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2. Specifications, CRM-510LP

RADIATION DETECTED.....Radon-222 alpha
DETECTORAir Ionization Probe
DYNAMIC RANGE.....0.5 to 200 pCi/l
UNITpCi/l or Bq/m³
SENSITIVITY0.3 CPM per pCi/l
.....(0.008 CPM per Bq/m³)
LINEARITY0 - 200 pCi/l (<10% Deviation)
SAMPLING MODE.....Passive Air Diffusion
OPERATING MODE: DATA STORAGE
CRM-510LP.....192 one hour data points (8 days)
CRM-510LP/CO w/carbon monoxide ..79 one hr. data points radon
316 fifteen minute data points carbon monoxide
ENVIRONMENTAL SENSORS:
TEMPERATURE.....Range 50-104 °F, 10-40 °C
.....Sensitivity ±1 °F, ±0.5 °C
BAROMETRIC PRESSURE.....Range 0-38 "Hg, 0-127 kPa
.....Sensitivity ± 0.2 "Hg, ±0.5 kPa
RELATIVE HUMIDITY.....Range 10-90%
.....Sensitivity ±5%
DISPLAY:
ALPHANUMERIC CHARACTERS.....16 digit one line LCD
LOW BATTERY INDICATOR.....LCD Message
PULSE INDICATOR.....Red LED
CONTROLS:
KEY SWITCH.....OFF, I/O & RUN Positions
TWO MOMENTARY PUSH BUTTONS....Menu Select & Execute
EXTERNAL OUTPUTS (FEMALE DB-25)
SERIAL.....RS-232C
PARALLEL.....8 Bit Simplified Centronics®
POWER:
ELECTROMETER.....9 volt battery (1 year typical life)
ION CHAMBER.....27 volt battery pack (2 year typical life)
COMPUTER/DATA LOGGER.....7.2 volt lithium battery pack
(1 year typical life)

SIZE: HEIGHT (w/handle).....5.4" (137 mm)
WIDTH.....6.6" (160 mm)
DEPTH.....7.4" (190 mm)
WEIGHT.....3.9 pounds (1.8 kg)
ENVIRONMENTAL OPERATING RANGE.....50-104 °F (10-40 ° C)
.....10 To 90% RH (noncondensing)

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3. General Description

The *femto*-TECH, INC. MODEL CRM-510LP is a precision airborne alpha radiation detection instrument based on the same field proven pulsed ion chamber technology of previous MODELS R210F and RS410F. Due to a unique patented electrometer and open grid probe design, the MODEL CRM-510LP is highly suited for a wide range of radon measurement applications. Because of the low current requirements of the electrometer detector and on-board computer, the MODEL CRM-510LP is truly a portable self-contained continuous radon monitor that can read and store test data for eight days of stand-alone operation. In this "PASSIVE" mode of operation the MODEL CRM-510LP is uniquely suited for screening and follow-up type testing.

The full function computer system incorporated in the MODEL CRM-510LP provides the operator with a highly flexible radon detection instrument and data logger operating system, while still maintaining the simplicity of operation for which *femto*-TECH instruments are noted. In addition to the measurement and storage of radon data, the highly sophisticated on-chip peripheral capabilities of the micro controller (MCU) used in the CRM-510LP provide for the measurement and storage of temperature, barometric pressure, and relative humidity. This multidimensional data acquisition capability provides the tester with a unique data base for evaluating the validity of short term radon measurements. Some of the features offered by this unique combination of computer control and open grid pulsed ion chamber detector are:

REAL TIME RADON MEASUREMENTS
AUTOMATIC TEST START DATE / TIME STAMP
TEMPERATURE (°F or °C)
BAROMETRIC PRESSURE ("Hg or kPa)
RELATIVE HUMIDITY (%)
CHOICE OF OPTIONAL PRINTERS
GRAPHIC PRINTOUTS
ALPHANUMERIC PRINTOUTS
PASSIVE SAMPLING (no pump or filters)
CHOICE OF UNITS (pCi/l or Bq/m³)
BUILT-IN RS-232 INTERFACE PORT
BUILT-IN PARALLEL PRINTER PORT
LCD SCREEN DISPLAY
PERMANENT EPROM BASED OPERATING SYSTEM
EEPROM DATA STORAGE
BUILT-IN UPLOAD SOFTWARE
KEYED SECURITY LOCK
ANTI-TAMPER MOTION (TILT) DETECTOR
BUILT IN NUCLEAR PULSE SIMULATOR SELFTEST
CONCEALED SCREEN TEST MODE

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4. Operation

4.1 Initial Set Up

Carefully unpack components from shipping package, inspect for damage, and insure that the following are included:

STANDARD EQUIPMENT:

Quantity	Item
1	CRM-510LP Continuous Radon Monitor, with Certificate of Calibration
1	Key and Key tag
1	CRM-510LP Carrying Case
1	Door Hanger

OPTIONAL PRINTER PACKAGE:

Quantity	Item
1	Parallel Printer
1	CRM-510LP / Printer Interface Cable
1	Roll of Paper
1	AC Adaptor / Charger (if applicable)
1	Printer Manual or Instructions for Use

OPTIONAL PC UPLOAD PACKAGE:

Quantity	Item
1	CRM-510LP / PC Interface Cable
1	CRM-510LP / PC Upload Program CD

OPTIONAL MODEM PACKAGE:

Quantity	Item
1	Portable Modem and AC adaptor (if applicable)
1	CRM-510LP / Modem Interface Cable
1	Modem Instructions
1	Telephone Cable—RJ11

Contact your dealer if any discrepancies are found.

Before attempting to operate the instrument, it is recommended that the user read the following CONTROLS and COMPUTER/DATA LOGGER sections of this manual as well as operation sections of the manuals supplied with any optional equipment and accessories that have been purchased. It is further recommended that the user perform practice tests to become familiar with the CRM-510LP, before carrying out actual field tests.

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4.2. Controls

Operating the CRM-510LP is simplicity itself. The instrument panel consists of a **KEY SWITCH**, a **PRINT** pushbutton, and an **I/O** pushbutton. Because the CRM-510LP operates on only micro-amperes of current, the electrometer detector operates continuously obviating the need for a warm-up period. All other functions are controlled by the internal microcomputer. The functions of all CRM-510LP front panel controls are described below.

CRM-510LP CONTROLS

KEY SWITCH:

POSITION	FUNCTION
OFF	All systems are inactive; software version displayed by pressing either pushbutton.
I/O	Minutes of stored data displayed on LCD screen. [PRINT] and [I/O] pushbuttons are active for data output control.
ON	Measurement units displayed on LCD screen. [PRINT] and [I/O] pushbuttons are active for UNIT SELECTION and START TEST commands.

[PRINT] Pushbutton (Left):

MODE	FUNCTION
Generic	Serves as ENTER key for executing selection on the LCD screen.
OFF	Ends test; displays software version.
I/O	Executes SUMMARY PRINT of stored data.
Run	Executes test initialization.

[I/O] Pushbutton (Right):

MODE	FUNCTION
Generic	Serves as SELECTION key for options shown on the LCD screen.
OFF	Displays software version.
I/O	Executes DOWNLOAD (RS-232 Port) of stored data.
Run	Scrolls LCD display (data or selection menus).

The keyswitch serves as a function indicator only. Power to the MCU remains on at all times. To conserve power, the display will be turned off if a pushbutton is not selected in a reasonable time. Pressing either button will wake the MCU to either continue or restart a selection.

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4.3. Computer / Data Logger

4.3.1. Description

The *femto*-TECH, INC. CRM-510LP Continuous Radon Monitor is a complete data acquisition system based on an internal microcomputer (MCU). All operator interaction is accomplished via easy to follow LCD screen prompted selections and push-button entered commands. Nearly all the features of the data logger program can be used immediately without extensive operator training, because responses are prompted by screen menus. Several types of information are used and/or stored by the MCU. The operating system and fixed parameters are stored in EPROM (Erasable programmable read only memory), whereas instrument settings which seldom need changing (such as units, calibration factor, background value, and serial number) are stored in an EEPROM (Electrically erasable programmable read only memory). Collected data are also saved in EEPROM and the timing/memory device and thus, are retained even when the CRM-510LP is powered down.

4.3.2. Run Mode

Description:

The RUN MODE is the data collection mode for the CRM-510LP instrument. In the RUN MODE the MCU reads and stores data from built-in radon and environmental sensors and displays current readings of these parameters on the LCD screen. Elapsed time in minutes; present radon concentration (Rate); average radon concentration, since reset; temperature; barometric pressure; percent relative humidity; and number of "tilts", since reset may be displayed in "real time" on the LCD screen. The MCU also monitors the status of the battery power systems and provides failure responses (See [BATTERY STATUS SECTION 4.3.6.](#) for details). The "real time" data are printed in either pCi/l or Bq/m³. Selection of units for screen display and printouts can be made at the start of the test program and remain in effect during the total data collection period. However, summary printouts can be obtained in the I/O MODE in either unit set, regardless of the unit set used for the RUN MODE collection period (see [Appendix A](#) for example printouts). The units selected at the start of the test will be retained as the default during output.

Up to 8 days (192 hours) of accumulated hourly count interval data are stored. These data are stored in EEPROM and the timing/memory device and thus are retained even on power down of the CRM-510LP. In the event of a system failure for any reason during a test, all data collected prior to the failure point will be retained. Moreover, the CRM-510LP will continue to operate, and recalculate even after the data storage memory is full.

For tamper-proof security during a test, a key lock switch is provided. Screen security is also provided whereby only elapsed time can be viewed without entering a digital unlock code.

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Computation Algorithm:

To fully utilize all the functions of the CRM-510LP an understanding of some of the features of the computational algorithm is helpful. The elapsed time and total accumulated count data are collected, stored, displayed, and printed directly in units of minutes and counts, respectively. However, the present concentration data are computed using an algorithm based on a digital model of a rate meter. To insure statistical integrity of the readings and to dampen large swings in the "real time" display of the data, counts are collected and integrated using a first-in-first-out ten register stack with six a minute collection interval per register. This procedure insures that sufficient counts are collected so that statistical counting errors in the present concentration data do not exceed $\pm 25\%$ (one sigma confidence level) for radon concentrations as low as 1 pCi/l.

Due to the above features, present concentration data will not reach a stable value for approximately one hour, after initial start-up. However, the accumulated average concentration data are computed and updated at one-tenth minute intervals and are immediately valid (within the counting statistical constraints of the radon level being measured). Thus, for the first hour of a test, the average concentration values are used to represent the "real time" or present concentration.

During the computations for both the present and average radon concentration, a correction of 0.075 CPM (0.3 pCi/l or 11 Bq/m³) background is applied to the data. The background value used in this computation is stored in EEPROM and can only be changed by procedures described in [Appendix E](#).

Operation:

1. Turn on the CRM-510LP by turning the key switch to the RUN position. Remove the key, and press the [PRINT] pushbutton once. The screen will temporarily display "RUN;" the units used in the last test will then be displayed on the LCD screen.

(pCi/l, "Hg, °F),

or

(Bq/m³, kPa, °C)

If a "LOW BATTERY" message is displayed rather than the unit set, the batteries must be changed before the unit will run a test. Call *femto*-TECH for battery replacement.

2. At this point the user has the option of accepting the unit set being displayed or to change it by pressing the [I/O] pushbutton. The test will be performed in the units displayed on the screen, when step 4 below is executed.

3. Press the [**PRINT**] pushbutton once. This will display the current date.
4. A test is initiated by pressing both the [**PRINT**] and [**I/O**] pushbuttons. It is best to press and hold the [**PRINT**] pushbutton first, then press the [**I/O**] pushbutton and release both.
5. At this point the current time will display (in 24-hour format), then the unit will begin a self test of the detector circuitry, using an internal nuclear pulse simulator (N.P.S.). The self test will last approximately 30 seconds, with the LCD displaying:

SELF TEST ACTIVE

6. If successful, the screen will display:

**PASSED SELF TEST
TEST STARTED!
COUNT 0**

After a few seconds, the screen will go “go to sleep,” as a feature to extend battery life.

If, however, the screen displays

FAILED SELF TEST,

then goes blank, repeat the test initiation procedure again. If the unit once again fails, contact *femto*-TECH for technical assistance at (937) 746-4427 EST. Typical causes of self test failures include electrometer upset due to rugged handling, high humidity conditions causing condensation (dewpoint), and very high ambient radon levels (over 100 pCi/l).

7. During the first six minutes of a test the security features (tilt and screen lock) are disabled to allow for operator setup. During this period the [**I/O**] pushbutton can be used to scroll through all seven data displays on the LCD screen. At the end of this six minute period, the screen locks to a blank display and the tilt transducer is activated, and remains active until the end of the test. The tilt transducer is designed for fixed position tests with the CRM-510LP in a level position.
8. After the first six minutes of a test, a digital code must be entered to unlock the screen for viewing the parameters other than elapsed time (See [DIGITAL COMBINATION SCREEN LOCK SECTION 4.3.4.](#) for details).
9. The CRM-510LP will continue to collect data until the test is terminated by the exit procedure below. However, only the first 192 hours (8 days) of the test data will be saved in EEPROM.

10. To terminate a test, simply turn the key switch to the OFF position, and press either the [PRINT] or the [I/O] pushbutton. The accumulated data will be retained as long as a new test is not initiated. However, when a new test is initiated, the previous data are cleared. Therefore, a test cannot be resumed once terminated.

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4.3.3. Real Time Set Mode

Description:

The current date and time are stored in the computer's "Clock in a Can" (CIC). If, for some reason the time must be changed (i.e. beginning/ending Daylight Savings Time, or change of time zone), the CRM-510LP has a feature allowing the user to do so. The unit must have no test (less than 1 hour of data) in its memory. To clear the memory, start a test; after the screen displays "TEST STARTED!" and goes blank, immediately end the test (see previous section).

Turn the keyswitch to the I/O position, and press the [PRINT] pushbutton. The screen will display

TIME 0 MIN.

then

NO DATA TO PRINT

As soon as either display appears, turn the keyswitch to the RUN position. The screen will then display the time in the MCU's memory. Use the [PRINT] pushbutton to scroll up through the hours (military time), and the [I/O] pushbutton to scroll up through the minutes. After the correct time is displayed, immediately turn the keyswitch off to secure the time.

4.3.4. Digital Combination Screen Lock

Description:

A built in screen security feature prevents unauthorized personnel from access to test parameters and results. After the initial operator setup period (6 minutes), the screen display defaults to the "sleep" (blank screen) mode and access to the other data display modes can only be obtained by entering a digital combination code.

Operation:

1. To unlock the screen scroll, press the [I/O] pushbutton once. The following screens should be displayed:

TIME XX MIN.,

then

0123456789

2. Move the blinking cursor to the right by pressing the [I/O] pushbutton until it is on the first digit of the code to be entered (5).

0123456789

3. Enter the first digit (5) by pressing the [PRINT] pushbutton. The cursor will return to the zero digit position upon a successful enter and you can proceed with the second code entry.

0123456789

4. Move the blinking cursor to the right by pressing the [I/O] pushbutton until it is on the digit of the second code to be entered (1).

0123456789

5. Enter the second digit code (1) by pressing the [PRINT] pushbutton. If the correct code has been entered, the count data display will come up on the

screen. However, if an incorrect code or if too much time (> 6 seconds) occurs between commands, the screen will return to the locked blank display.

6. Once the screen display is unlocked, the [I/O] key can be used to scroll through all seven data displays on the LCD screen. However, the scroll does not "wrap around" as in the setup period and it locks on the blank at the conclusion of one scroll cycle. The unit will display:

COUNT	X
RATE	.X pCi/l
AVG	.X pCi/l
TEMPERATURE	XX ° F
B/P	XX.X " Hg
TILTS	X

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4.3.5. I/O Mode

Description:

The CRM-510LP Continuous Radon Monitor has two built-in printer driver programs that provide a wide range of options for hard copy of the data collected and stored. Besides supporting the alphanumeric and graphic printers carried as accessories to the CRM-510LP by *femto*-TECH, INC., "generic" printer and graphic dot plotter drivers are included for use with user supplied peripherals.

Operation:

1. With the power off for both the CRM-510LP and the printer, make the interface connections required for the selected printer (consult the appropriate Appendix in this manual and/or the printer instruction manual for connection and cable details).
2. Turn the CRM-510LP key switch to the I/O position and turn the printer on. Press the [PRINT] pushbutton once, and the minutes of stored data are displayed on the LCD screen.

(TIME XXXXX min)

3. To initiate a printout, press the [PRINT] pushbutton once. At this point, the current unit selection is displayed on the LCD screen and the [I/O] pushbutton is used to toggle between the unit selections for the printout.
4. Press the [PRINT] pushbutton again to execute unit selection. At this point the word "TABLE" is displayed on the LCD screen and the [I/O] pushbutton is used to choose from a menu of printout formats and data review options.

5. If the **[PRINT]** pushbutton is pressed while the "REVIEW DATA" message is displayed on the LCD screen, a summary of the collected test data can be reviewed on the screen using the **[I/O]** pushbutton to step through the different parameters. Press the **[PRINT]** pushbutton to exit the data review and return to the selection menu of step 4 above.

6. Press the **[PRINT]** pushbutton to select the printout format displayed on the LCD screen. At this point, "USE ALL DATA" will be displayed on the

screen. Pressing the **[PRINT]** pushbutton will execute printing. If, however, the test was started under open house conditions, the user may instead press the **[I/O]** pushbutton. This will display "SKIP 1ST 12 HOURS" on the LCD screen, and the computer will recalculate the test, eliminating the first twelve hours from calculations. Keep in mind that the US EPA protocol test must have a minimum 44 hours of contiguous data. All hours of data will be printed, but the first twelve hours will have three asterisks printed in the hour column to signify that those hours' values were not used in the average radon concentration calculation.

The last test is retained memory until a new test is started. As many tests as desired may be printed, in as many printing formats available, until a new test is begun.

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4.3.6. Battery Status

The CRM-510LP has two separate built-in battery power sources - the radon detector and electrometer are powered by a 9 volt carbon zinc/ alkaline battery pack, and the microcomputer, display, and I/O interfaces are powered from a lithium battery pack. Test circuitry is built into the CRM-510LP to provide the operator with information on the charge level of both battery systems. The **BATTERY LED** will flash if the remaining charge in the microcomputer battery drops below that needed to sustain a 48 hour test. A test in progress is not jeopardized and may be continued for up to 48 hours. However, the computer will not allow a test to be initiated from the RUN key switch position and displays a **LOW BATTERY** message on the LCD screen, if a test is attempted with less than 48 hours of battery power supply available. If the battery discharges below the minimum voltage for the microprocessor to operate, an under voltage sensor holds the microprocessor in a reset state.

The status of the electrometer battery system is also checked by the microcomputer. If the charge on the electrometer battery drops to a point where the calibration factor of the radon detector could be affected, the computer in the CRM-510LP will not allow a radon test to begin. If a radon test is attempted from the RUN key switch position, a **LOW BATTERY** message is displayed on the LCD screen and test start-up is inhibited. If the

computer detects a low electrometer battery condition during a test, a low battery flag is set in the collected data and the condition indicated in the printed test summary.

The user may check the battery voltages with no test running, and the keyswitch in the “OFF” position, by pressing and releasing the [PRINT] key, waiting for software revision to appear, and pressing and releasing the [PRINT] key again while the message is displaying. The various battery voltages will then briefly display. The three typical results would be:

LI	batt.	= 72
ELE	batt.	= 93
FLD	batt.	= 27

The numbers would represent the lithium batteries at 7.2 volts, the electrometer battery at 9.3 volts and the field batteries at 27 volts.

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4.4. Environmental Sensors

The CRM-510LP has built-in environmental sensors for measuring temperature, barometric pressure, and relative humidity during a radon test. These sensors have been incorporated in the CRM-510LP to measure environmental parameters that effect the interpretation of short term radon analyses. The variation of these parameters, during a radon analysis, provides information that can be used to judge whether a test has been compromised by environmental conditions. Although the span and scale settings for these sensors are adjusted during manufacturing to agree with precision laboratory instruments, their measurement data should be used as qualitative time varying information only. The MCU reads and processes the information from the environmental sensors every six minutes and saves their hourly averages along with the hourly radon readings

4.4.1. Temperature

Temperature is measured with a thermistor transducer situated inside the CRM-510LP cabinet. The CRM-510LP MCU digitizes and processes the analog signals from the temperature transducer for display in °F or °C.

4.4.2. Barometric Pressure

The barometric pressure is measured with a differential pressure transducer referenced to vacuum. The CRM-510LP MCU digitizes and processes the analog signals from the pressure transducer for display and storage in units of "Hg or kPa. The pressure measured by the CRM-510LP is the actual atmospheric pressure at the test location (station pressure). This will correspond to the "Barometric Pressure" reported by local weather stations, only if your elevation happens to be mean sea level (MSL). If required, the CRM-510LP MCU can be programmed to apply a MSL adjustment to the pressure measurements (See [APPENDIX F](#)).

4.4.3. Relative Humidity

Relative humidity is measured with a capacitance transducer situated inside the CRM-510LP cabinet. The CRM-510LP MCU digitizes and processes the analog signals from the capacitance transducer for display and storage in units of percent relative humidity.

4.5. RS-232C Interface

The CRM-510LP has a built-in RS-232C serial port for interfacing with computers, modems, and other peripheral devices. The serial data output is from pin 22 on the rear 25 pin connector, since this connector also provides a simplified Centronics parallel output. Thus, a standard 25 pin to 9 pin cable available from computer parts stores **WILL NOT WORK**, and a custom cable is required. Contact *femto*-TECH for answers on the use of the RS-232C interface, or see [Appendix F](#) for details.

4.6. Parallel Printer Interface

The CRM-510LP also contains an 8 bit simplified Centronics (Registered trademark of Centronics Corporation) interface on the same DB-25 connector on the back panel. This is useful for connecting to a variety of low cost printers. This may also require a custom cable; see [Appendix F](#) for details of the connector. The parallel interface provides data for printers that use the Epson/Seiko escape sequence printer command set. Other command sets such as for Hewlett-Packard Laserjets and Deskjets or IBM printers will not work. The data printed for the TABLE may not work on

some printers since it only contains printable ASCII characters with each line terminated with a carriage return.

5. Radon Monitoring

5.1. Method

The *femto*-TECH CRM-510LP is a continuous radon monitor (CRM) employing passive diffusion sampling of the ambient air environment in which it is situated. Radon decay products are electrostatically removed and prevented from entering the internal pulsed ion sensing volume. As a radon atom decays within the sensing volume of the chamber, a "burst" of ions is produced and is converted to an electrical pulse in the electrometer. These pulses are counted, stored, and converted to pCi/l or Bq/m³ by the computer/data logger. The CRM must be calibrated in a known radon environment to obtain the conversion factor used to convert to radon concentration.

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5.2. Measurements

Reliable and reproducible measurements of indoor radon levels require considerable care and knowledge and this instrument should be used in accord with the measurement protocols described in the United States Environmental Protection Agency document: EPA 520/1-89-009 (Or any revision to this document).

In addition to the general protocol documentation referenced above, *femto*-TECH, INC. provides instrument specific test procedures for use with their various radon detection instruments. A document titled "INSTRUCTIONS FOR PERFORMING SCREENING-TYPE MEASUREMENTS WITH A CRM-510LP CONTINUOUS RADON MONITOR" is furnished as a supplement to this instruction manual. Additions and revisions to this document or new documents pertinent to the application of the CRM-510LP RADON MONITOR will be sent to registered owners as they are published.

6. Maintenance

6.1. Calibration

The factor relating counts per unit time and radon concentration is a consequence of the structural and electronic design of the CRM-510LP and

only small variations between different production units have been observed. Never-the-less, each unit is compared against a set of "master" units calibrated in a radon chamber at a U.S. Department of Energy Laboratory and the conversion factor verified before shipping. If a user application demands greater accuracy, direct calibration of the unit at a radon chamber facility is required.

To insure continued confidence in the accuracy of your instrument, it is recommended that a calibration be performed at least once a year. *femto*-TECH, INC. provides a maintenance service which includes replacement of all replaceable batteries, any needed electrometer adjustments, and a radon chamber calibration against a "master" unit (call for current price schedules for maintenance, calibration, and background determination service rates).

6.2. Background

The pulsed ion counter detector in the CRM-510LP discriminates against all ionizing radiation other than airborne alpha. Therefore, environmental gamma radiation or intrinsic ions are not sources of background as with most other types of detectors. However, progeny plate-out on the detector surfaces can result in a slow build-up of an alpha radiation background from Polonium-210. This background builds at a rate of approximately 3×10^{-5} CPM per day of exposure at 1 pCi/l radon. Thus, background build-up is insignificant when the CRM-510LP is used in applications where exposures are generally less than 100 pCi/l. However, if the CRM-510LP is used extensively in diagnostic applications where relatively high level radon exposures are common (100 pCi/l or more), the instrument background should be checked after every 1000 hours of use.

Background determinations can be carried out using outdoor air or air supplied from a compressed gas cylinder that has been "aged" for at least thirty days. The "aged" air source is preferred because outdoor air can contain detectable quantities of radon. A background determination can be performed by placing the CRM-510LP in an air tight enclosure or plastic bag. Flow the background gas through the enclosure or bag for at least six hours. Discard the first three hours of data and calculate the average CPM and/or pCi/l for the remaining hours of the test. If the measured background is greater than 0.3 pCi/l, the amount over 0.3 pCi/l should be subtracted from any measurements taken with this instrument. It is advisable to have the detector assembly replaced in any instrument that has a background over 1 pCi/l. Call *femto*-TECH for price schedules on this service.

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6.3. Battery Replacement

The battery packs in the CRM-510LP unit are custom build and are not meant to be user serviceable. Please contact *femto*-TECH for battery replacement.

7. Warranty

femto-TECH, INC. warrants this product to be free of defects in workmanship and materials, and to perform per published specifications for a period of one year from shipping date, providing the unit has been properly stored, handled, and used within the specified environmental limits. This warranty is limited to repair or replacement at *femto*-TECH's option. Buyer assumes responsibility to apply *femto*-TECH, INC. products with due regard to safety where personal injury, death, or property loss is concerned, and *femto*-TECH, INC. and its employees accept no responsibility for these or other consequences. *femto*-TECH, INC. recognizes no other warranty policy than this policy as stated.

8. Repair Policy

If this unit becomes defective due to workmanship or materials at any time within one year of purchase, return this unit to the distributor or dealer from whom the unit was purchased along with proof of purchase (Sales slip, invoice, or receiving slip copy), for repair or replacement. If the unit becomes defective beyond the one year warranty period, or was damaged due to physical abuse or attempts to operate the unit beyond its environmental specification limits, warranty repair or replacement does not apply. However, *femto*-TECH, INC. maintains a repair service which can repair and return your damaged unit in proper operating condition. For current service charges call (937) 746-4427 between the hours of 9 AM and 4 PM (EST), or send email to femtotch@aol.com with a subject line as Service Request, and include the company name, your name, unit serial number, telephone number and email address in the message body.

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APPENDIX A

OPTIONAL DPU-201G THERMAL PRINTER OPERATION

Before using the DPU-201G printer with the *femto*-TECH MODEL CRM-510LP radon monitor, it is recommended that you read pages 1 through 12 of the DPU-201G INSTRUCTION MANUAL. Once you are familiar with the operation of the printer, turn off both the DPU-201G and the CRM-510LP, and connect the two components using the cable supplied with the DPU-201G printer option. The FEMALE DB-25 end of the cable should be connected to the output port on the CRM-510LP and the MALE 14 pin end to the parallel input port on the DPU-201G.

Running DPU-201G Print Software:

1. Make certain the test has ended: turn the keyswitch in the OFF position, and press and release the [PRINT] pushbutton once. The display should read "Software Rev XXX" if the test had previously stopped, or "TEST ENDED!" if had still been running; the unit, in either situation, is now ready to print out.
2. Turn CRM-510LP key switch to the I/O position and press and release the [PRINT] pushbutton once. The number of minutes of stored data is displayed on the LCD screen.
3. Turn printer on.
4. To initiate a printout on the DPU-201G, press the [PRINT] pushbutton once. At this point, the current unit selection is displayed on the LCD screen and the [I/O] key is used to toggle between the unit selections for the printout (pCi/l and Imperial, or Bq/m³ and metric).
5. Press the [PRINT] pushbutton again to execute unit selection. At this point the word "TABLE" is displayed on the LCD screen and the [I/O] pushbutton is used to choose from a menu of printout formats and data review options (Table, Graph, and Review Data).
5. If the [PRINT] pushbutton is pressed while the "REVIEW DATA" message is displayed on the LCD screen, a summary of the collected test data can be reviewed on the screen using the [I/O] pushbutton to step through the different parameters. Press the [PRINT] pushbutton to exit the data review and return to the selection menu of step 4 above.
6. The screen should now display "Print All Data." Press the [PRINT] pushbutton to print the entire test. If open house conditions were encountered at the start of the test, the user has the option of deleting the first twelve hours of the test. Press and release the [I/O] pushbutton, and the screen will display "Skip First 12 Hours." Press the [PRINT] pushbutton to print out the test. The first twelve hours of the test will be printed, but will be marked by double asterisks instead of hours, and NOT calculated in the

final average at the bottom of the printout.

7. At the conclusion of a printout, turn off the power on the printer, and turn the CRM-510LP key switch to the OFF position, before disconnecting the printer.

Examples of both "TABLE" and "GRAPH" format versions of radon test reports from a 42 hour measurement with a CRM-510 are presented in [Figure 1](#) (page 20). In both formats a header is printed with lines for test information to be entered by the operator. The instrument serial number, calibration factor, and background are also printed in the report headers and test summaries of total time, total counts, and average concentration are printed at the end of both report formats. In the "TABLE" format seven columns of hourly data are printed for the radon concentration, the tilt status (/), the low battery warning (LB), the relative humidity, the atmospheric pressure, and the temperature.

The same 42 hour data set printed in "GRAPH" format is shown on the right in Fig. 1. The plot is scaled to provide maximum resolution for each of the plotted parameters. The scale values and a plot key for each of the parameters are printed in the header along the horizontal axis of the graph. Relative humidity and low battery warning are not available in the "GRAPH" format printouts. [Figure 2](#) (page 21) presents a printout of the "Skip First 12 Hours" option (see step 6); [Figure 3](#) (page 23) presents a printout in the Bq/m³ – metric format (see step 4)

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APPENDIX B

OPTIONAL DPU-H245 THERMAL PRINTER OPERATION

Print operation for the DPU-H245 Printer is the same as the DPU-201G. However, the DPU-H245 has the ability to run on either battery power or AC power, whereas the DPU-201G does not have true AC operation; it simply runs on battery power as it is being charged. Special instructions for DPU-H245 charging, battery and AC operations are:

Important Notes on Operating the DPU-H245 Printer



















1. The printer will not operate while in “CHARGE” mode. If the printer battery is low, the AC adaptor may be used as a power supply instead of as a battery charger by simply the adaptor into a wall outlet.
2. To use the adaptor as a battery pack charger, plug the adaptor into a wall outlet. Turn the printer on, and press the “CHARGE” button for about three seconds, then release. The “**ERROR**” and “**POWER**” lights will alternate flashing to indicate charging is in process. When the battery pack is completely charged, the “**ERROR**” light will turn off and the “**POWER**” light will stay on solid. At this point, turn the power switch off.
3. **DO NOT attempt to remove the adaptor connected to the DPU-H245 printer.** The DPU-H245 printer and its adaptor have a reverse polarity and a different voltage than other *femto*-TECH, INC. instruments. Any attempt to use an adaptor from other *femto*-TECH instruments, printer or data loggers will damage this printer, and its adaptor will damage all other *femto*-TECH instruments and printers.

Switch and Lamp Functions

Name	Function
Power Switch	Printer power On / Off
Feed Switch	Paper Feed (Paper is fed while this switch is pressed.)
Charge Switch	The internal battery starts charging when this switch is pressed for 3 seconds when using the AC adaptor.
Power Lamp	Lights when the power is ON (green LED) Blinks when the internal battery level becomes low.
Error Lamp	Lights when the paper cover is open Blinks when there is no paper.

- Test printing.**
Test printing starts when the power switch is set to ON while pressing the FEED switch.
- HEX dump printing.**
The HEX dump mode is entered by setting the power switch to ON while pressing the CHARGE switch. In the HEX dump mode, the input data is printed in hexadecimal.
- Selecting function setting mode.**
The function setting mode is entered by setting the power switch to ON while pressing simultaneously the FEED switch and the CHARGE switch.
- Selecting the charge mode.**
Charging begins when the AC adaptor is connected, the unit power switch is on, and the CHARGE switch is pressed for 3 seconds.
- Lamp status display.**
The following table shows the various LED display statuses. □ indicates ON of a LED for 0.5 seconds. ■ indicated OFF of a LED for 0.5 seconds.

Example: □■■■□■■■ indicates the blinking status of a LED that alternately lights for 0.5 seconds and goes out for 1.5 seconds.

Power switch	Status	LED Status
	No Error (printing enabled)	Power  Error 
	Error (no paper)	Power  Error 
	Error (cover open)	Power  Error 
	Low Battery	Power  Error 
	Hardware Error	Power  Error 
	Charging (returns to original status when charging is completed.)	Power  Error 
	Test print	Power  Error 
	HEX dump print	Power  Error 
	Function setting mode	Power  Error 

OFF	Power OFF	Power ■■■■■■■■■■■■ Error ■■■■■■■■■■■■
------------	------------------	--

< RADON TEST REPORT >

1/0 -----

START DATE 4/05/04

< RADON TEST REPORT >

1/0 -----

START DATE 4/05/04

Fig. 1 EXAMPLE CRM510LP RADON TEST
REPORTS, pCi/l.

< RADON TEST REPORT >

I/O _____
START DATE 4/05/04
START TIME 15:14
OPERATOR _____

SERIAL NO. - CRM5105107
C/F (CPM/pCi/l) .370
BKG (pCi/l) .5

Hr Conc. / RH B/P deg
pCi/l B % Hg F

***	.3	45	29.5	72	
***	1.0	45	29.5	72	
***	.8	45	29.3	72	
***	.1	45	29.3	72	
***	.4	45	29.3	71	
***	.3	45	29.3	70	
***	.6	45	29.2	69	
***	.4	44	29.2	69	
***	.6	44	29.2	69	
***	.4	43	29.2	69	
***	.9	42	29.5	69	
***	.7	42	29.2	69	
13	1.0	41	29.0	69	
14	1.5	41	29.0	69	
15	1.2	41	29.2	69	
16	1.0	41	29.2	69	
17	1.4	40	29.2	69	
18	2.4	41	29.2	69	
19	1.4	42	29.0	69	
20	1.6	43	29.2	69	
21	1.4	43	29.5	70	
22	1.7	44	29.2	70	
23	1.5	44	29.2	71	
24	.4	45	29.2	71	
25	.4	45	29.2	71	
26	.8	46	29.0	72	
27	.0	46	29.0	71	
28	.2	46	29.0	71	
29	.2	46	29.0	71	
30	.0	47	29.0	70	
31	.0	47	28.9	69	
32	.0	47	28.9	69	
33	.0	47	28.9	69	
34	.0	47	28.9	69	
35	.0	47	28.9	69	
36	.1	47	28.9	69	
37	.2	47	29.0	69	
38	.4	47	28.9	69	
39	.6	46	28.9	69	
40	.6	46	28.9	69	
41	.6	46	28.9	69	
42	.9	46	28.9	69	
43	.4	46	29.0	70	
44	.8	47	29.0	70	
45	.2	48	29.0	71	
46	.4	49	29.0	72	
47	.1	49	29.0	72	
48	.0	50	28.7	73	
49	.0	50	28.9	74	
50	.0	50	28.9	74	
51	.0	50	28.9	74	
52	.0	50	28.9	74	
53	.0	50	28.9	74	
54	.0	50	29.0	73	
55	.0	50	28.9	73	
56	.3	50	28.9	72	
57	.4	50	28.9	72	
58	.1	50	28.9	72	
59	.0	50	28.9	71	
60	.5	50	28.7	71	
61	.3	50	28.7	70	
62	.1	50	28.7	70	
63	.0	51	28.7	69	
64	.2	51	28.6	69	

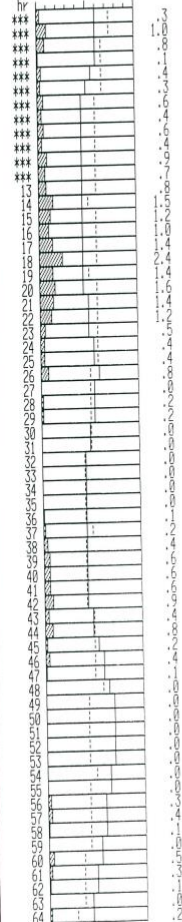
Elapsed Time (min.) 3120
Total Count 1138
Avg. (pCi/l) .4

< RADON TEST REPORT >

I/O _____
START DATE 4/05/04
START TIME 15:14
OPERATOR _____

SERIAL NO. - CRM5105107
C/F (CPM/pCi/l) .370
BKG (pCi/l) .5

--- 28 30 ³Hg
--- 60 80 ²²²Rn
--- 0 10 pCi/l



Elapsed Time (min.) 3120
Total Count 1138
Avg. (pCi/l) .4

Fig. 2 PRINTOUTS OF “SKIP FIRST 12 HOURS” OPTION

< RADON TEST REPORT >

I/O _____

START DATE 4/05/04

START TIME 15:14

OPERATOR _____

SERIAL NO. - CRM5105107
C/F (CPM/Bq/MS) .00010
BKG (Bq/MS) 18

Hr	Conc. Bq/MS	/L B	RH %	B/P kPa	deg C
1	11	45	100	22	
2	38	45	100	22	
3	33	45	99	22	
4	5	45	99	21	
5	16	45	99	21	
6	11	45	99	21	
7	23	45	99	20	
8	15	44	99	20	
9	23	44	99	20	
10	15	43	99	20	
11	36	42	99	20	
12	26	42	99	20	
13	29	41	98	20	
14	57	41	98	20	
15	44	41	99	20	
16	38	41	99	20	
17	54	40	99	20	
18	90	41	99	20	
19	54	42	98	20	
20	61	43	99	21	
21	52	43	99	21	
22	46	44	99	21	
23	55	44	99	21	
24	25	45	99	21	
25	15	45	99	21	
26	29	46	98	22	
27	0	46	98	22	
28	0	46	98	22	
29	0	46	98	21	
30	0	46	98	21	
31	0	47	98	21	
32	0	47	98	20	
33	0	47	98	20	
34	0	47	98	20	
35	0	47	98	20	
36	0	47	98	20	
37	0	47	98	20	
38	0	47	98	20	
39	0	46	98	20	
40	24	46	98	20	
41	24	46	98	20	
42	36	46	98	20	
43	16	47	98	21	
44	33	47	98	21	
45	10	48	98	22	
46	15	49	98	22	
47	15	49	98	22	
48	0	50	99	22	
49	0	50	98	23	
50	0	50	98	23	
51	0	50	98	23	
52	0	50	98	23	
53	0	50	98	22	
54	0	50	98	22	
55	0	50	98	22	
56	11	50	98	22	
57	16	50	98	22	
58	6	50	98	22	
59	0	21	98	21	
60	0	20	97	21	
61	13	20	97	21	
62	5	20	97	20	
63	0	51	97	20	
64	10	51	97	20	

Elapsed Time (min.) 3840
Total Count 1424
Avg. (Bq/MS) 18

< RADON TEST REPORT >

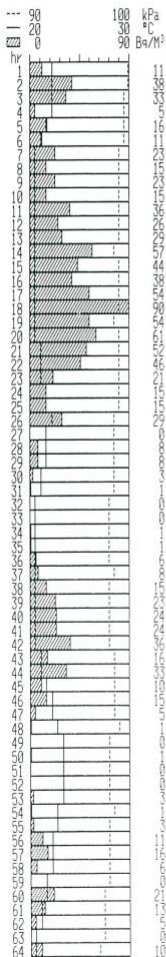
I/O _____

START DATE 4/05/04

START TIME 15:14

OPERATOR _____

SERIAL NO. - CRM5105107
C/F (CPM/Bq/MS) .00010
BKG (Bq/MS) 18



Elapsed Time (min.) 3840
Total Count 1424
Avg. (Bq/MS) 18

Fig. 3 EXAMPLE CRM-510LP RADON TEST
REPORTS, Bq/m³
[\[home\]](#)

< RADON TEST REPORT >

I/O _____

START DATE 4/05/04

START TIME 15:14

OPERATOR _____

SERIAL NO. - CRMS105107
C/F (CPM/Bq/M3) .00010
BKG (Bq/M3) 18

Hr	Conc. Bq/M3	L B %	RH %	B/P kPa	deg C
1	11	45	100	22	
2	38	45	100	22	
3	33	45	99	22	
4	5	45	99	22	
5	16	45	99	21	
6	11	45	99	21	
7	23	45	99	20	
8	15	44	99	20	
9	23	44	99	20	
10	16	43	99	20	
11	26	42	99	20	
12	26	42	99	20	
13	29	41	99	20	
14	57	41	98	20	
15	44	41	99	20	
16	38	41	99	20	
17	54	41	99	20	
18	50	41	99	20	
19	54	42	98	20	
20	51	43	99	20	
21	52	43	99	21	
22	46	44	99	21	
23	21	44	99	21	
24	15	45	99	21	
25	15	45	99	21	
26	26	46	98	21	
27	0	46	98	21	
28	0	46	98	21	
29	0	46	98	21	
30	0	46	98	21	
31	0	47	98	21	
32	0	47	98	20	
33	0	47	98	20	
34	0	47	98	20	
35	0	47	98	20	
36	0	47	98	20	
37	0	47	98	20	
38	15	47	98	20	
39	23	46	98	20	
40	24	46	98	20	
41	24	46	98	20	
42	36	46	98	20	
43	16	46	98	21	
44	33	47	98	21	
45	10	48	98	22	
46	15	49	98	22	
47	5	49	98	22	
48	1	50	99	22	
49	0	50	98	23	
50	0	50	98	23	
51	0	50	98	23	
52	0	50	98	23	
53	0	50	98	23	
54	0	50	98	23	
55	0	50	98	23	
56	11	50	98	22	
57	16	50	98	22	
58	6	50	98	22	
59	0	50	98	21	
60	21	50	97	21	
61	13	50	97	21	
62	5	50	97	20	
63	51	51	97	20	
64	10	51	97	20	

Elapsed Time (min.) 3840
Total Count 1424
Avg. (Bq/M3) 18

< RADON TEST REPORT >

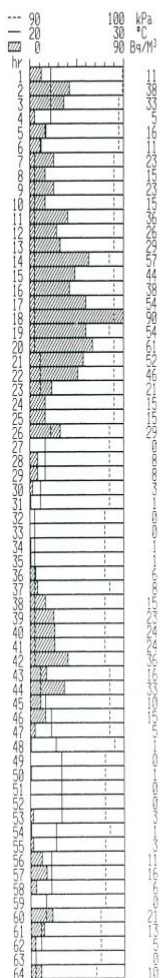
I/O _____

START DATE 4/05/04

START TIME 15:14

OPERATOR _____

SERIAL NO. - CRMS105107
C/F (CPM/Bq/M3) .00010
BKG (Bq/M3) 18



Elapsed Time (min.) 3840
Total Count 1424
Avg. (Bq/M3) 18

Fig. 4 EXAMPLE CRM-510LP RADON TEST REPORTS

APPENDIX C

***femto*-TECH UPLOAD SOFTWARE**

This section provides system requirements, instructions to install this program, a quick description of what it does and quick instructions on how to use the software to retrieve data from a unit. This section can also be found as the ReadMe.txt file on the download software CD.

System Requirements:

This program should install to any Win95 computer or greater with at least 10MB of hard drive space. To communicate with a *femto*-TECH radon monitor you will need an available COM port with the port number in the range of 1 to 4 and the serial cable provided with the unit.

Directions for Software Installation:

Insert the *femto*-TECH download software CD into your computer CD-ROM drive and the setup program should run automatically. If it does not run automatically, use your file browser and surf to the CD-ROM drive that the *femto*-TECH download software is in and double click the setup.exe file.

The setup.exe installation program will guide you through the rest of the process.

After completing the install process, choose your system settings before trying to retrieve any data from a *femto*-TECH radon monitor. To do this, start the program and click the 'View' menu option and then the 'System Settings' option.

Program Operations

The primary purpose of this program is to retrieve data from a *femto*-TECH radon monitor, store the data to your computer, and generate reports for both the technician and the customer. This program also allows the user to regenerate a report using the stored data retrieved from a *femto*-TECH radon monitor.

Each time new data is retrieved from a *femto*-TECH radon monitor, three files are created. The first file is the raw data from the unit stored in a .raw file. The second file is the technician report stored in a .tech file. And the third file is the customer report stored in either a .txt or .doc file depending on which file format you choose in 'System Settings'.

There is an example of each of the files created in the \Reports directory

under the directory the application was stored in. All files, except .doc files viewed by Microsoft Word, can be viewed from a simple text editor such as NotePad.exe. The files are designed to be viewed with courier size 10 font.

Using the Program:

1. **Start Program:**
To start the program, navigate to the program icon in your start menu and click it.
2. **Change System Settings:**
To see or change your system settings, click the 'View' menu option and then click 'System Settings'. Edit the window as needed and click 'Save' to store the data.
3. **Receive Data:**
To retrieve data from a *femto*-TECH radon monitor, click the 'File' menu option and then click 'Receive Data.'
4. The program will next ask you to specify a pathname for the report (i.e., street address, customer name, file number).
5. A **RECEIVE DATA** window will now appear. Turn the CRM510's keyswitch to the I/O position, and press and release the [I/O] button once. The LCD will display:

TIME XX MIN.

Press and release the [I/O] button again, and the LCD will display:

BEGIN UPLOADING,

then display:

USE ALL DATA

Press release the [PRINT] button once, and the **RECEIVE DATA** screen will begin checking off the STATUS column as items are completed. When "Complete!" is finally checkmarked, click on OK, turn the CRM510's keyswitch off, and disconnect it from your computer.

6. **Viewing Data.**
On the *femto*-TECH window, click on the 'View' menu option, and click 'Report Directory.' Three files will have been generated for each test: A RAW file (unformatted data), a TECH file (test data in a viewable table format), and a Word or Wordpad file (a sample report document). If you have a Radon/Carbon Monoxide instrument, three additional files will also be generated for the CO test.

Questions?

If you have any questions, please call *femto*-TECH, INC. at (937) 746-4427 or email to femtotch@aol.com. This information is also listed in the program. To access this information, Click the 'Help' menu option and then click the 'About' option.

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APPENDIX D

OPTIONAL CARBON MONOXIDE DETECTION

The *femto*-TECH, INC. CRM-510LP can include an internal a carbon monoxide sensor. The CRM-510LP reads and stores 15 minute averages for carbon monoxide (CO) levels in addition to the standard hourly radon, barometric pressure, temperature and humidity levels (for up to 79 hours). The data output provides a selection of either the "RADON REPORT" or the "CO REPORT" in either TABLE or GRAPH mode (on a DPU-201G or DPU-H245). Radon and CO levels can be obtained by printing both reports (data for radon and CO are retained until a new test is initiated). The "RADON REPORT" graphs radon, barometric pressure and temperature while the "CO REPORT" graphs CO, barometric pressure and temperature. Humidity results are only available using the "TABLE" output of the reports. A summary of the duration in minutes of the test and the average of the radon or carbon monoxide for the test period is provided at the bottom of the report. [Figure 4](#) (page 23) presents sample CO printouts.

Printing out a CO test on the DPU-201G or DPU-H245 Printer:

1. Follow the first three steps of applying to your specific printer.
2. At this point, the screen will display "RADON REPORT." To print out a radon report, proceed to step 4 of Appendix A.
To print out a CO report, press the [I/O] button once, and the display will change to "CO REPORT." Proceed to step 4, [Appendix A](#).

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APPENDIX E

OPTIONAL MODEM OPERATION

The CRM-510LP can be purchased with software and hardware that provide for uploading data files to a host computer via a telecommunications link. The data transfer link consists of modem driver software and hardware built into the CRM-510LP and a direct connect modem on the upload end of the connection and a "HOST" computer with a modem and communications software on the download end of the connection. All software and hardware required for the upload side of the link is furnished with the *femto*-TECH, INC. CRM-510LP MODEM I/O OPTION. *femto*-TECH, INC. also furnishes "example" download software for use on IBM or IBM compatible personal computers. The user must supply the necessary hardware and communications software to establish a "turnkey" download capability at the "HOST" computer end of the link. However, *femto*-TECH, INC. will furnish source code files for the example programs and technical support to assist users in developing their specific download system.

MODEM I/O MODE (CRM-510 DATA FILE UPLOAD)

Description:

When the optional MODEM I/O software and hardware are installed, a radon test data set can be transmitted via a telecommunications link with nearly the same ease as performing a local printout of data from the CRM-510LP. The built-in communications software performs all the local modem configuration, dialing, connect verification, password/handshake exchange, file transmission, and transmission verification functions with a minimum of operator input required. The CRM-510LP modem driver routines use standard AT command codes and recognize numerical result codes from the modem. Prompting and response messages are displayed on the CRM-510LP LCD at each stage of the communication. If the modem and connecting cable were purchased from *femto*-TECH, INC., two simple connections to the CRM-510LP and the phone line are all that you will need to perform a file upload. The modem must be connected to a private line and should not be connected to a party, call waiting, or coin-operated telephone line. If a user-furnished modem is being used, a special cable adapter must be prepared using the pin-out configuration for your modem and that given in this manual for the CRM-510LP I/O PORT ([APPENDIX E](#)).

Also the MODEM MODE jumpers described in APPENDIX F must be installed on the CRM-510LP side of the cable connector. It is recommended that only individuals with experience in this type of communication hardware attempt to interface a user supplied modem to the CRM-510LP. Moreover, modem manufacturers take certain liberties with the AT and RS-232C conventions which could make it difficult to establish a reliable interface for this application.

MODEM UPLOAD PROCEDURE

With the power off make the interface connections between the CRM-510LP and the modem and insert the modem's telephone cable into a telephone outlet. Once the hardware connections have been made, a file transfer is performed following the procedure described below.

1. Turn the Keyswitch to the I/O position; press and release the [I/O] button once. The LCD will display:

TIME XX MIN.,

2. Press and release the [I/O] button again, and the display will show:

USE ALL DATA

3. Press and release the [PRINT] button to accept this, and

OK

will display, then the preprogrammed phone number will display.

X,XXX-XXX-XXXX

4. Press and release the [I/O] button once, and the modem will dial out. If a connection is made, the LCD will display, in order:

**CONNECT 2400
TRANSMITTING
FILE RECEIVED.**

5. Press and release the [I/O] button one final time, and the LCD will display:

ON HOOK.

6. Turn the keyswitch to the OFF position, then turn off the power to the modem (if applicable).

Note 1. The RESPONSE/ (DISPLAY) sequence shown is for a successful upload session between the CRM-510LP and a HOST computer. If all hardware is operating properly and a successful password/handshake has been accomplished, the HOST computer will verify that it has received the upload file from the CRM-510LP by sending a FILE RECEIVED message.

Note 2. The phone number may be manually changed by the operator. Connect the modem cable to the CRM510LP, and turn the keyswitch to the RUN position. Pressing either button once should wake the unit up. Pressing the [I/O] button will increment a particular digit, and pressing the [PRINT] button will move the cursor to the next digit position.

Note 3. The JOB NO. is incremented each time a new test is started, giving each test a traceable identity.

Note 4. If a successful connection is not accomplished between the CRM-510LP and the modem or the telephone line, a NO DIALTONE or ERROR message will be displayed. Turn off the CRM-510LP, check all hardware connections and restart the upload sequence.

Note 5. The blinking cursor will progress through the digits as the number is dialed. If the HOST computer telephone line is busy, a BUSY message will be displayed. Press the [I/O] key to initiate a redial or press the [PRINT] key to restart an upload sequence from the beginning.

Note 6. An ERROR message indicates a problem in the password/handshake protocol between the CRM-510LP and HOST computer. If a connection can not be successfully made after several tries, check with the host computer operator to determine whether the receive hardware and software are operating properly.

MODEM I/O MODE (DATA FILE DOWNLOAD TO HOST COMPUTER)

Description:

A computer, a 2400 baud rate modem, a direct telephone line, and communication software are required to receive the data files transmitted from a CRM-510LP/MODEM link. Although the user is required to furnish this portion of the telecommunications link, a description of a simple workable system is presented as a guide for the user to develop a custom system. The system described below is based on a commercially available communications software program (ProComm Plus 1.1B by Datastorm Technologies, Inc.) running on an IBM type PC.

The communications software must perform the following tasks:

- 1. Auto answer on ring,**
- 2. Connect on-line at 2400 baud,**
- 3. Interpret password sent from CRM-510LP,**
- 4. Transmit a ready-to-receive file code to the CRM-510LP,**
- 5. Receive ASCII file transmitted from CRM-510LP,**
- 6. Store received file,**

7. Send file-received code to the CRM-510LP, and

8. Go on hook and wait for next call.

A "Script" file is used to command ProComm Plus to perform the above tasks. At the completion of the download sequence, a compiled BASIC program is called to format and save the data set in an ASCII file that can be easily transported to a data base, a spread sheet, a word processor, or another program specific to the reporting and record keeping needs of the

user. The required handshake protocols can best be understood by examining the example programs listed below.

MODEMJ.ASP

MODEMJ.ASP is a "script" file for configuring a host computer for unattended and log-on operations with ProComm Plus 1.1B telecommunications software. This program is specifically designed for the password and file transmission protocol required for downloading data from the *femto*-TECH, INC. CRM510LP Radon Monitor. Most of the modem hardware and/or software parameters can be set at their default values. The terminal option settings used for this application are as follows:

Terminal emulation	VT102
Duplex	FULL
Software flow control (XON/XOFF)	OFF
Hardware flow control (RTS/CTS)	OFF
Line wrap	OFF
Screen scroll	ON
CR translation	CR/LF
BS translation	DESTRUCTIVE
Break Length (milliseconds)	350
Enquiry (ENQ)	OFF
Break Length (milliseconds)	350

CRMJ.EXE (CRMJ.BAS)

This program translates the compressed and encoded data files transmitted from the CRM-510LP and saved in a temporary CRM.LOG file to an ASCII data file. The ASCII data file is saved with a filespec made up of the date and time the CRM-510LP logged on to the system, e.g., 09240930.LOG. The listable source file, CRMJ.BAS, has been included as a reference to the format and sequence requirements for receiving and translating the data stream sent from a CRM-510LP. The telecommunications data stream

sequence sent by the CRM-510LP is nearly identical to that used in the direct link for computer download - the only difference being that the telecommunication transmitted data stream includes an additional JN (JOB NUMBER) variable.

BASRUN.EXE And BASRUN.LIB

These programs are IBM BASIC "runtime" programs required to execute the compiled CRMJ.EXE program.

CRMPTJ.BAS

This is a simple example interpretive BASIC program demonstrating how the ASCII formatted *.LOG files can be utilized. This program functions similar to the DWNLCR.BAS program for computer download. Note: Line 70 will require modification to conform to the directory where your *.LOG files are saved.

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APPENDIX F

SPECIAL FEATURES

The CRM-510LP has special features and capabilities that can be utilized by advanced users. Because most of these features are either accessed through or controlled by the DB-25 I/O CONNECTOR PORT, a complete description of this port is presented below.

CRM-510 I/O PORT (MALE DB-25)

Pin	I/O	Description
1	O	Parallel Port Strobe
2	O	Parallel Data Line D0
3	O	Parallel Data Line D1
4	O	Parallel Data Line D2
5	O	Parallel Data Line D3
6	O	Parallel Data Line D4
7	O	Parallel Data Line D5
8	O	Parallel Data Line D6
9	O	Parallel Data Line D7
10	-	No Connection
11	I	Parallel Port BUSY
12	-	No Connection
13	O	Test*
14	I	Control Code Line (C0)
15	I	Control Code Line (C1)
16	-	No Connection
17	I	Control Code Line (C2)
18	-	No Connection
19	-	No Connection
20	I	RS-232 Receive Data Line
21	I	RS-232 Clear To Send (CS)
22	O	RS-232 Transmit Data Line
23	O	RS-232 Ready To Send (RS)
24	-	No Connection
25	-	No Connection

***The TEST output, pin 13, is used for electrometer evaluation and no user connection should be made to this pin.**

CONTROL CODE SETTINGS

The three control code lines on pins 14, 15, and 17 are internally pulled up to +5VDC so that an open circuit condition is interpreted by the computer as an ON logic state. An OFF logic state is set by connecting the particular pin to the ground pin (16). The computer reads these control code lines on power up and enters the operating mode designated by the setting. The code settings supported at this time are described below.

I/O PORT CODE LINE SETTINGS

C2	C1	C0	Function
1	1	1	Parallel Port Strobe
1	1	0	Parallel Data Line D0
1	0	1	Parallel Data Line D1
1	0	0	Parallel Data Line D2
0	1	1	Parallel Data Line D3
0	1	0	Parallel Data Line D4
0	0	1	Parallel Data Line D5
0	0	0	Parallel Data Line D6

a. In the normal or default operating mode a carriage return is sent after each line of print. If your printer requires both a carriage return and line feed, jumper pin 14(C0) to pin 16(GND) in the printer cable connector that plugs into the CRM-510LP I/O port.

b. If a jumper plug with pins 14(C0) and 15(C1) connected to pin 16(GND) is connected to the CRM-510LP output port, the CALIBRATION FACTOR, BACKGROUND, and PHONE NUMBER ENTER MODE are entered, when the key switch is turned to the RUN position. The present values that are stored in the CRM-510LP EEPROM memory are displayed on the LCD screen. New values are entered into the display by using the [I/O] key to toggle the digit at the blinking cursor to the desired value. The [PRINT] key

is then used to enter the digit selection and advance to the next digit or parameter. When the new values have been entered, turn the key switch to the OFF position and remove the DB-25 jumper plug - the new parameters are now stored in EEPROM and will remain in effect until reset by this procedure.

c. If a jumper plug with pins 14(C0) and 17(C2) connected to pin 16(GND) is connected to the CRM-510LP output port, a forty-eight hour test data set is generated, when the key switch is turned to the I/O position and the [PRINT] button is pressed and released.. This procedure is useful as a quick means of generating a test data set for evaluating printer and download functions.

d. If optional modem hardware and software are installed, this jumper configuration instructs the CRM-510LP to enter the MODEM I/O MODE, when the key switch is turned to the I/O position. Contact *femto-TECH, INC.* for description of MODEM I/O MODE.

e. If an interface cable with the appropriate data lines is used to connect the CRM510LP to a personal computer, a communications application may be used to program the unit in the ALL PARAMETER SETUP MODE. This will ordinarily be done by *femto-TECH* and should not be attempted by the user. Contact *femto-TECH* if more information is desired.

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INSTRUCTIONS FOR PERFORMING SCREENING-TYPE MEASUREMENTS WITH A CRM-510LP CONTINUOUS RADON MONITOR

STANDARD OPERATING PROCEDURES rev-2.0 (1/97)

1.1 Purpose

This instruction provides guidance for using the *femto*-TECH, INC. Model CRM-510LP continuous radon monitor to obtain accurate and reproducible measurements of indoor radon concentrations. Short-term measurements (greater than or equal to 48 hours) made in accordance with these procedures will produce measurements of radon concentration representative of standardized, closed-house conditions. Such measurements of closed-house concentrations have a smaller variability and are more reproducible than measurements made when the house conditions are not controlled.

1.2 Scope

This instruction guidance covers, in general terms, the equipment, procedures, and quality control objectives to be used in performing radon gas measurements in accordance with U.S. Environmental Protection Agency screening measurement protocols.

1.3 Method

The *femto*-TECH Model CRM-510LP is a continuous radon monitor (CRM) employing passive diffusion sampling of the ambient air environment in which it is situated. Radon decay products are electrostatically removed and prevented from entering the internal pulsed ion sensing volume. As a radon atom decays within the sensing volume of the chamber, a "burst" of ions is produced and is converted to an electrical pulse in the electrometer. The pulses are counted, stored, and converted to pCi/l or Bq/m³ by a built-in computer/data logger. All new CRM-510LP instruments are calibrated in a known radon environment to obtain the conversion

factor used to convert to radon concentration. To assure the continued accuracy of the measurements, scheduled calibration checks should be performed during the service life of the instrument (See Section 1.5 for details).

1.4 Equipment and Materials

The following equipment and materials are required to monitor an indoor environment using the *femto*-TECH Model CRM-510LP radon monitor:

1. A *femto*-TECH Model CRM-510LP continuous radon monitor.
2. An operating instruction sheet.
3. A quality assurance plan.
4. An analysis report form.

The following optional equipment may be employed:

1. A parallel input printer with graphics and/or alphanumeric printout.
2. A PC with an RS-232C input port and data transfer software.
3. Appropriate cables for connecting the above equipment to the CRM-510LP output port.

1.5 Pre Deployment Considerations

The measurement should not be made if the occupant is planning remodeling, changes in the heating, ventilating and air conditioning (HVAC) system, or other modifications that may influence the radon concentration during the measurement period.

The CRM should be carefully checked before and after each measurement to:

1. Verify that the CRM-510LP has not sustained any physical damage, since the last calibration or successful operation.
2. Verify that the screen inlet ports are clean and not obstructed.
3. Verify that the calibration is up-to-date.

Participation in a laboratory intercomparison program should be conducted at least once annually to verify that the conversion factor

used by the CRM is accurate. This is done by comparing the unit's response to a known radon concentration. Background count rate determinations should also be performed at least annually or sooner, if the instrument has been exposed to high levels of radon for extended periods of time (see section 1.7.2.1 for details). A calibration and background determination should also be performed after any maintenance or repair work on the instrument.

1.6 Measurement Criteria

Reliable and reproducible measurements of indoor radon levels require considerable care and knowledge and this instrument should be used in accordance with the measurement protocols published by the United States Environmental Protection Agency (EPA 402-R-92-004 and revisions thereof). In accordance with these EPA protocols the following house conditions should exist, prior to and during the measurement.

1. The measurement should be made under closed-house conditions. To the extent reasonable, windows and external doors should be closed (except for normal entrance and exit) for 12 hours prior to and during the measurement period. Normal entrance and exit includes opening and closing of a door, but an external door should not be left open for more than a few minutes. These conditions are expected to exist as normal living conditions during the winter in northern climates. Thus, measurements should be made during winter periods whenever possible.
2. Internal-external air exchange systems (other than a furnace) such as hi-volume attic and window fans should not be operating during the measurement and for at least 12 hours before the measurement is initiated.
3. In southern climates or when the measurements must be made during a warm season, the standardized closed-house conditions are satisfied by meeting the criteria just listed. These criteria can be most conveniently satisfied if the measurement is begun in the morning, after the occupant has been instructed to keep the windows closed during the night and not to open them until the measurement has been completed. Air-conditioning systems that recycle interior air may be operated. The closed-house conditions must be more

rigorously verified and maintained, however, when they are not the normal living conditions.

4. The measurement should not be conducted if severe storms with high winds are predicted during the measurement period. Weather predictions available on local news stations will provide sufficient information to determine if this condition is satisfied.

1.7 Deployment and Operation

1.7.1 Location Selection

The following deployment criteria should be applied to select the location of the Model CRM-510LP within a room.

- 1. Samples should be taken from the lowest livable level in the house -- i.e., a basement, a bedroom or a playroom. Bathrooms, kitchens, laundry rooms, root cellars, garages, crawl spaces or sumps are not suitable.**
- 2. The measurement should not be made near drafts caused by heating, ventilating, and air conditioning (HVAC) vents, doors, windows, and fireplaces.**
- 3. The measurement location should not be close to the outside walls of the house.**
- 4. The unit should be placed on a table or stool so that the air intake is at least 20 inches from the floor (30 inches, where practical).**
- 5. Because the Model CRM-510LP is self contained and not connected to a line power source and is shielded by its metal cabinet, it is generally unaffected by external electromagnetic disturbances. However, since it operates on an ion collection principal and employs an extremely sensitive electrometer, operating near microwave equipment or spark generating equipment, including electric arc welders or fan controllers, should be avoided. Electromagnetic field strength diminishes as the square of the distance from the source and a separation of ten feet or more between the Model CRM-510LP and such a source has been found to be sufficient to eliminate any interference with the radon measurement.**

6. Although extreme design measures have been taken to minimize microphonic sensitivity in the Model CRM-510LP, dropping or placing it in a high vibration environment can produce false counts. Thus, data collected during transport of the monitor should not be used.

7. Operating the Model CRM-510LP outside the specified humidity range (10 to 90% RH) is not recommended, due to the possibility of moisture condensation on the surfaces of sensitive electronic components. If a measurement must be performed under very high (>90% RH) humidity conditions, the condensation can be minimized by heating the Model CRM-510LP cabinet slightly above room temperature. A convenient way to accomplish this is by using radiant heating with a small wattage lamp (15 to 25 watt).

1.7.2 Operation

Operating the Model CRM-510LP is simplicity itself. The instrument panel consists of a key switch, a PRINT push-button, an I/O push-button, a battery indicator LED, and a sixteen character liquid crystal display. A test is initiated by turning the key switch to the RUN position, pressing and releasing the [PRINT] key twice, then pressing both the [PRINT] and [I/O] keys simultaneously. Before the operator leaves the instrument, proper startup should be verified by noting that the elapsed time clock is operating and that counts are being recorded (See CRM-510LP INSTRUCTION MANUAL for details on displaying parameters on the LCD). The CRM-510LP will collect and store hourly data for up to eight days, operating only on its internal battery power. A test is terminated by turning the key switch to the OFF position, and pressing either the [PRINT] or [I/O] button. As long as a new test is not initiated, the collected data are stored in non-volatile memory and can be read out to a printer or another computer as many times as needed.

1.7.2.1 Test Data

Although the built-in computer normally performs all the computations and provides the radon concentration data in pCi/l or Bq/m³, it is advisable for the operator to know how to carry out "hand" calculations. A back-up "hand" calculation should be carried out after entering a new calibration factor or background value to verify their correct entry.

To perform a "hand" calculation, record the number of counts accumulated and the elapsed time shown on the LCD display, convert to counts per minute, and apply the conversion factor (C.F.) and background (BKG) values supplied with the instrument to obtain the radon level in units of pCi/l. The following formula is used for this conversion:

Radon Conc. in pCi/l = (Ending Count – Beginning Count) / [Elapsed Time (in minutes) x C.F.] - BKG

The background subtraction is generally only necessary for radon levels below 10 pCi/l. Background of the Model CRM-510LP has been determined from aged air measurements to be in the range of 0.075 to 0.30 counts per minute. This corresponds to 0.25 to 1 pCi/l for a unit with a nominal 0.3 CPM/pCi/l calibration factor. The background does not vary significantly with time nor from unit to unit, because the pulsed ion counter detector and open grid chamber in the CRM-510LP discriminates against all ionizing radiation other than airborne alpha. Therefore, environmental gamma radiation or intrinsic ions are not sources of background as with most other types of detectors. However, progeny plate-out on the detector surfaces can result in a slow build-up of an alpha radiation background from Polonium-210. This background builds at a rate of approximately 3×10^{-5} CPM per day of exposure at 1 pCi/l radon. Thus, background build-up is insignificant when the Model CRM-510LP is used in screening and survey applications where exposures are generally less than 100 pCi/l. However, if the CRM-510LP is used extensively in diagnostic applications where relatively high level radon exposures are common (1000 pCi/l or more), the instrument background should be checked, after every 100 hours of use.

Background determinations can be carried out using outdoor air or air supplied from a compressed gas cylinder that has been "aged" for at least thirty days. The "aged" air source is preferred, because outdoor air can contain detectable quantities of radon. A background determination can be performed by placing the CRM-510LP in an air tight enclosure or heavy plastic bag. Flow the background gas through the enclosure or bag at a rate of at least one volume exchange per hour. Maintain the flow for at least twelve hours. Discard the first three hours of data and calculate the average CPM and/or pCi/l for the remaining hours of the test. The measured background should be entered into the CRM-510LP computer using the procedure given in APPENDIX B of the CRM-510LP INSTRUCTION MANUAL. It is advisable to have the detector assembly replaced in any instrument that has a background over 1 pCi/l. Call *femto*-TECH for price schedules on this service.

Because of the high sensitivity and fast response time of the CRM-510LP, counts will be obtained in a matter of minutes -- even at radon levels as low as 1 pCi/l. However, to obtain statistically significant data, collection times must be chosen according to the deviation and confidence level required for the measurements. In general, variations due to counting statistics will only be of significance where the CRM-510LP is being used for relative concentration measurements in short-term tracking or control applications. Thus, when using the CRM-510LP in accord with the U.S. EPA recommended survey protocols for performing indoor radon screening and

follow-up measurements, instrument counting statistics will not be limiting on the overall accuracy of the data. However to minimize other sampling errors, it is recommended that an acclimation period in the test environment of at least three hours be used before data collection.

1.8 Documentation

It is important that the operator of the CRM-510LP records enough information about the measurement in a permanent log so that data interpretations and comparisons can be made. This information includes:

- 1. Instrument identification, calibration, and background data.**
- 2. Start and stop times and date of the measurement.**
- 3. Exact location of the instrument, on a diagram of the room and house, if possible.**
- 4. Measured Radon levels**
- 5. Test operator's name.**

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