*
   1. Connect the provided AC Adapter (12VDC output) or any 12VDC battery to the “AC Adapter/Ext Battery” jack located on the left panel.
   2. Set the Power Source switch to the “EXT Power” position.
   3. Set the Function Switch (1) at the “On” position.
   4. Repeat procedures *4-5* above.

II. *Internal NiMH Battery Charging:*
   1. *(For May 2004 or later Models)* Set the Power Source switch to “INT BAT” position.
   2. Set the Function Switch (red) (1) on the top panel to the "BATTERY RECHARGE" (bottom) position.
   3. Connect the lead from the NiMH charger to the "Recharge Input" jack on the left-side panel.
   4. Plug the charger into a 110 V AC power source.
   5. A yellow (fast charge) light will illuminate on the charger when it is connected.
   6. While charging, the battery and charger may become warm. This is a normal condition.
   7. A green (float) light will illuminate on the charger when the battery is fully charged and ONLY when it has been charging for 10 consecutive hours. Disconnecting and reconnecting the charger will reset the timer inside the charger.
   8. If a battery does not charge properly:
      a) Check current at receptacle by plugging in a lamp or other appliance.
      b) Check to see if the receptacle is connected to a light switch, which turns power off when you turn off the lights.
      c) Check to make sure the Function Switch is set at the “Battery Recharge” position.

NOTE: Since battery power depletes over time even when it’s not used, only charge the battery the night before any testing.

Important Battery Charging Notes:

A) Do not operate charger with a damaged cord or plug. Have them replaced immediately.

B) Do not disassemble charger. There are no consumer serviceable parts inside.

C) DO NOT use any other battery charger. Any other charger may blow the fuse or shorten the battery life if the charging rate exceeds 1 amp. ONLY use the NiMH battery charger provided.

D) Do not use charger in wet or damp conditions. It is intended for indoor use only.

E) The charger is designed to operate on standard US electrical power (115- 120 volts AC only). Do not attempt to use any other voltage.

F) Unplug the charger when not in use.

G) Do not abuse the charger cord.

H) Charge battery overnight before using. The LED on the charger will only turn green when the battery is being charged continuously for 10 hours or more.

4.0 Operating Instructions

4.1 Initial Operation

Working Standard. Establish a working standard for your analyzer when you receive the instrument for the first time and every time it is recalibrated. *(Pg. 15 – 6.2)*

Location of Instrument. The tester should be used in a ventilated or large room to avoid exposing operator to aerosol concentration greater than the OSHA limit of 5 mg/m^3 .

Level position. The tester should be kept at a level position.

Nebulizer and Oil Filling. Fill the nebulizer reservoir from the housing opening with Rudol™ liquid (See Appendix F, Figure A, p23). The top level of the liquid should be about 1/4 inch below the joint line between the housing and the reservoir. Refill when the level drops to about 1/4 inch from the bottom of the dip tube.
Note: Remove nebulizer from the tester and empty all the oil before storage.

Wet the manifold O-ring with a little oil before using a twist and push motion to fully insert the nebulizer into the manifold. When you need to remove the nebulizer, tilt the instrument forward slightly for a few seconds to allow the oil at the tip to drain back into the nebulizer housing. This action will minimize any spillage when the nebulizer is pulled out. To avoid contamination, use a lint-free towel to wipe off residual oil in the manifold. After removing the nebulizer from the manifold, be sure to cover the opening of the nebulizer with the orange-colored cap provided to avoid contamination from room dust. Dust or lint from the inlet can easily get into the opening and contaminate the oil in subsequent use. The contaminant would cause blockage of the small hole inside the nebulizer and may cause unnecessary repair. The appearance of large bubbles coming out from the bottom of the dip tube is a symptom of clotting. See Appendix F, Figure B p23 and Appendix B for repair and cleaning instructions.

Drain Reservoir. The drain reservoir should be attached to the outlet tube tightly behind the nebulizer before any operation. Empty the reservoir before it becomes 3/4 full or *before storage*.

Dilution Air Adjustment. Connect one end of the hose to the Tester and the other end to the wands. Then connect the wand (with end fitting) to the shroud. Turn on the blower and use the dilution adjust knob to adjust the LED to green. Slight adjustment may be necessary to keep the dilution LED at green during the test.

Pressure Adjust. Connect the pressure line with the Luer fitting *(Pg. 4 – figure 1 (8))* on the nebulizer (or inlet *See page 18)* to the nebulizer. Do not rotate the fitting after insertion.

Turn on the Compressor switch and adjust the pressure indicator to “green” using the pressure adjust knob. If necessary, re-adjust pressure during testing to keep the pressure LED at green.

The oil in the reservoir will become cloudy due to emulsification after the pressure is applied. Testing is ready only after all the liquid above the suction tube in the reservoir is emulsified, in about 45 seconds.

Concentration Adjust. Use the concentration adjust valve to select the initial test value.

Reading. The LCD on top of the panel displays the readings for photoelectric (Photo) and ionization (Ion) for smoke detectors. The current temperature of the oil is also displayed at the lower left corner. The elapsed time is shown at the lower right corner.

4.2 Oil Temperature

Oil temperature in the reservoir would affect the aerosol output. The sensitivity reading on the LCD is corrected for the temperature variation.

If you are working at an ambient temperature below 70 °F on a **consistent** basis, the temperature may be too low to generate enough smoke. A blow dryer may be used to warm the oil or tester in a cold environment. Apply heat evenly. Temperature above 90 °F in a hot summer day during testing is perfectly normal. The reading on your LCD is adjusted accordingly.

4.3 Test Completion

After each test, set the Compressor Switch to the "OFF" position and allow the blower to remain on for at least 20 seconds to flush the line and the detector with fresh air. Turn the whole system off when it's not in actual use to conserve battery power. **Concentration adjust settings need not be changed if you want to retain similar setting for the next test.** If you remove the nebulizer from the manifold, be sure to cap the opening of the nebulizer with the orange cap. **DO NOT** put the instrument in storage with the nebulizer and drain reservoir attached. See *4.1 "Nebulizer and Oil Filling".*

4.4 Storage of Instrument

If the Analyzer is not being used for more than 1-2 weeks, its nebulizer and drain reservoir should be removed, emptied, capped and stored in a dust-free bag. The manifold should also be cleaned and with its opening capped. The instrument itself should be covered and stored in an upright position inside or outside the carrying case to avoid oil leakage into the unit.

⚠ ***WARNING:*** *Failure to empty the oil in the nebulizer and drain reservoir before storage may result in oil back draining into the system, which may subsequently damage the tester.*

5.0 Inspection Protocol and Test Procedures

5.1 General Objective

The Gemini 501-B Analyzer was designed to perform on-site inspections of installed smoke detectors to determine their sensitivities. Sensitivity is defined as the amount (concentration in mg/m^3 or obscuration in %/ft) of smoke needed to trigger the alarm of the detector under test.

Normally only a single test is needed for routine sensitivity inspection of detectors. To assure such an outcome, choose a smoke concentration at the upper limit of the sensitivity range specified by the manufacturer (usually located on the back of the smoke detector). The detector should alarm since it is statistically the highest concentration allowable by the manufacturer. However, if the above detector did not alarm, you have to do additional tests to determine the concentration that would trigger the detector.

In cases where the detector has a history of nuisance (false) alarm, you may have to do two or more tests to find the lowest concentration level below which the detector would not alarm.

Figure 2 (page 12) contains an example in selecting the smoke concentration settings for sensitivity tests under the NFPA 72 National Fire Alarm Code (1996) requirements. To get higher test precision than the routine inspection requirement, use an increment of 0.2 %/ft instead of 0.5 %/ft. *You may also want to establish other test criteria by consulting with your state Fire Marshall and manufacturers to fit your own needs and resource.* Record all data by using either the sample test report in APPENDIX C or your own recording method.

5.2 Legal and Technical Authorities

Smoke detector inspection and sensitivity testing techniques are based ONLY on the following three recognized authorities:

The National Fire Protection Association (NFPA) publishes the NFPA 72 National Fire Alarm Code (1996). It recommends evaluation of smoke detector sensitivity within one year after installation and every alternate year thereafter. The recommended test methods include the use of smoke aerosol and calibrated sensitivity test instrument to verify the approved or manufacturer specified sensitivity range.

Underwriters Laboratories, through its UL-268 standard, considers detectors to be acceptable if its sensitivity are between 0.5 to 4.0 %/ft obscuration when exposed to the visible (gray) smoke in a UL smoke chamber. This standard applies only if the manufacturer has not specified the sensitivity range.

Authority Having Jurisdiction (AHJ). The Fire Marshal or Fire Chief at the state or local level is responsible for enforcing their published standards or codes. These standards generally follow some national standards with or without modification to suit the local need. For example, the Boston Fire Department requires detectors located in elevator waiting areas to meet a sensitivity of 3.0 %/ft or higher. This is to avoid frequent false alarms from smoldering cigarettes that passengers leave prior to boarding the elevators.

5.3 Sensitivity Ranges

Smoke detector manufacturers are required by UL to specify the nominal sensitivity range of their production detectors. The ranges vary widely among manufacturers and between types of detectors. Typically, nominal sensitivity for a photoelectric type is about 3.0 ± 0.5 %/ft and for an ionization type is about 1.5 ± 0.5 %/ft.

If a nominal sensitivity is given without a range, then according to NFPA 72: 7-3.2.1 (1996), a detector will pass if it alarms between 0.5 and 4.0 %/ft. obscuration (See UL 268 Standards, 31.1, January 4, 1999 ed.).

All the detectors of a given model may not necessarily fall within the extreme values provided by the manufacturer. Consult the manufacturer, if necessary.

Because of the built-in uncertainty of ± 0.4 %/ft in relating field test results from the Gemini 501-B to that of the UL smoke chamber, detectors with results ± 0.4 %/ft beyond the given range may be considered acceptable. As an extreme example, results as high as 2.4 %/ft may be considered acceptable if the listed sensitivity is 1.5 ± 0.5%/ft

5.4 Test Procedures *(For duct detectors, please refer to APPENDIX G.)*

Start the test with the nominal sensitivity value given by the manufacturer. Depending on the test result, you can stop or do additional test using either the upper or lower limit of the sensitivity range. For example, if the specified sensitivity is 1.5 ± 0.5 %/ft, your first test would be 1.5 %/ft and your second could be 1.0 %/ft (1.5 - 0.5), 2.0 %/ft (1.5+ 0.5) or no test, depending on the result from the first test. The third test if needed, could be 0.6 (1.5 - 0.5 - 0.4) or 2.4 (1.5+0.5+0.4) %/ft.

Start testing after the initial warm-up period and total emulsification of the liquid in the reservoir. The pressure and dilution air LEDs should stay at green.

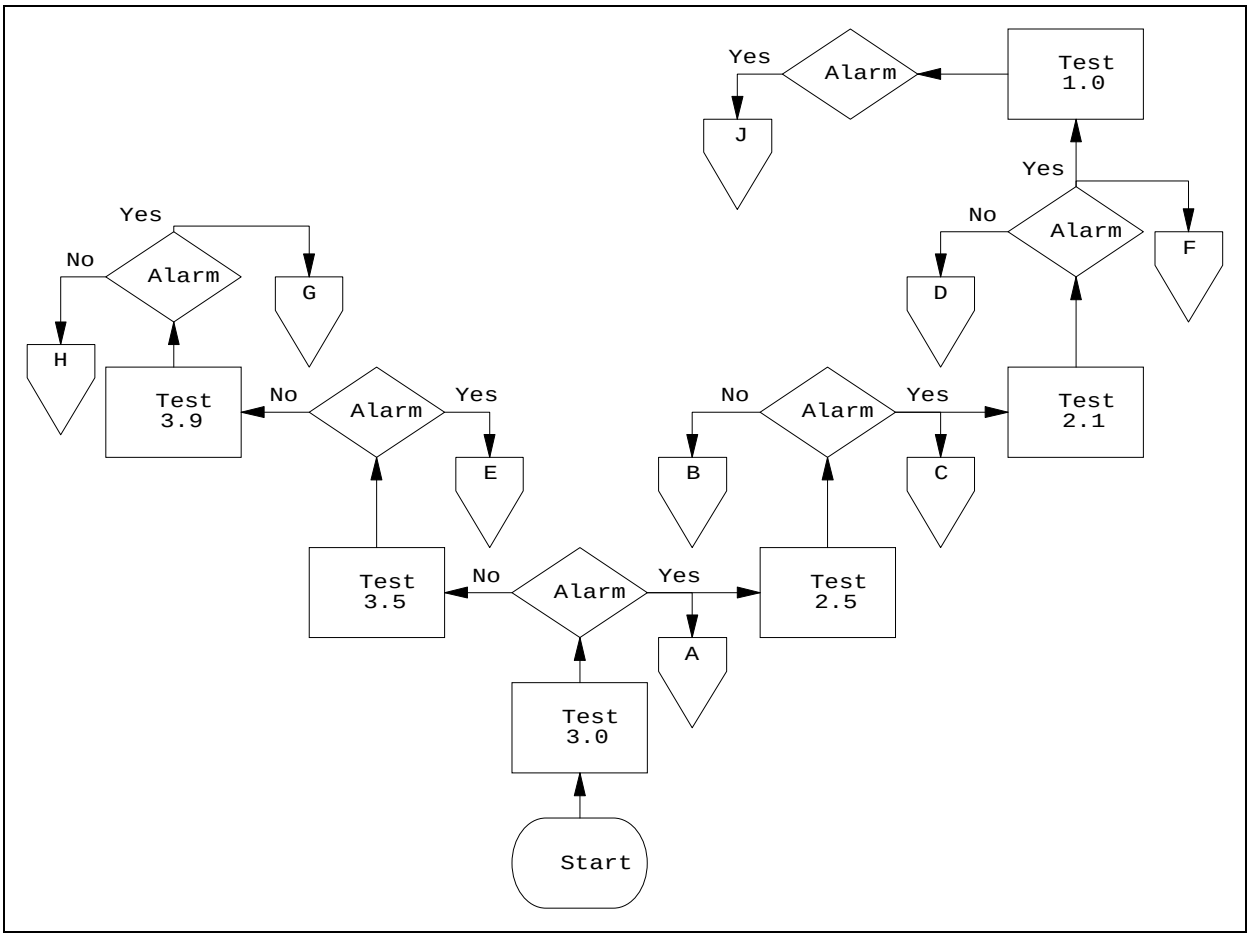
Place the shroud over the test detector. Adjust the flow meter reading to the desired level shown by the appropriate scale. Reset or note the timer as you begin. If the detector **alarms** within 30 to 40 seconds, hold the shroud in place while you reduce the concentration to zero. Immediately turn the compressor switch off. Wait an additional 5-10 seconds before removing the shroud and shutting off the blower.

If the detector **does not alarm** in less than 30 to 50 seconds, increase the concentration to the next higher value with the shroud still in place. Wait 30 to 50 more seconds for it to alarm.

If the test detector alarms and you want to continue the test at a lower setting, you must reset the alarm. Before testing at a lower value, allow at least 20 seconds to flush out the old smoke with the shroud in place and compressor off.

Figure 2 is an example of the test decision tree and statements you can make based on the test results. It is based on a detector with the stated sensitivity of 3.0± 0.5 %/ft.

Figure 2, Example of Test Decision Tree and Statement of Results



Statement	Alarm at	Not Alarm at	Statement of Test Results
A	3.0 %/ft		Is within manufacturer's specification of 3.0 ± 0.5%/ft
B	3.0 %/ft	2.5 %/ft	Is within manufacturer's specification of 3.0 ± 0.5%/ft
C	3.0 %/ft and 2.5 %/ft		Is within manufacturer's specification of 3.0 ± 0.5%/ft
D	2.5 %/ft	2.1 %/ft	Is within manufacturer's specification of 3.0 ± 0.5%/ft
E	3.5 %/ft and 3.0 %/ft		Is within manufacturer's specification of 3.0 ± 0.5%/ft
F	2.1 %/ft		Is a borderline case. Outside manufacturer's specification. Within test error
G	3.9 %/ft		Is a borderline case. Outside manufacturer's specification. Within test error
H		3.9 %/ft	Is above the upper limit of manufacturer's specification and outside of test error
J	At or below 1.0%/ft		Is outside of the manufacturer's range. Subject to false alarm

If you recommend rejecting detectors based on sensitivity test results, make sure that your tester is in calibration and would survive challenges from the manufacturer or Authority Having Jurisdiction. This is especially important in dealing with borderline cases. For confirmation of test results, we suggest testing the "accepted" and the "rejected" detectors of the same brand sequentially (one after the other or side by side) using a common concentration level.

5.5 Calibration and Accuracy

Each instrument is individually calibrated. The calibration relates instrument sensitivity display readings to smoke output in terms of its mass concentrations (mg/m^3) and to its corresponding UL 268 light obscuration (%/ft) scales for ionization and photoelectric detectors.

The calibration is based on tests performed with pressure LED at green (15 psig), dilution air LED at green (60 L/min) and aerosol temperature at 75 °F.
Estimated uncertainty based on our study relating detectors' sensitivity test results between the UL 268 Smoke box and the Gemini 501-B Tester is ± 0.4 %/ft (both operator and measurement errors).

5.6 Operational Precautions

(1) Attach drain reservoir to drain outlet before any operation.

(2) Empty the drain reservoir periodically.

(3) Do not reuse oil from the drain reservoir.

(4) Do not store Rudol™ Oil at temperature above 85 °F for long period.*

(5) Change vacuum filter when the color turns red.

(6) Cover nebulizer opening with orange cap when it is not in use to prevent dust from getting in through the inlet opening (see page 18).

(7) Remove nebulizer and drain reservoir before storage.

(8) Only Rudol™ Liquid, which has a consistent viscosity and physical properties, can be used. Other mineral oil may not trigger alarms.

* Rudol™ Oil left in a truck or car in hot summer days should be discarded because it would affect test result due to viscosity change from polymerization at high temperature. To prolong shelf life, store the unused oil in refrigerator or cold room.

6.0 Servicing

6.1 General

The servicing section discusses the procedure for internal calibration check, routine maintenance information, problem diagnostics, causes, and remedies.

6.2 Calibration and Working Standards

Though the instrument has been calibrated at the factory before shipment, there is no assurance that the calibration will remain unchanged after it has been used in the field for any length of time. By using a working standard, you can check your own calibration and avoid returning the instrument to the factory.

A working standard, in the form of two commercial smoke detectors (one ion chamber type and the other photoelectric), can be used to determine the reference benchmarks while the instrument is new and in calibration. The benchmarks are the alarm threshold of the two detectors based on the LCD sensitivity readings of the instrument. Store these two working standard detectors and only use them to check the Gemini Tester.

Any change in the alarm thresholds of these two detectors in subsequent tests can reasonably be assumed to be a shift in calibration of the instrument, rather than to shift in detector sensitivity. Periodic checking with the standards may be used as the criteria for need of service action (i.e., cleaning of small orifices and filter change) and thus to insure correct calibration.

The two working standard detectors we recommend are the System Sensor 1451 ionization type and the ESL 611U pulse LED photoelectric. Other well-designed detectors may also be used.

After familiarizing yourself with the instrument by triggering the alarm on several smoke detectors and recording the concentration/sensitivity readings, the alarm threshold for the two standard detectors should then be established. We suggest that the average of several replicate runs be taken. All readings for a single detector should be within 5 mm (one tic mark space = 5 mm) while the difference between the two detectors may be large.

Calibration check using the working standards may be performed after the instrument has tested over a few hundred detectors. The frequency for check should be guided by your own test experience.

Three main causes for shift in calibration are: (1) Clogging of the small orifices (holes) in the nebulizer or impactor. (2) Vacuum filter overload. (3) Not using Rudol Liquid. (See Table 1: Problem Diagnostics, on page 15 to remedy these situations.)

6.3 Routine Maintenance

The only periodic maintenance for the instrument is to change the vacuum line filter element when the color of the filter element turns red.
During a test, oil in the reservoir is oxidized continuously and would contaminate fresh oil added to it. The process would eventually affect the test results. We recommend that after about 5-6 oil additions to the nebulizer reservoir, the entire content should be discarded. Oil from the drain reservoir SHOULD NOT be reused to avoid clogging.

6.4 Problem Diagnostics

Table 1 lists common problems and possible causes and remedies during the operation.

Table 1. Problem Diagnostics

Symptom	Possible Causes	Remedies
Low aerosol generation and or large bubbles in Nebulizer reservoir.	Clogged impactor Or clogged nebulizer	Clean Nebulizer. See Figure 5-D p23 and Appendix B p18. Clean impactor holes using can-air. (**DO NOT enlarge**)
High aerosol generation	Overloaded filter Drain reservoir open	Replace vacuum filter element. Check filter connection elbows to make sure that all tubes are tightly connected. Install drain reservoir.
Calibration Shift	See above Vacuum line leak Wrong Nebulizer	See above. Check line, connections, drain reservoir. Calibrate the Tester with the Nebulizer.
Detector fails to alarm	Insufficient aerosol Defective detector Unmatched nebulizer	Increase to the maximum concentration. Switch to a new detector. Calibrate nebulizer with the Tester
Pressure LED cannot be adjusted to “green” (“OK”) (at 15 psig)	Leakage, defective pump Low battery	Contact Gemini Scientific Charge battery *overnight* using charger provided.
Concentration cannot be adjusted to reach zero	Filter overload Vacuum line leaks or pump fails.	Change filter element. Locate and fix leak. Or contact Gemini.
Pump running, no pressure	Major pressure leak	Check for leak or pump function.
Dilution air indicator stays at "Yellow". Or it cannot be adjusted to "Green".	Low battery Blockage in hose or wand Incorrect Diffuser openings Transducer calibration shifted	Charge battery overnight or use optional AC Adaptor Remove hose or wand blockage if present. "Yellow" - Enlarge some diffuser holes. "Red" - Tape-close some diffuser holes. Contact Gemini.

7.0 Replacement Parts

7.1 Table of Parts

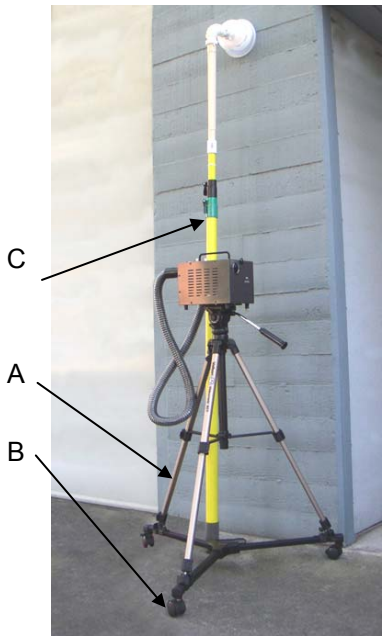
This section contains information on replacement parts for Model 501-B, Aerosol Generator from Gemini Scientific Corp. or from the originating manufacturer.

Table 2 Replacement Parts List

Gemini Part Number	Description
B0100	12V Ni-Metal Hydride Battery
B0101	Battery Charger (NiMH)
F0603-B	Vacuum Filter (with indicator) box of 10
F0603-B1	Vacuum Filter (each)
O1501	Rudol™ Liquid Oil
501-B AC-Adaptor (for earlier Models)	Optional AC adaptor for 501-B

Table 3 Accessories Parts List

Gemini Part Number	Description
M1080	Tripod *(A)*
M1081	Tripod Dolly (on wheels) *(B)*
Hi-reach Kit	Retractable Extension Pole (reaches up to 30 feet) *(C)*



7.2 Replacement of Battery

Please consult Gemini Scientific Corporation for more information.

APPENDIX A: Calibration of the Gemini 501-B

The mass median diameter of the aerosol from the Model 501 Aerosol Generator was determined by using the Anderson Cascade Impactor*. Based on 4 replicate runs from 3 generators at a concentration of about 20 mg/m^3, the mean mass median diameter was found to be 0.44 um with a calculated standard deviation of ±0.02 um. The estimated number median diameter is less than 0.2 um. The Model 501-B is based on and uses the same smoke generation apparatus as the original unit.

The mass concentration of the aerosol was determined by a mass monitor**, which electro-statically deposits the aerosol onto a piezoelectric quartz crystal. The frequency shift of the crystal is a function of its weight gain from the depositing aerosol. Thus the monitor measures aerosol mass concentration in terms of frequency change of the crystal. Sensitivity of the monitor is in the order of 0.01 mg/m^3.

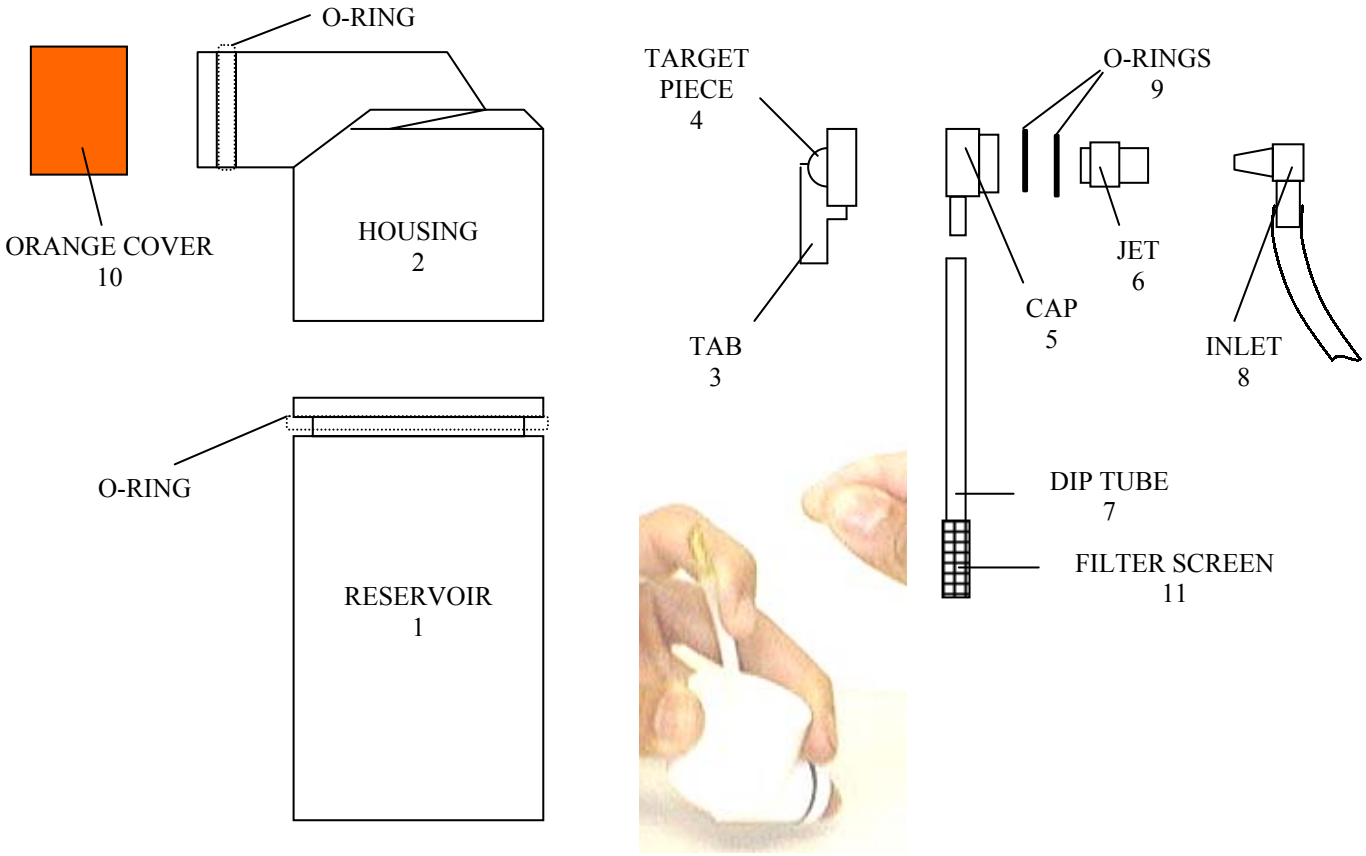
The UL Smoke Box and the Gemini 501-B use different methods to measure smoke. The light obscuration property of the smoke is used to quantify the smoke in the UL Box, whereas the mass (weight) concentration is used for the Gemini instrument.

Since the minimum amount of smoke needed to trigger the alarm of the detector, defined as its sensitivity, is equivalent for both the UL smoke box as well as for the Gemini 501-B, the alarm points of detectors are used to bridge the two systems by making equivalent scales.

The alarm points in terms of light obscuration for the 6 standard reference detectors were previously determined in the UL Smoke Box. The detectors cover the necessary sensitivity range and consist of both type detectors. There are valid physical reasons for the difference in the scales for the two types of detectors.

APPENDIX B: Nebulizer Assembly & Maintenance

Note: Nebulizer Assembly consists of part #3,4,5,6,7,9, 11 only.



To Disassemble Nebulizer: Remove Inlet (8) with hose from Housing (2). Remove Housing with the Reservoir from the Manifold on the front panel with a pulling and twisting motion. Separate Reservoir (1) and Housing with a breaking and pulling motion. Remove the exposed aerosol generating parts by grasping the Tab (3) with thumb and forefinger and pull Target Piece (4) straight out of the Housing. Remove Cap (5) and Dip Tube (7). Leave the Jet (6) and the O-ring (8) in place (DO NOT take the jet out from the nebulizer housing). *See Figure 5-E & F p27.*

To clean or remove obstruction: Soap or detergent may be used to clean all of the above parts. Flush parts with water. Be careful not to enlarge any of the holes in the parts. Air-dry only before reassemble.

To Assemble Nebulizer:
Place BOTH of the o-rings over the Jet*(6)*. Using dip Tube*(7)* as handle, insert the Cap*(5)* into the Jet*(6)* inside the Housing*(2)*. Hold the Housing*(2)* with your left hand as shown by the above picture, while bending the Dip Tube*(7)*, push the Cap*(5)* with your right index finger into the underside of the O-ring until it snaps. Grab the Tap*(3)* and slide the Target Piece*(4)* between the guides of Housing*(2)* and Cap*(5)* as far as it will go. A few attempts may be needed for it to work. Snap Reservoir*(1)* back into Housing*(2)*.

Note:
Always empty oil from the nebulizer and cover the opening with the provided orange cap *(10)* when it is not being used to prevent dirt from getting in through the inlet opening.

APPENDIX C: Sample Smoke Detector Test Report

SMOKE DETECTOR TEST REPORT

☐ Annual Inspection & Function Test

☐ Bi-Annual Sensitivity Test

Instrument used: ☐ Gemini 501-B S/N: _____ ☐ Other: _____

Property Name:

Property Address:

Property Contact Person:

Building: Location: Room/Zone:

Detector Location	ID Number	Serial Number	Brand/ Model	Type P/I	Listed Sensitivity Range	Alarm Point	Pass (P) Fail (F)	Comments

Tested By: Name _____ Signature _____ Date _____ Page of

APPENDIX D: Replacement of Vacuum Filter

1. Replace vacuum filter when the color on the filter element turns red.
2. Open the front panel by loosening the thumbscrews.
3. Loosen filter strap.
4. Locate elbow connectors with orange fittings on both ends of the vacuum filter.
5. Push in orange fitting towards the elbow.
6. Detach vacuum filter from elbows by pulling the black tubes (on the vacuum filter) away from the elbows while keeping orange fitting pushed in.
7. Replace with a new vacuum filter. Observe correct orientation.
8. Insert black tube from the vacuum filter completely into the elbow. Repeat the procedure on both ends of the filter.
9. Pull orange fitting out (towards filter) to hold filter in place.
10. Check and make sure that all tubing fit tightly in the elbows.
11. Refasten strap.

⚠ ***WARNING:*** *Make sure that the vacuum filter capsule is installed correctly. If the filter capsule is installed in the reverse direction, damages to the tester may result.*

APPENDIX E: Material Safety Data Sheet - RUDOL™ OIL

Witco MATERIAL SAFETY DATA SHEET

PRODUCT Rudol White Mineral Oil
FOR GEMINI 501 DETECTOR TESTER

HAZARD RATING (NFPA): 4 – EXTREME, 3 – HIGH, 2 – MODERATE, 1 – SLIGHT, 0 – INSIGNIFICANT
Fire 1 · Reactivity 0 · Toxicity 0 · Special

SECTION I

1 WITCO MANUFACTURING DIVISION OR SUBSIDIARY: Sonneborn Division

2 ADDRESS (NUMBER, STREET, CITY, STATE, ZIP CODE): P.O. Box 336, Petrolia, PA. 16050 — P.O. Box 308 Gretna, LA. 70054

EMERGENCY TELEPHONE (504) 366-7281
MANUFACTURER (412) 756-2210
CHEM TREC 1-(800) 424-9300

3 CHEMICAL NAME OR FAMILY: White Mineral Oil, NF

4 FORMULA: A mix of liquid hydrocarbons refined from petroleum.

SECTION II – CHEMICAL AND PHYSICAL PROPERTIES

CHEMICAL

5 HAZARDOUS DECOMPOSITION PRODUCTS: Upon combustion, CO_2 and CO are generated.

6 INCOMPATIBILITY (KEEP AWAY FROM): Keep away from flame, heat (150°F max.), and strong oxidizing agents.

7 LIST ALL TOXIC AND HAZARDOUS INGREDIENTS: None

PHYSICAL

8 FORM: Viscous liquid

9 ODOR: None

10 APPEARANCE: Colorless liquid

11 COLOR: None

12 SPECIFIC GRAVITY (WATER = 1): <1.0 @ 15°C

13 BOILING PT. IBP: > 230 °C / > 450 °F

14 MELTING PT.: NA °C / NA °F

15 SOLUBILITY IN WATER AT 25 °C: Negligible

16 % VOLATILE (BY WT %): Nil @ 25°C

17 EVAP. RATE (= 1): Nil @ 25°C

18 VAPOR PRESSURE (mm Hg at 20°C): <.5mm

19 VAPOR DENSITY (AIR = 1): NA

20 pH AS IS: NA
pH ( )

21 STRONG ACID ☐ / STRONG BASE ☐ / STABLE ☒ / UNSTABLE ☐

22 VISCOSITY SUS AT 100°F: <100 ☐ / 100 OR > ☐

23 CAS #8042-47-5

SECTION III – FIRE AND EXPLOSION DATA

24 SPECIAL FIRE FIGHTING PROCEDURES: Self-contained breathing apparatus is recommended for firefighters. Water-spray must be used with caution to prevent spread of flames.

25 UNUSUAL FIRE AND EXPLOSION HAZARDS: None

26 FLASH POINT (METHOD USED): ASTM D-92 > 176 °C > 350 °F

27 FLAMMABLE LIMITS %: NDA — LOWER ____ UPPER ____

28 EXTINGUISHING AGENTS: ☒ DRY CHEMICAL ☐ CO_2 ☒ WATER SPRAY ☐ FOAM ☒ WATER FOG ☒ SAND/EARTH ☐ OTHER ____

SECTION IV – HEALTH HAZARD DATA

29 PERMISSIBLE CONCENTRATIONS (AIR): See Section IX - COMMENTS.

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30 EFFECTS OF OVEREXPOSURE: NDA

31 TOXICOLOGICAL PROPERTIES: NDA

EMERGENCY FIRST AID PROCEDURES

32 EYES – Flush with water. If irritation exists consult a physician.

33 SKIN CONTACT – NA

34 INHALATION – NA

35 IF SWALLOWED – Call a physician.

NA = NOT APPLICABLE NDA = NO DATA AVAILABLE <= LESS THAN >= MORE THAN

CHEMCENTRAL

FORM NO. 851 (4/83)

Witco MATERIAL SAFETY DATA SHEET

PRODUCT Rudol

SECTION V — SPECIAL PROTECTION INFORMATION

VENTILATION TYPE REQUIRED (LOCAL, MECHANICAL, SPECIAL) [36]: NA	PROTECTIVE GLOVES [38]: None
	EYE PROTECTION [39]: Chemical splash goggles
RESPIRATORY PROTECTION (SPECIFY TYPE) [37]: NA	OTHER PROTECTIVE EQUIPMENT [40]: None

SECTION VI — HANDLING OF SPILLS OR LEAKS

PROCEDURES FOR CLEAN-UP [41]:

Shut off leak, dike up spills, absorb with inert material such as sand, earth or vermiculite. Sweep up and dispose of in accordance with Federal, State and local regulations.

WASTE DISPOSAL [42]:

Use methods consistent with Federal, State and local regulations.

SECTION VII — SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE [43]:

Avoid heat (150°F max.), flame and oxidizing agents.

SECTION VIII — TRANSPORTATION DATA

[44] UNREGULATED BY D.O.T. [X]	U.S. D.O.T. PROPER SHIPPING NAME [47]: NA	
[45] REGULATED BY D.O.T. [ ]	U.S. D.O.T. HAZARD CLASS [46]: NA	I.D. NUMBER [48]: NA
TRANSPORTATION EMERGENCY INFORMATION [49]: CHEM TREC 1-800-424-9300	RQ [50]: NA	LABEL(S) REQUIRED [51]: NA
	FREIGHT CLASSIFICATION [52]: Petroleum Oil NOIBN	
	SPECIAL TRANSPORTATION NOTES [53]: NA	

SECTION IX — COMMENTS

[54] This product is a fully refined white mineral oil meeting the requirements of the National Formulary XVII as well as the requirements of the Food and Drug Administration as per CFR 172.878. If used in applications where a mist may be generated, observe a TWA/PEL of 5 mg/m^3 of mineral oil mist (OSHA and ACGIH).

Tel: (212) 605-3911

SIGNATURE Alexander Coutras TITLE Manager, Regulatory Affairs

REVISION DATE Jan. 9, 1990

SUPERSEDES Dec. 1, 1989

SENT TO ATTN: DATE

We believe the statements, technical information and recommendations contained herein are reliable, but they are given without warranty or guarantee of any kind, express or implied, and we assume no responsibility for any loss, damage, or expense, direct or consequential, arising out of their use.

APPENDIX F: Pictorial Illustrations

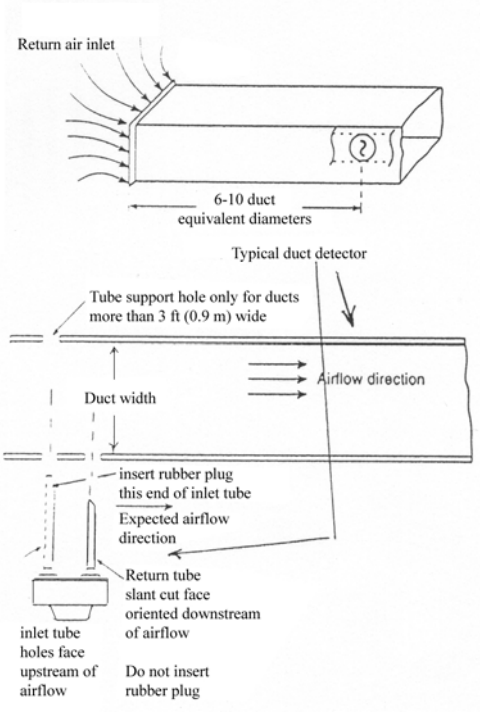
Fig. A Correct way of filling the nebulizer

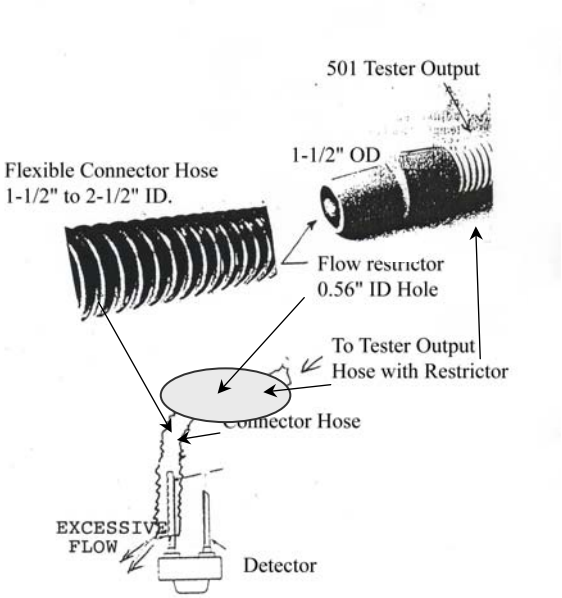
Fig. B Symptom of clogged nebulizer

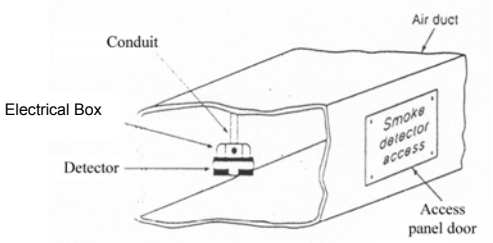
Fig. C Removal of nebulizer housing by twist & pull motion

Fig. D Removal of target piece from the housing

APPENDIX G: Duct Detector Testing







1. Use the normal method of generating smoke from the Gemini Tester.
2. Do not use the wands and the shroud.
3. Insert a restrictor at the end of the hose (0.6” diameter hole). *
4. Use a connector-hose to connect the hose from the tester.
5. Any flexible hose with 1-1/2” to 2-1/2” inside diameter can be used as connector. Tape the connection with duct tape.
6. Insert the hose into the inlet tube of the detector that has been removed from the duct for testing.
7. Allow space for excess smoke to flow out.
8. Maintain green on the LED.

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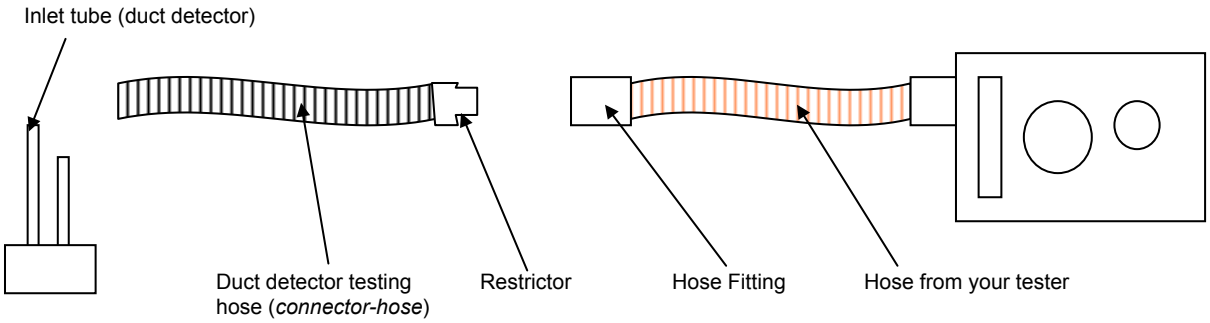
* The restrictor is available from Gemini. Contact Gemini at (408) 554-0310 if you have any questions.

Additional instructions on how to connect the duct detector testing hose:



1. Connect the optional duct detector testing hose (connector-hose) to the hose fitting from your tester as shown in the figure above. Do not connect any wands.
2. If the duct detector can be reached through an access panel door, extend the hose into the duct and place it over the inlet tube of the detector (see figure on the previous page). If not, remove the duct detector and perform the same procedure.
3. Turn the tester on. Adjust the dilution control knob to set the dilution LED indicator to green “OK” position.
4. Follow the usual procedure for the testing of detectors.