

Background Mode Pressing the StarKey saves the current background value(s) to be subtracted from future readings in other modes. Background(s) may be captured as many times as desired; only the last value(s) captured will be retained in memory.

Main Display

Measurements are displayed simultaneously in both analog and digital formats on a high-contrast liquid crystal display screen. Both displays show the same information; one is a simulated meter scale which provides a rapid and intuitive indication of trends; the other is a more precise numeric expression of the same data.

Arrowheads at each end of the analog meter scale provide a visual cue when it is necessary for the operator to switch the instrument to the next higher or lower sensitivity range. Automatic range selection is also available, but must be enabled during instrument configuration.

Between these two displays are icons which identify the type(s) of radiation being measured. The possibilities include alpha and beta particles, neutrons, gammas and user-defined energy windows. The available channels, their icons, and the range of energies they cover are defined in probe memory. Refer to section three of this manual for a detailed discussion of this topic.

The lower right corner of the display screen contains a five-digit numeric field, the meaning of which depends upon the selected mode:

Whenever a new probe is connected to the E-600, its model and serial numbers are displayed so that the operator may verify that the instrument has correctly identified the probe and is using the correct parameters.

If the LOG key is pressed, the log point serial number under which the current reading may be saved is displayed.

In check mode, the small numeric display is used to show the probe voltage.

In integrate mode, the time over which the displayed dose has been integrated is shown. Units of seconds, minutes or hours are selected automatically.

In scaler mode, either the remaining count time (if fixed count time mode has been selected) or the current precision (in fixed precision mode) is displayed.

In background mode, the precision of the displayed background is presented as a percentage. This permits the operator to capture background(s) when the desired level of precision has been reached. Indicated precision values are stated with a confidence of $\pm 2\sigma$.

Units and Ranges

Each set of probe parameters specifies one unit of measure; both ratemeter and integrated measurements are expressed in the appropriate forms of that unit. If rate is displayed in counts per second, for example, integrated measurements are displayed in counts. Possible unit selections include:

Ratemeter: Bq, CPS, CPM, DPS, DPM, DPS, Bq, or DPM/100 cm², Sv/sec, Sv/hr, Gy/sec, Gy/hr, R/sec, R/hr, Rem/sec, Rem/hr.

Integrated: Gy, Sv, R, Rem, counts and disintegrations.

These units may be prefixed with an appropriate multiplier, such as:

μ (micro), n (nano), m (milli) or K (kilo).

Under all circumstances, the same base units and range multipliers apply to both the analog and digital displays. As different sensitivity ranges are selected, the number of zeros at the high end of the bargraph change and the decimal point of the numeric display moves as appropriate. Note that the digital display continues to provide accurate information up to twice the range of the meter scale.

It is important to remember that the available multiplier prefixes are spaced three decades apart, and that the displays can also span three decimal places or zeros. It is therefore possible to represent some readings in two ways, such as 1 R or 1000 mR. The operator must understand the interactions between the multipliers and full-scale ranges in order to correctly interpret the displayed readings.

Other Display Icons

Several special-purpose icons along the left side of the display window indicate abnormal conditions such as alarms, detector overrange conditions, low battery voltage, etc.

Audible Indications

The E-600 produces tones of two frequencies, 600 and 2400 Hz, which may be heard either through the built-in speaker or through an optional headset. These tones are used independently for particle clicks or together to indicate other conditions.

Particle clicks may be enabled or disabled by pressing the SPEAKER key on the front panel. When enabled, the lower pitch is used to annunciate events detected in the upper energy window (eg. alpha counts) and the higher pitch annunciates events detected in the lower window (eg. beta counts).

Caution: The maximum click rate for each channel is limited to 75 clicks per second. Do not rely entirely on audible clicks for warnings of dangerous radiation fields!

The two tones are heard in rapid alternation when an alarm threshold (either rate or dose) has been exceeded. Pressing the StarKey will silence the audible alarm, but will not turn off the ALARM icon. The higher-pitched tone is also heard as short pulses when the instrument's range increases or decreases. This is particularly useful when automatic range selection is enabled as a warning to the operator that there has been a significant change in field strength. When configuring the instrument the user may choose to disable the audible indication of range change when automatic range selection is enabled.

SECTION 3

Probes

Smart Probes

Eberline offers a family of "Smart" probes which may be used with the E-600 and other instruments. These probes contain a non-volatile memory which carries information about the probe, including all of its operating parameters. All values which are referred to as being taken from "Probe memory" are in fact read from this device when a smart probe is first connected to the instrument. Parameters are entered into the memory of a smart probe only during calibration, which requires the use of a host computer. It is not possible to alter any probe memory contents from the E-600 control panel.

Up to three probe channels may be stored in probe memory, each of which defines the parameters used to count one or more type(s) of radiation. These three setups may be independent (ie. three user-defined energy windows used to identify three specific isotopes) or they may operate together to define (for example) alpha, beta/gamma and the total of alpha plus beta channels for a single gas-proportional probe. If the three setups are compatible (which requires that they all specify the same probe voltage, discriminator thresholds, calibration constants and display units), counts are simultaneously collected for all channels and the operator may switch freely among them without interrupting the counting process. If different high voltages, thresholds, units or cal constants are required, the accumulated total counts are zeroed whenever the CHANNEL key is pressed. The "HV" indication may flash for a few seconds while the instrument's power supply adjusts to a new setting.

In addition to the probe voltage and thresholds, each setup specifies rate display units, efficiency values used to convert from raw counts to the selected radiological units, and both rate and integrated alarm setpoints. As a setup option, the operator may temporarily edit the alarm levels, if *Alarm Editing* is enabled in the Instrument parameters. Any changes made to these values will NOT be stored in probe memory and will be lost if a different smart probe (as identified by its serial number) is connected to the instrument. Edited values will remain in effect until a different probe is connected to the instrument.

If Alarm Editing is disabled in the Instrument parameters, then whatever alarm settings are stored in the probe will always be used.

Conventional Probes

For operation with conventional probes (ie. those without built-in memories), the E-600 contains internal non-volatile memory of its own in which may be stored one complete set of probe information as described above. Whenever a probe is connected to the instrument via a special conventional probe cable assembly, the setup information from this internal memory is used.

Operation using parameters from internal memory is identical in all respects to that using information from the memory of a smart probe. The same set of three detector channels may be defined in either type of memory, along with other probe data including calibration dates. In neither case may probe parameters be permanently changed by the operator.

CAUTION: It is up to the operator to insure that the conventional probe connected via this cable is indeed the one for which the E-600 has been calibrated. The instrument cannot verify which type of probe is in use or whether the parameters stored in its internal memory are appropriate for that probe. Connecting a different probe may result in inaccurate readings or destruction of the probe due to the application of excessive voltage. If in doubt, leave the E-600 in CHECK mode until the probe identity is verified; high voltage is not applied until one of the measurement modes is selected.

Changing Probes

Whenever a probe is initially connected to the instrument, or when the unit is first powered on, the probe model and serial numbers are shown briefly in the lower right corner of the display window. The operator may compare this information against the probe's actual model and serial numbers to verify that the E-600 has correctly identified the probe. If these numbers contain alpha characters which cannot be represented on the numeric display, they will be replaced with dashes. Pressing the STAR key bypasses this display sequence.

Probe memory also carries the due date for probe calibration. If an out-of-calibration probe is connected to the instrument, the message "PROBE OUT OF CAL" is shown and the instrument will not operate. This feature may be defeated during instrument configuration, enabling the operator to ignore calibration dates. In this situation, pressing the STAR key will permit operation past the probe's calibration due date, however the warning message will remain on.

Crossover Correction

When using the E-600 with all alpha/beta probes there is both an alpha-to-beta channel crossover component (alpha radiation which shows up in the beta channel) and a beta-to-alpha channel crossover component (beta radiation which shows up in the alpha channel) which is always present at some level. The existence of this crossover can lead to a misinterpretation of readings. The E-600's reading is most confusing when one displays the beta channel while monitoring an alpha source. Alpha-to-beta crossover can lead one to believe that beta contamination exists where none is present.

The crossover component can be reduced by applying a software correction. To do so, each channel in the E-600 (e.g. alpha, beta alpha/beta) contains crossover correction factors for each of its two windows. These correction factors are included in the probe channel parameters and may be edited using the Windows E-600 interface software. See the Windows E-600 software manual for more information.

The following method of crossover correction has been implemented to prevent falsely enhancing the beta measurement when the alpha signal is creating noise in the beta channel.

$$\text{Corrected Net } \alpha \text{ Rate} = (\text{Net } \alpha \text{ Rate} - (\text{Lower to Upper Crossover} \times \text{Net } \beta \text{ Rate}))$$

$$\text{Corrected Net } \beta \text{ Rate} = (\text{Net } \beta \text{ Rate} - (\text{Lower to Upper Crossover} \times \text{Net } \alpha \text{ Rate}))$$

A calibration routine included in the Windows E-600 software can be used to determine the appropriate crossover factors for a particular probe. See the Windows E-600 software manual for more information.

SECTION 4

Check Mode

Power-On Diagnostics

When the E-600 is initially powered on, the instrument performs a number of internal self-tests. These are invisible to the user and no test results are displayed. If any of the tests fail, the unit simply indicates "FAIL" and refuse to operate.

One of the diagnostic checks is a comparison of the instrument's calibration due date (stored in configuration memory) against the present date. If the due date has passed, an OUT OF CAL message will be displayed. Depending upon the option selected at configuration, this may either prevent any further operation or the operator may be permitted to continue by pressing the STAR key. In this case, the above message will remain on the display until the unit is re-calibrated.

Once the instrument has verified its own integrity, it will read probe parameters from either the probe (if it is a smart probe) or from internal non-volatile memory. The probe parameters (including calibration due date) will be checked as if the probe had just been connected to the unit.

Display Screens

When CHECK mode is first entered, whether through the power-on sequence or by switching from another mode, the first information displayed is battery status. The BATTERY icon is turned on to identify the display and voltage is presented as a percentage on both the analog meter scale and the small numeric display. A reading of 100% indicates a new set of batteries; 0% means that there is little or no energy available. Note that batteries are temperature sensitive; even new cells may read less than 100% if they are very cold. Some brands of alkaline or carbon cells may produce less than 1.5 Volts, even when new. These will also indicate less than 100%.

Note: Nickel-Cadmium cells have a nominal output voltage of approximately 1.2-1.3 Volts per cell during most of their useful life. For this reason, they will never give a reading of

100%, even when fully charged. Avoid operating NiCad cells after they reach 0% on the display; doing so may damage the batteries.

Pressing the CHANNEL key will advance to the next display, which shows the first defined probe setup. If additional setups are available, they may be viewed in sequence by repeatedly pressing CHANNEL. Each setup is identified by the icon(s) for the activity type(s) it measures, and the probe voltage for that setup is shown in the lower right corner of the display.

The current alarm setpoint for the selected setup is presented on the large numeric display, expressed in the appropriate units. If enabled (under instrument parameters) the alarm setpoint may be edited with the RANGE UP and RANGE DOWN keys. As described in the previous section, edited values will remain in effect until a different probe is connected to the instrument but are not stored in probe memory. If both rate and integration alarm setpoints are defined for the probe, the user may switch back and forth between these two values by pressing the STAR key. Note that the type of setpoint (rate or integrated) selected is identified by the units in which they are displayed.

Note: Setting the rate alarm setpoint to zero disables alarm checking for all modes that are computing a rate. Similarly, setting the integration alarm setpoint to zero disables alarm checking for all modes that are computing dose.

If a background count rate has been stored for the channel being displayed, it may be viewed by pressing the GROSS/NET button.

If an ion chamber type probe, such as an SHP-400 is connected, pressing CHANNEL again will allow access to a calibration routine that allows the user to determine the zero frequency of the probe. Refer to the SHP-400 Technical Manual for more information.

Pressing CHANNEL again will display the instrument's network address, which may be edited with the RANGE UP and RANGE DOWN keys. This parameter is used when multiple instruments are connected in a network as area monitors; if this use is not anticipated, the value is unimportant.

Note: All E-600s will respond to commands sent to address zero. This makes it easy to communicate with a single instrument connected to a computer. If an E-600 with this address is ever included in a network, however, all others in the net will attempt to respond to messages intended for that one.

After all of the above screens have been viewed, pressing the CHANNEL key will turn on all display segments for inspection.

Pressing the LOG key in CHECK mode will display the next available log point number. If this number is not equal to one, the instrument's memory contains data which may need to be read out. Press STAR to exit this display.

SECTION 5

Operating Modes

Ratemeter Mode

In this mode the E-600 operates as a basic ratemeter. Results are displayed in the units specified in probe memory, which may be simply counts per unit time or, if the probe has been appropriately calibrated, source activity or exposure rate. The rate alarm limit, which is also read from probe memory, is used in this mode. If *Alarm Editing* is enabled in the Instrument parameters, then the alarm levels may be temporarily changed from the E-600 keypad in Check mode. Any changes made to these values will NOT be stored in probe memory and will be lost if a different smart probe (as identified by its serial number) is connected to the instrument. If Alarm Editing is disabled in the instrument parameters, then the alarm levels stored in the probe will always be used and cannot be altered from the E-600.

If multiple channel setups are defined in probe memory, the CHANNEL key may be used to switch among them. If the available channels are compatible (ie. if they use the same probe voltage, discriminator threshold settings, cal constants and display units), the change will be immediate and smooth. If changes in high voltage or threshold settings are required, there will be a momentary discontinuity while the new voltages settle and the selected response time constant is applied to the new readings.

During instrument configuration, the StarKey may be assigned either of two functions in ratemeter mode. The first is to immediately display the currently measured instantaneous rate, bypassing the normal time constant calculations. Alternatively, it may initiate a fixed-time or fixed precision count cycle depending on the chosen scaler count mode to obtain a rate measurement of known precision. This option is particularly useful when the instrument is used for frisking; it provides a convenient means for accurately characterizing an area which attracts attention during a rapid scan. Pressing the StarKey a second time will return the E-600 to normal ratemeter mode.

As in all modes, if an alarm is sounding, the first press of the StarKey will silence the audible alarm. Thereafter, the key will revert to its normal function.

Integrate Mode

An integrated measurement (eg. counts, R, Sv or disintegrations) is acquired in this operating mode, starting at zero when integrate mode is first selected. If the integrate alarm limit specified in probe memory is exceeded, an alarm indication is posted. As always, the StarKey may be used to silence the audible alarm. If *Alarm Editing* is enabled in the Instrument parameters, then the alarm levels may be temporarily changed from the E-600 keypad in Check mode. Any changes made to these values will NOT be stored in probe memory and will be lost if a different smart probe (as identified by its serial number) is connected to the instrument. If Alarm Editing is disabled in the instrument parameters, then the alarm levels stored in the probe will always be used and cannot be altered from the E-600.

In this mode, the numeric field in the lower right corner of the display window is used to show the total time over which the integrated counts, disintegrations or dose have been accumulated. Units of seconds, minutes or hours will be selected automatically.

If all of the defined probe channel setups are compatible, the user may switch among them without interrupting the integration process. In this situation, all channels are counted continuously, and the CHANNEL key merely selects which is displayed. If the defined setups are not compatible, selecting a new channel will reset the accumulated dose to zero and begin a fresh integration process once the probe voltage and thresholds have stabilized.

As a configuration option, the StarKey may be defined to perform either of two functions in integrate mode. The first is simply to reset the integrated value and running time to zero. The second available StarKey function is to provide a temporary ratemeter readout without exiting from integrate mode. This alternate display will last only while the key is held down, and integration will continue without interruption or loss of data.

Scaler Mode

In this operating mode, the StarKey is used to initiate a timed count cycle. Depending upon the option selected during instrument configuration, the results of this count may be displayed either as total counts or dose, or as activity or count rate averaged over the count time. In either case, the applicable alarm limit from probe memory will be used to determine whether an alarm is posted.

As a second configuration option, the scaler mode count time may be specified as a fixed interval, or else a required measurement precision may be entered. In the latter case, the E-600 will count until the specified precision is attained. In fixed

current measurement precision will be displayed as counts are accumulated. The confidence level of displayed precision values is $\pm 2\sigma$.

If the defined probe channels are compatible, pressing the CHANNEL key after a count has completed will display the scaler count totals for the next channel. If the channels use different high voltages or thresholds, pressing CHANNEL will step to the next defined channel and, after a delay to permit the voltages to settle, start a new scaler count.

Peak-Trap Mode

This is identical to ratemeter mode, however the highest measured rate is held on the display until manually reset by pressing the StarKey. The units and alarm limit specified in probe memory for ratemeter mode are also used in peak-trap.

SECTION 6

Background Mode

Gross/Net Display Selection

In any of its four operating modes, the E-600 offers the option of background subtraction. This feature is toggled on or off by pressing the GROSS/NET key on the front panel; the "NET" icon on the display is turned on whenever background is being subtracted. Alarm setpoints reference the displayed reading, regardless of whether that value is gross or net. Background mode must be enabled (during instrument configuration) to permit the display of net measurements.

Note that background values are stored in non-volatile memory, and will therefore be retained even after the instrument has been turned off. This permits the user to take a background reading in a location far from any contamination, then use that background to obtain true net counts for as long as desired. Background values will be zeroed only when a new detector is connected to the E-600.

Note: Gross/Net mode for the SHP-400 is treated differently and is explained in detail in the SHP-400 Technical Manual.

Accumulating Background Values

When switched into background mode, the E-600 begins counting background. The value displayed in this mode is simply a long-term average of counts per unit time, and is not computed with the same response time algorithm used in rate mode. While the large numeric display and bargraph show count or dose rate, the small numbers in the lower right corner of the display window show the precision of this rate value. When the precision reaches an acceptable level, the user may capture the displayed rate value by pressing the STAR key. The last value captured before exiting background mode will be used for future net rates.

Note: Refer to the SHP-400 Technical Manual for information on accumulating background values for the SHP-400 probe.

If the defined probe channel setups are compatible, as will generally be the case with energy-proportional probes, all channels will be counted simultaneously in background mode, and a value will be stored for each when the STAR key is pressed. If the probe channels require different high voltage, threshold settings, calibration constants or display units, only the background for the currently displayed channel will be stored.

SECTION 7

Data Logging

How to Log a Data Point

In any of the four operating modes (ratemeter, integrate, peak-trap and scaler), the user may invoke the data logging function by pressing the LOG key. The display will immediately be frozen to permit the operator to verify that it is indeed the value he wishes to record, or to enter a location identifier via a barcode reader. The small numeric display will, at this time, display the log point number under which the data will be stored. At this point, the Range Up and Range Down keys may be used to edit the log point number, if desired.

If the displayed measurement value is acceptable, and the log ID Source has been set to internal/Aux or Internal only, pressing LOG again will store the date, time, instrument and probe serial numbers, reading and location code (if any). Measurement units, operating mode, channel type and gross/net reading information are also saved for each log point. Pressing the STAR key or waiting for fifteen seconds will cause the instrument to return to normal operation. Note that this feature may also be used to hold the display while readings are manually copied.

As an instrument configuration option, the user may choose the means of identifying log data points. Selecting internal ID mode means that the log data will be identified by the log point number displayed on the small numeric display when the LOG key is pressed. Selecting auxiliary ID mode means that a barcode reader input will be used to identify the log data. Using the Windows E-600 interface program, the LOG ID source may be selected as Internal/Aux, Internal only or Aux only. Internal/Aux allows internal or auxiliary ID mode, Internal only allows internal ID mode, and Aux only allows Auxiliary (bar code) ID mode. If the instrument log ID Source is configured as internal only and the user attempts to use a barcode reader, the display will remain frozen for 15 seconds or until the STAR key is pressed. No data is logged. This also happens when the instrument Log ID is configured as Aux only and the user attempts to complete a log cycle by pressing the LOG key a second time.

Barcode Inputs

If a barcode reader is connected to the E-600, and the log ID Source has been set to Internal/Aux or Aux only, it may be used to input location identifiers which will be saved along with measurement results. Successfully reading a location code will also complete the logging operation and store the reading to memory, eliminating the need to press the LOG key a second time.

Data Retrieval and Display

Measurement data from the E-600's log memory is read out by connecting the instrument to a host computer on which the interface program is running. Details of this process are included in the software manual and the on-line help functions included in the interface program itself.

SECTION 8

Troubleshooting

Low Battery

The E-600 is powered by three alkaline "C" batteries, which start out at a nominal 4.5 Volts when new. Operation will continue until this voltage falls to about 3.0 Volts. The battery icon on the display will come on when the batteries fall below 3.15 Volts, and will begin to flash at 3.08 Volts. Because batteries degrade rapidly once they fall below approximately 60% of their initial voltage, it is advisable to replace them soon after the battery icon first appears. Dead batteries may also leak; remove them from the instrument to prevent corrosion.

Battery life is significantly decreased at low temperatures. Cells which give a mid-scale voltage reading in a warm building may fail rapidly if the instrument is then operated outdoors in winter.

Out of Calibration

When the E-600 is first powered on, the calibration due date stored in its memory is compared against the current date. If the instrument is past due for calibration, the Out of Calibration icon is turned on and normal operation is inhibited. If enabled (as a configuration option), the user may bypass this indication and use the instrument by pressing the STAR key while in check mode.

In a similar manner, the probe's calibration due date is checked when the E-600 is powered on or when a new probe is connected. The ability to continue operation with an out-of-calibration probe by pressing the STAR key is also a configuration option.

Probe Failures

If no probe is connected to the E-600, it will display a "PROBE FAIL" message. This indication is also given when the memory contained within a "Smart" probe is not readable, or if its contents do not appear valid. Specific problems which may result in this indication include probe memory failure, broken wires or poor connections in the probe cable, or damage to the components within the instrument which communicate with the probe connector.

High Voltage Failures

This message is displayed when the instrument's high voltage power supply goes out of tolerance. It is most often caused by a shorted probe which loads the supply beyond its capacity. If the same failure is indicated with different probes, it is probable that a component within the supply has actually failed.

If probe memory contains definitions for channels with different high voltage settings, an indication of "HV" may be displayed briefly when the CHANNEL key is pressed. This is normal and simply indicates that the high voltage supply has not yet stabilized at its new voltage setting.

Instrument Failures

If the 'Fail' icon alone is displayed, the E-600 has detected an internal component fault which prevents normal operation or a situation which the software cannot correctly handle. The most common cause of this 'failure' is an invalid setting of the clock/calendar circuit used for timestamping logged data and verifying calibration dates. Before returning the instrument for service, use the interface program to re-initialize the instrument's clock.

SECTION 9

Instrument Configuration

Purpose

In the design of an instrument such as the E-600, versatility must be traded off against simplicity and ease of use. Adding more controls increases the number of instrument parameters which may be adjusted and hence the range of functions which the unit can perform. Doing so, however, complicates operation and invites operator errors. The opposite design philosophy results in instruments which require less skill, attention and understanding to operate, but which support only a small number of applications.

The E-600 strikes a balance between these two extremes by including a wide range of capabilities, but omitting some of the physical controls used to select and adjust them. Instead, these options are selected before the instrument is placed in service, during the configuration procedure. In effect, configuration permits the 'design' of a 'custom' instrument with just the correct set of features for the application in which it will be used and the operator who will use it.

The E-600 Interface Program

Configuration, calibration and other E-600 utilities are performed by a program which runs under Microsoft Windows® on an IBM®-compatible personal computer. The functions provided by this software include configuration options such as the available operating modes and StarKey definitions. In addition, parameters for one "Dumb" probe may be loaded into the instrument's memory.

Other utilities in the same software package permit calibration of both the E-600 and any "Smart" probe connected to it, retrieval and display of measurement data from the instrument's log memory, and a number of utilities for testing both instruments and probes. A detailed manual is provided with this software.