

CS725

Snow Water Equivalency Sensor



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Cautions / Safety Notes

- If you are unable to determine that your structure or mounting method is suitable for the CS725 sensor, please contact an expert or professional who can assist you in determining the structural mounting requirements for your installation of the CS725.
- The CS725 is sensitive to shock vibrations over 5G. Therefore, sufficiently pack the sensor before transporting it and properly handle the sensor during installation.
- Always ensure that the collimator is secured to the structure with the long safety cable.
- Do not disassemble the CS725 without consulting the factory first. The CS725 contains a fine bead-like insulation material called Aerogel Nanogel. The material is manufactured by Cabot Corporation. Proper MSDS sheets and instructions should be obtained prior to opening the CS725.
- The collimator is heavy and proper handling procedures need to be followed when handling the part.
- Never force the connector on to the CS725. If the connector does not easily fit into place then it is likely misaligned.

Abbreviations/Syntax

- | | |
|-----------------|---|
| K | The Element Potassium |
| SWE | Snow Water Equivalency |
| Tl | The Element Thallium |
| [] | Square brackets identify a typed command. The content inside the brackets is what is sent or typed and the brackets are excluded. |
| <> | Denotes a special key for example <Enter> represents the Enter Key. |

CS725 Snow Water Equivalency Sensor

1. Introduction

The CS725 sensor is primarily designed to measure the SWE (Snow Water Equivalency) in a snow pack.

The CS725 obtains a measurement by passively monitoring the attenuation of naturally existing electromagnetic radiation, due to the presence of potassium and thallium. As snow accumulates on top of the ground, the CS725 measures a decrease in the normal background radiation levels. The higher the water content, the higher the attenuation of the radiation.

The CS725 has several characteristics that make it an excellent sensor for SWE measurement applications.

- The sensor is non-contact. It is installed simply by mounting it above the snow surface.
- The measurement is passive.
- Its performance is not affected by adverse weather conditions.
- The sensor measurement covers a large surface area. Typically 50 to 100 m² (538 to 1076 ft²) when mounted 3.0 m above the ground.
- It is effective with any type of snow or ice.

Proper operation of the CS725 is dependent on suitable amounts of potassium (K) and thallium (Tl) being present in the ground. Since the radiation levels will vary from site to site, the CS725 performance can also be site specific.*

*No special licenses or precautions are required to install or operate the CS725.

2. Specifications

Power Requirements:	11 to 15 VDC
Power Consumption:	180 mA
Measurement Time:	Continuous, 24 hours/day
Output Format:	RS-232 (1200 to 115200 bps) Default is 9600 bps
Measurement Range:	0 to 600 mm (0 to 23.6 in) of water equivalency
Accuracy:	±15 mm (±0.6 in) for 0 to 300 mm (0 to 11.8 in) ±15% at 300 to 600 mm (11.8 to 23.6 in)
Resolution:	1 mm (0.004 in)

Coverage Beam Angle: 60°
Operating Temperature: -40° to +40°C
Maximum Cable Length: 30 m (95 ft) (9600 bps or less)
Cable Type: 4 conductor, 2-twisted pair,
 22 AWG, Santoprene jacket

**Dimensions
 (Without Collimator)**

Length: 62 cm (24.4 in)
Diameter: 12.7 cm (5 in)

Weight

Main Body: 9.0 kg (20 lbs)
Collimator: 25 kg (55 lbs)
Total: 34 kg (75 lbs)

3. Wiring

The wiring for the CS725 connector-cable assembly is as follows:

Color	Function	Connection
Black	Power Ground	System Ground and/or RS-232 Receiver Ground (Pin 5 of a computer (DTE) DB-9 connector)
Red	+12VDC Power	Power Source
Green	RS-232 (Sensor Output)	Recorder/Reader RS-232 Input (Pin 2 of a computer (DTE) DB-9 connector)
White	RS-232 (Sensor Input)	Recorder/Reader RS-232 Output (Pin 3 of a computer (DTE) DB-9 connector)
Clear	Shield	Shield/Earth Ground

4. Connecting the CS725 to a Computer

The CS725 can communicate directly to a computer using a terminal program such as Hyperterminal. To provide a DB9 connection between the CS725 and a computer RS-232 port, the DB9F-TERM interface PCB is used. The DB9F-TERM is shipped with the CS725. The following diagram demonstrates how to connect the CS725 to the DB9F-TERM.

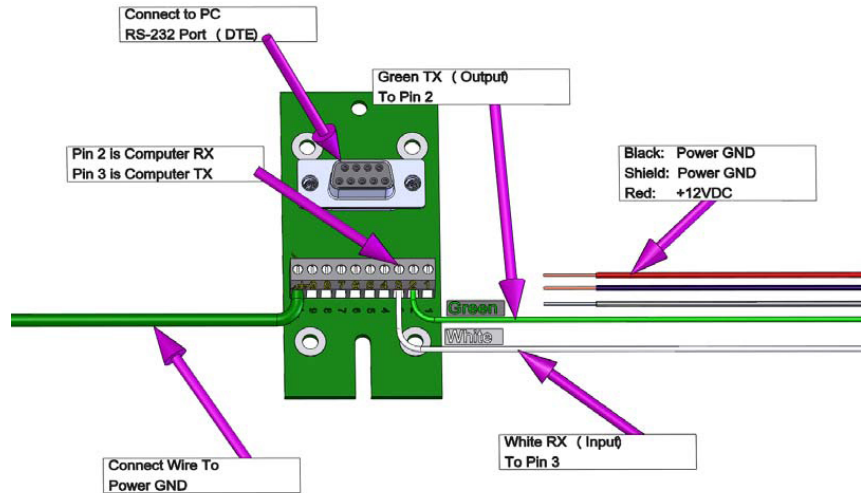


FIGURE 4-1. CS725 connection to DB9F-TERM

When connecting the CS725 to a computer, a power source is required to power the CS725. A good quality regulated +12 VDC power source should be used such as a bench power supply or a +12 VDC battery. It is recommended to disconnect the cable from the CS725 while terminating the cable connections. After the connections are verified, the connector can be reconnected to the CS725.

5. Terminal Setup for RS-232 Communications

The following are the settings required for the terminal program to communicate with the CS725. Typical programs include Hyperterminal or Procomm.

Baud Rate:	9600 (Default)
Data Bits:	8
Parity:	None
Stop Bits:	1
Flow Control:	None
Local Echo:	Enabled
Terminal Mode:	ANSI
Send Line Ends with Line Feeds:	Disabled

When the power is applied to the CS725 or the connector is plugged in, the CS725 will output the following message on the RS-232 port on power up:

GMONIII Scionix 3x3 V4f_13u SN: 9999

Where:

GMONIII: Is the original sensor Identifier (now known as CS725)

Scionix 3x3: Is the Gamma Detector Type

V4f_13u: Is the Firmware Software Revision

SN: 9999 Is the sensor serial number

6. Communicating with the CS725

6.1 General

Immediately after power on, the CS725 will default to a baud rate defined by the “DefaultBaudRate” parameter. This is normally 9600 bps and it is recommended to leave the setting at 9600 bps.

The escape key resets the current command line being entered into the CS725. If you are communicating with the CS725 using another intelligent device, the commands should be preceded with the ESC character to ensure more reliable operation.

The commands to the CS725 are case sensitive.

All commands are terminated by the enter key or <CR> character.

6.2 Auto Baud Rate Detection

If the terminal speed does not match the CS725 baud rate, the startup message will either be absent or garbled. The CS725 does support an Auto Baud Rate Detection feature. In order to synchronize the CS725 with the terminal, one can type the letter ‘U’ in uppercase followed by a period “.” and a carriage return. This will trigger the auto-baud system, and the CS725 will adjust its baud rate to the baud rate of the terminal. The period “.” followed by a carriage return (CR) launches the Main menu once the baud rates are synchronized.

NOTE Any changes to the CS725 baud rate must be accounted for in the data logger program.

6.3 Main CS725 Menu

The Main menu can be prompted by sending a period “.” followed by the enter key

.<Enter>

The menus can be switched between English and French. To change the language setting, key the command `.L<Enter>`. This will allow the selection of either English or French. The English version of the Main menu is as follows:

*** LIST OF COMMANDS ****

[.l] Language (French or English)
 [.h] Read the current live histogram
 [.hp] Display the K and TI peak positions from the live histogram
 [.hl] Display the current histogram in log scale
 [.hr] Display results after completion of a manual measurement (histogram, position and #counts K and TI).
 [.e] Same as <h> command , but erases histogram at end of operation
 [.a] Special command: define start/stop time limits for one measurement
 [.t] Display temperature data in °C
 [.d] Display date and time
 [.dd] Modify date and time
 [.hd] Read back histograms from EPROM according to selected dates
 [.f] Read back measurement results from EPROM according to dates
 [.fl] Read back the current day measurement results
 [.flla] Read back last calculated line result
 [.fs] Read back calculated line result in short form ? (Time and EENS only)
 [.p] Display Parameter menu
 [.s] Display status and current measurement information
 [.0xps] Parameters save to file function
 [.0xpr] Parameters recovery from file function
 [%Rhard]/[%Rboot] Restart software processor/reboot firmware
 [UU] CS725/terminal synchronizing sequence for rates other than 9600 bps

6.4 Detailed Main Menu Command Information

1. [.l]

The [.l] command is used to set the language setting to either French or English.

The following menu is activated once the [.l] command is received:

```
[0] Francais
[1] English
```

Type the number 0 for French or the number 1 for English followed by <Enter>.

2. [.h]

The [.h] command is used to obtain the current histogram results. This information would normally be used for diagnostics or by a user who requires an analysis of the gamma radiation spectrum. The counts for 1024 bin values are returned in this command. The format is as follows:

```
12<CR><LF> This line represents the counts for BIN#1
345<CR><LF> This line represents the counts for BIN#2
333<CR><LF> This line represents the counts for BIN#3
.
.
.
30<CR><LF> This line represents the counts for BIN#1024
```

3. [.hp]

The [.hp] command is used to obtain the current bin positions for the Tl and K peaks. In general the Tl peak should be near 438 and the K peak should be near 245. It is important for the software to find the peaks properly in order to obtain proper SWE measurements.

In most cases, the sensor must be monitoring for at least two minutes. It may take as long as a full hour if the radiation counts are very low.

Once the command is typed, the following is immediately displayed:

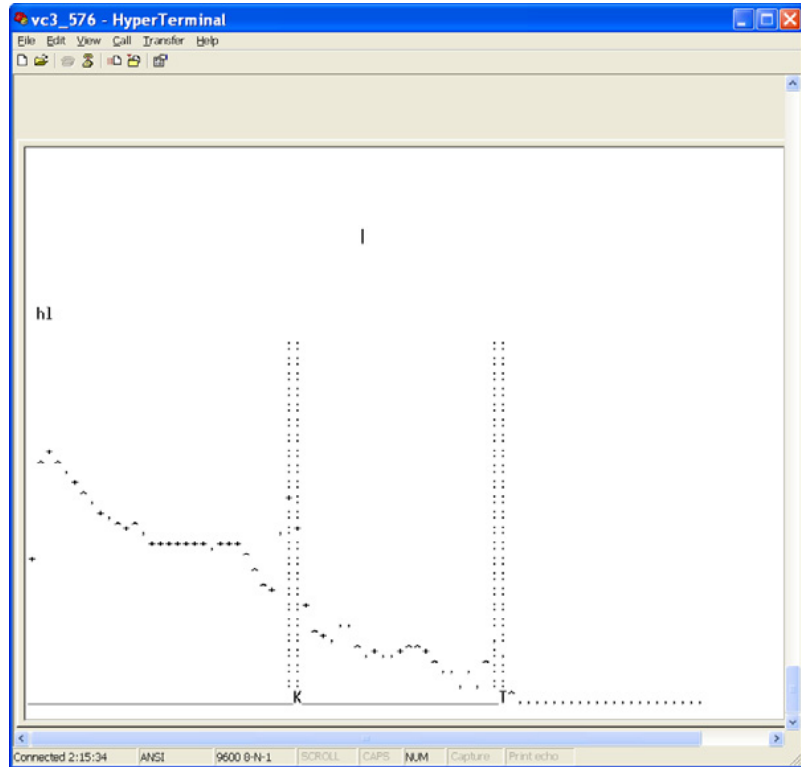
This operation may take 1-2 minutes

Once the calculation has been completed, the values are displayed. Even under ideal conditions, the values are allowed to vary from the target values. If the value does vary by more than 30 BINS, then there may be issues with the sensor finding the proper peaks. The displayed values are formatted as follows:

Tl (nom = 438)	K (nom = 245)
435.4	244.7

4. [.hl]

The [.hl] command is used to obtain a graphical representation of the current histogram results. This information would normally be used for diagnostics or by a user who requires an analysis of the gamma radiation spectrum. The command produces a log scale graph as follows:



5. [.hr]

The [.hr] command is used to verify radiation counts in manual mode. The [.hr] command would normally be used in the process of qualifying a site for adequate background radiation counts and is used in conjunction with the [.a] command. See the [.a] command for details.

Please note that the [.hr] command can take several minutes to complete. When the command is entered, the [.hr] command will immediately report the duration of the current manual count time as follows:

```
-Elapsed time,current histo : 00:03:59 (HH:MM:SS)
Wait for the calculation to complete...
```

There will then be a pause that can take several minutes. After the pause, a histogram will be output followed by the radiation count summary. The summary will report three lines; the duration of the counting, the position of the potassium peak and its processed count value, the position of the thallium peak and its processed count value. The output format after the histogram is as follows:

-Elapsed time,current histo : 00:03:59

Pos K = 240.4; Pos Tl = 427.5;

Cnt K = 003679.8; Cnt Tl = 000088.3;

6. [.a]

The [.a] command is used to set the start and stop times for a specified measurement interval. This command could be used in the process to qualify a site for appropriate amounts of background radiation.

This parameter is only made use of when the CS725 is in the manual mode. The CS725 is placed in in the manual mode by entering the Parameter menu [.p] and set parameter 19 to 1 for manual mode.

Once the parameter is set (the setting will be saved automatically), use the .a command to specify the delay and duration in seconds. For qualifying a site, it is recommended that the sensor be setup in the desired location and the delay of 5 be used with a duration of 3600 seconds (1 hour) as a minimum. The example below shows the syntax for the recommended delay and duration for the manual measurement:

(Delay should be larger or equal to 5s)
 Format =>Delay Duration
 =>5 3600<Enter>

After completion, the [.hr] command can then be used to view the results in detail. If the CS725 is placed in Auto or HCalib mode, the following message will be printed:

This function should be called in manual mode only.

7. [.t]

The [.t] command is used to read the internal temperature sensor of the CS725 (degrees Celsius). This feature is mainly used for diagnostics to apply temperature compensations. Temperature measurements are made inside of the internal electronics and on the surface of the gamma detector crystal. The output format is as follows:

temp crystal:23 temp electronics:27

8. [.d]

The [.d] command is used to display the current date and time. The display order is:

Day of Month/Month/Year <4 space characters>
 Hour:Min:Sec<CR><LF>

The format is as follows: 16/09/2009 15:00:20

The CS725 does not perform any time zone or daylight-savings time correction. This can be done in the data logger.

9. [.dd]

The [.dd] command is used to set the current date and time. The following menu is activated from the [.dd] command:

```
Modify that date? :
[1] aaa: 2009
[2] mm: 09
[3] jj: 16
[4] hh: 15
[5] mm: 01
[6] ss: 54
[0] Exit
[99] Accept selection
```

To Modify: [parameter number, space, new value,CR]

The current values at the time the .dd command was entered are displayed. To change a value, enter the parameter number followed by the new value and then the enter key. To change the minute to 02 from 01, one would enter the following:

```
5<Space>02<Enter>
```

After new values are entered, the long format of the date/time will be displayed once the 99 is entered to accept the selection.

```
99<enter>
```

and the CS725 will print

```
16/09/2009 15:02:54
```

The time should be set for the purpose of control and analysis of the data. It can be local time, GMT, or any other. The CS725 does not perform any time zone or Daylight-Savings time correction.

The time can also be updated using the long command line format of the date/time as follows:

```
.dd dd/mm/yy hh:mm:ss<enter>
or
.dd<space>dd/mm/yyyy<space>hh:mm:ss<enter>
```

Exampe:

```
.dd 05/11/2010 10:46:00<enter>
or
.dd<space>05/11/2010<space>10:46:00<enter>
```

Use a .d command to confirm the time has been set.

10. [.hd]

The [.hd] command is used to read back histograms from EPROM according to selected dates. When the [.hd] command is entered, the following menu is displayed:

Histograms: Select first day to retrieve

Modify that date? :

[1] aaa: 2009

[2] mm: 09

[3] jj: 16

[.] Exit

[99] Accept selection

To Modify: [parameter number, space, new value,CR]

This is the first day that the historic histograms will be displayed from. Once the start date is entered and accepted, the menu will prompt for an end date as follows:

Histograms: Select last day to retrieve

Modify that date? :

[1] aaa: 2009

[2] mm: 09

[3] jj: 16

[.] Exit

[99] Accept selection

To Modify: [parameter number, space, new value,CR]

After the last day or end date is accepted, the Histograms will be reported in the following format. For each day requested the date is placed first followed by the 1024 bin values.

```

22/09/2009 23:59:50 Time stamp of first requested day
29 This line represents the counts for BIN#1
52 This line represents the counts for BIN#2
67 This line represents the counts for BIN#3
.
.
7 This line represents the counts for BIN#1024
23/09/2009 23:59:50 Time stamp of second requested day
359 This line represents the counts for BIN#1 for
the second day
No more histogram data available in this time window.
```

11. **[.f]**

The [.f] command is used to read back measurement results from EPROM according to selected dates.

Four lines will be output for every day requested where monitoring occurred. See the section under [.fl] for output details.

The date selection procedure is the same as the [.hd] command.

12. **[.fl]**

The [.fl] command is used to read back the current day readings, which can be up to four detailed measurement results. The output will consist of four lines as follows:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
01/10/2009	00:59:	1	2	52913	11342	5716	393	343	411	18	18	64	120	9	24	24	13	4.2	12.98
01/10/2009	06:59:	1	2	57037	13168	6074	371	309	392	18	18	77	110	7	19	24	13	4.2	12.23
01/10/2009	12:59:	1	2	69645	13016	6415	371	360	375	18	18	27	165	2	8	24	12	3.2	12.23
01/10/2009	18:59:	1	2	58951	14218	6280	359	292	382	18	18	83	032	1	16	24	13	3.2	12.23

The format is the date and time stamp followed by the following numbers:

1. Date and Time Stamp
2. Station ID
3. CS725 Serial number
4. K counts total uncorrected
5. K counts total corrected (this value is used in the actual SWE calculations)
6. Tl counts total corrected (this value is used in the actual SWE calculations)
7. SWE value generated from K
8. Radio generated from K and Tl
9. SWE value generated from Tl
10. Soil Moisture values generated from K
11. Soil Moisture values generated from Tl
12. Soil Moisture values generated from K and Tl
13. Precipitation index: Flag indication recent snowfall or rain
14. Crystal temperature min
15. Crystal temperature max
16. Total number of histogram blocks used for the analysis
17. Displacement of the K peak from its nominal position (in bins)
18. Statistical significance of the SWE Tl measurement
19. Power input voltage at the CS725 (after protection diode drop)

13. **[.fla]**

The [.fla] command is used to read back last calculated line results. The output will be in the same format as [.fl] command.

08/11/2010 11:59: 1234 1023 637733 485431 24425 0 -706 0 -47 68 -47 0
26 27 24 -1 1.3 12.05

14. **[.fs]**

The [.fs] command is used to read back last results in short form. The short form consists of the date and time of the readings and the SWE values in millimeters. The format is as follows:

```
DD/MM/YYYY HH:MM:SS SWE_K SWE_TL

01/10/2009 06:59:50 123 129
```

15. **[.p]**

The [.p] command is used to display the Parameter Setup menu. The Parameter Setup menu is as follows:

```
[1] Station ID (Max 8 characters; ex: Gouin_21)           : CS725_#1
[3] Time of start of measure (relative to GMON 00h RTC) : 00
[4] Delay after start of measure for data transmission (secs.)
      0=> No transmission) : 0
[5] Frequency of data transmission:      0 => every 24 h
      1 => every 6 h       : 1
[6] GMON height above ground in centimeters             : 300
[7] Observed position for the K line on the histogram    : 245
[8] Collim (1: Collimator installed; 0: no collimator) : 1
[9] Nominal soil humidity in %weight,(min: 1, max: 150) : 25
[10] Estimated soil humidity in %weight (min: 1, max: 150)
      for HCalib mode : 27
[11] NoK                                                : 230000
[12] NooK (residual K counting) Default:0              : 0
[13] N0TI                                              : 41000
[14] n00Tl ( residual Tl counting)                    : 0
[16] SN Threshold for the snow cover                   : 5
[17] Baud rate for scheduled transmissions             : 9600
[18] Number of hours per partial histo (hours),(1,2,3,or 6) : 1
[19] Manual mode (1); Auto mode (0) ; HCalib mode (2); : 1
[0] Quit without saving the new parameters on EPROM
[99] Save parameters on EPROM
      To modify: [parameter number, space, new value,CR]
=>
```

To modify: [parameter number, space, new value,CR]

[1] Station ID

This is a user-selectable value that can be used to identify a CS725. The Station ID is part of the output information for certain data formats. The value is a string (maximum 8 alphanumeric characters). Avoid using spaces as this can cause problems when parsing the data output strings.

```
[1] Station ID (Max 8 characters; ex: Gouin_21) :CS725_#1
```

[3] Time of start of measure (relative to CS725 00h RTC)

This defines the hour at which a 24-hour period of measurements will begin. This number is relative to the time set in the internal Real Time Clock (RTC) by the user. The format is an integer, with values from 0 to 24. This also defines the time a 24-hour measurement will end. This end time is 10 seconds before the start of measure.

[4] Delay after start of measure for data transmission (secs.)

This defines the time at which the calculated results from the previous 24-hour period will be automatically transmitted from the serial port. It is recommended to set the value to zero in order to disable the automatic transmission of data via the serial port.

This is in seconds after the start of the new 24-hour period. The minimum value should be 300 in order to allow the calculations to complete. The maximum value is 23 h 55 min (86100 seconds) in the case of one transmission every 24 hours, and 5 h 55 min (21,300 seconds) in the case of one transmission every 6 hours. This option is set with parameter [5]. There will be four transmissions spaced by 6 hours.

[5] Frequency of data transmission: 0 => every 24 h 1 => every 6 h

This configures the Automatic Data output, and allows output every 24 h or every 6 h.

This parameter is a flag to instruct the software to transmit the calculated data once a day (value = 0), or once every 6 hours (value = 1). All data output configured with this parameter is relative to the “Time of start of measure” parameter.

It should be noted that the daily output transmission consists of four averaged values from four overlapping 24-hour periods, which are offset by 6 hour intervals.

When the every 6 hours mode is selected, the same four periods will be transmitted, but one at the time, as they become available.

[6] CS725 height above ground in centimeters

Enter the actual installed height of the CS725 above the ground, measured from the bottom of the main body, not from the collimator. This is a parameter used in the SWE calculation to account for the absorption of gamma rays in air.

[7] Observed position for the K line on the histogram

This is a parameter used by the peak finding and identifying algorithm, in order to properly frame the search window. It is the bin position at which the ⁴⁰K isotope peak is observed on the histogram. This is to allow for small shifts in the detector gain. The format is an integer with a value equal or close to 245.

[8] Collim (1: Collimator installed; 0: no collimator)

This parameter indicates whether the collimator is being used with the CS725. Be sure to select the appropriate configuration, as this does affect the proper function of the CS725.

[9] Nominal soil humidity in % weight (min: 1, max: 150)

The value (site specific) for the soil humidity is used to account for the amount of water in the soil. This quantity is defined for a unit volume of soil as

$$100 \text{ (mass of water/mass of dry soil)}$$

Once the soil is frozen, this quantity is relatively constant. The format is an integer between 1 and 150.

[10] Estimated soil humidity in % weight (min: 1, max: 150) for HCalib mode

This is a site-specific parameter used for the auto calibration of the CS725. The auto calibration mechanism calculates baseline values for the coefficients n0Ke and n0Tl. These coefficients correspond to the integrated rates of gamma rays seen by the detector for the K peak (n0Ke) and the Tl peak (n0Tl) with zero moisture. The HCalib parameter is normally the humidity measured by some other means at the time of the calibration in order to account for this humidity in the soil when the parameters n0Ke and n0Tl are evaluated. The format is an integer.

[11] N0K

This site specific parameter is used in the calculation of the SWE. It represents the integrated gamma ray count rate for the potassium ⁴⁰K isotope peak, with no snow cover and dry soil. This number is, of course, dependent upon the level of natural radio-activity of the soil at the installation site. It can only be calculated on the site. The auto-calibration method is a tool to obtain the first estimate of that parameter. The format is an integer.

[12] N00K (residual K counting) Default: 0

This is a parameter to account for the gamma rays coming from above the surface of the snow. This is typically a very small number (less than 225), and affects the SWE evaluation only under very high SWE conditions (above 300 mm). This value is normally obtained after a full season of operation and can only be determined by comparing the CS725 data with manual measurements.

NOTE

This value should not be altered above 225 unless extensive site data analysis has been completed and Campbell Scientific has been consulted.

[13] N0Tl

This site-specific parameter is used in the calculation of SWE. It represents the integrated gamma ray count rate for the thallium ²⁰⁸Tl isotope peak, with no snow cover and dry soil. This number is, of course, dependent upon the level of natural radio-activity of the soil at the installation site. It can only be calculated on the site. The auto-calibration method is a tool to obtain the first estimate of that parameter. The format is an integer.

[14] N00Tl (residual Tl counting)

This is a parameter to account for the gamma rays coming from above the surface of the snow. It affects the SWE evaluation only under high SWE conditions (above 300 mm). This value is normally determined after the first year of operation. The value is typically 1900 or less.

[16] SN Threshold for the snow cover

This parameter is a threshold above which the normal calculation of the SWE will be performed. The threshold is applied to a calculation of the SWE based on the ratio of K/Tl, which is independent of the humidity of the soil, but less accurate than the SWE measured from the K and Tl information independently. When the SWE calculated from the K/Tl ratio is reached, it is assumed that there is a snow cover. The nominal humidity parameter is then used for the calculation. Otherwise, the snow cover is assumed to be zero, and the CS725 calculates the humidity of the soil. The default value is 5 mm.

[17] Baud rate for scheduled transmissions

This parameter defines the baud rate to be used for the automatic data transmissions. In interactive mode with a terminal, the CS725 can adjust to the terminal baud rate by typing capital UU period then enter "UU.<Enter>". However, for scheduled transmissions, the CS725 will use the baud rate specified by this parameter. This is for the cases when an interactive terminal used for the configuration of a site is disconnected and replaced by the normal communication device (modem, satellite, data logger) with a different baud rate. This guarantees that the scheduled transmissions will be done at the proper baud rate for the communication device. The default rate is 9600 bps. Valid values for this parameter are: 1200, 2400, 4800, 9600, 19200, 38400, 57600, and 115200.

[18] Number of hours per partial histo (hours),(1,2,3,or 6)

It is highly recommended to leave this setting to 1 hour. It is recommended to contact Campbell Scientific technical support prior to using other values.

In normal operation, 1-hour histograms generate 24 partial histograms per day. However, under very large snow packs (more than 500 mm), the absorption of the gamma rays is such that the peaks do not stand up much above the cosmic radiation background after one hour of counting. In this case, the peak identifying mechanism may fail. To overcome this situation, it is possible to have histograms generated in periods of 2,3, or 6 hours.

[19] Manual mode (1); Auto mode (0) ; HCalib mode (2);

This parameter defines the operating mode of the CS725. In the manual mode (code =1), the CS725 will accumulate a histogram from the initialization cycle until it a manual command is sent to delete it. No calculations of SWE will be performed, and no results transmission will be scheduled. This mode is used normally when setting up the CS725 (i.e., verifying the peak positions, modifying parameters, setting the time, etc.).

The HCalib mode (code = 2) has been referred to in the parameter description for [10] HCalib. When this mode is set, the CS725 will acquire the data in a normal manner, and the results will be transmitted at the end of the period at the scheduled transmission time. However, instead of calculating the SWE, it will assume that the SWE is zero. Then, it will perform the inverse SWE calculation, and infer the values of the n0Ke and n0Tl from the measured integrals for the K and Tl isotope peaks, taking into account the

humidity of the soil specified in the parameter HCalib. When this is done, the new values of n0Ke and n0Tl will be stored in the parameter block, and the operation mode will be changed internally by the CS725 to automatic (code = 0).

The automatic mode (code =0) is the normal mode of operation. The CS725 will continuously cycle through 24-hour periods, calculating the SWE for the previous 24 hours at 6 hours intervals.

16. [.s]

The [.s] command is used to display status and current measurement information:

```
System status:
-Present time           : 05/11/2010 12:40:05
-Firmware Version      : 5c
-Software Version      : 15_L
-V bat(Volts)          : 12.64
-V HV (Volts)          : 380.02
-V HV-DAC (code)       : 20472
|-Data acquisition start time : 05/11/2010 12:37:15
-Data acquisition stop time  : 06/02/2136 06:28:15
-Next Results Xmission time  : 06/02/2136 06:28:15
-Elapsed time,current histo : 00:02:39
-Mode                   : MANUAL
-Automatic heating      : disabled
-TMax                   : 24 0 0 0
-Min                    : 24 0 0 0
```

17. [.0xps]

[.0xps] Parameters save to file function

The [.0xps] command is used to save the parameters list from the CS725 in a text file. It is useful when a new CS725 replaced an old CS725 at a site. The CS725 will prompt:

Enable the screen capture to a file with the Hyper Terminal to begin the transfer of parameters, type S (CR)

where CR is the enter key. Before typing S, the file will be named using the Hyper Terminal function.

18. [.0xpr]

[.0xpr] Parameters recovery from file function

The [.0xpr] command is used to recover the parameters list from a text file created with the [.0xps] command and send the list to the CS725. It is useful when a new CS725 replaced an old CS725 at a site. The CS725 will prompt :

Allocating tempory buffer,,,,,,,,,
Launch the parameter file transfer with the Hyper Terminal

The file to retrieve will then be selected using the Hyper Terminal function.

19. [%Rhard][%Rboot]

[%Rhard] restarts the software processor.

[%Rboot] restarts the firmware and it has the same effect as a power off /power on.

20. [UU]

[UU] CS725/Terminal synchronizing sequence for rates other than 9600 bauds

The [UU] command synchronizes the baud rate of the CS725 to the terminal baud rate.

6.5 Hidden Commands

Two commands are intentionally hidden from the Main menu to avoid inadvertent use of them. These two hidden commands are as follows:

[.edata]

The [.Edata] command is used to erase all internal data memory. Do not use this command unless you are very sure that the data is no longer required in the CS725. Once executed, this command cannot be reversed and **ALL DATA IS LOST**.

[.0xw]

The [.0xw] command is used to upload new firmware into the CS725. The “0” character is the number zero. Please refer to Section 11, *Firmware Update (using command .0xw)* (p. 27), for more details.

6.6 Data Logger Talk Through Mode

Users who use Campbell Scientific data loggers such as the CR800, CR1000, or the CR3000 can communicate to the CS725 directly using the serial talk through mode feature in Loggernet Terminal Emulator Mode.

This will allow users to access the CS725 remotely via the data logger, so that they can remotely do tasks such as change settings or update the CS725 clock.

7. Parts Overview

The following diagram shows a standard CS725 and some of its included accessories.

The optional collimator is shipped in a box separate from the CS725 due to its weight. You will also find a carrying strap for the collimator to facilitate carrying the part.

CAUTION The collimator weighs 25 kg (55 lb).

A long safety strap is also included for securing the collimator to the mounting structure once it is installed.

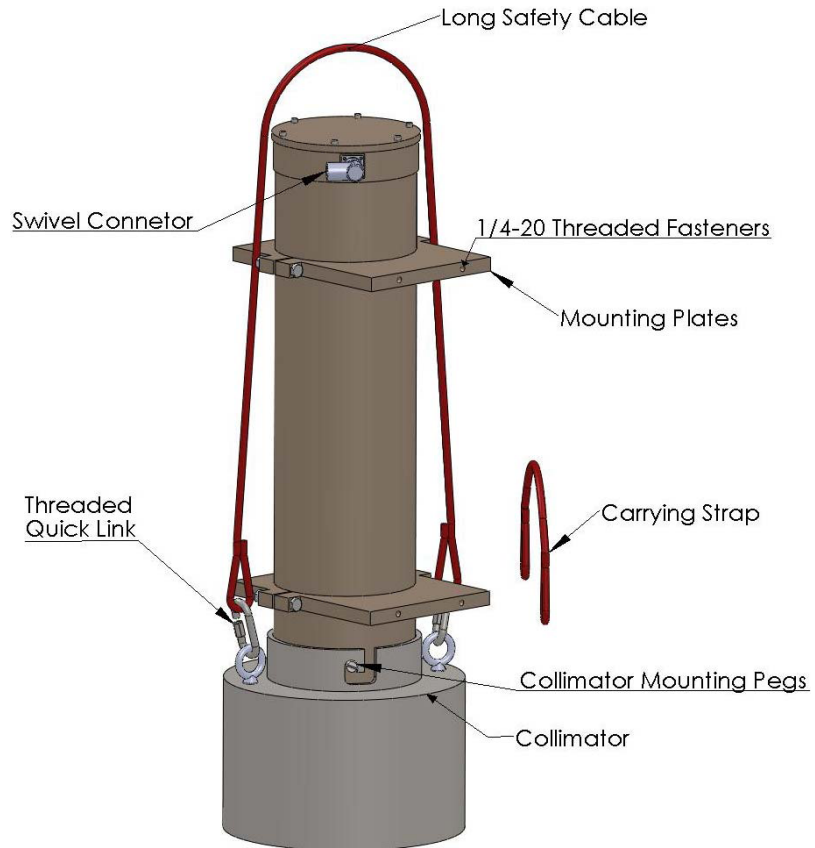


FIGURE 7-1. CS725 components

8. Site Selection Details

It is important to determine if the intended installation site of the CS725 will have appropriate sources of potassium and thallium to provide sufficient counts for the expected SWE. It is also important to reduce the affects of background sources that will adversely affect the SWE measurement.

Do not mount the CS725 in close proximity to wood material or trees. Wood material can contain potassium (K) and thallium (TI) which can be a source of gamma radiation that will interfere with the measurements. Potassium sources above the snow will emit gamma radiation that is not attenuated by the snow pack. Refer to the following sections for recommendations on how to select a site.

It is reasonable to have small amounts of wood material within the 6 m clearance radius. Be aware that reducing the amount of material near the CS725 or increasing the distance will reduce its influence on the readings.

8.1 Collimator

The need for a collimator is typically dictated by the characteristics of the intended site. The presence of wooded vegetation, man-made structures and the expected SWE for a given site are all a factor.

It is possible to use the sensor and obtain accurate measurements without using the collimator option. The following table is a guideline for determining if a site can be used without a collimator.

Site Characteristics	Maximum SWE <300 mm	Maximum SWE 300 to 400 mm	Maximum SWE >400 mm
Very open site with no proximity to trees, buildings or tall vegetation within a 48 m (160 ft) radius.	Optional	Optional	Optional
No trees, buildings or tall vegetation within a 24 m (80 ft) radius.	Optional	Optional	Required
No trees, buildings or tall vegetation within a 12 m (40 ft) radius.	Optional	Required	Required
Site with minimum clearance radius of 6 m (20 ft) radius.	Required	Required	Required

NOTE Always confirm that your sensor has the *Collimator Installed* parameter set properly. The SWE calculations are different for a sensor with and without a collimator.

8.2 Soil Moisture Considerations

Moisture in the soil can influence the CS725 readings. It is important to avoid low lying spots where water will pool or saturate the soil during the snow melt. Sandy or rocky soil types will have more stable soil moisture levels throughout the measurement season. Bog type ground conditions should be avoided due to the potentially high moisture content and variations.

8.3 Obtaining Site Qualifying Counts

There is variability in the natural occurring radiation levels from site to site. For this reason, it is recommended to qualify the site prior to setting up the

permanent installation for the CS725. You may find that your site has low background levels of K and Tl counts, and moving the location may be required to improve the results from the CS725.

Required equipment:

- CS725 with accessories.
- Suitable +12 VDC power supply or battery to run the CS725 for several hours.
- Suitable mounting mechanism to suspend the CS725 vertically over the ground at the qualifying site (with the collimator). For qualifying purposes, the distance above the ground is not critical.
- Laptop computer with Hyperterminal or another suitable terminal emulator program.

Steps to follow:

- Mount the CS725 as close as reasonable to its desired permanent location.
- Avoid placing items underneath the CS725 during this testing.
- For best results try to maintain a mounting height of 1 m or more.
- Ensure that the collimator is installed on the CS725.
- Connect the CS725 to the laptop computer and power supply as shown in Section 3, *Wiring* (p. 2).
- Run Hyperterminal or the terminal program that you have chosen to use.
- Access the Parameter Setup menu by typing “.p<Enter>”.
- If not already done, change the operating state of the CS725 to Manual mode. To do this type “19<space>1<Enter>”.

NOTE

Once the site is qualified, the CS725 will need to have the operating mode reconfigured to Auto or HCalib mode. This can be done as part of the final parameter setup discussed in Section 10, *Final Parameter Setup* (p. 25).

- The CS725 will automatically save this change and exit the Parameter Setup menu.
- Enter into the “Special Command” by typing “.a<Enter>”
- The command will send out a prompt as follows:
 Delay and Duration for the measurement (seconds)
 (Delay should be greater than or equal to 5 s)
 Format: =>Delay Duration
 (example: => 5 3600)

- A delay will need to be typed in followed by the run time duration. It is recommended to run the test for 1 or 2 hours; a value of 1 second can be entered for the delay. A 1-hour test is 3600 seconds, so the following would be typed in “1<space>3600<Enter>”.
- The CS725 will now monitor the gamma radiation for an hour.
- The .hr command can be issued several minutes into the test for verification that it is running properly. The .hr command may take several minutes to complete. Upon completion, the command will output the current histogram (which can be captured to file for advanced diagnostics) followed by the following lines.

```
-Elapsed time,current histo : 00:03:59

Pos K = 240.4; Pos Tl = 427.5;

Cnt K = 003679.8; Cnt Tl = 000088.3;
```

The first line indicates how long the CS725 has been monitoring. The second line indicates the position of the potassium peak and its counts. The third line indicates the position of the Tl peak and its counts.

It is important to record these numbers and refer to the radiation count range in TABLE 8-2 and TABLE 8-3 for determining the suitability of your site.

Count Range 24 Hour K	Count Range 1 Hour K	Recommendation
0 to 96000	0 to 4000	Insufficient K counts for CS725 SWE measurements.
96000 to 180000	4000 to 7500	Useable K count range for CS725 SWE measurements. May experience larger errors for higher SWE values.
180000 to 264000	7500 to 11000	Good K count range for CS725 SWE measurements. Should maintain specified operating characteristics.
264000 or greater	11000 or greater	Excellent K count range for the CS725 SWE measurements.

TABLE 8-3. Thallium (Tl) Count Range Guideline		
Count Range 24 Hour Tl	Count Range 1 Hour Tl	Recommendation
0 to 9600	0 to 400	Insufficient Tl counts for CS725 SWE measurements.
9600 to 36000	400 to 1500	Useable Tl count range for CS725 SWE measurements. May experience larger errors for higher SWE values.
36000 to 48000	1500 to 2000	Good Tl count range for CS725 SWE measurements. Should maintain specified operating characteristics.
48000 or greater	2000 or greater	Excellent Tl count range for the CS725 SWE measurements.

9. Mounting

CAUTION

- If you are unable to determine that your structure or mounting method is suitable for the CS725 sensor, please contact an expert or professional who can assist you in determining the structural mounting requirements for your CS725 installation.
- Always ensure that the collimator is secured to the structure with the long safety cable.
- Always install the collimator after the main CS725 body is mounted and secured to the structure.

The exact mounting height for the CS725 is not critical. However it is recommended to mount the CS725 approximately 3.0 m (10 ft) above the ground. If it is possible for snow levels to exceed 3.0 m (10 ft), then the CS725 should be mounted higher than the maximum snow height. If the CS725 is submersed in the snow, it may be damaged by water ingress. The CS725 can also be mounted lower than 3.0 m (10 ft); however, this will reduced the effective area of coverage.

Once the CS725 is mounted, the actual installed height will need to be entered into the appropriate setup parameter.

9.1 Mounting Options

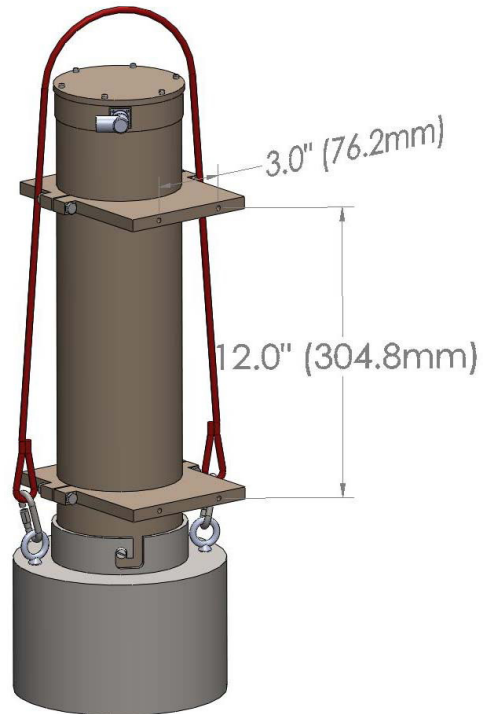


FIGURE 9-1. Position of 1/4 - 20 mounting holes

The CS725 comes with mounting plates that can be used with the 27412 mounting kit and 27413 right-angle mounting kit to mount the sensor. The mounting plates contain four 1/4-20 threaded holes for fastening the sensor to the 27413 or wall mount. Refer to [FIGURE 9-1](#) for details.

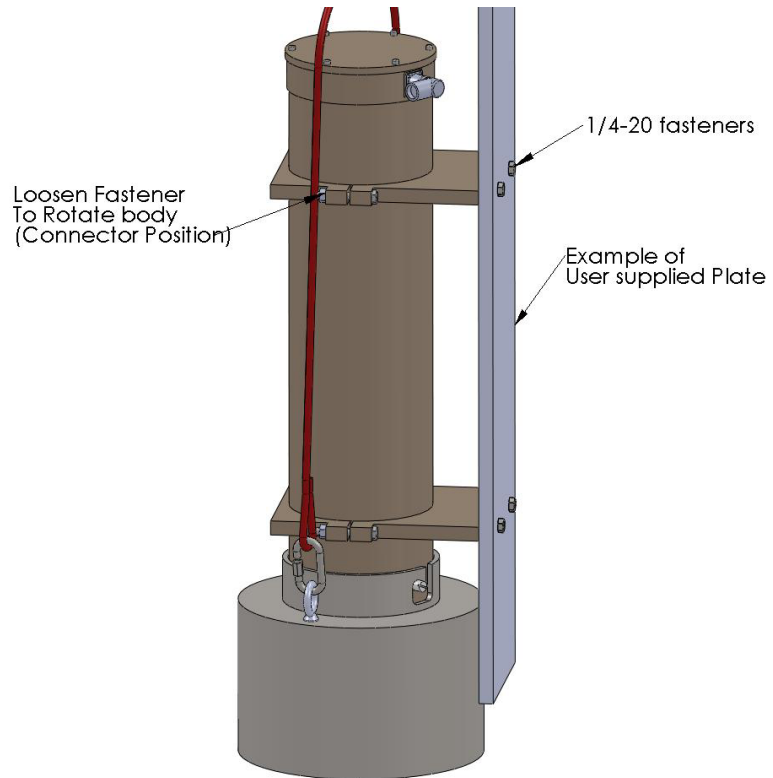


FIGURE 9-2. Example of wall/plate mounting

It is possible to rotate the CS725 main body with respect to the mounting plates. FIGURE 9-2 shows one of four fasteners that need to be loosened to rotate the main body. Ensure that the fasteners are not loosened too much to prevent the body from sliding through the mounting plates.

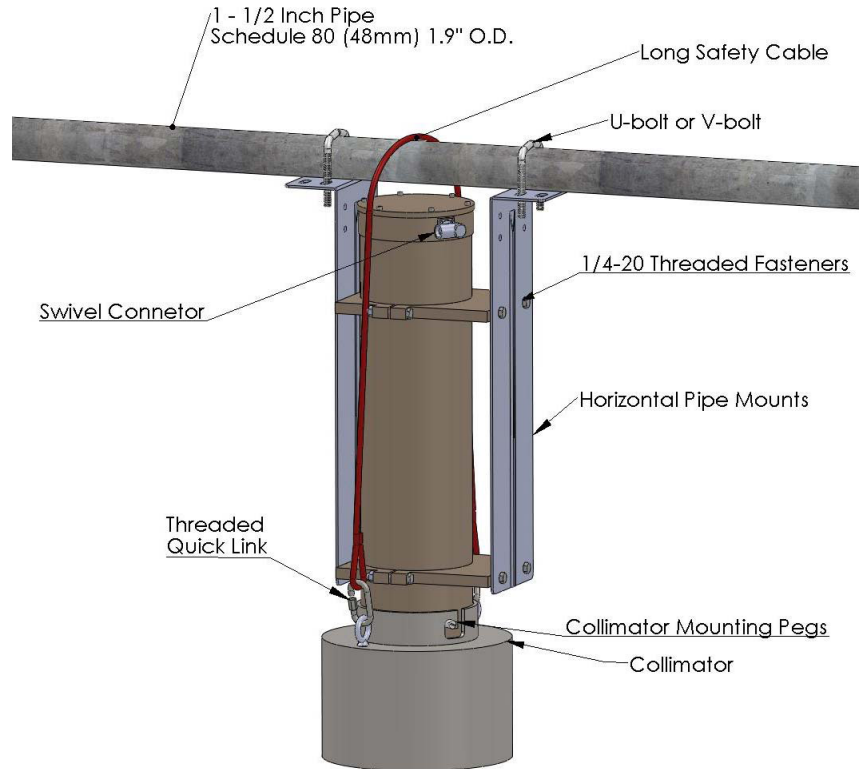


FIGURE 9-3. Horizontal pipe mounting shown with the 27412 Mount Kit

A fully mounted CS725 with the 27412 mounting brackets is shown in FIGURE 9-3.

10. Final Parameter Setup

Once the CS725 is installed, the following items are required for the final setup of the CS725.

- Obtain the soil moisture values for the ground under the CS725. The recommended depth of the measurements for most soil types is 20 cm (8 in). However, when well-drained soils are present, the measurements should be made at a depth of 30 cm. The value should be in percent by weight [100 *(mass of water/mass of dry soil)].
- Measure the final installed height of the CS725 in centimeters from the bottom of the sensor to the ground.

It is best to have the CS725 installed prior to having any snow on the ground. If the CS725 is being installed with snow already on the ground, then the average existing SWE value in mm will need to be obtained. The existing SWE is needed to calculate the background radiation count with no snow present (i.e., n0Ke and n0Tl parameters). Campbell Scientific technical support will need to be contacted so that calculations can be performed to determine the n0K and n0Tl values.

If the installation is being done with no snow present, then the following needs to be done to complete the setup:

Access the Parameter menu of the CS725 via the terminal emulator by keying in the command [.p<Enter>]

```
[1] Station ID (Max 8 characters; ex: Gouin_21)      : 001
[3] Time of start of measure (relative to GMON 00h RTC)  : 00
[4] Delay after start of measure for data transmission (secs.)
      0=> No transmission) : 0
[5] Frequency of data transmission: 0 => every 24 h
      1 => every 6 h      : 1
[6] GMON height above ground in centimeters           : 300
[7] Observed position for the K line on the histogram  : 245
[8] Collim (1: Collimator installed; 0: no collimator) : 1
[9] Nominal soil humidity in %weight,(min: 1, max: 150) : 25
[10] Estimated soil humidity in %weight (min: 1, max: 150)
      for HCalib mode   : 27
[11] NoK                                               : 230000
[12] NooK (residual K counting) Default:0             : 225
[13] N0Tl                                             : 41000
[14] n00Tl ( residual Tl counting)                   : 1900
[16] SN Threshold for the snow cover                  : 5
[17] Baud rate for scheduled transmissions            : 9600
[18] Number of hours per partial histo (hours),(1,2,3,or 6) : 1
[19] Manual mode (1); Auto mode (0) ; HCalib mode (2); : 0
[0] Quit without saving the new parameters on EPROM
[99] Save parameters on EPROM
      To modify: [parameter number, space, new value,CR]
=>
```

- Set parameter [6] to reflect the actual installed height of the CS725 in cm.
- Set parameter [9] to the obtained soil moisture value in %.
- Set parameter [10] to the obtained soil moisture value in %.
 - If for any reason the soil moisture values cannot be obtained, then an estimate could be made based on the soil type as follows:
 - Sandy soil – 15%
 - Sand/Organic mixture – 30%
 - Humus soil – 50%
- Ensure any other parameter is set to meet your requirements.
- Set parameter [19] last. Set the value to 2 - “Calibration Mode”. The CS725 will automatically reset when this parameter is changed and saved.
- Always key in the [99] command to save the parameters. The CS725 will prompt the user a second time for the 99 command to avoid an inadvertent save.
- The setting can be verified by going back into the [.p] Parameter menu again.

By placing the CS725 in calibration mode (HCalib), it will automatically adjust the initial n0K and the n0Tl values for you. The n0K and the n0Tl values can also be calculated by running the CS725 for 24 hours and observing the

radiation count values seen in the detailed measurement data output string which can be accessed by typing the command [.fl].

11. Firmware Update (using command .0xw)

The firmware for the CS725 can be updated using the RS-232 serial communication interface. This can be accomplished by connecting the CS725 to a computer using the DB9F-TERM (see Section 4, *Connecting the CS725 to a Computer* (p. 2)).

A terminal communication program such as Hyperterminal will be required to transfer the new firmware file to the CS725.

The firmware update involves the transfer of a large file, and for this reason the baud rate setting can be increased for the program update procedure. The maximum baud rate that can be used is a function of the cable length. The following table shows the recommended maximum baud rate for various cable lengths:

Cable Length	Maximum Baud Rate
0 to 7.6 m (0 to 25 ft)	57600
0 to 15.2 m (25 to 50 ft)	38400
0 to 30.5 m (50 to 100 ft)	9600

Terminal settings should be as follows:

Baud Rate:	See table above
Data Bits:	8
Parity:	None
Stop Bits:	1
Flow Control:	XON/XOFF
Local Echo:	Enabled
Terminal Mode:	ANSI
Send Line Ends with Line Feeds:	Disabled

Note that the XON/XOFF flow control needs to be enabled. For all other normal communications, the XON/XOFF flow control will need to be disabled.

Once the terminal program is setup and the CS725 is connected to the computer using the DB9F-Term, power can be applied to the CS725.

If a baud rate other than 9600 was selected, the auto baud rate synchronization can be invoked by typing the command “UU.<Enter>”. Once the menu is displayed, the command “.0xw” can be entered for reprogramming the firmware.

The following will be displayed once the “.0xw” is entered:

allocating memory buffer,,,,,,,,,,,,,

After the memory is allocated (within 1 minute), the CS725 will prompt for the file transfer with the following message:

Launch the file transfer with the Hyper Terminal

If you are using HyperTerminal, select “Send Text File...” from the Transfer menu.

The supplied programming file will need to be selected and sent to the CS725. The process will take approximately 5 minutes at 57600 bps and in excess of 30 minutes at 9600 bps. If the scrolling characters stop for a long duration, it is possible that an error occurred in communications. Shut down Hyperterminal, power down the CS725, and restart the process again.

A single line of scrolling data will be displayed as the transfer takes place. Once the transfer is complete, the following text will be displayed on the terminal:

Transfer completed; type w to overwrite the EPROM memory, type . to abort

CAUTION

Once the following step is done, it is critical to not interrupt this process or power down the CS725. If the process is interrupted, the CS725 may need to be sent back to the factory for reprogramming.

Type in the character w followed by the enter key “w<Enter>”.

After the w command is entered, the terminal will display that the programming has begun and the progress will be displayed as follows:

Begin EPROM programming

Erasing block 0x0

Writing EPROM from 0x0 to 0xffff

Upon completion the CS725 will prompt to be reset. It is recommended to cycle power only after the following message is displayed:

Programming done .. cycle power on the GMONIII, or do a Hard Reset

It is recommended to restart Hyperterminal as well and change the baud rate setting back to 9600 bps and to disable the XON/XOFF flow control to resume normal communications and verify that the CS725 powers up properly and retained its parameter settings.

12. System Power Requirements and Recommendations

12.1 Non Solar-Powered Sites

It is always recommended that the CS725 be operated from an uninterruptable power supply. Normally an AC charger is used to charge +12 VDC batteries. For sites that operate this way, it is recommended that the batteries have the capacity to supply the system for a minimum of 48 hours. This should be increased for sites where frequent power outages are possible.

12.2 Solar-Powered Sites

The maximum power draw from the CS725 is 180 mA or 4.32 Ah per day. It is recommended that solar-powered systems be designed with a minimum reserve capacity of 60 days. This results in a minimum reserve capacity of 260 Ah for the CS725. It is also important to account for the power draw from other equipment that may operate from the power supply.

The following are some reasons for the large reserve capacity.

- Solar panels can become covered in ice and snow and charging may not be present for long periods of time.
- Battery capacity decreases with cold temperatures.
- Cold temperatures also significantly reduce a battery's capacity to charge. Generally very little charging occurs at temperatures below -30°C.

Solar Panel Size

The size of solar panel required for charging the CS725 system should be sized according to the geographic location of the installation and total maximum system power draw.

13. Detailed Measurement Theory

The CS725 sensor is, in fact, a gamma radiation spectrometer that has been specifically designed for the purpose of measuring SWE. The CS725 uses a thallium doped sodium iodide crystal NaI(Tl) for detecting the gamma radiation.

The natural gamma radiation from the ground is produced by the traces of long-lived radioactive elements that it contains. The most abundant of those elements is Potassium_40 (^{40}K) and Thallium_208 (^{208}Tl). Potassium_40 emits gammas at 1.460 MeV (megaelectronvolts), and Thallium_208 at 2.613 MeV. Gamma rays have a well defined "probability of interaction" per unit of length as they go through a material according to the energy of the gamma and the nature of the material. The net effect when the natural gamma rays from the ground go through the snow cover is that a fraction of the gammas do not interact at all with the snow, and that another fraction is either degraded in energy, or totally absorbed in the snow. The precise measurement of the

absorption and energy degradation by the snow of the gamma rays from the ground is the basic information for the calculation of the SWE.

Each time a gamma ray is detected by the CS725, it is placed in its corresponding bin in the energy histogram. This histogram is the basic data set for the calculation of the SWEs. Since it is statistical in nature, the accuracy of the SWE evaluation is proportional to the square root of the measurement time. The CS725 builds each histogram for a period of 24 hours in order to achieve the specified accuracy. An example of such a histogram is shown in FIGURE 13-1.

It should be noted that only selected portions of the histogram can be used to evaluate the SWE. The reason is that the SWE is evaluated by measuring the absorption by the snow cover of the natural radiation coming from the ground. However, some of the measured radiation comes from above the snow cover. This is the case of the cosmic radiation and the bismuth isotopes produced by the radon decay chain. In short, the integrated counts under the ^{40}K and ^{208}Tl peaks need to be evaluated after removing or accounting for all the other contaminants.

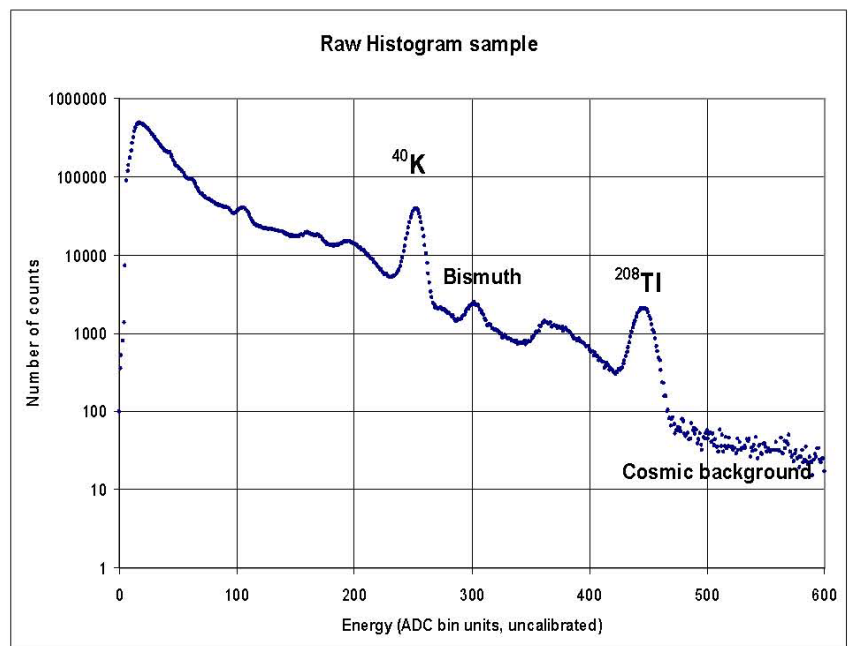


FIGURE 13-1. Gamma histogram

14. Maintenance and Assembly

There is no recommended user maintenance required for the CS725.

CAUTION

We do not recommend disassembling the CS725 for any reason. The CS725 instrument is very complex and is intended to be repaired or maintained only by factory trained personnel.

It is recommended that the CS725 be calibrated every seven years. The reason for the timeline is to ensure the CS725 gamma ray detector does not drift out of specification.

The following diagrams demonstrate the internal makeup of the CS725. To reduce drastic temperature gradients, the CS725 is filled with an advanced insulating material known as Nanogel (see FIGURE 14-3). The manufacturer's (Cabot Corporation) MSDS sheet should be consulted prior to exposing the Nanogel insulation.



FIGURE 14-1. CS725 main body

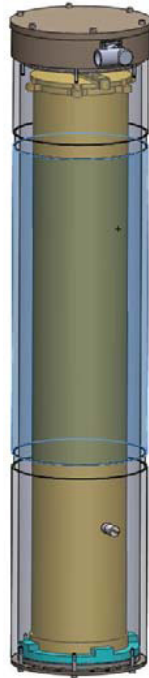


FIGURE 14-2. CS725 inner tube shown

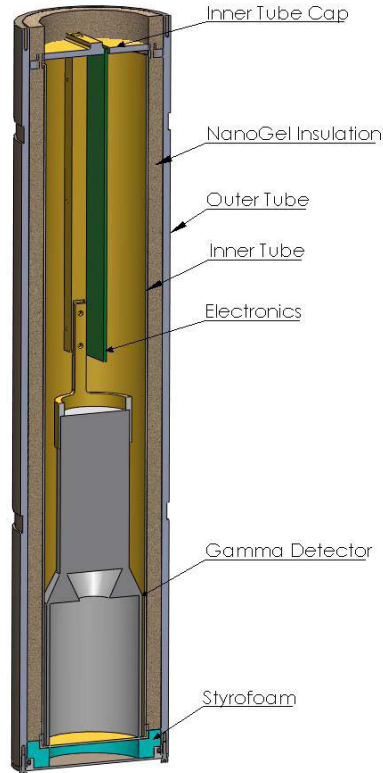


FIGURE 14-3. CS725 cutout view

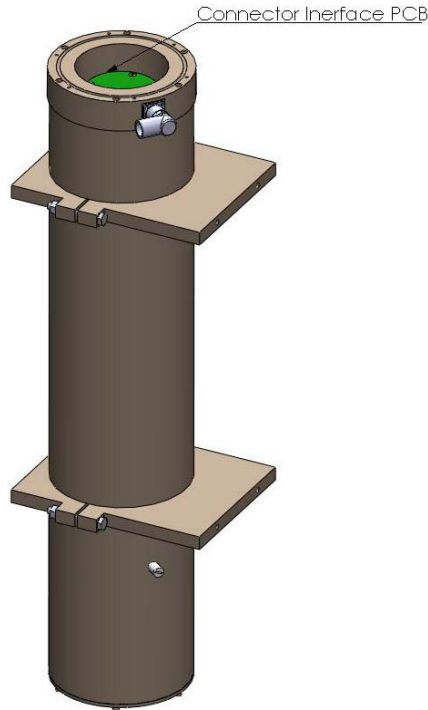


FIGURE 14-4. CS725 with top cap removed

15. Data Logger CRBasic Programming

15.1 Extended Data Output (.fla) Command

The following program example reads the data values from the CS725 using the command [.fla].

This program obtains information in addition to reported SWE values such as radiation counts and other diagnostic information.

CRBasic Example 15-1. CR1000 program using the CS725 extended data command

```
'CR1000 Series Data Logger
'Program for CS725 Sensor

'Wiring CS725
'Red - +12VDC
'Black and Clear- G - Ground
'Green RS-232 TX - C2
'White RS-232 RX - C1
'Clear Shield- G - Ground

'Declare Public Variables and alias
Public PTemp As Float,batt_volt As Float
Public Read_CS725_SWE_Flag As Boolean
Public CS725SerialIn As String * 120
Public CS725_COMMAND_String As String * 20
Public CS725_TIME_String As String * 17
Public CS725_Date_Time(5) As Float
Alias CS725_Date_Time(1) = CS725_Day
```

```

Alias CS725_Date_Time(2) = CS725_Month
Alias CS725_Date_Time(3) = CS725_Year
Alias CS725_Date_Time(4) = CS725_Hour
Alias CS725_Date_Time(5) = CS725_Min

Public CS725_StationID As String * 10
Public CS725_Values(17) As Float

Alias CS725_Values(1) = CS725_SerialNum
Alias CS725_Values(2) = CS725_K_Uncorrected
Alias CS725_Values(3) = CS725_K_Counts
Alias CS725_Values(4) = CS725_TL_Counts
Alias CS725_Values(5) = CS725_SWE_K
Alias CS725_Values(6) = CS725_K_TL_Ratio
Alias CS725_Values(7) = CS725_SWE_TL
Alias CS725_Values(8) = CS725_SM_K
Alias CS725_Values(9) = CS725_SM_TL
Alias CS725_Values(10) = CS725_SM_K_TL
Alias CS725_Values(11) = CS725_Precip_Index
Alias CS725_Values(12) = CS725_Crystal_TEMP_MIN
Alias CS725_Values(13) = CS725_Crystal_TEMP_MAX
Alias CS725_Values(14) = CS725_Hist_Blocks
Alias CS725_Values(15) = CS725_K_Disb
Alias CS725_Values(16) = CS725_Stats
Alias CS725_Values(17) = CS725_PWR_Volt

Public CS725SplitStr(20) As String * 16

Dim loopcount As Long

'Declare Constants
'Command to Read back last results in short data output form
'precede .flla with an ESCAPE key CHR(27) and end with an Enter CHR(13)
Const CS725_Command_get_output = CHR(27) + ".flla" + CHR(13)

'Define Data Tables
DataTable (Diagnostics,1,-1)
  DataInterval (0,1440,Min,10)
  Minimum (1,batt_volt,FP2,0,False)
  Maximum (1,batt_volt,FP2,0,False)
  Minimum (1,PTemp,FP2,0,False)
  Maximum (1,PTemp,FP2,0,False)
EndTable

'Define Data Tables
DataTable (CS725_6Hour,1,-1)
  DataInterval (30,360,Min,10)
  Sample (1,CS725_TIME_String,String)
  Sample (1,CS725_StationID,String)
  Sample (1,CS725_SerialNum,IEEE4)
  Sample (1,CS725_K_Counts,IEEE4)
  Sample (1,CS725_TL_Counts,IEEE4)
  Sample (1,CS725_SWE_K,IEEE4)
  Sample (1,CS725_K_TL_Ratio,IEEE4)
  Sample (1,CS725_SWE_TL,IEEE4)
  Sample (1,CS725_Crystal_TEMP_MIN,IEEE4)
  Sample (1,CS725_Crystal_TEMP_MAX,IEEE4)
  Sample (1,CS725_Hist_Blocks,IEEE4)
  Sample (1,CS725_K_Disb,IEEE4)
  Sample (1,CS725_PWR_Volt,IEEE4)
EndTable

'Main Program
BeginProg

'Prepare COM1 for the CS725
SerialOpen (Com1,9600,3,0,1000)

```

```

'Scan rate is dependent on application
Scan (30,Sec,7,0)
PanelTemp (PTemp,250)
Battery (batt_volt)

'Based on the Factory default settings of the CS725 will
'calculate SWE on the Hour every 6 Hours.
'The CS725 is read every 6 hour in this program.
'The reading will take place 10 minutes After the period to ensure the CS725 is not
'processing calculations at the top of the hour when the measurement is requested

'flag is set 10 minutes into every 6 hour period
If TimeIntoInterval (10,360,Min) Then Read_CS725_SWE_Flag = TRUE
'If the flag is high obtain a measurement
If Read_CS725_SWE_Flag = TRUE Then
'Reset the Flag
Read_CS725_SWE_Flag = False

'Load the command into the string
CS725_COMMAND_String = CS725_Command_get_output

'Flush the serial buffer
SerialFlush (Com1)

'Send the command string out
SerialOut (Com1,CS725_COMMAND_String,"",0,0)

'Wait up to 2 seconds, a <CR> or 100 chars for the values to be returned.
SerialIn (CS725SerialIn, Com1, 200,13, 100)

'The string is in the following format
'08/11/2010 11:59: 1234 23 637733 485431 24425 80 76 79 22 23 21 0 6 12 24 -1 1.3 12.05

'Split out the string into smaller strings - use a space as the filter
SplitStr (CS725SplitStr(1),CS725SerialIn," ",20,5)

'first string contains 08/11/2010
SplitStr (CS725_Date_Time(1),CS725SplitStr(1),"",3,0)

'Next string contains HH:MM
SplitStr (CS725_Date_Time(4),CS725SplitStr(2),"",2,0)

'Next string contains the station identifier and is left as a string
CS725_StationID = CS725SplitStr(3)

'The next 17 strings are all numerical values
For loopcount = 1 To 17 Step 1

'Convert all strings to numbers
'Values produced are as follows"
'CS725_SerialNum *Suggest to Output to Final Storage*
'CS725_K_Uncorrected
'CS725_K_Counts *Suggest to Output to Final Storage*
'CS725_TL_Counts *Suggest to Output to Final Storage*
'CS725_SWE_K *Suggest to Output to Final Storage*
'CS725_K_TL_Ratio *Suggest to Output to Final Storage*
'CS725_SWE_TL *Suggest to Output to Final Storage*
'CS725_SM_K
'CS725_SM_TL
'CS725_SM_K_TL
'CS725_Precip_Index
'CS725_Crystal_TEMP_MIN *Suggest to Output to Final Storage*
'CS725_Crystal_TEMP_MAX *Suggest to Output to Final Storage*
'CS725_Hist_Blocks *Suggest to Output to Final Storage*
'CS725_K_Dispatch *Suggest to Output to Final Storage*
'CS725_Stats
'CS725_PWR_Volt *Suggest to Output to Final Storage*
SplitStr (CS725_Values(loopcount),CS725SplitStr(loopcount + 3),"",1,0)

```

```
Next
```

```
'Prepare the output time string from when the CS725 produced the data
'Format is YYYY-MM-DD HH:MM
CS725_TIME_String = FormatFloat (CS725_Year,"%04.0F") + "-" + FormatFloat
(CS725_Month,"%02.0F") + "-" + FormatFloat (CS725_Day,"%02.0F") + " " + FormatFloat
(CS725_Hour,"%02.0F") + ":" + FormatFloat (CS725_Min,"%02.0F")
```

```
EndIf
```

```
'Call Output Tables.
CallTable Diagnostics
CallTable CS725_6Hour
```

```
NextScan
EndProg
```

15.2 Short Form Data Output (.fs) Command

The following program example reads the SWE values from the CS725 using the command [.fs].

The format of the data output from [.fs] command is as follows:

```
DD/MM/YYYY HH:MM:SS SWE_K SWE_TL
01/10/2009 06:59:50 123 129
```

CRBasic Example 15-2. CR1000 program using the CS725 short form data command

```
'CR1000 Series Data Logger
'Program for CS725 Sensor

'Wiring CS725

'Red -Power          +12VDC
'Black -Power Gnd   G - Ground
'Green -RS-232 TX   C2
'White -RS-232 RX   C1
'Clear -Shield      G - Ground

'Declare Public Variables
Public PTemp As Float,batt_volt As Float
Public Read_CS725_SWE_Flag As Boolean
Public CS725_RET_Values(8) As Float

Public CS725SerialIn As String * 100
Public CS725_COMMAND_String As String * 20

Alias CS725_RET_Values(7) = SWE_K
Alias CS725_RET_Values(8) = SWE_TL

'Declare Constants

'Command to Read back last results in short data output form
'precede .Fs with an ESCAPE key CHR(27) and end with an Enter CHR(13)
Const CS725_Command_get_output = CHR(27) + ".Fs" + CHR(13)

'Define Data Tables
DataTable (Diagnostics,1,-1)
DataInterval (0,1440,Min,10)
Minimum (1,batt_volt,FP2,0,False)
Maximum (1,batt_volt,FP2,0,False)
```



```

Minimum (1,PTemp,FP2,0,False)
Maximum (1,PTemp,FP2,0,False)
EndTable

'Define Data Tables
DataTable (CS725Hourly,1,-1)
  DataInterval (0,60,Min,10)
  Sample (8,CS725_RET_Values(1),IEEE4)
EndTable

'Main Program
BeginProg

'Prepare COM1 for the CS725
SerialOpen (Com1,9600,3,0,10000)

'Scan rate is dependent on application
Scan (30,Sec,7,0)
  PanelTemp (PTemp,250)
  Battery (batt_volt)

'Based on the Factory default settings of the CS725 the CS725 will
'calculate SWE on the Hour every 6 Hours.
'We will simply read the CS725 every hour in this program.
'The reading will take place 10 minutes After the hour to ensure the CS725
'is not burdened with extra processing when the measurement is requested

If TimeIntoInterval (10,60,Min) Then Read_CS725_SWE_Flag = TRUE
EndIf

If Read_CS725_SWE_Flag = TRUE Then
  'Reset the Flag
  Read_CS725_SWE_Flag = False

  'Load the command into the string
  CS725_COMMAND_String = CS725_Command_get_output

  'Send the command string out
  SerialOut (Com1,CS725_COMMAND_String,"",0,0)

  'Wait up to 2 seconds, a <CR> or 100 chars for the values to be returned.
  SerialIn (CS725SerialIn, Com1, 200,13, 100)

  'The string is in the following format
  '23/09/2009 18:59:50 123 456
  'Split out the time stamp and values 8 numbers are returned
  SplitStr (CS725_RET_Values(),CS725SerialIn,"",8,0)
  'The contents of the array are as follows:
  'Day,Month,Year,Hour,Min,Second,SWE-from K, SWE-from TL
EndIf

'Call Output Tables.
CallTable Diagnostics
CallTable CS725Hourly

NextScan

EndProg

```

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Use tripods, towers, and attachments to tripods and towers only for purposes for which they are designed. Do not exceed design limits. Be familiar and comply with all instructions provided in product manuals. Manuals are available at www.campbellsci.com. You are responsible for conformance with governing codes and regulations, including safety regulations, and the integrity and location of structures or land to which towers, tripods, and any attachments are attached. Installation sites should be evaluated and approved by a qualified engineer. If questions or concerns arise regarding installation, use, or maintenance of tripods, towers, attachments, or electrical connections, consult with a licensed and qualified engineer or electrician.

General

- Protect from over-voltage.
- Protect electrical equipment from water.
- Protect from electrostatic discharge (ESD).
- Protect from lightning.
- Prior to performing site or installation work, obtain required approvals and permits. Comply with all governing structure-height regulations.
- Use only qualified personnel for installation, use, and maintenance of tripods and towers, and any attachments to tripods and towers. The use of licensed and qualified contractors is highly recommended.
- Read all applicable instructions carefully and understand procedures thoroughly before beginning work.
- Wear a **hardhat** and **eye protection**, and take **other appropriate safety precautions** while working on or around tripods and towers.
- **Do not climb** tripods or towers at any time, and prohibit climbing by other persons. Take reasonable precautions to secure tripod and tower sites from trespassers.
- Use only manufacturer recommended parts, materials, and tools.

Utility and Electrical

- **You can be killed** or sustain serious bodily injury if the tripod, tower, or attachments you are installing, constructing, using, or maintaining, or a tool, stake, or anchor, come in **contact with overhead or underground utility lines**.
- Maintain a distance of at least one-and-one-half times structure height, 6 meters (20 feet), or the distance required by applicable law, **whichever is greater**, between overhead utility lines and the structure (tripod, tower, attachments, or tools).
- Prior to performing site or installation work, inform all utility companies and have all underground utilities marked.
- Comply with all electrical codes. Electrical equipment and related grounding devices should be installed by a licensed and qualified electrician.
- Only use power sources approved for use in the country of installation to power Campbell Scientific devices.

Elevated Work and Weather

- Exercise extreme caution when performing elevated work.
- Use appropriate equipment and safety practices.
- During installation and maintenance, keep tower and tripod sites clear of un-trained or non-essential personnel. Take precautions to prevent elevated tools and objects from dropping.
- Do not perform any work in inclement weather, including wind, rain, snow, lightning, etc.

Maintenance

- Periodically (at least yearly) check for wear and damage, including corrosion, stress cracks, frayed cables, loose cable clamps, cable tightness, etc. and take necessary corrective actions.
- Periodically (at least yearly) check electrical ground connections.

Internal Battery

- Be aware of fire, explosion, and severe-burn hazards.
- Misuse or improper installation of the internal lithium battery can cause severe injury.
- Do not recharge, disassemble, heat above 100 °C (212 °F), solder directly to the cell, incinerate, or expose contents to water. Dispose of spent batteries properly.

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