

FLUKE®

Biomedical

CAL/RAD MARK VI

Operators Manual

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Section 1

General Information

1.1 Introduction

The MARK VI is Veenstra Instruments by touch-screen based dose calibrator. It is a combination of hardware and software that allows the user to measure radioactive sources, syringes and other items. The dose calibrator consists of an ionization chamber and the touch-screen based controlling unit.

The first Section of this manual describes how to unpack, locate and install the components.

The remainder of the manual describes how to operate the MARK VI and also discusses all the relevant topics.

Before using the MARK VI, the users must read this manual and must be familiar with the system.

1.2 Unpacking and Installing the Hardware

The MARK VI is a touch screen based dose calibrator. The system can be easily unpacked and installed.

1.3 Unpacking of the MARK VI

The MARK VI system consists of the following components:

- The VIK-202 ionization chamber.
- The VIK-202 has a cable with a 15-pin sub-D connector, which can directly be connected to the MARK VI control unit.
- The MARK VI control unit.
- This is the versatile instrument with which the ionization chamber can be controlled. All functions are accessible by means of the touch-screen window.
- A power cable
- A well-liner
- A dipper
- A Manual
- An RS-232C Personal Computer cable (Optional)
- A Seiko SLP-240, a STAR DP-8340 or an Epson TMU-295 label printer (Optional)
- A Mo-99 break-through kit (Optional)

1.4 Installation of the Hardware

Be sure to connect the VIK-202 ionization chamber to the display unit before connecting the power cable.

If an optional label printer is supplied with the system, please connect the printer to the MARK VI display unit before plugging in the power cable.

After plugging in the power cable, the MARK VI will produce a short beep. The start-up procedure takes about one minute and the main screen appears.

The VIK-202 needs one-hour to stabilize and to reach its specified accuracy. At the beginning, the measuring value will not yet be zero, but during the stabilization time it will gradually stabilize.

The zero/bias adjustment will take care of the final deviation from zero. Refer to Section 2.2.2 on information how to adjust the bias.

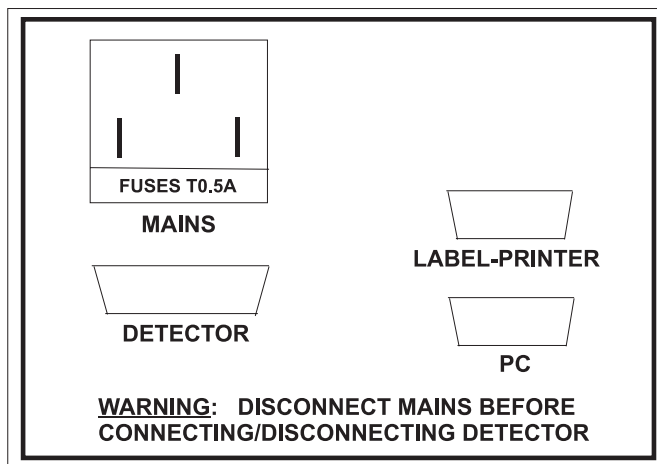


Figure1-1. Back Panel of the MARK VI Display Unit

The MARK VI cannot be switched off in any other way than unplugging the power cable. The best option is to simply leave the MARK VI on at all times.

Section 2 Theory of Operation

2.1 Working with the Dose Calibrator

2.1.1 System Initialization

To configure the MARK VI dose calibrator, push the Menu button and select the System settings menu option.

MARK VI																	
<input type="button" value="Menu"/>	<input type="button" value="Isotope"/>	<input type="button" value="Vial"/>															
<input type="button" value="Daily check"/>	<input type="button" value="Quarterly check"/>																
<div style="font-size: 2em; font-weight: bold;">0.016</div> <div style="font-size: 1.5em; font-weight: bold;">MBq</div> <div style="font-size: 1.2em; font-weight: bold;">Vial</div>		<p>Vial:</p> <p>Isotope:</p> <p>Concentration:</p>															
<p>Isotope: Tc-99m</p> <p>Half-life: 6,02 h</p> <p>Factor: 236 x 1.0</p>		<p>Future dose</p> <p>Required act: <input type="text"/> MBq</p> <p>Applic. Time: <input type="text"/></p> <p>Applic date: <input type="text"/></p> <p>Prepare:</p> <p>Retrieve:</p> <p>Act. on Applic.:</p> <p style="text-align: right;"><input type="button" value="Print label"/></p>															
<p>Measured in: <input type="button" value="Vial"/></p> <p>Correction: 1.0</p>																	
<table style="width: 100%; text-align: center;"> <tr> <td><input type="button" value="Tc-99m"/></td> <td><input type="button" value="Tl-201"/></td> <td><input type="button" value="Ga-67"/></td> <td><input type="button" value="F-18"/></td> <td><input type="button" value="Y-90"/></td> </tr> <tr> <td><input type="button" value="I-123"/></td> <td><input type="button" value="I-125"/></td> <td><input type="button" value="I-131"/></td> <td><input type="button" value="Sm-153"/></td> <td><input type="button" value="Re-186"/></td> </tr> <tr> <td><input type="button" value="Er-169"/></td> <td><input type="button" value="Cs-137"/></td> <td><input type="button" value="Co-57"/></td> <td><input type="button" value="Co-60"/></td> <td><input type="button" value="Ba-133"/></td> </tr> </table>			<input type="button" value="Tc-99m"/>	<input type="button" value="Tl-201"/>	<input type="button" value="Ga-67"/>	<input type="button" value="F-18"/>	<input type="button" value="Y-90"/>	<input type="button" value="I-123"/>	<input type="button" value="I-125"/>	<input type="button" value="I-131"/>	<input type="button" value="Sm-153"/>	<input type="button" value="Re-186"/>	<input type="button" value="Er-169"/>	<input type="button" value="Cs-137"/>	<input type="button" value="Co-57"/>	<input type="button" value="Co-60"/>	<input type="button" value="Ba-133"/>
<input type="button" value="Tc-99m"/>	<input type="button" value="Tl-201"/>	<input type="button" value="Ga-67"/>	<input type="button" value="F-18"/>	<input type="button" value="Y-90"/>													
<input type="button" value="I-123"/>	<input type="button" value="I-125"/>	<input type="button" value="I-131"/>	<input type="button" value="Sm-153"/>	<input type="button" value="Re-186"/>													
<input type="button" value="Er-169"/>	<input type="button" value="Cs-137"/>	<input type="button" value="Co-57"/>	<input type="button" value="Co-60"/>	<input type="button" value="Ba-133"/>													
6080	Operator: NONE	13:00 22-5-03															

Figure 2-1. Selecting the System Settings Menu

NOTE

Every time an empty field which requires the input of alphanumeric data, is activated a virtual keyboard will pop up. When only numeric data is expected, a numeric keyboard will pop up.

After selecting the System Settings option for the first time, the following window will appear.

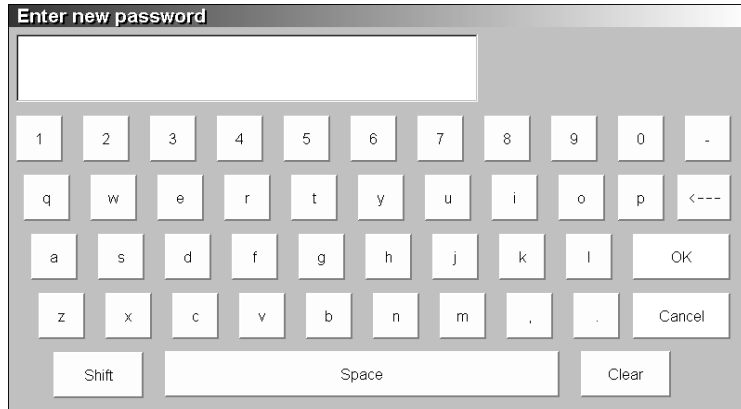


Figure 2-2. The New Password Entry Dialog

The first time the system settings menu is entered the program will ask for a password. Because the system settings feature does allow a user to change important parameters, we have secured it with a password. Changing the system settings will affect the read-out of the dose calibrator. Define a password and enter it twice so the program can check if you entered the password correctly. Now you only need to enter the password (which is now defined) and push OK to continue. The general settings menu will then appear on the screen.

2.1.2 The General System Settings

Clicking on the System settings menu item will result in the following window appearing on the screen.

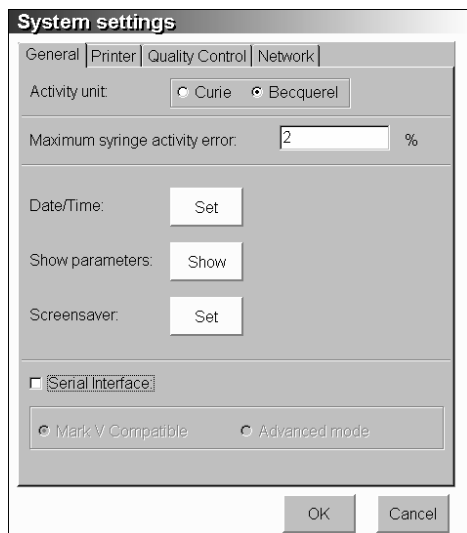


Figure 2-3. The System Settings Window

Most of the fields are pretty much self-explanatory. You can select the desired activity unit, select the error percentage allowed with preparations, set date and time, show the different parameters, set the screensaver delay time, activate the optional printer and adjust several quality control parameters. The tab network settings are added for future implementation.

Most of the settings do not cause any problems. The MARK VI program is able to detect syringe preparation errors. The MARK VI program allows you to enter the measured vials that are going to be used for the patient preparations for a certain day. This information is then used to calculate the actual volume needed for the preparation of the syringes. The activity in the syringe is measured with the ionization chamber. The MARK VI program will compare the actual syringe activity read-out with the calculated activity. If the difference is more or less than the percentage shown in the system settings window, a prompt will be shown on the screen. You can still print a label and accept the value but it is a way to hint the user that there may be a problem with that particular syringe.

When the MARK VI is connected to a personal computer, the serial interface and the MARK V compatible option needs to be checked. The MARK VI sends out measuring data every two or three seconds to the PC. This data can be logged. The advanced mode is only intended for service purposes.

2.1.3 The Printer Settings

The MARK VI can make use of a printer to generate labels. To set the label size, click on the printer settings tab in the System settings window. The following window will appear on the screen.

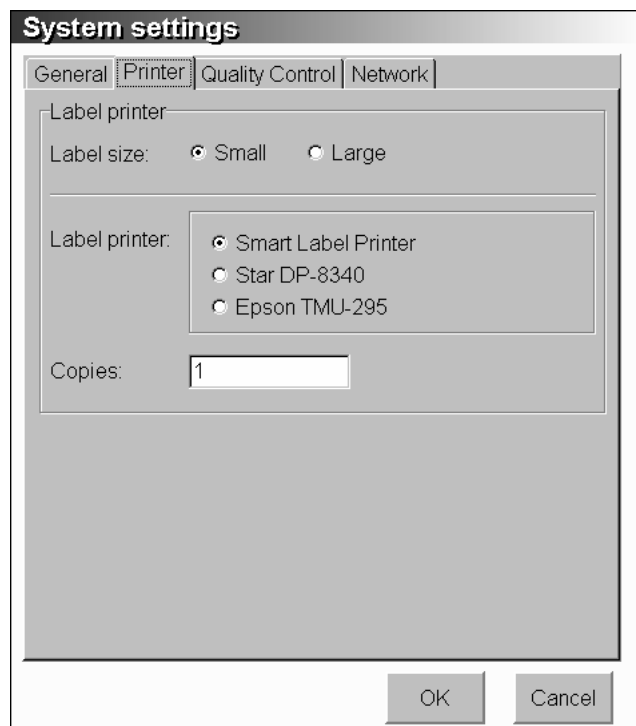


Figure 2-4. The Printer Settings Window

You can choose between a small and a larger size label and three different printer models. The copies field is used to print a sequence of identical labels.

The dimensions of the labels are:

- Small 89 x 28 mm
- Large 89 x 54 mm

2.1.4 The Quality Control Settings

The quality control system menu (Figure 2-5) is used to set additional information for the different quality control tests.

There are five parameters that can be set: the maximum contamination allowed for dipper and well liner, Mo99 breakthrough, Zero effect, Accuracy and Linearity.

1. Maximum contamination allowed for dipper and well liner is set to 100 kBq. If desired, the user can modify this value here.
2. Mo99 Breakthrough:
 - Maximum contamination: The contamination percentage must apply to this value. The default value is 0.01%.
3. Zero Effect:
 - Bias current scale: The bias current must lie between the two values entered here. Recommended settings are between 0.05 and 0.20.
4. Accuracy:
 - Maximum deviation: The error percentage must not be larger than this value. The default value is $\pm 3\%$.
5. Linearity:
 - Maximum deviation: The linearity error must not be larger than this value. The default value is $\pm 2\%$ and $\pm 5\%$ for the Calicheck linearity test.

Now that the system settings have been set to the correct values and the printer settings are such that labels can be printed, it is time to continue with the next section that explains how to set-up the ionization chamber.

The screenshot shows a dialog box titled "System settings" with four tabs: "General", "Printer", "Quality Control", and "Network". The "Quality Control" tab is selected. It contains several input fields for setting quality control parameters:

- Dipper/Well liner contamination:** Maximum contamination: 100 kBq.
- Molybdeen breakthrough:** Maximum contamination: 0.01 %.
- Zero effect/Auto bias:** Current scale: 0,05 pA till 0,20 pA.
- Accuracy test:** Maximum deviation: 3,0 %.
- Linearity test:** Maximum decay deviation: 2,0 %; Maximum calicheck deviation: 5,0 %.

At the bottom of the dialog box are "OK" and "Cancel" buttons.

Figure 2-5. The Quality Control Settings

2.2 Setting Up the Ionization Chamber

The ionization chamber, Model VIK-202, is an intelligent measuring device. The ionization chamber itself is connected to an amplifier and micro controller board. All this is build together with a high-tension battery into the ionization chamber's housing. The ionization chamber accepts commands from a master system over the serial line. It responds to these commands by executing the desired action and sending back the appropriate response.

There are commands that have to do with the actual measurement, the high voltage battery and the amplifier settings. The next subsections describe the different commands in more detail.

The commands needed for a proper set-up of the chamber are: Background subtraction, and via the VIK Quality control menu Zero check, BIAS adjustment and High Voltage check.

Furthermore, the reference sources that are going to be used for the Chamber Accuracy and Constancy Tests need to be defined. If one is going to use the CaliCheck linearity test kit (optional), this also needs to be calibrated before first use. Both items can be found in the VIK Quality control menu.

2.2.1 Background Subtraction

The background subtraction feature of the ionization chamber can be switched on and off. Switching the background subtraction function on by clicking on the background subtraction menu option will numerically subtract the current measured background value from the following assay's, until it is switched off again.

You can see that the background subtraction feature is active by looking at the text in the upper left corner of the MARK VI main screen. If the background subtraction feature is active, the text Background Subtracted will be displayed (Figure 2-6).

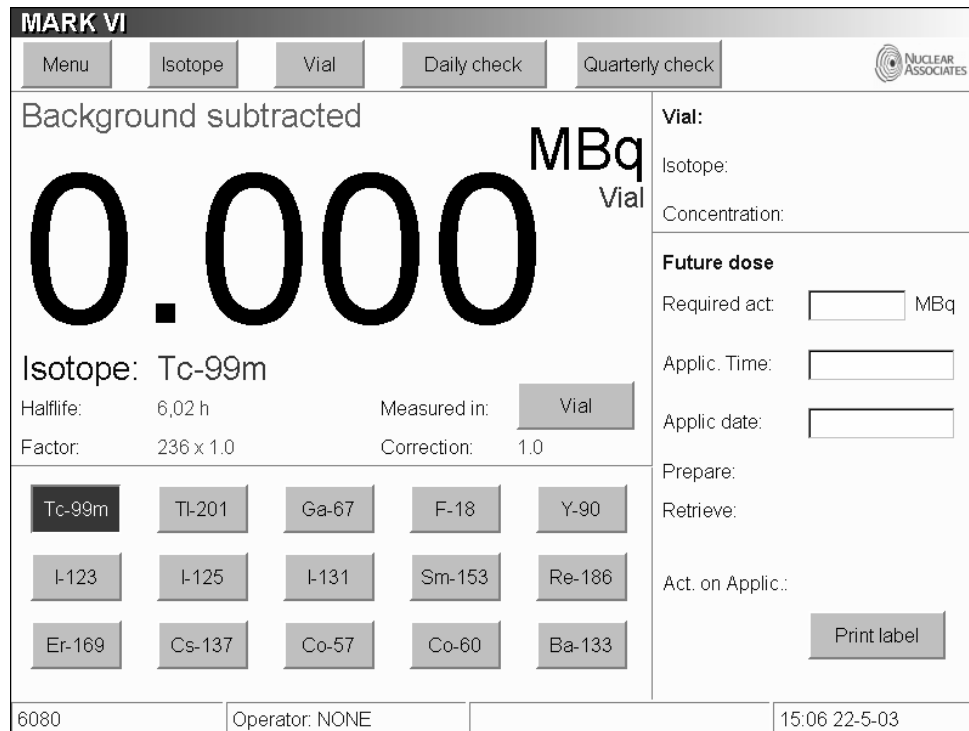


Figure 2-6. The Background Subtraction Function is Switched On

It is very important to check that there is no activity in the ionization chamber before the background subtraction option is activated. Switching the background subtraction on will effectively remove the offset caused by any activity in the ionization chamber.

Switching the background subtraction off is accomplished by clicking on the Background subtraction menu item in the file menu once more. The background subtraction text will be removed from the screen to reflect the correct background status.

The background subtraction should only be used when measuring low activities or when there is a temporary increase of the background level. Long-term background changes should be corrected with the zero/bias adjustment. Avoid leaving on the background subtraction function for prolonged periods of time. You are masking a possible high background value that could influence the accuracy of the instrument in a negative way.

2.2.2 ZERO Adjustment

The Mark VI Dose Calibrators has a special feature that allows them to zero the amplifier completely automatically. Click on the ZERO adjustment option in the Quality Control menu to activate this function.

For a correct measurement of the zero setting, all activity needs to be removed from the chamber. It is advised to also remove the well liner and dipper from the well. After starting the measurement, the following window (see Figure 2-7) appears on the screen.



Figure 2-7. Warning Window

After 45 seconds, the result will be shown on the screen (Figure 2-8). Two values will be produced, the PREAMP and the ITOUB value.

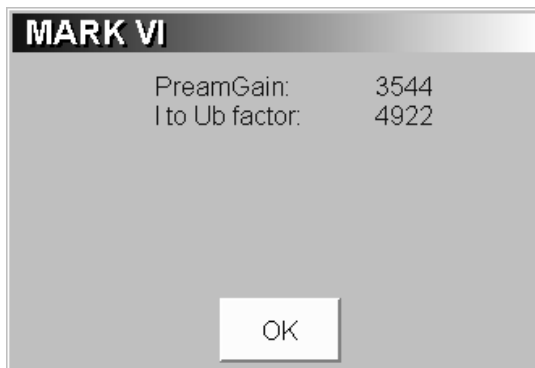


Figure 2-8. The ZERO Calibration Results

These two values should correspond to the values indicated on the calibration sheet. Perform these procedures on a regular basis (daily check).

2.2.3 BIAS Adjustment

Adjusting the BIAS setting is necessary to obtain a near zero readout from the ionization chamber. The amplifier that is connected to the ionization chamber has to amplify the very small currents generated by the ionization chamber. These currents are so faint that the stray current that exists in any electronic circuit has to be compensated. The BIAS adjustment dialogue allows you to do so.

From the Main Menu select Quality Control and from the Quality Control menu, click on the Bias adjustment menu. The following window will appear on the screen.

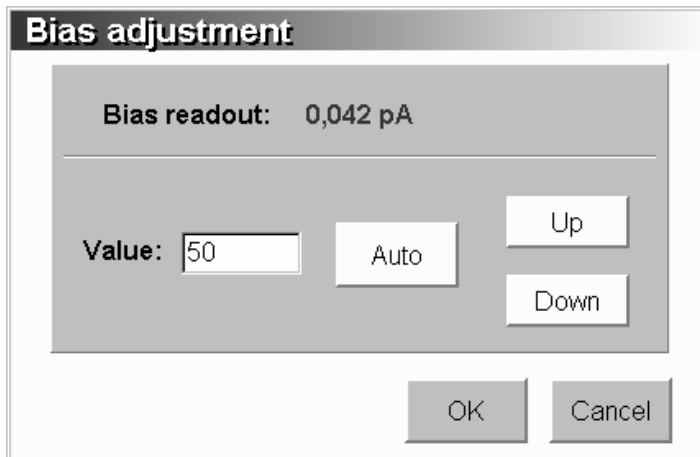


Figure 2-9 The BIAS Adjustment Dialog Window

The current read-out should be about 0.1 pA. Increasing the BIAS adjustment value by entering a higher value in the edit box will result in a lower current read-out (and vice-versa). When the current read-out is between 0.08 and 0.1 pA, the BIAS adjustment window can be closed with the OK button. It is also possible to adjust the bias automatically by pressing the auto button.

2.2.4 High Voltage Check

The VIK-202, the ionization chamber, has a built-in high-tension battery. This battery provides a 155-Volt nominal high-tension for the ionization chamber. Without this high tension the ionization chamber cannot produce an output current. It is very important to check the high tension setting on a regular basis to ensure a reliable operation of the dose calibrator. The life expectancy of the battery is 8 to 10 years. Only a very small current is drawn from the battery and the cells themselves are of a high quality and very stable over time.

To check the actual high-tension level, click on the High voltage check option in the Quality Control menu. Executing this command will instruct the ionization chamber's amplifier to measure its own battery and report back the result. The result will be displayed on the screen. For a correct measurement of the high voltage setting, all activity needs to be removed from the chamber. Therefore, after starting the measurement the following window (see Figure 2-10) appears on the screen.



Figure 2-10. Warning Window

After you convinced yourself that all activity has been removed you can start the program by clicking on the OK button.

During the measurement the following window will appear on the screen.

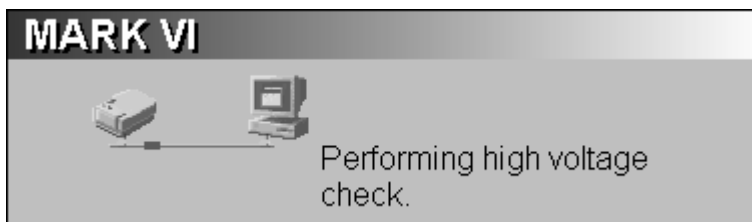


Figure 2-11 Obtaining the Battery High Tension

It takes the ionization chamber a while to measure the battery high tension. During this measurement the user is informed about the current status. As long as the communication between the PC and the ionization chamber is going on, this screen is shown. After about five seconds the next screen will appear.

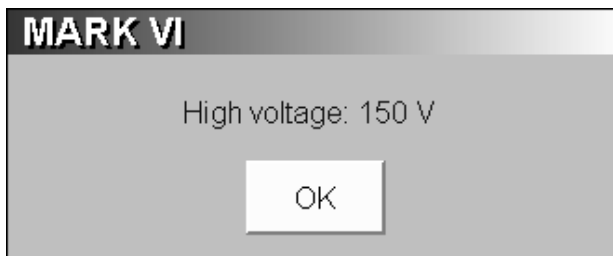


Figure 2-12. The Battery Check Result

The high-tension settings indicated should be over 135 Volt. If this high-tension result is below the 135 Volt, then first perform a ZERO adjustment (see Section 2.2.2) and BIAS (see Section 2.2.3) and measure the battery voltage afterwards. Performing a ZERO/BIAS adjustment before performing a battery voltage measurement will ensure that the amplifier is working correctly. If the high-tension setting remains too low, then contact Fluke Biomedical, Radiation Management Services so we can arrange to have the unit repaired.

It is normal that the activity read-out of the ionization chamber is higher than the background level right after a battery measurement. The signal generated by the battery upsets the amplifier in such a way that it takes a couple of seconds before the read-out is back to the background level.

2.2.5 Definition of the Reference Sources

The reference sources (Standard sources) are used for the Chamber Accuracy and Constancy Tests.

The Chamber Accuracy and Constancy may be tested using Co57, Co60, Ba133, Cs137 or Ra226. There can be a test source for each of these nuclides. One or more of the test sources must be designated as the source to be used in the Daily Check. One of the daily sources must be designated as the source to be used for the Constancy Test. Mostly Cs137 is selected for this purpose due to its long half-life.

The Reference sources menu allows you to enter or edit data for any reference source and to choose if the source will be used for a constancy test, an accuracy test or both. Also, you can indicate if the defined source will be used for the daily check and/or quarterly check.

From the VIK Quality control menu select Reference sources. The following window will appear (Figure 2-14).

Figure 2-13. The Reference Sources Menu

To add or edit the reference source data click one of the desired buttons. The next window will appear (Figure 15).

Figure 2-14. The Reference Source Main Menu

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A name for the source can be chosen freely. It would be a good idea to use the serial number of the source for identification purposes. The desired isotope can be chosen from the available isotopes in the list. In case an isotope is not present it can be added through the Isotopes menu (see Section 2-5).

The reference activity, reference time and reference date of the standard source, needed for the accuracy test can be found on the calibration certificate that is supplied by the manufacturer of the source.

To use the source for a Constancy test you have to measure the actual activity of the source to obtain a reference value. Put the source into the chamber and click on the Measure button. The measured activity, time and date of measurement are automatically filled in.

In the daily check field you can indicate if the source will be needed for the Daily Check procedure. Finally, you can decide for which tests you want to use the source: the Accuracy test, the Constancy test or both. To save all entered data click on the OK button.

2.2.6 Calibration of the CaliCheck Linearity Test Kit (Optional)

As an option, the so-called CaliCheck kit for performing linearity measurements can be used. Before using this kit a calibration needs to be done. From the VIK Quality control menu select CaliCheck calibration. The following window will appear (Figure 2-15).

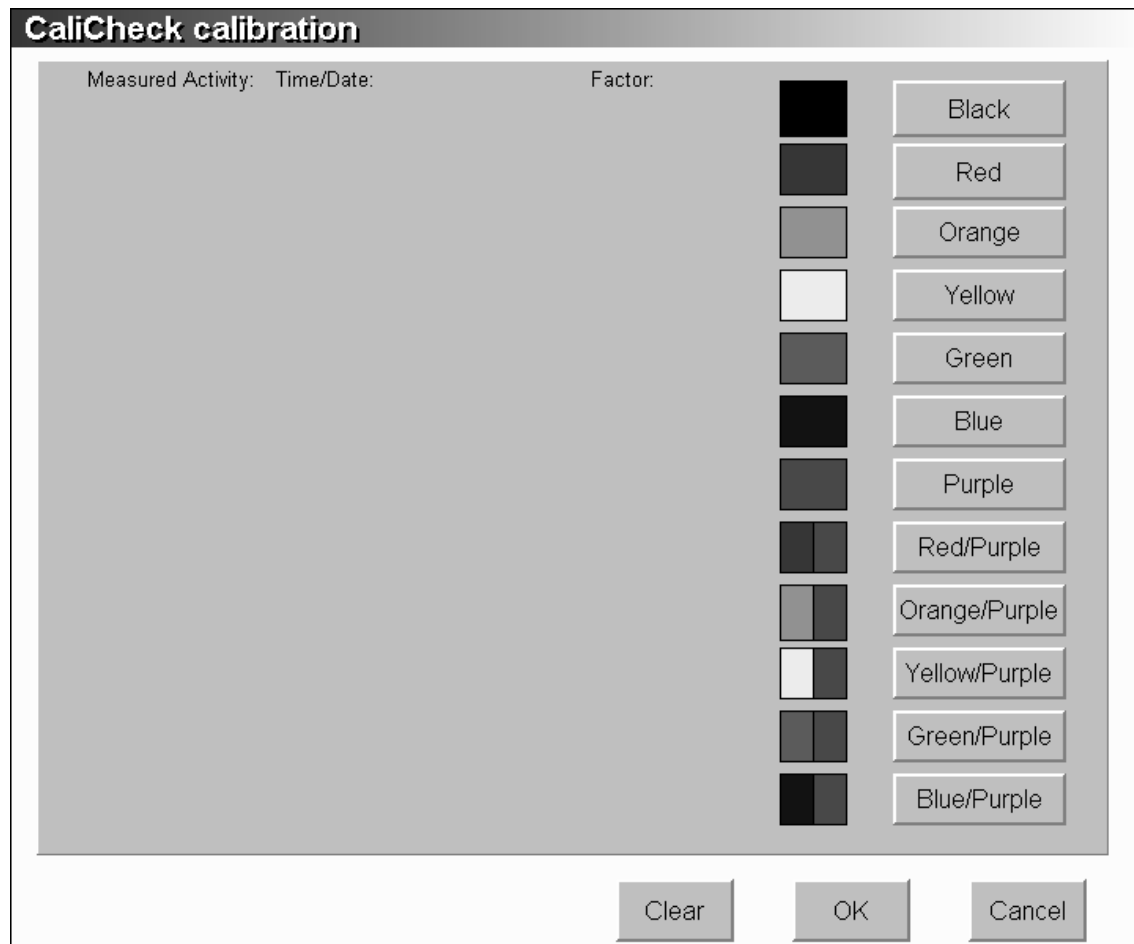


Figure 2-15. The Calicheck Calibration Window

A source of Tc-99m is placed into the central black tube. This source is placed in the dose calibrator. The measurement is started by clicking the Black button and a calibration factor is calculated. Place the red tube in the dose calibrator over the black tube and start the measurement by clicking the Red button.

Replace the red tube with the orange one and start the next measurement by clicking the Orange button. Keep on performing the measurements according to the instructions received with the CaliCheck kit.

The results will look something like this (see Figure 2-16):

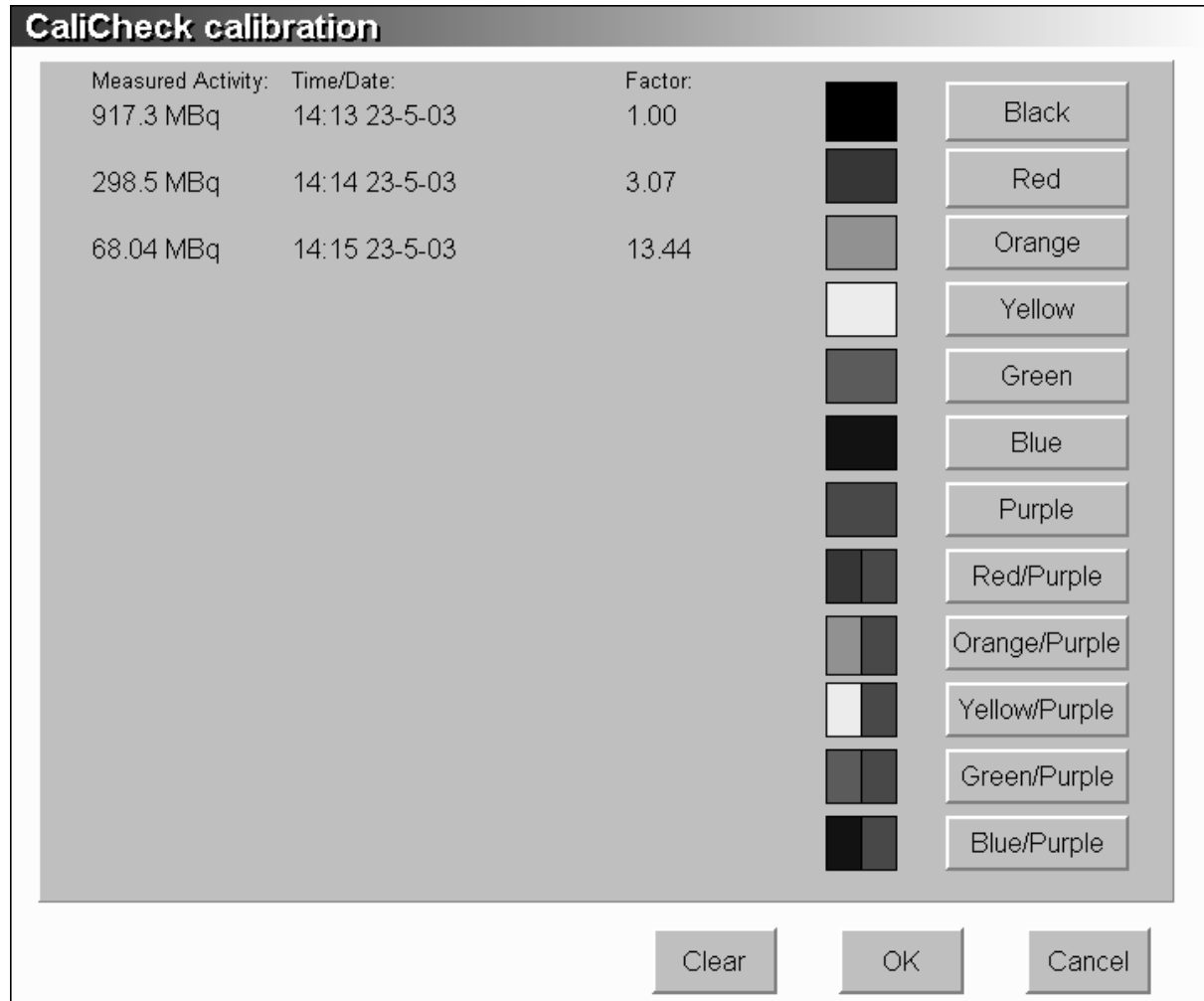


Figure 2-16. The CaliCheck Calibration Factors

After performing all measurements one can save the data by clicking on the OK button.

2.3 Quality Control

The MARK VI dose calibrator has a built in feature to check the performance of the unit on a regular basis. There are two procedures, a Daily check and a Quarterly check. To insure proper operation of the MARK VI the following test should be performed at the indicated intervals.

2.3.1 Daily Check

The daily check should be conducted at the beginning of each working shift, prior to measuring any samples, which will be administered to patients. In practice this results in a daily-performed test.

The daily check consists of a battery check, a system check, an auto bias and auto zero operation, accuracy and constancy test and finally a dipper/well liner contamination test. The program is started by clicking on the Daily check button. The following window will appear.

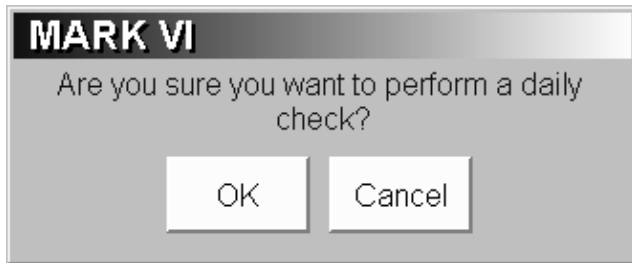


Figure 2-17. Confirmation Window

If you accidentally pushed the wrong button, you have the opportunity to cancel the test. If you are certain that you want to perform the Daily check procedure, you can start the program by clicking on the OK button. During the performance of the Daily QC procedure an extra window will appear. This window gives you an indication about the tests that already have been completed and the tests that still need to be performed.

2.3.1.1 System Check

The instrument internal databases are checked. In case of an inconsistency, it is possible to restore a back up of the database. If this procedure fails, you should consult the manufacturer.

2.3.1.2 Auto Zero Adjustment

The Mark VI Dose Calibrators has a special feature that allows them to zero the amplifier completely automatically. Click on the ZERO adjustment option in the Quality Control menu to activate this function. For a correct measurement of the zero setting, all activity needs to be removed from the chamber. It is advised to also remove the well liner and dipper from the well. After starting the measurement, the following window (see Figure 2-18) appears on the screen.

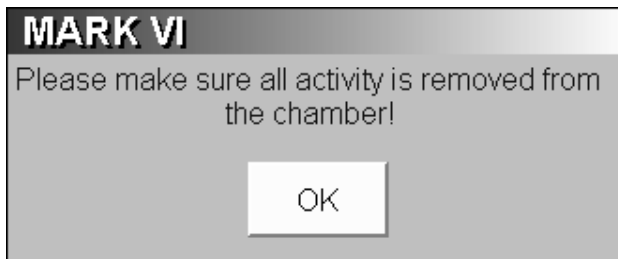


Figure 2-18. Warning Window

After 45 seconds, the result will be shown on the screen (Figure 2-19). Two values will be produced the PREAMP and the ITOUB value.

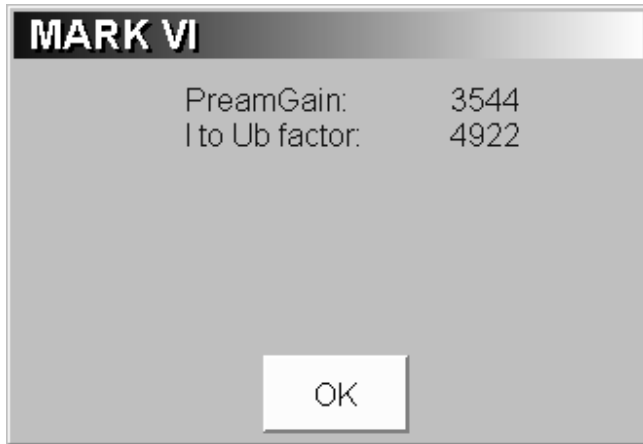


Figure 2-19. The ZERO Calibration Results

These two values should correspond to the values indicated on the calibration sheet. The ZERO adjustment window can be closed with the OK button.

2.3.1.3 Auto BIAS Adjustment

Adjusting the BIAS setting is necessary to obtain a near zero readout from the ionization chamber. The amplifier that is connected to the ionization chamber has to amplify the very small currents generated by the ionization chamber. These currents are so faint that the stray current that exists in any electronic circuit has to be compensated. The BIAS adjustment dialogue allows you to do so (see also Section 2.2.3).

The following window will appear on the screen (see Figure 2-20).

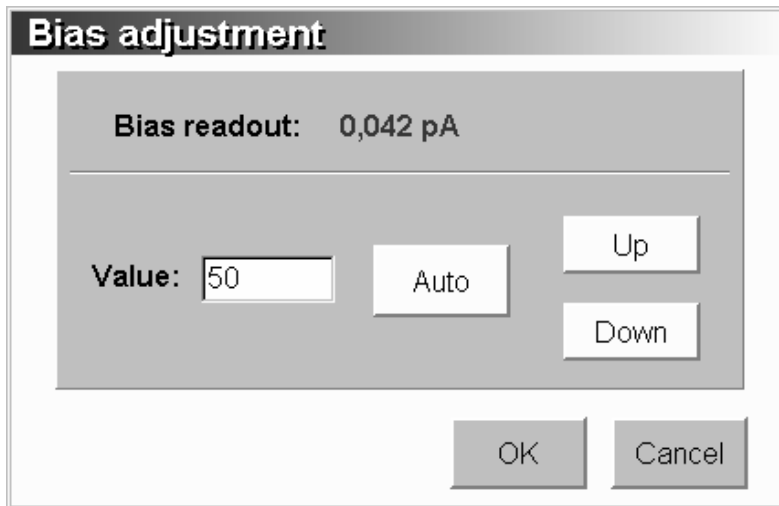


Figure 2-20. The BIAS Adjustment Dialog Window

The current read-out should be about 0.1 pA. Adjust the bias automatically by pressing the Auto button. The test starts and the text of the Auto button changes in Abort. This gives you the possibility to abort the test procedure if wanted. When the test is finished, the button text changes back to Auto again. The BIAS adjustment window can now be closed with the OK button.

2.3.1.4 The Zero Effect Measurement

The zero effect measurement is performed to determine if the read out of the chamber is stable when there is no activity inside the ionization chamber. The program will first retrieve the bias setting. Then it takes 10 measurements and will show the results in the left part of the window.

Press the Start button. The test starts and the text of the Auto button changes in Abort. This gives you the possibility to abort the test procedure if wanted. When the test is finished, the button text changes back to Start again. The BIAS adjustment window can now be closed with the Close button.

If the 10 results are obtained, the end result will be shown in the lower part of the window. The time and date of the measurement are shown together with the bias settings, the amplifier settings and the avg. background at the time of measurement (Figure 2-21).

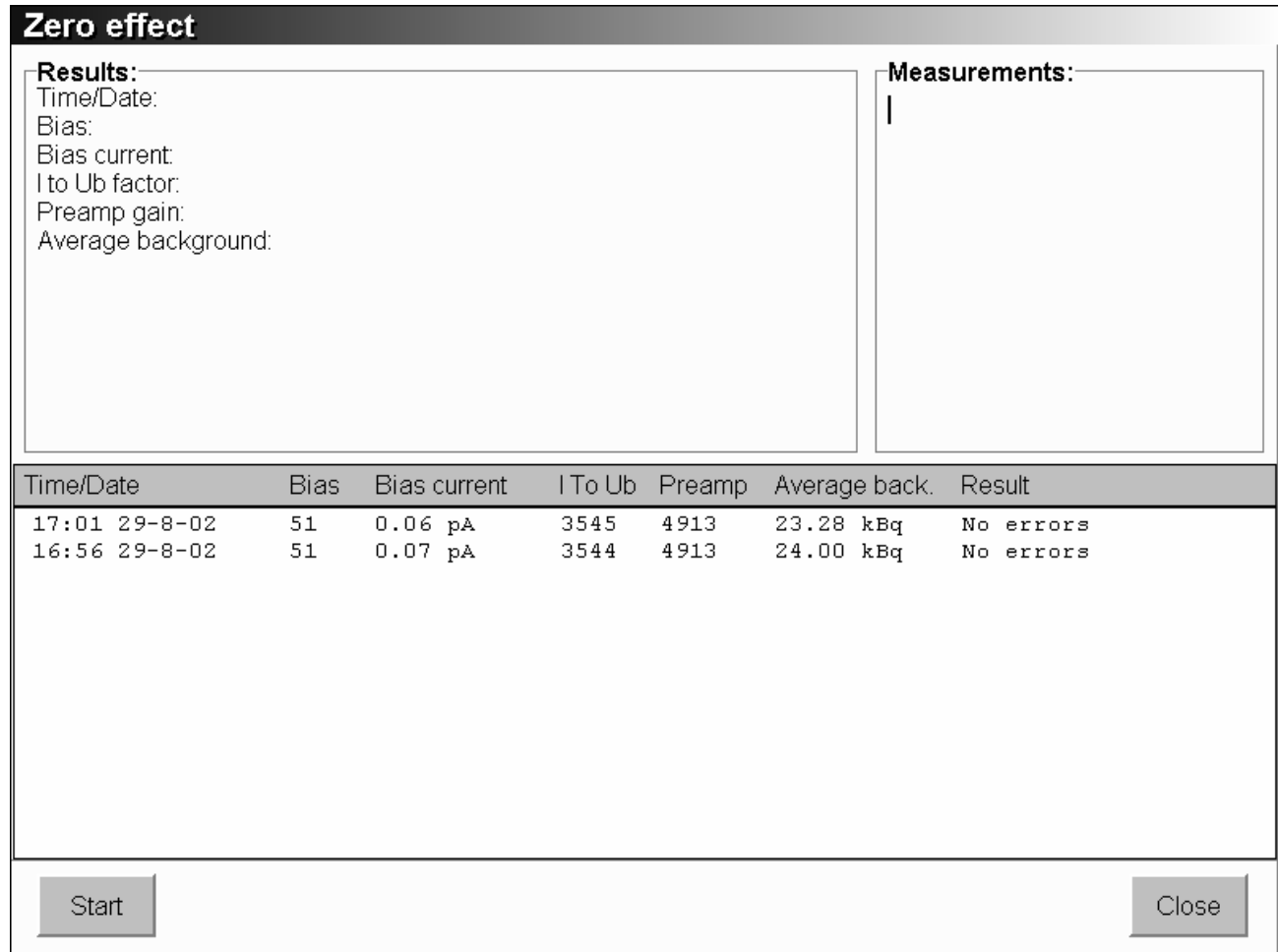


Figure 2-21. The Zero Effect Measurement

2.3.1.5 The Accuracy and Constancy Measurement

The Accuracy and Constancy measurement is a straightforward reference source measurement. The Accuracy and Constancy test enables you to monitor the performance of the calibrator by measuring the same source over and over for a long period of time.

After clicking the Start button, you will be stepped through performing the Accuracy test for all sources that have been designated as a Daily check source. The measured value is compared with subsequent measurements of the same source and the error percentage is given (Figure 2-22)

Accuracy test

Results: Time/Date: Reference source: Isotope: Ref. activity: Ref. time/date: Calculated activity: Measured activity: Current time/date: Deviation:		Measurements:			
Time/Date	Ref. Source	Isotope	Calculated Act.	Measured Act.	Deviation
17:18 22-5-03	Co-57 Accu	Co-57	3.62 MBq	3.58 MBq	-3.13 %
17:17 22-5-03	Co-57 Accu	Co-57	3.62 MBq	3.63 MBq	-2.18 %
17:12 22-5-03	Co-57 Accu	Co-57	2.94 MBq	0.016 MBq	Aborted
17:11 22-5-03	Co-57 Accu	Co-57	2.94 MBq	0.016 MBq	Aborted

Start OK

Figure 2-22 The Accuracy Test Measurement

If the source also is being used for a Constancy test, you will be instructed to perform the Constancy test as well (see Figure 2-23).

Constancy test

Results: Time/Date: Reference source: Isotope: Ref. activity: Ref. time/date: Calculated activity: Measured activity: Current time/date: Deviation:		Measurements:			
Time/Date	Ref. Source	Isotope	Calculated Act.	Measured Act.	Deviation
17:18 22-5-03	Cs-137 Cons	Cs-137	3.57 MBq	3.60 MBq	0.65 %
17:12 22-5-03	Cs-137 Cons	Cs-137	3.00 MBq	0.016 MBq	Aborted

Start OK

Figure 2-23 The Constancy Test Measurement

2.3.1.6 The Dipper/Well Liner Contamination Test

This is a simple test procedure to test for contamination of the dipper and well liner. The system checks against Tc99m contamination. After clicking the Start button, you will be stepped through the test re first asked to remove the dipper and well liner. After pressing the OK button, the measurement starts.

Dipper/Well liner check

<p>Results:</p> <p>Time/Date: 11:47 23-5-03 Without dipper/well liner: 0.014 MBq With dipper/well liner: 0.024 MBq Contamination: Not contaminated!</p>	<p>Measurements:</p>
---	-----------------------------

Time/Date	With dipper	Without dipper	Contamination	Result
11:47 23-5-03	0.024 MBq	0.014 MBq	0.010 MBq	Not contaminated!
11:47 23-5-03				
17:12 22-5-03				

Start
OK

Figure 2-24. The Dipper/Well Liner Window

A window will appear with the results of the contamination test. In case of a contamination the following warning window will be displayed.

MARK VI

Dipper/Well liner contaminated!

OK

Figure 2-25. Contamination Warning Window

If there is a contamination you have to check afterwards by measuring the dipper and well liner separately which of the two is causing the contamination. Should either the dipper or the well liner exhibit contamination greater than 100 kBq (ca. 3 µCi), they should be decontaminated or replaced. This user-defined limit can be changed in the system settings.

2.3.1.7 High Voltage Check

The VIK-202, the ionization chamber, has a built-in high-tension battery. This battery provides a 155-Volt nominal high-tension for the ionization chamber. Without this high tension the ionization chamber cannot produce an output current. It is very important to check the high tension setting on a regular basis to ensure a reliable operation of the dose calibrator. The life expectancy of the battery is 8 to 10 years. Only a very small current is drawn from the battery and the cells themselves are of a high quality and very stable over time.

To check the actual high-tension level click on the High voltage check option in the Quality Control menu. Executing this command will instruct the ionization chamber's amplifier to measure its own battery and report back the result. The result will be displayed on the screen. For a correct measurement of the high voltage setting all activity need to be removed from the chamber. Therefore, after starting the measurement, the following window (see Figure 2-26) appears on the screen.

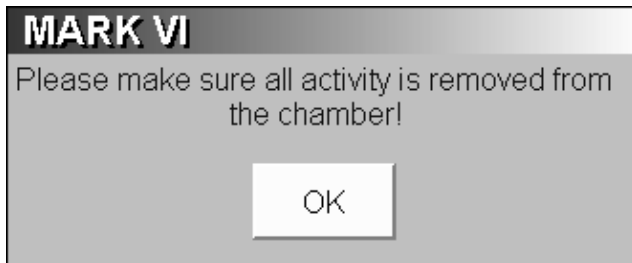


Figure 2-26. Warning Window

After you convinced yourself that all activity has been removed, you can start the program by clicking on the OK button.

During the measurement the following window will appear on the screen.

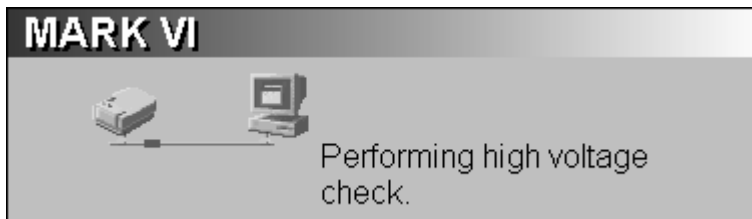


Figure 2-27. Obtaining the Battery High Tension

It takes the ionization chamber a while to measure the battery high tension. During this measurement the user is informed about the current status. As long as the communication between the PC and the ionization chamber is going on, this screen is shown. After about five seconds, the next screen will appear.

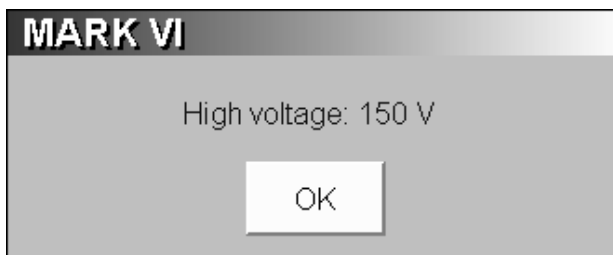


Figure 2-28. The Battery Check Result

The high-tension settings indicated should be over 135 Volt. If this high-tension result is below the 135 Volt, then first perform a ZERO adjustment (see Section 2.2.2) and BIAS (see Section 2.2.3) and measure the battery voltage afterwards. Performing a ZERO/BIAS adjustment before performing a battery voltage measurement will ensure that the amplifier is working correctly. If the high-tension setting remains too low, then contact Fluke Biomedical, Radiation Management Services so we can arrange to have the unit repaired.

It is normal that the activity read-out of the ionization chamber is higher than the background level right after a battery measurement. The signal generated by the battery upsets the amplifier in such a way that it takes a couple of seconds before the read-out is back to the background level.

When all test are finished, the following confirmation window appears. The window can be closed by clicking on the OK button.

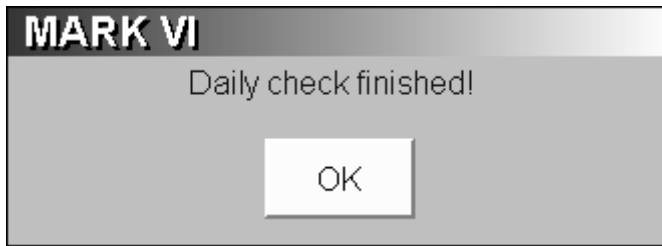


Figure 2-29. Confirmation Window

2.3.2 Quarterly Check

The quarterly check should be conducted once every three months. The quarterly check consists of the normal Daily check, an Accuracy test for those nuclides that are not used in the Daily check and finally a Linearity test. The program is started, by clicking on the Quarterly check button. The following window will appear.

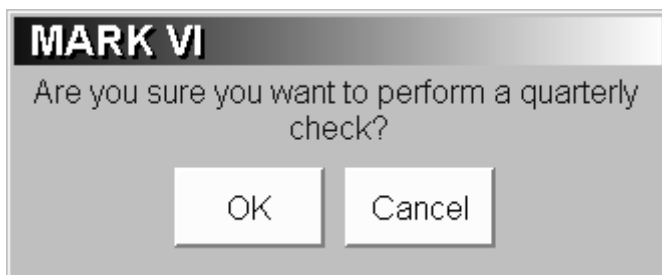


Figure 2-30. Confirmation Window

If you accidentally pushed the wrong button, you have the opportunity to cancel the test. If you are certain that you want to perform the Quarterly check procedure, you can start the program by clicking on the OK button. During the performance of the Quarterly QC procedure an extra window will appear. This window gives you an indication about the tests that already have been completed and the tests that still need to be performed.

2.3.2.1 The Linearity Measurement

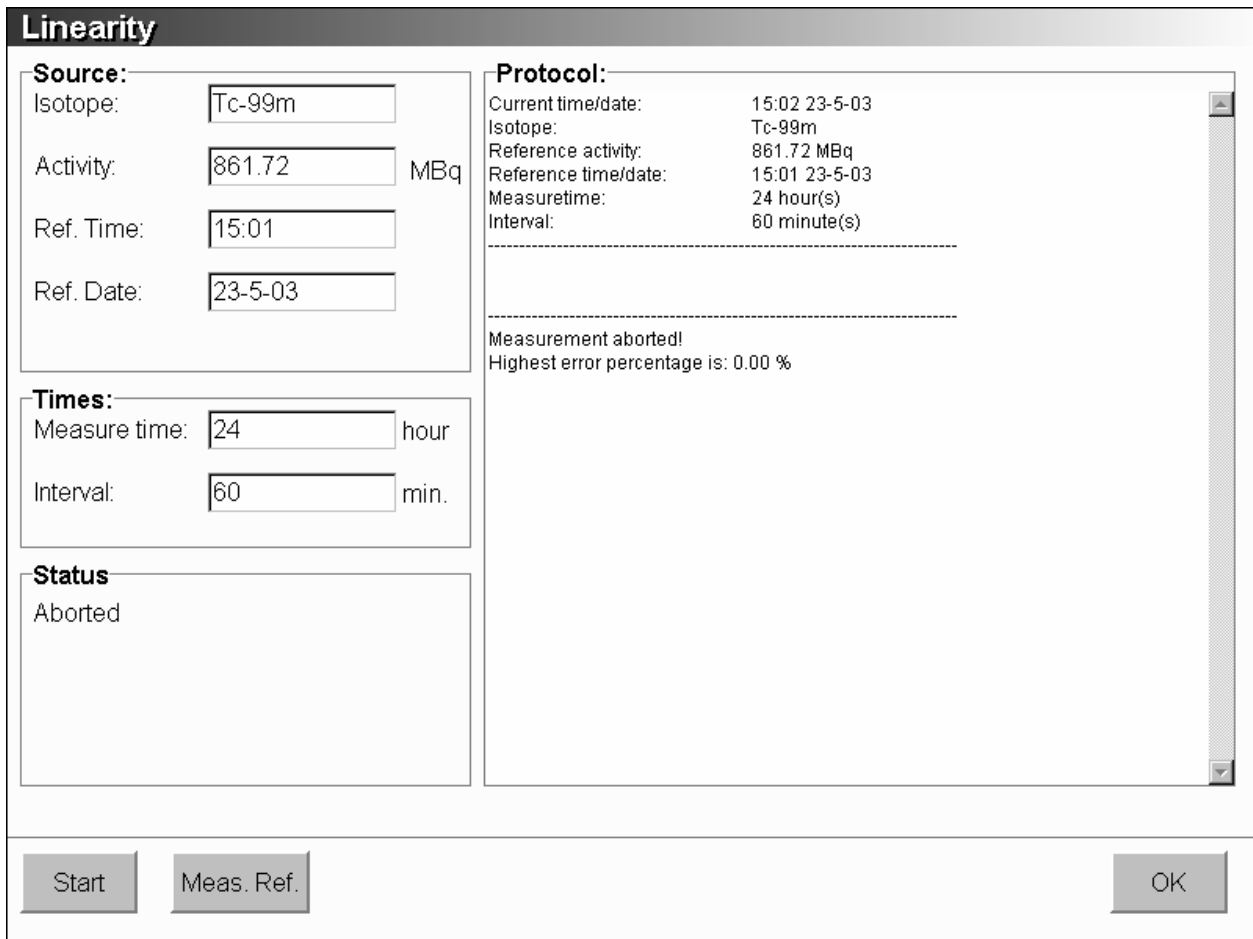
The ionization chamber can measure activity from background levels up to 200 GBq (6 Ci). To do this the amplifier has to cover six decades of measuring range. The unit must be linear over the entire range within a certain margin. The linearity test function can check if this is the case. The user can choose between two different methods for measuring the linearity of the system, the decay method and the Calicheck method.

Using the decay method, Tc-99m can be used to measure the linearity curve over for example the weekend. The test assumes that there is enough activity to be measured in the highest range. The best isotope to use for this test is Tc-99m. Tc-99m has a half-life time value of about six hours.

As an alternative, the user has the opportunity to use the so-called Calicheck test kit (optional). With this method the linearity test can be performed within approx. 15 minutes. The following screen will appear.



Figure 2-31. Linearity Test Window



After selecting the Decay method, the following window appears:

Figure 2-32. The Linearity Measurement

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To perform a new linearity test press the Start button. Now all the values of the source have to be entered. The activity of the selected source can be entered or measured with the Meas. ref. button. Also the total measurement time and the interval have to be entered. After all values are entered, press the Start button. The test starts and the text of the Start button changes in Abort. This gives you the possibility to abort the test procedure if wanted. When the test is finished, the button text changes back to Start again. The window can now be closed with the OK button.

The linearity test can also be paused. Click on the Abort button and the measurement will be stopped. When at a later moment the Start button is clicked, the measurement will resume. When the end activity has been reached, the linearity measurement will stop automatically and cannot be resumed.

Measured Activity: Time/Date:	Factor:	Calc. Activity:	Error (%)	Old Error (%)	
	1.00				Black
	3.07				Red
	13.44				Orange
	67.44				Yellow
	197.08				Green
	201.18				Blue
	197.14				Purple
	208.17				Red/Purple
	284.58				Orange/Purple
	546.46				Yellow/Purple
	1113.41				Green/Purple
	11328.49				Blue/Purple

Mean activity on black measurement time/date:

OK Cancel

After selecting the (optional) CaliCheck method the following window appears:

Figure 3-33. Calicheck Linearity Measurement

The Calicheck measurements needs to be performed according to the instructions found in the instruction manual delivered by the supplier of the CaliCheck kit.

2.3.3 The Molybdenum Breakthrough Measurement

This quality check does not refer to the ionization chamber itself, but to the quality of the eluate from the Technetium generator. It is a very common measurement and the MARK VI dose calibrator program provides an effective solution for this type of measurement.

Clicking on the Molybdenum breakthrough item in the main menu on the main screen will result in the following screen to appear on the monitor.

Time/Date	Mo-99 back	Mo-99	Tc-99m back	Tc-99m	Contamination

Figure 2-34. The Molybdenum Breakthrough Measurement

To start the measurement click on the Start button. The test starts and the text of the Auto button changes in Abort. This gives you the possibility to abort the test procedure if wanted. When the test is finished, the button text changes back to Start again. The Mo-99 Breakthrough window can now be closed with the OK button. The program will guide you through the molybdenum measurement. It will indicate on the screen what is expected at certain stages of the measurement procedure. Then for every measurement 10 values are taken from the chamber and displayed in the upper right window. The end result is displayed in the bottom window.

2.4 Calibrating the Ionization Chamber

The ionization chamber's output signal is dependent on the isotope that is measured with it. When the unit leaves the Veenstra factory it is calibrated. To be able to calibrate the unit easily both in the workshop and in the field, the program has been equipped with the calibration feature. The calibration is performed with three isotopes Co-57, Co-60 and Cs-137. The nominal activity of these sources must be known before the calibration can be performed.

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The calibration procedure makes use of the three sources by adjusting the calibration factors in such a way that the read-out is correct for Co-57 (122 keV), Co-60 (1173/1333 keV) and Cs-137 (662 keV).

After selecting the calibration menu item, the following window appears.



Figure 2-35. The Password Entry Dialog

Because the calibration feature does allow a user to change important parameters, we have secured it with a password.

WARNING

Changing the calibration settings will affect the read-out of the dose calibrator.

After entering the password, the calibration menu screen will be shown.

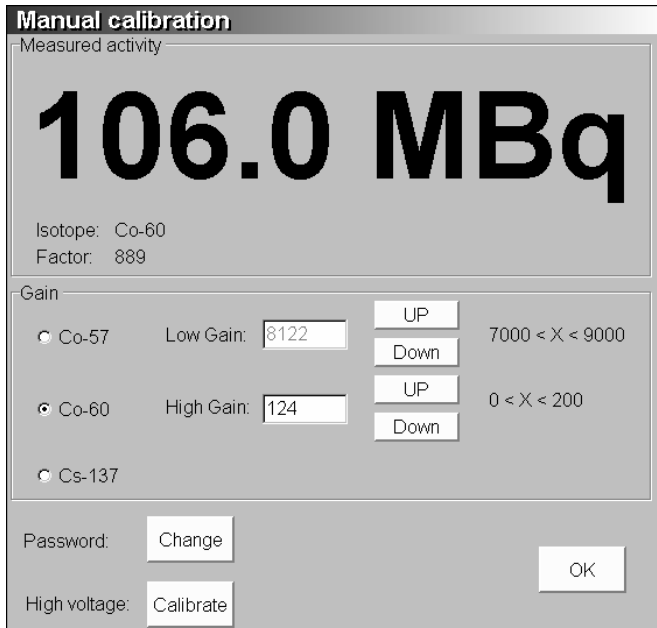


Figure 2-36. The Calibration Dialog Window

There are two fields that can be edited, the Co-57 and the Co-60 field. The values given are equal to the values on the calibration certificate that you received with the unit when it was shipped.

Insert the Co-57 source into the chamber and adjust the “low” field in such a way that the read-out equals the nominal activity of the source at this particular moment. Insert the Co-60 and do the same with the “high” field. It may be necessary to repeat the above steps a number of times over. Changing the one factor will affect the other one.

When the calibration is performed in this way the calibration can be checked with Cs-137. Click on Cs-137 and check the value on the screen. Cs-137 is in the middle of the energy range and the two Cobalt's are on the sides of the range. If the Cs-137 value is indicated correctly, then the unit is calibrated and ready for use. Normally, it should be possible to calibrate the instrument within $\pm 2\%$ with these three sources.

Within the calibration menu it is also possible to change your password. After clicking the Change button, you are asked to enter a new password. After a confirmation, the new password is valid.

The High voltage calibrate option is only meant for service purposes.

2.5 Working with the Isotope Database

The MARK VI program has a built-in isotope database. The content of this database is used to set the ionization chamber settings correctly when an isotope is selected. Parameters such as energy and isotope setting along with the half-life time are important for certain system functions.

The program is started by clicking on the Isotope button. The following window will appear.

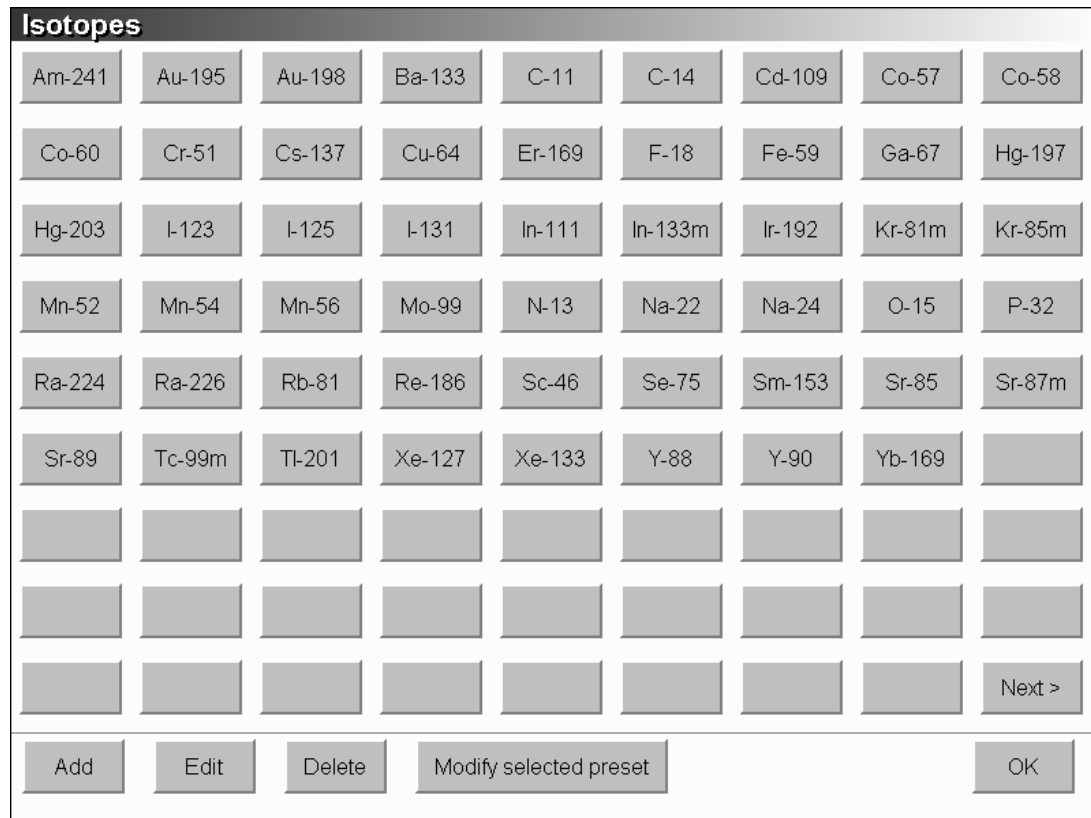


Figure 3-37. The Isotope Menu

The menu has items to insert, edit, delete and modify the selected pre-sets. The first three items are password protected. When one of these three menu items is selected, the following password dialog will appear on the screen.

WARNING

Be aware to select the correct isotope.

The image shows a 'Password Entry Dialog' window. At the top is a title bar with the text 'Enter password'. Below the title bar is a rectangular text input field. Underneath the input field is a virtual keyboard layout. The keyboard consists of several rows of buttons: the first row contains numbers 1 through 0 and a hyphen/underscore key; the second row contains letters q, w, e, r, t, y, u, i, o, p, and a left arrow key; the third row contains letters a, s, d, f, g, h, j, k, l, and an 'OK' button; the fourth row contains letters z, x, c, v, b, n, m, comma/semicolon, apostrophe/quotation mark, and a 'Cancel' button. At the bottom of the dialog are three larger buttons: 'Shift', 'Space', and 'Clear'.

Figure 2-38. The Password Entry Dialog

Because the isotope settings are important system settings, we have secured it with a password. Changing the isotope settings will affect the readout of the dose calibrator.

2.5.1 Inserting an Isotope in the Isotope Database

After clicking on the Add button and selecting one of the desired empty buttons, the following menu will appear (the password dialog will always appear first, refer to Section 2-5 for more details).

The image shows an 'Add isotope' dialog window. It has a title bar with the text 'Add isotope'. The main area contains several labeled input fields: 'Isotope:', 'Halflife' (with a small 's.' to its right), 'Scale:', 'Factor:', 'Syringe factor:', 'Vial factor:', and 'Capsule factor:'. To the right of these fields are two buttons: 'OK' and 'Cancel'.

Figure 2-39. The Isotope Data Insertion Dialog

Just enter the data in the fields presented in the dialog. The isotope name must be unique and values for half-life time, scale, factor, syringe, vial and capsule-factor needs to be entered. The factor and scale factor values are isotope dependent and have to do with the energy efficiency of the ionization chamber. The isotope factor has a value between 0 and 999. Most isotopes have a scale value of 1, but some isotopes require a different scale value (= multiplication factor). If the isotope is very efficient, the scale value can be 0.5 or 0.1. If the isotope is very inefficient, the scale can be 10, 100 or even 1000. These last values often have to be used with beta emitters. A good starting point to determine an unknown scale and factor is to use the data of an isotope that is in the same energy range as the new isotope. Adjust the factor in such a way that the read out of the calibrator corresponds to a calibrated activity of the new isotope. A standard isotope list with known factors and scales of the 50 most used isotopes are found in Appendix A. In Appendix B you will find a detailed description on how to determine a correct calibration factor for an isotope not found in the standard isotope list.

The material of the containment of the activity influences the accuracy of the measurement. The difference between measuring in a glass vial and in a plastic syringe is caused by the attenuation of the low energy gamma/x-ray components of an isotope. For most isotopes it has been established that the error will stay within $\pm 2\%$. For some isotopes (see Section 2-8) the errors can be much larger and you do have the possibility to enter a correction factor for the medium used to measure the activity. Most factors are set to 1.0.

When all the needed values are entered, press the OK button to add the isotope to the database table. In this window an isotope can also be selected.

2.5.2 Editing an Isotope in the Isotope Database

After clicking on the Edit button, followed by selecting one of the desired buttons the following dialog will appear (the password dialog will always appear first, refer to Section 2-5 for more details).

Edit isotope	
Isotope:	<input type="text" value="Tc-99m"/>
Halflife	<input type="text" value="21672"/> s.
Scale:	<input type="text" value="1.0"/>
Factor:	<input type="text" value="236"/>
Syringe factor:	<input type="text" value="1.0"/>
Vial factor:	<input type="text" value="1.0"/>
Capsule factor:	<input type="text" value="1.0"/>
<input type="button" value="OK"/>	
<input type="button" value="Cancel"/>	

Figure 2-40. The Edit Isotope Dialog

WARNING

Be aware to select the correct isotope.

The edit procedure is analogue to the insert procedure be it that most of the fields already contain information. The information shown at start of dialog corresponds to the currently selected isotope. Clicking on OK will update the information in the database.

2.5.3 Deleting an Isotope from the Isotope Database

After clicking on the Delete button and selecting one of the desired buttons, the following dialog will appear (the password dialog will always appear first, refer to Section 2-5 for more details).

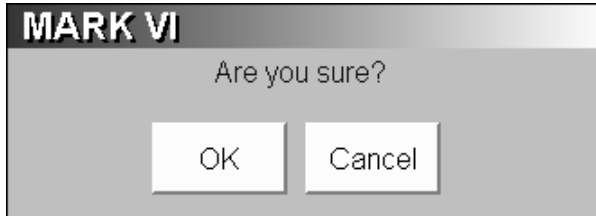


Figure 2-41. Deleting an Isotope from the Database

Clicking on OK will remove the entry from the database. Once an isotope is removed, it must be entered again to have the same data in the database again.

2.5.4 Modifying a Selected Isotope Pre-set

The isotope pre-set window on the main screen allows you to quickly select 1 out of 15 of the most commonly used isotopes in your laboratory. The user can determine which isotopes are displayed in this

pre-set window. From the main screen, click once on the isotope position you want to change.

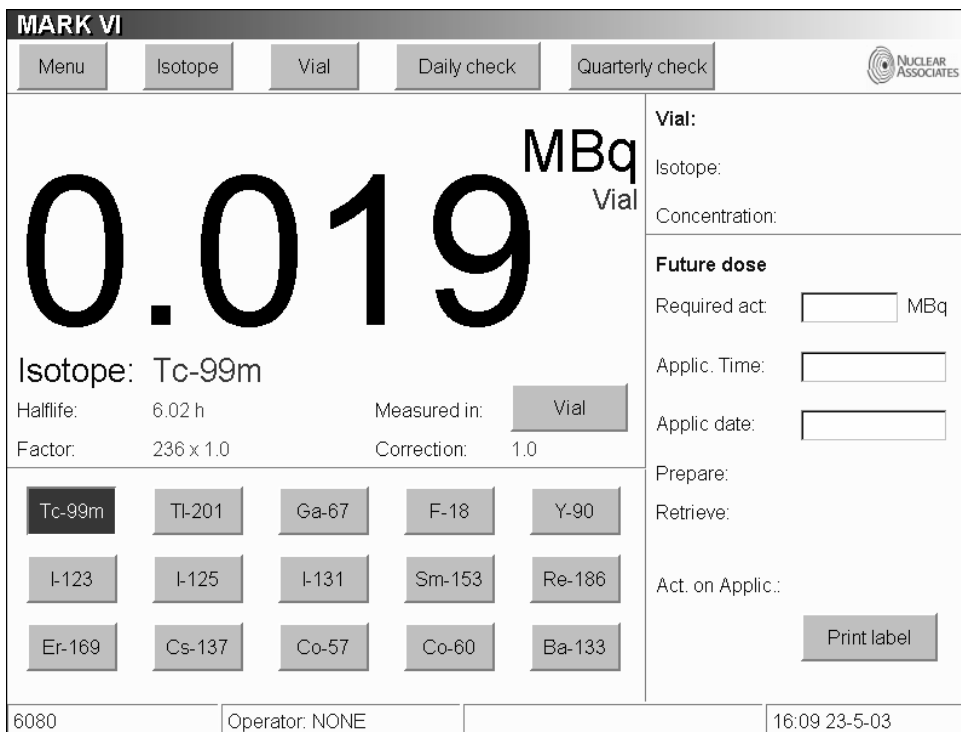


Figure 2-42. Select the Isotope Pre-Set Button to be Modified

Now select the Isotope menu followed by the Modify Selected Pre-set button. Choose from the isotope database the desired isotope, for instance O-15. You will be returned to the main menu. The former selected isotope has now been replaced by the newly chosen one.

The screenshot shows the MARK VI software interface. At the top, there are navigation buttons: Menu, Isotope, Vial, Daily check, and Quarterly check. The 'Isotope' button is highlighted. The main display area shows a large '0.016 MBq Vial' reading. Below this, it indicates 'Isotope: O-15', 'Half-life: 0.03 h', 'Factor: 773 x 1.0', 'Measured in: Vial', and 'Correction: 1.0'. A grid of isotope buttons is visible, with 'O-15' selected. Other buttons include Tl-201, Ga-67, F-18, Y-90, I-123, I-125, I-131, Sm-153, Re-186, Er-169, Cs-137, Co-57, Co-60, and Ba-133. On the right side, there are input fields for 'Vial:', 'Isotope:', 'Concentration:', 'Future dose', 'Required act.', 'Applic. Time:', 'Applic date:', 'Prepare:', 'Retrieve:', and 'Act. on Applic.'. A 'Print label' button is also present. At the bottom, the interface shows '6080', 'Operator: NONE', and '16:11 23-5-03'.

Figure 2-43. Changed Pre-Set Isotope Button

2.6 Working with the Vial Database

The MARK VI program has a built-in vial database. The content of this database is used in combination with the Future Dose menu on the main screen to facilitate the preparation of syringe for examinations. Parameters such as isotope and pharmaceutical setting along with volume and activity are stored in this database. This information can be retrieved at a later time to help prepare the syringes.

Normally, the kit vials are prepared first by injecting eluate in the vials and processing them to finish labeling. From these product vials the syringes are drawn. When you measure the hot vials with the dose calibrator and store them in the vial database along with the volume and a logical name, the program can help you in determining how many millilitres to draw up from a vial in order to get the correct amount of activity in a syringe. The combination of patient data and vial data to prepare syringes takes a lot of the work out of preparing syringes.



Figure 2-44. The Vial Menu Items

The menu has items for insertion, editing and deleting vials. The next sections will discuss these items in more detail.

WARNING

Be aware to select the correct vial.

2.6.1 Inserting a Vial in the Vial Database

After clicking on the Add button the following menu will appear.

The image shows a dialog box titled "Add vial". It contains the following fields and controls:

- Name:** A text input field.
- Isotope:** A text input field.
- Volume:** A text input field followed by the unit "ml".
- Booking time:** A text field containing the value "16:19:54".
- Booking date:** A text field containing the value "23-5-03".
- Concentration:** A text field containing the value "0.000 MBq/ml".
- On the right side, there are two buttons: "OK" and "Cancel".

Figure 2-45 The Vial Data Insertion Dialog

Just enter the data in the fields presented in the dialog.

WARNING

Be aware to select the correct pharmacon name and corresponding isotope.

The name field must preferably be unique. All vials will be accepted even if it has an identical name. The booking time field will be entered automatically when clicking on the OK button and cannot be edited.

The activity per ml stored with this vial is shown in the specific act. field that cannot be edited. The program will register the activity automatically when you click on the OK button and calculate the concentration. Make sure that the vial which data is to be stored in the database is in the ionization chamber at the time you finish entering data and click on the OK button.

2.6.2 Editing a Vial Entry in the Vial Database

After clicking on the Edit button and selecting the desired vial, the following dialog will appear.

Edit vial	
Name:	<input style="width: 80%;" type="text" value="HDP"/>
Isotope:	<input style="width: 80%;" type="text" value="Tc-99m"/>
Volume:	<input style="width: 80%;" type="text" value="10"/> ml.
Booking time:	16:33:08
Booking date:	23-5-03
Concentration:	56.22 MBq/ml

Figure 3-46. The Edit Vial Dialog

WARNING

Be aware to select the correct vial.

The edit procedure is analogue to the insert procedure, be it that all fields already contain information. The information shown corresponds to the currently selected vial. Clicking on OK will update the information in the database. The edit feature is used in those situations that a vial's data was entered incorrectly.

2.6.3 Deleting a Vial from the Vial Database

After clicking on the Delete button and selecting one of the desired vials, the following dialog will appear (see Figure 2-47).



Figure 2-47. Deleting a Vial From the Vial Database

Clicking on OK will remove the entry from the database. Once a vial is removed, it must be entered again to have the same data in the database again.

2.6.4 Selecting a Vial from the Vial Database

The MARK VI program needs to know a number of things in order to prepare a syringe. Selecting a vial from the vial database will set-up the program so that the corresponding syringe can be prepared. To do this, select the needed vial from the vial menu. The main menu will appear on the screen within the upper right window the selected vial and the actual concentration (see Figure 2-48).

WARNING

Be aware to select the correct vial.

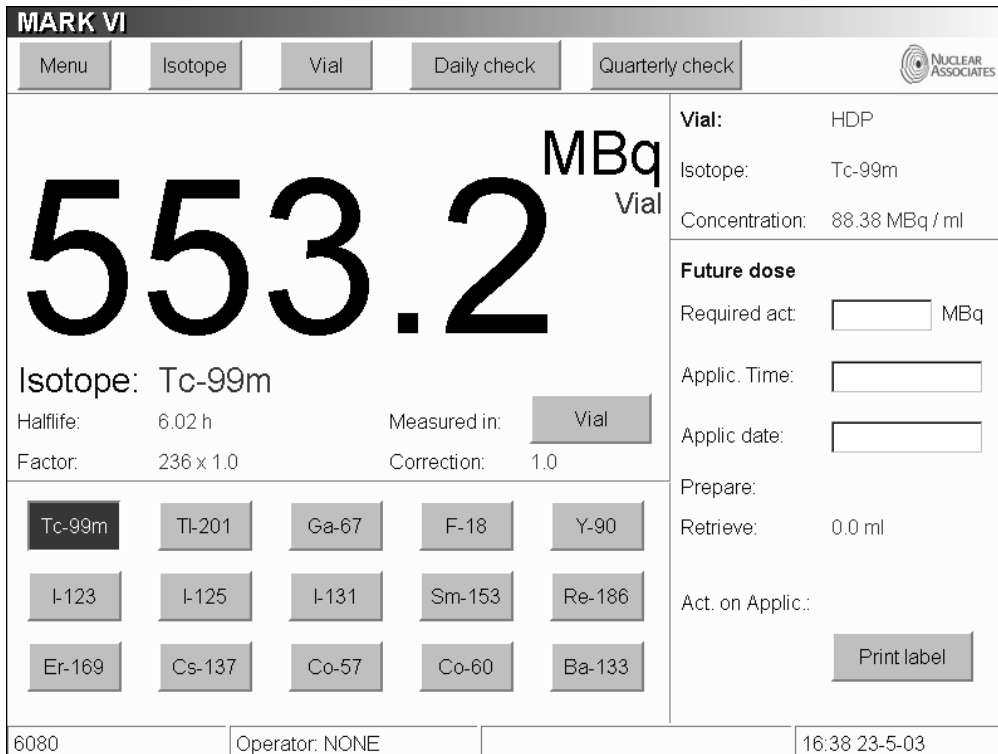


Figure 2-48. Selecting a Vial from the Vial Database

2.6.5 Preparing a Patient Dose with the Future Dose Menu

After selecting the appropriate vial (Section 2.6.4), you can use the Future dose window to calculate the volume needed to get the correct dose at the desired application time. Just fill in the required activity, the scheduled application time and date. The program calculates the required activity dose and the volume needed (Figure 2-49) to get this dose. It is also possible to print a label to identify the just prepared syringe.

The MARK VI program is able to detect syringe preparation errors. The prepared dose in the syringe is measured. The MARK VI compares the measured syringe activity with the calculated activity. If the difference exceeds the percentage shown in the system settings, a prompt will be shown on the screen. You can still print a label and accept the value, but it is a way to hint the user that there may be a problem with that particular syringe.

MARK VI																										
Menu	Isotope	Vial	Daily check	Quarterly check																						
<div style="font-size: 2em; font-weight: bold; margin: 0;">534.5</div> <div style="font-size: 1.5em; margin: 0;">MBq</div> <div style="font-size: 1.2em; margin: 0;">Vial</div>				<table style="width: 100%; border: none;"> <tr><td style="padding: 2px;">Vial:</td><td style="padding: 2px;">HDP</td></tr> <tr><td style="padding: 2px;">Isotope:</td><td style="padding: 2px;">Tc-99m</td></tr> <tr><td style="padding: 2px;">Concentration:</td><td style="padding: 2px;">87.77 MBq / ml</td></tr> <tr><td colspan="2" style="padding: 2px;">Future dose</td></tr> <tr><td style="padding: 2px;">Required act:</td><td style="padding: 2px;"><input type="text" value="270"/> MBq</td></tr> <tr><td style="padding: 2px;">Applic. Time:</td><td style="padding: 2px;"><input type="text" value="17:15"/></td></tr> <tr><td style="padding: 2px;">Applic date:</td><td style="padding: 2px;"><input type="text" value="23-5-03"/></td></tr> <tr><td style="padding: 2px;">Prepare:</td><td style="padding: 2px;">287.8 MBq</td></tr> <tr><td style="padding: 2px;">Retrieve:</td><td style="padding: 2px;">3.3 ml</td></tr> <tr><td style="padding: 2px;">Act. on Applic.:</td><td style="padding: 2px;">501.4 MBq</td></tr> <tr><td colspan="2" style="text-align: right; padding: 2px;"><input type="button" value="Print label"/></td></tr> </table>	Vial:	HDP	Isotope:	Tc-99m	Concentration:	87.77 MBq / ml	Future dose		Required act:	<input type="text" value="270"/> MBq	Applic. Time:	<input type="text" value="17:15"/>	Applic date:	<input type="text" value="23-5-03"/>	Prepare:	287.8 MBq	Retrieve:	3.3 ml	Act. on Applic.:	501.4 MBq	<input type="button" value="Print label"/>	
Vial:	HDP																									
Isotope:	Tc-99m																									
Concentration:	87.77 MBq / ml																									
Future dose																										
Required act:	<input type="text" value="270"/> MBq																									
Applic. Time:	<input type="text" value="17:15"/>																									
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Prepare:	287.8 MBq																									
Retrieve:	3.3 ml																									
Act. on Applic.:	501.4 MBq																									
<input type="button" value="Print label"/>																										
Isotope: Tc-99m																										
Half-life:	6.02 h	Measured in:	<input type="button" value="Vial"/>																							
Factor:	236 x 1.0	Correction:	1.0																							
<input type="button" value="Tc-99m"/>	<input type="button" value="Tl-201"/>	<input type="button" value="Ga-67"/>	<input type="button" value="F-18"/>	<input type="button" value="Y-90"/>																						
<input type="button" value="I-123"/>	<input type="button" value="I-125"/>	<input type="button" value="I-131"/>	<input type="button" value="Sm-153"/>	<input type="button" value="Re-186"/>																						
<input type="button" value="Er-169"/>	<input type="button" value="Cs-137"/>	<input type="button" value="Co-57"/>	<input type="button" value="Co-60"/>	<input type="button" value="Ba-133"/>																						
6080	Operator: NONE			16:41 23-5-03																						

Figure 3-49. Future Dose Syringe Preparation

2.7 Geometry

The accuracy of a measurement is dependent of the location, the size, the shape and the container of the sample to be measured. To be able to compensate for these influences, measurements have been carried out to establish:

- The height-dependency
- The volume-dependency
- The vial/syringe dependency

of the sample.

2.7.1 Height Dependency

In Figure 2-50 the normalized ionization current $I(h)/I(o)$ is given as a function of the height h of the sample above the bottom of the chamber.

The best height to measure is between 5 and 13 cm above the bottom because in this region the sensitivity is maximal and nearly height-independent. The test has been carried out with isotopes with different energies and in all cases the error in this range stays within 2% ($5 \text{ cm} = 100 \%$).

$I(h)$ = ionization current at h cm from the bottom of the chamber.

$I(o)$ = ionization at the bottom of the chamber.

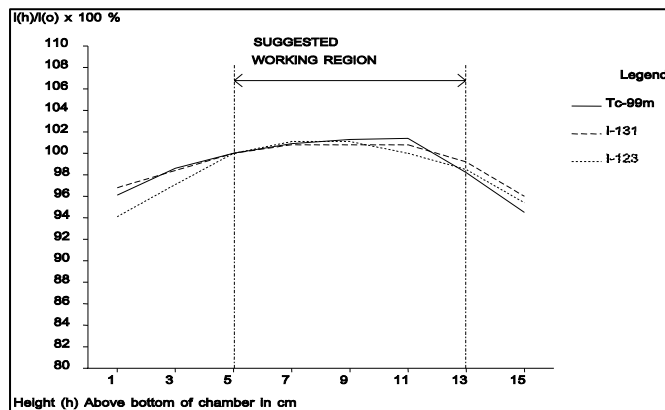


Figure 2-50. Height-Dependence of the Ionization Chamber Response

2.7.2 Volume Dependency

In Table 2-1 the error in measured activity is give as a function of the concentration. The percentages have been rounded to the nearest full percent. As a rule, measuring errors due to different volumes will stay within $\pm 2\%$.

Table 2-1. Volume Dependency

		Correction (%)	
		Tc-99	I-123
10 ml vial	2 ml	-	+1
	5 ml	-	-
	10 ml	-1	-1
10 ml syringe	2 ml	-1	-2
	5 ml	-	-
	10 ml	+1	+2
5 ml syringe	2 ml	-	-
	5 ml	+2	+2
10 ml syringe	1 ml	-	-
	2 ml	+1	+1
1 ml syringe	0.5 ml	-	-
	1 ml	+2	+1

2.7.3 Containment Dependency

The material of the containment of the activity influences the accuracy of the measurement. The difference between measuring in a glass vial and in a plastic syringe is caused by the attenuation of the low energy gamma/x-ray components of an isotope. For most isotopes it has been established that the error will stay within $\pm 2\%$. For some isotopes mentioned in Table 2-2, the errors can be much larger. In Table 2-2 correction factors are given for glass vials and plastic syringes. The calibration factors of the MARK VI are based on the measurements of thin-wall glass ampoules.

Table 2-2. Correction for Vial/Syringe Attenuation

	Glass vial	Plastic syringe
Cd-109	+40 %	-40%
In-111	+10 %	-10 %
I-123	+15 %	-15 %
I- 125	+25 %	-25 %
Xe-127	+10 %	-10 %
Xe-133	+10 %	- 10 %
Ba-133	+10%	-10 %
Am-241	+5 %	-5 %

The given correction factors are an indication. Even different kinds of glass can sometimes make a difference of a few percent.

2.7.4 Isotopes with Impurities

The user always has to be aware of the fact that a radionuclide can contain impurities of another isotope. These impurities can influence the measurement of activity of the prime isotope if the impurities are large enough. The supplier of the radionuclide should be able to tell you how pure the product is.

2.8 Use of the Dipper

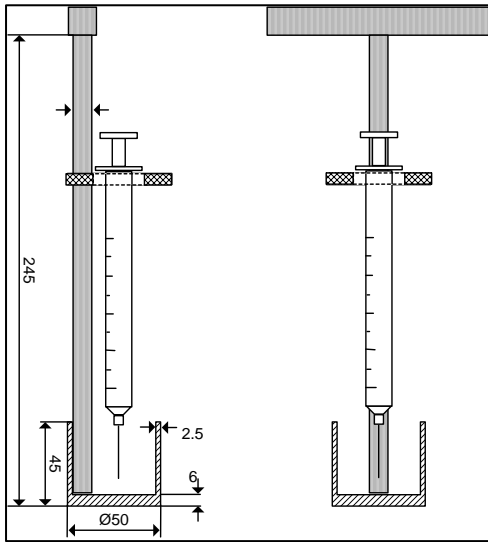


Figure 2-51. Dipper Dimensions (Dimensions in mm).

The syringe clamp will accommodate most sizes of syringes. Vials and ampoules can be placed in the lower cup.

Section 3

Troubleshooting/Maintenance

3.1 Troubleshooting

This Section discusses the diagnostic steps that should be taken when the MARK VI system does not function the way it should.

3.2 Errors in Use

Errors in use should only occur when selecting a wrong isotope, after a faulty calibration or when the VIK-202 ionization chamber is not connected properly.

3.3 Errors in the Equipment

3.3.1 Communication Error

The most probable error that can occur is a communication error between the ionization chamber and the control unit. The most probable cause is a faulty connection.

Please check the cable between the control unit and the ionization chamber. If the cable is connected correctly, the cable itself has to be checked.

3.3.2 No Zero Value

If the measuring value cannot be adjusted to zero with the bias adjustment, there are three reasons this could happen:

- The well-liner is contaminated. Decontaminate the well-liner.
- High background value because of a large source in the surrounding of the ionization chamber. Shield or remove this source.
- The bias current is too high because of moisture. The silicagel package inside the VIK-202 needs to be changed.
- If changing the bias adjustment setting doesn't bring the reading close enough to zero, use the background subtraction option to produce a close to zero value.

3.3.3 No Proper Calibration is Possible

If no proper calibration is possible, this can be caused by:

- An improper bias/zero adjustment
- An excessively high background value
- A defective amplifier
- A defective ionization chamber

3.4 Maintenance

The VIK-202 ionization chamber is apart from regular cleaning, service free for the end user. There are a few points however, that need attention:

- The high voltage battery has an expected lifetime of about ten years. The battery voltage should be checked regularly (daily check). If the battery voltage drops below 135 Volts, the battery should be replaced. Only qualified service personnel should perform the replacement of the battery.
- The well-liner and the dipper should be cleaned and checked for contamination regularly. Never use alcohol to clean the chamber accessories.
- Zero adjustment should be performed once daily.
- The Bias setting should be checked and if needed, adjusted once daily.
- A daily stability test with Cs-137 is advisable
- A good practice is to have the instrument calibrated at least once every year. The calibration should be done with a Co-57, a Cs-137 and a Co-60 source.

3.5 Exchanging a Moisture Absorber

On very rare occasions it may be necessary to exchange the silicagel moisture absorber in the ionization chamber after a prolonged period of exceptionally damp weather. If the ionization chamber cannot be zeroed or biased properly, this might indicate a saturated moisture absorber.

The silicagel filter can be exchanged by opening the VIK-202 ionization chamber. To open the ionization chamber it must be turned upside down, after which three socket screws on the side of the chamber and two socket screws on the bottom can be removed. Now the bottom plate of the ionization chamber itself can be removed.

The silicagel filter holder, a large plastic screw, is now revealed and can be exchanged by screwing the old one out, and placing a new one in. A saturated moisture filter can be recognized by a light pink color. A still active silicagel filter has a blue color.

The bottom can now be reinstalled again.

3.6 Literature

For the development of the MARK VI, the following literature is used:

- International standard IEC 1145, Calibration and usage of ionization chamber systems for assay of radionuclides.
- Leerboek nucleaire geneeskunde, Elsevier/De tijdstroom.
- Aanbevelingen Nucleaire Geneeskunde. Commissie Kwaliteitsbevordering NVNG.

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Appendix A Mark VI Standard Isotope List

A-1 Mark VI Standard Isotope List

<u>NAME</u>	<u>FACTOR</u>	<u>SCALE</u>	<u>HALFLIFE</u>
Am-241	514	2,00	3786072
Au-195	285	1,00	4392
Au-198	441	1,00	64,7
Ba-133	813	1,00	91980
C-11	771	1,00	0,34
Cd-109	337	2,00	11136
Co-57	380	1,00	6502
Co-58	738	1,00	1699
Co-60	889	1,00	46174
Cr-51	309	10,00	665
Cs-137	587	1,00	264289
Cu-64	345	2,00	12,7
Er-169	730	1000,00	226
F-18	762	1,00	1,83
Fe-59	756	1,00	1071
Ga-67	287	1,00	78,3
Hg-197	443	1,00	64,1
Hg-203	260	1,00	1118
I-123	618	1,00	13,1
I-125	590	1,00	1443
I-131	447	1,00	193
In-111	676	1,00	67,9
In-113m	172	1,00	1,66
Ir-192	746	1,00	1776
Kr-81m	643	1,00	0,0036
Kr-85m	93	100,00	4,48
Mn-52	835	0,50	134
Mn-54	682	1,00	7505
Mn-56	821	1,00	2,58
Mo-99	236	5,00	66,0

<u>NAME</u>	<u>FACTOR</u>	<u>SCALE</u>	<u>HALFLIFE</u>
N-13	771	1,00	0,17
Na-22	885	1,00	22794
Na-24	831	0,50	15,0

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O-15	773	1,00	0,034
P-32	850	100,00	343
Ra-226	862	1,00	14016000
Rb-81	495	1,00	4,58
Re-186	756	10,00	90,6
Sc-46	863	1,00	2011
Se-75	631	1,00	2875
Sm-153	580	1,00	46,7
Sr-85	532	1,00	1556
Sr-87m	264	1,00	2,81
Sr-89	798	100,00	1213
Tc-99m	236	1,00	6,02
Tl-201	552	1,00	73,1
Xe-127	723	1,00	874
Xe-133	460	1,00	126
Y-88	775	0,50	2558
Y-90	902	100,00	64,1
Yb-169	871	1,00	767

Appendix B

Determining A Calibration Factor

B.1 Determining a Calibration Factor

To be able to determine a calibration factor of an isotope that is not in the isotope list, a calibrated source is needed. With a radiation source with a defined activity and with a formula it is easy to determine the calibration factor that is needed to give a proper readout for the MARK VI.

WARNING

The use of this formula will give an indication of the calibration factor you can use. Please determine the actual factor with a calibrated source of the isotope of which you want to determine the calibration factor.

First select "Tc-99m" to obtain a relative readout. Then fill in this readout in the following formula:

$$1009 - \frac{V_s}{V_{Tc}} \times 773 = \text{Cal Factor}$$

Where:

V_s = actual value of the source

V_{Tc} = readout of the MARK VI when "Tc-99m" is selected

Cal Factor = Calibration factor which should be filled in

WARNING

We assume that the isotope factor for *Tc-99m* is 236. If the factor was changed, please select a user definable Cal factor, and set this to 236 to perform this procedure.

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When this formula results in a negative calibration factor or a calibration factor greater than 999, a suitable scale factor should be chosen to adjust the source value V_s in such a manner that a proper calibration factor can be obtained. The readout of the MARK VI will be divided or multiplied by this factor to obtain the actual measurement value.

Example 1:

The calibration source currently is 500 MBq (V_s). The readout with "Tc-99m" selected shows 350 MBq (V_{Tc}). Entering this in the formula shows:

$$1009 - \frac{500}{350} \times 773 = -95$$

Instead of Using $V_s = 500$ this value is divided by 2, resulting in a calibration factor 457

$$1009 - \frac{250}{350} \times 773 = 457$$

In this case 457 should be used as calibration factor, and the scale factor should be 0.5.

Example 2:

The calibration source has a current activity value of 3 MBq ($V_s = 3$) and the readout with Tc-99m selected shows 350 MBq. The formula shows the following results:

$$1009 - \frac{3}{350} \times 773 = 1002$$

By using a suitable multiplication factor 10 for V_s the calibration factor obtained can again be in range between 0 and 999

$$1009 - \frac{30}{350} \times 773 = 943$$

A scale factor of 10 should be entered and the readout of the MARK VI is now multiplied by 10 to obtain the activity value.

Once a calibration factor is determined it can be entered in the isotope database. When the value was entered, the readout of this isotope can be checked with the calibration source the calibration factor was determined with. It is possible that the determined factor has to be adjusted slightly to obtain a proper readout.

Appendix C Specifications

C.1 Detector Unit, VIK-202

Ionization chamber	Pressurized. (12-bar argon)
Ionization voltage	150 V lithium battery
Well size	60 mm diam. x 250 mm
Saturation	> 200 GBq (Tc-99m) > 6 Ci (Tc-99m)
Resolution	0.001 MBq 0.01 μ Ci
Energy range	25 keV - 3 MeV
Lead shielding	3 mm Pb
Linearity	± 1 % between 1 MBq and 200 GBq (Tc-99m)
Electrometer accuracy	± 1 %
Battery test accuracy	± 5 %
Temperature coefficient	0.1%/°C between 10°C and 40°C at 5 MBq and up
Reproducibility	± 1 % over 24 hours, stable conditions.
Overall accuracy	± 3 % dependant of specific calibration source and geometric variations
Response time	Maximum 2 seconds for 95% of the end value
Ranges	Auto ranging
Gain	Digital adjustment
Bias correction	Digital adjustment
Zero adjustment	Digital adjustment
Calibration	Digital adjustment
Background subtraction	Digital control
Battery test	Digital control
Interface	Standard RS-232C interface, no handshake 9600 Baud
Power supply	5 VDC
Cable	2.5 meters
Dimensions	150 mm diameter x 420 mm
Weight	15 Kg

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Controller / Readout unit

Display	8.4" TFT Display, 800 x 600 resolution.
Touch screen	8.4" Analogue resistance.
Label	Grey/ Transparent
CPU	300 MHz NS Geode GX1 CPU with NS Geode CS5530A Chipset.
Operating system	Microsoft ® Windows XP Embedded.
Memory	64 MB 133 SDRAM. 64 MB Compact Flash card.
Peripheral interfaces	1 x special RS-232 for detector 1 x standard RS-232 for label printer 1 x standard RS-232 for PC Optional: 1 x network connection
Readout	0.001 MBq – 200 GBq 0.01 µCi – 6000 mCi
Defined isotopes	55 touch screen selectable isotopes
User definable isotopes	100 user definable isotopes
Pre-set isotopes	15 pre-set isotopes
Software support	Future Dose calculation QA protocols for daily and quarterly checks Mo-99 breakthrough protocol
Temperature range	0°C - 40°C / 35°F - 105°F
Humidity	Max. 90% rel. humidity, non condensing
Dimensions	280 x 360 x 230 mm
Weight	5 kg
Voltage	85 – 264V ~, 47 – 63 Hz.
Power consumption	20 Watt (60 Watt peak).

Appendix D

Calibration Factors For Beta Emitters

D.1 Calibration Factors for Beta Emitters

Calibration factors have been determined for five radioisotopes Sr-89, Y-90, Sm-153, Er-169 and Re-186.

The ionization chamber is relatively insensitive for Beta emitters and large multiplication factors are needed to get a correct readout in Becquerel or Curie.

The factors given are for reference only because of the above-mentioned reason and because of the high (self) absorption for these isotopes.

Isotope	Factor	Mult. Factor	Comment
Sr-89	798	100	Glass vial
Sr-89	808	100	Syringe
Y-90	902	100	Glass vial
Y-90	865	100	Syringe
Sm-153	580	1	Glass vial
Sm-153	608	1	Syringe
Er-169	730	1000	Glass vial
Er-169	810	1000	Syringe
Re-186	756	10	Glass vial
Re-186	775	10	Syringe

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